ABSTRACT

Title of Document:	From Grain to Waste: Repurposing Buffalo’s Grain Elevators
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The Buffalo River, as it winds its way through the city of Buffalo, New York, is home to some of the finest examples of grain elevators to be found anywhere in the United States. These remnants, which embody cultural values and traditions of a bygone industrial age, are currently threatened with abandonment and demolition. The city of Buffalo is actively promoting improvements to its industrial riverfront area and is interested in developing current building usage standards. This thesis will attempt to repurpose and reuse the historic grain elevator complexes that define the Buffalo River waterfront in order to better use the land and recreate a place within the historic industrial fabric of the city. The goal of this thesis will serve as an example of a method for design in derelict sites where grain elevators have lost their original purpose and identity, but have retained their architectural prominence.

From Grain to Waste: Repurposing Buffalo’s Grain Elevators

By

Scott Derek Behrens

Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
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Professor Garth Rockcastle, FAIA Chair
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Preface

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Dedication

This thesis is dedicated to my family, and my professors. Without their continuing support and efforts, this thesis would not have been possible.

Acknowledgements

Thank you,

City of Buffalo, New York

Jerry Malloy

University at Buffalo

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Why the Grain Elevator?

> *They do have an almost Egyptian monumentality . . . and in abandonment and death they evoke the majesties of a departed civilization. Or so it used to seem to me, looking downstream on the Buffalo River . . . It was a privilege to know them in their ravaged antique grandeur . . .*
>
> Reyner Banham

As long as the human race has eaten grain products, it has been faced with the problem of storing them. With a surplus of grain produced for a rising nation, the grain elevator remains "the most important yet least acknowledged invention in the history of American agriculture."[1]

What does it mean to elevate the grain? The verb "to elevate," derived from the Latin word '*attollo*,' means to rise or move to a higher place. The term "grain," derived from the Latin word '*granum*,' means a small, hard seed of a food plant. In the context of language, a grain elevator refers to the Latin idiom '*pars pro toto*,' a part taken for the whole. Where a portion of an object or concept represents the entire object or context, the term grain elevator also covers facilities attached to the elevator itself, such as receiving and testing offices, weighbridges, and storage facilities.

When beginning to understand the very phrase "grain elevator," it is curious to question, "why would grain need to be elevated in the first place? Isn't grain

[1] William Cronon, *Nature's Metropolis: Chicago and the Great West* (W.W. Norton, 1992), p.111.

shipped horizontally, along the surface of the earth, not raised above it?”[2] Grain is elevated so that the force of gravity can deposit it into large storage silos, and then redistribute the grain to alternate means of transshipment.

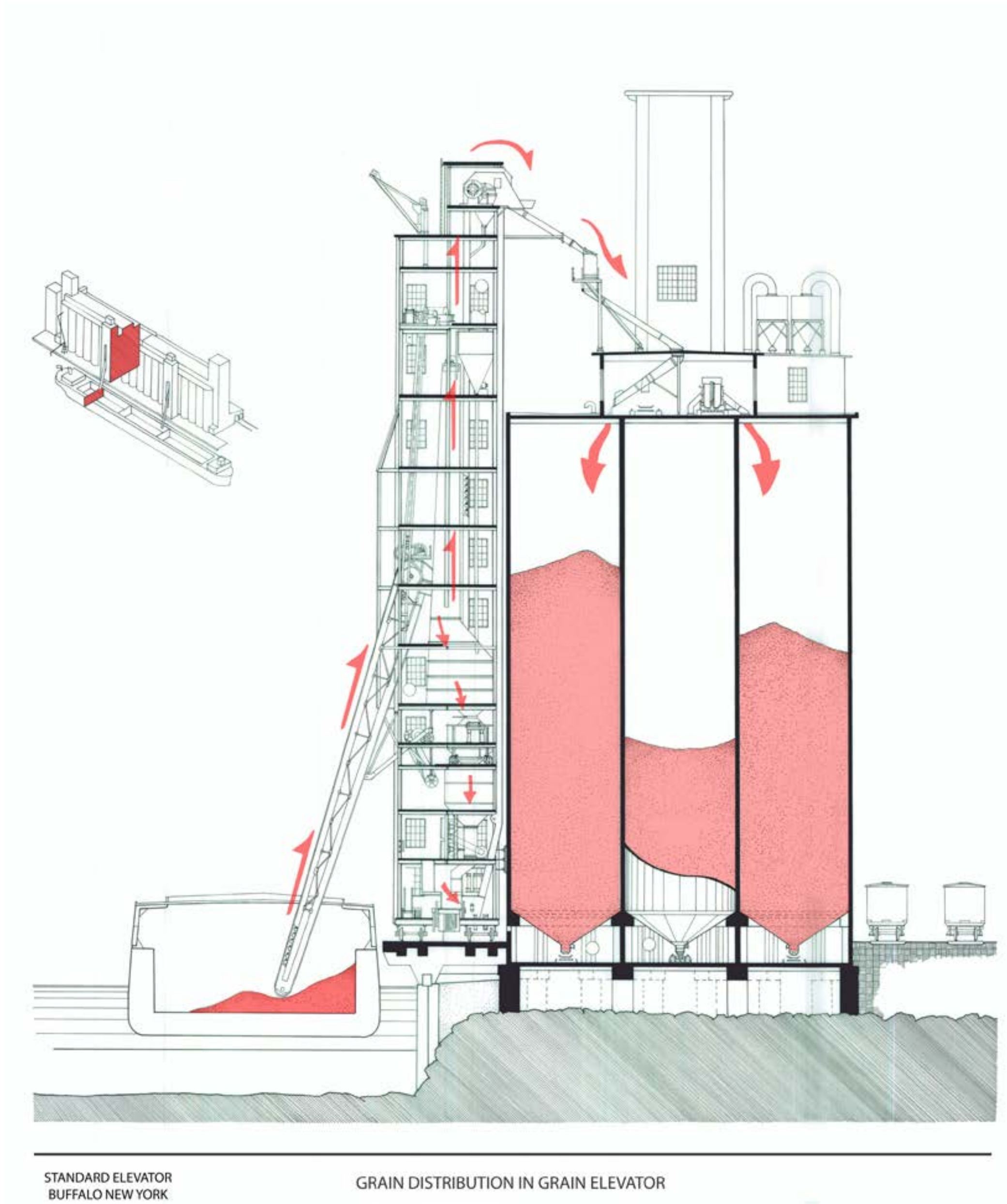


Figure 1: Flow of Grain Movement, Standard Elevator, Buffalo, New York
Image from Historic American Engineering Record

[2] Lewis Mumford, *Technics and Civilization* (Hardcourt, Brace and World, 1934), pp. 192, 437-446.

Why the City of Buffalo?

> *They were, however, buildings of great quality and power . . . like an avenue of mighty tombs . . . Certainly, no other city in the world possessed so concentrated a set of historically valuable elevators as Buffalo then did . . .*
>
> Reyner Banham

It is common to see a grain elevator sitting lonesome out on the prairie, but it is an extraordinary sight to see a dozen of them lining an industrial waterway. In the nineteenth and twentieth centuries, Buffalo, New York grew as a city recognized for its storing and handling capacity of grain produced in the American Midwest. With its location along the grain trade route in the great lakes region, Buffalo became the easternmost port city that functioned as the primary destination for the transshipment of grain. Transshipping grain in bulk from water to land created a problem in Buffalo, a problem that ultimately stimulated a city's development by the invention of a building type, the grain elevator. Invented in Buffalo in 1843, the grain elevator ended up serving as a utility that induced the intense rapid growth of American agriculture and thus to the rise of the country as a whole.

Although dormant, the grain elevators still distinguish the silhouette of the Buffalo city skyline. In the context of today, the grain elevators amass an enormous problem that is subjected to the city of Buffalo. The problem the city of Buffalo faces is what should be done with the historic grain elevators that have lost their reason for being? Grain Elevators are initially designed and built for one original purpose: the storing and distribution of grain. Reusing, repurposing, or even recycling the function of a grain elevator, a building topology that was initially designed and constructed for one specific purpose, is now the difficult problem that the city of Buffalo confronts.

Figure 2: Erie Canal Harbour, Buffalo, New York, circa 1915
Image from Detroit Publishing Company

Chapter 2: Background

Buffalo: The Lost Grain Industry

Prior to the year 1827, there was no grain handled in Buffalo. The surplus of Grain grown in the American Midwest reached markets in the East only after long and difficult transportation routes. Grain grown in the states of Ohio, Indiana, and Missouri, for example, had to be shipped on flatboats down the Ohio and Mississippi Rivers to New Orleans. From the port of New Orleans, grain was transferred to sailing vessels that carried it to its eventual destination in the East or across the Atlantic Ocean in to Europe. Besides the Mississippi River functioning as the primary route for grain flow, grain was also carried by land in wagons along difficult terrain that crossed through the rugged Appalachian Mountain chain.

In the handling of grain, as in other employments of man, there has been a gradual development of machinery and a corresponding lessoning of the proportion of human labor. All grain was once taken from the holds of vessels by the slow process of shoveling it into barrels, hoisting it by a tackle, weighing it in a hopper and scales swung over the hatchway of the craft, and carrying it into the warehouse on men's shoulders. A man by the name of Joseph Dart put an end to the slow and human labor intensive method of handling grain, and on the wharves of Buffalo in 1842-1843, he erected the first steam storage and transfer elevator in the world.

Opening of the Erie Canal in 1825

When the Erie Canal was opened in 1825 with Buffalo as its western terminus, the course of grain transshipment from the west to the east altered drastically. Located where the Niagara River flows out of Lake Erie toward Lake Ontario, Buffalo stood at the easternmost point of navigation on four of the Great Lakes and at the westernmost point of the new canal. Located roughly fourteen miles down river from Buffalo, Niagara Falls precluded a navigable link between Lake Erie and Lake Ontario and the direct access the latter would have afforded to the Atlantic Ocean by way of the St. Lawrence River. Hereafter, grain would move across the western Great Lakes to Buffalo, where, unloaded and transferred to canal boats, it was carried eastward some 360 miles by way of the Eire canal to Albany (see Figure 3). It was then placed on vessels for the 150-mile journey down the Hudson to New York City. There it could be exported to European and other world markets. What had once been a three-thousand-mile journey was now reduced to 450 miles.

Figure 3: Map of Erie Canal through the state of New York
Image from <http://kids.britannica.com/elementary/art-88804>

Development of the Railroads

In addition to the Erie Canal and the historic transformation of marine travel by steam power, the railroad revolutionized the transportation of goods, including grain, in the early nineteenth century. Indeed, almost from the beginning of its existence, the Erie Canal faced competition from the new railroad industry. Rail beds began to be constructed parallel to the Erie Canal in the early 1830s. At first, competition was small because early railroads were built with iron rails that could sustain only relatively light loads. Furthermore, the early railroads had no terminals for loading and stowing grain and other goods. With the introduction of steel rails and the steady improvement of trackside facilities, railroads began first supplementing and then drawing away business from the canal. Rail travel was faster, and unlike the canal, the railroads could run all year round; they did not shut down when winter ice closed the lakes-canal route. By the middle of the nineteenth century, the rail link between New York City and Buffalo was consolidated, with a number of rail lines being absorbed into the New York Central railroad company.

> *"This great route almost equaling in importance the Erie Canal…..and to which it already proves a formidable rival…..has been yearly extending its operations until it now forms one of the most reliable channels of commerce between the produce of the west and the manufacturers and markets of the east."*[3]

> Stated by a Buffalo business journal, 1854

[3] Francis R. Kowsky, *Monuments of a Vanished Prosperity: Buffalo's Grain Elevators and the Rise and Fall of the Great Transnational System of Grain Transportation* (Published in Reconsidering Concrete Atlantis: Buffalo Grain Elevators. L. Schneekloth, 2006).

By investing in steamboat lines along the Great Lakes as subsidiaries and by building warehouse facilities and storage elevators at the terminus of the Buffalo River waterfront, railroads eventually intensified their levels of commerce on grain transportation within the Buffalo Niagara region.

Joseph Dart’s Elevator

As Buffalo's harbor became port of call to more and more vessels arriving to unload grain, it was perhaps inevitable that invention would be applied to the laborious process of transferring grain from lake vessels to canal boats. Handling the grain by hand was slow and inefficient, causing delays and congestion of people and boats in Buffalo Harbour. It was at this time that Buffalo entrepreneur Joseph Dart and engineer Robert Dunbar who applied the new technology of the age to the handling of grain. As the grain trade began to develop in Buffalo after the opening of the Erie Canal, he turned his sights on this growing industry.

> *It seemed to me, as I reflected on the amazing extent of the grain producing regions of the Prairie West, and the favorable position of Buffalo for receiving their products, that the eastward movements of grain through this port would soon exceed anything the boldest imagination had conceived.*

Joseph Dart

In 1842, Dart built the first steam-powered grain elevator. Dart, in addition to creating the first steam transfer and storage elevator in the world, devised a means of lowering the bottom end of the bucket into the holds of the large vessels that brought grain across the Great Lakes or of the barges that moved it along the Erie Canal. This was a turning point in the industry, marking a shift from the manual labor of men on ladders to a mechanized system. One of the most crucial features in Dart's invention was the employment of a rigid, nearly vertical frame to carry the bucket, chain, and sprocket assembly. This vertical frame, if contained in a building of its own, was (and still is, where it survives) identified as a "marine tower" or more familiarly as a "leg."[4] Housed in a tall wooden sleeve, the conveyer could be canted outward at the bottom of the elevator structure and lowered directly into the hold of a waiting boat. Figure 4 illustrates how Joseph Dart's elevator operated.

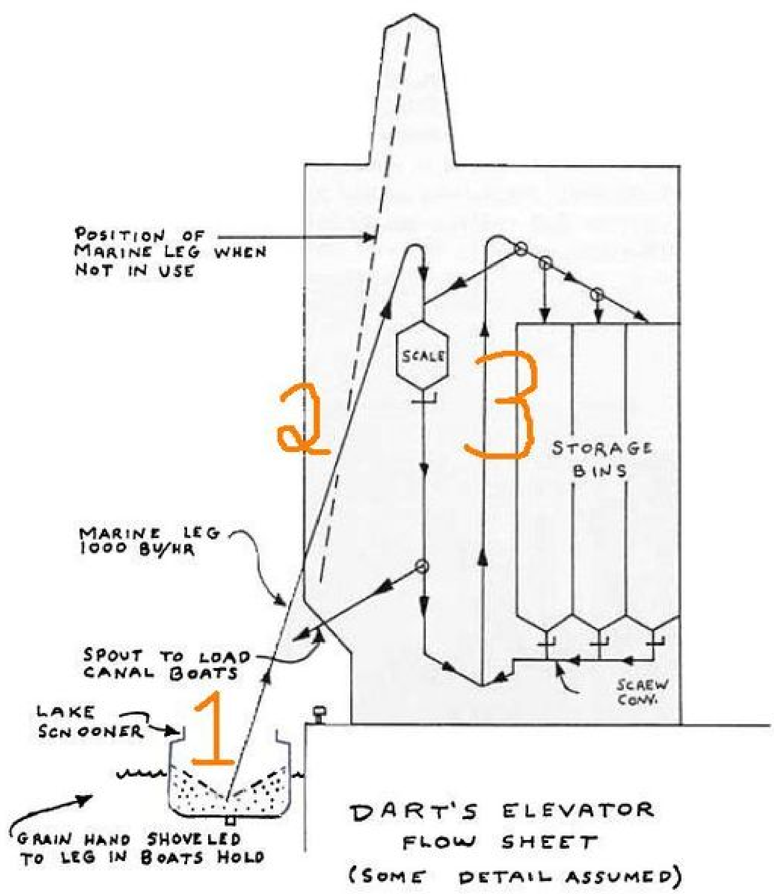
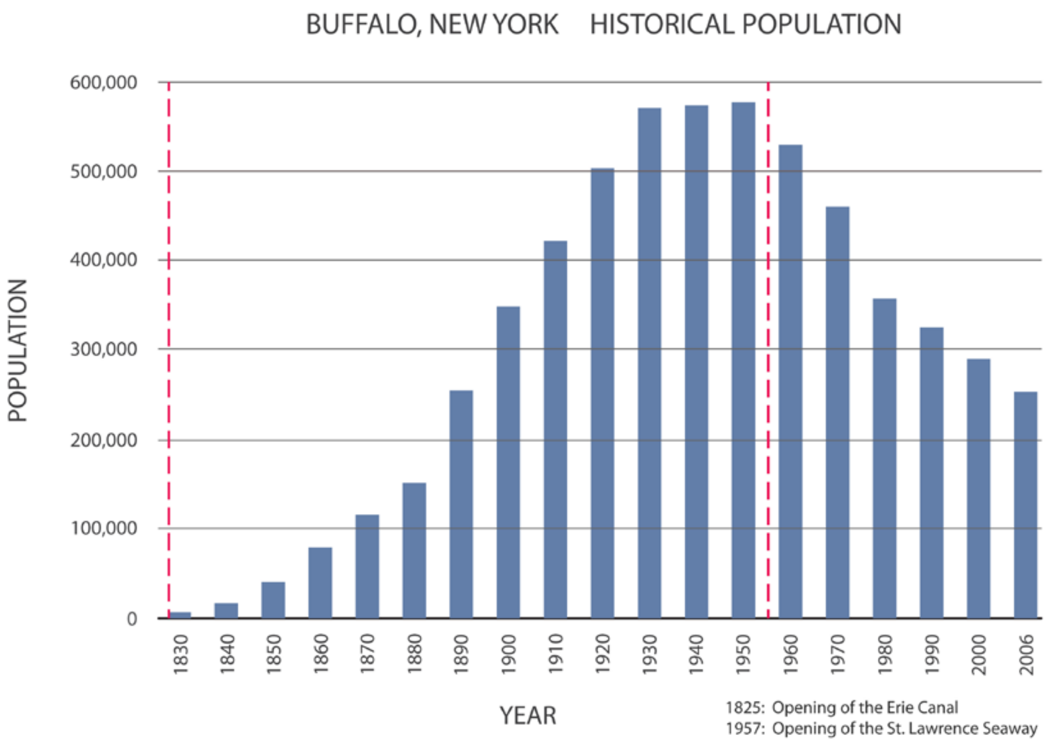


Figure 4: Flow Chart of Joseph Dart's Grain Elevator
Image from Buffalo and Erie County Historical Society

4 Reyner Banham, *A Concrete Atlantis*, pp. 110-111)



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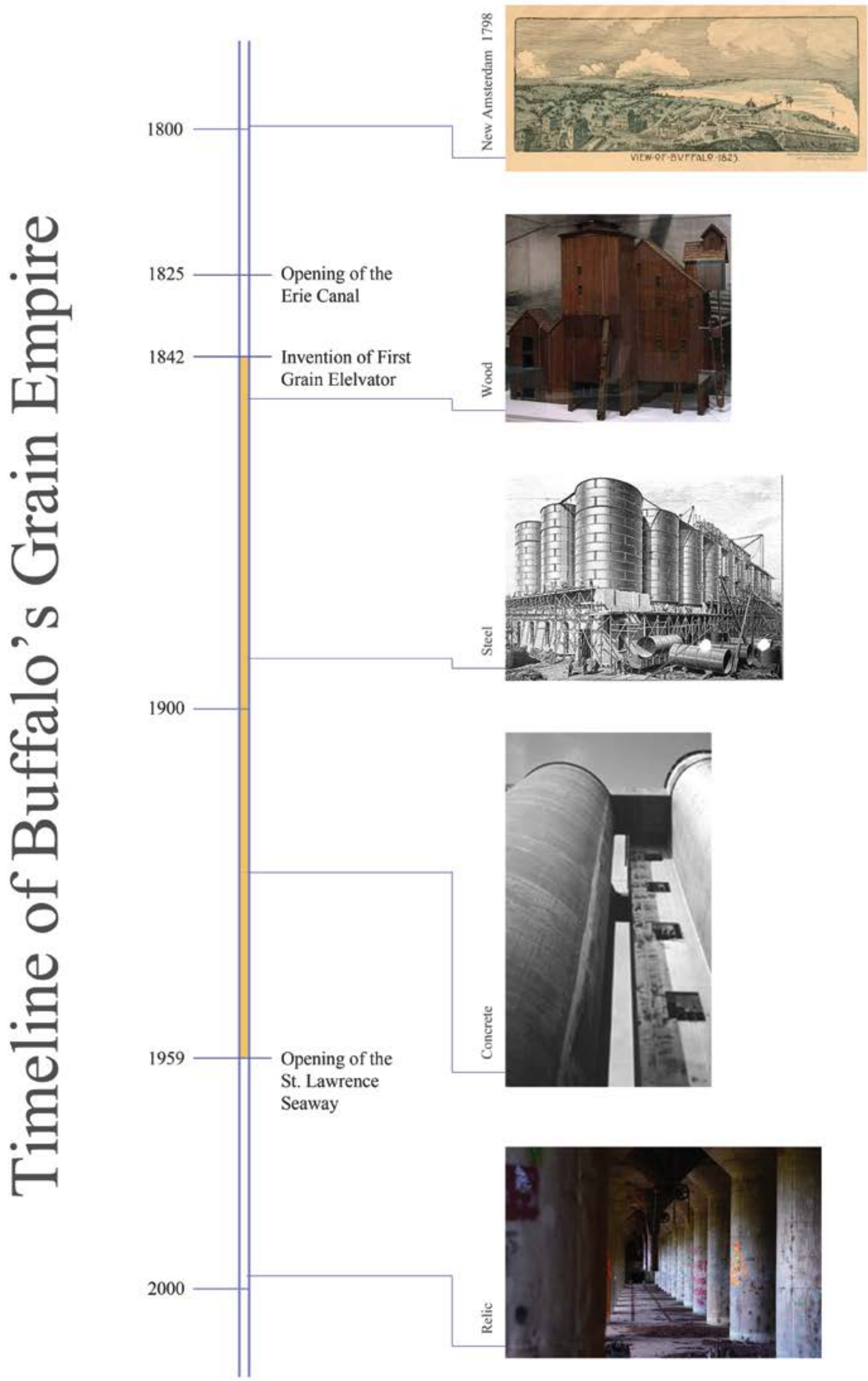

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Top Image from Map Division of Library of Congress
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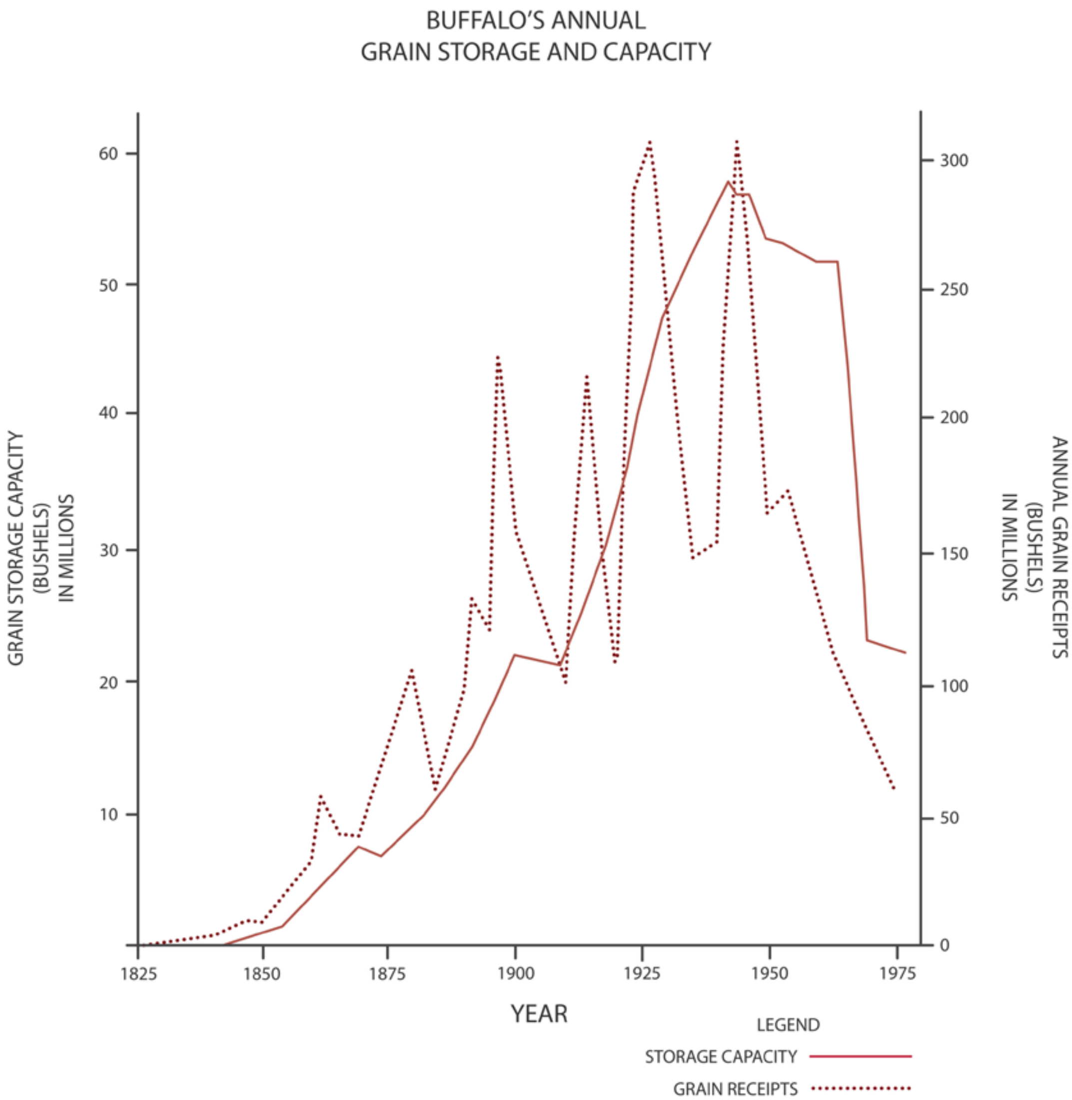

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Image from <www.conservapedia.com>

Understanding the Past

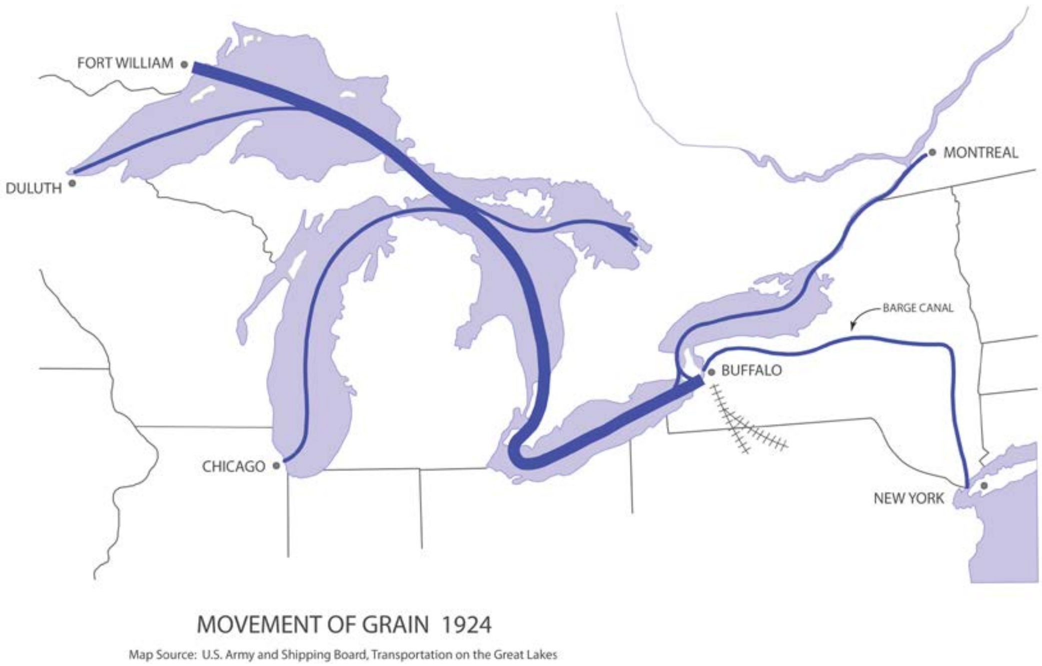

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Image from Detroit Publishing Company

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Image from Detroit Publishing Company

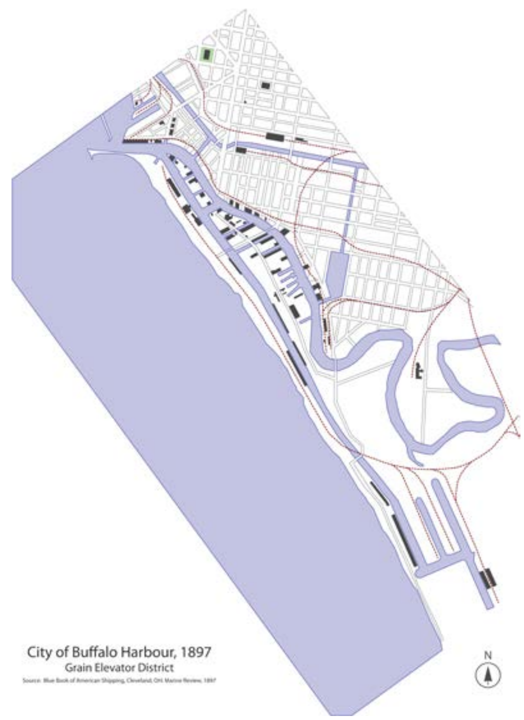

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Image from < http://www.buffalohistoryworks.com>

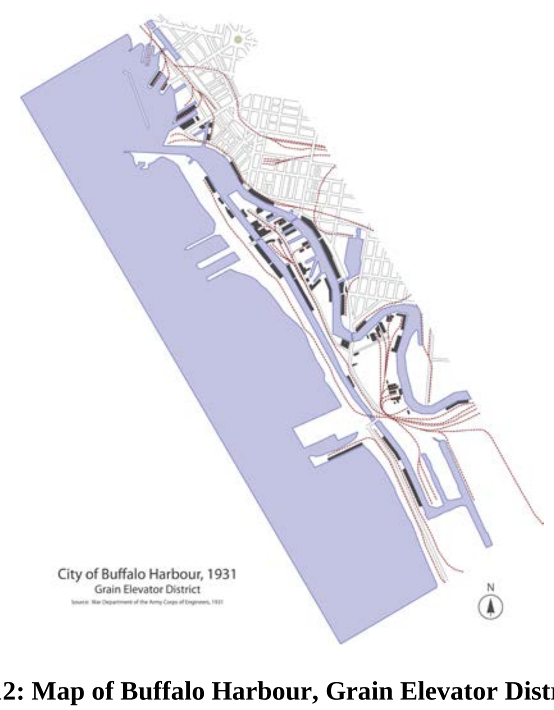

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Image from < http://www.buffalohistoryworks.com>

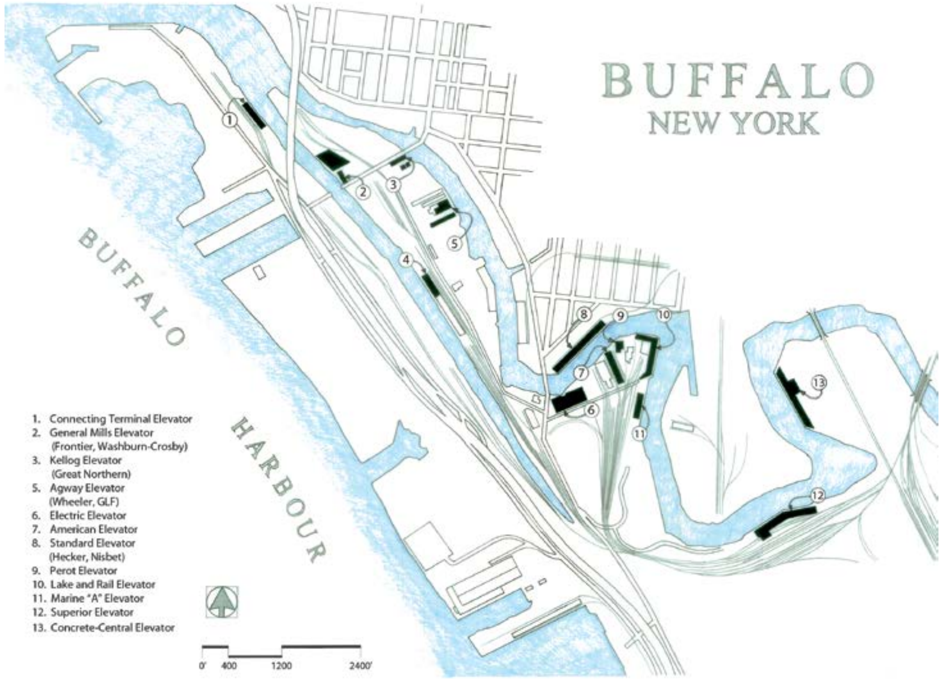
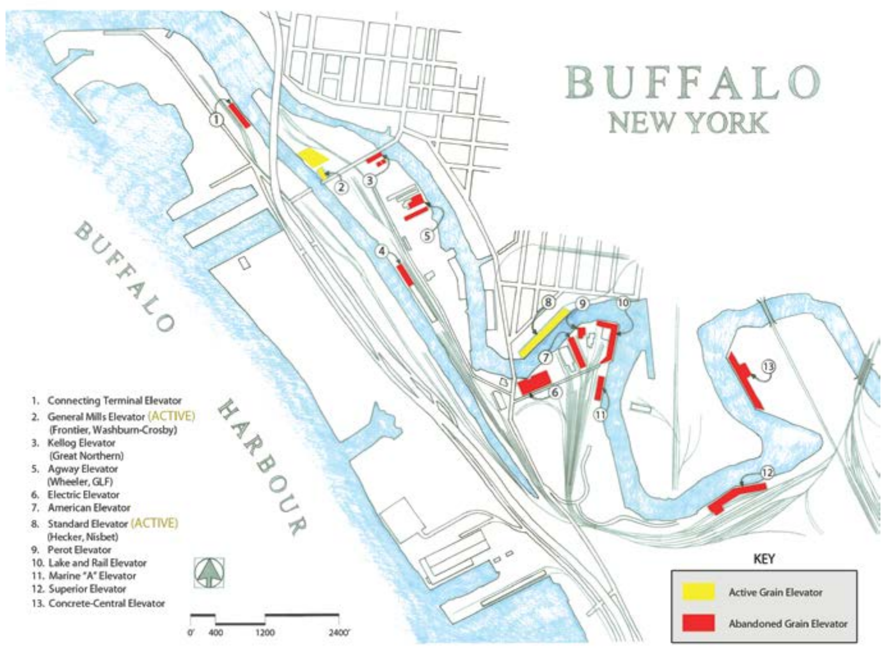


Figure 13: Map of Buffalo Harbour, Grain Elevator District, Present day
Image from < http://www.buffalohistoryworks.com>



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Area of Intervention and Analysis

Figure 15: Aerial Image of the City of Buffalo with Outlined Grain Elevator District
Aerial Image from Google Earth

This thesis will focus on the grain elevators that are located along the banks of the Buffalo River near the terminus into the lake Eerie waterbody (see Figure 15). The Buffalo River divides the city of Buffalo into two distinct halves: the half to the north with an established city grid relevant to the Joseph Ellicott plan, and the half to the south heavily influenced by the grain and steel industry. The grain elevators built along the Buffalo River are ideal docking areas for water vessels and barges because these areas are shielded and protected from the lake winds that blow from the southwest with excessive force. As the Buffalo River meanders its way through the city of Buffalo, the historic grain elevators are heavily fortified in close proximity to one another such that they are easily accessed by both barge and rail traffic. Grain elevators typically respond to a site by being orientated parallel to the primary direction of grain transportation and traffic. Many of the larger grain elevator complexes that line the Buffalo River are orientated parallel to the riverbank because transportation by water vessel was the primary method of grain transportation in Buffalo.

Figure 16: Faded Aerial Image of Grain Elevator District along Buffalo River
Aerial Image from Google Earth

It is important to note that none of the grain elevators in Buffalo respond to the city's street network and overall city plan. Grain elevators in their own right are tall robust structures that easily retain their architectural presence from the human eye. The grain elevators in Buffalo do not have any relationship connecting them to the city plan other than the Buffalo River. The river itself bends and meanders around plots of land forming peninsulas, and the grain elevators follow the same organic pattern (see Figure 16). To the naked eye, the grain elevators in Buffalo are only perceived on the oblique by a distant measure because the Buffalo River essentially isolates the grain elevator compounds from the adjacent neighborhoods and communities (see Figure 17). In all their architectural presence, the grain elevators in Buffalo are only appreciated from a distant view, deprived of any interaction at close proximity, and left in isolation from the surrounding city.

Figure 17: Street Level View of First Ward Neighborhood with Standard Elevator in Background, Buffalo, New York
Image from <http//:www.global site plans.com>

One might question: 'Why are the grain elevator complexes in Buffalo located in isolation from the rest of the city?' Quite simply, a typical grain elevator complex is not an ideal place for inhabitation and public interaction amongst civilians. Grain elevators are strictly utilized for the storage and distribution of grain. Furthermore, the terminal grain elevators in Buffalo require considerable adjacent infrastructure in order to efficiently distribute grain. Freight trains, barges, and tractor trailers are all simultaneously navigating around the confines of a grain elevator complex, which makes the premises extraordinarily dangerous when in operation. Railroad lines and freight yards were excessively developed and built in conjunction with the grain elevators along the industrial parcels of land located to the south of the Buffalo River, which made it almost impossible for the development of traditional neighborhood planning to take place. It's also important to understand the typology of the grain elevator is prone to rare dust explosions that can be catastrophic in magnitude. The grain elevators in Buffalo, with an exception to the Standard Elevator, were all built at a safe distance away from nearby communities and adjacent neighborhoods to prevent a disaster from spreading if a dust explosion were to occur.

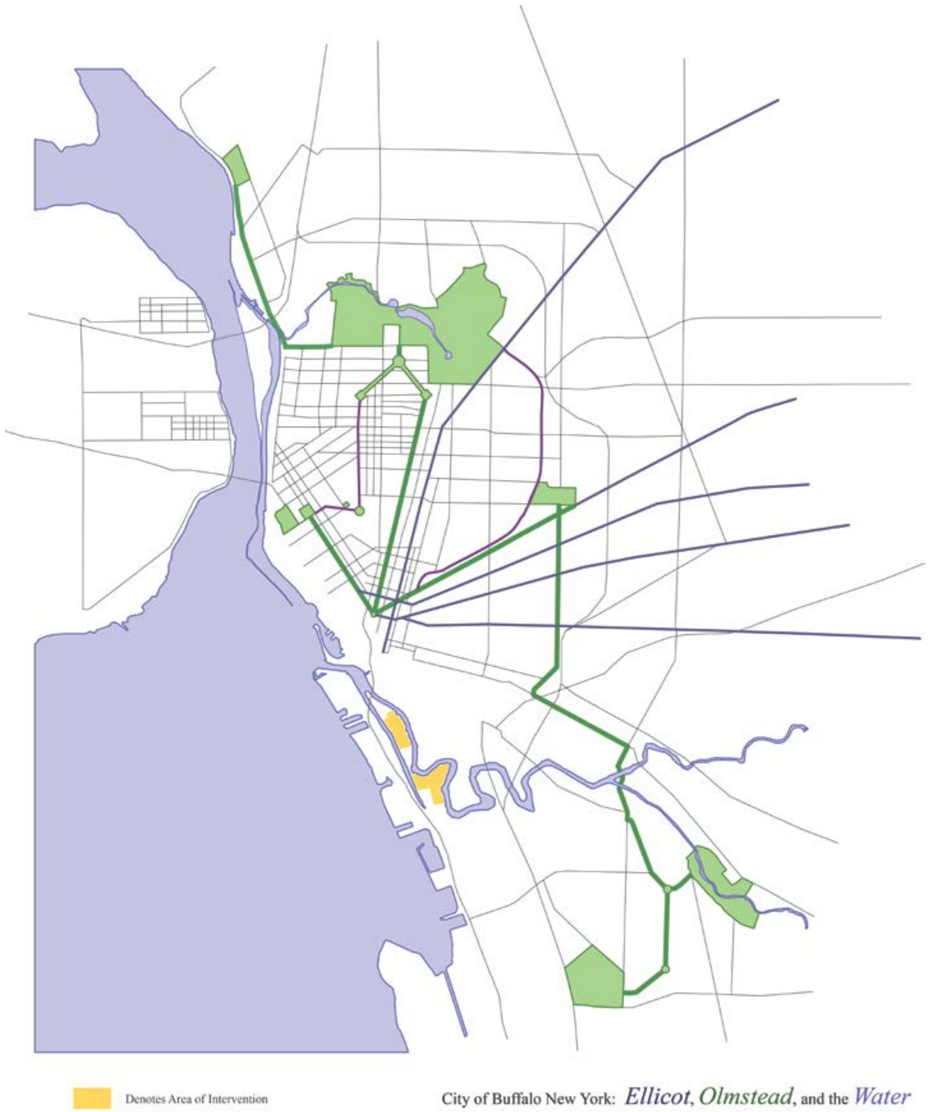

Figure 18: Frederick Law Olmstead and Joseph Ellicott Plan of Buffalo
Image Composed and Diagramed by Author

The city of Buffalo is structured by two city planning principals: Joseph Ellicott's 1804 radial city and grid street plan of New Amsterdam, and Frederick Law Olmstead's designed system of parks and parkways that connect to and extend Ellicott's radial streets (see Figure 18). The Olmstead Park and parkway system together with the Ellicott radial and grid plan connect the city to its destination parks, downtown districts, and to the waterfront areas along the Buffalo River, the Niagara

River, and Lake Erie. It is interesting to note the Olmstead Park and parkway system do not ultimately tie into the Grain Elevator district along the Buffalo River. With a strong architectural presence, the grain elevators would seemingly benefit from a green corridor that establishes a link from downtown Buffalo that stretches through the Grain Elevator District and continues to extend into South Buffalo. This link could add value to the grain elevators, and ultimately sponsor a preservation strategy that would reduce the threat of demolition.

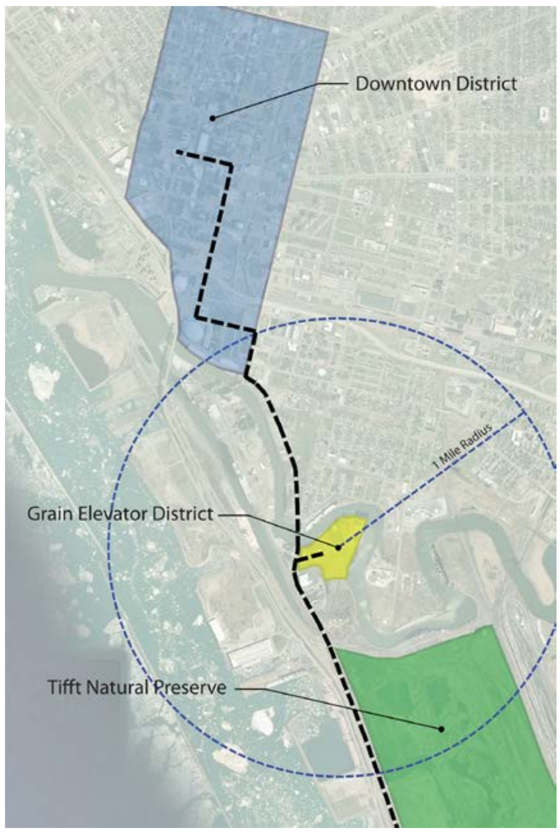

Figure 19: Grain Elevator District in Relationship to Downtown District
Image Composed and Diagramed by Author with Aerial Background Content from Google Earth

In relationship to where it is located at the scale of the city, the Grain Elevator district is situated between the Downtown District located to the north, and Tifft Nature Preserve located to the south (see Figure 19). The Tifft Nature Preserve is a

264-acre urban nature preserve, which is dedicated to protection of the site's natural resources, scientific research, environmental education, and public enjoyment. Located in South Buffalo, the Tifft Nature Preserve was an area formerly used as a farm, stockyard, railroad shipping center, and dumping facility until the City of Buffalo created the first urban nature sanctuary on a restored brownfield site in the early 1970's.[5] The Grain Elevator District is within a one mile radius of both the Tifft Nature Preserve and the Downtown District. The primary artery connecting the Tifft Nature Preserve in South Buffalo to the Downtown District located to the north is Ohio Street, which is a two lane roadway that runs in a north-south direction along the Lake Erie shoreline.

The Buffalo River is a recovering riparian system. The river has a history of heavy industrial discharge that resulted in poor water quality and badly contaminated sediments. The Buffalo river was considered biologically dead as recently as the early 1970's, and it was designated as a Great Lakes area of concern in the 1980's by the New York State Department of Environmental Conservation. Combined sewer overflows and upstream pollutant inputs remain concerns, but historical sediment contamination and poor habitat opportunities persist as the major obstacles to recovery. Pertaining to this thesis, how can habitat restoration along areas of the Buffalo River be linked to grain elevator reuse?

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[5] Lauren Makeyenko, *Energy Efficiency and Enhancements at Tifft Nature Preserve* (Green Renaissance of Western New York, April, 2012).

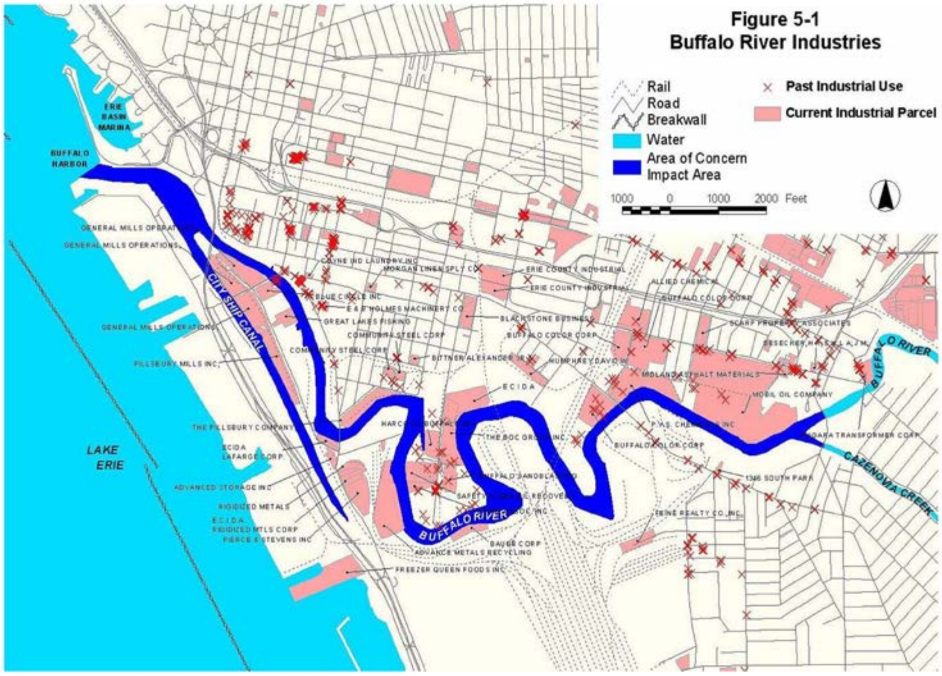

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Image from < http://buffaloriverermp.ene.com/>

Figure 21: Satellite Image of Industrial Land Parcels, Buffalo, New York
Image from < http://www.city-data.com/city/Buffalo-New-York.html>

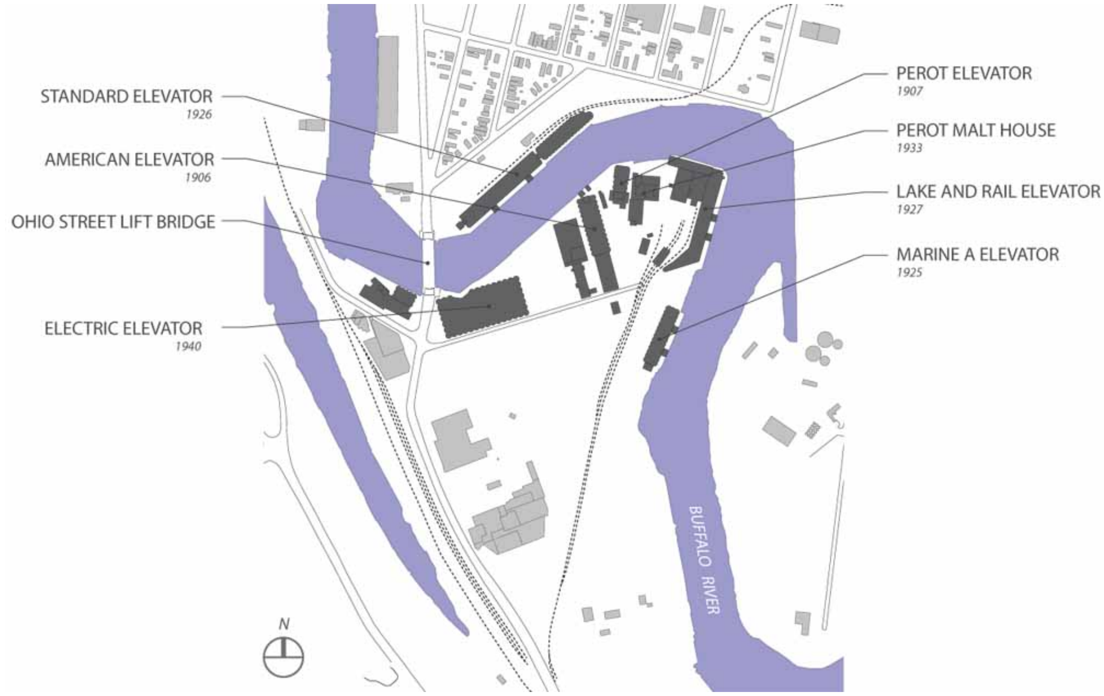

Figure 22: Childs Street Industrial Complex, Existing Site Plan
Image Composed and Diagramed by Author

The area of concern this thesis narrows down to and addresses within the Grain Elevator District along the Buffalo River is the Childs Street Industrial District. The Childs Street Industrial District is located off the Buffalo River, on a peninsula of land directly south of the First Ward District. Present day, there are five existing grain terminal elevators that make up the entire district: Electric Elevator, American Elevator, Perot Elevator, Lake and Rail Elevator, and Marine A. Elevator. The arrangement of the cluster of grain elevators on the site is rather disorganized with no clear organizing principle. Three of the industrial buildings are oriented at an orthogonal angle in relationship to Childs Street, while the remaining structures are fronted to face the Buffalo River. This random gothic like aggregation of grain elevators is what ultimately characterizes the Childs Street Industrial Complex as a unique site, almost indicative of a reliquary of industrial ruins. Of the five remaining grain elevators, only the Lake and Rail Elevator complex is still in operational use today, with only a fraction of its silo storage capacity being utilized to store grain (see Figure 23).

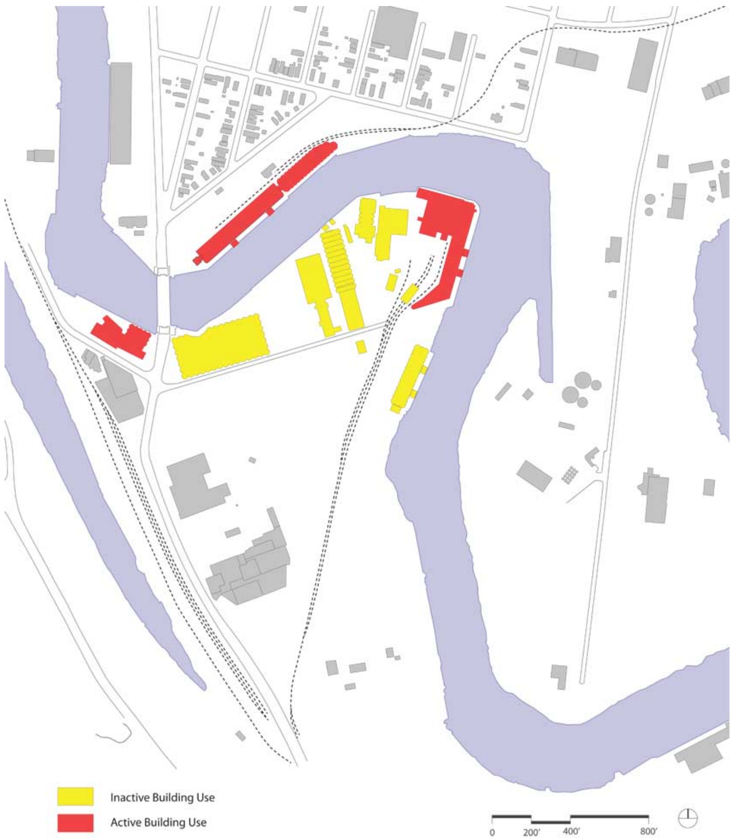

Figure 23: Active vs. In-active Grain Elevators
Image Composed and Diagramed by Author

Directly across the Buffalo River located to the north, stands the Standard Elevator, which is still in operation today. Where the Buffalo River flows around the grain elevators at the Childs Street Industrial District, this part of the river is famously referred to as 'Elevator Alley.' The term 'Elevator Alley' refers to the close proximity of grain elevators that dominate the edge conditions along the Buffalo River with soaring heights above the ground plane (see Figure 28).

The Childs Street Industrial Complex is accessed by three methods of transportation: roadway, barge, and rail line. The primary point of entry into the site by means of roadway is the intersection Ohio Street and Childs Street (see Figure 24). This point of entry into the site by roadway is the only access point for cars and tractor trailers.

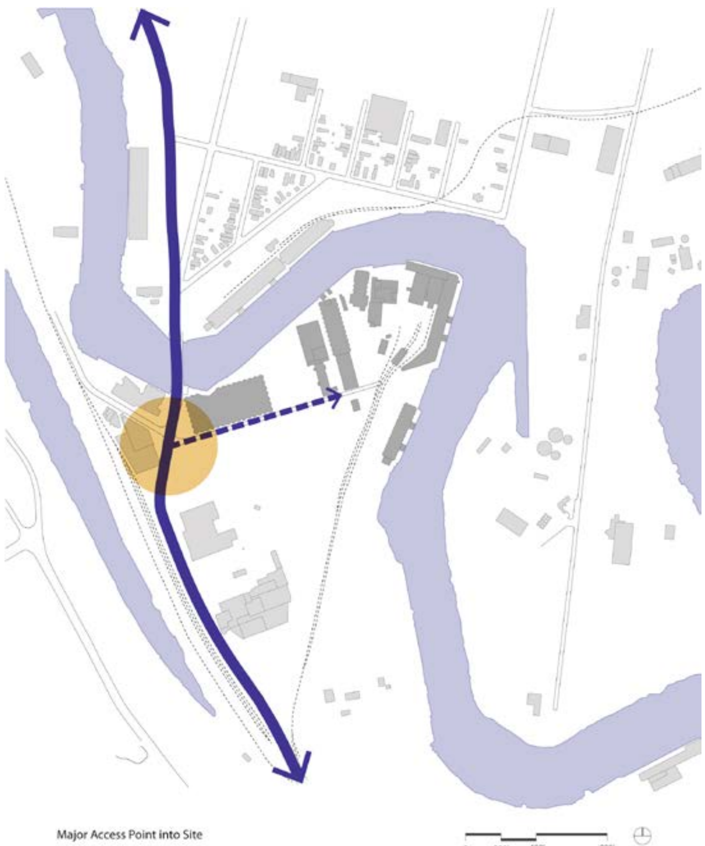

Figure 24: Site Access into Childs Street Industrial District
Image Composed and Diagramed by Author

The site is also accessed by rail, with a series of railroad lines that terminate to form a freight yard. The freight yard is defined by negative spaces in between each of the grain elevators, and also by the edge conditions of the grain elevators. Present day, the rail line is only in partially active use, primarily servicing the Lake and Rail Elevator (see Figure 25).

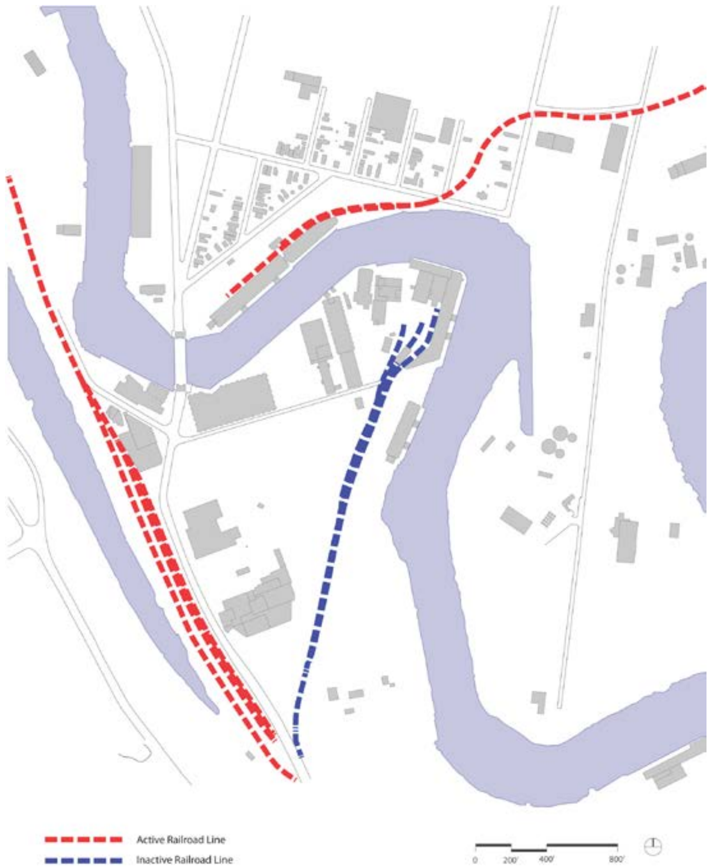

Figure 25: Diagram Illustrating Active vs. Inactive Railroad Lines
Image Composed and Diagramed by Author

Site Photographs

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Image Photographed by Author

Figure 27: Photograph of Existing Rail Yard (present day)
Image Photographed by Author

Figure 28: Photograph of Elevator Alley, looking Southwest
Image Photographed by Author

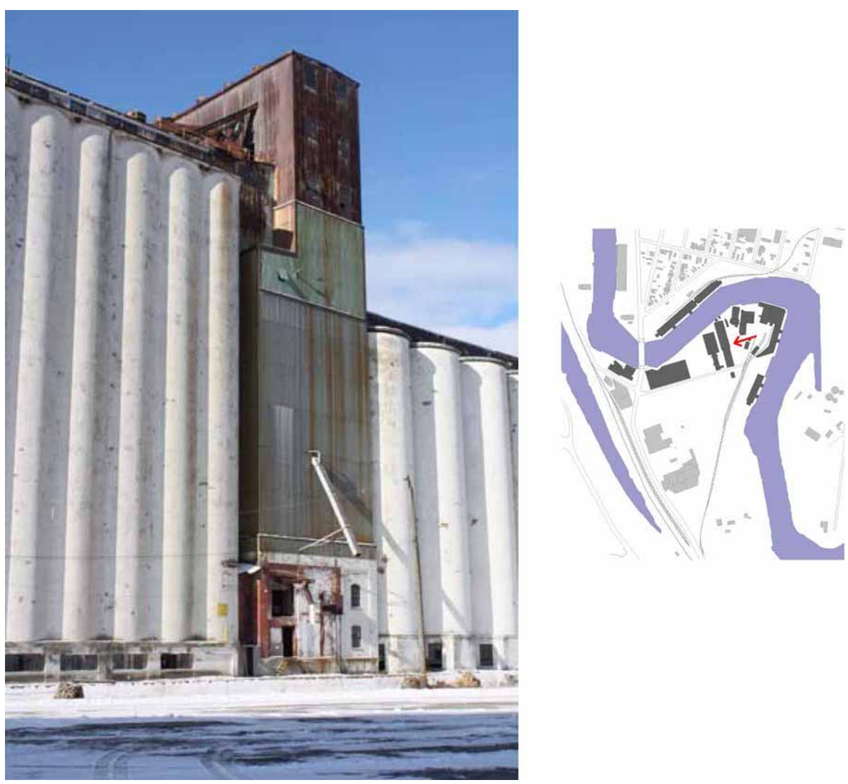

Figure 29: Photograph of Existing Workhouse at American Elevator
Image Photographed by Author

Figure 30: Photograph of Lake and Rail Grain Elevator, Looking Northeast
Image Photographed by Author

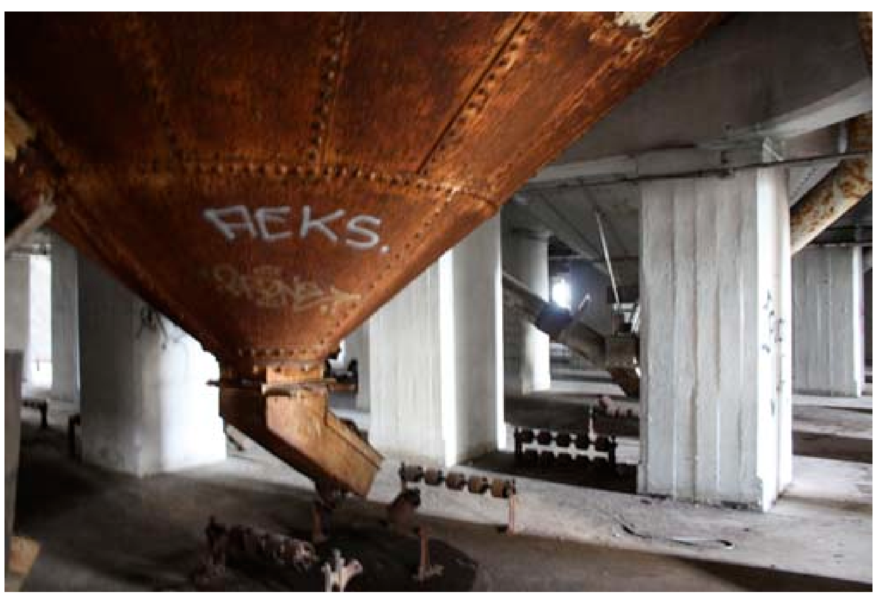

Figure 31: Interior Photograph of Steel Hopper at American Elevator
Image Photographed by Author

Figure 32: Interior Photograph of Lower Gallery at American Elevator
Image Photographed by Author

Chapter 3: Defining the Problem

Understanding Derelict Sites

In the context of today, cities are recognized as cultural entities that contain depictions from the past, by way of the present, to the future, proceeding through the entire cultural evolution of the "city as object." Outlining the history of an existing city, a city is influenced by the accumulation of different visions, different urban models, and by significant changes in consumption and production patterns. Similar or unlike, every city possesses its own tale to a growing empire, where its tale is distinguished by sentiments of time.

The end of the twentieth century has created a break in the industrial sector and with it an accelerating obsolescence of industrial landscapes.[6] The industrialized world is experiencing similar effects of the restructuring of the global economy, the automation of production processes, and the relocation of industry to areas characterized by low production costs.[7] The global expansion of industry consequently affects industrial regions all over the world, contributing to the appearance of derelict and post-industrial landscapes that intensify the reduction of development potential and the quality of life.[8] In regards to the truth, industrial landscapes are hindered economically, environmentally degraded, and socially challenged through industrial contamination. Confronted with the challenges ahead,

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[6] Thomas Sieverts, *Cities without Cities: An Interpretation of the Zwischenstadt*. (London & New York: Spon Press, 2003).
[7] Fredric Jameson, *Postmodernism or, the Cultural Logic of Late Capitalism.* (NC: Duke University Press, 1991).
[8] J Handley, *The Post Industrial Landscape.* (The Groundwork Foundation: Birmingham, 1996).

it is clear that reclamation projects should enable the redefinition of industrial landscapes through solutions based on cultural, social, economical and ecological values (see Figure 33).

Figure 33: Chart of Solution Based Values
Images from < http://www.buffalohistoryworks.com>

Even though a set of solution based values has been conceived at the forefront of revitalization, industrial landscapes are termed derelict and decadent enlarge part to the negative public perception they receive. Associating this perception with the need to protect the environment can spark the catalyst to the redevelopment and renaissance of industrial landscapes. It can be argued that because of their prominent locations near downtown districts, embanked along waterways, supported by existing infrastructure, and neighboring to residential communities, industrial landscapes embody enormous potential to be functionally productive and reintegrated into the surrounding community.

Buffalo’s Industrial Landscape

As industrialization expanded in the city of Buffalo, it promoted significant changes in the landscape: higher densities in urban areas and the urbanization of the natural and rural environment. The city of Buffalo thus acquired a new industrial face, a face that was shaped both physically and culturally by industrialization. Buffalo’s industrial face cultivated a landscape defined by the aggregation of industrial complexes and by the needs of a growing population.   Over the past few decades, with the city of Buffalo victimized of the declining grain trade, deindustrialization, industrial relocation, and economic reconversion has had a profound impact on industrial sites all over the Buffalo-Niagara region and thus facilitated a vast array of obsolete industrial facilities. Together with its forgotten role as a functioning industrial empire and a plethora of abandoned and dilapidated industrial structures now characterizing the industrial landscape in Buffalo, the city’s population has steadily declined and expanded outwards in recent decades (see Figures 34 & 35).

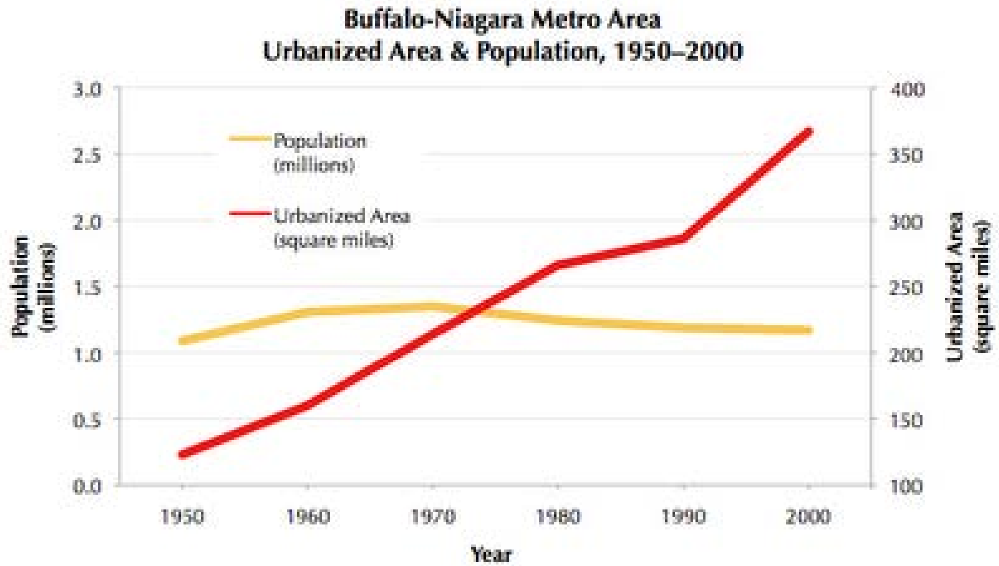

Figure 34: Graph of Buffalo-Niagara Urbanized Area and Population
Image from < http://joeplanner.blogspot.com>

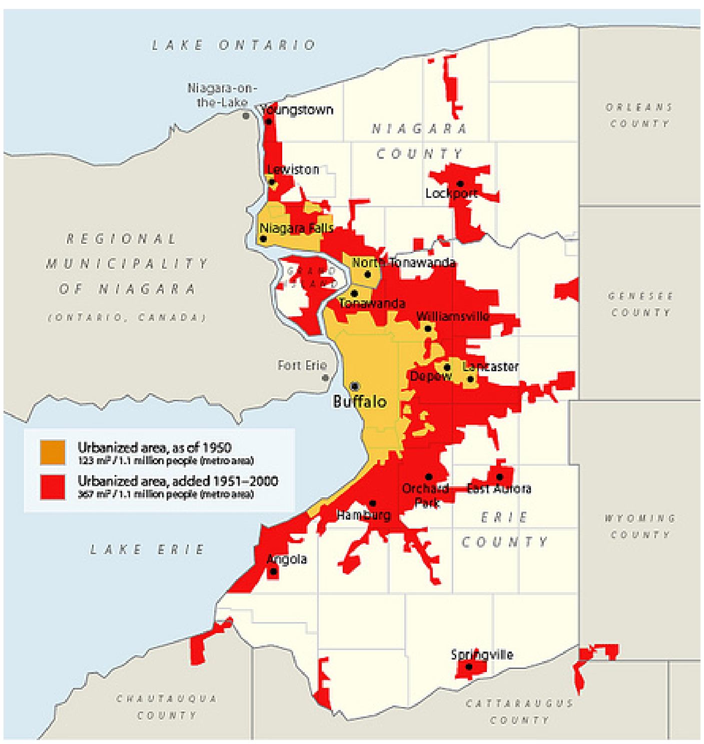

Figure 35: Urbanized Area within Metropolitan Buffalo, 1950 -2000
Image from < http://joeplanner.blogspot.com>

Why should Buffalo's Cultural (Industrial) Landscape be Reclaimed and Protected?

Cultural landscapes give us a "sense of place and reveal our relationship with the land over time."[9] They are places that characterize our "origin and development through their forms, features, and history of use."[10] Along the Buffalo River, it is important to recognize the entire industrial landscape as a single entity, as opposed to recognizing a building, or a group of buildings of an industrial site, because it will enhance the conception of industrial preservation to accommodate "recognized patterns of activity in time and place."[11] With the intention to ascribe it a new meaning by adapting to new program standards and new cultural uses, the concept of industrial landscape is used to describe and identify the remnant materials of the industrial culture.

Historic and Cultural Values

The justification to protect and reclaim the grain elevators of Buffalo will be based on diverse criteria, which considers their environmental, economical, and cultural value. Grain elevators, similar to their colossal size and ability to store grain, possess an enormous amount of cultural heritage in Buffalo simply because of their dominating presence as architectural icons. Synthesizing cultural values of grain elevators with economic opportunities on industrial landscapes can formulate the

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[9] Paul Drury, *The Historic and Cultural Dimensions of Landscape*. Naturopa, No.98 (Belgium: Bietlot Gilly, 2002) pp.12-13.
[10] Marc Antrop, *Why Landscapes of the Past are Important for the Future*. Landscape and Urban Planning, vol. 70 (Belgium: Ghent University, 2000).
[11] Donald Meinig, *The Interpretation of Ordinary Landscapes: Geographical Essays*. (Oxford: Oxford University Press, 1979).

protagonist in the transformation of the city of Buffalo as a tool for urban development. With the preservation of these monolithic structures, it constitutes the remembrance of an industrial culture that not only established Buffalo as port city, but ultimately cultivated the American landscape as well (see Figure 36). Standing as sentiments of time in the American landscape, grain elevators are international artifacts that influenced modern architecture by evoking a pure sense of functional design uncluttered by ornament.

> *"Thus we have the American grain elevator and factories, the magnificent FIRST FRUITS of the new age. The American engineers overwhelm with their calculations our expiring architecture."*
>
> Le Corbusier, *Towards a New Architecture,* 1923

Figure 36: Classic Landscape, Oil Painting by Charles Sheeler, 1931
Image from <www.artchive.com>

Environmental Values

Aside from being physically intimidating at the scale of the human eye, grain elevators evoke environmental concerns that are completely devoid when compared to conventional industrial facilities. The typical industrial factory of the twentieth century is perceived as an entity that contaminates, pollutes, and quarantines itself from the surrounding community. Grain elevators, on the other hand, present no immediate environmental concern other than the sheer size they occupy at the scale of the city. If a grain elevator is to be dormant and distant from its original purpose as a terminal elevator, then the only threat it poses against the environment is the threat against demolition. Demolition, in its nature, revolves around the notion of the deconstruction of building material that ultimately produces environmental side effects.

Would it be environmentally beneficial to demolish a grain elevator? One must first be mindful of the material culture that a grain elevator, the grain elevators of Buffalo in particular, naturally inherits. With the exception of one, the standing grain elevators in Buffalo are all conceived of concrete as the primary material component. By nature, concrete is energy inefficient during its formulation process, but extremely efficient in its structural integrity and sustainable lifespan as an aging material. Having been constructed within the most recent century, the grain elevators in Buffalo may have outlived their original purpose, but have not outlived their structural integrity. Argued by many, the most sustainable structure to have ever been built is the Pantheon in Rome. Having survived for over two thousand years, the Pantheon owes is its aging lifespan in large part to its durable and resilient material use of concrete (see Figure 37). To the extent at which concrete sustains the structural integrity of the grain elevators in Buffalo, to demolish them would be foolish and a missed opportunity would result, and their potential use as sustainable monolithic structures would be undervalued.

Figure 37: Interior Image Concrete Rotunda, Pantheon, Rome
Image from Jean-Christophe Benoist

Figure 38: Exterior Concrete Silo of Standard Elevator, Buffalo, New York
Image from *The Urban Design Project*, University of Buffalo

Social and Economic Values

The grain elevators of Buffalo not only represent a historic industrial past that shaped the city both culturally and physically, but they also represent infrastructure the city has invested in. Prior to the decline of the grain trade, the grain elevators as a collective whole represented the economic wealth within the Buffalo Niagara region. In the context of today, all the capitol utilized to build and construct the grain elevators in Buffalo now ceases to exist with the absence of the grain trade. The financial burden Buffalo now faces is whether or not to invest in a demolition strategy that will tear down the grain elevator complexes over a period of time, or will the city reinvest in the existing industrial infrastructure by repurposing the grain elevators. Figuratively speaking, the cost to build and construct one single grain elevator complex out of reinforced concrete and structural steel is considerably expensive. The amount of energy utilized to provide the formwork and pouring of cement for a network of concrete silos might be equal to the estimated cost and energy required to demolish the same network of silos. If a new use can be conceived of that repurposes both the existing grain elevators and surrounding infrastructure, the new proposed use will raise the social and economic value of the grain elevator typology as a whole, and reduce the threat of demolition.

From an economic standpoint, the cost of preservation compared to the cost of demolition, are two opposing approaches that ultimately decide the future and fate of an abandoned grain elevator complex. Is there any economic value to a dysfunctional derelict grain elevator that has lost all reason for being, or will demolition of the building and surrounding structures make better use of the land for future development? Needless to say, the answer to that question can be studied on a case by case basis because all grain elevators are inherently different from one to another.

In the case of Silo Point, an adaptive reuse project of a historic grain elevator complex repurposed and converted to luxury condominiums in Baltimore, Maryland, both social and economic values were reinvested into an abandoned industrial grain terminal to bring about a new use. The original grain elevator complex was divided into two different massing components: the workhouse, and silo bins (see Figure 39). Although the workhouse was utilized for vertical distribution of grain, it also contained a network of octagonal shaped storage bins built within its structural frame.

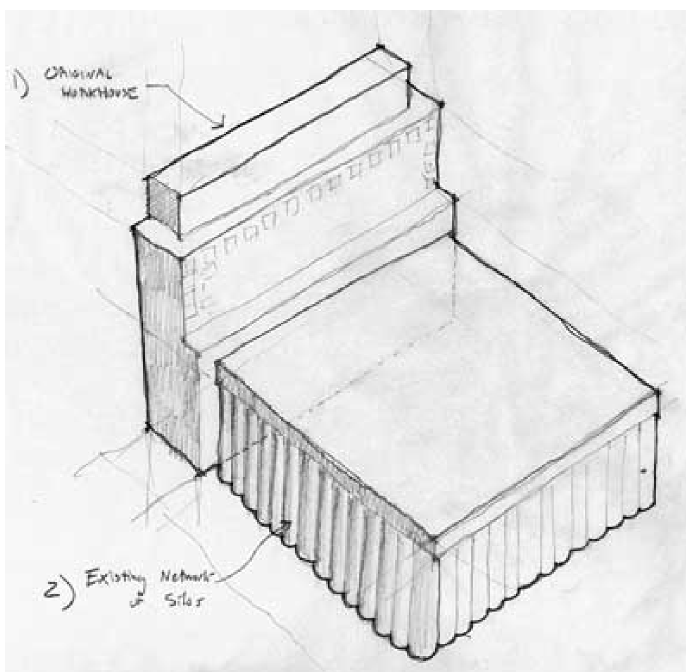

Figure 39: Massing Diagram Sketch of Silo Point, Baltimore, Maryland
Image Drawn by Author

The round silo bins were made out of reinforced concrete, all tangentially connected to one another, and utilized for grain storage. With a new program to bring about a new building use, both the original workhouse and silo bins were significantly altered. Many of the existing round silos bins were destroyed and ultimately sacrificed (see Figure 40), and almost all of the bin partition walls were cleared in the workhouse. Following the phase of demolition prior to the start of any new construction, Silo Point stood in ruin, completely deprived of any architectural merit reminiscent from an industrial time period.

Figure 40: Image of Demolished Silos at Silo Point, Baltimore
Image Photographed by Brian Kelly

Chapter 4: Case Studies

Before an intervention occurs on a site of previous development, analysis and research must be completed in order to develop new strategies and ideas that formulate a rational proposal. When trying to intervene on the Childs Street Industrial Complex in Buffalo, an appropriate narrative must be conceived of by investigating relevant past precedents that confront comparable points of issue. There are three case study approach themes that address projects with different design typologies, but also with different design program. Design strategies for the reclamation of the Childs Street industrial Complex in Buffalo will focus on these different themes: Socio-Economic, Historic and Cultural, and Environmental and Aesthetic.

Historic and Cultural

The Distillery District, Toronto, Canada, 2001

The Distillery District is a thirteen acre de-industrialized historical site that has been redeveloped and reused to form an entertainment precinct located in Toronto, Canada. The closing of the remaining distillery operation in 1990 created redevelopment and investment opportunities for a district that contained the largest and most well preserved collection of Victorian-era industrial architecture in North America. As an industrial centre for transshipment in North America in the twentieth century, the city of Toronto was confronted with the problem of de-industrialization. The winding down of distillery operations left derelict buildings unused and subject to demolishing. With a unique collection of Victorian-era industrial architecture, the Distillery District created redevelopment and investment opportunities based on combining de-industrialization and cultural globalization.

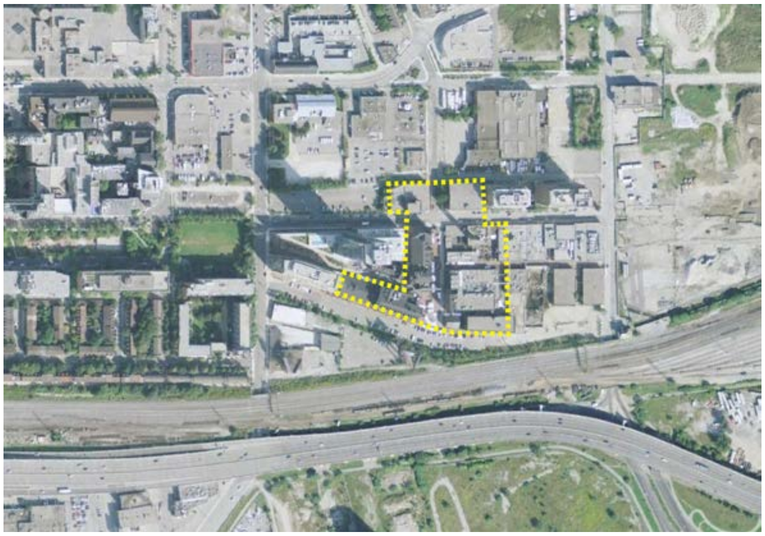

Figure 41: Aerial Image of Distillery District, Toronto Canada
Aerial Image by Google Earth

Figure 42: Aerial View of Distillery District, Toronto Canada
Image from Michelle Lu0Do, 2008

Figure 43: Street Level View of Distillery District, Toronto Canada
Image from Art Branch, 2011

Environmental and Aesthetic

Emscher Park, Germany

In Emscher Park, Germany, the adaptation of an industrial landscape into a network of reclaimed parks has been used to drive the restoration of one of the most degraded landscapes in Europe. Emscher Park is located in the Ruhr Valley in Western Germany, and was the country's industrial heartland for more than a century. With the decline in Germany's industrialization in the 1920's, mines and factories in the region began to close and fall silent, and their gates closed as they became brownfield sites in need of restoration. The transformation of a once industrial heartland into a reclaimed landscape suggests how powerful the concept of a park can be once the boundaries of the traditional definition are challenged.

Given the terminology of an 'imaginative landscape out of industrial dereliction,' Emscher Park has been created by multiple practitioners including architects, artists, gardeners, scientists and planners.[12] Out of the abandoned coke plants, blast furnaces, ore bunkers, and manganese depots, a deprived industrial landscape has been transformed into a heterogeneous landscape to spawn new purpose and activity. By allowing the reclamation of ruined spaces by plants and animals to simply inhabit in certain areas, by removing patches of industrial contamination, and through the deliberate fabrication of ponds, meadows, and gardens, a hybrid mixture landscape of places both untouched and transformed has been created.

Social and Economic

Mill City Museum, Minneapolis

Mill City Museum is an example of adaptive reuse of an industrial ruin based on the theme of socio-economic. The case study of the Mill City Museum selectively investigates the social and economic influence a single repurposed industrial ruin can have on a surrounding neighborhood and city. Originally a flour mill dating to 1880, the structure housing the present day Mill City Museum was known as the Washburn A. Mill, when it was nearly destroyed by fire in 1991. Milling operations were abandoned in 1965, and after a fire in 1991, the mill stood in ruin, fragile, and needing to be braced. The question for repurposing the building was how to turn the

[12] Latz and Latz, 2001:73

ruin into something that could be used by the public, and yet would honor the history of the Minneapolis Milling industry.

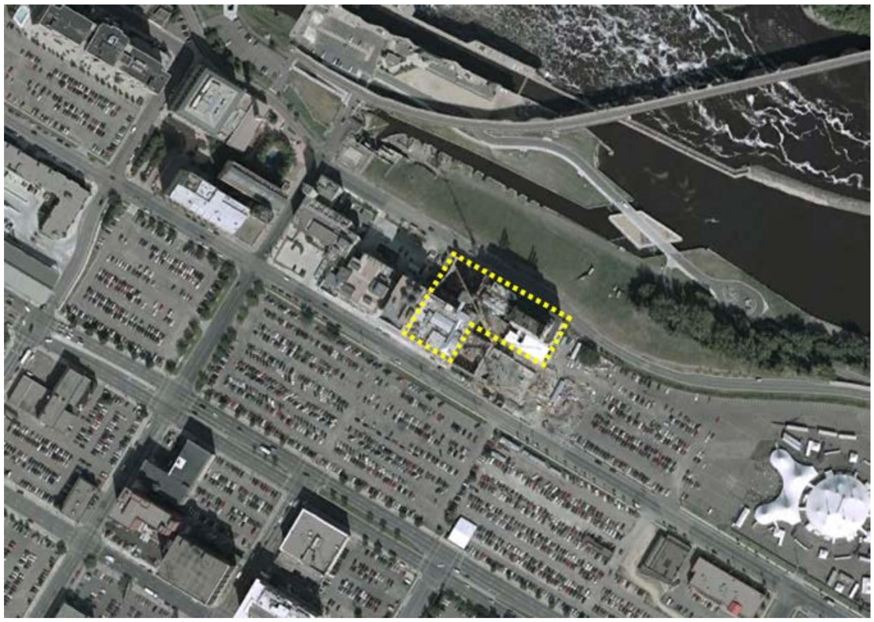

Figure 44: Aerial Image of Mill City Museum, Minneapolis, Minnesota
Aerial Image by Google Earth

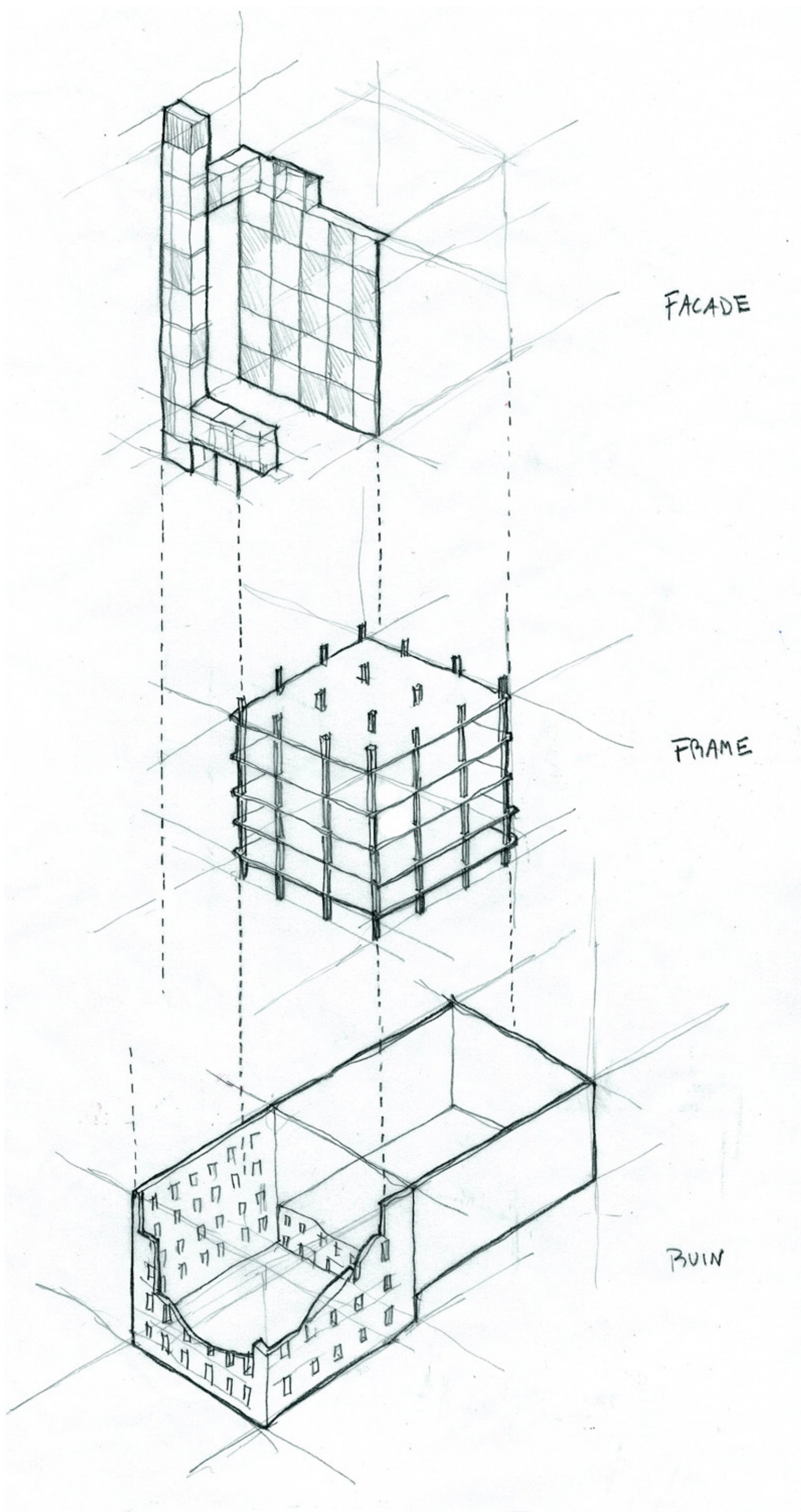

Figure 45: Exploded Axonometric Sketch of Mill City Museum
Image Drawn by Author

Chapter 5: Design Proposal

Infusion of New Industry

The big underlying question of this thesis is: What is the physical intervention that will take place inside the core of an empty grain silo? To answer that question will be the infusion of new industry, but more specifically, what is the "new industry" to be inserted in the emptiness of concrete silos? The new industry is the same known technology that is used to generate the biological process of anaerobic digestion for wastewater treatment, and infusing it inside the core of an existing concrete silo. Anaerobic digestion is a biological process by which microorganisms break down biodegradable material in the absence of oxygen. In other words, anaerobic digestion is the same natural process that humans and all living organisms utilize to digest food and dispose organic waste.

One might question, why does it make sense to retrofit an abandoned grain silo to support the process of anaerobic digestion? To understand and answer that question would be to link the inherent properties of a typical anaerobic digester to that of an empty concrete silo. The ideal properties of an anaerobic digester are dark spaces containing no oxygen, while round and resembling the shape of a cylinder in architectural form. To perform at a high rate of efficiency, an anaerobic digester is extremely well insulated to prevent heat loss and maintain an internal temperature, and built at a minimum height to diameter ratio of three to one. Similarly, a concrete grain silo is round and cylindrical in architectural form, where grain is initially stored in dark spaces containing little to no oxygen to prevent vermin contamination and dust explosions.

The most recognizable similarity between an anaerobic digester and a grain silo is the resemblance of a round cylinder in architectural form. Why are both a grain silo and anaerobic digester round and cylindrical in architectural form? The resemblance in architectural form of a grain silo to that of an anaerobic digester is strictly derived from their function: the storage of an excess material or substance. The curved walls of either a concrete grain silo or steel binned digester inherently are both round because of structural efficiency. The round walled nature of a storage bin utilizes the efficient structural form of 'the arch' to maintain structural integrity and stability. The gravitational forces of stored grain or processed waste are evenly exerted and distributed across the curved wall surfaces of a concrete silo or steel binned digester.

Although similar in architectural form, the inherent type of program use is what differentiates a waste digester from that of a grain silo. A grain silo is utilized for 'storage,' where as a waste digester is utilized for 'digestion.' When grain is elevated and deposited into a silo, it is stored in isolation, and its physical properties are not altered or interfered with. When waste is pumped into a digester, it undergoes a chemical reaction, and is thus converted into new substances. More simply, a grain silo relies upon the force of gravity for grain distribution, whereas a waste digester performs more like a machine, with internal mechanical systems that both process and distribute waste accordingly.

New Industry: Anaerobic Digestion

Anaerobic Digestion is a biological process in which bacteria break down biodegradable material in a controlled environment in the absence of oxygen.[13] It occurs naturally in anaerobic niches such as marshes, sediments, wetlands, and the digestive tracts of ruminants and certain species of insects. Anaerobic digestion systems are employed in many wastewater treatment facilities for sludge degradation and stabilization, and are used in engineered anaerobic digesters to treat high-strength industrial and food processing wastewaters prior to discharge. Internationally, anaerobic digestion has been used for decades, primarily in rural areas, for the production of biogas for use as a cooking and lighting fuel. Anaerobic digestion of municipal solid waste is used in different regions worldwide to:

- Reduce the amount of material being land filled.
- Stabilize organic material before disposal in order to reduce future environmental impacts from air and water emissions.
- Recover energy

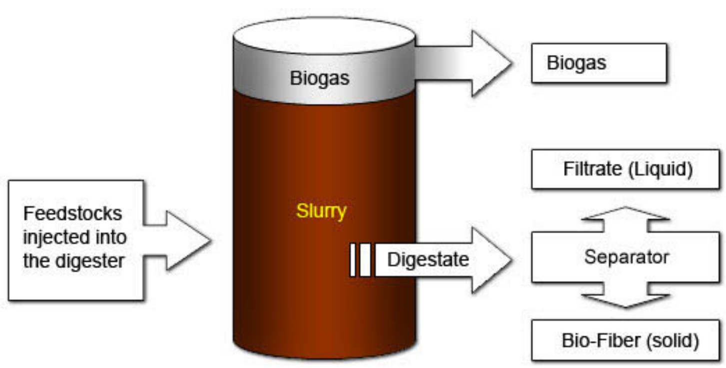

Figure 41: Basic Process of Anaerobic Digestion
Image from <www.hacaustralia.com>

[13] California Integrated Waste Management Board, *Current Anaerobic Digestion Technologies Used for Treatment of Municipal Organic Solid Waste* (March 2008), pp. 1-2.

There are four fundamental steps of anaerobic digestion that include hydrolysis, acidogenesis, acetogenesis, and methanogenesis (see Figure 42).[14]

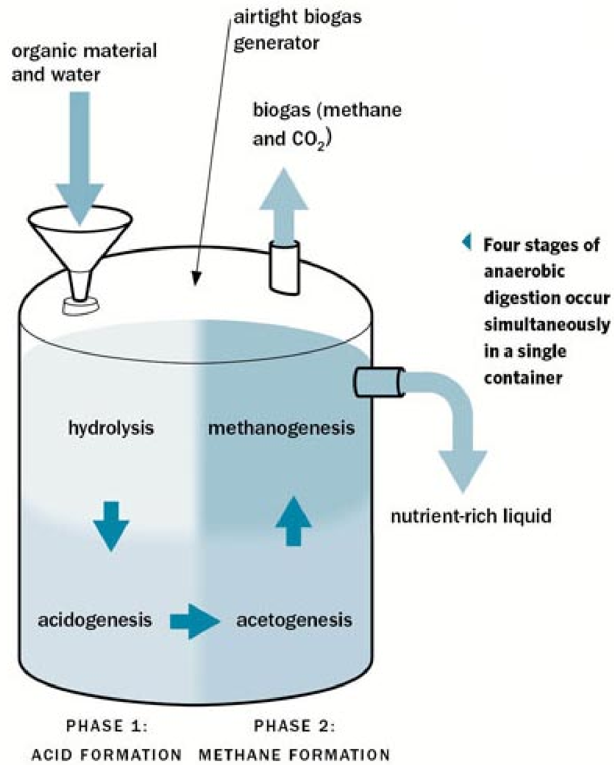

Figure 42: Four Stages of Anaerobic Digestion
Image from < solarpanalscuracao.com>

The first step is hydrolysis, which is the decomposition of plant or animal matter. Hydrolysis breaks down the organic material to usable-sized molecules such as sugar and amino acids. The second step is acidogenesis, where fermentative bacteria then convert the sugars and amino acids into carbon dioxide, hydrogen, ammonia, and organic acids. The process of acidogenesis is similar to the way milk

[14] National Non-Food Crops Centre, *NNFCC Renewable Fuels and Energy Factsheet: Anaerobic Digestion* (November, 2011), pp. 1-2.

sours. The third step is acetogenesis, where acetogenic bacteria then convert these resulting organic acids into acetic acid, along with additional ammonia, hydrogen, and carbon dioxide. The final step is methanogenesis, which converts these products to methane and carbon dioxide. Throughout the entire digestion process, large organic polymers that make up biomass are broken down into smaller molecules by chemicals and microorganisms. Upon completion of the anaerobic digestion process, the biomass is converted into biogas, namely carbon dioxide and methane, as well as digestate and wastewater.

An anaerobic digester is an enclosed tank with attached heating and mixing systems that stimulate the digestion process (see Figure 43). There are three principal concepts that make up a kit of parts within the digester: buffer, mediate, and barrier. The concept of ‘buffer’ refers to an external layer of insulation that minimizes the difference in air temperature between the inside core of a digester and the outside atmosphere. The concept of ‘mediate’ refers to a mixing system, either mechanical or gas induced, that brings the raw influent sludge in contact with actively digesting sludge. Without a uniform environment in the digester, there would be pockets of sludge not degrading properly, potentially leading to undigested sludge leaving the digester and a decreased digestion rate. The third concept of ‘barrier’ refers to an expandable membrane functioning as a storage and collection capsule for the offset gas produced from the digestion process. The three concepts of buffer, mediate, and barrier are all necessary factors in determining the design criteria for an efficient anaerobic digester.

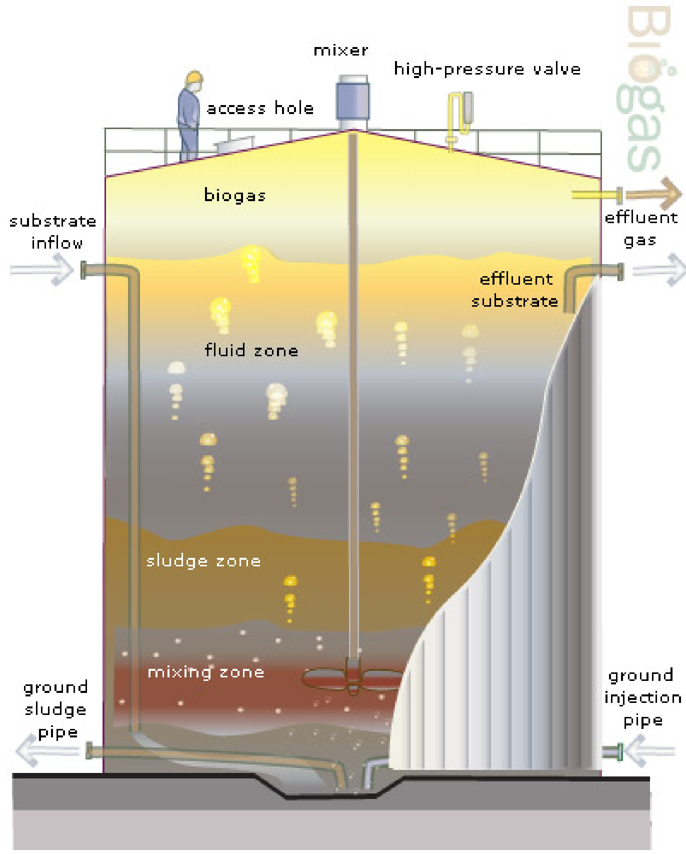

Figure 43: Cross Section of an Anaerobic Digester
Image from <http://www.mannvit.com>

Byproducts of Anaerobic Digestion

Anaerobic digestion is widely used as a source of renewable energy. There are three principal byproducts from the digestion process: biogas, digestate, and wastewater.

Biogas is the primary waste product of the bacteria feeding off the input biodegradable feedstock, and mostly consists of methane and carbon dioxide.[15] The biogas that is produced from the digestion process is typically stored on top of the digester in an inflatable gas bubble. When extracted from biogas, the methane can be

[15] United States Department of Energy, *How Anaerobic Digestion (Methane Recovery) Works* (August 2007).

burned to produce both heat and electricity. Electricity produced by an anaerobic digester is considered to be renewable energy and may attract subsidies. Methane and electrical power produced from anaerobic digestion facilities can be used to reduce the dependence on energy derived from fossil fuels, which in part will reduce emissions of greenhouse gases. In contrary to the carbon dioxide produced from the combustion of fossil fuels, the biogas produced from anaerobic digestion does not contribute to increasing atmospheric carbon dioxide concentrations. The reason is because the biogas produced from anaerobic digestion is not directly released into the atmosphere, and the carbon dioxide is generated from an organic source with a short carbon cycle.

The second principal byproduct of anaerobic digestion is digestate. Digestate is both the solid and liquid remnants of the original input material to the digesters that microorganism can not breakdown and make use of. Digestate is a nutrient rich byproduct that comes in three forms: whole, liquor, and fibre (see figure 44).[16]

Whole: similar in its appearance to a livestock slurry with typically less than 5% dry matter.

Liquor: this is whole digestate, which has had most, or all, of the solid material separated.

Fibre: similar to compost, this is solid material separated out of the whole digestate.

[16] WRAP, *Using Quality Anaerobic Digestate to Benefit Crops* (Summer 2012), pp 3-4. <http://www.wrap.org.uk/sites/files/wrap/Using%20quality%20digestate%20to%20benefit%20crops.pdf>

Whole: similar in its appearance to livestock slurry, with typically less than 5% dry matter.

Liquor: this is whole digestate which has had most, or all, of the solid material separated.

Fibre: similar to compost, this is the solid material separated out of the whole digestate.

Figure 44: Three forms of Digestate: Whole, Liquor, and Fibre
Images from Environmental Protection Agency (www.epa.gov)

The primary use of digestate is for land application as a fertilizer and soil conditioner.

A benefit by using digestate produced from anaerobic digestion is that it can serve as a replacement for mineral fertilizers, thus reducing agricultural costs to farmers and minimizing greenhouse gas emissions from cultivation. By using digestate instead of synthetic fertilizers derived from natural gas, energy can be saved, and the consumption of fossil fuels can be decreased to reduce the overall carbon footprint.

The third byproduct from anaerobic digestion is wastewater. The wastewater originates from the moisture content of the original waste that was treated, and also from the water produced during the microbial reactions in the digestion systems. Further wastewater is released during the dewatering stage of residual digestate, where solid material is separated from whole digestate by means of aeration. The wastewater produced from anaerobic digestion will have elevated levels of biochemical oxygen demand and chemical oxygen demand. Measures of the reactivity of the effluent indicate contaminated wastewater with the ability to pollute. Thus further processing and treatment of wastewater from anaerobic digestion will need to occur in order to redistribute the wastewater into the surrounding natural environment without harm.

Proposed Intervention

Although there are several grain elevators located at the Childs Street Industrial Complex, this thesis will hypothetically propose an intervention for the American Elevator that currently stands abandoned and derelict. Originally built in 1906, the American Elevator is located to the east of its neighboring flour mill, and to the west of the Perot Elevator (see Figure 45).

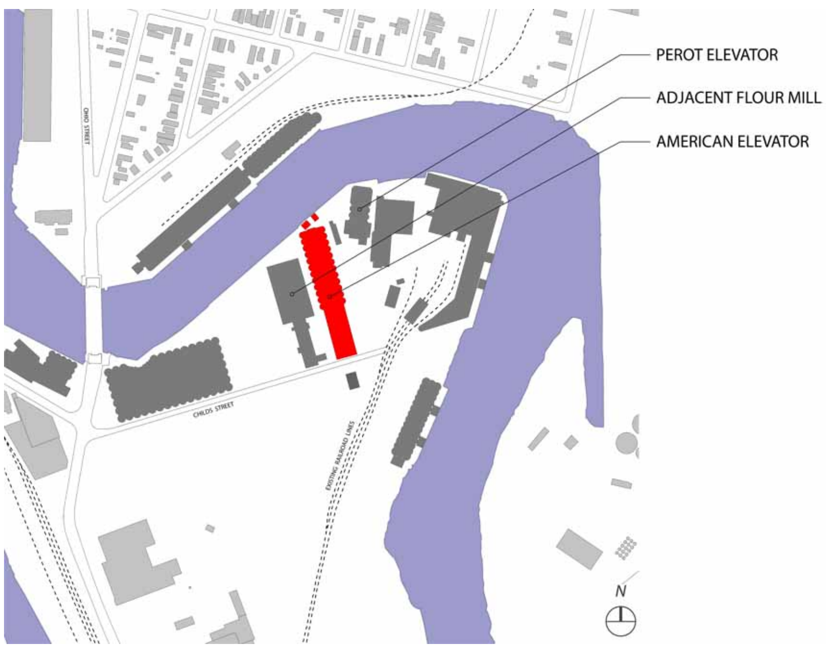

Figure 45: Diagram of Location of American Elevator
Image Drawn by Author

Instead of a building orientation that is parallel to the Buffalo River, the American Elevator is almost orientated at a perpendicular angle to the river with the width of the building facing the water. The reason for this is because the railroad line that previously serviced the American Elevator was orientated at a parallel angle along the length of the building. With the railroad line at a parallel angle along the length of the building, this made it more efficient to distribute grain into railroad cars. The two distinct building elements that make up the existing massing to the American Elevator are the concrete silos, and the steel framed workhouse. The silos were utilized for the storage of grain, and the workhouse was utilized for the vertical distribution of grain.

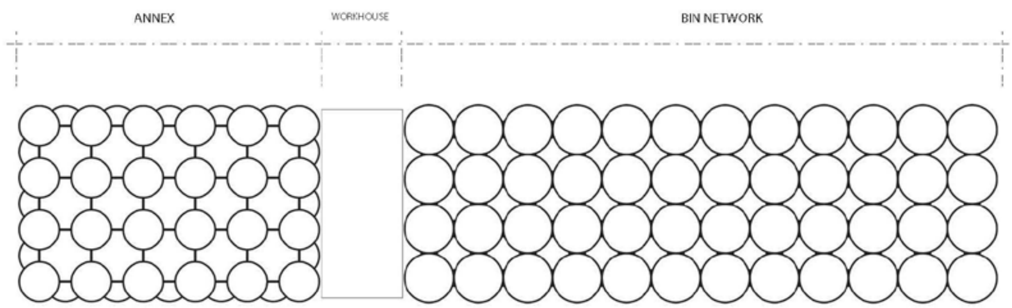

Figure 46: Existing Bin Floor Plan of American Elevator
Image Drawn by Author

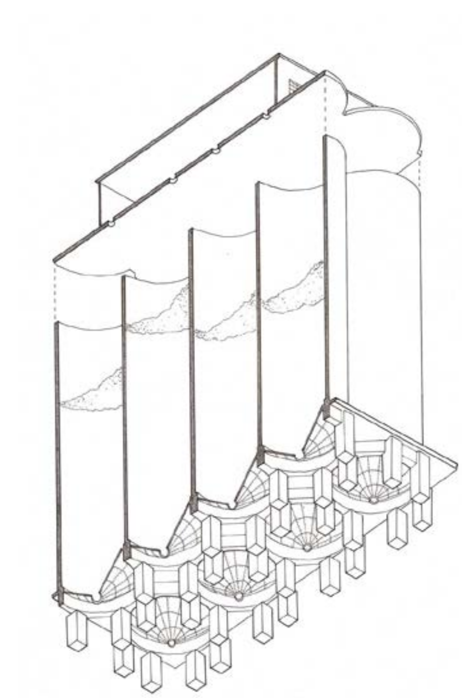

Figure 47: Axonometric Drawing of Original Bin Network of the American Elevator
Image Drawn by Author

The silo compartments at the American Elevator complex are broken down into two different building masses: The original bin network and the annex (see Figure 46). The original bin network was built in 1906, with concrete silos arranged in a four row twelve row grid, with each silo measuring 2 feet in diameter and rising ninety feet in height. The annex was composed of a bin layout arranged in a four row by six row grid configuration with five feet of tangential thickening between each silo. Each round silo within the annex measures roughly nineteen feet in diameter, and rises one hundred ten feet in height.

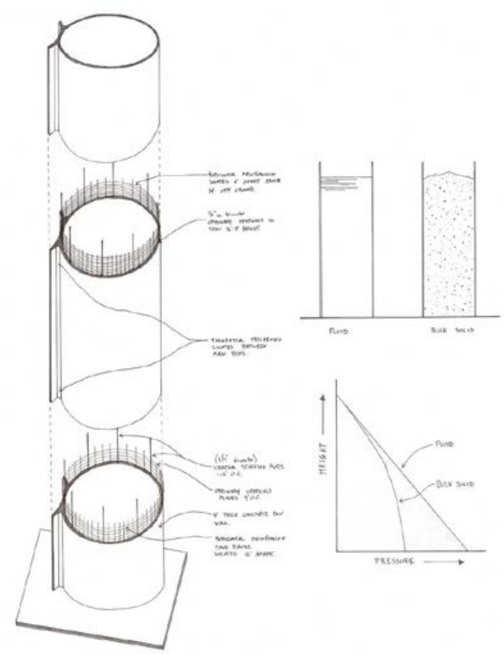

Figure 48: Cross Section Showing Steel Reinforcing, American Elevator
Image Drawn by Author

With a new industry to be deployed into the silos at the American Elevator Complex, the existing silos are retrofitted to support the technology that is deployed in anaerobic digestion. The technology to be deployed into the silos is broken down into a kit of parts comprising of an inner membrane, mechanical mixing blades, a work floor, and a gas collection chamber (see Figure 49).

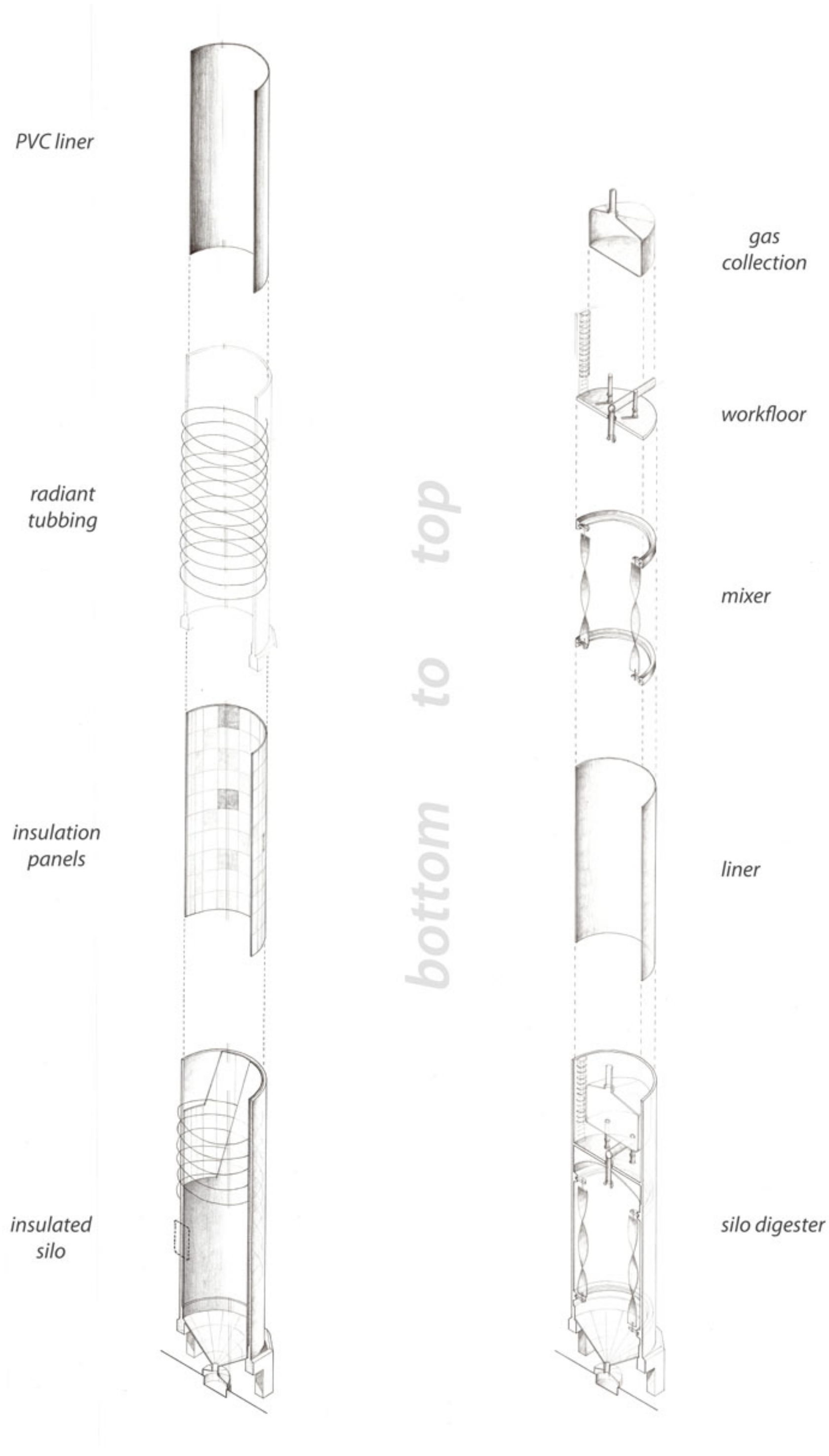

Figure 49: Exploded Axonometric Drawings of Silo Digester
Image Drawn by Author

The inner membrane is simply the barrier that separates the existing concrete silo shell from the waste substance undergoing the digestion process. The mixing blades are two inserted metal blades that rotate around the inside diameter of the silo, and provide a continuous mixing process that stimulates the biological process of anaerobic digestion. The metal mixing blades mechanically function the same way a paint mixer churns and blends paint together. In order to provide maintenance to the mechanical systems that make up mixing blades, a work floor is lowered down into the hull of each silo, with an access hatch from above. The final part to be inserted is the gas collection chamber. As the digestion process continuously operates, it offsets chemically produced gas. The produced gas, mostly methane, rises up through release valves that connect the mixing chamber to the gas collection chamber. Similar to the lung, the gas collection chamber operates in a comparable way by serving as the respiratory organ that enables the digestion process to breathe.

With the supporting technology of anaerobic digestion inserted into the shell of an empty grain silo, insulation is a critical area of concern regarding the ability of a silo digester to sustain an efficient rate of performance. The internal temperature that is required to be maintained within an anaerobic digester is ninety-seven degrees Fahrenheit, similar to that of the human body. From an insulation standpoint, the proposed intervention of a silo digester will have to be well insulated enough to tolerate the bitterly cold winter seasons that Buffalo, New York endures. The layers of insulation within a silo digester can be broken down into three functions: barrier, mediate, and buffer (see Figure 50). The concept of ‘barrier’ refers to a thin water-proofing membrane layer that seals the inside environment of the digester from the outside atmosphere. The concept behind 'mediate' refers to a system that regulates the internal temperature of the silo digester. This system is composed of radiant tubes that are embedded within the insulation panels. The wastewater generated from the digestion process is heated and re-circulated through the radiant tubes, thus allowing the radiant tubes to serve as a heat conductor to the anaerobic digester with different temperature allowances. The concept of 'buffer' refers to insulation panels that mitigate the temperature difference between the concrete core shell and the waterproofing membrane layer.

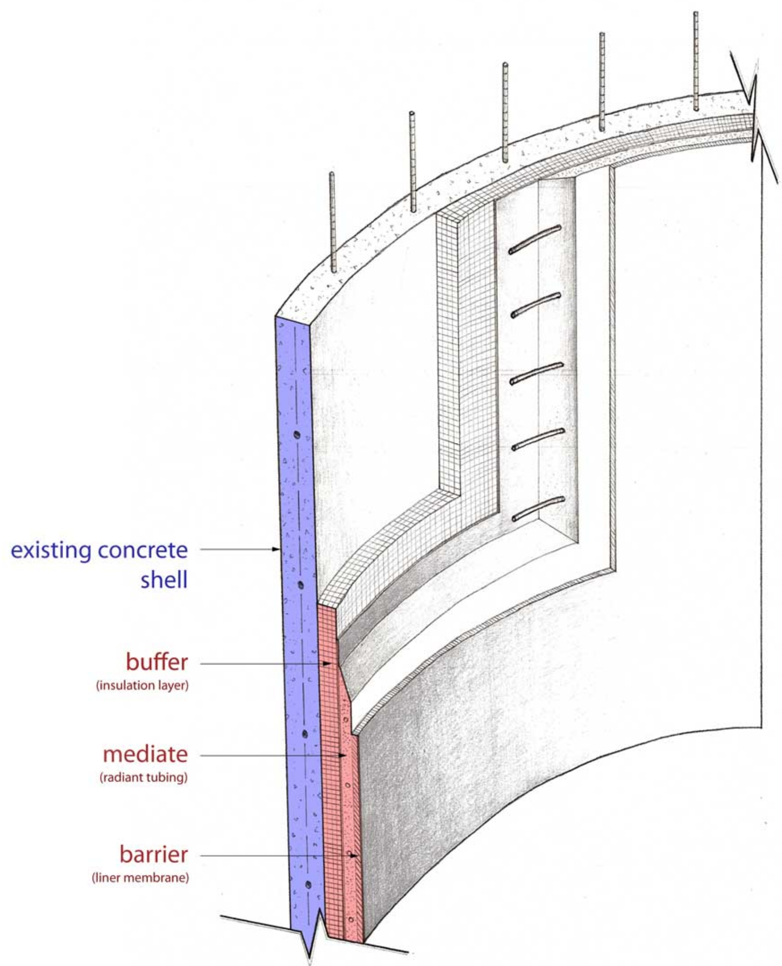

Figure 50: Wall Section Detail of Silo Digester
Image Drawn by Author

By converting existing concrete grain silos into functioning anaerobic digesters that process waste, this thesis presents the question of ‘how will waste be distributed into the confines of each silo digester?” At the scale of the building, waste inflow will ultimately mimic the same flow patterns as that of a typical grain elevator. Waste inflow will initially need to be elevated off the ground plane, and then distributed horizontally along the level of the bin floor before being deposited into a silo digester (see Figure 51). Compared to the conventional flow patterns of how grain is initially elevated in a workhouse by means of a vertical conveyor system, the initial inflow of waste will be different by requiring a pump system to provide the vertical distribution of waste. For the proposed intervention of the American Elevator, there are three different program layouts in section for the building: waste discharge on the lower gallery level, waste digestion on the bin floor level, and gas collection on the upper gallery level (see Figure 52). The rectangular steel framed building element located between the original bin network and annex is utilized as a pumphouse, responsible for the vertical distribution of waste.

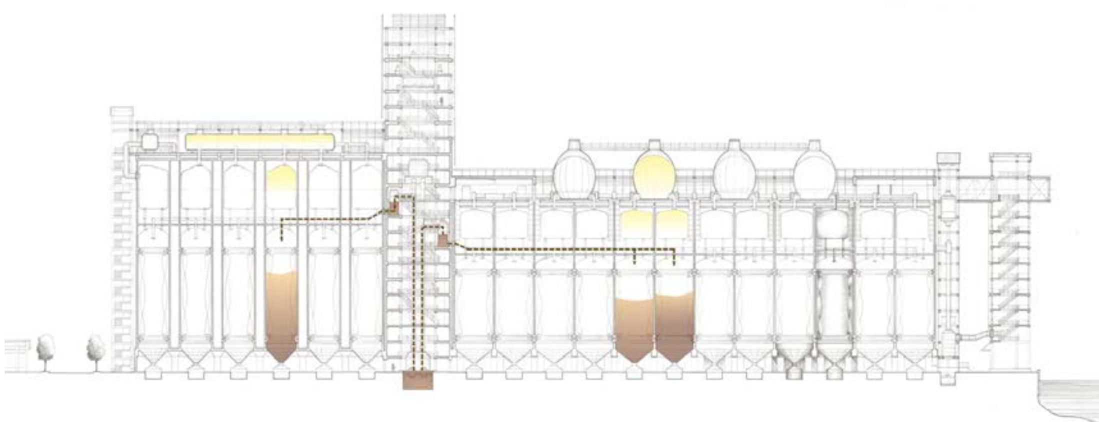

Figure 51: Diagram of Waste and Gas Flow
Image Drawn by Author

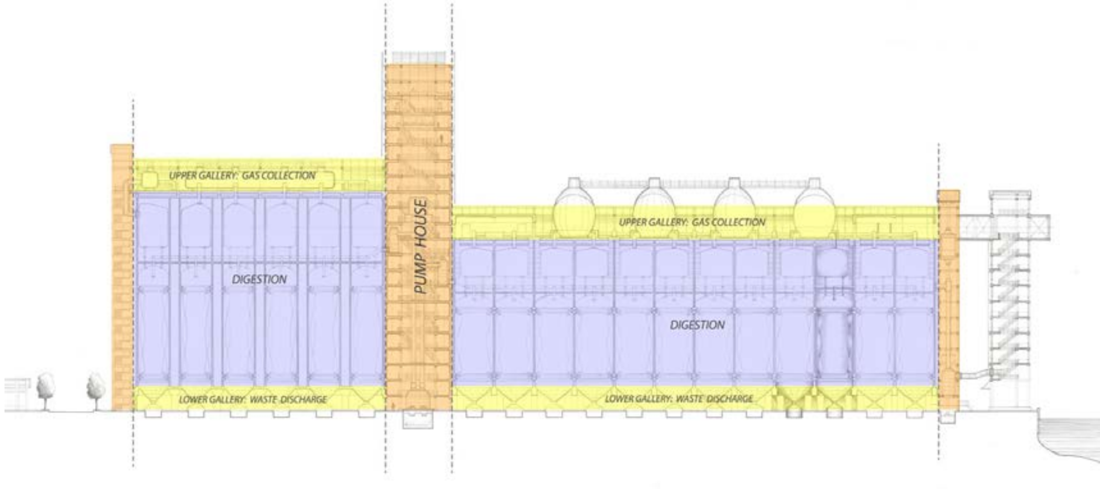

Figure 52: Diagram of Proposed Program Layout per Floor Level
Image Drawn by Author

As waste inside the digester chamber is continuously being processed, it is being broken down into four zones comprised of a different liquid to solid ratio in each zone (see Figure 53). Located at the top of the digestion chamber is the biogas zone, where the top layer of waste is being converted into biogas. The zone directly beneath the top layer of biogas is referred to as the fluid zone, where waste has a high liquid to solid ratio. It is within the fluid zone that liquid effluent can be extracted from the digestion chamber in the form of liquid fertilizer. Beneath the fluid zone is the mixing zone, where processed waste contains a smaller liquid to solid ratio from the fluid zone directly above. Within the mixing zone the raw influent sludge is in direct contact with actively digesting sludge to stimulate the digestion process and maintain a uniform temperature throughout the digester tank. Near the bottom of the silo digester chamber within the area of the conical shaped hopper is where the sludge zone is located. The sludge zone comprises of the accumulation of grit and thickened sludge build up from waste that has been weighed down from the mixing zone above.

The conical shaped hopper at the bottom of the digester functions as a funnel that empties the thickened sludge into a dewatering chamber for aeration treatment.

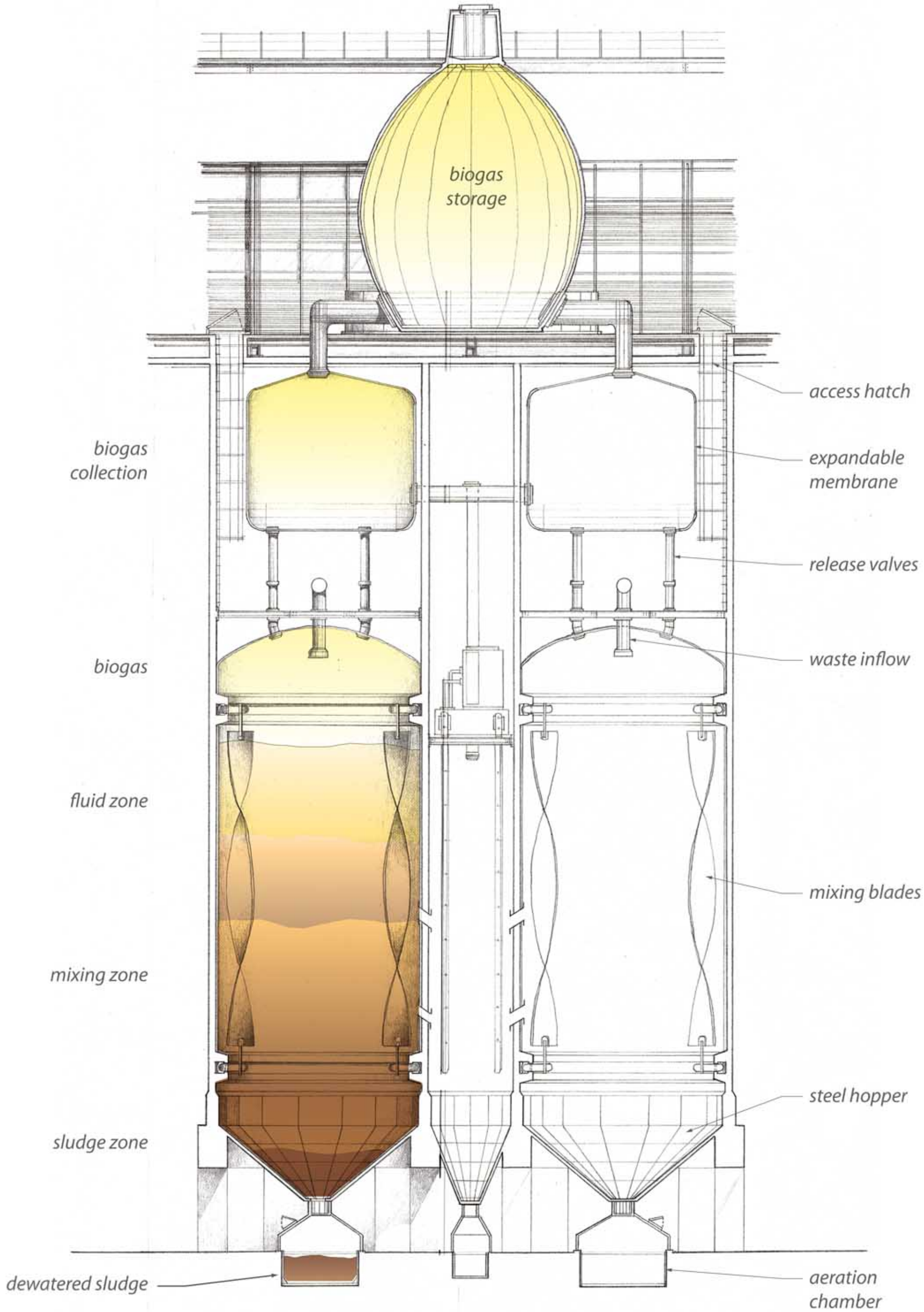

Figure 53: Section through Silo Digester
Image Drawn by Author

The three types of floor plans for the proposed building intervention of the American elevator are: lower gallery for waste discharge, bin floor for waste digestion, and upper gallery for gas collection (see Figure 55). At the level of the lower gallery, processed waste is discharged into a conical shaped steel hopper that funnels the waste into an aeration chamber that is located beneath each silo. The aeration chambers are interconnected to one another by air-sealed pump lines that recirculate processed waste back to the main pump house for further distribution. The bin floor is comprised of added parts and elements of new technology that make up the digesters within the shell of each concrete silo. With the insertion of new technology, the bin floor utilizes the full height of the existing concrete silo shell for the waste treatment process. Located above the bin floor level is the upper gallery, where gas collection tanks are located to provide storage chambers for the produced biogas. Laboratories, classrooms, and building control rooms are additional program elements that have been added to the upper gallery floor level (see Figure 54).

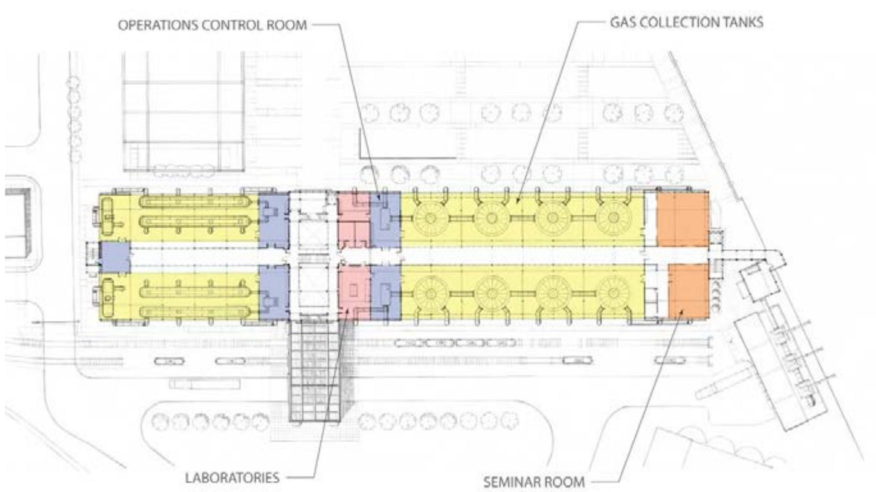

Figure 54: Program Distribution on Upper Gallery Floor Level
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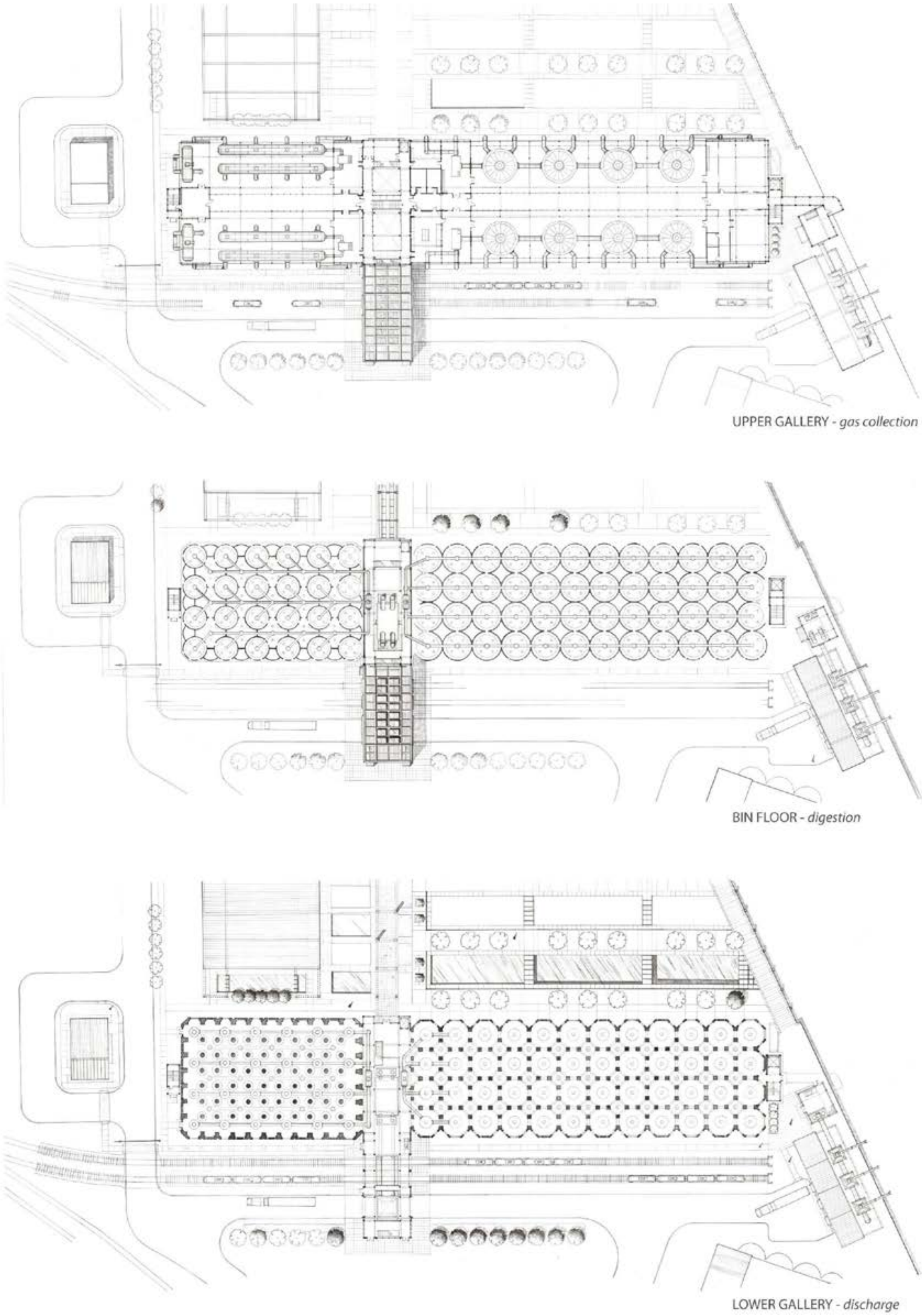

Figure 55: Plan Drawings of Repurposed American Elevator Complex
Image Drawn by Author

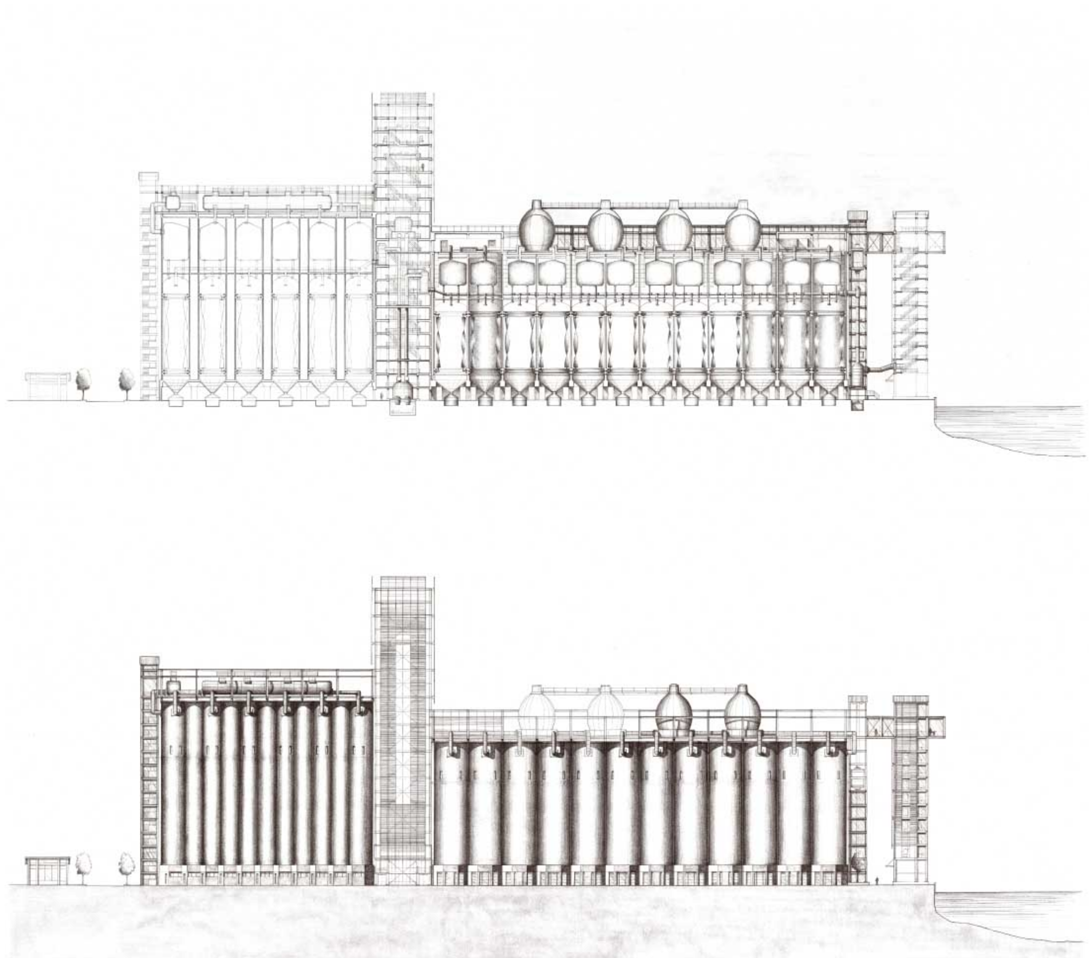

Figure 56: Section to Elevation Drawing
Image Drawn by Author

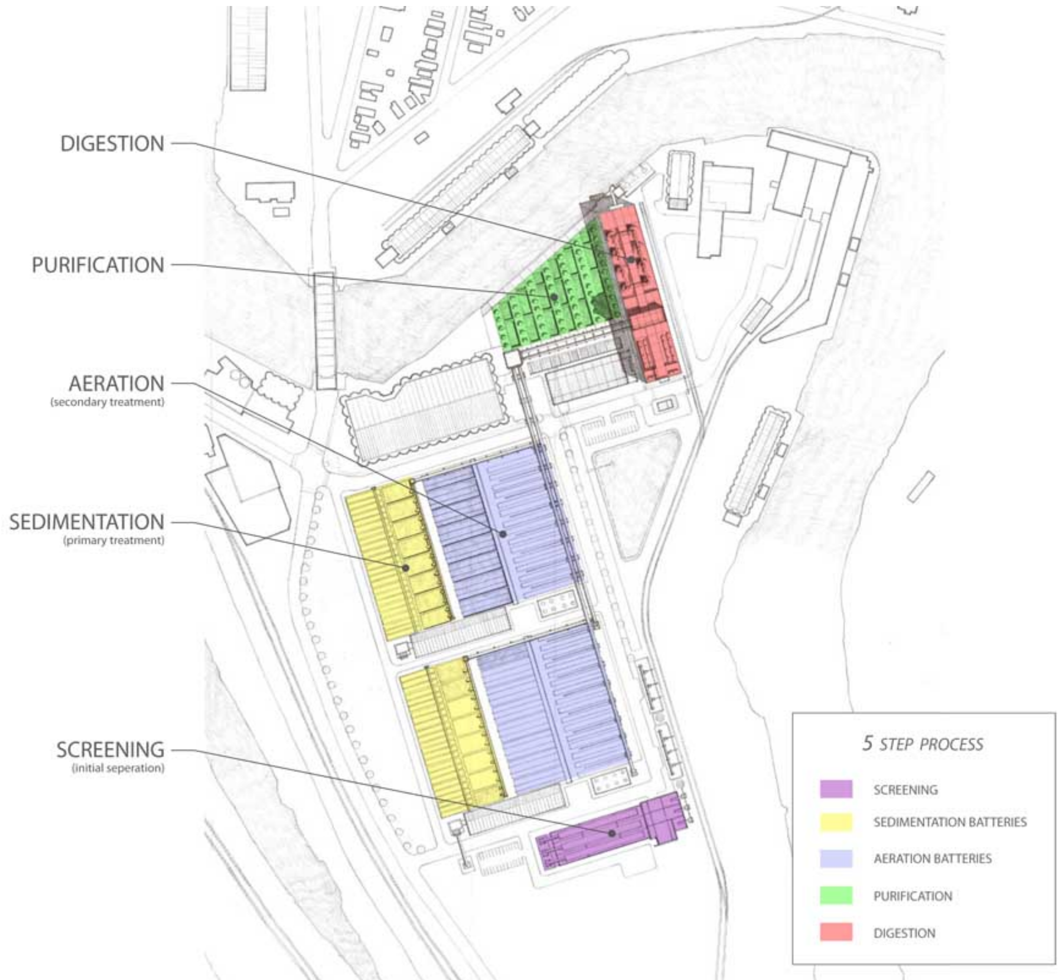

Figure 57: Proposed Site Plan of Childs Street Industrial Complex
Image Drawn by Author

Anaerobic digestion is part of a five step wastewater treatment process. In order of sequence, the five steps of wastewater treatment are: screening, sedimentation, aeration, purification, and digestion. The proposed site plan of the Childs Street Industrial Complex is programmed around the required steps to complete the wastewater treatment process (see Figure 57). In order to supply raw waste in the form of feedstock to the silo digesters located in the American Elevator, wastewater must first undergo primary and secondary treatment. Primary and secondary wastewater treatment screen out large inorganic contaminates, and reduce the levels of liquid effluent by diluting water molecules from the concentrations of more solid based raw waste. The primary responsibility of digestion in the overall wastewater treatment process is to break down and decompose organic matter, and not aid in the wastewater treatment process.

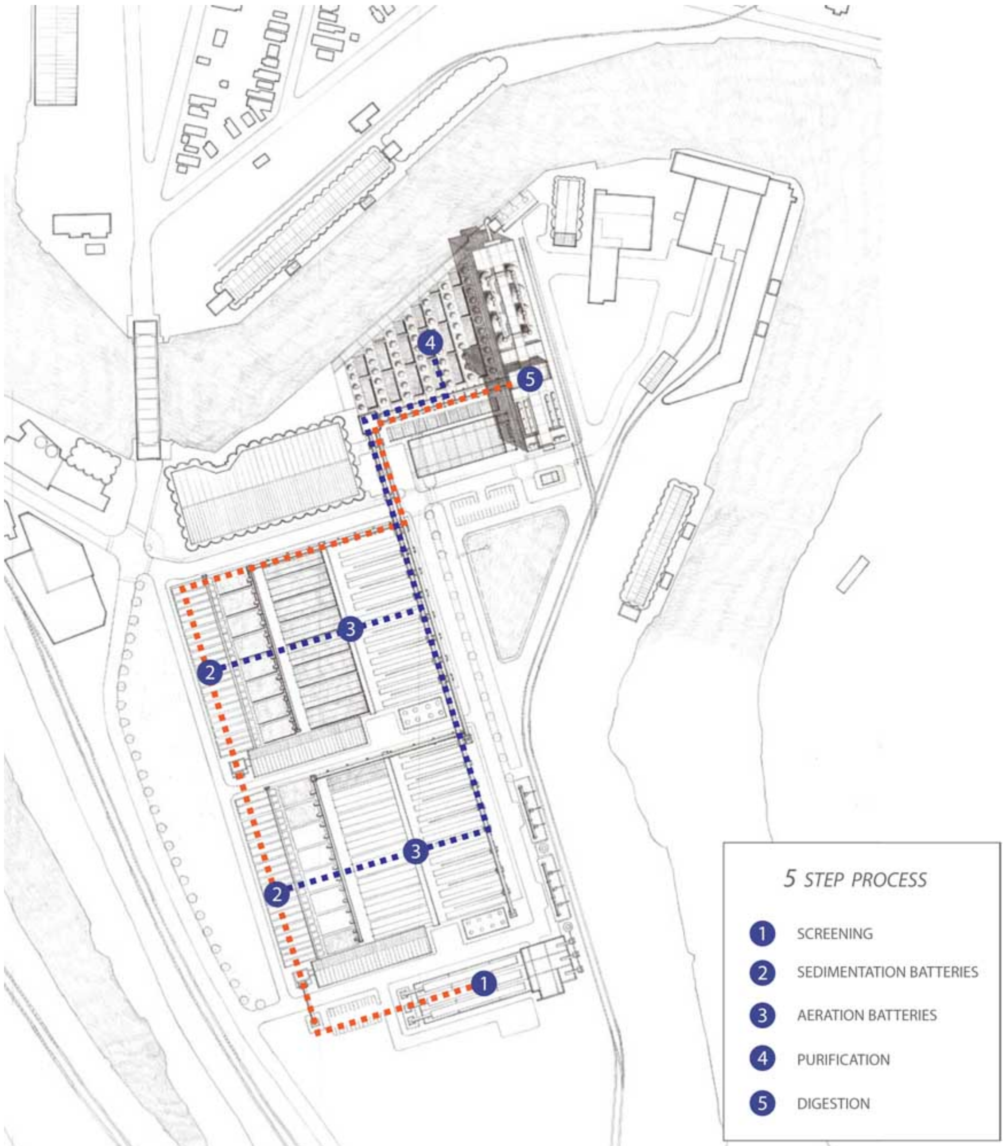

Figure 58: Waste Flow Diagram of Wastewater Treatment
Image Drawn by Author

Understanding how waste flow is distributed over the course of the building is similar to the way grain was previously distributed in the American Elevator. Either by barge, rail, or truck, the inflow of waste is initially stored in a collection pit at the bottom of the pumphouse. There are four pump lines that then elevate the waste from the pit in a vertical direction. Once elevated above the level of the silo digesters, waste is then distributed in a horizontal direction, and eventually deposited into the hull of a silo digester for processing (see Figure 59).

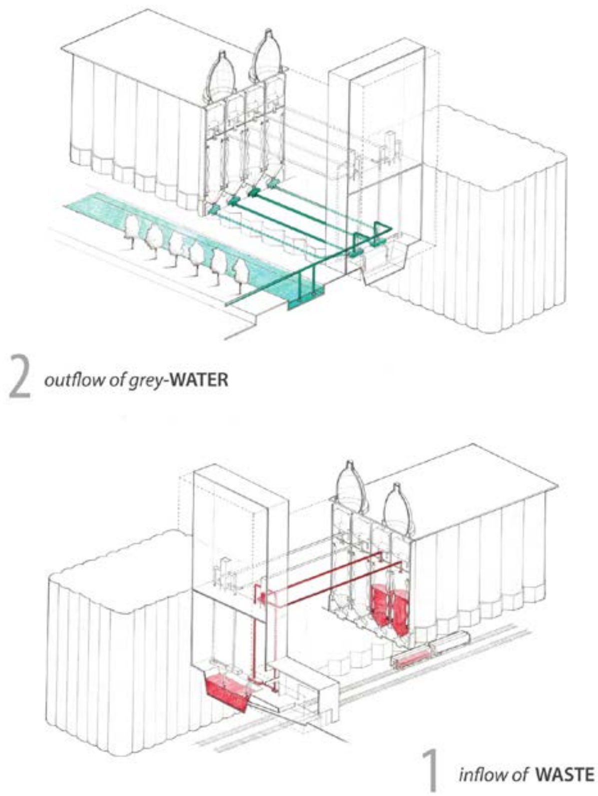

Figure 59: Diagram of Waste Inflow to Waste Outflow
Image Drawn by Author

After the waste has been anaerobically digested, the remaining waste is now a useful byproduct, and is then redistributed back to the pumphouse for future transshipment. The residual greywater leftover from the silo digesters serves as waste outflow, which is then deposited into adjacent constructed wetlands on the site (see Figure 59). The constructed wetlands utilize natural processes to remove harmful contaminants from the greywater, and ultimately purify the water quality prior to discharge into the Buffalo River.

The final transformation of the American Elevator is an additive process composed of three distinct building elements: workhouses, top deck, and gas collection tanks (see Figure 60). The workhouses are inserted at the end bay conditions of both the original silo network and annex, with internal pump lines that distribute waste flow in a vertical direction. The main workhouse is located in between the original bin network and annex. The workhouses function as vertical circulation shafts for building occupants, and also provide scaffolding that structurally supports the vertical pump lines. The top deck is an elevated platform supported by the shell walls of the concrete silos below.   Laboratories, classrooms, and operational control offices are located along the top deck, and all connected by a central corridor that parallels the length of the building along the centerline. Bearing on the slab of the top deck are gas collection tanks, which are uniformly positioned in relationship to the grid layout of concrete silo bins below.

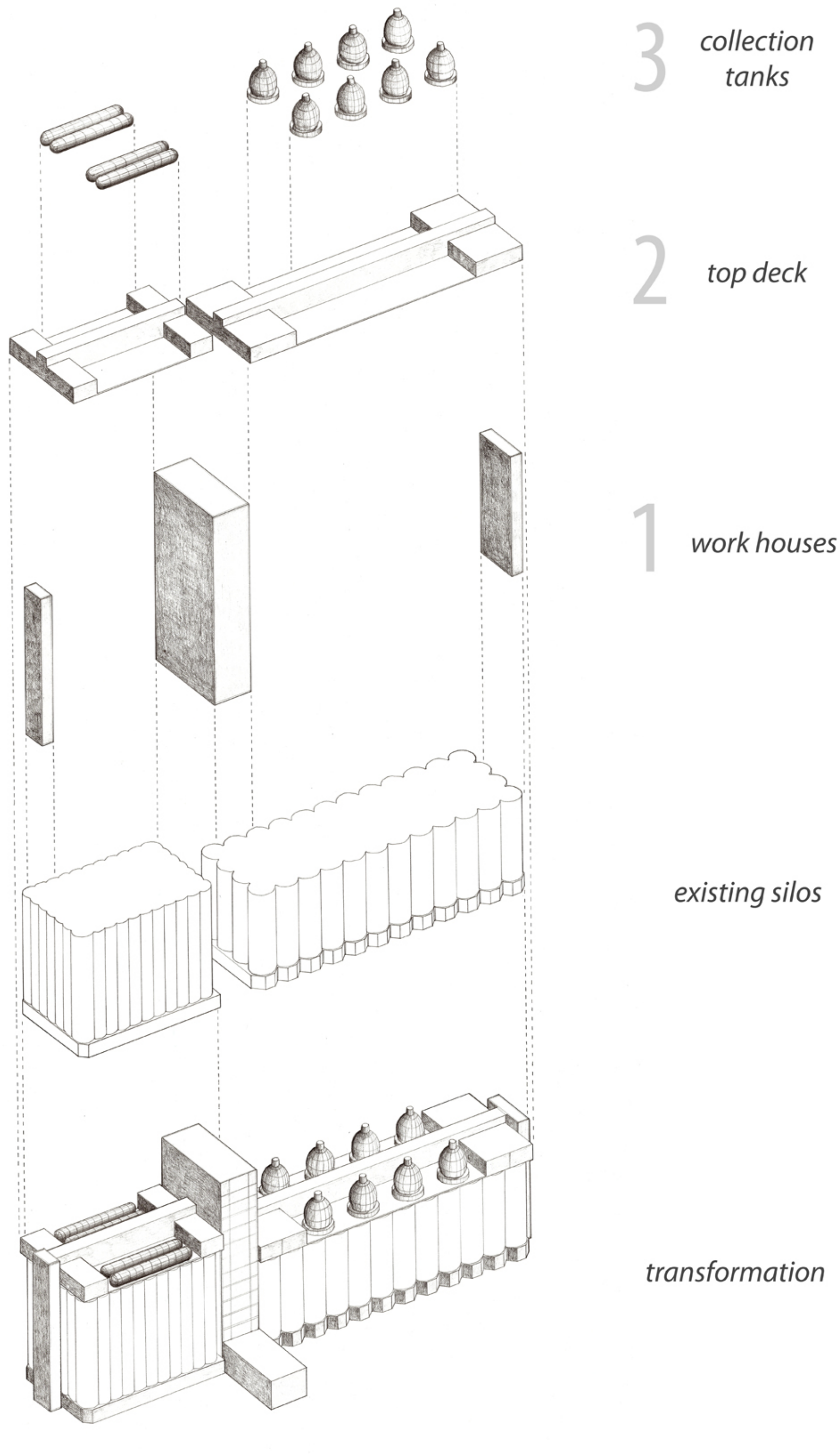

Figure 60: Exploded Axonometric Diagram of Additive Building Elements
Image Drawn by Author

Architectural Response

Although this thesis addresses the question of repurposing grain elevators from a sensible standpoint, another question in need of response is what is the prevailing architectural solution for a grain elevator that has spawned a new use and has been repurposed? To answer that question will be to study the relationship between the materials of both steel and concrete. The materiality that is most commonly associated with a grain elevator is the combination of both structural steel and concrete.

Figure 61: Steel Workhouse Cladded with Corrugated Metal, Standard Elevator, Buffalo
Image Photographed by Author

The material of concrete is associated with the austere nature of concrete curved silo walls, whereas steel is associated with the structural steel framing of grain elevator workhouses. This thesis will respond in a similar approach by preserving the same inherent relationship between the material use of both steel and concrete. Steel will be utilized to provide the structural framework for the pumphouse, and concrete along the face of silo walls will be preserved and unaltered. Typically, a grain elevator workhouse is cladded with corrugated metal panels that wrap the building, and conceal the structural frame (see Figure 61). The proposed pumphouse, which operates similar in principal to that of a grain elevator workhouse, is cladded with glass to express the structural steel framework. By cladding the pumphouse with glass, a contrasting relationship is established between the austere nature of the concrete curved silo walls against the light delicate nature of structural steel framing.

The material relationship of both steel and concrete is also in contrast to one another by the use of 'wall.' When proposing an architectural response, the idea of 'wall' is thought of as a vertical plane that separates rooms, spaces, environments, and even atmospheres. A wall can rise to a defined or implied height, and still function and hold true to its meaning even if it is transparent. In the proposed architectural response for the American Elevator, the concrete silo walls are left solid, and the glass curtain walls of the pumphouse are transparent. Structure is expressed and held truthful to form by maintaining a continuous uninterrupted wall surface along the face of the concrete silos. Contrary to the walled nature of concrete silos, the structure of the pumphouse is expressed by the linear elements that make up the structural framing and lateral bracing. The exterior walls of the pumphouse function as a transparent plane that establishes a visual link connecting the internal program to the outside environment. As a result, the pumphouse introduces a relationship between the inside and outside environments, whereas the walls of the concrete silos deny any visual relationship to occur between the internal silo digesters and the outdoor environment.

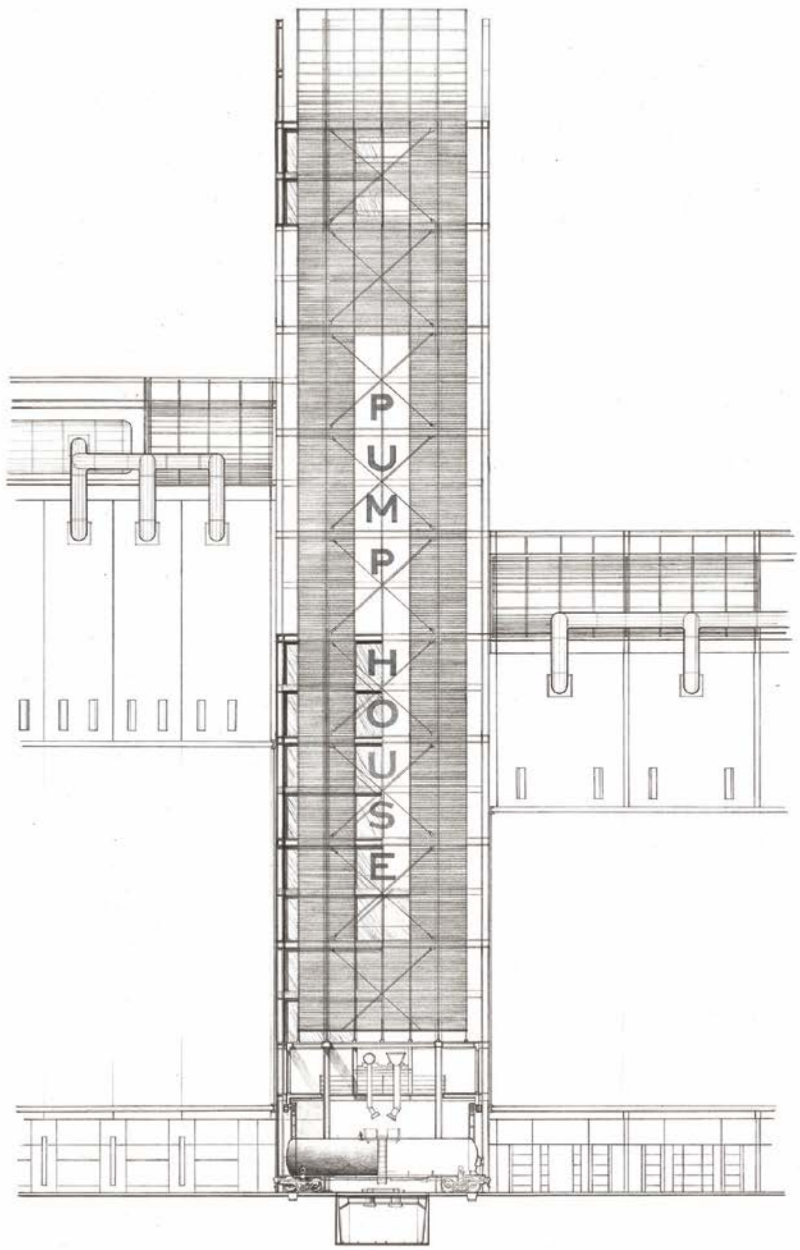

Figure 62: Main Elevation of Proposed Pumphouse
Image Drawn by Author

The architectural detailing of the façade for the pumphouse is broken down into four layers: pump, envelope, frame, and screen (see Figure 63). The main idea for the façade is to express the internal program elements of the vertical pump lines onto the exterior face of the building.

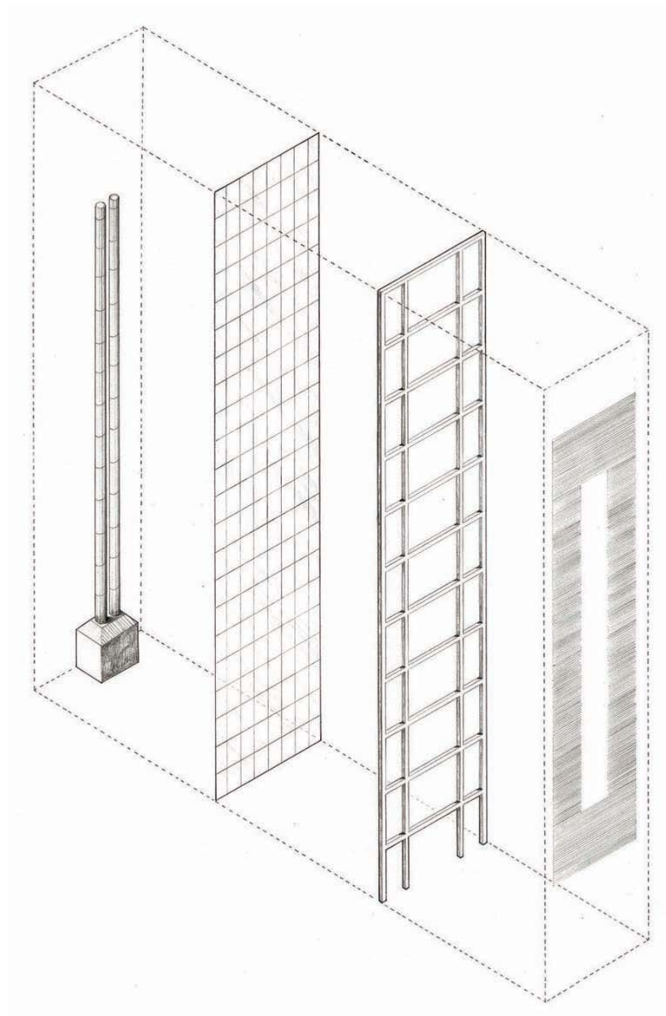

Figure 63: Axonometric Drawing of Facade at Pumphouse
Image Drawn by Author

Starting from the interior, the concept behind the 'pump' is a linear element that gives the appearance of an object in space. The concept behind the 'envelope' is a volumetric element defined by vertical glass planes that ultimately encase the linear element of the pump-line as an object in open space. The concept behind the 'frame' references a grid composed of structural steel columns and beams. The structural framework of the columns and beams add a layer of depth to the façade by sitting proud of the glass envelope, but also providing an element of scale by distinguishing floor to ceiling heights (see Figure 64).

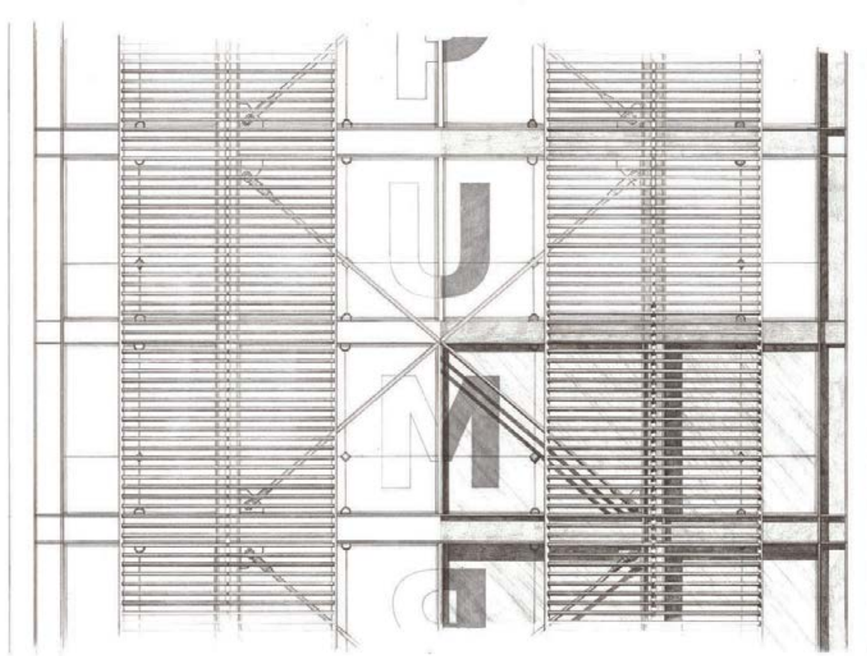

Figure 64: Elevation Detail of Pumphouse
Image Drawn by Author

The outermost layer of the façade is the 'screen', which is a continuous vertical plane that runs up the face of the building, primarily functioning as a rain screen and sun shading device. The screen is composed of individual horizontal louvers that mediate the amount of direct sun exposure the pumphouse receives. From the main elevation, the screen wall of horizontal louvers frame a void around the centerline of the internal vertical pump lines, which reinforces the idea of the vertical pump lines serving as an object in space.

Figure 65: Perspective of Constructed Wetlands
Image Drawn by Author

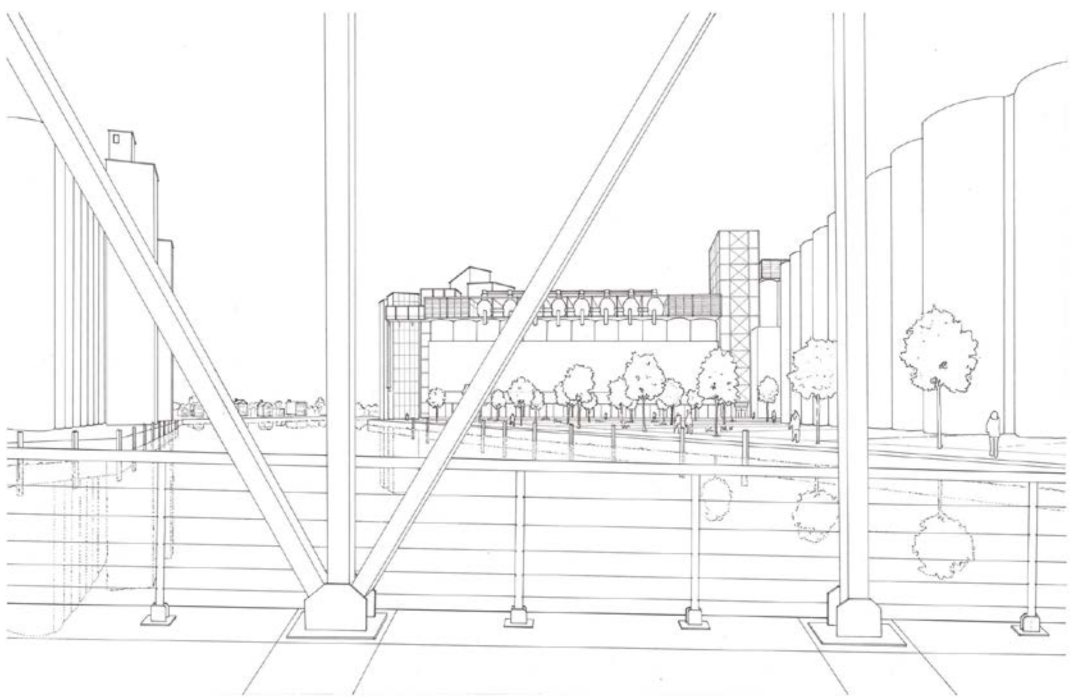

Figure 66: Perspective of Proposed Intervention from Ohio Street Lift Bridge
Image Drawn by Author

Conclusion

The big underlining question of this thesis is: what is a sensible response to repurposing and reusing an abandoned grain elevator? Does it make sense to restore abandoned grain elevators by converting them into loft apartments for people to occupy? Would it be more economical to minimize the amount of transformation and intervention if the grain elevators of Buffalo could only be served as industrial artifacts from a bygone age? Or is the only solution to repurposing the grain elevators along the Buffalo River is to convert the silos into storage containers that process and treat waste? There are many theories that can be conceived of, but there is no prescribed solution for the sensible reuse of the grain elevator typology. The grain elevator is a typology that is strictly designed for one purpose: the storage and distribution of grain. The grain elevators of Buffalo symbolize cathedrals of wealth the American economy possesses, and how much grain is ultimately consumed in the process of feeding a country.

If hypothetically the grain elevators of Buffalo were successfully transformed and repurposed into functioning waste treatments facilities that yield renewable energy and produce byproducts, the typology of the grain elevator will inherit a new meaning. Once representing enormous storage containers symbolizing consumption, grain elevators will be given a rebirth to their meaning, and symbolize as a catalyst to production. If silo digesters are the cure to a rather infectious disease of the derelict grain elevators of Buffalo, then the theory behind the proposal is 'industrializing a natural waste treatment process' (see Figure 67). New meaning and program is given to a depreciated typology of the grain elevator by infusing new technology into the hull of empty concrete silos.

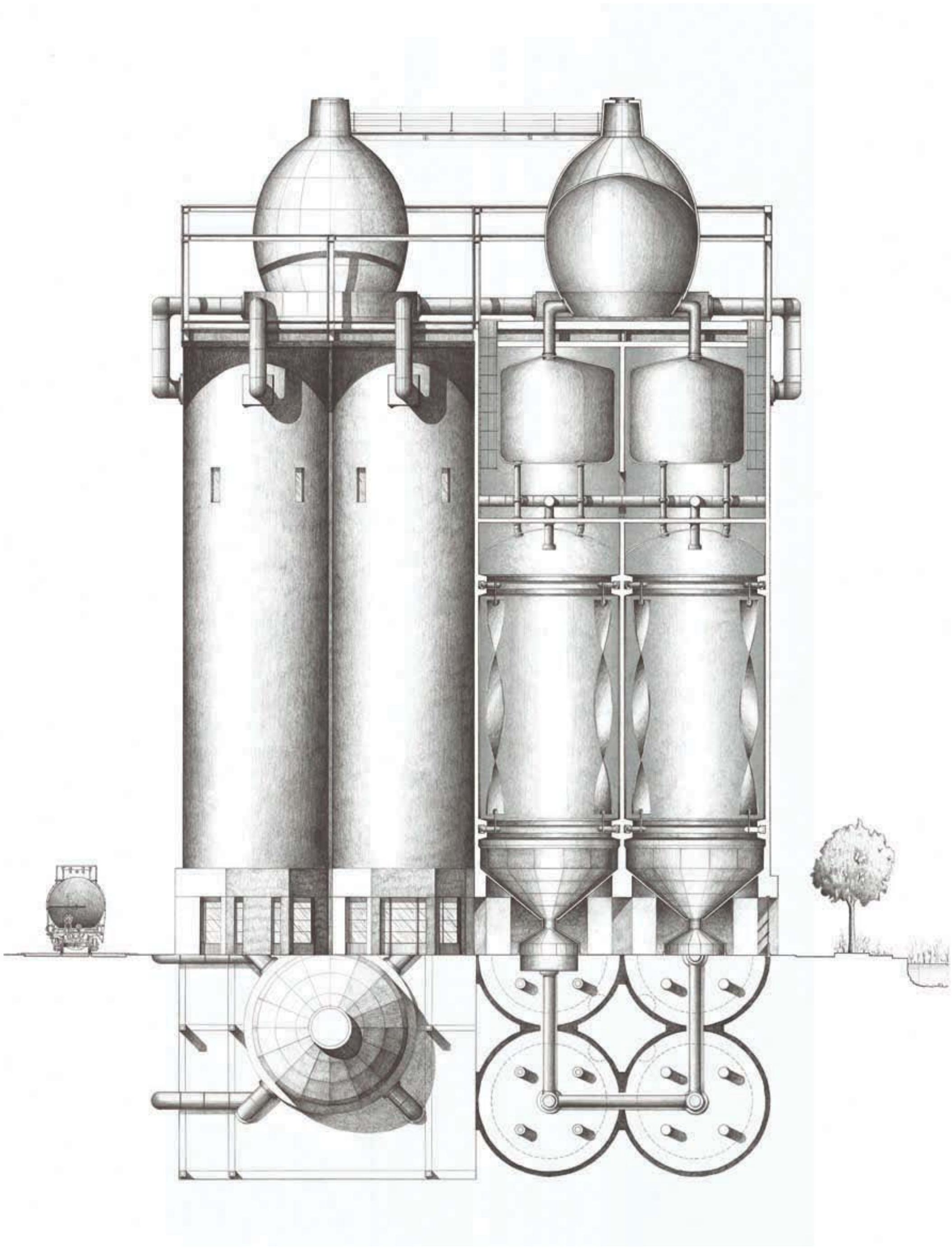

Figure 67: Hybrid Drawing of Silo Digester
Image Drawn by Author

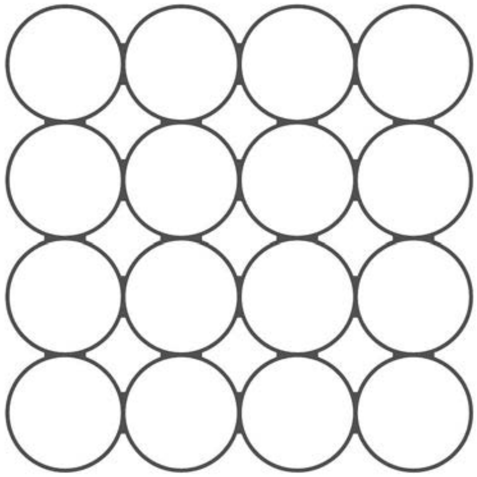

Figure 68: Typical Grain Silo Configuration (right)
Figure 69: Honeycomb Network

Nature has essentially provided the blueprint of design for storage vessels that are arranged in an interconnected network of cellular like spaces and modules. Humans are not the only species that are considered habitat building. There are existing patterns and structures found in nature that mimic the same principal in structure to that of a network of concrete grain silos constructed by mankind. How a typical arrangement of grain silos are interconnected to one another resembles the same natural pattern of the honeycomb (see Figure 68). The theory of this thesis is to propose a new building use of existing grain silos, in which the prevailing building use is similar in function to the original use. It is important to remember that grain silos are nothing more than storage containers. Grain silos do not garner the responsibility of providing inhabitable space. Grain silos are not known for their unique spatial quality of tall dark cylindrical spaces. On the contrary, grain silos are known for their vastness in storage capacity and load bearing capabilities of a supplied substance. This thesis investigates and proposes a new method for design that responds in a sensible manner to the unique inherent properties of the grain silo.

Is a silo digester considered to be a sensible response for repurposing a grain silo? If a grain silo is to be successfully converted into a silo digester that processes waste and produces byproducts, there would be considerable changes made to the existing concrete shell. It is by no means an easy and simple solution for repurposing a grain silo by infusing it with new technology to create an atmosphere that simulates the process of anaerobic digestion. The insertion of new parts and technology would require a high degree of craft regarding construction and installation. The mechanical systems that operate the mixing chambers inside the silo digester would require performance testing for durability and efficiency measures such that the silo digester is guaranteed to function correctly over an extended period of time. The sensible response is stemmed from the idea that the existing concrete curved walls of the preserved grain silo provide the structural shell for an anaerobic digester. Technology is the only element needed to be added, whereas structure is inherited and thus provided.

Figure 70: Oil on Canvas, 'Grain Elevators in Saskatchewan,' by Howard Behrens
Image Photographed by Howard Behrens

Process Drawings

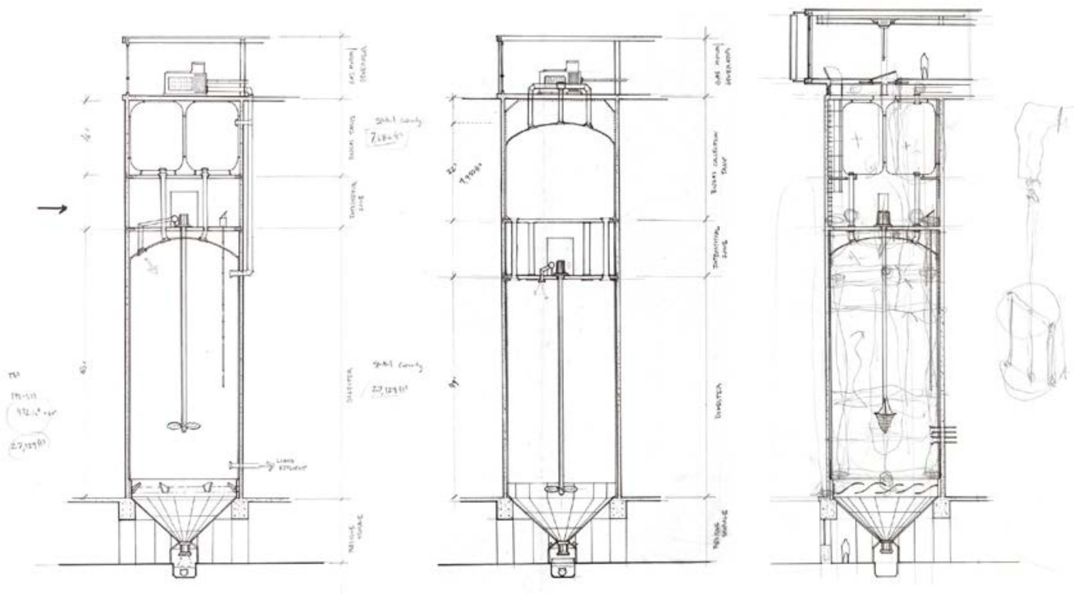

Figure 71: Development of Section Drawings of Silo Digester
Image Drawn by Author

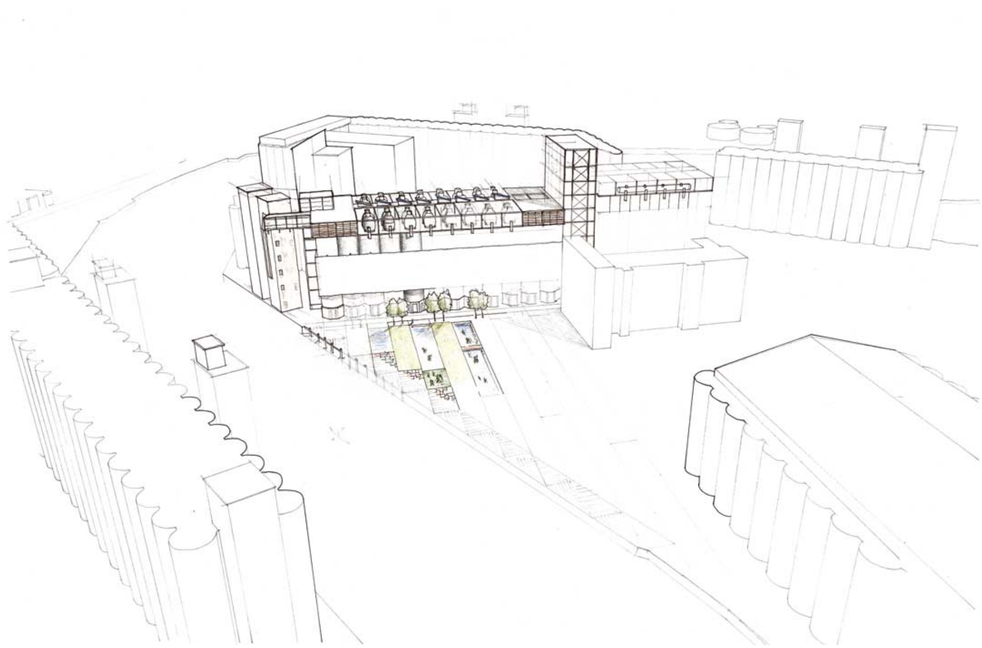

Figure 72: Aerial of Constructed Wetlands adjacent to American Elevator
Image Drawn by Author

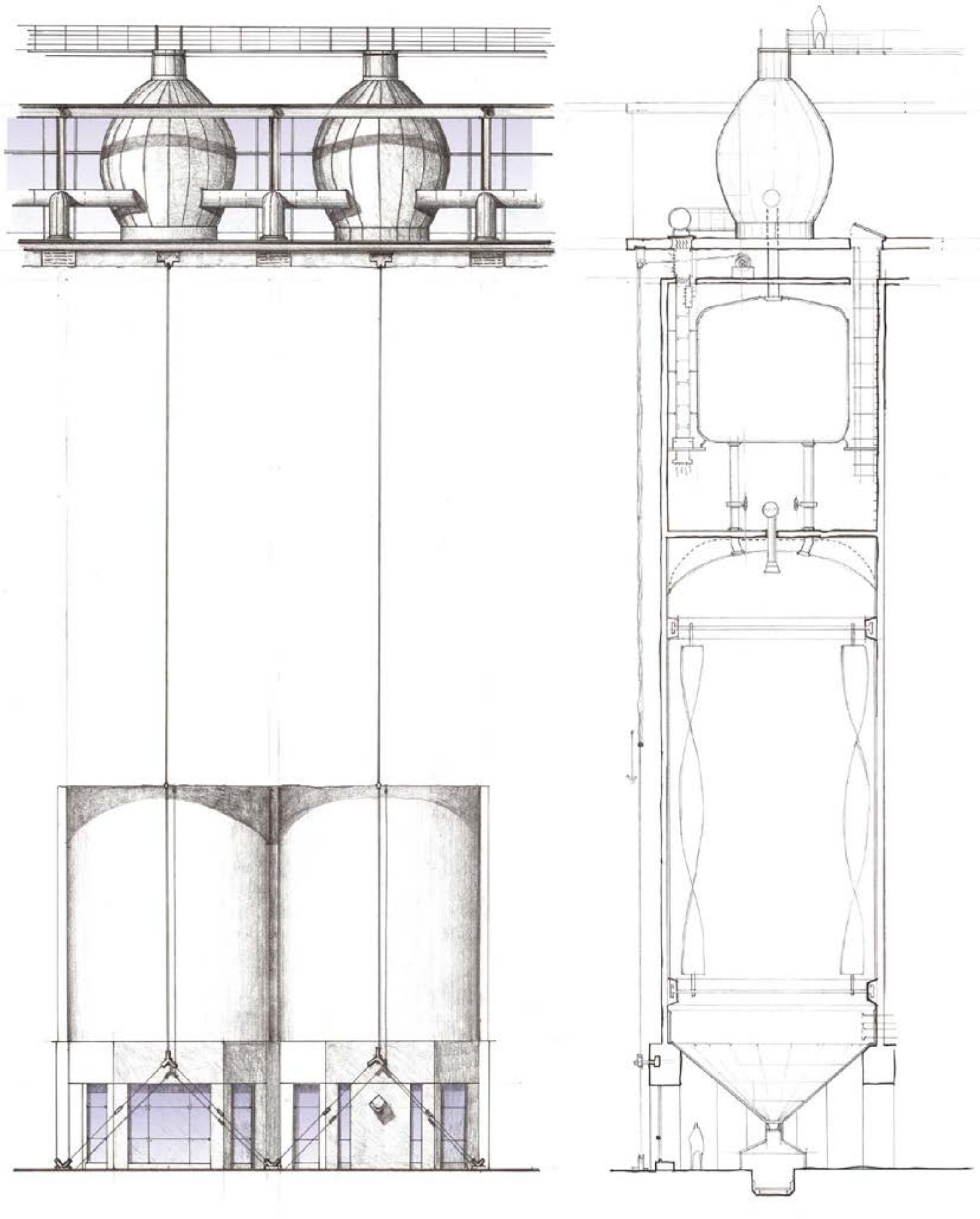

Figure 73: Process Elevation Bay Drawing with Digester Section
Image Drawn by Author

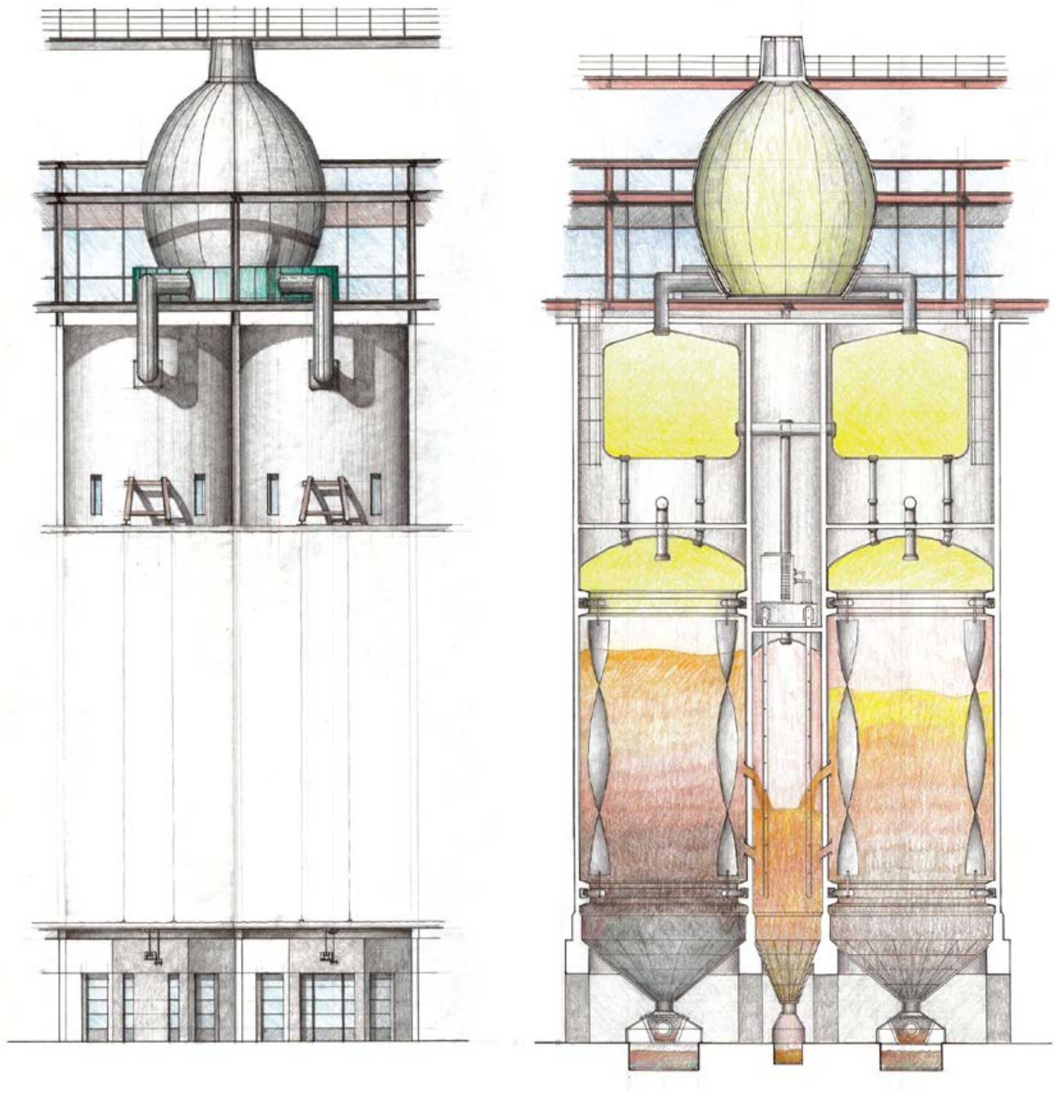

Figure 74: Process Elevation to Section Drawing
Image Drawn by Author

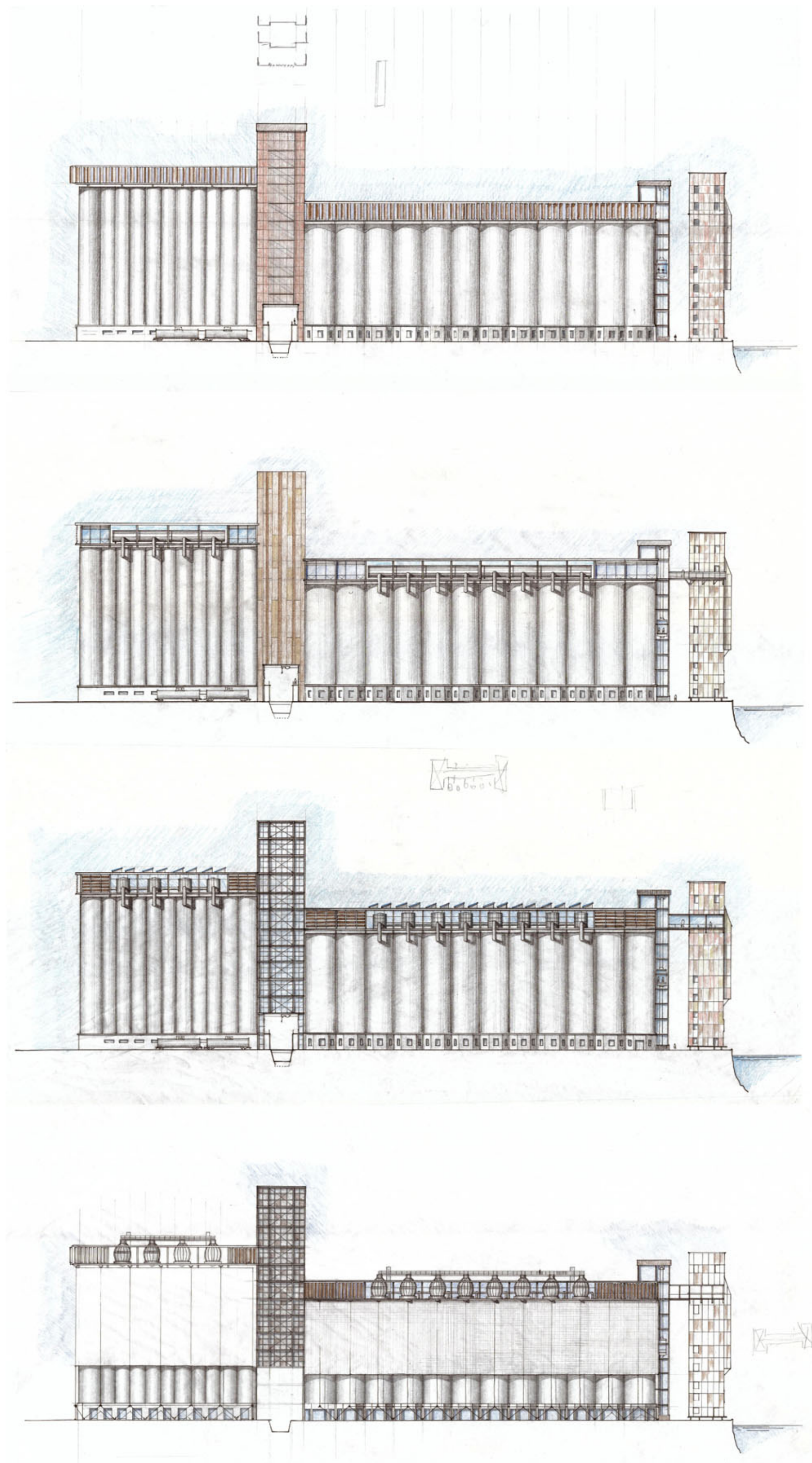

Figure 75: Process Building Elevations
Image Drawn by Author

Figure 76: Site Plan: Constructed Wetlands Adjacent to American Elevator
Image Drawn by Author

Figure 77: Site Plan of Constructed Wetland System along Buffalo River
Image Drawn by Author

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