

ABSTRACT

Title of Document: MOTHBALLED: TRANSFORMING THE CARCASS OF A NAVAL WAREHOUSE INTO AN AGRICULTURAL INCUBATOR

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Philadelphia has one of the oldest and most rich industrial heritages in the United States. The Philadelphia Navy Yard itself was one of the first established shipyards in the United States. After a long history of shipbuilding, the end of the Cold War had rendered the site and its production of military ships inoperative. Since the yard's closure in 1996, the remaining derelict buildings and vessels are a ghostly reminder of the Navy Yard's past significance.

This thesis will explore the stimulation of the yard by reestablishing its reason for being. The rapid progression of technological advancements has left shipbuilding a trade of the past. As a result, many structures that were once hubs of superior industrial manufacturing now remain neglected. This project will investigate adaptively reusing the abandoned carcass of a naval warehouse and its surrounding officer quarters. Memory of the site's industrial past will foster the integration of an agricultural research center that demonstrates state-of-the-art processes as part of a renewed form of technological tradition. This research center will become a beacon of agricultural research, education, and exhibition, while carrying on the building and Navy Yard's tradition as a place of technology and production.

MOTHBALLED: TRANSFORMING THE CARCASS OF A NAVAL
WAREHOUSE INTO AN AGRICULTUREAL INCUBATOR

By

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Thesis submitted to the Faculty of the Graduate School of the
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of the requirements for the degree of
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Dedication

To my father,
for all the years of hard work at the Philadelphia Navy Yard.



Anthony S. Pizzo Jr. (Philadelphia Navy Yard, 1986)

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For direction, passion, and inspiration:

Garth C. Rockcastle
Michael A. Ambrose
Brian P. Kelly

For patience, love, and support:

Mom
Dad
Lisa

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Chapter 1: Introduction

Industrial Reuse and Urban Agriculture

“The beauty created by an engineer arises from the fact that he is not conscious about its creation”¹

Since the dawn of the industrial revolution, enormous sites were created and dedicated as hubs of manufacturing, production, and innovation. As a feat of engineering and architecture, massive structures were erected at these sites to support the burden of heavy equipment and raw materials. These large spaces and stretches of land served functionally for the purpose of manufacturing, but also became icons of industrial technology and the future of modernization. Unfortunately, with the advancement of technology today, many of these sites across the world have since then become wastelands left as scars on the earth’s surface. These large brownfields are now nothing but relics of the past and constant reminders of their former industrial prominence.

Fortunately, architects, planners, landscape architects, and designers alike have been keeping a close eye on these types of sites. They have been praised as having strong potential in becoming redeveloped often for their spatial richness and their excellent location within the larger city context. This interest in tracing and revitalizing the past is no stronger represented than at the Philadelphia Navy Yard. Since its decommission and closure as a navy site in 1996, the majority of the yard has been left to decay over the last 15 years. Only about 25% of the Navy Yard remains active in the manufacturing and repairing of vessels. The remainder of the

site is a blank canvas infused with beautiful historic buildings and immensely engineered structures.

The problem that arises is what do we do with these empty lots and derelict architecture? In many cases, contamination and the enormous size of space available make it difficult to imagine a program that could inhabit these once industrial hubs. A solution to this question is a trend that has been quickly rising; urban agriculture. The idea of agriculture has been around since the beginning of civilization, but the notion that food production can occupy the spaces of densely populated cities, rooftops, and vacant industrial sites has largely gone ignored.

In 2050, the world's population will have increased 28% to 9 billion people. In order to feed that amount of people with traditional agricultural practices, roughly 2.3 billion acres of new land would be needed. That is an area roughly the size of the entire United States (figure 1).

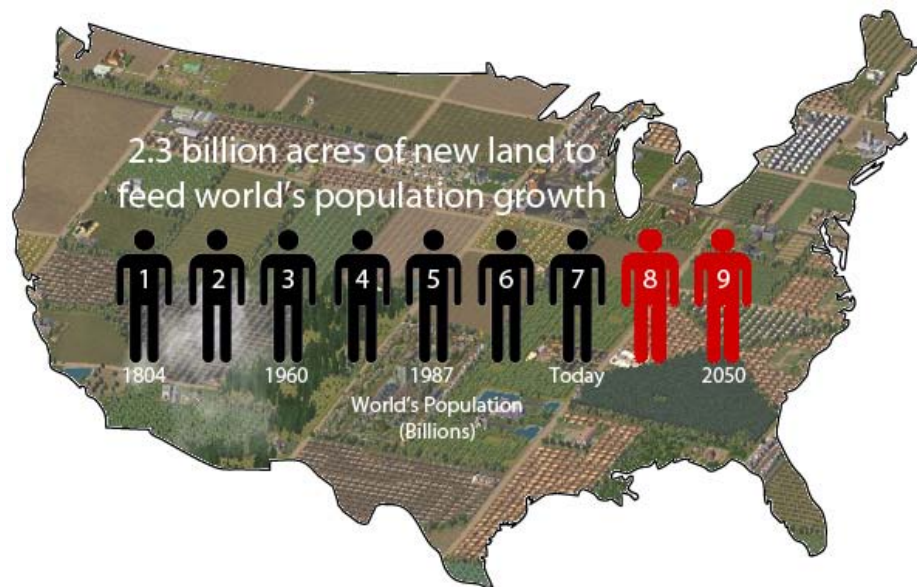


Figure 1. Amount of land needed to feed population growth in 2050 (Source: Author)

In addition to the rapid increase in population, only 10.5% of the world's land area is considered to be arable for the growing and harvesting of crops². Of that fraction, only 2% of today's arable surface remains unused (figure 2).

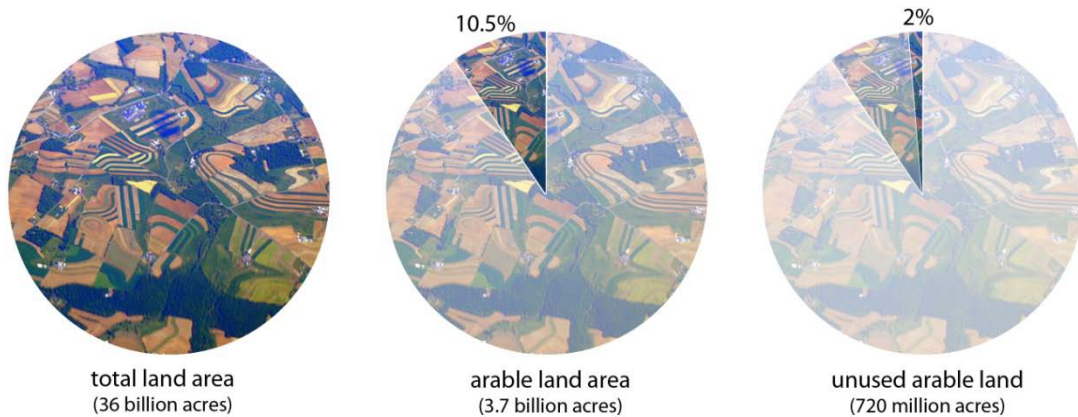


Figure 2. Total arable land area (Source: Author)

This data supports the realization that if we continue to develop suburban greenfields and practice farming in traditional methods, we will surely run out of enough land to sustain ourselves as a growing civilization. The need to shift this paradigm and focus food production in urban settings is becoming increasingly apparent. Utilizing underdeveloped industrial land in cities is a viable option to explore ways in which urban agriculture can be sustainability integrated. This thesis calls this phenomenon sustainable agricultural transformation (figure 3).

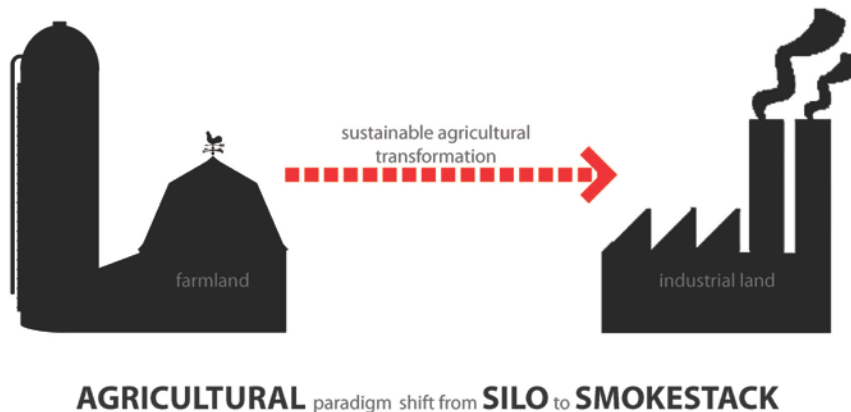


Figure 3. Agricultural paradigm shift (Source: Author)

These underutilized urban wastelands accumulate 47,000 acres around the U.S. of potentially transformative land³. More site specifically, Philadelphia alone has an estimated area of 17,800 acres of industrially-zoned land, 21% of Philadelphia’s land total. Of that industrially-zoned area, 2,500 acres have been certified for redevelopment⁴ (figure 4).

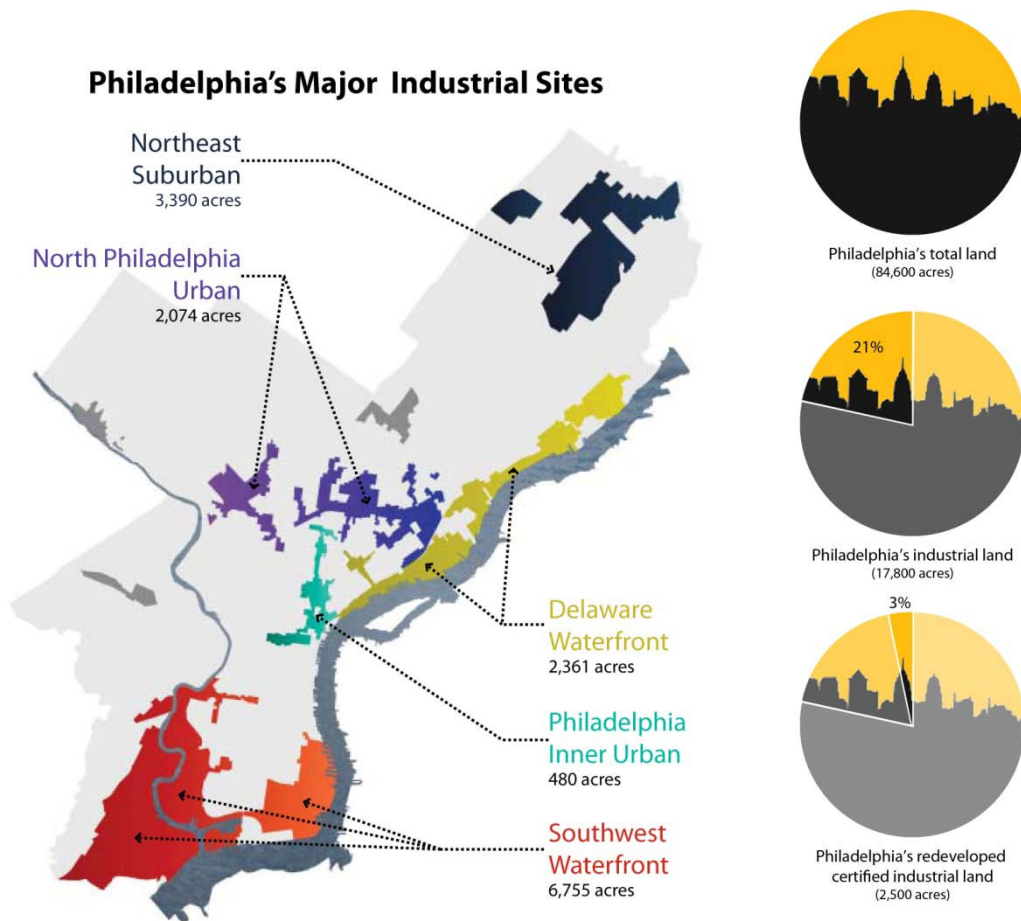


Figure 4. Philadelphia’s industrial land (Source: Author)

Philadelphia, among other major cities across the world, has the potential in becoming centers of urban agriculture. By utilizing the surplus of urban industrial land, agricultural techniques can undergo a transformation from traditional cultivation to a more sustainable and higher crop yielding methods of modernized food production. The thesis explores this potential agricultural transformation by

examining the conversion of a 221,000 square foot naval warehouse into an agricultural research center at the Philadelphia Navy Yard. The carcass of this existing warehouse will be transposed as a scaffold for the fostering of agricultural education, production, and advanced technologies. Through this conversion, the existing structure's true potential will be utilized, and the site's tradition as hub for technology and production will be retained.

Chapter 2: The Philadelphia Navy Yard

Site Description



Figure 5. Philadelphia aerial with the Navy Yard highlighted (Source: Author)

The site for this thesis is located at the Philadelphia Navy Yard (figure 5). As a major part of Philadelphia's industrial past, the Navy Yard has been positioned along the Delaware River bend at the city's southern edge. This 1,200 acre plot of land has been officially titled League Island since the yard's original development in the mid 19th century. With over 4 miles of waterfront land, the island served as an ideal location for the expansion of the shipbuilding industry in Philadelphia. In addition to the Delaware River defining the site's southern edge, the Schuylkill River flows along the yard's west periphery prior to the converging of both bodies of water.



Figure 6. Navy Yard divisions (Source: Author)

The Philadelphia Navy Yard was originally divided into two distinct areas of naval function that are separated by Broad Street (figure 6). West of Broad Street was designated for industrial operations geared mostly towards military shipbuilding and repairs in addition to steel and other material manufacturing. Large assembly facilities, mobile rail cranes, dry docks, and a reserve basin are all located here in order to facilitate the development of naval vessels. East of Broad Street was the location of the Naval Base and air strip. In this division, the majority of administrative duties took place. Military housing for officers and their families were

also situated here in small colonies of barracks. This section of the Navy Yard was also the site for the private military air strip along Kitty Hawk Avenue. A variety of warehouses and hangers were positioned here as support structures for the storage of materials that were manufactured by the shipyard or delivered out of house by the railroad just north of the yard.

After its closure in 1996, much of the shipyard was reclaimed and activated by private non-military shipbuilding and repair companies. The largest of these manufacturers is Aker, a leading U.S. commercial shipyard specializing in the building of large merchant vessels. The Naval Base has been shut down and currently lies mostly vacant. The area directly east of Broad Street has been selected as the site for a major adaptive reuse project of early 20th century naval administrative buildings by the PIDC. In addition, the land further to the east surrounding the air strip has been studied as the location for a large master plan initiated in 2004.



Figure 7. Philadelphia Navy Yard aerial highlighting the site proper (Source: Author)

The site proper used in the exploration of this thesis is located at the Philadelphia Navy Yard's south perimeter along the Delaware River waterfront. It is positioned just one block south of the intersection between Broad Street and Kitty

Hawk Avenue, two major streets into and around the yard (figure 7). The site stretches across one and a half blocks with an area of 700,000 sq. ft. (16 acres). The site is situated between the Urban Outfitters Campus to the west (figure 20), a navy controlled industrial facility to the east (figure 23), and a large 8 story vacant warehouse to the north (figure 19). Two adjacent open lots are also located north where additional warehouses existed prior to their demolition. Dominating the site is Building 611, a large 221,000 total sq. ft. naval air material warehouse. Lining the south of the site along Delaware Avenue is a series of 8 former officer quarters, creating perhaps a very challenging scale juxtaposition. The remainder of the site is covered with surface parking and open space with modest tree and ground coverage.



Figure 8. Thesis site aerial (Source: Author)

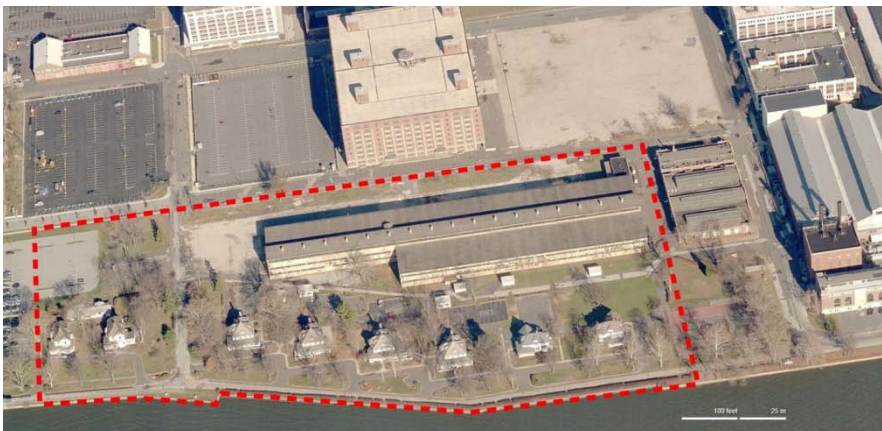


Figure 9. Thesis site bird's eye view (Source: Author)

Site Documentation

The Shipyard

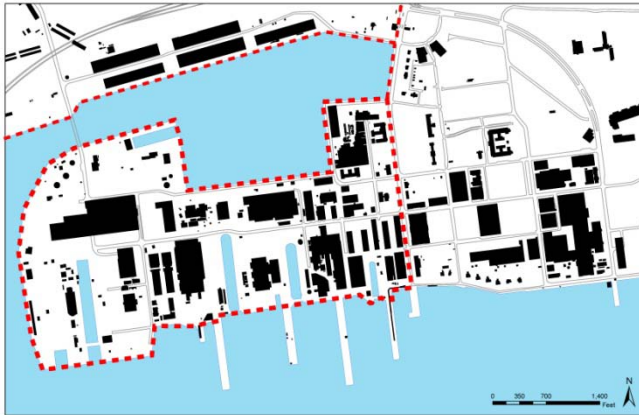


Figure 10. Shipyard highlighted (Source: Author)

The shipyard occupies the entire western portion of League Island. It remains the only fully active part of the Philadelphia Navy Yard. These 400 acres of land are comprised of a variety of industrial facilities that are enormous in scale to facilitate the manufacturing, repair, and storage of ships and their components. Additionally, the shipyard contains a large reserve basin, 5 dry docks, and 6 piers. Since the Navy Yard's initial closure in 1996, most of the land and its buildings have been sold to private shipbuilding companies including Aker, Rhoads (figure 11), and the Philadelphia Shipyard. The integrity of these structures has been well maintained over the years, partly because segments of the yard have been sold to private companies after the Navy's closure and immediately reactivated. Despite the removal of the military's presence, a few buildings are still retained by the Navy (figure 14). Additionally, mothballed vessels (figures 15 & 16) are scattered around the shipyard as they become stripped and sold for parts.

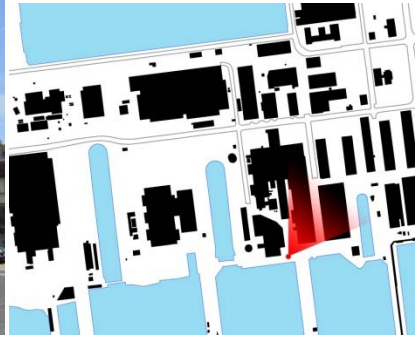


Figure 11. Propeller manufacturing shop (Source: Author)

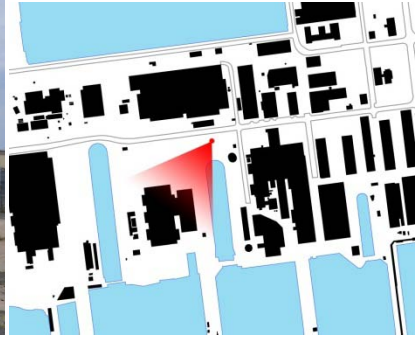


Figure 12. Former turret facility (Source: Author)

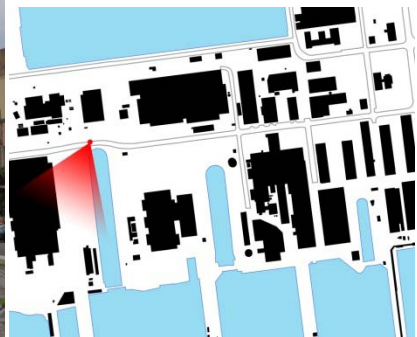


Figure 13. Inactive rail crane (Source: Author)



Figure 14. NAVSEA facility (Source: Author)

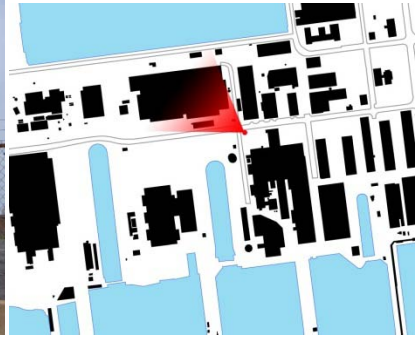


Figure 15. Mothballed aircraft carrier (Source: Author)

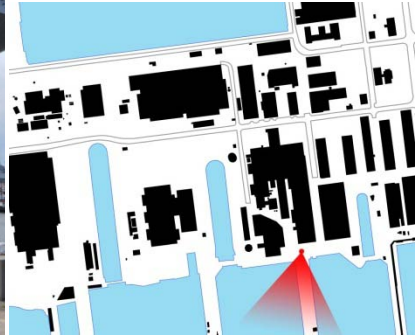


Figure 16. Mothballed battleship in the reserve basin (Source: Author)



The Historic Core



Figure 17. Historic Core highlighted (Source: Author)

This core is the oldest section of the Navy Yard. The first development began in the mid 19th century when the shipyard expanded its site to League Island. Today, much of this area maintains more of a college campus feeling than a once industrial site. 100 year old sycamores line broad streets with wide pedestrian paths. Varying open green spaces are scattered throughout the historic core that were once used for military ceremonies. A range of classical architectural languages have been used to establish a neighborhood of historically elegant buildings. Many of these buildings were once housing for military officers (figure 18) and soldiers (figure 21). Since the PNY's closure, much of this district has been left vacant and underutilized. Many of the structures had to be demolished due to their neglected condition. The buildings that remain have been considered historically valuable and have been secured and stabilized. The surplus of these vacant buildings and empty lots has become the site for a major preservation and adaptive reuse project initiated in the 2004 Master Plan. Over 2 million square of renovation have been considered in the revitalization of the site's historically characteristic potential. The first of these projects was the Urban Outfitters Campus project completed in 2006 (figure 20).



Figure 18. Dock Commander's quarters (Source: Author)

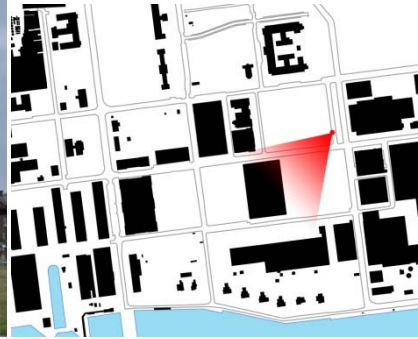


Figure 19. Naval warehouse (Source: Author)

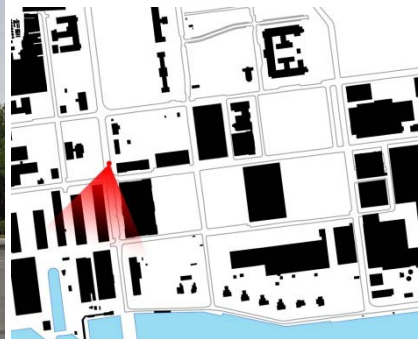


Figure 20. Urban Outfitters building along Broad Street (Source: Author)



Figure 21. Marine barracks and drill field (Source: Author)

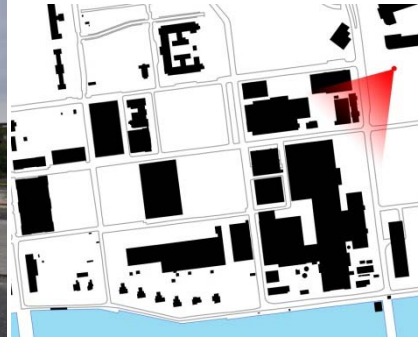


Figure 22. Naval air control facility (Source: Author)

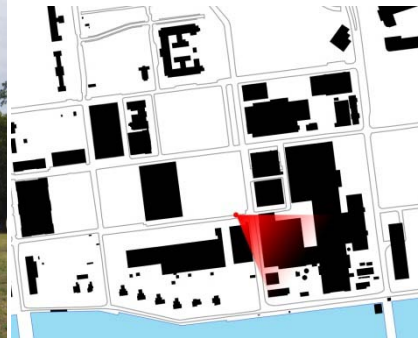


Figure 23. Navy controlled industrial facility one block east of site (Source: Author)

New Construction



Figure 24. New construction highlighted (Source: Author)

Since the completion of the PNY master plan, initial phases of new development have begun taking place. New construction has been concentrated in the northern portion of the Navy Yard where the majority of vacant land is located (figure 25). Currently, businesses have already begun investing in property at the Navy Yard. Major companies like Tastykake (figure 26) have started relocating their headquarters from Center City to the yard. With close proximity to the water, easy accessibility from 95, and connections to Center City, the PNY has become a desirable location for new development fostering a unique mix of historical context and contemporary architecture.



Figure 25. Breaking ground for new construction at north PNY (Source: Author)

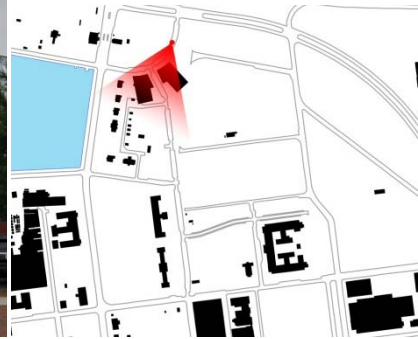


Figure 26. Tastykake Baking Company Headquarters (Source: Author)



Figure 27. Office building (Source: Author)

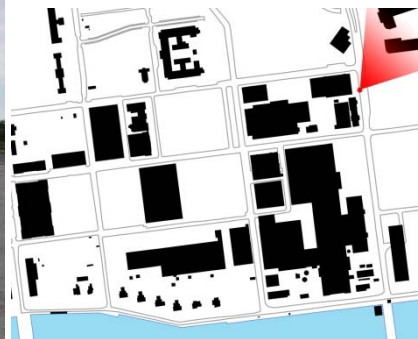


Figure 28. Iroko Pharmaceutical R&D (Source: Author)

Building 611 & Officer Quarters



Figure 29. Building 611 key plan (Source: Author)

Building 611 was a large Naval warehouse and materials center built in 1942. It is located to the north of the site, situated between Flagship Drive to the north, Admiral Peary Way to the south, 11th Street to the east, and 13th street to the west. The warehouse is a long building stretching 700 feet long and 200 feet at its widest. With a footprint area of 124,000 sf., it dominates the site and reads massive in scale when compared to the officer quarters to its south. Despite its size, the building maintains a low profile with slightly sloped roofs and the step back of the massing creating different readings between the east and west façades (figures 30 & 31).



Figure 30. West Elevation (Source: Author)

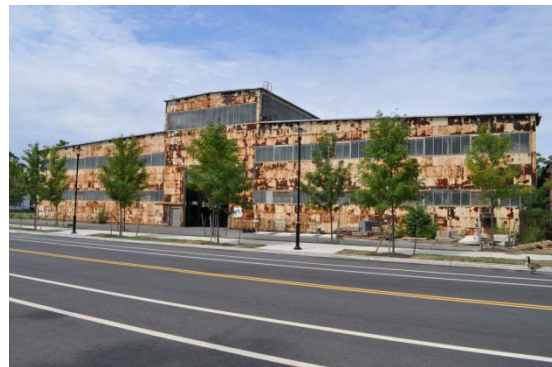


Figure 31. East Elevation (Source: Author)

The exterior is dressed in metal panels that have begun to rust over the years (figure 32) likely due to the brackish nature of the Delaware River. Since the skin is deteriorated, exterior envelope replacement presents the opportunity to wrap the building in a new skin that could offer expansive views out towards the river. Plastic wire-framed ribbon windows express the horizontality and elongation of the massing while allow diffused light to enter the interior space. Large metal roll-up garage doors are primary features on the major elevations for easy transportation of materials.



Figure 32. Exterior steel cladding (Source: Author)



Figure 33. Warehouse Massing (Source: Author)



Figure 34. South Elevation (Source: Author)

The warehouse is two storied with the second floor being a taller space. The central aisle is a double-height space that projects past the side wings allowing light to enter through a clerestory. The roof and supporting trusses seem to float above the center space. Stairs are placed every 6 bays for vertical circulation, in addition to one existing elevator shaft (figure 37). Suspended on opposite ends above the main aisle are cranes that rolled on a steel track designed for picking up heavy material and equipment that was stored on the upper floors (figure 38).



Figure 35. Existing plans and sections (Source: Stern Architects)



Figure 36. Double-height central space (Source: Author)



Figure 37. Second floor with elevator shaft (Source: Author)

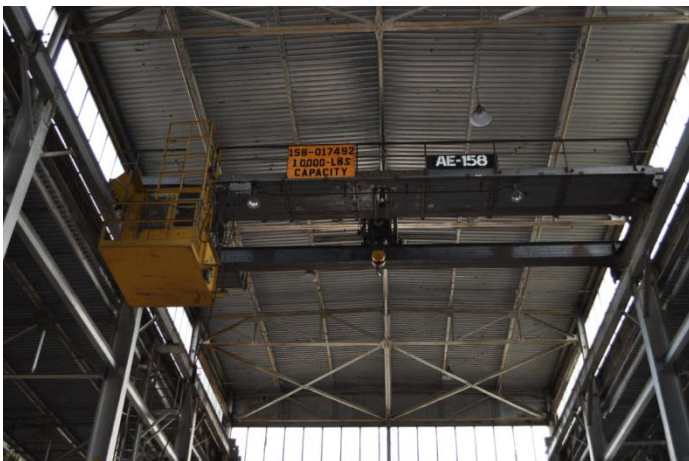


Figure 38. Suspended track crane (Source: Author)

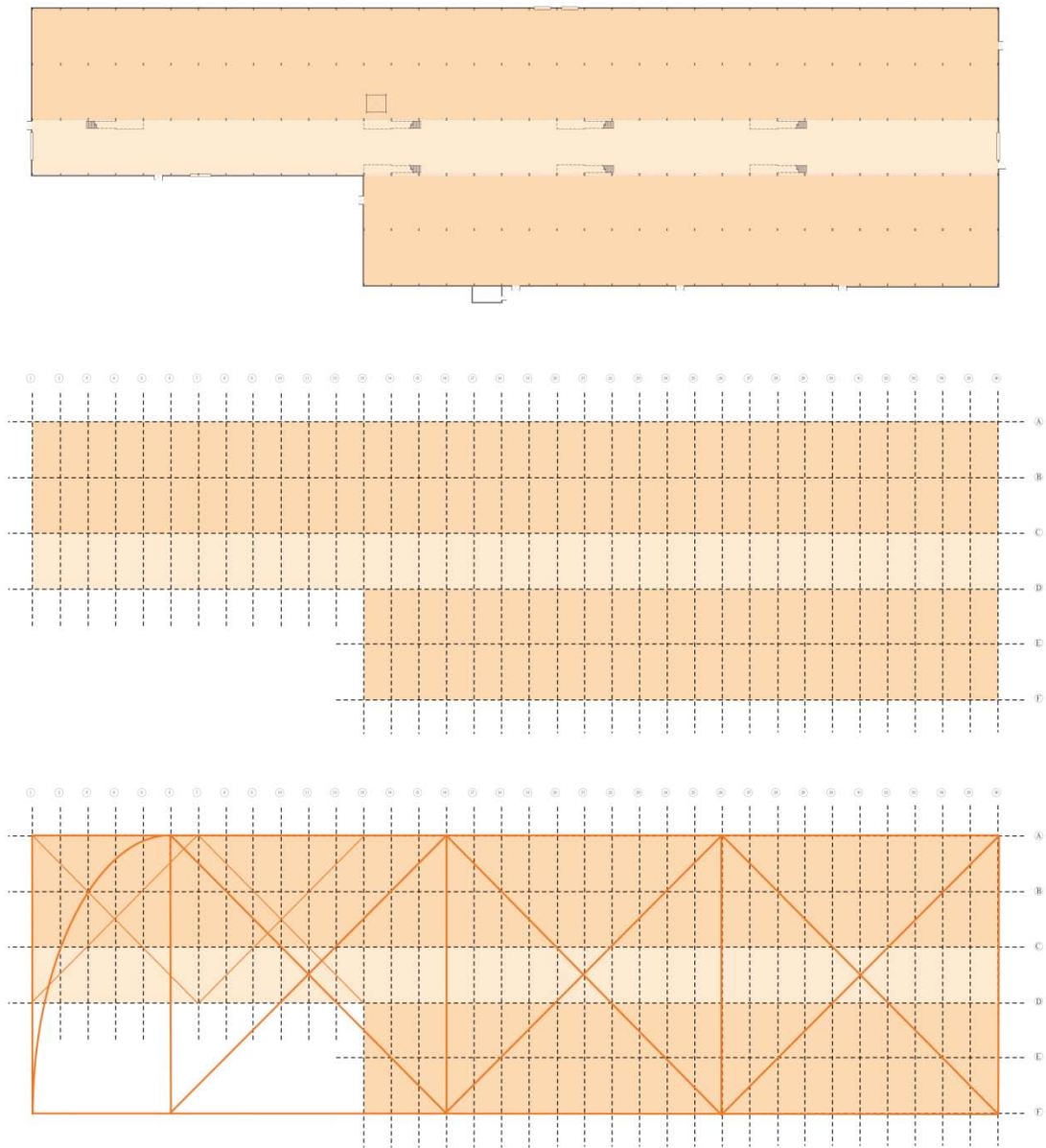
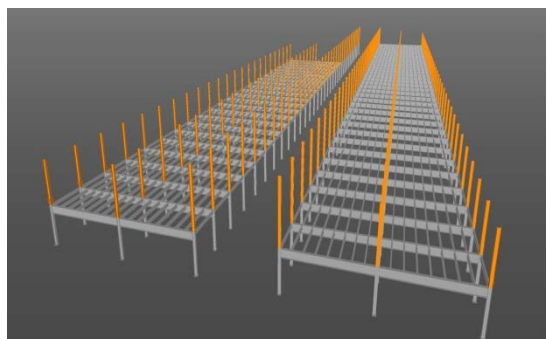
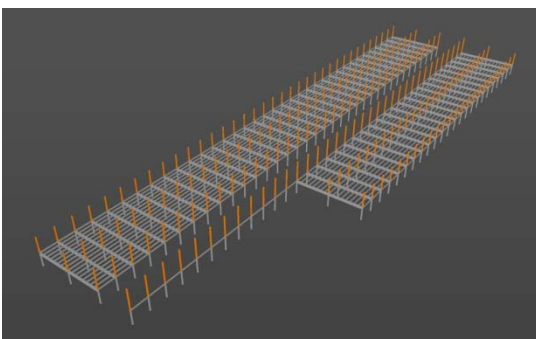
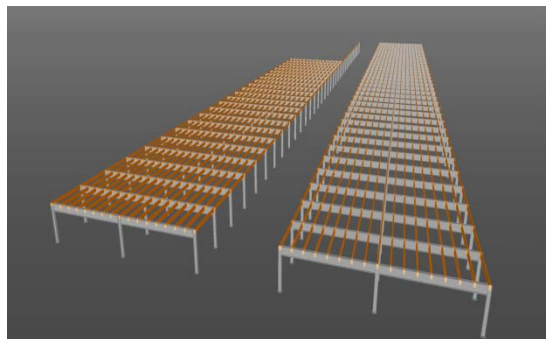
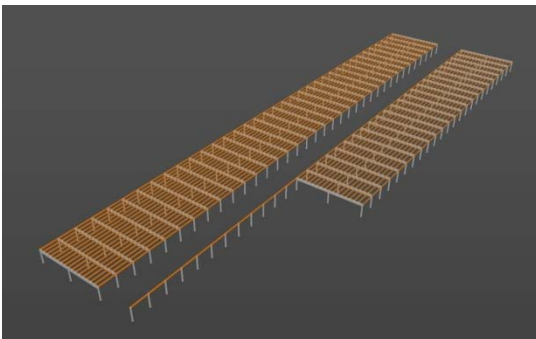
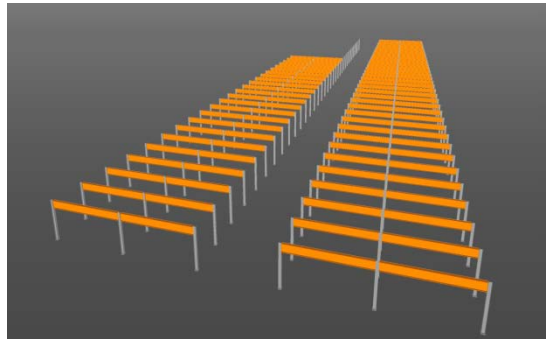
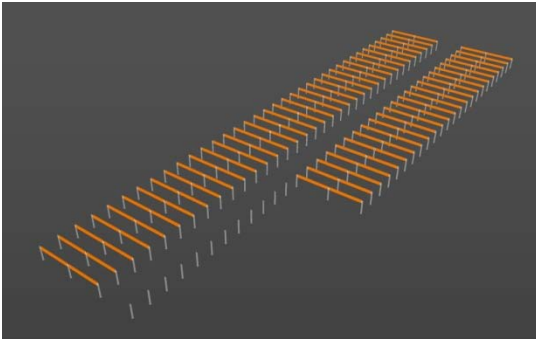
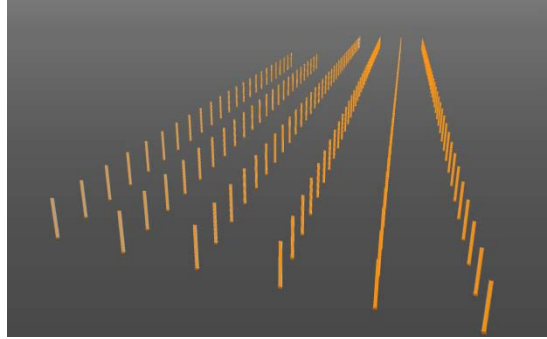
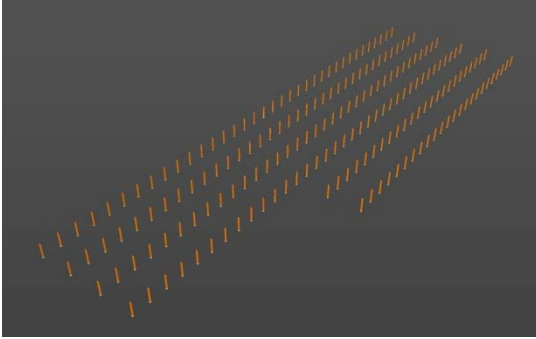


Figure 39. Grid and proportion systems (Source: Author)

The interior is composed of exposed industrial structure. Large steel columns march along a thirty-five bay grid system running north-south and five bays along the east-west direction. This structural grid establishes a proportional system consisting of two squares and a root 1 rectangle that defines the entire length of the warehouse (figure 39). Additionally, two smaller squares compose the western section. Trusses support the weight of the metal decked roofs while beams are used to support the

second story loads. The structure is heavily braced and laterally supported for the strength required to support heavy material, but when experiencing the space, the structure appears light.



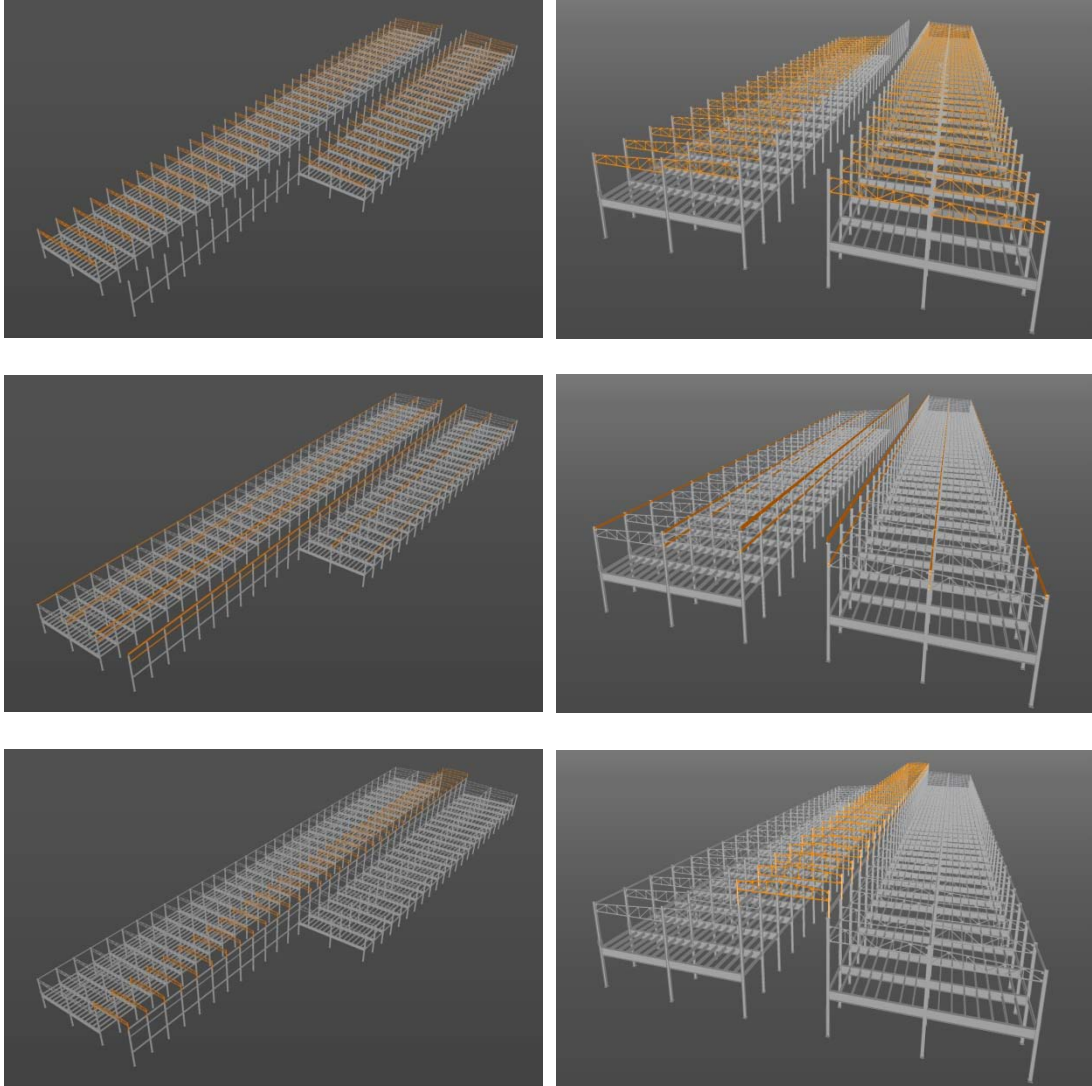


Figure 40. Structural Layering (Source: Author)

This series of diagrams represent the simplistic yet robust tectonic layering system of the existing structure. Steel I beam columns are positioned in a 40' x 20' grid defining the interior spaces of the warehouse. The loads from the mezzanine level are carried by large 3' deep beams spanning 40' across the larger length of the column grid. Additional W 16 x 36 wide flange beams run the opposite direction at 5' on center for lateral bracing. A lighter and more airy truss structural system is used above the mezzanine levels and double-height aisle to support less substantial loads from the roofs.

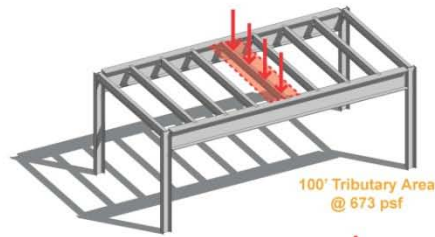


Figure 41. Existing structure: view from central aisle (Source: Author)

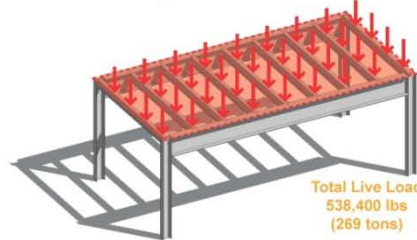


Figure 42. Existing structure: view from mezzanine (Source: Author)

These are views generated from a 3D model created of the existing structure. They demonstrate the variety of scales experienced depending on the position of the viewer. From the central aisle (figure 41), the double heighted space in combination with the light truss structure seems to expand the space vertically in harmony with the horizontal nature of the building. The 15' wings off to the side are in contrast to the expansive 45' central space. This spatial juxtaposition could be related to a cathedral with its nave and side aisles. Up on the mezzanine (figure 42), the space is compressed by two bays of repetitive columns and slightly sloping trusses above.



100' Tributary Area
@ 673 psf



Total Live Load
538,400 lbs
(269 tons)

W16 x 36 Wide Flange Beams @ 5' o.c.:

Elastic section modulus of cross section = $S_x = 56.5 \text{ in}^3$
Assume beam yield strength (F_y) = 36 ksi

$$F_y = M / S$$

$$M = S_x (F_y) = (56.5 \text{ in}^3)(36 \text{ ksi}) = 2,034 \text{ k in (1 in / 12)} = 169.5 \text{ kft}$$

$$M_{\text{max}} = 169.5 \text{ kft}$$

$$M = q_t L^2 / 8$$

$$q_t = 8M / L^2 = 8(169.5 \text{ kft}) / (20')^2$$

$$q_t = 3.4 \text{ k/ft}$$

$$q_r = 3.4 \text{ k/ft}$$

$$q_{DL} = 36 \text{ lb/ft}$$

$$\text{Live Load } (q_{LL}) = \text{Total } (q_t) - \text{Dead Load } (q_{DL})$$

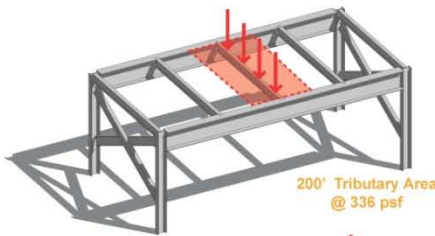
$$q_{LL} = 3,400 \text{ lb/ft} - 36 \text{ lb/ft} = 3,364 \text{ lb/ft}$$

$$\text{Floor}_{LL} = 3,364 \text{ lb/ft} / 5' = 673 \text{ psf}$$

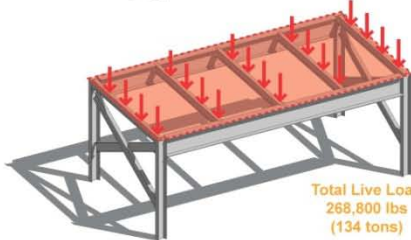
Live Load Capacity of a 20' long W16 x 36 beam @ 5' o.c. = 673 psf

Typical heavy manufacturing is designed for 250 psf

Total live load capacity in one 20' x 40' bay = 538,400 lbs (269 tons)



200' Tributary Area
@ 336 psf



Total Live Load
268,800 lbs
(134 tons)

W16 x 36 Wide Flange Beams @ 10' o.c.:

Elastic section modulus of cross section = $S_x = 56.5 \text{ in}^3$
Assume beam yield strength (F_y) = 36 ksi

$$F_y = M / S$$

$$M = S_x (F_y) = (56.5 \text{ in}^3)(36 \text{ ksi}) = 2,034 \text{ k in (1 in / 12)} = 169.5 \text{ kft}$$

$$M_{\text{max}} = 169.5 \text{ kft}$$

$$M = q_t L^2 / 8$$

$$q_t = 8M / L^2 = 8(169.5 \text{ kft}) / (20')^2$$

$$q_t = 3.4 \text{ k/ft}$$

$$q_r = 3.4 \text{ k/ft}$$

$$q_{DL} = 36 \text{ lb/ft}$$

$$\text{Live Load } (q_{LL}) = \text{Total } (q_t) - \text{Dead Load } (q_{DL})$$

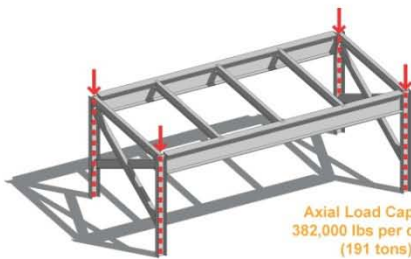
$$q_{LL} = 3,400 \text{ lb/ft} - 36 \text{ lb/ft} = 3,364 \text{ lb/ft}$$

$$\text{Floor}_{LL} = 3,364 \text{ lb/ft} / 10' = 336 \text{ psf}$$

Live Load Capacity of a 20' long W16 x 36 beam @ 10' o.c. = 336 psf

Typical heavy manufacturing is designed for 250 psf

Total live load capacity in one 20' x 40' bay = 268,800 lbs (134 tons)



Axial Load Capacity
382,000 lbs per column
(191 tons)

W16 x 67 Wide Flange Column:

Assume beam yield strength (F_y) = 36 ksi

$$\text{Axial Load } (S) = P / A$$

$$P = (S)(A) = (F_y)(A) = 36 \text{ ksi } (10.6 \text{ in}^2)$$

$$P = 382 \text{ k} = 382,000 \text{ lbs}$$

Load Capacity of a W16 x 67 column = 382,000 lbs (191 tons)
4 columns = 1,528,000 lbs (764 tons)

Figure 43. Existing structural capacity (Source: Author)

An extensive analysis of the existing structure was done to verify the capacity of the steel columns, beams, and girders. The bulk of the analysis was focused on the load carrying capabilities of the 20' long W16 x 36 joists that were spaced 5' on center. As originally assumed, the structure was oversized with a live load capacity of 268,000 lbs (134 tons) in just one 20' x 40' structural bay

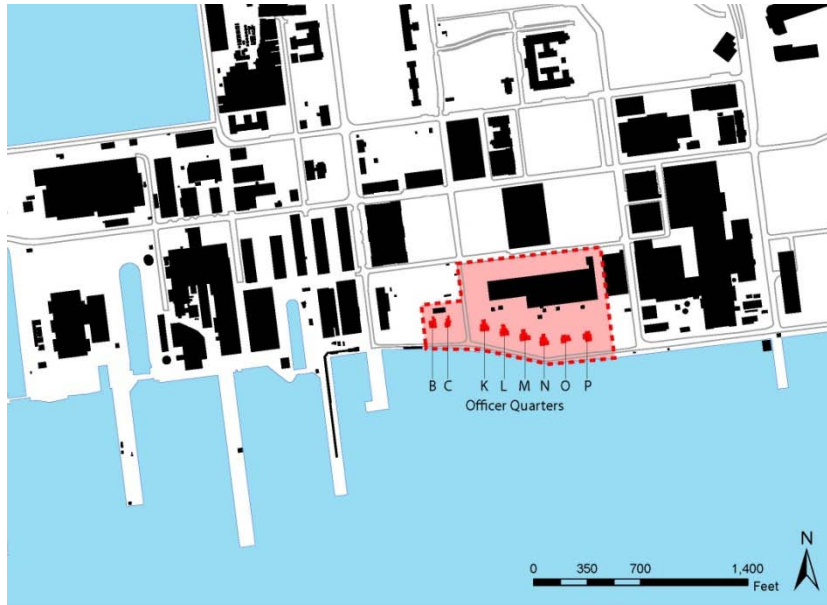


Figure 44. Officer quarters key plan (Source: Author)

Along the southern edge of the site, situated on the waterfront with unobstructed views across the Delaware River are 8 former officer quarters. Built at the beginning of the 20th century, these 3 story homes are excellent examples of the Colonial Revival and Prairie style architecture popular at the turn of the century. The majority of these quarters were designed by civil engineers utilizing similar plans and architectural elements. Common among all of the structures are symmetrical plans, hipped roofs with dormers, and wrapping porches.

Currently, a portion of these quarters are being used as satellite offices for companies located in the shipyard. The others have been left vacant. Despite their inactive usage, the majority of these buildings have been kept in good condition with nothing but roof, gutter, and siding repairs needed. Additionally, the landscape surrounding the quarters has been well maintained. Generous yards and tree coverage encircle the homes (figure 45) sheltering them from the adjacent shipyard industries.



Figure 45. Officer quarters along Admiral Peary Way (Source: Author)



Figure 46. Quarters L (Source: Author)



Figure 47. Quarters B & C (Source: Author)

Site History

The Philadelphia Navy Yard has a long history as one of the first commissioned naval shipbuilding sites in the United States. In 1762, Philadelphia opened its first shipyard site, Southwark (figure 48), along the eastern edge of the city. The site served as an official naval shore establishment until 1868, when the demand for repairs to steam engines greatly increased during the Civil War. This sudden increase in the need for machinists and machine shops lead to the acquisition of another naval shipyard site at League Island (figure 49), which today still remains the location of the current Philadelphia Navy Yard.



Figure 48. Southwark Yard (Source: Dorwart)

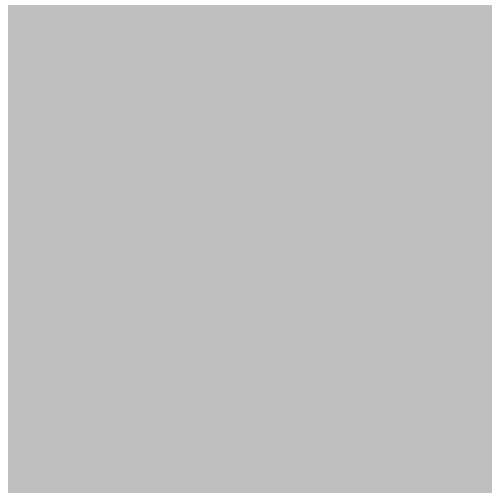


Figure 49. League Island Yard (Source: Dorwart)

Through the 234 year history of the Philadelphia Navy Yard, the site has been an important hub for the production and repairing of military vessels. From wooden frigate ships to steam power steel vessels, the Navy Yard has had a significant role in supplying ships during important periods of war including the Civil War, WWI, WWII, and the Cold War. During wartime, the site became a powerhouse of activity, state-of-the art technology, and rapid manufacturing. In addition to the supply of ships, the Philadelphia Navy Yard was a major source of jobs within the city by

employing up to 40,000 naval citizens during battle. Directly after WWI, the reserve basin was filled with destroyers (figure 50). More recently, technically advanced vessels like the USS Constellation (figure 51) were built and launched from the Philadelphia Navy Yard to defend the United States. Some of these ships were the first in the country to carry nuclear weapons.



Figure 50. Reserve Basin 1919 (Source: Dorwart) Figure 51. USS Constellation (Source: Author)

Unfortunately, after the end of the Cold War, shipbuilding began to decline and in 1996 the Navy Yard was decommissioned as a naval site and downsized from 12,000 employees to 2,000. In contrast to the images during wartime, ships at the site today have been reduced to scrap and the reserve basin remains almost completely empty. These remnants are reminders of the site's once historically significant past.



Figure 52. Current mothballed ships and empty reserve basin (Source: Author)

Stern 2004 Master Plan

Robert A.M. Stern Architects have developed a comprehensive master in conjunction with the Philadelphia Industrial Development Corporation. Across the Navy Yard's 1,200 acres, the plan explores dividing the site east of the existing shipyard into five districts (figure 53). The districts are defined as⁵:



Figure 53. The 5 districts of the 2004 Master Plan (Source: Stern Architects)

- The Corporate Center: (72 acres) 1.4 million square feet of new office and 100,000 square feet of ground floor retail space.
- The Historic Core: (167 acres) The reuse of 2.4 million square feet of existing building in addition to 1.4 million square feet of new development, including the reuse of this thesis site. This district will incorporate a variety of office, retail, cultural, and residential typologies.
- The Research Park: (81 acres) Primarily R&D facilities and light manufacturing

- The Marina District: (115 acres) A 250-slip marina with recreation and mixed use commercial and residential
- The East End: (87 acres) Three alternatives are presented: an industrial development, residential neighborhood, and an 18-hole golf course.



Figure 54. 2004 Master Plan (Source: Stern Architects)

Overall, the 2004 master plan aims at renovating 2.5 million square feet of existing structure and 12 million square feet of new development. The plan carefully considers the site's existing infrastructure and green network while recreating a dynamic sense of place by harmonizing historic qualities with contemporary construction. The urban organization revolves around a hierarchical diagonal street (figure 55) that connects the yard's main entrance to the marina. Remaining districts are linked by a triangular grid of secondary streets. The plan maximizes the site's potential by increasing a mix of density. The southern edge of Philadelphia's urban fabric is strengthened by a reactivated waterfront (figure 57) and a blend of typologies while maintaining the site's industrial heritage.



Figure 55. The diagonal boulevard (Source: Stern Architects)



Figure 56. Green open space (Source: Stern Architects)



Figure 57. The Marina District (Source: Stern Architects)

Site Analysis

Major City Connections

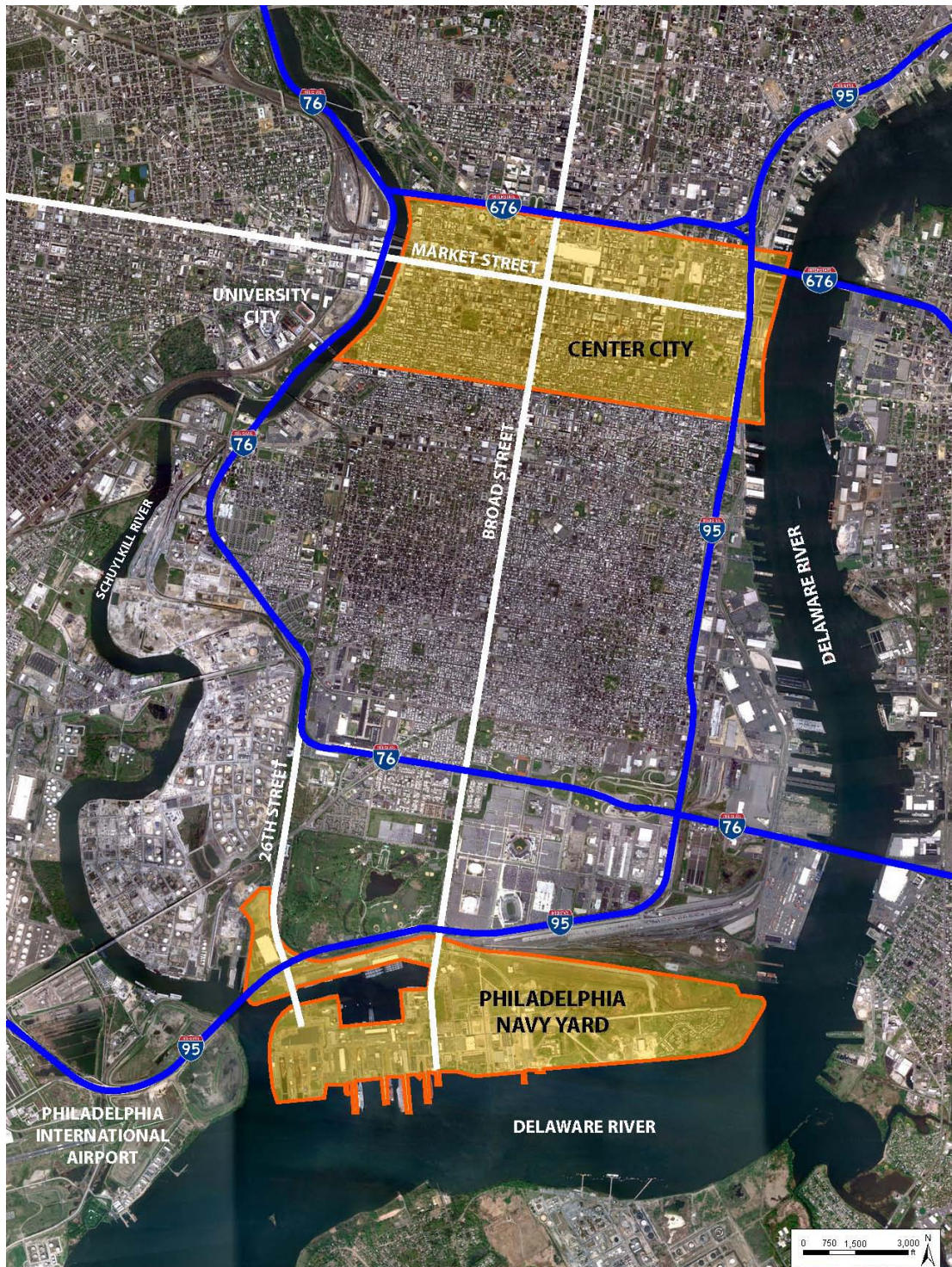


Figure 58. Major connections between the Philadelphia Navy Yard and Center City (Source: Author)

League Island is positioned at Philadelphia's southern edge roughly 4 miles from Center City. Despite the distance, there are strong connections available from the Philadelphia Navy Yard to the city's core (figure 58). Major arteries such as Interstates 76, 676, and 95, which extend along the Navy Yard's northern boundary, provide a ring of highways that encompass Center City and allow for entry to and from the city across the Walt Whitman, Benjamin Franklin, and Girard Point Bridge. Access into the site is reinforced by the introduction of Broad Street. As Philadelphia's major axis, Broad Street bisects the entire city, connecting Historical La Mott to the far north, through Center City, and eventually terminating directly into the Navy Yard just one block west of the site.

Connections to areas of interest are also facilitated by the surplus of infrastructure surrounding the site. Places like the International Airport to the west, Penn's Landing to the northeast, and University City to the northwest are all made readily accessible from the site. Adversely, 95 can also be seen as a barrier that isolates the Navy Yard from the rest of the city. Although it has the potential to provide immediate entry into the yard, the highway also segregates it from major public venues like Franklin D. Roosevelt (FDR) Park, and the sports stadiums just north of the Navy Yard. The need for a better association between these public places and the site is a necessity.

City Infrastructure Network



Figure 59. Philadelphia's infrastructure network (Source: Author)

The city of Philadelphia has an extensive infrastructure network consisting of primary, secondary, and tertiary roads (figure 59). Major highways are located to the east and west edges of the city. As they stretch their way up north, they begin to conform to the shapes of the Delaware and Schuylkill Rivers. These primary roads loop around South and Central Philadelphia and compress the developed density within. As the city widens north of Center City, so too does the distance between 76 to the west and 95 to the east. Secondary roads establish a major axis and cross axis through the city. Broad Street (north/south) and Market Street (east/west) directly intersect at Penn Square where City Hall is located, the core of Center City. Broad Street in addition to 26th Street also serves as the only access routes into the Navy Yard.

A continuous grid exists with the connection of tertiary roads. The grid remains regular throughout the majority of the city with the exception west of the Schuylkill River. Here, the grid starts to fragment as it shifts and orients itself according to the shape of the river. Additionally, the continuity of tertiary roads begins to dissolve towards the southern edge of the city. The blocks begin to increase in size and irregularity as the typology transitions from residential to largely industry.

Railroads also have a strong infrastructural presence in Philadelphia. They follow relatively the same path as the highways, extending along the river's edge. Inactive rail lines help to define the Navy Yard's northern boundary that could pose as a potential benefit for transportation of industrial products. A bike network (shown red in figure 59) has been put into place, but largely concentrated to the north. The bike path that extends down Broad Street is terminated at the yard's entry.

Subway Concentration

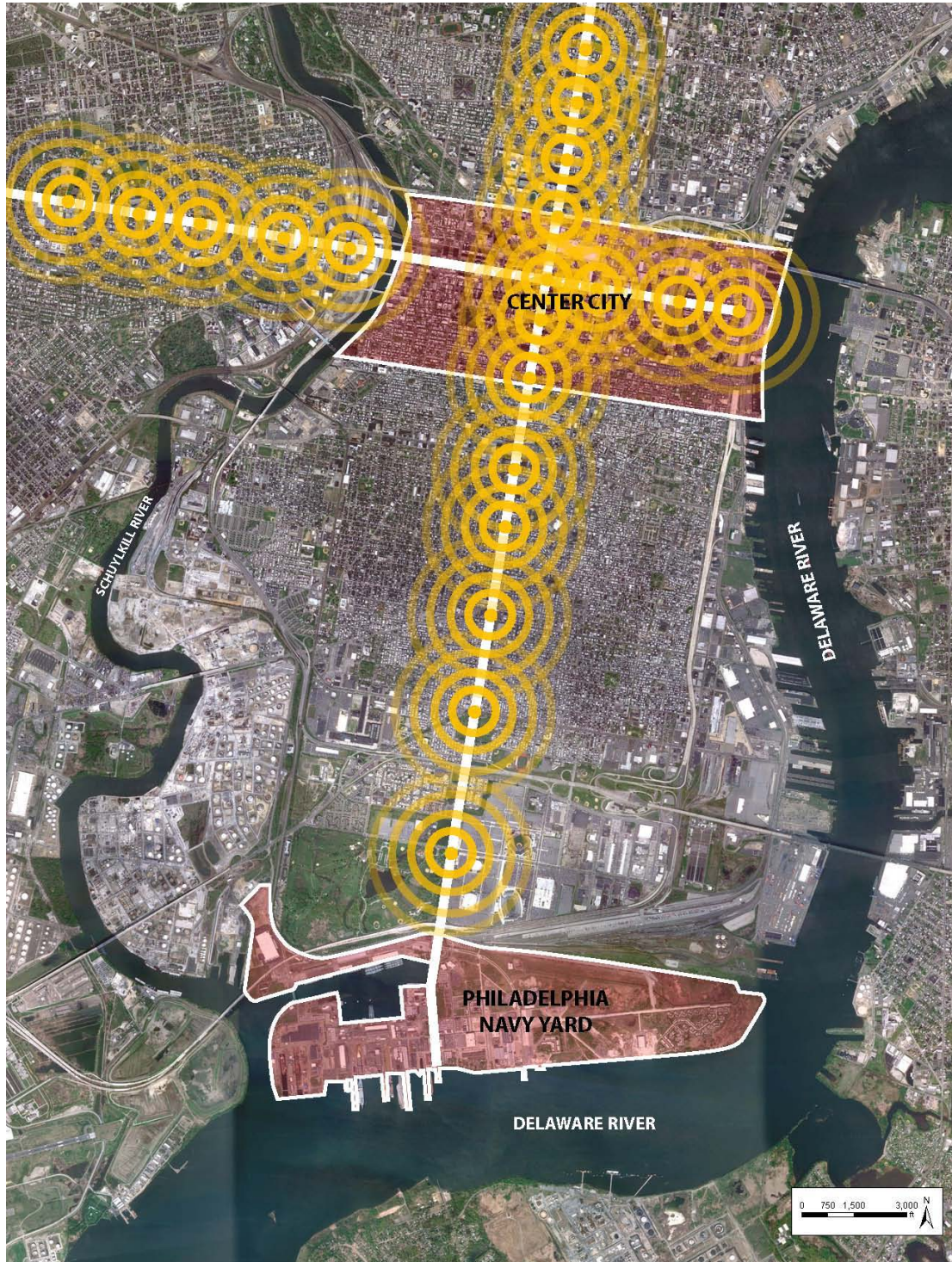


Figure 60. Subway locations with walking distances (Source: Author)

The Southeastern Transportation Authority (SEPTA) has instilled a comprehensive arrangement of public transportation that serves Bucks, Chester, Delaware, Montgomery, and Philadelphia Counties. This transportation network contains bus routes, a regional rail, trolley routes, a high speed line, and a subway system. This subway system is composed on two lines, Broad Street (figure 61) which runs north/south, and Market-Frankford (figure 62) running primarily east/west. These lines run along Philadelphia's two major thoroughfares, Broad and Market streets.

The two lines are vital ways of travel that people utilize in order to get around the city. They intersect at the core of Center City with the City Hall as their primary joining hub. The Broad Street line terminates at the sports and entertainment complexes just three blocks north of the PNY entrance. The line is detached at this point and no form of public transportation is brought through into the Navy Yard. The concentration of subway stops increase as the Broad Street line travels north towards Center City, away from the thesis site.



Figure 61. Broad St. Line (Source: SEPTA)



Figure 62. Market-Frankford Line (Source: SEPTA)

City Context

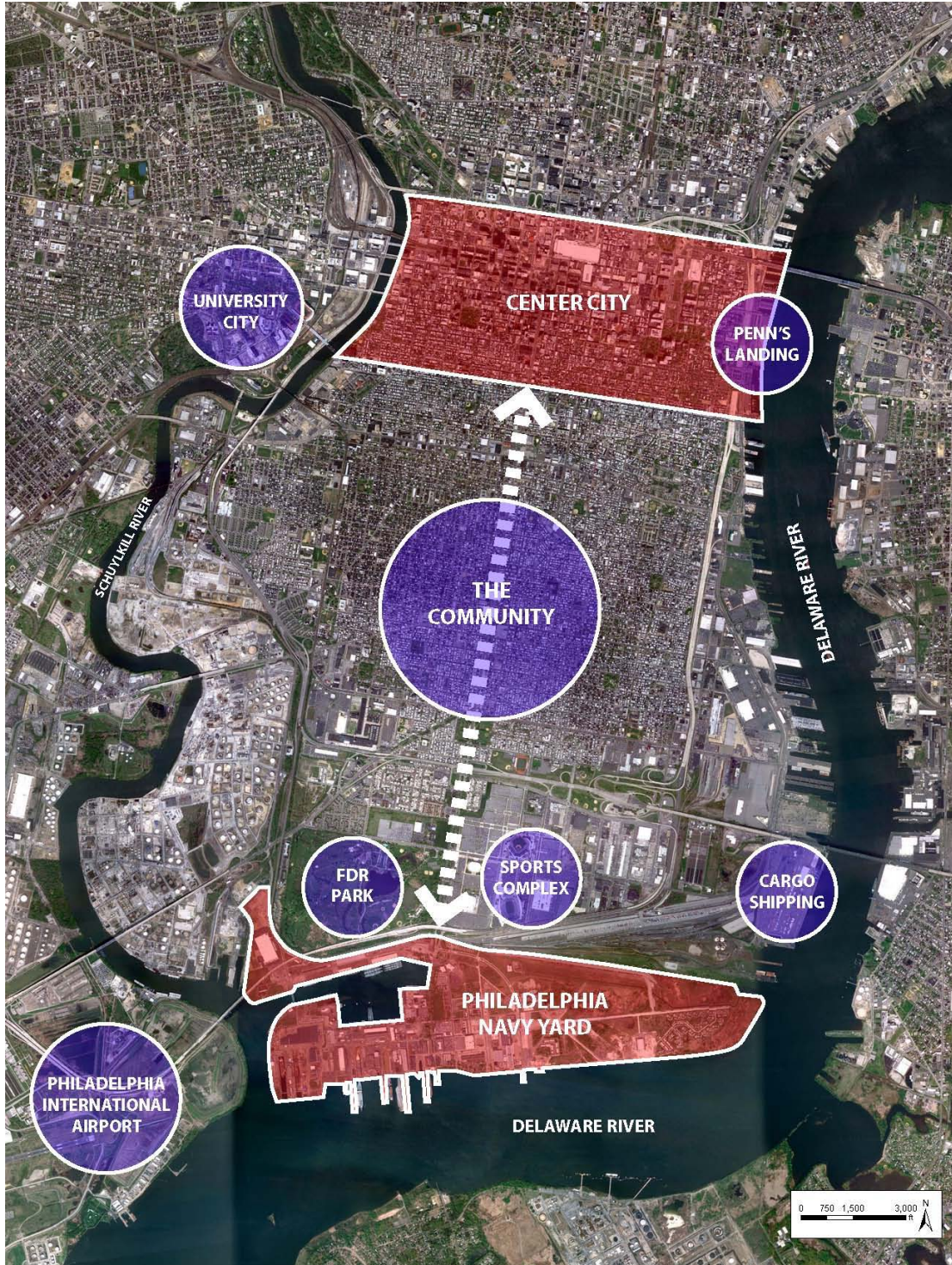


Figure 63. Surrounding contextual hubs (Source: Author)

A variety of important areas are situated in close proximity to the Philadelphia Navy Yard. Despite the yard's isolated location at the city's edge, assortments of cultural, social, environmental, institutional, and economic hubs are positioned in a rather direct relationship to the thesis site. The Navy Yard is divided from Center City by the densely populated community of southern Philadelphia. This strong relationship between this enormously diverse neighborhood could be utilized as an excellent resource in an attempt to foster the reactivation of the site. Popular entertainment and recreational locations define the Navy Yard's northern boundary. Sports complexes and FDR Park (figure 64) establish a cultural threshold at the yard's main public entrance. The Philadelphia International Airport to the west and the Cargo Shipping port to the east are focal points of both national and international transportation. People, materials, ideas and information can be transferred from these two major city globalizing cores. The heart of downtown, Center City, anchors the opposite end of the city in comparable size from the Navy Yard. Flanking both ends of the vibrant downtown are institutional and cultural epicenters: Penn's Landing (figure 65) and University City. All of these contextual elements help to solidify the significance of the Philadelphia Navy Yard's essential location.



Figure 64. FDR Park (Source: Scott Frederick)



Figure 65. Penn's Landing (Source: Uristocrat)

City Figure/Ground



Figure 66. City figure/ground (Source: Author)

Topography

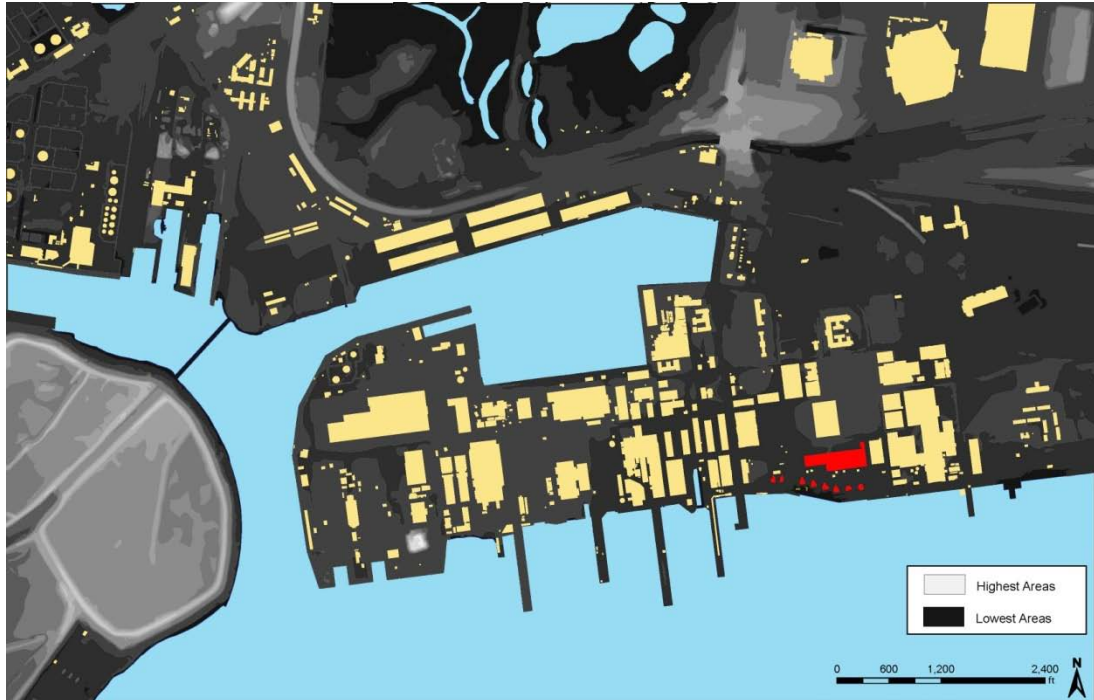


Figure 67. Topographic High and low points (Source: Author)

The overall topography of the land at the Navy Yard is relatively low and flat. There is roughly only a 5' change in elevation. This is one rationale why the majority of the yard falls within the 100 year flood plain. The industrial area, west of Broad Street, is raised slightly higher than the eastern portion of the yard. The highest immediate areas are located west, across the Schuylkill River. Here the elevation tops at a height of 35' creating an excellent view over the Navy Yard and across the river. Leaving the yard through the main gate also has an increase in elevation as one passes underneath of Interstate 95. Due to yard's level characteristic, there is virtually little to no obstruction of views out to the waterfront, specifically as one approaches the site down Broad Street.

Temperature, Precipitation, Sun/ Wind Orientation

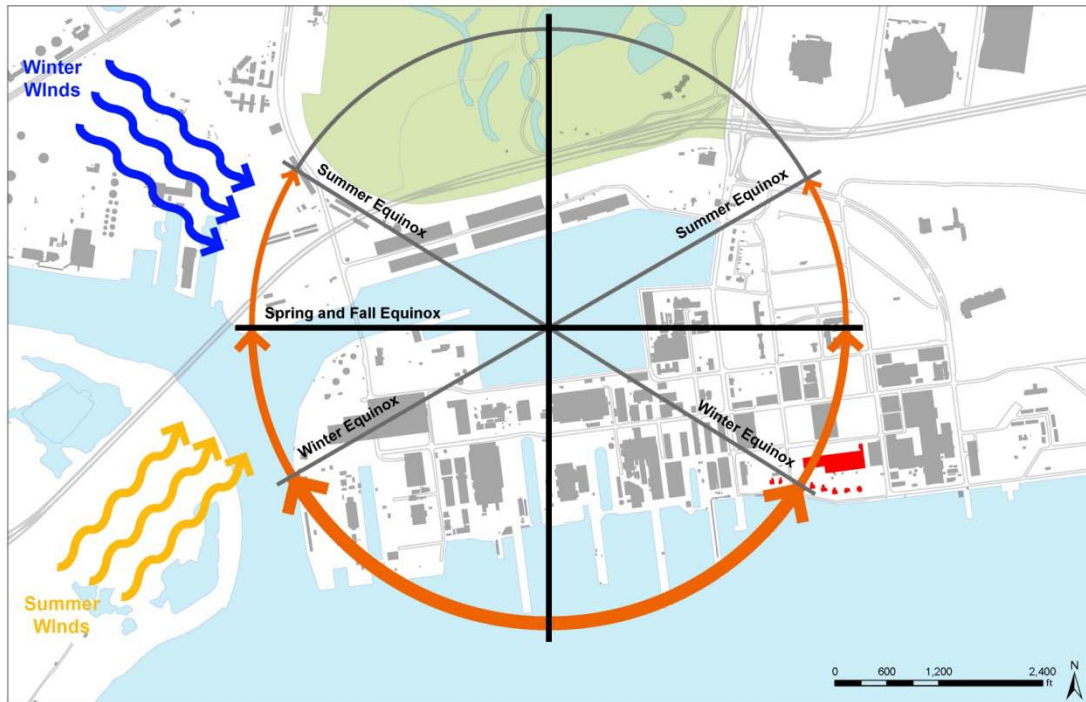


Figure 68. Seasonal sun path and wind direction (Source: Author)



Figure 69. Temp. (Source: rssWeather)

Month	Low	High
Jan	25.5°F	39.0°F
Feb	27.5°F	42.1°F
Mar	35.1°F	51.3°F
Apr	44.2°F	62.0°F
May	54.8°F	72.1°F
Jun	64.0°F	80.6°F
Jul	69.7°F	85.5°F
Aug	68.5°F	84.0°F
Sept	60.9°F	76.7°F
Oct	48.7°F	65.7°F
Nov	39.5°F	54.8°F
Dec	30.6°F	44.2°F



Figure 70. Precip. (Source: rssWeather)

Month	Precipitation
Jan	3.52in.
Feb	2.74in.
Mar	3.81in.
Apr	3.49in.
May	3.88in.
Jun	3.29in.
Jul	4.39in.
Aug	3.82in.
Sept	3.88in.
Oct	2.75in.
Nov	3.16in.
Dec	3.31in.

The diagram above (figure 68) displays the sun's path during all seasonal equinoxes from sun rise to sunset. The largest warehouse's facades are exposed to southern and northern sunlight. Eastern and western building faces contain more than 50% less surface area. Prevailing summer winds generally come from the southwest at an average speed of 8 mph. Winter winds are blown in from the northwest at speeds of 10 mph on average. With the site being situated along the river, wind speeds tend to be slightly higher at this site than the city's average.

Philadelphia falls in the northern fringe of the humid subtropical climate zone (figure 71) with characteristically hot, humid summers and mildly cool winters. The city's warmest month is July with an average temperature of 85.5° F, and its coldest month being January with an average of 25.5° F. There is a rather consistent monthly precipitation, but the city's driest month is February with 2.75 inches of precipitation and 4.39 inches in July as the wettest month⁶.



Figure 71. World map of humid subtropical climate zones (Source: Humid Subtropical Climate)

Hydrology



Figure 72. Flood zones and water discharge points (Source: Author)

Hydrology has a significant impact on the Philadelphia Navy Yard as it is almost completely surrounded by water. The Schuylkill River flows to the west, while the Delaware River defines the yard's southern and eastern boundaries. Additionally a back channel was carved allowing the Schuylkill to course its way in and create the Reserve Basin to the Navy Yard's rear. All 14,000 feet of League Island's southern waterfront is exposed to the highly active Delaware River. It has been known to flood on many occasions due to its flow rate and narrow width. Fortunately the site is situated at the river's bend where it widens to approximately 3,500 feet and ultimately calming the water's surge. Despite the rivers widening, 75% of the yard (site included) is within the 100 year flood plain. Additionally, there are numerous outfall structures dispersed around the site potentially discharging industrial waste and storm water. Opportunely, these structures are not located in close proximity to the site.

Green Spaces

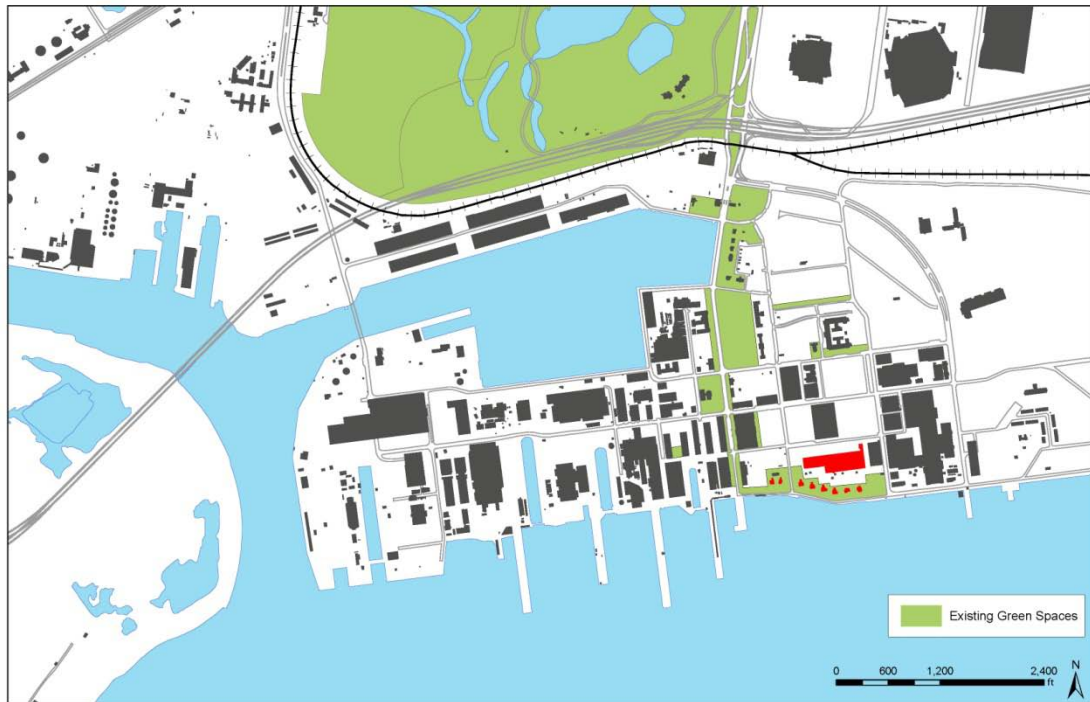


Figure 73. Existing green spaces (Source: Author)

There is a severe lack of designated green space at the Philadelphia Navy Yard. The majority of the site is covered with impervious material specifically in the western portion of the island where the majority of industry takes place. The vacant land to the east of the yard consists mainly of dead vegetation and overgrown weeds and shrubs grown out of fractured pavement. There is little to no tree coverage.

Interestingly enough, the only maintained vegetated spaces exist along Broad Street. There is an apparent green corridor established that begins at FDR Park, down along tree lined Broad Street, with smaller green spaces that branch off. The largest of these spaces is located in front of the PIDC Headquarters where the military use to commence their parade ceremonies. The green corridor terminates to the south at the site proper, wrapping around the warehouse along the waterfront.

Contamination Points

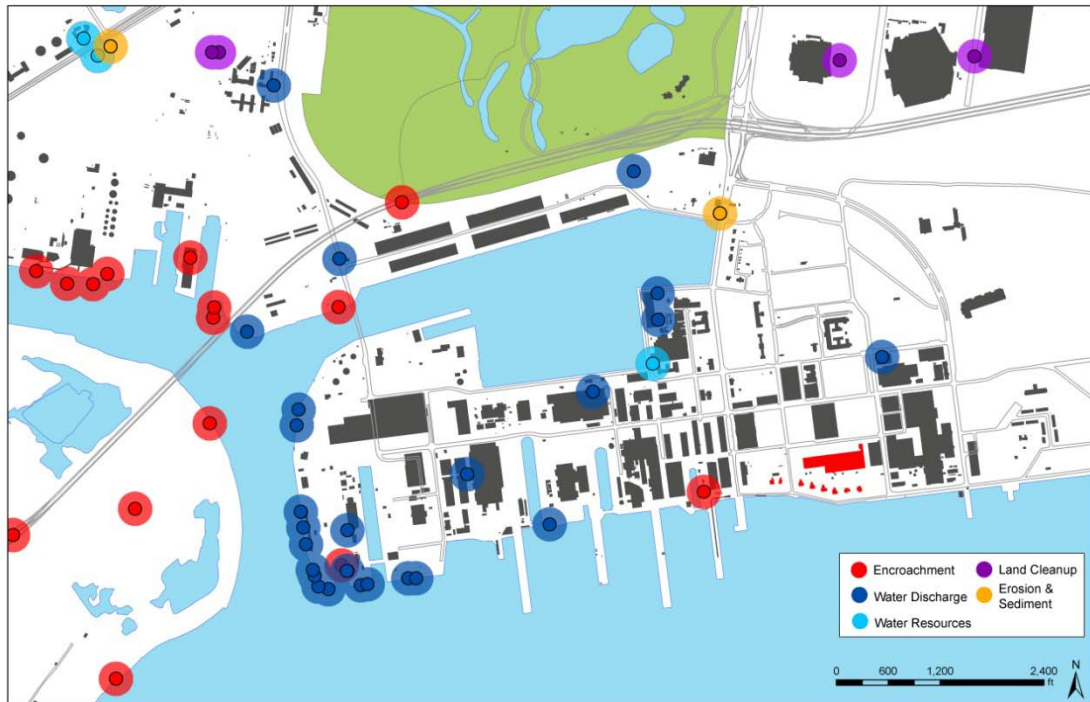


Figure 74. Locations of potentially contaminated sites (Source: Author)

The site has been an industrial powerhouse since the 19th century, and is still partly active today. Over the years, the land has been contaminated by the industrial processes that have taken place here. The city has broken these areas of potential contamination into five categories:

- Encroachment (red): structures that are obstructing water quality and mgt.
- Water Discharge (dark blue): industrial waste and storm water outfall points
- Water Resources (light blue): storage and return water used at treatment plants
- Land Recycle and Cleanup (purple) of various environmental media
- Erosion and Sediment (green) due to storm water runoff during development

Fortunately, the majority of potentially contaminated locations are located to the west of the site, outside of harmful proximity.

Building Orientation and Scale

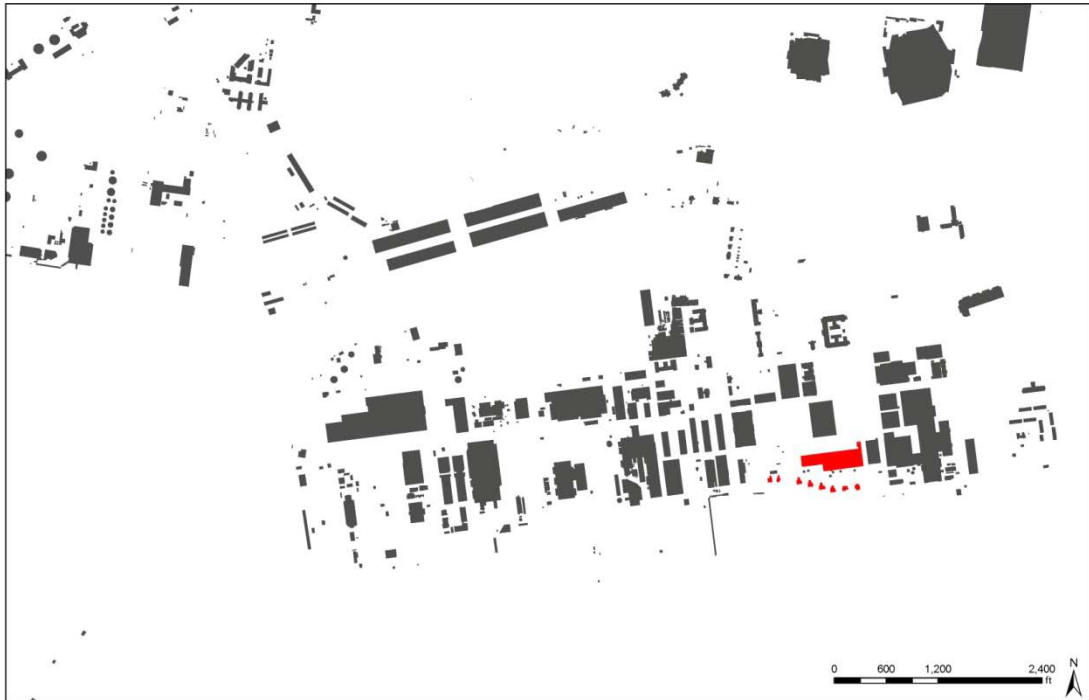


Figure 75. Navy Yard figure/ground (Source: Author)

The Philadelphia Navy Yard is truly an industrially organized district. Large blocks were created in order to situate oversized facilities and equipment. Wide gaps between structures destroy any sense of a continuous street edge. Along the Delaware River, buildings have been placed with their shortest façade exposed to the water. As a result, porosity and access towards the water has been increased. Inversely, along the Reserve Basin, elongated facilities have been oriented with their longest building face towards the basin. Predominately warehouse types, this allows for easy storage of ship materials directly off the basin. The yard has a coarse grain of scale with building sizes ranging from 400,000 sf. manufacturing facilities to small equipment sheds. East of Broad Street, the context that surrounds the thesis site is more generously scaled, but the area is not continuous enough to create a sense of place.

Street Hierarchy

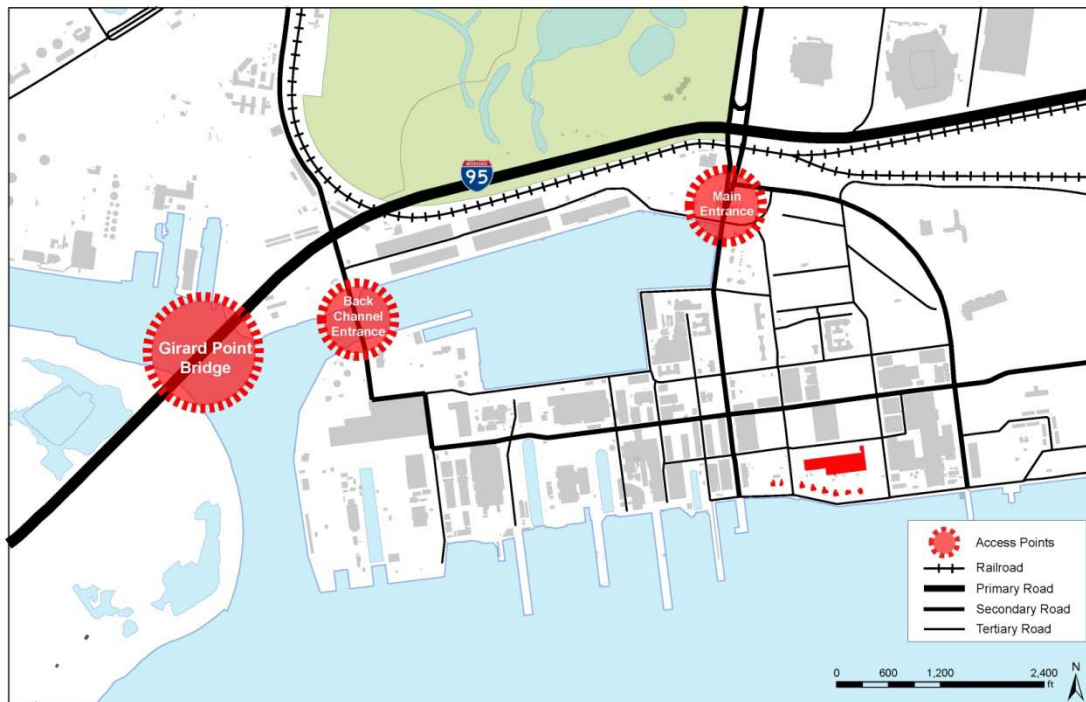


Figure 76. Street network hierarchy and access points (Source: Author)

Despite the rather haphazard organization of buildings in the Navy Yard, there is a relatively clear network developed consisting of primary, secondary, and tertiary streets. 95 is the primary artery into and around the city. It stretches across the yard's entire northern edge. Broad Street and 26th Street are secondary roads that provide the only available access into the site; the Back Channel entrance and the Main Gate entrance. Kitty Hawk Avenue is another secondary street that crosses through the center of the entire Navy Yard. It's the only street that fully connects the western portion of League Island to the east in a direct fashion. Numerous tertiary roads create a fairly continuous grid. This network of existing infrastructure allows for easy transportation around the site. Because of such an extensive grid, urban development around the site could be possible with little infrastructure addition.

Navy Retained Properties



Figure 77. Properties controlled by the Navy (Source: Author)

Before the Philadelphia Navy Yard's closure in 1996, all buildings on League Island were owned and controlled by the Navy or other forms of the military. After the closure, most of the ship building and repair facilities west of Broad Street were sold to private companies. The remaining buildings, mostly east of Broad Street, have been left vacant and under the ownership of the Philadelphia Industrial Development Corporation. Although the site is no longer a fully commissioned naval base, there is still four million square feet of property retained by the Navy⁷. A portion of that includes the Reserve Basin which has become an area for the storage of mothballed ships.

Reuse and Renovation

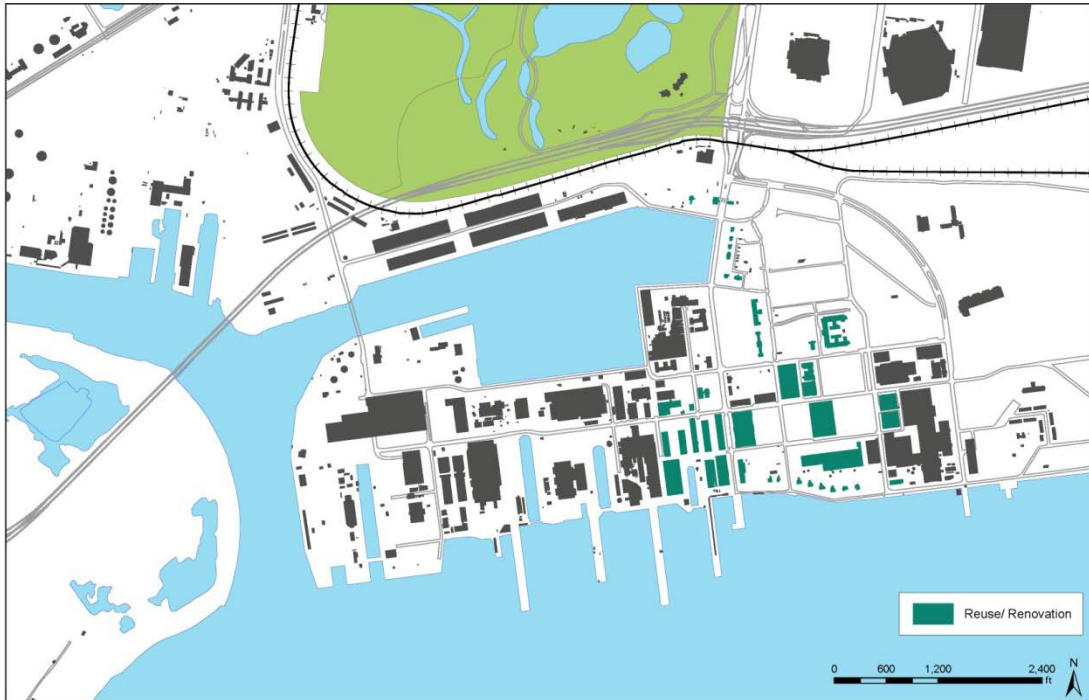


Figure 78. Buildings designated for reuse (Source: Author)

The central core of the Navy Yard has been predominately left vacant and abandoned. The majority of facilities to the east of the active industrial area have been deemed by the Philadelphia Industrial Development Corporation as potential reuse and renovation opportunities. The 2004 master plan has taken interest in the adaptive reuse of many of these buildings as office, residential, and industrial retrofits. The Urban Outfitters Corporate Campus was the catalyst for adaptive reuse at the yard. Additionally Building 661, one block north of the thesis site, will be one of the first sustainably retrofitted buildings at the Navy Yard. It's the Greater Philadelphia Innovation Cluster's (GPIC) first step in the use of energy-efficient building technologies at the yard. They look to retrofit additional historic buildings around the site after the first GPIC HUB project is completed.

Immediate Areas of Interest

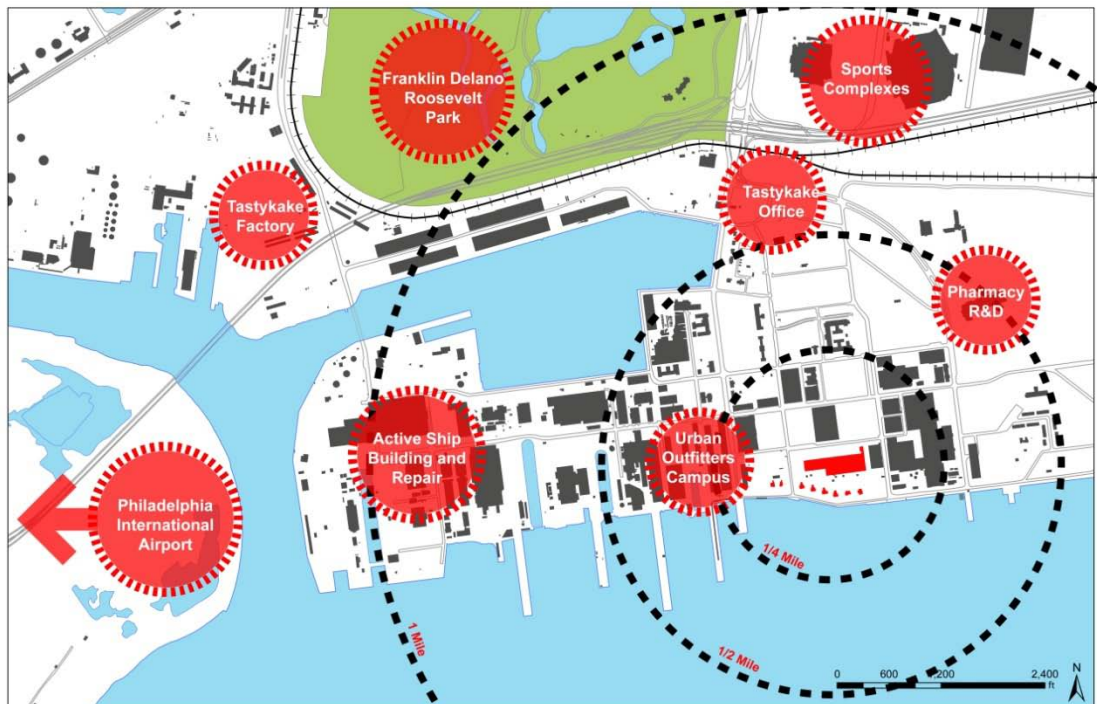


Figure 79. Surrounding businesses and attractions (Source: Author)

Despite the site's rather segregated location from downtown Philadelphia, there are many areas that are located within and just outside of the Navy Yard. Since the Stern's 2004 Master Plan, many companies have begun relocating their businesses in the Navy Yard. As the site begins to develop into a more desirable location, businesses like Urban Outfitters, Tastykake, and Iroko Pharmaceutical R&D, have invested their efforts and finances into repositioning their companies within the historic portion of the yard.

The Navy Yard still maintains an active ship building and repair industry that takes place west of Broad Street. Aker Shipyard, Rhodes Shipbuilding & Repair, metal manufacturers, and Navy technology companies run their businesses in this location. In addition, large attractions like FDR Park, sports stadiums, and the International Airport are all situated within a reasonable distance from the site.

Development Zones

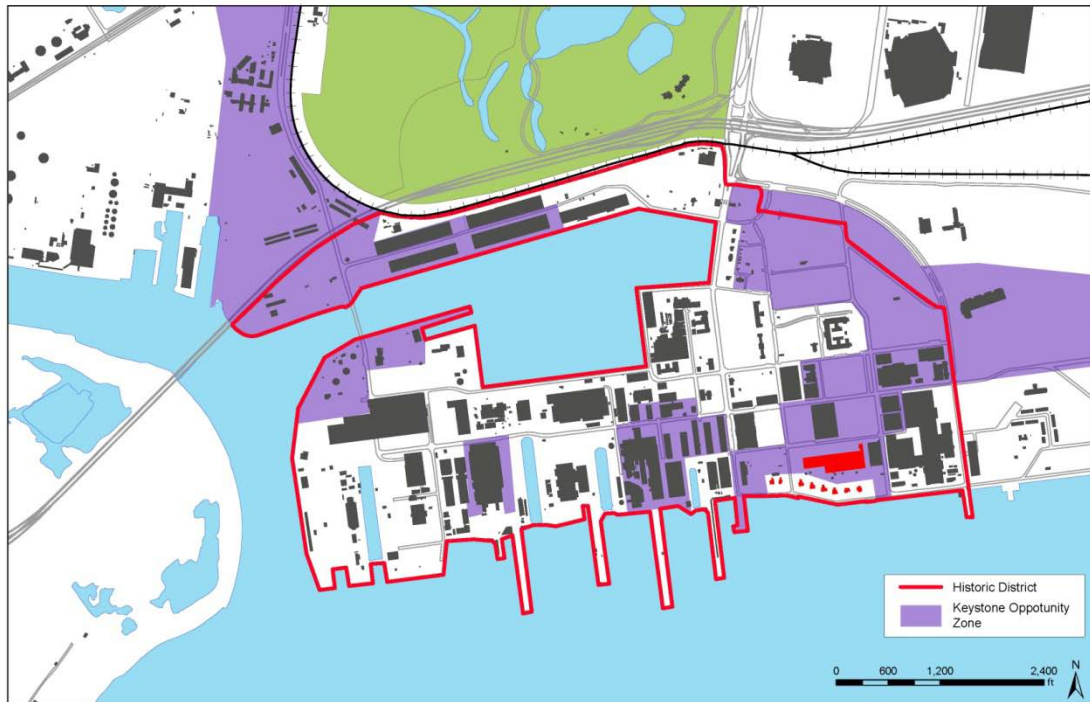


Figure 80. Historic and KOZ development zones (Source: Author)

The western portion of the Navy Yard has been designated as the Historic District. The earliest of League Island development began here in the mid 19th century as the beginning of what would become the Philadelphia Navy Yard. In March 1999, the Philadelphia Navy Yard National Register of Historic Places was established, listing a total of 282 buildings. Of that total, 233 were considered to be contributing resources to the historical development of the yard depending on a variety of criteria including craftsmanship, materials, and location⁸. As a result investment tax credits up to 20% for renovation can be applied for qualified buildings. Keystone Opportunity Zones (KOZ) have also been designated in order to stimulate economic development by offering a variety of tax savings typically between \$10 and \$20 per square foot annually for established companies⁹.

Zoning



Figure 81. Zoning designations (Source: Author)

The Navy Yard is mostly designated into three categories of industrial type. The historic core surrounding the thesis site is zoned under mixed use commercial¹⁰.

G2: General Industrial

- Maximum Occupied Area: 100% of lot
- Maximum Open Area: None
- Setback: None
- Maximum Height: None
- Maximum Floor Area: 500% of lot
- Manufacture of: aircraft, apparel, baking powder, yeast, bicycles, broom and brushes, electric motors and generators, fabricated metal products, furniture, glass, lead pencils, locomotives, motor vehicles, pickled fruits or vegetables, wines, brandy.

L2: Limited Industrial

- Maximum Occupied Area: 60% of lot
- Minimum Open Area: 40% of lot
- Setback: 40 ft. from all street lines
- Maximum Height: None
- Maximum Floor Area: 180% of lot
- Manufacture of: apparel and garments, bread, butter, cheese, condensed or evaporated milk, cigarettes, rope, twine, drugs, jewelry, leather gloves, macaroni, spaghetti, statuary and art goods made of plaster of Paris

LR: Least Restricted Industrial

- Maximum Occupied Area: 100% of lot
- Minimum Open Area: None
- Setback: None
- Maximum Height: None
- Maximum Floor Area: 500% of lot
- Manufacture of: abrasive, asbestos, gypsum, buttons, coke, coal, felt, fuel briquettes, glue, cement, lime, ice, industrial organic and inorganic chemicals, jute and burlap bags, rubber tires, and soap.

C3: Mixed Use Commercial

- Maximum Occupied Area: 75% of lot
- Minimum Open Area: 25% of lot
- Setback: None
- Maximum Height: 35 ft. (3 stories)

Ordering Principles

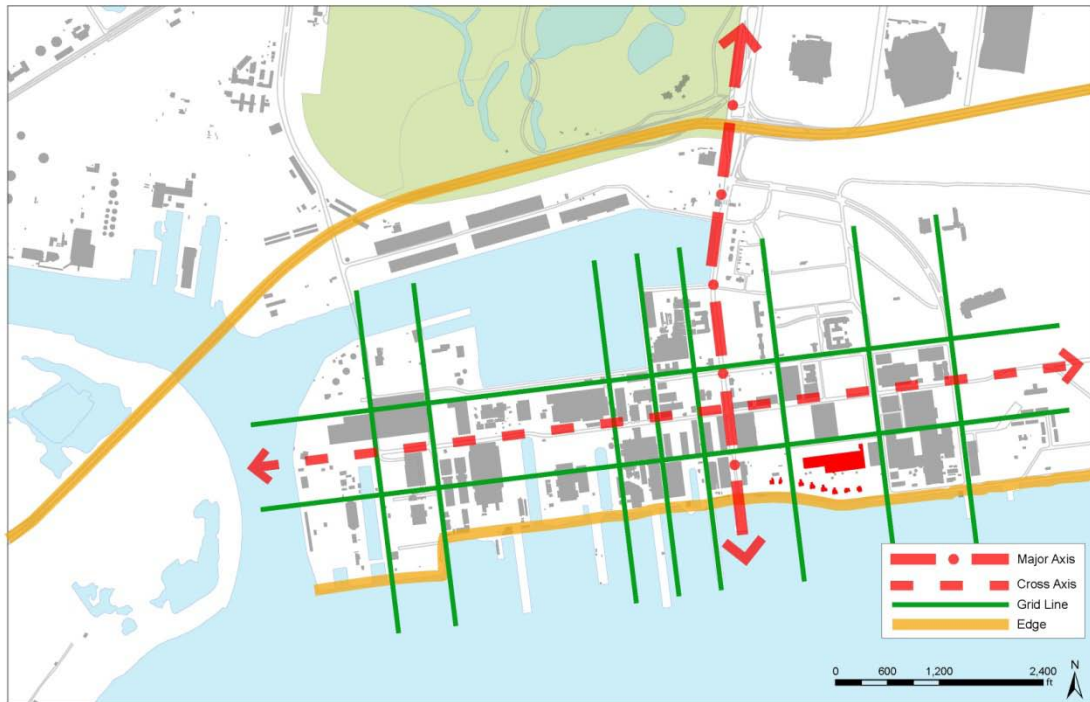


Figure 82. Grid, axis, and edge conditions (Source: Author)

Broad Street enters the Navy Yard as the primary axis. It acts as a boundary separating the industrial functions of the site from the commercial. The cross axis, Kitty Hawk Avenue, bisects the yard in an east/west direction giving ease of access across all of League Island. Both of these major axes run one block from the thesis site allowing for the potential of great accessibility to the site. A regularized grid reinforces movement throughout the Navy Yard. Emphasis is given to the north and south direction to increase porosity towards the water. Despite the site's organized circulation system, two edge conditions exist that restrict accessibility and movement. Highway 95 is the most apparent of these conditions. The infrastructure isolates the yard from development to the north and only allows two points of entry. In addition, the waterfront could be understood as an edge restricting development, but increasing market value and environmental quality.

Chapter 3: Precedents

Artscape Wynchwood Barns:

*Du Toit Allsopp Hillier Architects, Artscape, The Stop Community Food Center
Toronto, Ontario, Canada*

This 60,000 square foot adaptive reuse project focused on the rehabilitation of five barns built in the early 20th century that were used for repairing Toronto's streetcars until the 1980's. These structures have been revitalized as a multiuse cultural and urban agricultural space. Artscape worked in conjunction with The Stop Community Center, an organization that has been providing and securing healthy food alternatives to promote equality and community. These two groups worked in leading the design of fifteen artist studios, twenty-six live-work studios, office space, and a large agricultural component¹¹ within these historic structures.



Figure 83. Artscape Wynchwood Barns site plan (Source: Gorgolewski & Author additions)

The barn to the south, “The Green Barn”, is home for the Community Food Center (CFC) model. Within this 10,000 square foot green house, food production takes place all year around (figures 84). In this state-of-the-art facility, a variety of systems, including computer-controlled windows, drip water systems, and maximum light designs¹², are incorporated to foster the growth of a variety of plants, fruits, and vegetables. Water from rain is stored in cisterns to be used for greenhouse irrigation. Additional passive approaches to energy and ventilation are also integrated. Directly to the south, a barn has been stripped of nothing but its structure. In this space, a composting area and industrial kitchen opens out to a large outdoor gathering space for visitors and larger plant storage (figure 85).

This project serves as an incubator for cultural and social strengthening within the city of Toronto. These once direct structures now hold weekend and evening events like cooking and gardening classes to teach the community how to adopt healthy habits while simultaneously fortifying neighborhood bonds.



Figure 84. The Green Barn (Source: Gorgolewski)



Figure 85. Outdoor gathering space (Source: Gorgolewski)

Evergreen Brick Works

*Du Toit Allsopp Hillier Architects, Diamond + Schmitt, ERA Architects, Claude Cormier Architects Paysagistes
Toronto, Ontario, Canada*

In 1994, this 40-acre clay quarry was shut down. Since 1889, this site was established to manufacture brick for the city of Toronto (figure 86). Recently, it has become a part of the city's park system, and plans for its reuse have gone into effect. This adaptive reuse project explores the manipulation of a former industrial site into an environmental and community complex (figure 87).



Figure 86. Photos of the Brick Works before reuse (Source: Gorgolewski)



Figure 87. Evergreen Brick Works aerial (Source: Gorgolewski)

Due to their decaying state, many of the existing buildings had to be torn down, but much of their parts have been salvaged and stored for future construction. The remaining buildings have been stabilized, and in some cases new floors and additional structure had to be integrated for them to become fully functional. Within these historic structures, a variety of programmatic environmental and cultural components are instilled with the creation of edible landscapes and multiple farmers' markets. The largest facility in the complex is a 110,000 square foot demonstration greenhouse for a vegetable garden and nursery¹³. Here, people can also buy gardening equipment, seeds, fertilizer, and organic soils while learning about plant care and how to properly manage growing organic vegetables.

The Centre for Green Cities (figure 88) is the only portion of new construction at the Evergreen Brick Works site. The design of the building has been thought of as a sustainable hub for the sharing of ideas, including classrooms and offices for the Evergreen Foundation. A variety of sustainable processes have been utilized to achieve 58% less energy consumption than a typical office building¹⁴. The moveable skin provides solar shading as well as a vertical wetland for tenant plant growing.



Figure 88. The Centre for Green Cities (Source: Gorgolewski)

The structural remains a factory building have been utilized as a sheltered outdoor space (figure 89). Within 27,000 square feet of space, farmers markets, nurseries, and community events can be flexibly held here during all seasons. In these pavilions, reminisce of the past is juxtaposed by the growth of new plant life and lively activity. This project is truly a great example of the integration between urban agriculture and a site that was once utilizing the earth's resources in a far more detrimental way. The scars from the quarrying of clay deep within the earth's surface have healed and now the same land is being used for the harvesting of agriculture, the support of community development, and food security.

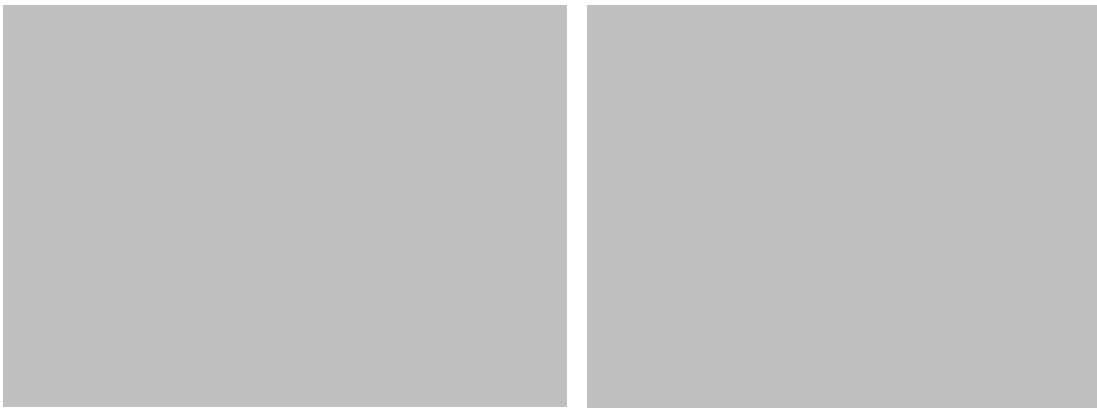


Figure 89. The Pavilion outdoor space (Source: Gorgolewski)

Gardiner Urban Agriculture Hub

Andy Guiry

Toronto, Ontario, Canada

This theoretical project examines the contrast of agricultural programming with underutilized infrastructural space. The site for this design is located under the Gardiner Expressway at the edge of Lake Ontario. In addition to the pollution from the infrastructure above, this once highly contaminated site used to be the location of an oil refinery. With the integration of social programming like agriculture, this site investigates the notion of knitting and revitalizing the urban fabric back together from these types of barriers.



Figure 90. View from the south (Source: Gorgolewski)

In the facility's south space, sustainable agriculture and ecological processes promote food production, while educational and commercial space is located in the northern linear bar (figure 91). These social and agricultural programmatic elements are separated in both plan and section to achieve proper air quality and lighting conditions. The highway above is used for the high thermal mass of its concrete. The occasional flooding of the lake is incorporated into a hydrological cycle that is reused

for irrigation in the greenhouse. Walls to the north of the site are built of densely packed contaminated earth. When combined with specific filtering plants, contaminants are pulled out of the soil. As time progresses, the walls will slowly erode away and become an open park grounded with remedial soil appropriate for planting. Mini-turbines are placed in the middle of the expressway to harness energy from moving vehicles. Pollution from cars is alleviated by protecting the building's air intakes with a green "billboard" that filters harmful fumes prior to entering into the facility. With these sustainable methods, the Gardiner Hub rejuvenates underused urban space by recognizing their potential for natural and man-made integration.



Figure 91. Site plan with infrastructure shown above (Source: Gorgolewski & Author additions)



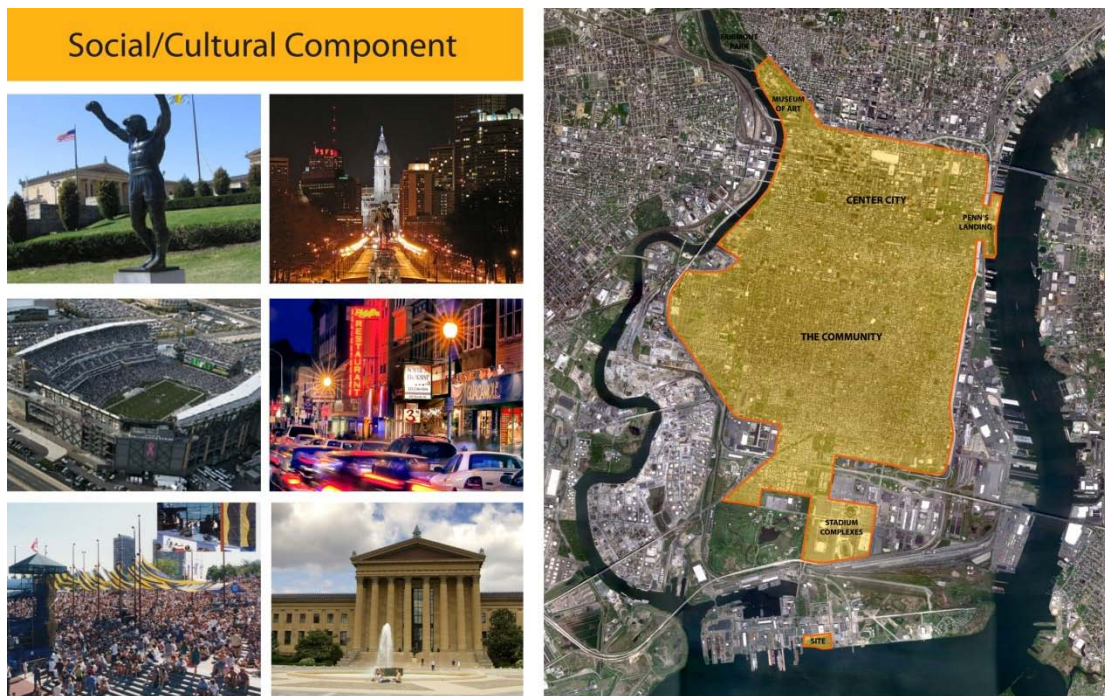
Figure 92. Building section (Source: Gorgolewski & Author additions)

Chapter 4: Program Analysis

Program Initiatives

The program for this adaptive reuse project is used as a catalyst for strengthening site prominence and social connections. Utilizing existing nodes within the city of Philadelphia, the program promotes multiple realms of activity in harmony with a diverse range of prominent city interactions. Four major programmatic initiative components have been considered in establishing this attachment to the city:

The Social/Cultural Component: The city of Philadelphia is a hub for social and cultural interaction. The residents of Philadelphia are a community that takes much pride in what they have to offer as a city. All year around, movement and excitement can be felt throughout the city. Cultural nodes vary greatly in scale from the large social epicenter of Center City and its flanking neighborhoods, to the smaller settings of Penn's Landing, stadiums, and the Museum of Art.



The Educational Component: Philadelphia is the home for many great institutions that are known all around the world for their educational practices and comprehensive learning environments. Like small cities themselves, these universities are the generators for innovation and social vigor. With close proximity to University City and other Pennsylvania schools outside of downtown, the site has great potential in becoming an extension of these educational campuses.

Additionally, The Greater Philadelphia Innovative Cluster (GPIC) has already begun the adaptive reuse of Building 661, one block north of the thesis site. In conjunction with Penn State University, the retrofit of this building and the integration of its sustainable systems will become a vehicle for the reuse of more historic buildings around the Navy Yard. Besides higher education, the educational component of this thesis also has the potential to instruct adults and young children about healthy habits for themselves as well as the environment.

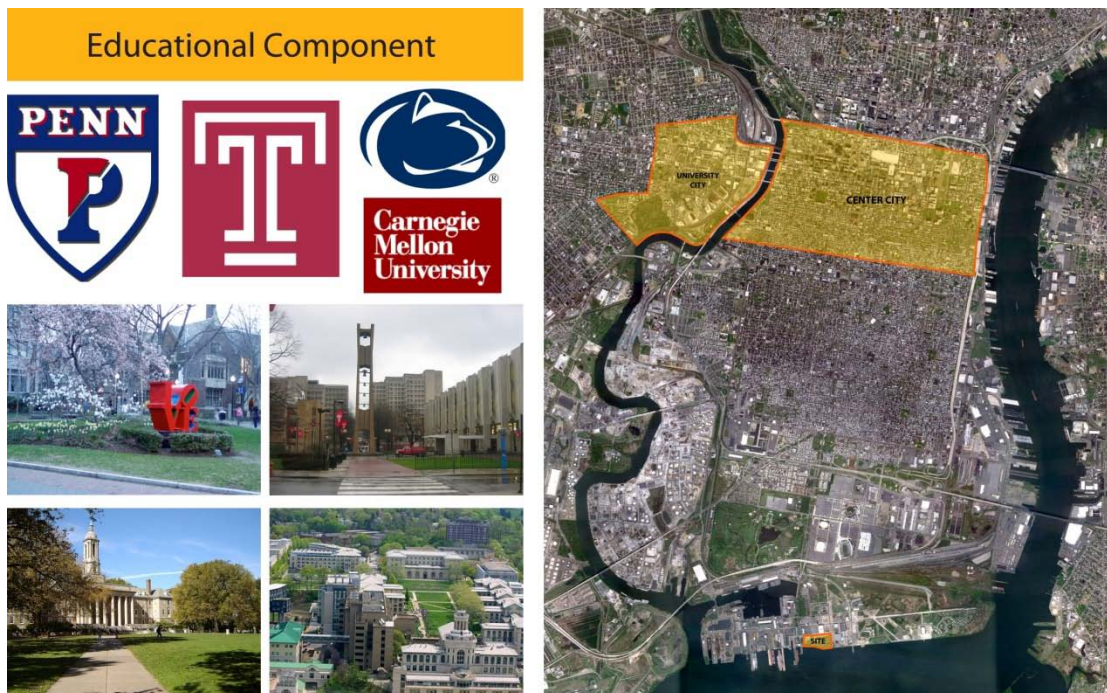


Figure 94. The Educational Component (Source: Author)

The Technological Component: With the progression of time, technology has been on the constant rise of innovation and advancement. As a result, industries and manufactures have been forced to rapidly transform in a way to foster this movement of technology. In a fight to maintain their reason for being, industries have completely manipulated their operations to utilize more efficient state-of-the-art approaches. Industries that cannot support this progression end up overrun and eventually withdrawn as an active manufacturing element within the city.

The Philadelphia Navy Yard, in addition to many of South Philadelphia's manufacturers, is a prime example of this paradigm. Shipbuilding has become a lost trade due to technological development despite its long history. Now the scars of this decommissioned industrial site can be mended with the integration of newer and more sustainable forms of technology that carry on the memory of its manufacturing tradition.



Figure 95. The Technological Component (Source: Author)

The Environmental Component: Much of design today views sustainability simply as a trend. Making a building more efficient and healthy for both the environment and its tenants is an issue that should not be taken lightly. In order for a design to be successful it must contain an environmental component and be utilized not just for media purposes, but in such a way that the building has the potential to become an efficient living and breathing machine.

Philadelphia is scattered with a network of green spaces. Within the urban density, the fabric is occasionally alleviated with open public park space. The largest of these spaces is the Frank Delano Roosevelt Park, just north of the Navy Yard. The program for this thesis has the ability to tie itself into and expand upon these already existing green hubs. As an agricultural center, the structure can become a self-sustaining entity that utilizes sustainability and agricultural processes to rectify the site's condition, and embellish the quality of Philadelphia's environmental state.



Figure 96. The Environmental Component (Source: Author)

Crop Studies

Rotation Group & Vegetable Family	Plant Type	Date to Sow Indoors	Date to Sow Outdoors	Seed Spacing b/t plants (p)	Seed Spacing b/t rows (r)	Seed Depth	Maturity	Yield per 100 ft of row
Group 1								
Cruciferae	Cabbages	February - March	April	24"	24" - 36"	1/2"	4 - 5 months	85 heads
Cruciferae	Cauliflowers	January - February	May	15"	24" - 36"	1/2"	4 - 5 months	60 heads
Cruciferae	Broccoli	n/a	April - May	24"	30" - 36"	1/2" - 1"	4 - 5 months	70 heads
Cruciferae	Brussels Sprouts	n/a	June	18" - 24"	3 ft	1/4"	90 days	n/a
Allium	Onions	February	April	3"	12" - 18"	1/12"	3 - 4 months	220 lbs.
Allium	Garlic							
Allium	Leeks							
Umbelliferae	Celery							
Group 2								
Umbelliferae	Carrots	n/a	April	2" - 4"	18" - 24"	1/2"	90 days	150 lbs.
Umbelliferae	Beetroots	n/a	April	4"	18"	1/2"	40 - 70 days	100 lbs.
Umbelliferae	parsnips							
Compositae	salsify							
Cruciferae	turnips							
Group 3								
Solanaceae	Tomatoes	March	May	30" - 36"	30" - 36"	1/2"	4 - 5 months	250 lbs.
Solanaceae	Potatoes	n/a	April - May	8"	36"	3" - 6"	90 - 150 days	200 lbs.
Solanaceae	Peppers	February - March	May	24"	24"	1/2"	4 - 5 months	125 lbs.
Solanaceae	Eggplants	February - March	n/a	24"	36"	1/4"	4 - 5 months	150 lbs.
Compositae	Lettuce	February - March	April	8" - 12"	18" - 24"	1/4"	70 - 90 days	100 heads
Amaranthaceae	Swiss Chard							
Group 4								
Legume	Snap Beans	n/a	April - May	4"	18" - 24"	1 1/2"	60 days	1.5 bushel (30 lbs.)
Legume	Lima Beans	n/a	April - May	4"	18" - 24"	1 1/2"	60 days	1 bushel (32 lbs.)
Legume	Broad Beans	n/a	April - May	4"	18" - 24"	1 1/2"	60 days	n/a
Legume	Runner Beans	n/a	May	36"	48"	1 1/2" - 2"	60 days	n/a
Legume	French Beans	n/a	May	36"	48"	1 1/2" - 2"	60 days	n/a
Legume	Snake Beans	n/a	May	36"	48"	1 1/2" - 2"	60 days	n/a
Legume	Peas	n/a	April	3" - 6"	36"	1 1/2" - 2"	60 days	40 lbs.
Miscellaneous								
Cucurbitaceae	Cucumbers	n/a	May - June	36" - 48"	36" - 48"	1"	2 - 3 months	170 lbs.
Cucurbitaceae	Pumpkins	n/a	May	6" - 8"	36"	3 - 4"	4 - 5 months	150 lbs.
Cruciferae	Radishes	February - March	April	1" - 3"	18" - 24"	1/2"	30 days	30 lbs.

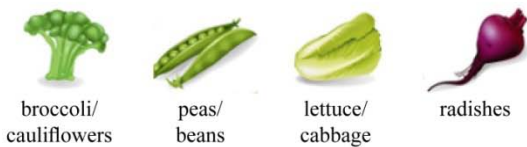
Figure 97. Vegetable Information Chart (Source: Author)

Crops are grouped in a variety of families. It is important to acknowledge which vegetables share the same families, because distinctive attributes range between family groups. The chart (figure 97) lists various vegetables that can be grown both indoors and outdoors. Information for each crop includes, indoor sow date, outdoor sow date, seed spacing, seed depth, time to mature, and yield. Having this information is necessary when designing greenhouse spaces. The amount of greenhouse area can determine specific yield estimates depending on the length of planting rows within the growing beds. It is also important to take into account the time it takes for a specific vegetable to reach its maturity level in order to be harvested. The more rapid maturity, the quicker the turnover rate for that specific crop will be, and ultimately more of that crop can be grown. From the data above, it

seems that group 1 (the cruciferae family) take the longest to mature. Inversely, group 4 (the legume family) has the shortest maturity time of only 60 days.

The amount of light is also essential in the proper growth of crops. No vegetable can grow in complete shade, but the cruciferae and legume families can develop in only 3 hours of diffused sunlight. Group 3, the solanaceae family, are considered sun-lovers and require 8 hours of sunlight to grow.

Shade Vegetables:



Sun-loving Vegetables:

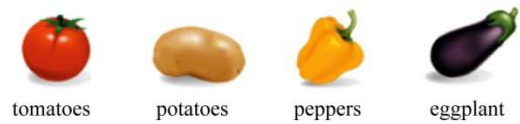


Figure 98. Shade and sun-loving vegetables (Source: Author)

Crop rotation is just as important as proper sunlight in order to have a successful harvest. It is essential to not plant the same vegetables in the same growing beds consistently. This ensures avoiding certain soil-borne diseases and proper soil fertility. Understanding which vegetables belong to which family is imperative, because specific diseases are common amount family groups. Crops can be rotated in a 4 year cycle (figure 99). Seed sowing dates and maturity duration must be taken into consideration in order to maintain a smooth and successful rotation without the loss of crops.

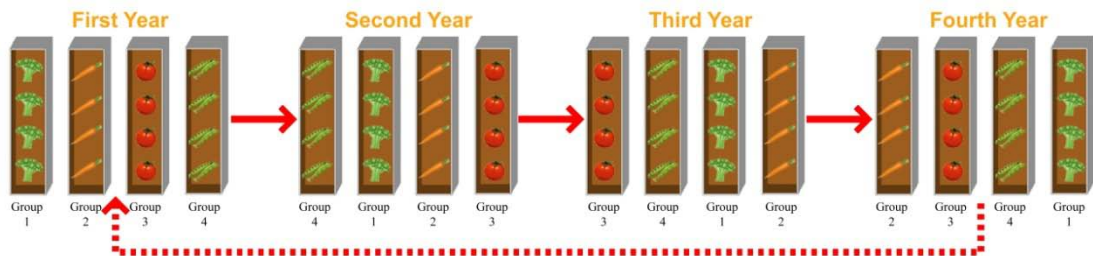


Figure 99. Crop rotation (Source: Author)

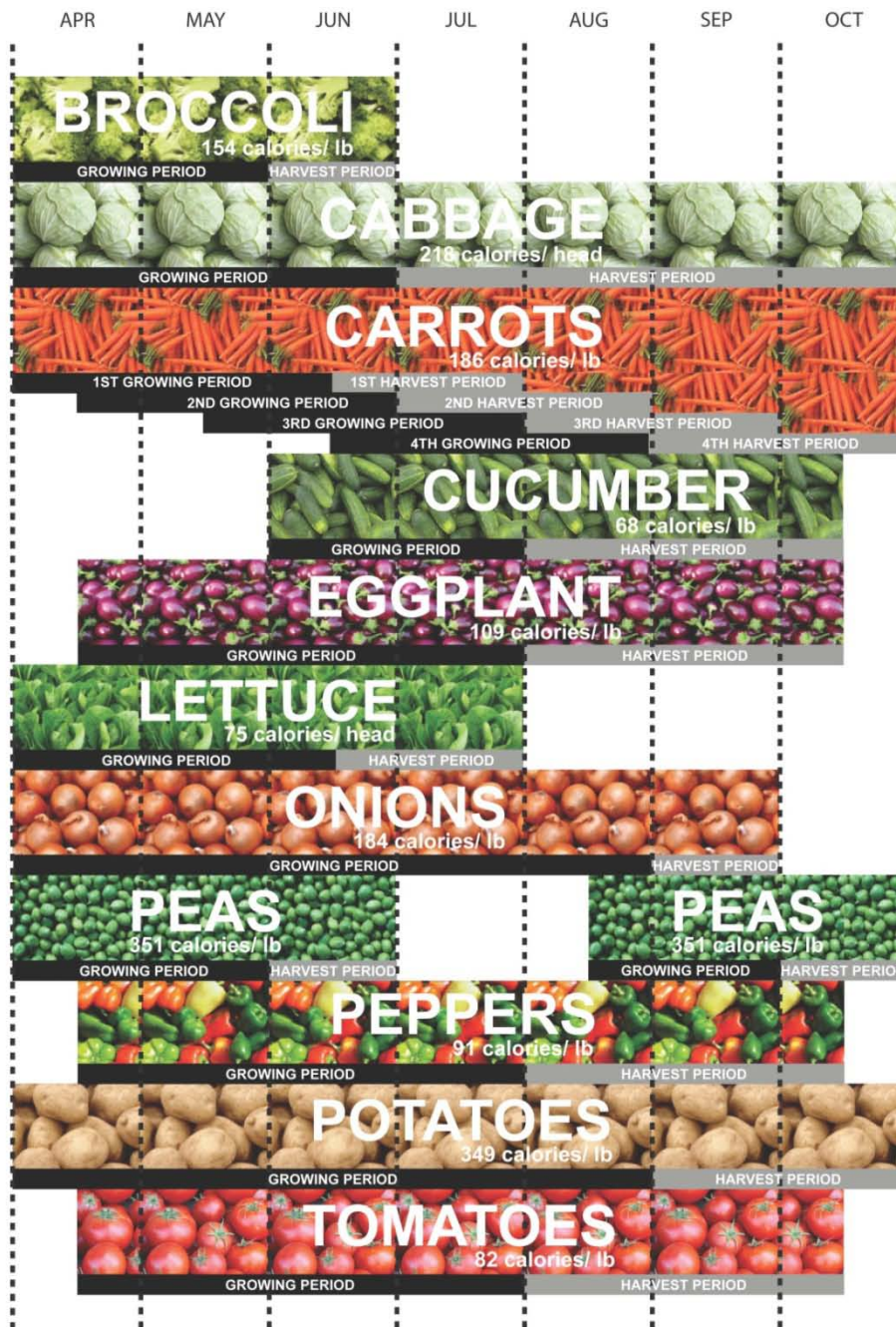


Figure 100. Crop growth and harvest chart (Source: Author)

This chart is a graphic representation of the growth and harvest period for 11 vegetables that will be grown within the agricultural center. Highest yield is possible when these time periods are properly taken into consideration during planting design. These growth and harvesting periods will be accelerated within the facility because of controlled light and temperatures, and reduced soil diseases, pests, and insects.

Agricultural Processes

A variety of advanced agricultural systems will be integrated into the building as prototypes for research and education. Visiam Waste Recycling, anaerobic digestion, and aquaponics will assist in the conversion of food and agricultural waste into crop production and fresh fish. They can then be sold to local markets and distributed around the city, helping to cycle waste back into the system (figure 102). In comparison, oil is largely consumed in a typical industrial agriculture process (figure 101) with high levels of travel between all stages that are sometimes located across the country. Large equipment and multiple facilities are used in order to facilitate this type of agricultural production. At the end of the process, much of the product ends up in a landfill with little to no waste reduction or cycle return.

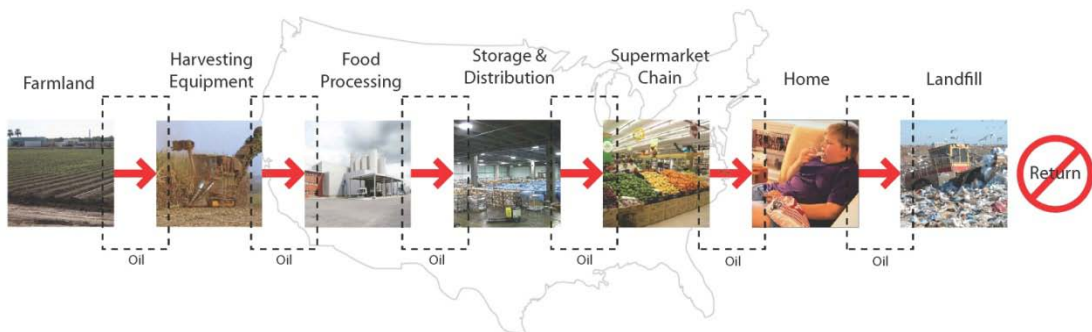


Figure 101. Typical industrial agriculture process (Source: Author)

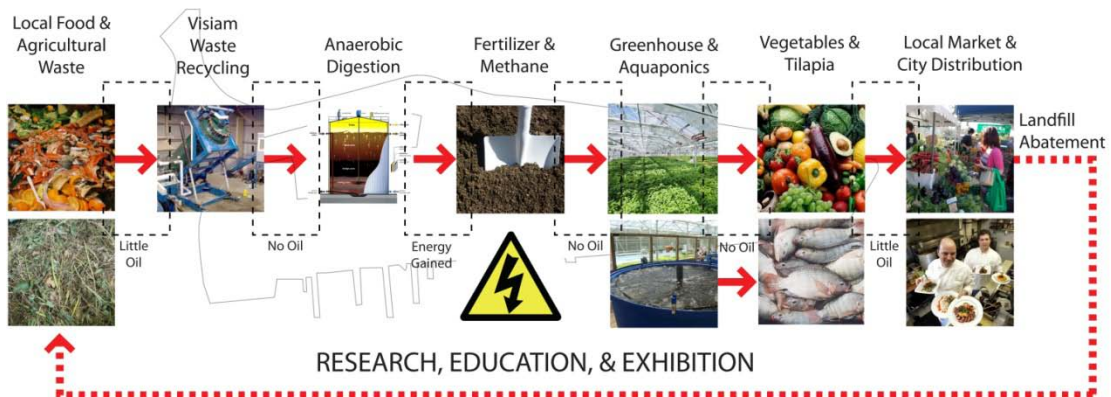


Figure 102. Proposed agricultural process (Source: Author)

Visiam Waste Recycling:

Visiam is a processing technology for landfill bound municipal solid waste (MSW) and a variety of biomass including manure, food waste and agricultural waste. This biomass feedstock is stored into an 8' x 24' Visiam Thermal Vessel (figure 103) which requires about 3,500 square feet of space. A vacuum is created to internally heat the waste for sixty minutes. During this process, the heat and water mixture breaks down the chemical structures of the loaded biomass into a pasteurized organic material. Recyclable MSW, like aluminum and plastics, that are not broken down are reclaimed through a separating machine. The organic mass can then be feed into a variety of additional processes, such as anaerobic digestion and fermentation for the creation of ethanol and methane. The Visiam system uses little energy and results in 80-85% reduction of MSW volume in a landfill¹⁵.

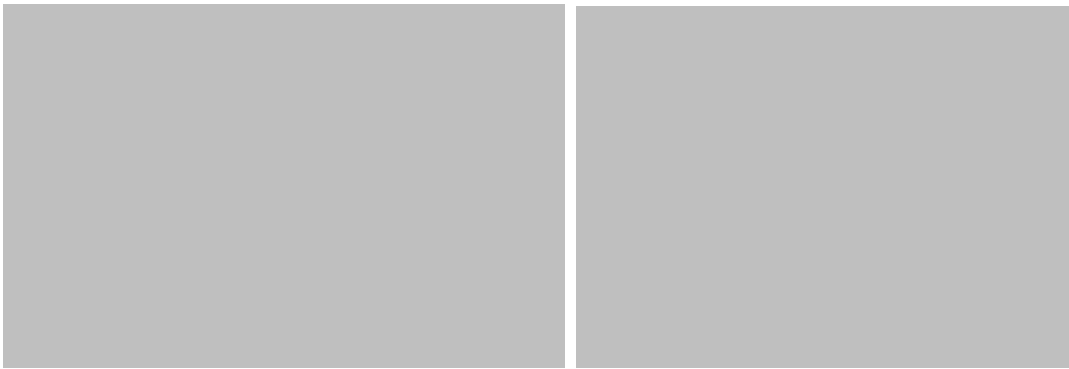


Figure 103. Visiam Waste Recycling Process (Source: Visiam)

Avatar Energy Anaerobic Digestion:

The Avatar Anaerobic Digester is a new design that captures the large economic resources available in organic waste. Food processing waste, agricultural waste, and animal manure can be converted into energy that can power farms and other facilities, as well as generate income for selling the harvested biogas. Additional by-products from the digester, like sterilized solids, can be composted, or pelletized and used as solid organic nitrate-rich fertilizer and potting soil for crops and plants. This state-of-the-art closed system also has the added benefit of reducing odor emissions by more the 90% ¹⁶ in comparison to a typical anaerobic digesting system.

This is the first scalable anaerobic system with a modular design platform. Unlike larger digesting plant which requires thousands of square feet of space to operate, the avatar tanks are designed as an elongated module of 140' by 30'. This feature makes it very suitable for mid-sized operations and the varying configurations allow maximum space utilization. The systems can be installed above ground to decrease costs of installation as well as equipment maintenance. This automated system runs 24/7 reducing personnel, and can operate in the most extreme of weather conditions.



Figure 104. Avatar Anaerobic Digester (Source: Avatar Energy)

Aquaponics:

Aquaponics is a sustainable food production method which promotes a symbiotic relationship between the raising of fish in tanks (aquaculture) and the cultivation of plants in water (hydroponics). The process is relatively simple and easy to maintain. Tilapia and Yellow Perch are raised in large tanks (figure 105). The toxicity of the water is increased as it becomes enriched with nutrients from fish waste. Beneficial bacteria break down the toxic ammonia in fish waste and convert it to nitrate which is used for plant development. Nitrifying bacteria will either be attached to tank walls, or to the underside of the plant rafts. The nitrate rich water flows into growing beds where plants and crops absorb the nutrients to further purify the water. The water is then pumped back into the fish tank as the cycle repeats itself. The largest aquaponic commercial system can produce 5,000 lbs of fish, 112,000 heads of lettuce, and 17,000 lbs of tomatoes in a year¹⁷. In this form of agriculture, water is greatly conserved and little energy and man power is needed to run the system. It also reduces the need for crop land, soil, and waste disposal.



Figure 105 Fish tanks (Source: Nelson Pade)



Figure 106. Growing beds (Source: Nelson Pade)

Major Programmatic Elements

Greenhouse: (34,000 sq. ft.)

The greenhouse will serve as the largest piece of programming within the building. This specifically conditioned space can serve as a garden and nursery where large growing beds can be housed to grow a variety of plants, fruits, and vegetables. The greenhouse will also be a space for the various agricultural processes to take place. There must be enough circulation for the caring of the harvest, as well as movement of materials and waste. There can be additional demonstration areas to learn proper agricultural techniques while outdoor space can also be accommodated for the storage of larger plants and trees in addition to community gardens.



Figure 107. Gotham Greens (Source: Zeveloff)



Figure 108. BBK Veksthus (Source: Hydro)

Vertical Farming: (10,000 sq. ft.)

Vertical farming is an additional piece of agricultural program that will help increase yield in combination with the greenhouse. Vertical farming is a process that has been receiving much attention amongst designers, engineers, and planners primarily in urban environments. The importance of this process is that high yield can be achieved in a relatively condensed footprint. These vertical farms will be seamlessly integrated into a portion of the existing building as a test for compact growing, enhanced light, and controlled climates all to help attain a large yield.



Figure 109. Agro-Housing (Source: Gorgolewski)

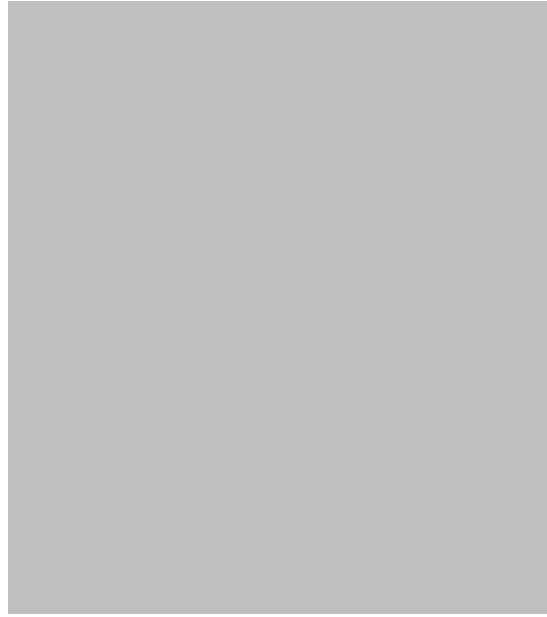


Figure 110. Center for Urban Agriculture (Source: Gorgolewski)

Classrooms & Laboratories: (32,000 sq. ft.)

As an agricultural research center, the incorporation of classrooms and laboratories is essential for the understanding and exploration of innovative agricultural methods. These spaces can be flexible in arrangement and must be of close proximity to the greenhouse to collect samples and study the processes taking place. Plant sciences will be the main area of focus with concentration in vegetable genetics and produce quality and safety. The laboratories will mostly be for professional and university uses, but the classrooms can be open to the public for various community programs.

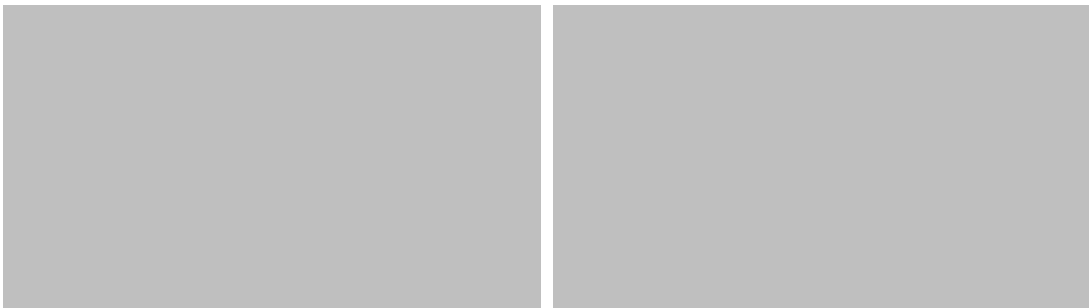


Figure 111. Komohana Agricultural Research Facility (Source: RFD)

Public Market & Café: (20,000 sq. ft.)

A public market is being proposed in order to facilitate social strengthening as well as a funding and economic resource. People from all over the city of Philadelphia can come to sell their personally grown produce among other products. Additionally, fresh fish, vegetables, and fruit grown in the research facility and in the outdoor urban farm and orchard will also be sold to demonstrate the agricultural systems' ability to convert waste to food. A café will also be incorporated to serve organic food and beverages to visitors, students, and workers in the building. These various amenity spaces may also be used by employees from other companies located within the Navy Yard. This programming element will be the primary source for bringing the public down to the site, where activities like a weekend farmers market, concerts, and city events can take place.



*Figure 112. Milwaukee Public Market
(Source: CG Schmidt)*



*Figure 113. San Francisco Organic Cafe
(Source: The Organic Plant Café)*

Chapter 5: Preliminary Design Approach

Site Approaches

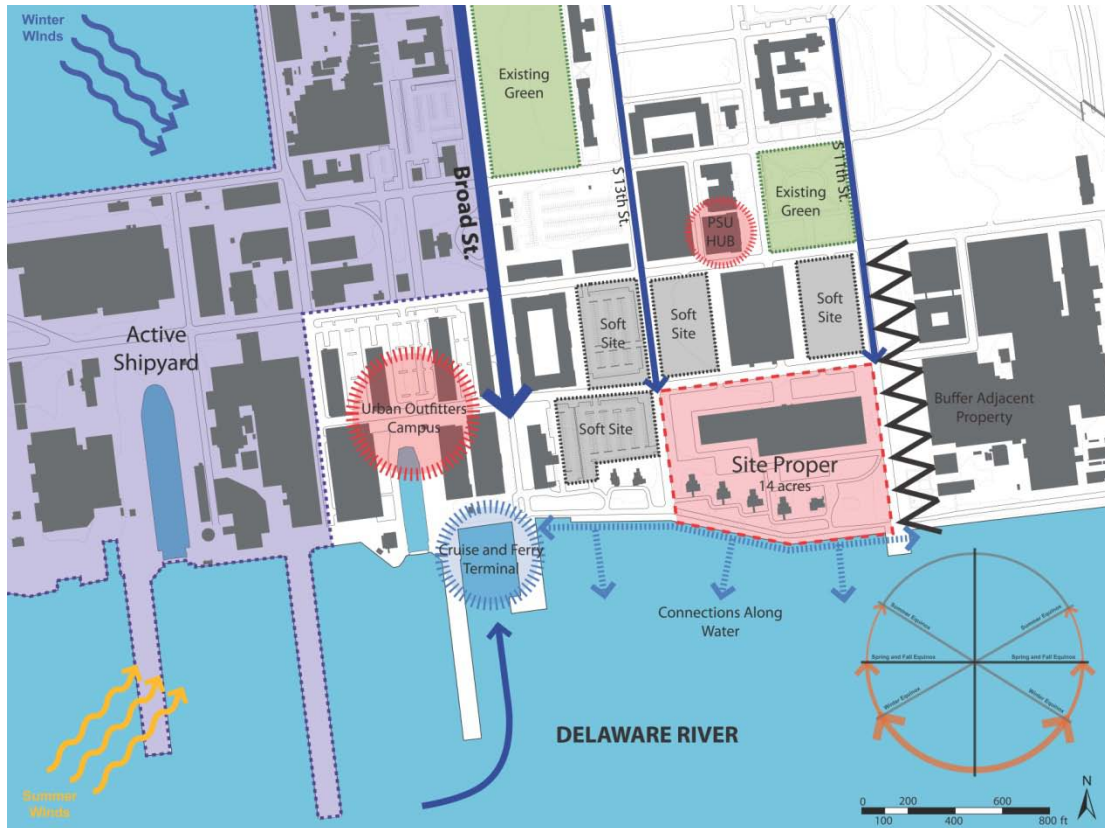


Figure 114. Existing conditions (Source: Author)

To begin establishing site schemes, an analysis was done which examines the site's current conditions and potential opportunities at a scale much larger than the site proper itself. Four lots surround the immediate site, which have been deemed as "soft sites" for future development. Three potential entries give tremendous porosity to and from the site. Although Broad Street is not directly connected to the site proper, it will most likely still remain the primary access point, because of its significance as an artery to the entire city. With the site's close proximity to important hubs of activity, like the Urban Outfitters Campus and the cruise and ferry terminal, there is a strong potential for connections to major nodes.



Figure 115. Site scheme A “Diagonal Connection” (Source: Author)

Scheme A proposes a diagonal connection between two hierarchical spaces across the site at an angle that is consistent with the echeloning of the officer quarters.



Figure 116. Site scheme B “Infill and Buffer” (Source: Author)

All soft sites in scheme B are infilled to increase density around the site while a hardscape plaza is incorporated to the south of the building. With this increase in impervious surface, the vegetated space in between the officer quarters is converted into a bioswale to help filter and reduce runoff into the Delaware River.



Figure 117. Site scheme C "Riverwalk" (Source: Author)

Scheme C focuses on the rejuvenation of the waterfront. A large pedestrian promenade is created to activate the edge of the site along the water. Stronger connections from the site to Urban Outfitters and the cruise terminal are made.



Figure 118. Site scheme D "Urban Farm" (Source: Author)

In scheme D, the intent was to transform the site into a completely productive plot of cultivated land where farming and composting would be the primary features.

Initial Building Transformations

These transformations were the first attempts at discovering ways in which the strength of the existing structure could be utilized to promote more appropriate growing spaces. This series of transformations begins by stripping away the rusted skin to expose the existing structure. A new more sustainable transparent skin is applied, and portions of the building become eroded away. The structure that is removed is then repurposed and stacked to create vertical farms that take advantage of the uninterrupted southern sun exposure.

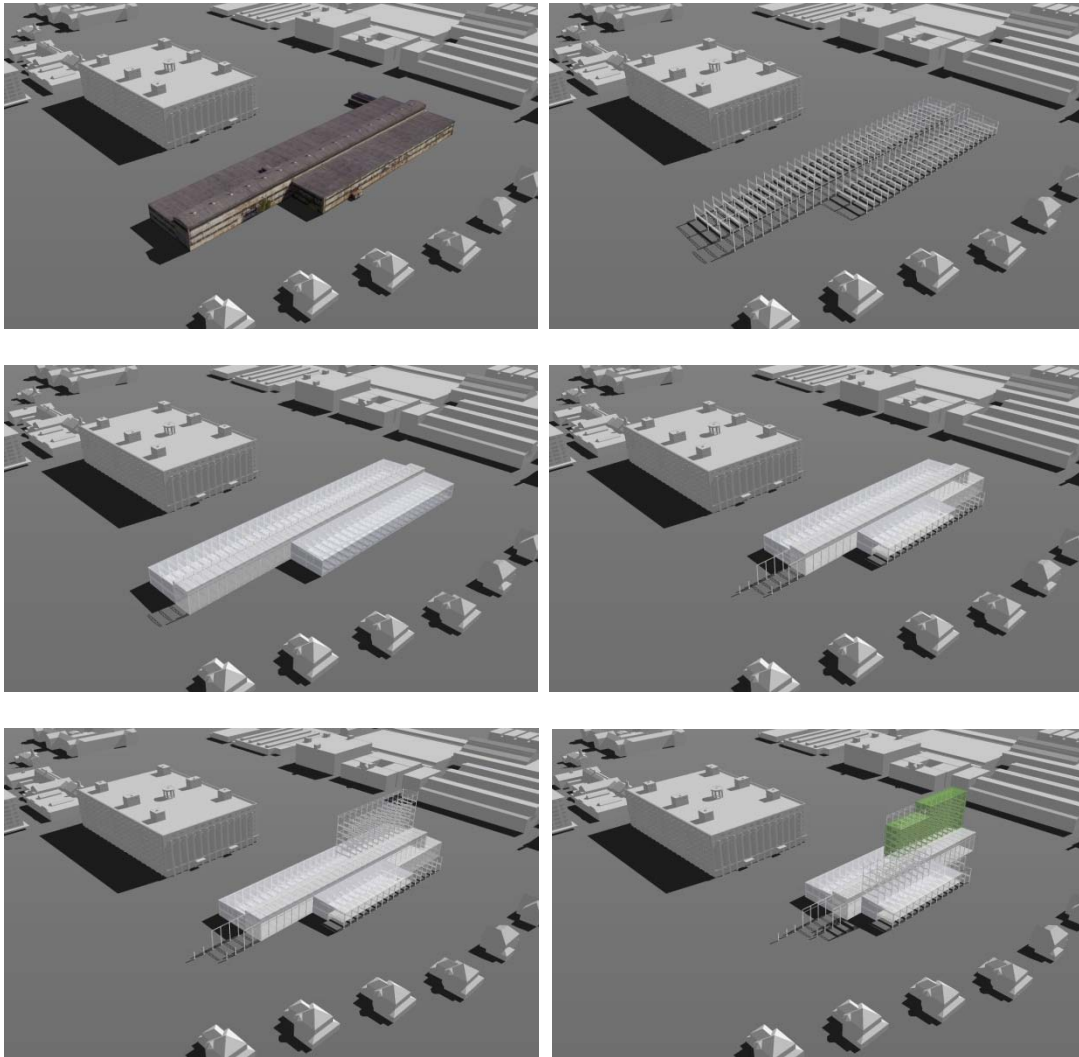


Figure 119. Initial Building Transformations (Source: Author)

Sectional Studies

These sections studies were done at the beginning stages of the design process. The exercise examines multiples ways in which a variety of agricultural methods and programmatic elements can be integrated into the existing structure of the warehouse. Attention was focused particularly on climate conditions and necessary responses including sun angles, wind direction, heat recycling, and heat exhausting.

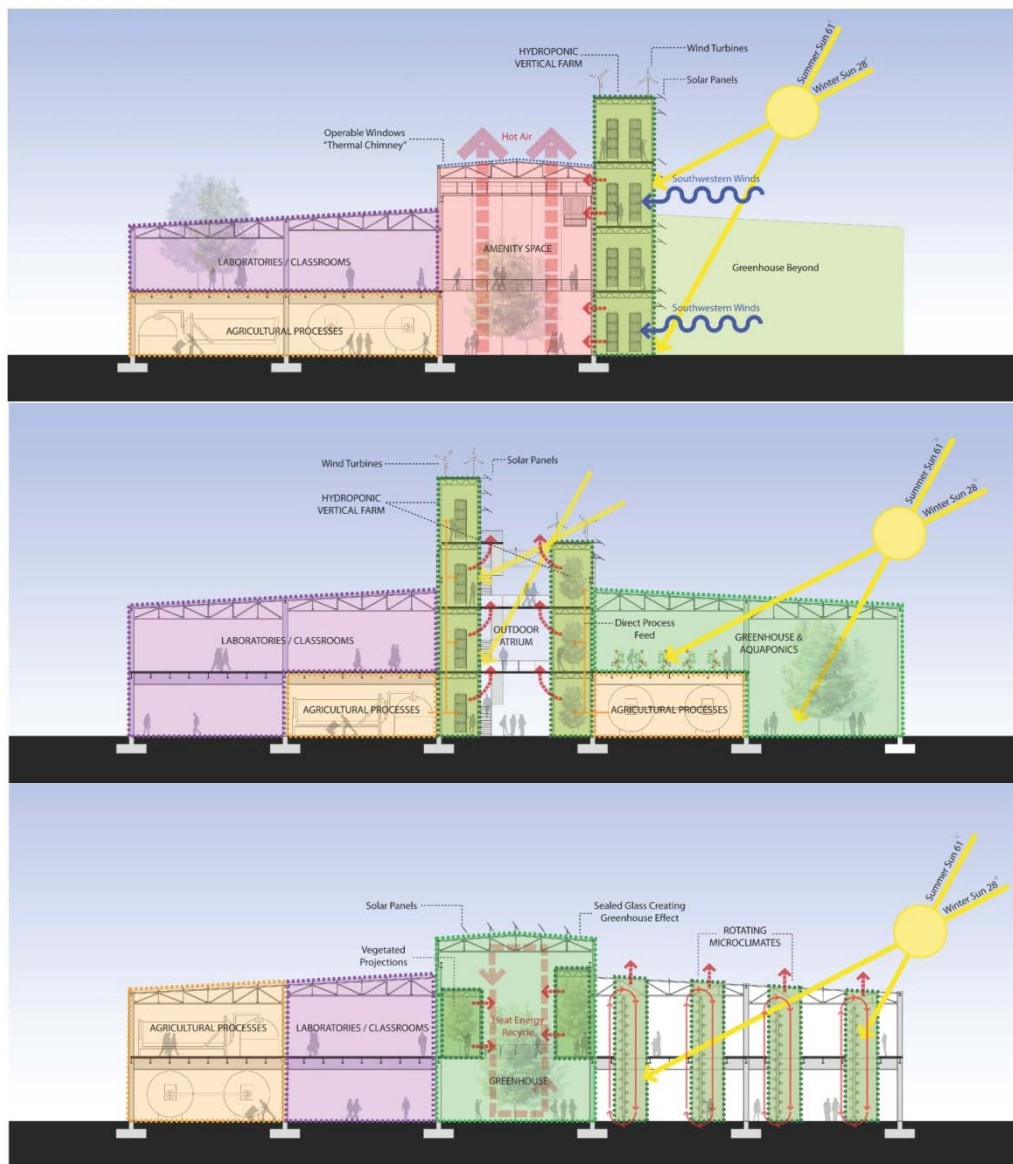


Figure 120. Sectional studies (Source: Author)

Model Studies

Conceptual process models were used to explore a variety of methods for how the vertical farms could become integrated into the existing structure. The form of these vertical farms were explored by slicing and projecting through the building, opening and inhabiting the existing atrium space, and finally by inserting into the existing structure as an extension of the building's original form.

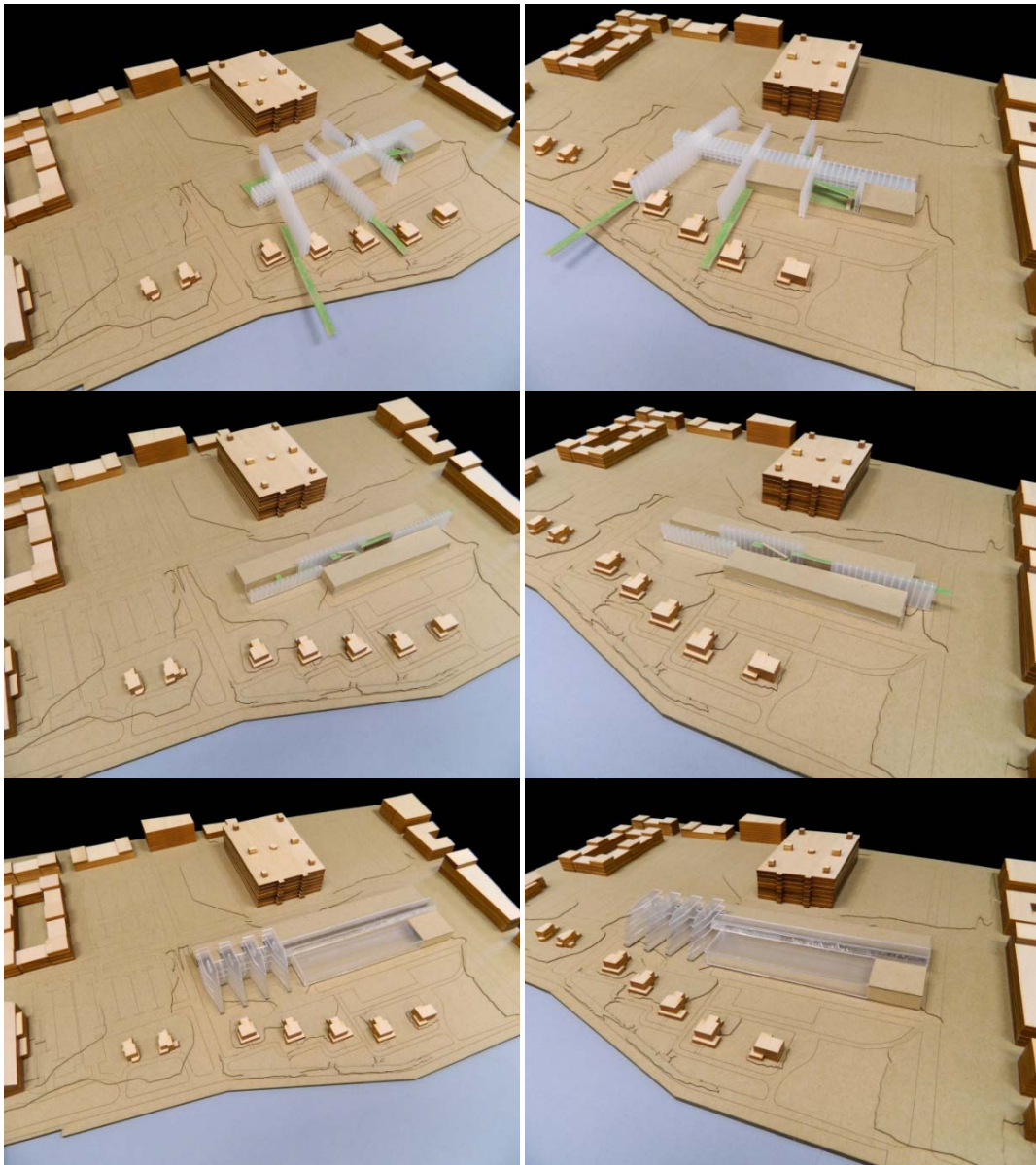


Figure 121. Process model studies (Source: Author)

Chapter 6: Final Design Proposal

Conceptual Transformations

After initial analysis of the building and its structural capacity was completed, the metaphor of the design concept began to unfold. The structure is envisioned as scaffolding that could be manipulated and repurposed to reveal its new potential as an agricultural incubator. This scaffolding would be the platform for which verities of transformations occur. These transformations would breathe new life back into both site and building while preserving its history as a hub for innovation and production.

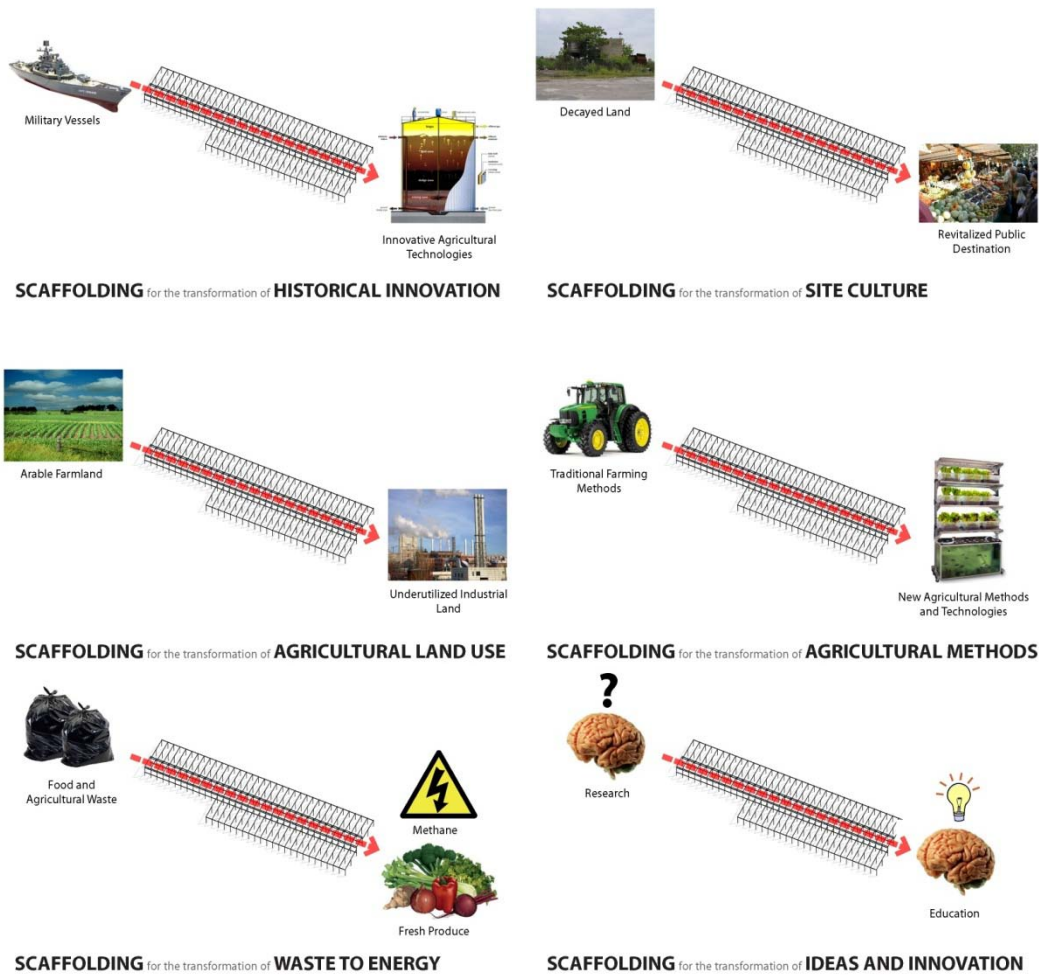


Figure 122. Conceptual transformations (Source: Author)

Agricultural Form Generation

In order to create an architecture that produces superior agriculture, a series of form manipulation was studied to optimize growing conditions. This manipulation begins by removing a segment of the existing structure and four vertical farms are positioned in its place. These vertical farms and a portion of the existing building are transformed by rotating, widening, and tapering to maximize sunlight penetration and exposure. Finally, the farms are raised to allow the integration of a market below.

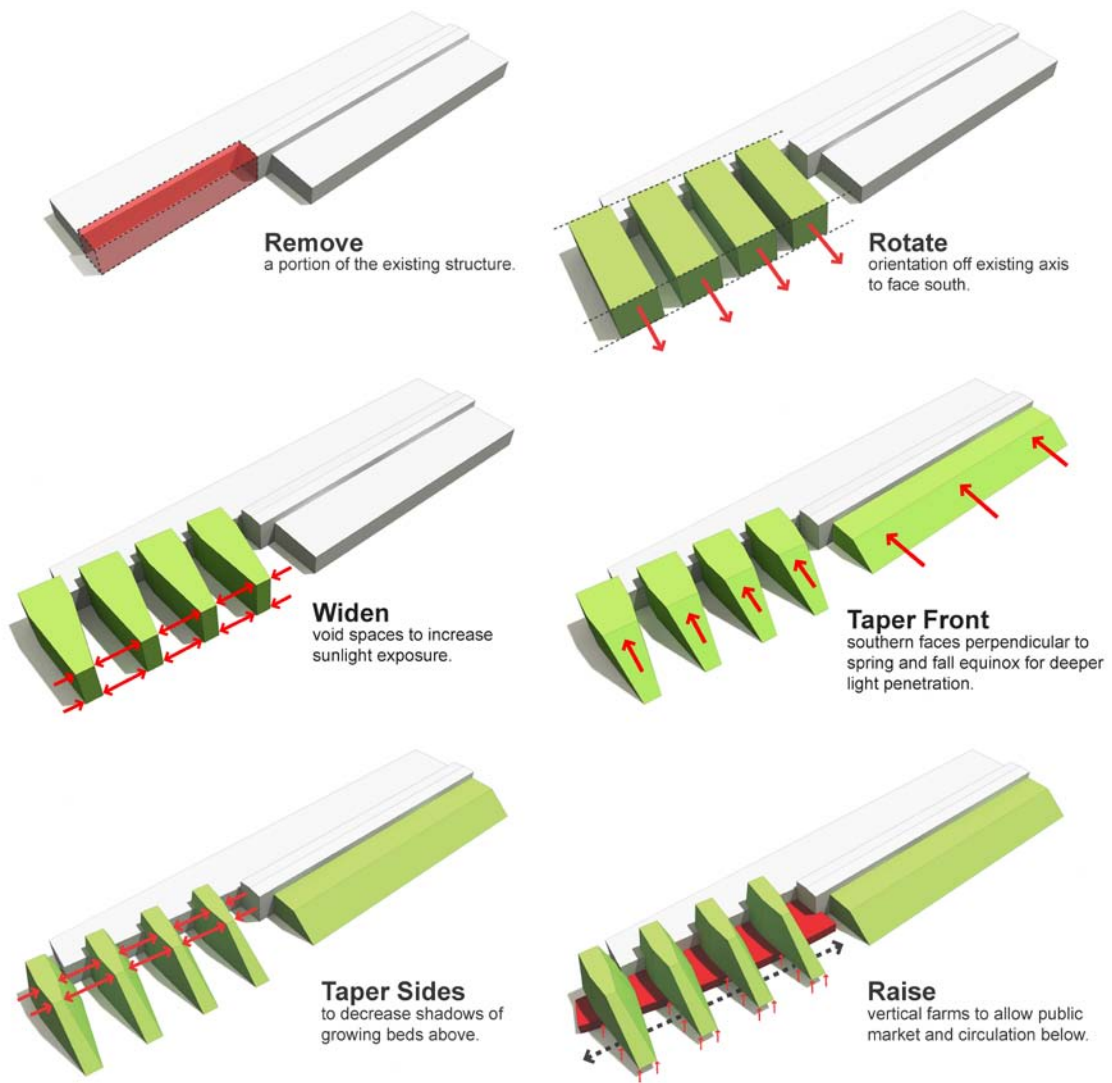


Figure 123. Vertical farm and greenhouse form study (Source: Author)



Figure 124. View of vertical farms and repurposed greenhouse from the urban farm (Source: Author)

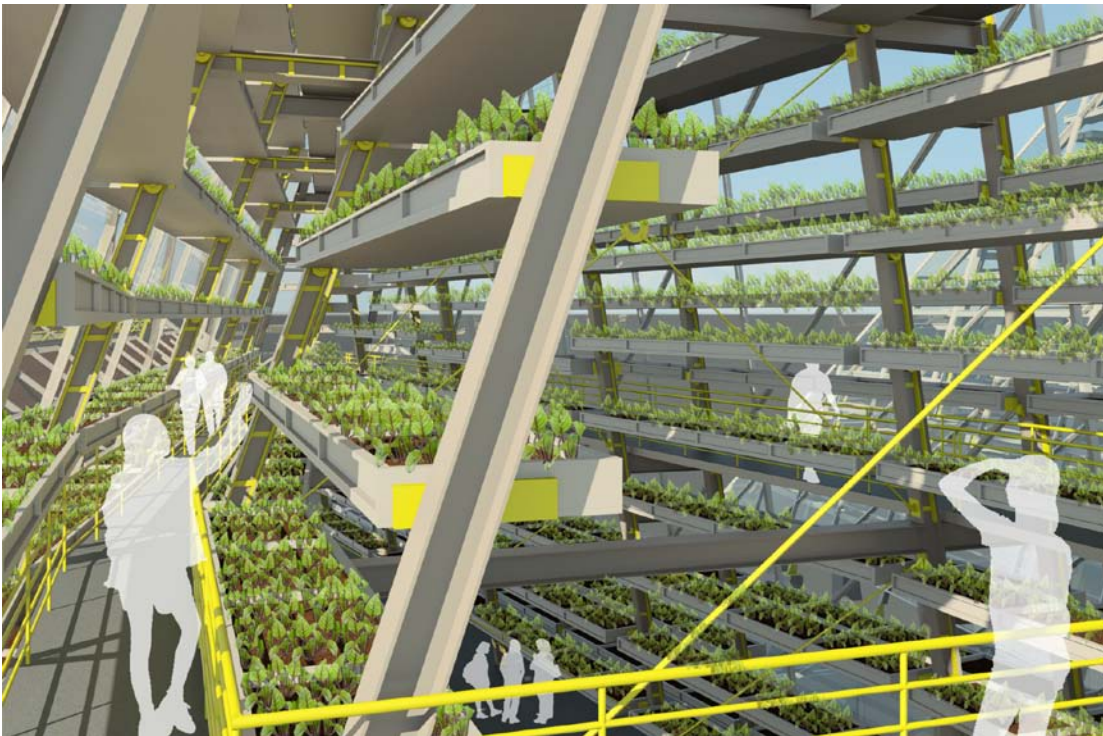


Figure 125. View inside vertical farm with rotating growing beds along the edge (Source: Author)

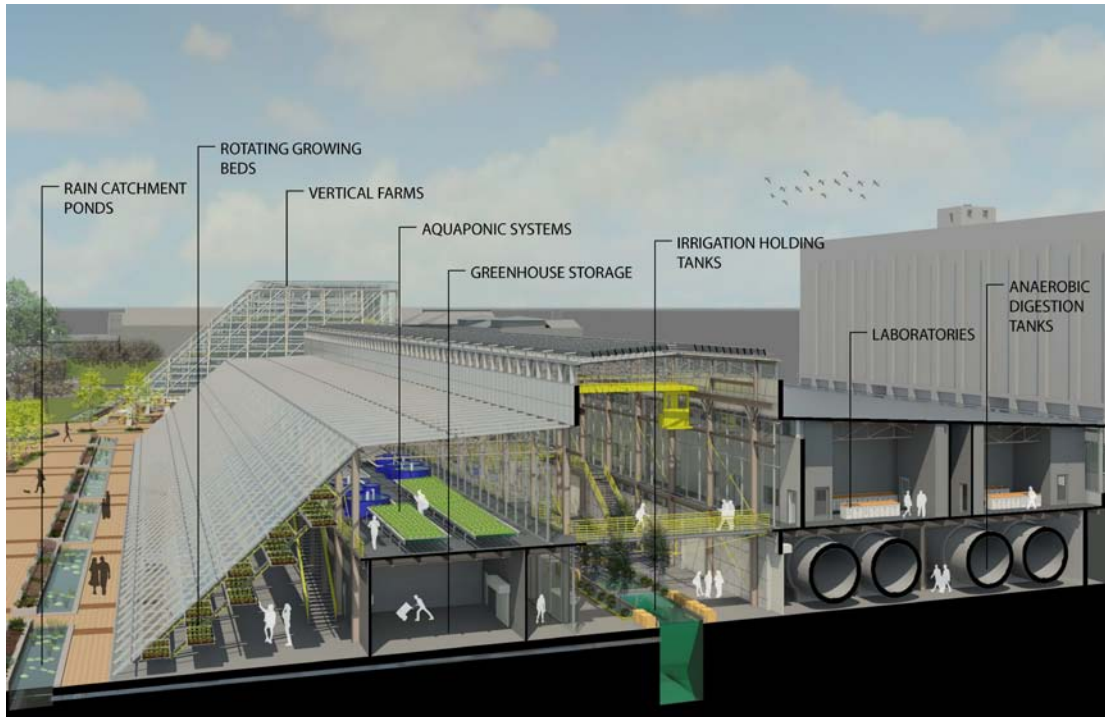


Figure 126. Section perspective highlighting all agricultural processes (Source: Author)

Crop Yield

The agricultural research center was designed with the intent on creating a significant enough yield to become a major source of food production and distribution. The creation of a stacked rotating growing bed system in both the greenhouse and vertical farms allow for high levels of plant production in relatively small footprints. Additionally, controlling the climate, lighting, soil borne illnesses, and pest/insect infestation, all help to further increase the yield. The compactness of these growing systems in combination with the controlled environment, achieves high enough food production in a year to feed 40,000 people. That is roughly 25% of South Philadelphia’s entire population (figure 128). Although these crops can be sold directly on site in the public market, the majority of the harvest will be distributed out to restaurants around the city to promote localized sustainable food production.

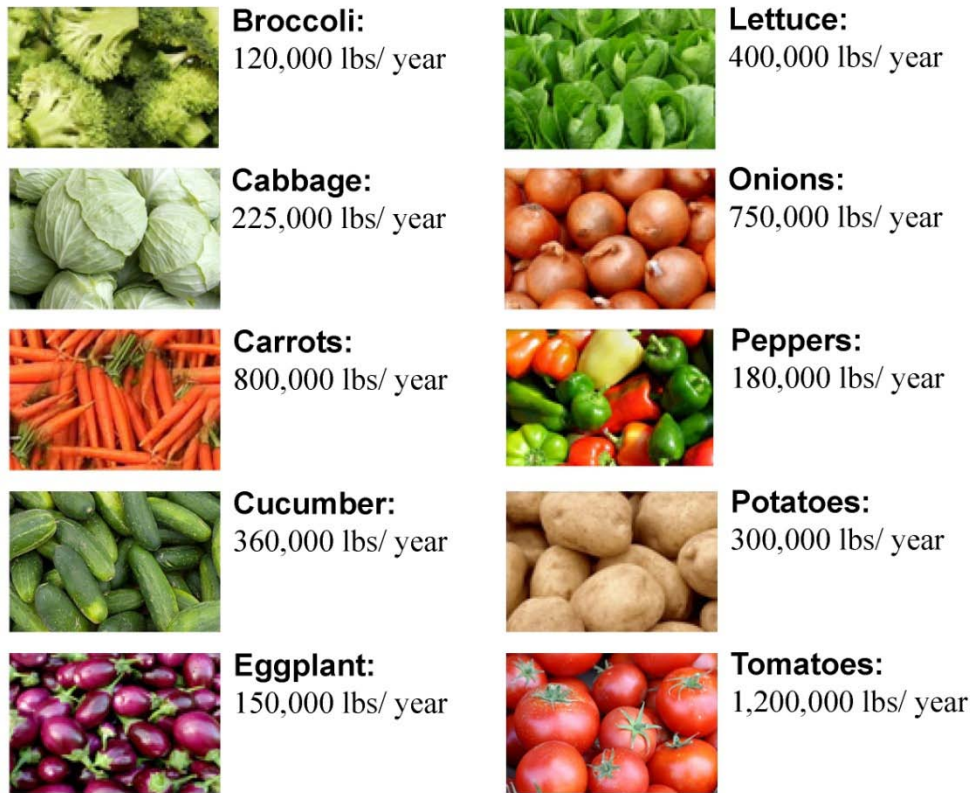
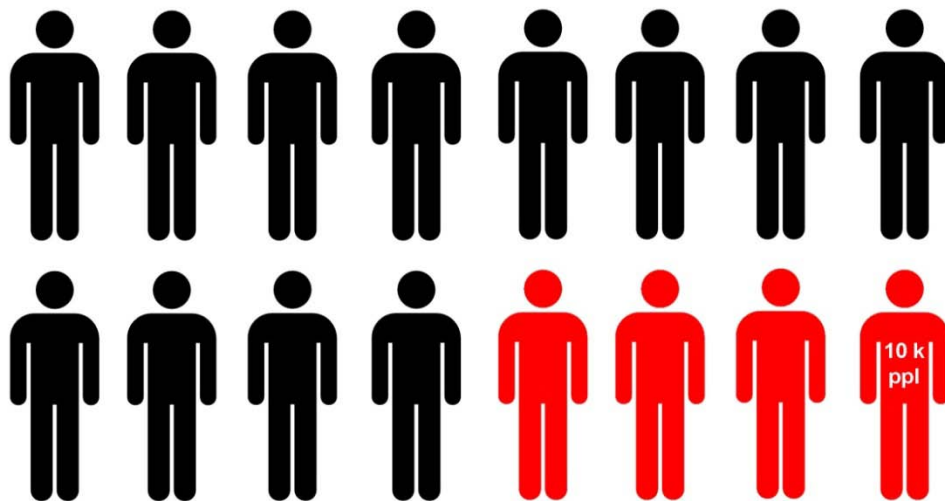


Figure 127. Crop yield totals (Source: Author)



**The agricultural facility can produce enough food
in a year to feed 40,000 people**

25% of South Philadelphia's population

Figure 128. Total population sustained by food production (Source: Author)

The image below (figure 129) represents the agricultural facility's efficiency and high rate of crop production. The effectiveness of the design allows the building to achieve an extremely high yield in just 44,000 sq. ft. of dedicated growing space. In comparison, if the same total yield was to be achieved by traditional agricultural methods, farmers would need approximately 16 times the amount of growing space

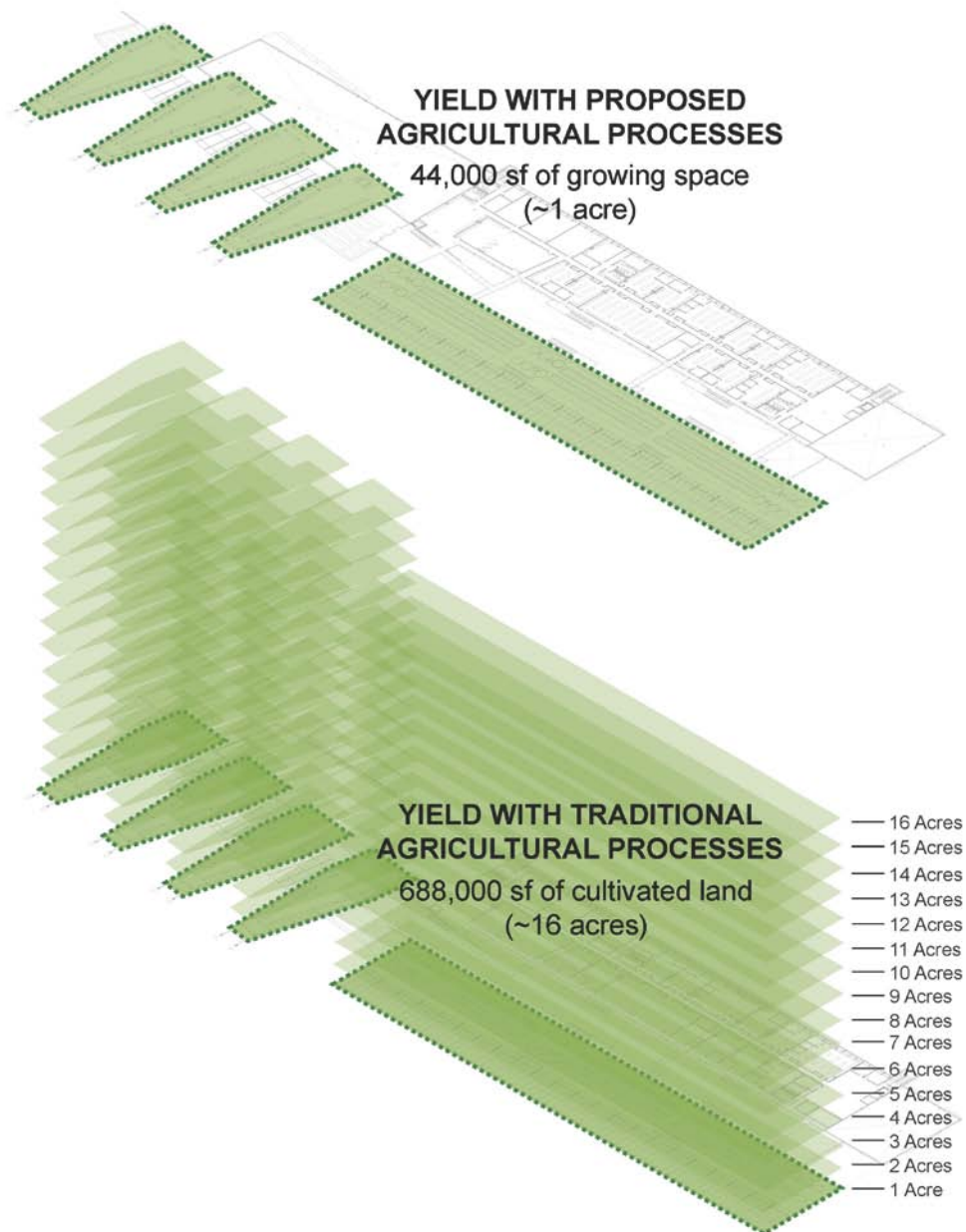


Figure 129. Proposed vs. traditional agricultural yield (Source: Author)

Site Strategy



Figure 130. Existing site (Source: Author)



Figure 131. Proposed site plan (Source: Author)

The majority of the existing site (figure 130) is covered by impervious materials. Large asphalt parking lots and rooftops dominate the character of the site. The only heavily vegetated area is between the officer quarters to the south. Three prominent points of entry give access to the site, one of which is Broad Street, Philadelphia's major secondary artery. The location of the site is directly along the edge of the Delaware River, but no opportunity is taken to make connections to the water. Four of the eight officer quarters have been removed because of their condition and the need to make room for outdoor growing spaces.

The proposed site (figure 131) utilizes all three entry points into the site, but 11th Street to the east would be used primarily as service. Four public plazas, each with their own unique qualities, are positioned around the site. A pedestrian promenade slices across the site to make connections to the water, as well as relating to the public market and vertical farms. An urban farm and orchard is integrated into the design to promote exterior agriculture in addition to the processes that take place within the facility. The urban farm is extended into the water as floating hydroponic gardens. A portion of the site to the east has been carved away to allow barges with waste to offload directly into the building from the water. This form is meant to be reminiscent of the multiple dry docks located in the Navy Yard. The officer quarters that remain are converted into green demonstration homes as well as dormitories for students who may be visiting the site for a semester of research. The land surrounding these officer quarters has been retained and is left heavily tree covered and vegetated. The more invasive design strategy to the site appears to wrap around the officer quarters within minimal interference to its existing condition.

Building Plans

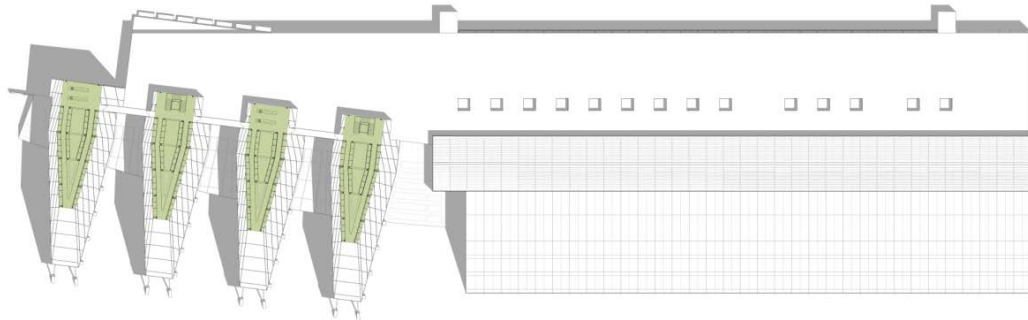


Figure 132. Vertical farm level 3 plan (Source: Author)

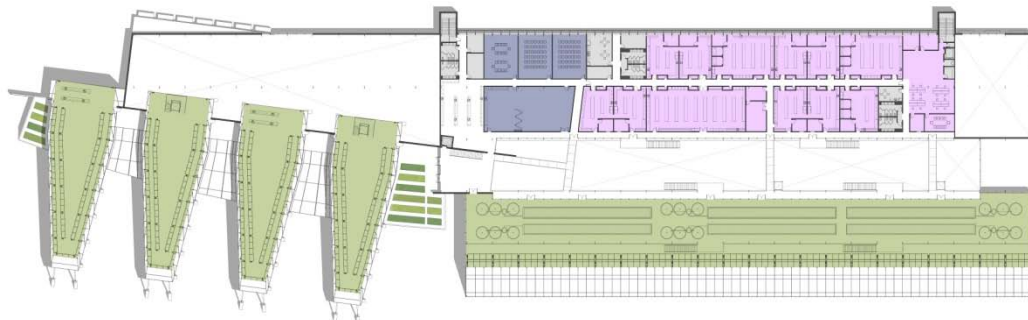


Figure 133. Level 2 plan (Source: Author)



Figure 134. Ground floor plan (Source: Author)

The west portion of the ground floor is dedicated to the public market, with the shipping and distribution center behind. The eastern half of the facility is for the greenhouse and waste to energy processing. Classrooms, offices, and laboratories are placed on the second floor, in addition to aquaponic systems and more greenhouse.

Program Diagrams

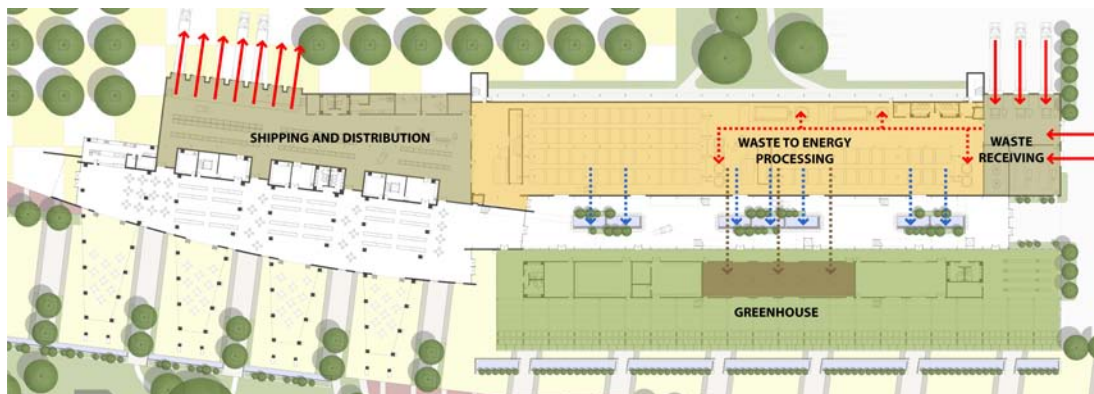


Figure 135. Waste to energy processing (Source: Author)

21,000 lbs of food waste can be brought to the facility daily for processing. The waste is converted into methane to power the building, water that is pumped to holding tanks for irrigating the crops, and organic fertilizer that is stored in the greenhouse for easy accessibility when needed. Harvested crops and additional fertilizer can be packaged and distributed out to the city and local markets.

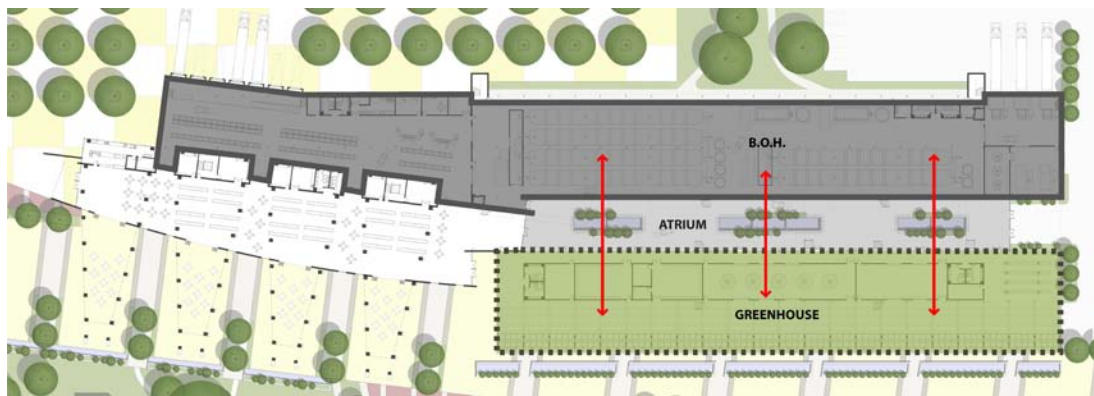


Figure 136. Program Separation (Source: Author)

The atrium acts as a buffer separating the back of house spaces to the north, from the growing that occurs to the south. A contrast is made in the materials used for these different programs. The back of house is wrapped in a solid metal panel to damper smells and noise from the processing. The southern half is left completely transparent to create a proper growing environment.

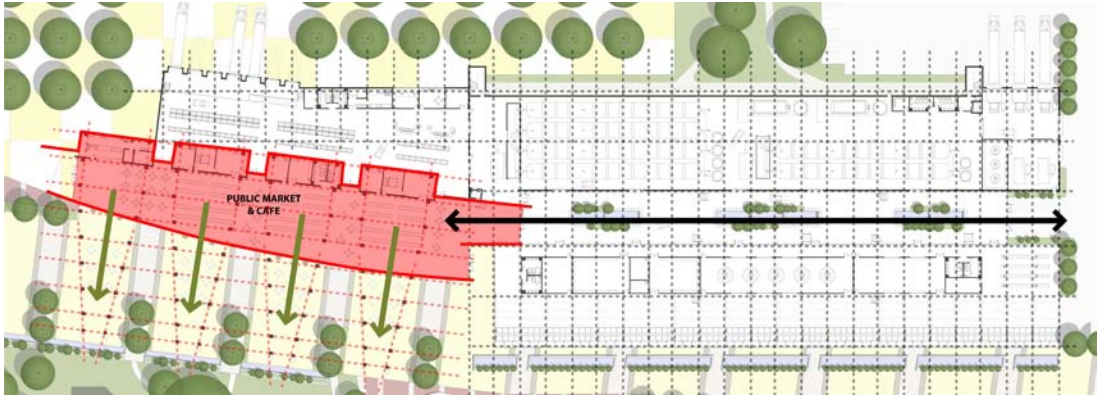


Figure 137. Grid overlap and public market integration (Source: Author)

The existing grid is met with a new grid that responds to the orientation of the vertical farms. Where these two grids overlap, a new form is generated. The subtle curve helps to mitigate between the two geometries. This new form becomes the public market and café as an extension of the atrium and vertical farms above. Within this space, visitors are visually connected to the significance of the vertical farms, and the role they play in the production of fresh produce.



Figure 138. View inside public market & café (Source: Author)

Building Elevations and Sections



Figure 139. North elevation (Source: Author)



Figure 140. South elevation (Source: Author)

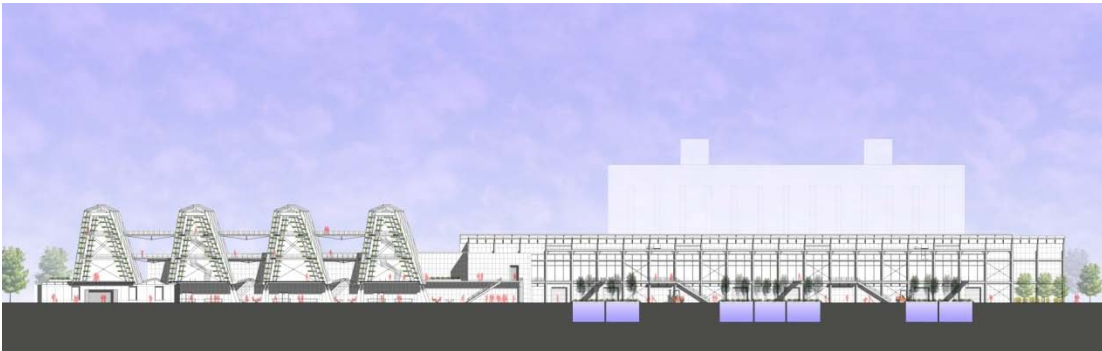


Figure 141. Longitudinal section through atrium and vertical farms (Source: Author)



Figure 142. Transverse section through building and site (Source: Author)

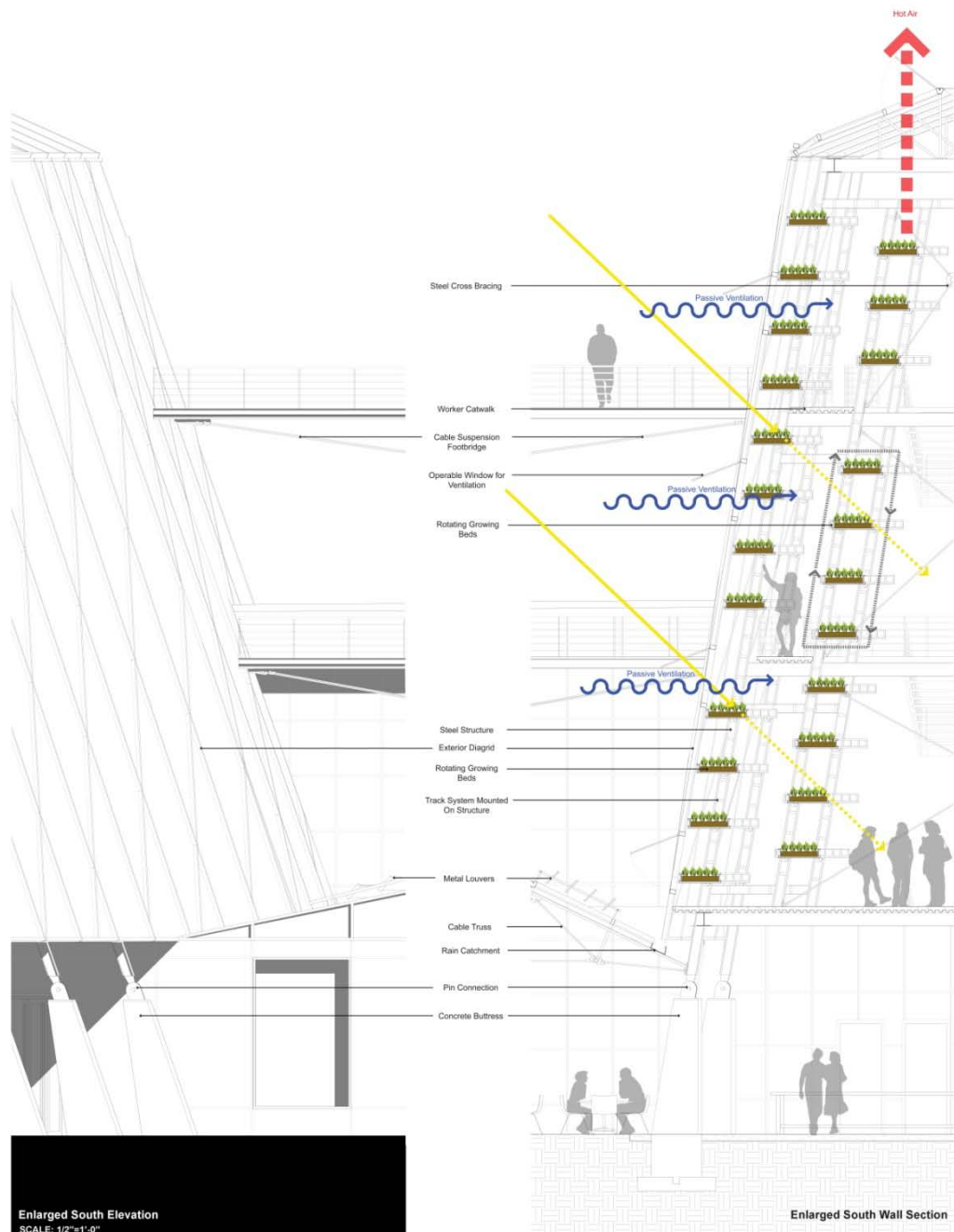


Figure 143. Enlarged south elevation and wall section (Source: Author)

This enlarged section (figure 143) highlights the rotating growing systems within the vertical farms. The doubling of structure provides two layers of growing to occur and also supports catwalks that supply workers with access to the growing beds. The use of these walkways allow for a completely open space in the center of

the vertical farms. Passive ventilation is achieved through operable windows that are positioned within the curtain wall diagrid. Heat can be trapped and recycling during the winter months, and exhausted through the top of the structure during the hotter spring and summer months. The section also reveals how the steel structure of the vertical farms meet the concrete buttresses, and how the structure of the folding glass roof over the public market is tied into that system.

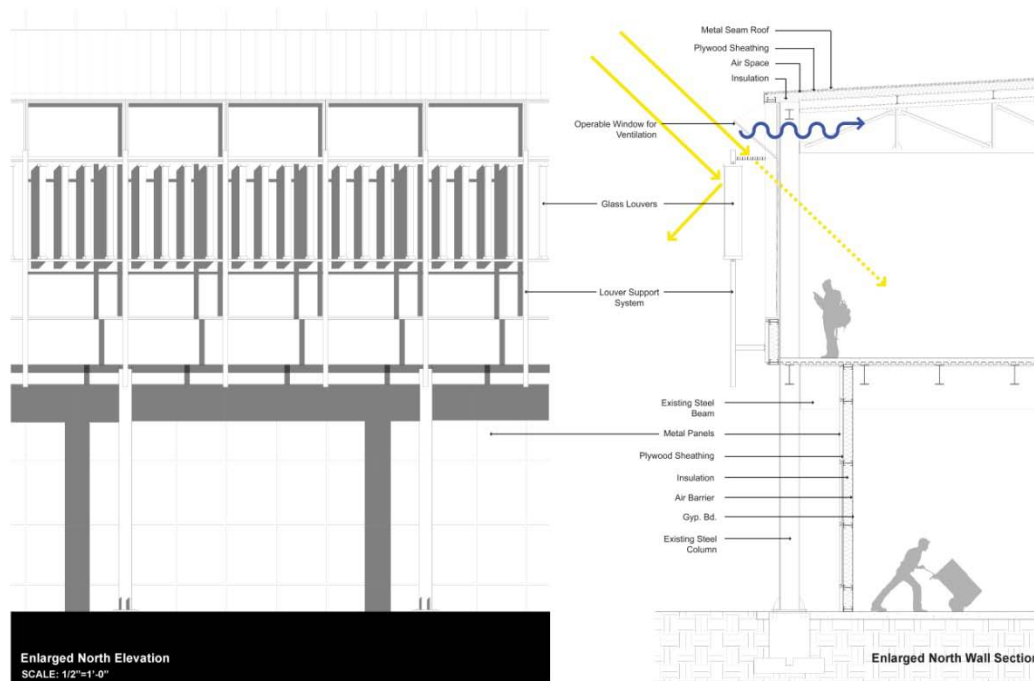


Figure 144. Enlarged north elevation and wall section (Source: Author)

The enlarged section through the north façade (figure 144) contains a completely different character in comparison to the southern façade where the growing occurs. It is wrapped completely in metal panels that are reminiscent of the warehouse’s original cladding. The solidity of the material dampers noise and smell that occurs during waste processing. On the second level, the panels are removed and windows are used to allow light into the laboratories and classrooms while a double skin is attached to protect the interior spaces from late afternoon sun.

Building transformations

Existing South Façade



Figure 145. Existing south façade (Source: Author)

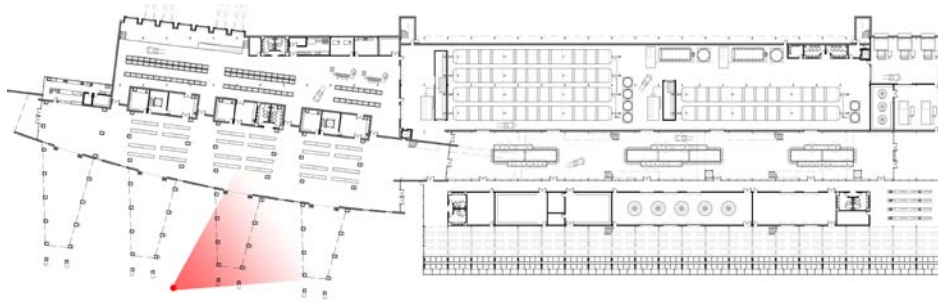


This view highlights the only portion of the existing building that was completely removed. This segment of the south façade was stripped away to allow for a more flexible space that incorporates an environment more suitable for growing. Additionally, the shorter section of the façade in the distance is manipulated and transformed into a two story greenhouse.

Proposed South Façade



Figure 146. Proposed south façade (Source: Author)

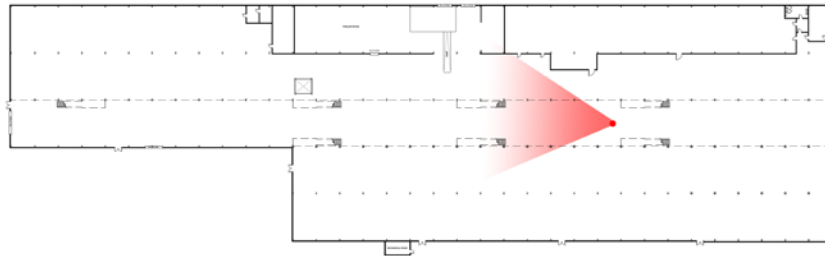


Vertical farms were integrated in place of the existing structure's removed portion. A public market and café is located below the vertical farms to help activate the ground level. The open spaces between and underneath the farms can now be completely occupied by the public. This new amenity space will serve as the driving resource for bringing people from the city to the site. The existing building with the transformed greenhouse can be seen in the distance

Existing Center Aisle



Figure 147. Existing center aisle (Source: Author)

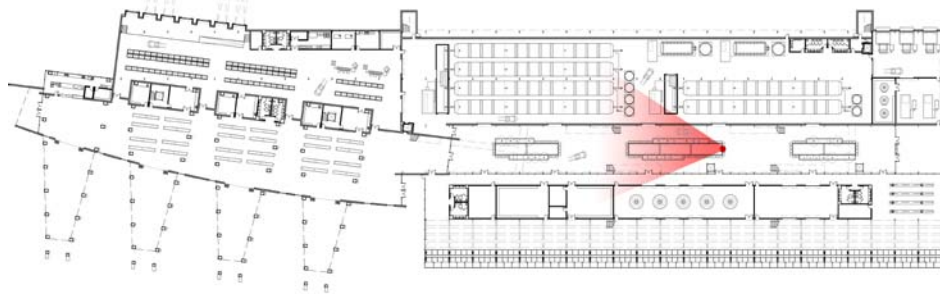


Currently, the existing center aisle has no function. The monumentality of the structure in this enormous space emits a strong feeling of its industrial past. The car in the foreground helps to give scale to how large the center aisle is. The excellent condition of the interior structure, including the stairs, illustrates its need to be repurposed in a way that exemplifies the building's original reason for being. To leave the space underutilized would be doing the building and its structural potential a complete disservice.

Proposed Center Aisle



Figure 148. Proposed center aisle (Source: Author)

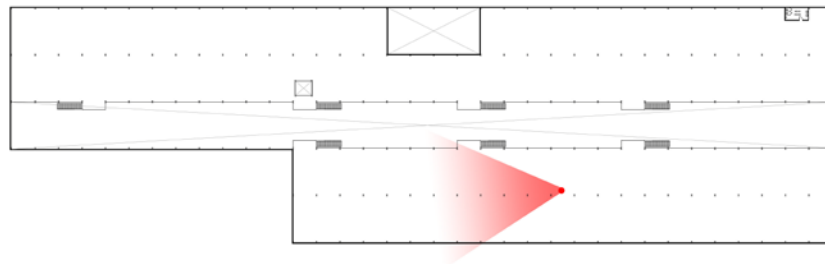


The design transforms the center aisle into a work atrium that serves spatially as a buffer between the growing to the south, and the waste to energy processing to the north. The contrast in materials can be seen in this view which identifies the distinction between the two programs. Bridges were placed to create stronger connections between the greenhouse and the laboratories while expressing a new sense of tectonics in addition to the existing structure. Irrigation holding tanks and trees help to convey the notion of agriculture throughout the space.

Existing Mezzanine Level



Figure 149. Existing mezzanine level (Source: Author)



The mezzanine levels which flank the larger center aisle have been used as storage spaces for materials accumulating at the Navy Yard over the years. The expansiveness and open quality of the space exposes its potential as an area for growing to take place. Currently, the materials that enclose the space are not appropriate for necessary light and ventilation. Additionally, the low height to the bottom of the structure compress the space and cast significant shadow that could effect proper crop growth.

Proposed Mezzanine Level

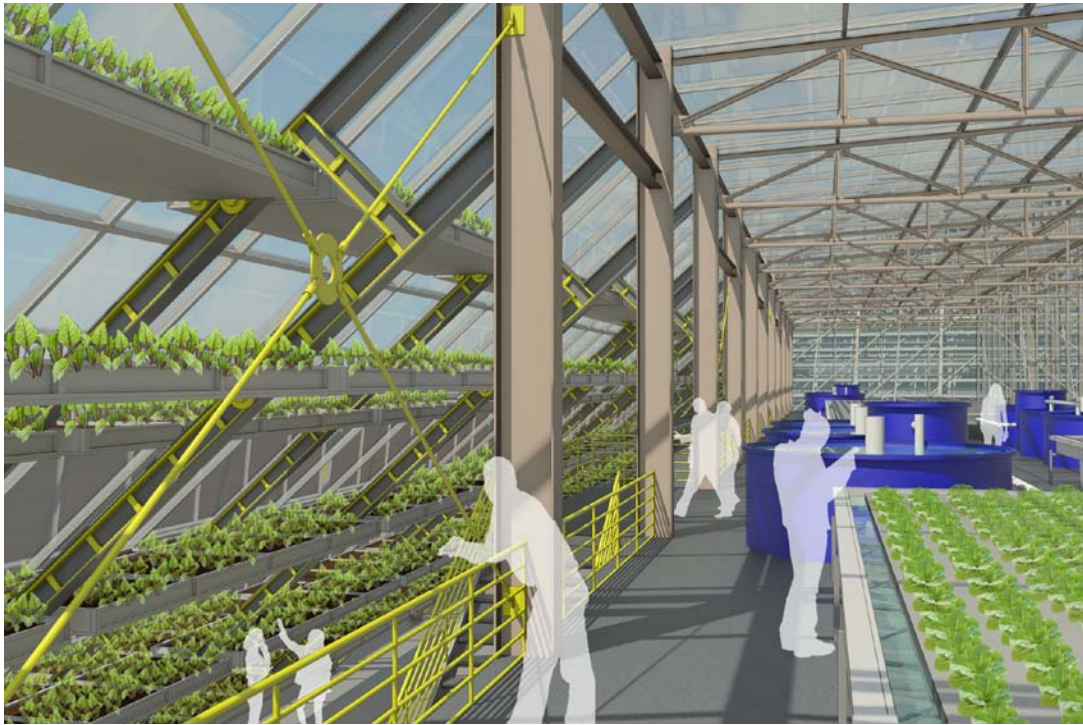
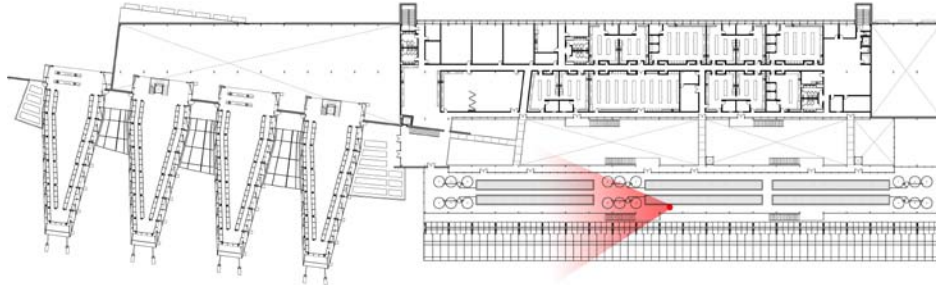


Figure 150. Proposed mezzanine level (Source: Author)



Half of the mezzanine floor is removed to create a double heighted space. In that same area, the existing framing was removed and repurposed to support sloped rotating growing beds. The front half of the mezzanine space is now devoted to soil grown crops and the upper portion is used for the aquaponic systems. Under these aquaponic systems are additional work spaces and large storage areas for water and fertilizer. All of the existing skin has been removed and replaced by glass to create a greenhouse environment suitable for the growth and harvesting of crops.

Chapter 7: Conclusion

The industrial revolution was a major turning point in history for countries all around the world. This historical period led to an increase in technological advancements that changed the world forever. Breakthroughs in transportation, communication, agriculture, and manufacturing were the beginnings of many technologies used today. In order to facilitate these advancements, enormous forms of architecture on massive sites were erected as hubs for creative and industrial activity. Much of these immense structures were considered engineering feats for its time. Today, the further progression of modern day technologies has led to a shift in the development methods of many industries. This change in the dynamics of technology has left many of these former industrial epicenters underutilized and neglected.

As a response to the surplus in abandoned industrial lands, this thesis explores the rejuvenation of both building and site at the Philadelphia Navy Yard. Although shipbuilding has become a lost trade, the Navy Yard continues to emit a strong presence of its past industrial history. The initiative of this thesis was to repurpose a naval warehouse into a program that would not only reveal its structural potential, but to carry on its long tradition of production. As an agricultural research center, the transformation solves a problem much larger than the site itself while exemplifying the true possibility of these dormant industrial sites. From shipbuilding to food production, the transformation of this warehouse forges a paradigm shift in both sustainable agricultural methods and the potential of adaptive reuse. The application of this paradigm shift can be the catalyst in resolving the world's food production crisis while breathing new life back into these once technologically significant sites.

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