ABSTRACT

Title of Thesis: ARCHITECTURE AND WATER: AN AMPHIBIOUS SOLUTION TO URBAN FLOODING

Bryan Asson
Master of Architecture, 2018

Thesis Directed By: Lecturer Julie Gabrielli, School of Architecture

This thesis intends to address the phenomenon of urban erosion through an understanding and application of Metabolist principles. One of the core elements of the Metabolist movement is a versatile was a megastructure that would create a framework onto which program modules could be attached. Currently, cities like Cape Town in South Africa seek refuge as the water crisis looms overhead. However, In the United States continues to debate whether global warming is an issue. With storms and sea level changes becoming more prevalent it is clear that many cities and suburbs are at risk of being caught under water. At its core, this thesis exploration seeks to create proactive solutions to this global challenge by connecting people to the ecological systems that surround them. To achieve this, this thesis will look to determine place making modules and the interplay between a living space, a home, a community and an ecology.

ARCHITECTURE AND WATER; AN AMPHIBIOUS SOLUTION TO URBAN FLOODING

by

Bryan J. Asson

Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Master of Architecture
2018

Advisory Committee:
Professor Julie Gabrielli, Chair
Professor Karl Du Puy
Professor Hooman Koliji

Table of Contents

List of Figures

Chapter 1: Water and Architecture

Water v. Architectural Permanence

"Designs of purely arbitrary nature cannot be expected to last long." Kenzo Tange

Humankind's obsession with architectural permanence has existed since the times of the ancient Egyptians. Their pyramids sought to establish their culture and beliefs in the world. The creation of architecture is an intimate act because it represents the underlying values of its creators. Their architecture in turn became a means of "re-presenting" the world to themselves. Built form becomes important, not merely, in the fact that it creates shelter but rather because it creates a psychological symbol of where we stand in the world and our cultural significance. Architectural representation is important because it gives people a sense of place and being in the world. Water throughout the ages has been both a catalyst and destroyer to built-form and our sense of place.

Figure 1: Hydrology in Ancient Rome. Located in Tarragona, Catalonia, Spain. Image in the Public Domain

One of the major drivers of urban development is water. Water funds the generators which include agriculture, trade, transportation, technology and even

defense. The success of historic cities was often derived from their proximity to the water and later the technology that allowed them to move it closer to them via aqueducts dams, pipes and sewers (Figure 1). Water provides critical resources for humans and architecture. It becomes important because of its inherent ability to create secondary transportation and create energy. It provides navigation and trade through ports around the world and supplies energy in the form of water mills and dams. The benefits of water are numerous. One of the most important attributes of water is its ability to connect humans to the fourfold. The fourfold, according to Martin Heidegger, a famous German architectural philosopher, is comprised of mortals, the earth, the sky and the divinities.[1] Our connection to elements, such as water, helps one connect to that fourfold. It creates our sense of place and dwelling in the world. The role of architecture within this fourfold is to connect people to nature as a means of helping humans find themselves. Dwellings that connect people to the fourfold while timeless, can also suffer from this connection. Places like Venice which is known for its beautiful canals and mix of architecture and water are suffering from poor planning. It was built in a lagoon because of its defensible properties and later became a port largely known for tourism its location however, made it susceptible to sinking. Since 1930, Venice has seen 15 centimeters of sinking that if ignored could see the city left uninhabitable.[2] Water throughout history has created a boundary between where and how we build. Whereas urban development benefits from its proximity to the water, built form often seeks to distance itself from water at all costs.

---

[1] Heidegger, Martin, and Albert Hofstadter. *Poetry, Language, Thought*. New York: Harper & Row, 1975.

[2] Ammerman, Albert J., and Charles E. McClennen. "Saving Venice." *Science* 289, no. 5483 (2000): 1301-302. http://www.jstor.org.proxy-um.researchport.umd.edu/stable/3077613.

The shift became more apparent during the Enlightenment period when architecture was moving from a monolithic style of construction to a layered architectural kit of parts in which each layer maintained a specific purpose. Currently these layers are the façade, insulation, a vapor barrier and interior finish. Each of these layers are meant to be continuous and work in unison with roof and floor layers to keep water out. The façade which sometimes works as a rain screen is used to prevent water from entering the interior surfaces of the structure. The vapor barrier intends to prevent water that does get past the façade from diffusing through the layers and entering the interior surfaces of a structure. When water does make it through the buildings membrane multiple problems can occur.

Water as a Threat

Water that infiltrates the buildings surface can lead to mold, sickness and structural instability. Water and humidity can lead to mold between the temperature range of 40°F and 100°F the effects of this mold are not merely aesthetically unappealing but can also lead to sickness. According to research conducted by the 'American Real Estate Society', "Mold has been linked to a wide variety of medical problems, from bloody noses, nausea, diarrhea, hay fever-like allergic symptoms, skin and throat irritation, to respiratory problems such as asthma and hemorrhaging and neurological disorders such as headaches, memory loss and even cancer."[3] These affects come at the cost of the residents' heath and the owners' wallet. Mold according to some estimates can cost thousands of dollars to fix. Downspouts, a roof

[3] Zumpano, Leonard V., Suzanna Hartley, and Ken H. Johnson. "The Problem of Indoor Mold for Portfolio and Property Managers." *The Journal of Real Estate Portfolio Management* 9, no. 2 (2003): 187-92. http://www.jstor.org.proxy-um.researchport.umd.edu/stable/24882318.

element that guides water away from the base of a building, are a very important aspect of building design. When water is allowed to standstill near a building it can attract bothersome insects and allow water to penetrate the buildings foundation. Water that penetrates the foundation above the frost line has the ability to expand and contract based on the weather. This property allows for structural instability by forming cracks in the very foundation that holds the building up. Keeping water out is an imperative for any successful building structure. While there are many examples and ways to protect against water infiltration, global warming has become an increasingly bigger issue in the current architectural landscape. The most important of which being how global warming affects our architectural permanence.

The duality of water and architecture lies in the fact that it is necessary for the sustenance of urbanism but also is a threat to the very permanence of it. With sea level rise becoming more prevalent it is important to find ways to mediate architecture and water. The mediation of these elements allows inhabitants to maintain the stability key building functions while benefiting from the amenity of the water that surrounds it.

Climate Change

Climate change has become a topic of discussion over the past 50 years due to rising global temperatures. The major source of these rising temperatures is the greenhouse effect. The Greenhouse effect according to the National Resources Defense Council (NRDC), "occurs when carbon dioxide (CO2) and other air pollutants and greenhouse gases collect in the atmosphere and absorb sunlight and solar radiation that have bounced off the earth's surface. Normally, this radiation would escape into space—

but these pollutants, which can last for years to centuries in the atmosphere, trap the heat and cause the planet to get hotter"[4] these rising temperatures have led to a cycle in which the earth is progressively getting hotter which many scientist believe to be inevitable. The heat does more than simply making the use of air-conditioning skyrocket.

Global warming leads to the melting of glaciers, sea level rise, arid conditions and air pollution. The melting glaciers have allowed for massive displacement of water which is causing sea levels to rise rapidly. Storms which are beginning to happen more severely are creating massive flooding in cities with poor drainage and rural areas that are below sea level. Arid conditions are expected to become more pervasive due low humidity which allows for more forest fires similar to the ones California experienced in 2017. The duality between humans and water is one that has generally been understood and respected; climate change however, has become a disruptor of the relationship between the two. With sea levels rising due to global warming buildings are being forced to either adapt to the coming changes or be demolished. It is the duty of architects and urban planners to be proactive about finding solutions to these problems before they arise, by determining where and when these changes will occur and planning accordingly.

One of the effects on water that has become more evident in recent times is water availability. Cape Town, Africa has had to learn to cope with its own water crisis. Whilst the city is known for its water management, the diversity of its "water income" found the city trapped in a 3 year drought. To deal with the lack of water the

[4] MacMillan, Amanda. "Global Warming 101." NRDC. February 08, 2018. Accessed March 24, 2018. https://www.nrdc.org/stories/global-warming-101.

city created a conservation plan that limited its citizens to 87 liters per day with the goal of defeating a critical point, dubbed day zero that would limit them further to 50 liters (13.2 gallons) per day. Whilst Cape Town was progressive in its practices it still

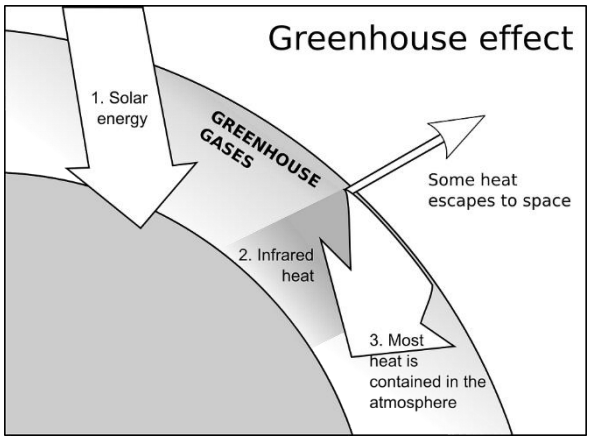

Figure 2 Green House Effect. Image in Public Domain.

suffered at the expense of the water crisis. Norimitsu and Somini of 'The New York Times a that, "those problems should serve as a potent warning to other governments [in Africa], which typically don't have this city's resources and have done little to adapt"[5] the way civilization adapts and plans for changes is very important because it allows people to be proactive about finding solutions rather than reactive. These problems have been finding their way to America in the form of severe meteorological conditions.

Storms have become more pervasive with the onset of global warming. Within the last 50 years storms have increased in both their number and severity. Storms like Hurricane Harvey, Irma and Maria have cost the government and families

[5] Onishi, Norimitsu, and Somini Sengupta. "Dangerously Low on Water, Cape Town Now Faces 'Day Zero'." The New York Times. January 30, 2018. Accessed March 24, 2018. https://www.nytimes.com/2018/01/30/world/africa/cape-town-day-zero.html.

millions of dollars in damage, “The insured property losses from Hurricane Harvey were estimated to cost between $1billion and $2billion from wind and storm damage”[6] according to CoreLogic these issues put stress on the government and rebuilding efforts. Storms like Harvey also displace and kill many people with terrible winds and flooding. Places like Puerto Rico and Houston suffered as residents found their houses and livelihood in ruins. How much global warming affects storms is debate but that fact that it does is undeniable. Recent hurricanes like Harvey, according to two independent research teams report that global warming increased precipitation anywhere from 15 to 38 percent more than should be normal.[7] While Houston suffered due to its poor drainage sea level rise is coastal regions has the potential to be far more severe.

Sea level rise is becoming a threat to building permanence and has the ability to change the landscape of live ability of many places along the east coast. Much of this change will be due to human carbon dioxide emissions. While much of the earlier predictions foretold of its disastrous effects newer studies predict it could be far worse. Scientist have created scenarios for sea level rise the worst being the high emissions scenario, “Under the high emissions scenario” Strauss, director of the program on sea level rise, claims that the”22nd century would be the century of hell. There would really be an unthinkable level of sea rise. It would erase many major

---

[6] Alan, Butterfield. "One Family's Desperate Fight to Live through Harvey: Survivor Says He 'didn't Stand a Chance' When His House Blew Apart in 130mph Winds as Two Are Confirmed Dead, Dozens Hurt and Flooding Looms." Daily Mail Online. August 27, 2017. Accessed March 24, 2018. http://www.dailymail.co.uk/news/article-4826838/Family-s-desperate-fight-survive-HurricaneHarvey.html.

[7] Achenbach, Joel. "Global Warming Boosted Hurricane Harvey's Rainfall by at Least 15 Percent, Studies Find." The Washington Post. December 13, 2017. Accessed March 24, 2018. https://www.washingtonpost.com/news/post-nation/wp/2017/12/13/global-warming-boostedhurricane-harveys-rainfall-by-at-least-15-percent-studies-find/?utm_term=.9d57bb05c39b.

cities and some nations from the map … That century would become the century of exodus from the coast."[8]The cause of sea level rise is attributed to glaciers from Greenland and Antarctica which have been destabilized by warm weather and are melting at a rapid pace. The 2 main reasons that account for this rapid melting are marine sheet ice instability and hydro fracture. Marine sheet ice instability refers to the fact that a lot of the melting ice is located on a downward facing slope, new warm water allows ice to melt and expose more ice, thus creating an irreversible cycle. Hydrofracture the other ice melting catalyst, is introduced when ice melts at the top of a mass and causes it to split. This split allows for cliff collapse where ice can then rapidly melt in warmer waters.[9] By the end of the century many see a total of a 6 foot change in sea level which doesn't bode well for areas on the periphery of civilization.[10] Florida is a coastal city that has been facing new challenges with the rise of its waters. These issues however are on a 20-30 year track to get worse. While many visitors don't notice the 3rd of an inch change in water height a year, the residents and fishers do. Different saltwater species are being found where they weren't before. With average projections set to see levels rise around 17 inches by 2030 there are a lot more problems in store for Florida. Seventeen inches becomes far more critical when considering that, "with just a 9-inch rise in sea level, NOAA advisories for coastal flooding capable of causing 'significant risks to life and

[8] Dennis, Brady, and Chris Mooney. "Antarctic Loss Could Double Expected Sea Level Rise by 2100, Scientists Say." The Washington Post. March 30, 2016. Accessed March 24, 2018. https://www.washingtonpost.com/news/energy-environment/wp/2016/03/30/antarctic-loss-coulddouble-expected-sea-level-rise-by-2100-scientists-say/?utm_term=.ee7e1b3d31f3.
[9] Dennis, Brady, and Chris Mooney. "Antarctic Loss Could Double Expected Sea Level Rise by 2100, Scientists Say." The Washington Post. March 30, 2016. Accessed March 24, 2018. https://www.washingtonpost.com/news/energy-environment/wp/2016/03/30/antarctic-loss-coulddouble-expected-sea-level-rise-by-2100-scientists-say/?utm_term=.ee7e1b3d31f3

property' could occur 25 times more often" said Sweet, lead author of NOAA's January report.[10] These problems may catch Florida before it's able to adapt its infrastructure to face its problems, which is dangerous considering the risk to property and civilians alike.

According to one worker for the city some infrastructure is already inadequate, "The water level is 5 to 6 inches higher than when drainage pipes were installed 50 or more years ago" which creates problems because, "when it rains heavily we have an issue because the water just can't get out of the canal or storm water basin"[12] Fixing these problems cost time and money but also government acceptance of the problem that is global warming.

Climate change is heavily affecting the residents of Miami. The city according to Gus Lubin at 'Business Insider' is set to take on 3.5 trillion dollars in damage to assets if nothing is done to mitigate its effects. Flooding is especially severe in Florida because its built on porous limestone which is seeing water rise up through the ground floor. To alleviate these problems Miami has invested 400 million dollars in south beach alone; investing in pumps, wet lands and raising elevations in the hopes that enough can be done to mitigate the rising sea levels.

A Catalyst for Change

Acceptance of climate change as fact has gained consensus in the scientific world however, in America fact and fiction have changed along with its leaders. Climate change in the United States is very much a partisan issue. While many

[10] Pulver, Dinah Voyles. "Sea Level Rise Is Accelerating in Florida, Scientists Warn." The Washington Times. July 20, 2017. Accessed March 24, 2018. https://www.washingtontimes.com/news/2017/jul/20/sea-level-rise-is-accelerating-in-floridascientis/.

remember Al Gores film, 'An Inconvenient Truth' which gained notoriety in 2006, many have also disregarded it as a money making attempt. The truth behind Global Warming must be accepted socially and politically if any changes can be made and accepted in society. One major factor that affects our social views toward global warming is party identification, "Scholars have long held that one's party affiliation represents a broader social identify and psychological attachment" this ideal has plagued many scientists who warn of global warming but are shunned simply because of politics. These political ideas see republicans as 30 percent more likely than democrats to believe global warming is a myth. Ignorance promoted by partisanship ignores fact and allows climate policy to be affected by individuals who admit they don't know much about the issue.[11] On a societal level care for the environment often relates to peoples personal experiences. A study by Hamilton and Keim in 2009 found that, "perceptions of global warming are significantly related to temperature changes in the respondent's area of residence."[14] The sad proof of this theory reveals itself in the history of global warming in America. According to surveys taken by the Gallup and Pew organizations, belief in global warming had risen from 50% in 2000 to 70% in 2008 however this growth ended in 2010 when there was a 20% drop due to record snowfall. The schism between science and politics is a division that important because it creates holistic policies that affect the globe. These political gestures affect when, how and if we create solutions to the problems we face.

The task of architects, landscapers and architects is to consider future predictions of sea level rise and its effect on the built environment and creating

[11] Borick, Christopher P., and Barry G. Rabe. "A Reason to Believe: Examining the Factors That Determine Individual Views on Global Warming." *Social Science Quarterly* 91, no. 3 (2010): 777-800. http://www.jstor.org.proxy-um.researchport.umd.edu/stable/42956430.

planning solutions which don’t force the retreat of architecture but rather embraces the changes thus allowing humans to fully connect with their environment.

Chapter 2: Background of Metabolism

Kit of Parts

Japan is a county in East Asia steeped in its cultural history and technological progressiveness. As a sovereign island, japan, developed largely independently from outside sources. The determinates of Japanese architecture according to Arata Isozaki lie between "Japan and the West, somewhere between Japan's own nostalgia and utopia, recurrently mutating and reincarnating itself, evading any fixed recognition" [12] Its independence allowed the island to create a framework of guiding principles that would inform its building design and technique. The framework of context, class and religion allowed Japan to create a kit of parts that became a module for its design.

The essential kit of parts included the Tatami, Shoji, and ken.

The kit of parts create a module that can be mixed and matched according to user type but allow for a mass production of the parts key to Japanese living. Tatami mats are premade rugs of rice and straw that come in two ratios: 2:1 "regular" mats and half mats which are 1:1. Tatami are often structured as modules which create a multitude of room sizes and organize their function. While the room sizes change the system remains present within the rooms' proportions. The second elements are shoji screens which are a translucent wall system used to subdivide the rooms. Lastly the Ken is an organizing system based on six Japanese feet that helped to create a rational datum between these elements. While these were traditional ideas they remain ever

[12] Bharne, Vinayak.

present in modern Japanese structures due to Japans reverence for its past. The link between Japans past and present would become linked through the work of Kenzo Tange and the Metabolists.

Kenzo Tange

Japan is a county in East Asia steeped in its cultural history and technological progressiveness. As a sovereign island, japan, developed largely independently from outside sources. The determinates of Japanese architecture according to Arata Isozaki lie between "Japan and the West, somewhere between Japan's own nostalgia and utopia, recurrently mutating and reincarnating itself, evading any fixed recognition" [13] Its independence allowed the island to create a framework of guiding principles that would inform its building design and technique. The framework of context, class and religion allowed Japan to create a kit of parts that became a module for its design.

The essential kit of parts included the Tatami, Shoji, and ken.

The kit of parts create a module that can be mixed and matched according to user type but allow for a mass production of the parts key to Japanese living. Tatami mats are premade rugs of rice and straw that come in two ratios: 2:1 "regular" mats and half mats which are 1:1. Tatami are often structured as modules which create a multitude of room sizes and organize their function. While the room sizes change the system remains present within the rooms' proportions. The second elements are shoji screens which are a translucent wall system used to subdivide the rooms. Lastly the

[13] Bharne, Vinayak.

Ken is an organizing system based on six Japanese feet that helped to create a rational datum between these elements. While these were traditional ideas they remain ever present in modern Japanese structures due to Japans reverence for its past. The link between Japans past and present would become linked through the work of Kenzo Tange and the Metabolists.

Japan is a county in East Asia steeped in its cultural history and technological progressiveness. As a sovereign island, japan, developed largely independently from outside sources. The determinates of Japanese architecture according to Arata Isozaki lie between "Japan and the West, somewhere between Japan's own nostalgia and utopia, recurrently mutating and reincarnating itself, evading any fixed recognition" [14] Its independence allowed the island to create a framework of guiding principles that would inform its building design and technique. The framework of context, class and religion allowed Japan to create a kit of parts that became a module for its design.

The essential kit of parts included the Tatami, Shoji, and ken.

The kit of parts create a module that can be mixed and matched according to user type but allow for a mass production of the parts key to Japanese living. Tatami mats are premade rugs of rice and straw that come in two ratios: 2:1 "regular" mats and half mats which are 1:1. Tatami are often structured as modules which create a multitude of room sizes and organize their function. While the room sizes change the system remains present within the rooms' proportions. The second elements are shoji screens which are a translucent wall system used to subdivide the rooms. Lastly the

[14] Bharne, Vinayak.

Ken is an organizing system based on six Japanese feet that helped to create a rational datum between these elements. While these were traditional ideas they remain ever present in modern Japanese structures due to Japans reverence for its past. The link between Japans past and present would become linked through the work of Kenzo Tange and the Metabolists.

Emergence of Metabolists

In 1953 Kenzo Tange was invited to visit The Ise Shrine a rare and special invitation and symbol within the Japanese culture. The shrine is quite unique in the fact that it is reconstructed and demolished every 20 years. This process is very much similar to The Ship of Theseus Paradox, in which the old structure is demolished whilst a new structure is built on the adjacent property. The structure is allowed to age over time. By the time the new structure is built, the old structure appears worn. Its untreated thatched roof is often covered in moss and its paint worn by the weather. Tange was very influenced by the visit to The Ise Shrine. He wrote a book, "Ise: Prototype of Japanese Architecture" which praised the very same elements he had been attracted to in his own ideals of traditional Japanese architecture. He lauded its functional design and prefabricated elements. Later referring to the 20 year process as a natural process, (read: Metabolic)[15].Zhongjie Lin, writer of Kenzo Tange and The Metabolist Movement argues that this building would have extreme significance on Tange's next career move. Lin's thesis being, "By equating Japanese architectural practice with natural processes, the Metabolists

[15] Tange, Kenzō, and Noboru Kawazoe. *Ise, Prototype of Japanese Architecture*. Cambridge, MA: M.I.T. Press, 1965.

hoped to rediscover a true Japanese tradition that would not only transcend the naïve imitation of form in the prewar period, but also trump the mechanical and unnatural methods that predominated the west"[16]

Figure 3 Ise Shrine Geku. Image in the Public Domain

Metabolists would soon emerge during the World Design Conference. By 1946 Kenzo Tange spent a majority of his time as a teacher, who was very much involved in his student's careers, much like his mentors were for him. They often ate together and worked in Tange's home which was joked of as an incubator for inquiring minds. In May of 1960 Louis Kahn would make his first and only journey to Japan for the World Design Conference. This was a unique opportunity for young Japanese architects because it allowed them to interact with their European and American peers. Kiyonori Kikutake, a student under the leadership of Tange invited Kahn post-lecture to talk about his own designs. Kikutake showed him, Skyhouse. This building would later help to take elements apparent in Tanges earlier buildings (Hiroshima Memorial Peace Park and Tange's Home) to the next level, and thus diverging

[16] Lin, Zhongjie. *Kenzo Tange and the Metabolist Movement: Urban Utopias of Modern Japan*. New York: Routledge, 2010.

further from Corbusier's own works. In this project Kikutake supported his house on piloti however this consisted of 4 monolithic columns, He put utility spaces on the exterior of the structures floorplan which helped to provide for flexibility of the interior plan as well as the possibility for future addition and renovations.

Kikutake's talk led to Louis Kahn's most informative seminar on the distinction between form and design. In this talk he referred to form as having no shape and no design saying it, "-represents a sense of order a harmony of systems" whilst design on the other hand, "is a circumstantial act evolving from form." He then gave an analogy to a spoon. Kahn states "The design of a spoon can vary in material, mold and size, how that a spoon proves to be a spoon however is due to its form consisting of a cuplike container and an arm"[17] He applies this technique to his own design of Richards Medical Research Lab in Philadelphia which would in turn help inspire the Metabolists future concepts. The Laboratory much like Kikutakes', Skyhouse places private functions and facilities on its exterior. These facilities take the shape of towers which act seemingly independently of its façade. This articulation of private vs public spaces would become a key influence in the ideals of Tange and his students. Tange saw this feature as a solution to his own goals of permanence and adaptability.

After the meeting expired the young architects were invited to another conference, to represent the whole of Japan. They would not go unprepared. Kenzo Tange and his group of students and peers put together a series of projects based on urban design drawings by, star pupil, Kikutake and his 'Marine City' His city used the organic principles of metabolism and thus Metabolism would inspire the groups own

[17] Lin, Zhongjie. *Kenzo Tange and the Metabolist Movement: Urban Utopias of Modern Japan*. New York: Routledge, 2010.

interpretations of the word. Urban planning was a very important topic of these discussions because it was part of a rebuilding effort in a post-World War II Japan at a time when contemporaries, Archigram were also thinking of avant garde ways to redevelop devastated European cities. These ideas were very spectacular in size and scale using megastructures, steampunk-esque powered robots and new urbanist ideas.

Figure 4: Archives of Kiyonori Kikutake (2016). Sky House. [image] Available at: http://archeyes.com/sky-house-kiyonori-kikutake/ [Accessed 15 May 2018].

Chapter 3: Works of the Metabolists

The Metabolist Manifesto

The Metabolists weren't much different from their European contemporaries. They used concepts Tange learned though his own studies of Le Corbusier's Ville Radieuse and blended it with what they learned from Kahn and their own Japanese history. Metabolism as defined by the Merriam-webster dictionary, "the sum of the processes by which a particular substance is handled in the living body", it is one such process that is essential to life. To the young Japanese this took a different meaning. The word Metabolism in Japanese translates to, "Shinchin Taisha" which has an idiomatic meaning of, "out with the old, in with the new". They maintained the English translation however as a means to communicate this value on a more practical and international scale. Metabolism has a broad definition that applies to many biological processes, consequently the Metabolists themselves remained divided on what metabolism truly meant. One design strategy conceived of the city as one gigantic building and proposed organization and hierarchy of the buildings around megastructures that determined the configuration of smaller elements (ie. Tokyo Bay Plan) The other design strategy used a grouping of smaller elements to make a whole form (ie. 1968 Housing Competition of Per, Tanges Mekka plan in 1974) many of these elements found their way into the manifesto.

The Manifesto contained several important design plans including "Tower-Shaped City," "Marine City," "Neo-Tokyo plan, ", "Wall City," "Architectural City" and "Mushroom-shaped house" however one of the most important of the bunch was

the original concept: “Ocean City Unabara”. In this plan Kikutake created an Industrial City intended for 500,000 residents. The layout consisted of two rings. The inner ring for housing and the outer for production. The body of water between the two layers is used for fish farms whilst the inner ring is used for recreation and swimming. The overall design seems to be a criticism of the countries Marxist history by creating a class system literally based on inner and outer rings. Population control was also important in this plan. The overlying rule in this strategy was that once the population reached its limit, the city would multiply as a means of cellular division thus the idea Metabolism became self-evident.

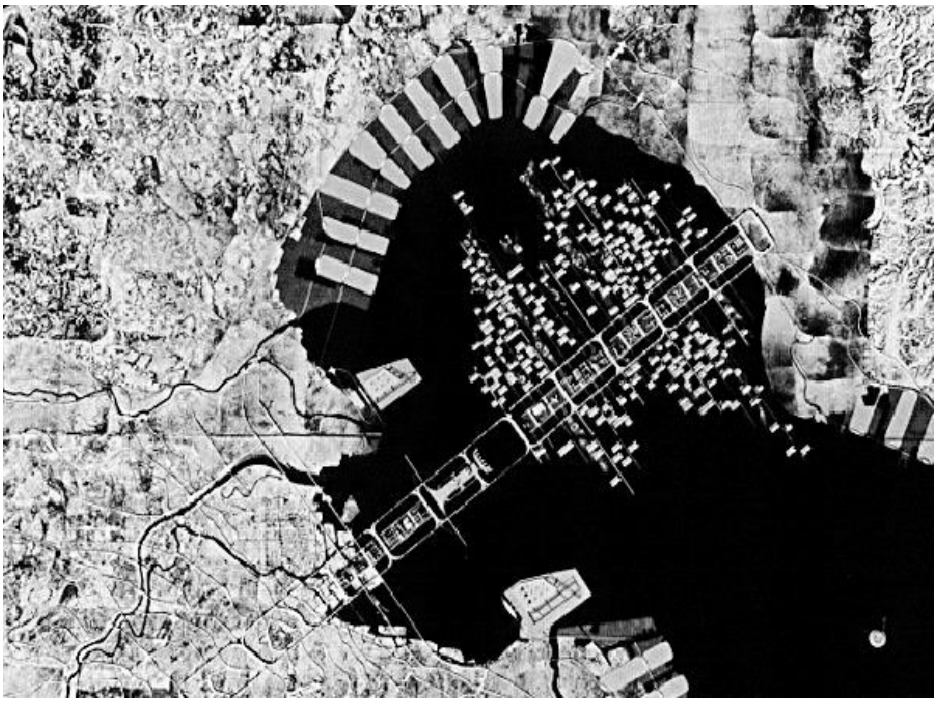

Figure 5 Tange, K. (2018). Kenzo Tange's plan for Tokyo Bay. [image] Available at: https://dprbcn.wordpress.com/2010/05/10/floating-cities-reloaded/#jp-carousel4338 [Accessed 15 May 2018].

The Tokyo Bay plan was yet another important urban design project that was developed by Tange, himself. The plan applied Metabolist principles in their

experimental as an expansion of Tokyo into the Tokyo Bay. This linear expansion allowed for a modular addition that evolved over a series of phases. The plan uses a megastructure to connect the existing transportation systems through the bay. The project would carry an estimated 5 million people daily. The use of the megastructures also allowed for a system of organization for buildings and future instalments much like the ken and tatami did for Tange's own built structures (Memorial Peace Park, Tange's house) In this structure, public buildings could be added within the main roads while the residential structures could be added to its exterior much like Khans' Laboratories had inspired thus further establishing the difference between public and private spaces. The plug and play relationship and expandability features which are key in all Metabolists structures are undoubtedly an homage to The Ise Shrine which inspired it. While these structure's were never fully realized, they helped Metabolists gain notoriety. This would allow the metabolists' intangible ideas to be built and experienced. One such building was The Yamanashi Press and Broadcasting Center.

Architectural Analysis

The Yamanashi Press and Broadcasting Center developed by Tange in 1961 is a building project that resembles Richardson Medical Research Laboratories more than it does a typical Japanese structure. Tange developed a building based on what he calls, "a three dimensional space network" The building was intended to house 3 media firms and uses a sub diving strategy to allow the firms to share facilities. Offices are located in the middle of the building and surrounded by balconies to let in natural light in much like the Skyhouse that proceeded it. The service spaces

(elevators, stairs, piping, equipment rooms and sanitary) are all ground loaded into reinforced concrete towers with diameters of 5 meters. These towers were created to allow for changing technologies and expansion on the exterior of the building.

Figure 6 Yamanashi Press and Broadcasting Centre. Image in the Public Domain.

When looking at Metabolist structures it's often hard to see the differences between them and brutalist ones. They share many common elements. They both use concrete generously which was a very powerful technology. Le Corbusier's use of reinforced concrete in the Domino House helped to push what one could do with concrete. The two typologies also create monolithic landmarks with large heavy effects on the land much to the contrast of contemporary Corbusian structures that use piloti. The lack of decoration and color are also quite similar. Both typologies seem to be about exemplifying the qualities of permanence and creating a sense of place.

Structures such as the Pyramids which are brutalist in nature have become symbols of a place and culture which brutalism attempts to harmonize with architectural form. The biggest difference that makes Metabolism uniquely different

from that of Brutalism however is its biomechanical nature. Metabolisms reproductive processes allow for its permanence. The building shafts allow for the revival of its utilities and technology. These features set it apart from its more archaic relative, brutalism. It can be argued that if Metabolism is an organic process, then Brutalism is a rock slowly eroding away for it didn't look far enough into the future. Ironically some Metabolist structures fall into the same trappings as brutalist architecture. The Yamanashi building for example, did not expand on the exterior as Tange originally hoped for.

The building currently remains alien within the context of its location.

Figure 7 Nagakin Capsule Tower. Image in the Public Domain.

Another important structure within the multitude of projects built by the Metabolists is The Nagakin Capsule Tower. This structure is important because it became the poster child for the Metabolist movement. The project was created in 1972 by Tanges' student Kisho Kurokawa it's a residential hotel that prominently features individual rooms around a central core comprised of an elevator and stairs. The building makes use of many ideals key to Metabolist structures. It makes use of

prefabricated elements or modules in the form of housing units. It also uses a megastructure as its core upon which the units are attached. This allows for rooms that can be updated with time and replaced on a schedule. While the capsules are small for the individual user, the interior supports a kitchen bath and bed. The amount of units help to create unique exterior, making it look very much like a city. Where Le Corbusiers Radiant city led him to Unité d'habitation the compilation of the Metabolists work had seemingly led them to Nagakin Capsule Tower two building ideals with divergent paths.

Fall of Metabolism / Diaspora

By the 1980s Metabolist buildings and projects began to fade out of existence. The Oil crisis was partly to blame it made places like Africa gain an economic boom of sorts the helped to create a diaspora of Japanese architects on an international level. This spread helped to weaken the movement from its own ideals to more independent projects. Buildings like Nagakin Capsule Tower began to be seen as a failure and that's partly due to how high maintenance these buildings are.

Currently the Capsule Tower is in a state of purgatory. After its construction the rapid growth of Tokyo required updates at the scale of a building beyond the individual units. Poorly maintained units that were meant to be replaced every 25 years were soon falling into complete disarray. The building began to fall apart with a stunning 80 percent of residents voting for its demolition so that new infrastructure could be created. Ironically its megastructure which was built to last 200 years would cost more to demolish than would be cost effective. Before his death Kurokawa fought for the building to remain. It's now owned by a private corporation

that auctions rooms to individuals in hopes of preserving its legacy. Whilst the more simple architecture of brutalism can be critically and harshly compared to that of a rock, Metabolist architecture can in some cases be doomed to the same fate. Whereas the precedent, Ise Shrine is allowed to wither and age before it is rebuilt every 20 years Metabolist structures are not and cannot be given the same leniency. They must be updated and replaced upon a regular time schedule otherwise the results are nothing more than a failure of the goal Tange and his students set of, permanence and growth in Japan.

Post metabolism in the 1980's Tange went on to participate in a multitude of great buildings that vary in size scale and place. Buildings such as Yoyogi National Gymnasium, the Tokyo Metropolitan Government Building and St. Mary's Cathedral are all building which seemingly took a drastic turn from his Metabolists past. Tange would gain multiple accolades before his death in 2005, the most important of which being the AIA gold award he received in 1966. The importance of Tange was his ability to mediate traditional Japanese values with contemporary western ones. His students were through his teaching able to impact the culture of Japan and teach on their own as well current Japanese architects such as Toyo Ito, Tadao Ando and Kengo Kuma all directly and or indirectly learned from Tange. Ando went on to say, "Tadao Ando, one of Japan's greatest living architects, likes to tell the story of the stray dog, a stately akita, that wandered into his studio in Osaka some 20 years age,

and decided to stay. "First, I thought I would call her Kenzo Tange; but then I realized I couldn't kick Kenzo Tange around. So I called her Le Corbusier instead"[18]

[18] Glancey, Jonathan. "Obituary: Kenzo Tange." The Guardian. March 23, 2005. Accessed March 31, 2018. https://www.theguardian.com/news/2005/mar/23/guardianobituaries.artsobituaries1.

Chapter 4: Precedent

Precedent

Climate change is quickly becoming a more prevalent issue within the architectural landscape. It is important that architects consider the present as well as the future projections of sea level rise. These projects have implications that directly affect heath, money and sense of place because they affect the permanence of the structures that people call home. By planning for these issues and using Metabolist principles architecture can create a system that invites these changes and promotes expandability and adaptability. In reaching these goals it was important that the program be conducive in exploring the ways in which a community develops. The best way to create and environment for this is a Mixed-Use development that allows users to live, work and eat from the comfort of their home. These elements create an ad hoc community through a kit of parts that allows users to grow and change. Each part of this structure becomes more apparent through precedent research. The key architectural precedents are split into three main categories, metabolism, water and modular units. These sections help inform how the building will be designed and the problems it needs to address. These problems include, the way in which the building deals with the Metabolist philosophies, how it deals with water and how it meets the ground. The philosophical principles of the building are guided by the Metabolists movements' architecture and planning.

Tokyo Bay Plan

Kenzo Tange, de facto leader of the Metabolist movement, developed the Tokyo Bay plan as part of a series of drawings that would define metabolism. In the Tokyo Bay plan, Tange saw and expansion of Tokyo onto its bay, as a means of, creating expansion for the city. In this expansion he used a megastructure in the form of a road network that would sponsor a ruleset for attached modules. These attached modules were residential units which attached on the roads exterior and civic buildings which attached to the road infrastructures interior. This building relates back to the goal of this thesis because it expands on the water to gain space in a densifying japan. This project seeks to do much of the same by addressing sea level change as it expands onto urban infrastructure. Another important Metabolist structure is the Yamanashi Press and Broadcasting Centre.

Figure 8 Tokyo Bay Plan. Arch Eyes. Tokyo Bay Plan. Image, 2018. Accessed May 18, 2018. http://archeyes.com/plan-tokyo-1960-kenzo-tange/.

Yamanashi Press and Broadcasting Centre

The Yamanashi Press and Broadcasting Centre developed by Tange in 1966 sees a more brutalist take on the Metabolist movement and the module. The Centre connects 3 programmatic elements and provides and open floorplan with room for expandability. One of the defining elements of this brutalist concrete center however is that ability to update the buildings technology. This ability is seen through several 5 meter diameter cylinder shafts which break vertically through the space to provide service and utility spaces. This module allows for technology to be updated, but also created a rubric for the division of public and private spaces.

Figure 9 Yamanashi Press and Broadcasting Centre. Image in the Public Domain

Another important topic of discourse within the buildings precedent research is water. Water determines how this building meets the ground. There are several ways in which architecture treats water. It can have a sacrificial floor in which the ground floor is allowed to flood. It can be put on stilts and remove important elements from the ground plane. It can be a floating structure where it is placed on the water or it

can be flood resilient. With these factors being set it was important to research a variety of these precedents to determine how architecture can have a discourse with water.

Makoko Floating School

The first water precedent is the Makoko Floating School done by NLE architects. It uses buoyancy to create a school that floats. Its modular system creates a building that is meant to link with other structures to create a school complex on the water. It weakness however came when rather sever winds hit and demolished it wooden structure. The temporary nature of this structure plays to the sustainability of its module.

Figure 10 Makoko Floating School. Image in Public Domain.

Flood House

Another important water structure is the Flood House a conceptual architectural project done by f9 Productions this house sits on stilts and creates a minimalist floorplan as a means of allowing for the least flooding possible all whilst planning for the event of a flood where residents can escape to safety on an elevated back porch.

Figure 11 F9 Productions. Flood House. Image, 2018. Accessed May 18, 2018. https://www.archdaily.com/138242/flood-house-f9-productions/f9-main.

Amphibious House

Lastly the Amphibious House by Baca Architects is a house that uses rather unique properties to remain afloat during flooding issues. Located on the River Thames in Buckinghamshire, Marlow it uses the Archimedes principle of buoyancy to displace itself and rise with the water levels the surround it. Using all of these properties is key in understanding the changing ground plane created by sea level rise however another issue that arises is the treatment of modular systems.

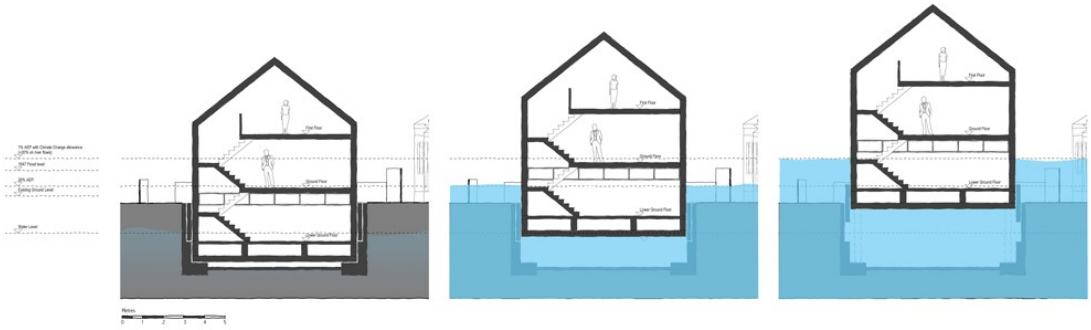

Figure 12 Dezeen. Amphibious House. Image, 2018. Accessed May 18, 2018. http://static.dezeen.com/uploads/2014/10/Formosa_The_Amphibious_House_by_Baca_dezeen_0_1000.gif.

Homed

Modular systems as treated by the Metabolists were prefabricated elements that were small and upgradeable however as seen in the Nagakin Capsule Tower they were perhaps to small when compared to the cultural differences pervasive in American culture as such it is important to understand the ways modular systems can be done and how they can interact with one another to become larger.

One example of modular treatments researched is Homed a shelter space created by architects at Framlab which saw a modular system of prefabricated rooms that each join together through a central. This is a different take on the modular unit opposed to the one seen in the Nagakin Capsule Tower in which the entire unit was the module. The strength of this idea is the fact that it allows multiple rooms to work together with some units containing more rooms than others.

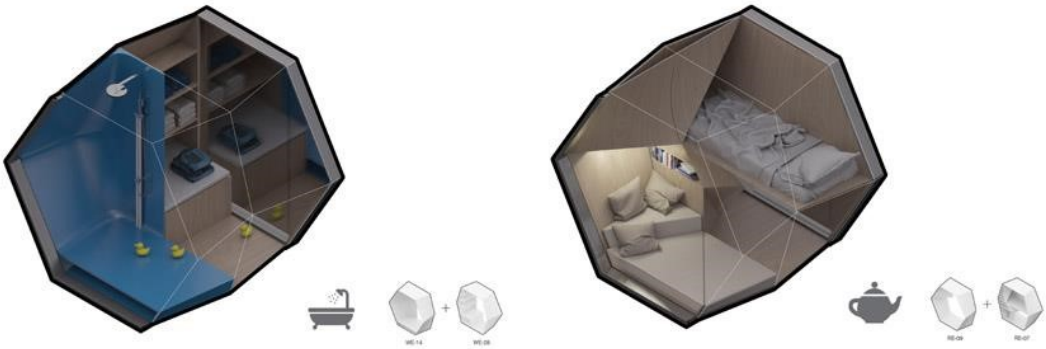

Figure 13 Homed. https://www.inexhibit.com/wp-content/uploads/2018/01/Framlab-Homed-New-York-interior-3-4.jpg

Eco-pods

Another modular system that was researched were the eco pods designed by Howeler and Yoon this unbuilt form saw pods as a unit which used algae as a bio fuel which was moved around in accordance with the sun. The strength of this precedent les in its manipulation in accordance with changing circumstances and the ability for pods to interact with one another in any direction they faced. This allows for a system that like Lego pieces is truly modular

Figure 14 Howeler and Yoon. Eco-Pods. Image, 2018. Accessed May 18, 2018. http://www.howeleryoon.com/projects/eco-pods.

Chapter 5: Location

Site Selection

Sea level rise was an important factor in the decision making process of determining a site location. While sea level is threat predominantly in coastal areas the site also needed to address access to roadway infrastructure, population density, and its proximity to construction equipment and local amenities. With recent events in Houston, Texas due to flooding it became the initial topic of research. It dealt with severe flooding that turned many of its residents into refugees. Its access to a dense urban population and roadway infrastructure made it a great candidate however because it was inland it suffered due to poor drainage rather than sea level rise. Another candidate was The Keys in Florida which are in threat of sea level rise. The 7 mile bridge which connects the islands is in a state of disrepair. The distance between Florida and Houston from Maryland prompted a site that was more local to Maryland so that research and site analysis could be conducted on site. The site selection was narrowed to three particular areas in Maryland afflicted with climate change. The first being Kent Island which had great infrastructure in the form of the Chesapeake Bay bridge. Its historical building typology and low density however created concern for the number of people addressed with the building solution. Middle River, the next location in Maryland had a higher density but still struggled with managing a connection to a road way infrastructure.

Dundalk, the final site location had a higher density then the previous sites and a lot of unused land which made it a prime location for the thesis's architectural solution. The biggest strength of the site however was its location to the Dundalk

marine terminal. The marine terminal serves as one of Maryland's largest ports. Adjacent to the site is Sparrows point which is set to see 2.9 million dollars in economic growth and 17,000 new jobs to the site. While the site has a lot of great aspects it is also dealing with a lot of problems in its future context.

Flooding is a major issue on the site and will see an expected 10 feet to the site in total flooding due to 1 storm event by 2100 (see figure 36). The area is also set to take in numerous flood waters due to sea level rise. This sea level rise will most critically affect nearby residents who will have their assets affected by 4 feet of sea rise (see figure 34) in 2100.

Figure 15: Flooding Present. NOAA

Figure 16: Sea Level Rise 2050. NOAA

Figure 17: Sea Level Rise 2100. NOAA

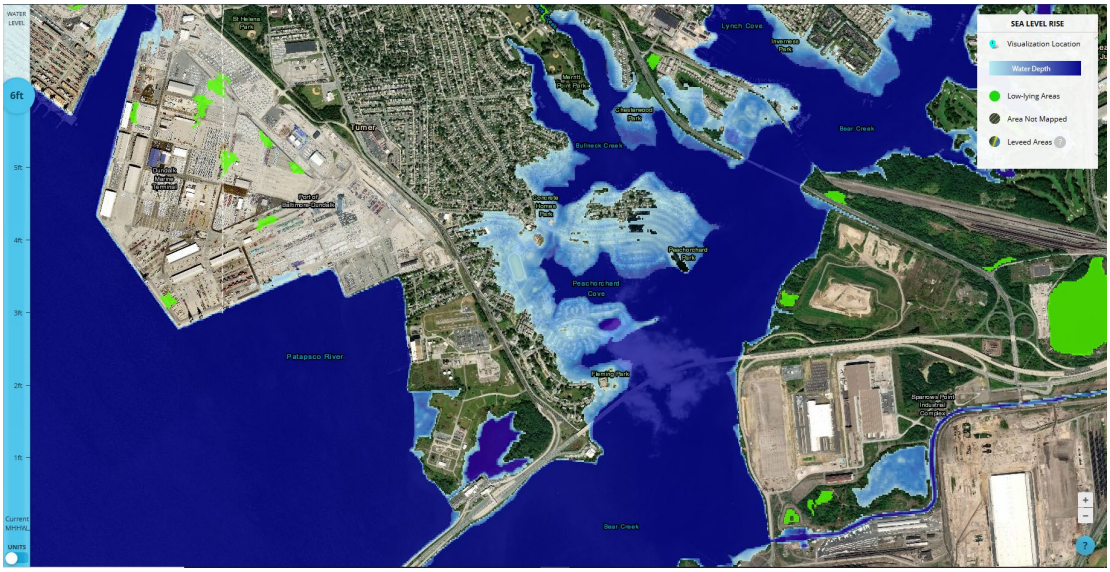

Figure 18 Sea Level Rise 2150. NOAA

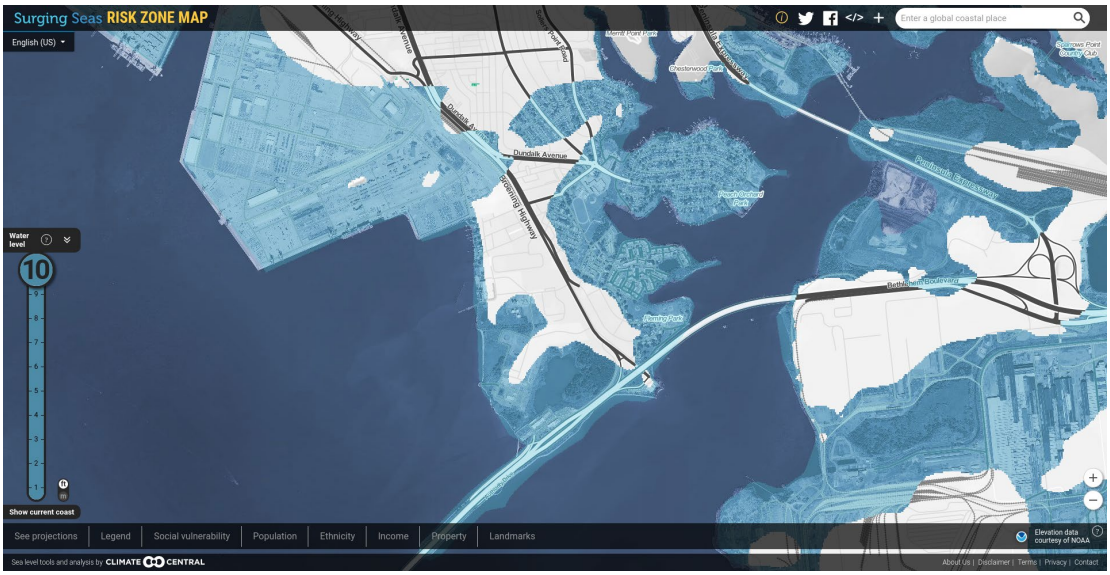

Figure 19: Flood Risk Areas during 10 Feet Flood. NOAA

The effects of flooding on the site create an adequate testing ground for application of principles learned by other aquatic urban design and architectural solutions.

Chapter 6: Solution

Amphibious Solution

The amphibious design solution was created to solve the many problems encountered on the site.to create a manifesto of design principles both goals and rules were created and adhered to during the design process.

The first goal being providing a safe place for people to live and thrive in flood conditions. This goal speaks more to the resilience of the site in creating a place that allows people safe egress from the site during flood conditions and also protects property and their assets so that people can return to these spaces once the water recedes. The second goal was to create a green infrastructure and water sensitive urban design that would allow for an interactivity between pedestrians, vehicles and the effects of rising water. The third goal was to show the community how they intersect with the ecological system. This goal sought a means of helping the output of the community at a ground level and influencing a better future at the level of an individual. Showing each individual and their impact on the environment would hopefully help show them ways to improve by connecting them to the larger systems that encompass them. To achieve these goals a ruleset was established.

The first and most important rule is that the buildings should adapt to sea level rise. This is necessary for the buildings to provide the safest possible space for community efforts during the most difficult periods. The second ruleset is that landscape and architecture should be treated with the same care. Buildings and their systems need to operate in tandem to best control and disperse water within the

environment. The third ruleset is that buildings should be modular and adaptable. To make the development cheaper local facilities (The Dundalk Marine Terminal) should be taken advantage of to create buildings that are a part of their environment. The last ruleset is that the Building technology should facilitate the environmental changes and use the water to its benefit.

Kit of Parts

When designing the building it was conceived of as a kit of parts (see figure 37) in which the environmental system could create its organizing infrastructure. These kit of parts, following the ruleset that buildings should be treated as one and the same, were subdivided into two categories. The first category being architecture and the second landscape. The architectural kit of parts includes 4 different residential buildings which deal with living at 4 scales as well as utility buildings. The utility buildings are comprised of commercial buildings, parking, waste management and pump facilities each of which is necessary in the management of the sites systems. The landscape features do much of the same. But tackle the water areas of the site most heavily. The canal which cuts through the site is controlled by the pump facilities on site but also functions as a node that deals with the transportation of people and creating a sense of space.

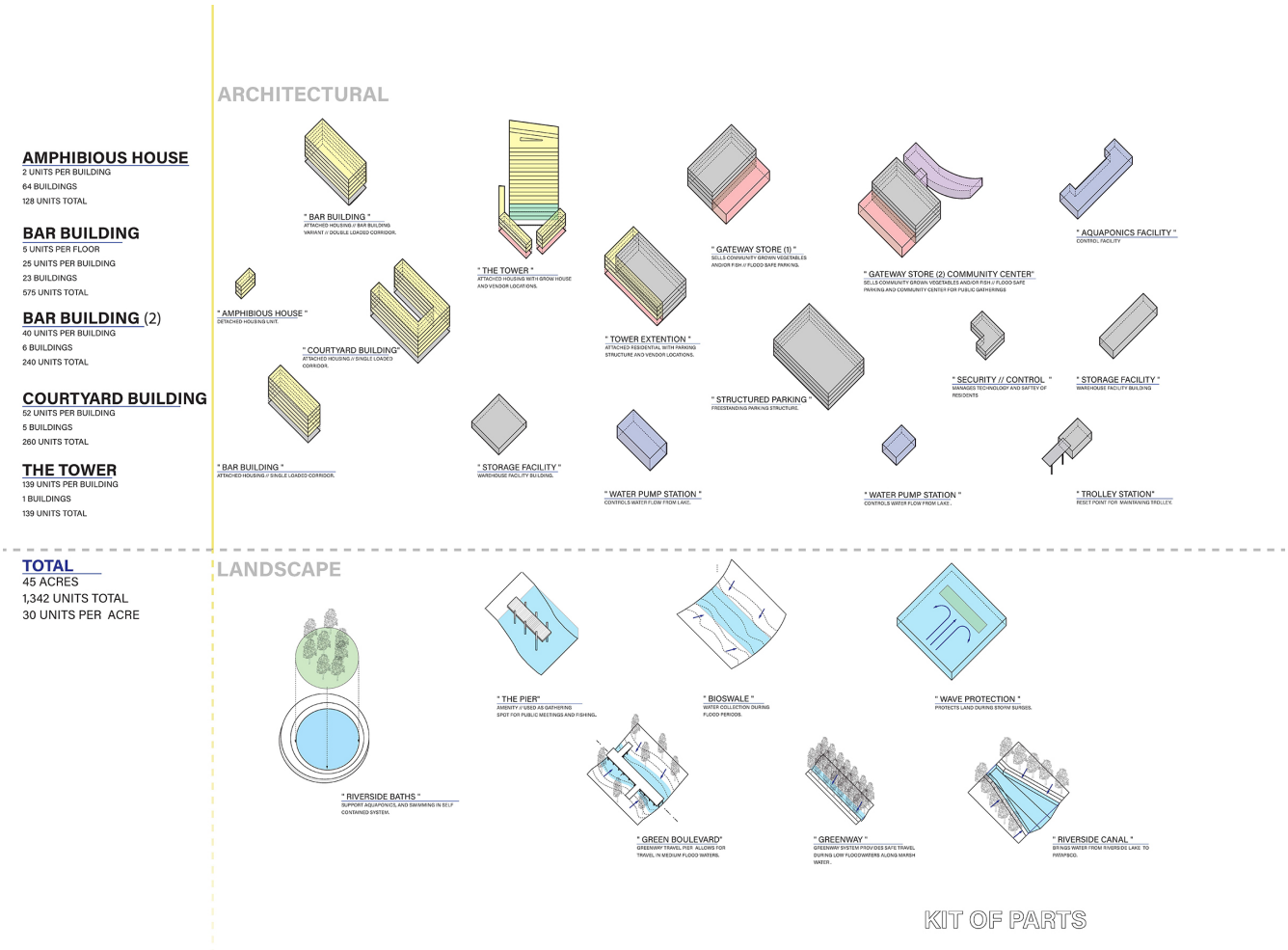

Figure 20: Kit of Parts. Image by Author.

Systems

Thinking about the systems for which the developed kit of parts fit in was also important to the 'Amphibious Solution' (see figure 38)

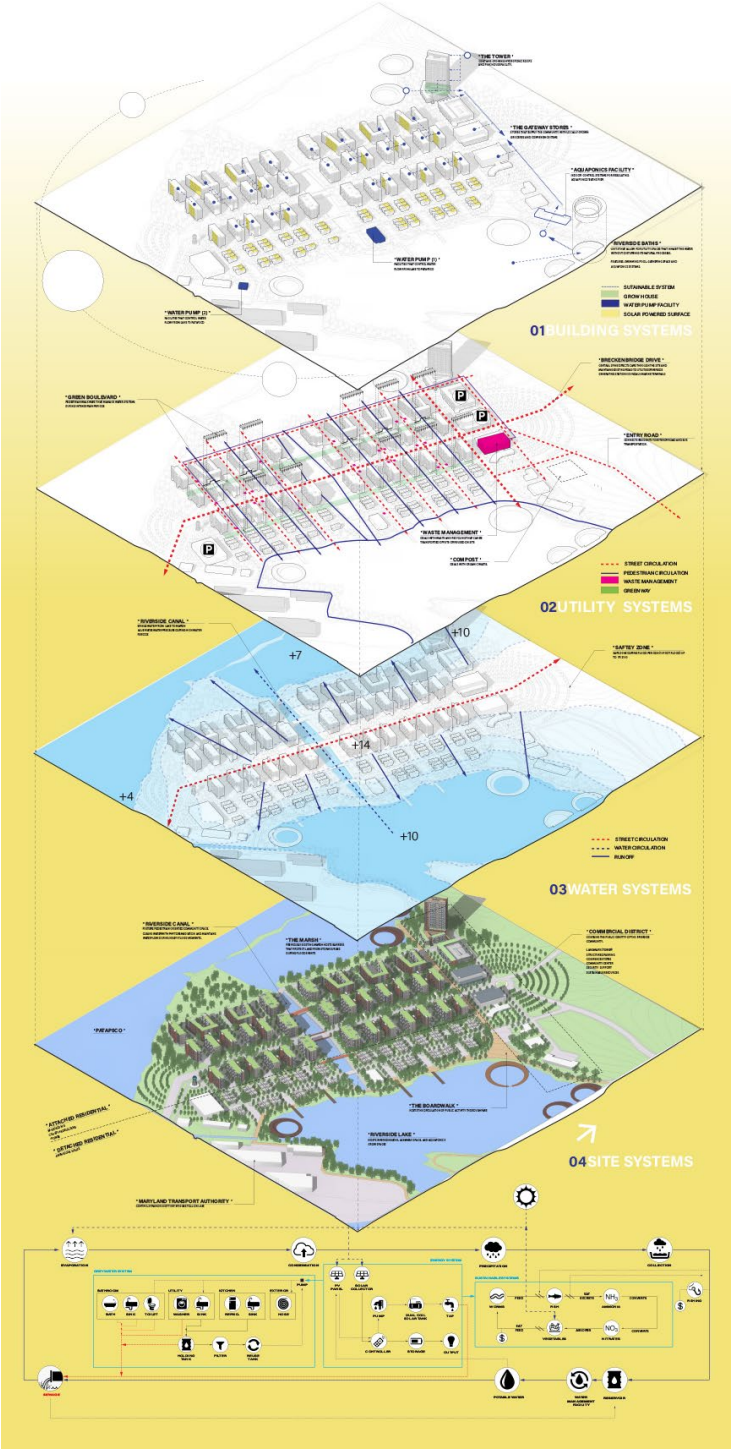

Figure 21: Systems Drawing. Image by Author.

The systems approach started from the level of water. It begins from a more general water cycle following water from its natural processes into the societal system. On this journey water travels from a body of water through evaporation, after this it condenses into clouds and then precipitates in the form of rain where it can repeat these processes in perpetuity. These process have throughout the history of civilization become entangled with the systems of civilization which include collection and recycling of waste water into potable (drinkable) water and then back into a waste system. This thesis looked for a way of incorporating our own technologies into the system to create zero water waste by showing how grey water systems, solar power and aquaponics could interplay to create buildings that directly interact with larger more robust systems.

Another system that was important within the scope of this project was transportation. Transportation along the central spine was maintained to allow for a main road that wouldn't flood thus providing the safest egress path in emergency situations. Pedestrian circulation was also considered.

Pedestrian circulation was based on garden cities, such as Greenbelt, MD where pedestrian circulation happens between buildings and waste management and utility happens along exterior street frontage. This usage of interior circulation is twofold in that it one give the community access to the water and two that it allows for a co-op community that fosters community connection, not found in highly urbanized areas.

The Amphibious Plan

These ideas would be realized in the plan (see figure 39) in which Breckenbridge drive became the main road connecting the urban development to its context. The lake becomes the main hub of activity. It sponsors a boardwalk and Riverside Baths which hold water activities such as swimming and ice skating. Along its boardwalk are low density housing (amphibious houses) which juxtapose the higher density buildings (Bar Building, Courtyard building and tower) which occur along the opposite water side.

Figure 22: Site Plan

Chapter 7: Architecture

Residential Architecture

At its core this project deals with the lives affected by flooding. To deal with these issues it was pivotal that the thesis address the people at multiple scales to see how the urban planning of systems could affect the individual. To do so units were tested at four different scales from detached housing to attached housing. These housing types took 4 forms: The Amphibious House, Bar Building, Courtyard Building and Tower.

Amphibious House

The Amphibious house (figure 40) is a house that uses the Archimedes principle to float. Using a waffle slab and bar fins at its edges the structure floats and maintains position during high flood periods.

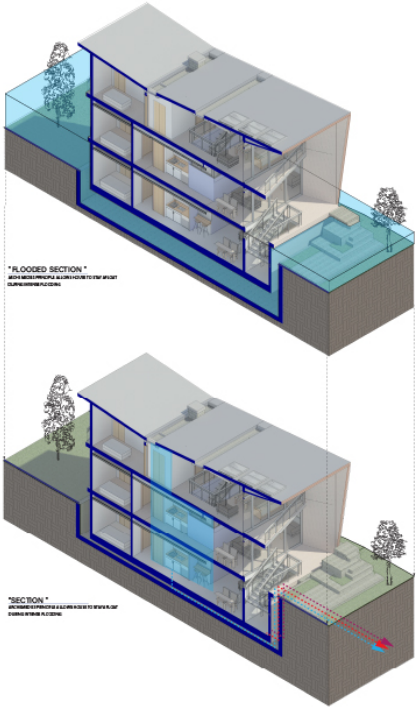

Figure 23: Amphibious House during Flood. Image by Author.

Bar Building

The Bar Building, a medium density building provides the most typical unit type on site. Comprised of studio and 2 bedroom units it provides safe egress and utility spaces on the second floor and parking on the lower floor as a means of keeping valuables out of harm's way during flood events.

Figure 24: Bar Building Plan. Image by Author.

Courtyard Building

The Courtyard Building (Figure 42) uses more urbanistic approach to the site. Its location by the marsh called for a building that could in essence redirect views of the public circulation through the courtyard and frame views outward to the marsh, thus giving everyone access to the public amenity of the water front.

Figure 25: The Courtyard Building. Image by Author.

The Tower

The Tower (Figure 43) became critical in creating a landmark for the site as a whole and encompassed the key issues of sustainability. It maintains the key ideals of accessibility on its second floor however the buildings specialty happens in its core which supports growing labs that support the community.

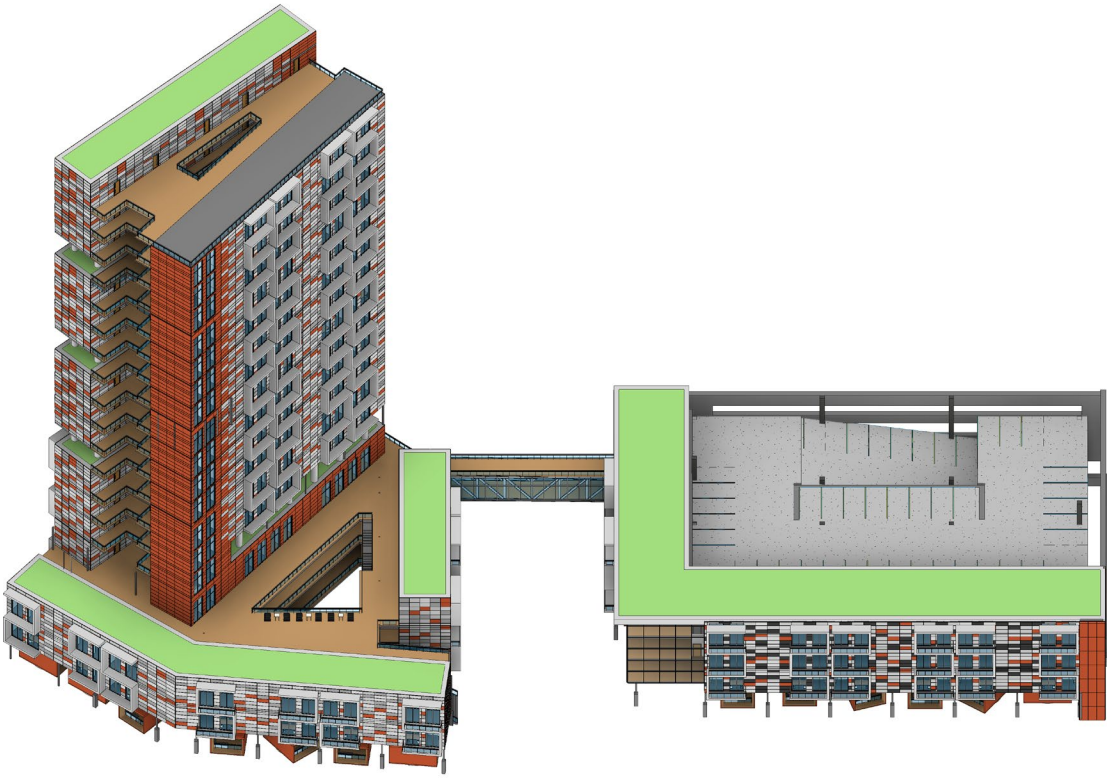

Figure 26: Tower. Image by Author

Conclusion

The goal of this thesis was to create a means of experimenting with resilient design principles so as to create an architecture that deals with the issue of flooding in an urban context so that these goals could applied holistically to other design processes

Bibliography

Wallace, Bruce. "Kenzo Tange, 91; Architect Blended Traditional Japanese, Modern Elements." Los Angeles Times. March 24, 2005. Accessed March 31, 2018. http://articles.latimes.com/2005/mar/24/local/me-tange24.

Glancey, Jonathan. "Obituary: Kenzo Tange." The Guardian. March 23, 2005. Accessed March 31, 2018. https://www.theguardian.com/news/2005/mar/23/guardianobituaries.artsobituaries

Kunstler, James Howard. *The Geography of Nowhere: The Rise and Decline of Americas Man-made Landscape*. New York: Simon & Schuster, 1994.

Lin, Zhongjie. *Kenzo Tange and the Metabolist Movement: Urban Utopias of Modern Japan*. New York: Routledge, 2010.

Tange, Kenzō, and Noboru Kawazoe. *Ise, Prototype of Japanese Architecture*. Cambridge, MA: M.I.T. Press, 1965.

AASchoolArchitecture. YouTube. September 18, 2015. Accessed March 31, 2018. https://www.youtube.com/watch?v=OpwcTQ5RKbw.