A META-GREEN

A Dynamic Architecture Along the Banks of the Saint John River

by

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DEDICATION

For my Mother, who taught me the value of perseverance.

For my Father, who taught me the value of perspective.

CONTENTS

ABSTRACT

Through the catalytic theory of cybernetics, this thesis proposes a local intervention within the vast network of synthetic and organic systems that span the watershed of the Saint John River Valley in New Brunswick, Canada. Cybernetics is described as a way to understand a constantly changing world, where networks of synthetic and organic systems interact spatially and temporally to produce emergence and consequence. Systems thinking and architecture inspired by cybernetics can respond to the uncertainty of climate change and the challenges it poses to urban areas in relation to watersheds. Using Fredericton and the watershed to test a future climate scenario with increased precipitation and as a result significant increases in freshet flooding. The project proposes an infrastructure/architecture that accommodates the feedback of this changing landscape, limiting future flooding through the investigation of dynamic space and an augmented topography along 'The Green', a riverside park in Fredericton.

GLOSSARY

Meta: Denoting a change of position or condition: metamorphosis. Cyberneticians think of systems in terms of connections, through a layering of systems 'meta-patterns' begin to emerge. That is to say that similair patterns exist throughout many relational layered systems and that a system can take many forms.

Cybernetics: The science of communications and automatic control systems in both machines and living things. The study of the interrelation and communication of synthetic and organic systems is the broad field of cybernetics. The concept can be leveraged for framing territorial, urban and architectural narratives through both time and space and was advanced by Gordon Pask.

Systemic: Relating to a system, in particular a non-localized condition but one being wide spread. Within the field of systems design Allan Berger sees this type of thinking as critical to any urban intervention. In economics it is widely used as the notion that all assets are effected indirectly by market conditions.

Topological: the continuous deformation of space. In landscape architecture there is a movement to understand topography as a surface that is continuously changing, which has lead to the adoption of topological as a poetic term to define this view point.

Freshet: A great seasonal rise or overflowing of a stream or river caused by heavy rains or melted snow.

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This architectural adventure would not have been possible without the support of My Family, as they have helped me navigate the ups and downs of student life. The project and my success generally in the architecture program, has been inriched by my peers, who's comradery helped advance the work. Finally the academic guidance of Professors Catherine Venart, James Forren and Eric Stotts, helped shape this thesis and a large part of my time at Dalhousie University. Specifically Catherine's Netherlands Studio, Eric's enthusiastic aperture assignment and assisting with James' concrete research, stand out as moments that I will carry forward.

CHAPTER 1: INTRODUCTION

The Green, a riverside park located along the Saint John River in Fredericton, New Brunswick, Canada is an edge condition between an urban area and a dynamic river system. Over the coming centuries, The Saint John River can expect a period of uncertainty in freshest flooding, with climate models still inconclusive as to the regional effect of climate change in the 55,000 sqkm watershed. The Green is home to much of Fredericton's institutional and cultural buildings, which are typically singular, of masonry construction and surrounded by public spaces interconnected with parks. The river and therefore The Green is the perfect space for negotiating between natural and urban systems, experiencing a spring freshet that could reach 8.4m to 9.5m.[1] This thesis addresses a not so distant future through the development of a methodology based on cybernetic philosophy and the layered modeling of synthetic and organic systems, to produce a zone of augmented topography and an insertion of a dynamic architecture/infrastructure along The Green.

Complexity of Systems

There is great complexity in infrastructures and natural systems that make up our environment. Systems crisscross every part of the globe interacting with ecology, people and machines; interconnected webs, create a vast, complex and unknowable set of systemic connections that are being placed under pressure due to anthropogenic climate change. In this way, systemic consequences of actions can be felt globally, territorially and locally. Critically the fragmentation of territorial systems is a consequence of humanities actions across time and scales, that do not account for humanities relation to dynamic ecological systems. Watersheds as a dynamic system illustrate this interconnected web of systemic connections. Actions are, or seem, localized, specific and directed, however they often reverberate throughout the watershed; a city's hard edge condition along a waterway places it in direct conflict with that water way and the larger territory. These relationships are increasing in complexity as the local effects of climate change alter the relationship between synthetic and natural systems.

1 Van Lantz, Ryan Trenholm, Jeff Wilson, William Richards, "Assessing Market and Non-market Costs of Freshwater Flooding Due to Climate Change in the Community of Fredericton, Eastern Canada," *Climatic Change*110, no. 1-2 (2011): 367.

Photograph of east side of Officer's quarters, Queen Street, showing 1887 flood, two men in a canoe in flooded water around the square, 1887, P5-316, *Taylor, George: photographs, Provincial Archives of New Brunswick*, Fredericton, New Brunswick, Canada.

Systems pace, a layering of synthetic and ecological systems along The Green a riverside park in Fredericton.

Local Effects of Climate Change

The local effects of climate change are an example of how interconnected synthetic and natural systems within a territory can be disrupted. Over the next century global climate will be reshaped, with regional effects being predicted uncertainly and within a margin of error difficult to anticipate. Variables of unknowability in current models make it difficult for researchers and climatologists to accurately predict the exact local effects of climate change across regions.[2] However, there are trends; river deltas, estuaries and coastlines are some of the most dynamic natural landscape systems and in many cases they exist next to interconnected synthetic systems of urban areas and their infrastructures. These regions are expected to be altered significantly over the next centuries, with sea level rise of approximately 1.6 meters and the potential for more or less rain in watersheds.

2 E Swansburg, N. El-Jabi, and D. Caissie, "Climate Change in New Brunswick (Canada) Statistical Downscaling of Local Temperature, Precipitation, and River Discharge," *Canadian Technical Report of Fisheries and Aquatic Sciences,* no. 2544 (Moncton, N.B: Fisheries and Oceans, 2004), 7.

Extreme weather events and climate fluctuations affect watersheds in various ways due to a series of regional issues such as deforestation, land management and fragmentation. These changes are exacerbated or softened by our actions, as our infrastructures and architecture are often interconnected with these systems and will need to adapt to new uncertainties.

Cybernetics as Means to Understand Complexities

Cybernetics proposes a philosophical framework to understand the complexities of systems through their relation to feedback and external disruption across scale, time, living and nonliving. Originally, part of core programming research and computation seeking an artificial intelligence, cybernetics split off and became an anti-discipline, with its philosophies found across varying academic fields. Therefore, it provides the useful concept of feedback while second-order cybernetics considers the designer of systems as part of the system. In this way cybernetics does not differentiate between the communication in an organic or synthetic system, a biological or robotic organism, a natural ecosystem or a constructed one. Instead cybernetics evaluates emergence of systems and finds patterns in one system that might begin to reveal themselves within another. Wiener described the transdisciplinary field as, "the scientific study of control and communication in the animal and the machine."[3]

Cybernetics as a Design Tool in Complex Environments

Cybernetics seeks to understand communication across all systems and views them as evolutionary. Gordon Pask, an early cybernetician psychologist and theorist proposes that architecture might begin to act in such a way that it could consider the vast set of systems that it interacted with and that architects should incorporate systems theory, along with the concept of feedback into the programming of architecture. Buildings might begin to interact directly with their inhabitants, re-arranging or organizing their spatial systems such that there is continuous feedback between the user of space and space itself. This thesis seeks to build from the existing context using street and park networks, building systems, space, programs, events and materials to propose a flexible architecture along The Green, such that an infrastructural system within which a flexible architecture inspired by cybernetics might be a strategy for operating in the dynamics and complexity of a floodplain.

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3 Paul Pangaro, "Cybernetics as Phoenix: Why Ashes, What New Life?" in *Cybernetics: State of the Art*, ed. Liss C. Werner (Berlin: Universitätsverlag Der TU Berlin, 2017), 16-18.

Overview of Following Chapters

1: Over the next chapters an exploration of cybernetics and systems theory will take place, along with a critical vision in regard to how it might be leveraged as a design tool in dynamic systems of systems, such as urban floodplains. 2: A discussion of how The Green in Fredericton is itself a dynamic system of systems, examining how its urban systems will be impacted and altered in the worst-case climate scenario and contextualizing this within the region and its history. 3: An outline of ecological, social and synthetic systems is mapped and an evaluation of the current urban condition along with the regional context, as to facilitate design criteria and site selection. 4: A design proposal of an infrastructure system within which a dynamic architecture is proposed that considers feedback from ecological, social and synthetic systems in flux, proposing a Meta-Green, a park that responds to the topological changes of the Saint John River.

> The role of the architect here, I think is not so much as to design a building or city as to catalyze them: to act as they may evolve.[4]

4 John Frazer and Gordon Pask, "Forward," in *An Evolutionary Architecture* (London: Architectural Association, 1995), 7.

CHAPTER 2: CYBERNETICS AS A CONCEPTUAL FRAMEWORK FOR DESIGN

Systems Thinking

Changes within systems are not singular but occur as a result of scalar dynamics, where collisions or intersections with other systems also in flux occur cyclically or dramatically as a consequence. For this reason, change is the result of actions foreseen or unforeseen but certainly interconnected. Nowhere is this more problematic than within the realm of regional territories and within environmental process, where actions reverberate across the global scale. As examples, such as shipping, resource extraction and transportation linkages, and the network of global economies, which often come into conflict with environmental systems and result in systemic consequence on local and territorial conditions. Ian McHarg outlines, "a variety of economic, social, and technological forces drive change. What drivers of change influence landscape around the world? A few probable drivers are" population dynamics & consumption / urbanization / along with global and regional environmental processes.[5] all processes that are global, and which affect all scales of environmental processes. The totality of these systems can be measured in their relation to a specific landscape or watershed and an account of these systems can be used in the decision-making processes. McHarg observes the urgent need in accommodating or controlling change across systems.

> Can modern man aspire to the role of agent in creation, creative participant in a total, unitary, evolving environment? If the pre-atomic past is dominated by the refinement of concern for man's acts towards man, the inauguration of the atomic age increases the dimension of this ancient concern and now adds the new and urgent necessity of understanding and resolving the interdependence of man and nature. [6]

This philosophical separation of 'Man and Nature' has obscured humanities interdependence on nature allowing it to act to it's own detriment. The more that this separation is reduced through a careful consideration of systems the less imbalance will be present. McHarg's statement distills the complexity of systems of organic and synthetic origins down to a simple understanding of them, as not man-made and natural, rather interconnected and layered. It is necessary that ecological and synthetic problems are confronted within the designs of architects, as humanities process are systemic. McHarg understood this through his development of a regional inventory of input and outputs of materials in the atmosphere, hydrosphere, lithosphere and biosphere.[7]

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5 Ian Lennox McHarg and Frederick R. Steiner, *The Essential Ian McHarg Writings on Design and Nature* (Washington: Island Press, 2006), xv.

6 Ibid., 2.

7 Ibid., 24.

1963 Land Use, 1969; illustration by Ian McHarg, from *Design with Nature*, p. 83.

The formal landscape conditions that exist around and beyond a site is of great importance to building sensitive architecture.[8] There are a set of exsisting systems on every site, these systems in the modern western city are distinguishable, mappable and mostly quantifiable. Economic or ecological values can be assigned to resource consumption, energy use and recycling, to leverage strategies of reduction or increase, respectively. This metabolism is well studied, its main consideration, evaluating the impacts of changing a territories consumption in relation to a larger territorial condition, an example pulp and paper production and its systemic consequences for a watershed.

8 Susannah Hagan, *Ecological Urbanism: The Nature of the City* (London: Routledge, 2015), 83.

Systems in Turmoil

Change within nature, is of course natural, a beautiful illustration of this change is Harold Fisks meander maps of the Mississippi River. Over geological time the Mississippi, like all rivers, would spill its banks and form new channels, however as river edges have hardened due to our synthetic infrastructure this natural process has been altered. Along with these concerns, infrastructure is now also stressed due to anthropogenic climate change, which is accelerating and altering environmental change in watersheds. The cyborg offers a line of understanding as to how regional infrastructure systems must begin to accommodate environmental disruptions of climate change, particularly in urban floodplains. Matthew Gandy argues, “The reading of the city as a “cyborg” highlights the tension between body and the wider sets of technological augmentation of the individual human body and the wider sets of technological networks that sustain modernity; the emphasis is not so much on augmented technological capabilities as on the vulnerability of technological networks to disruption.”[9]

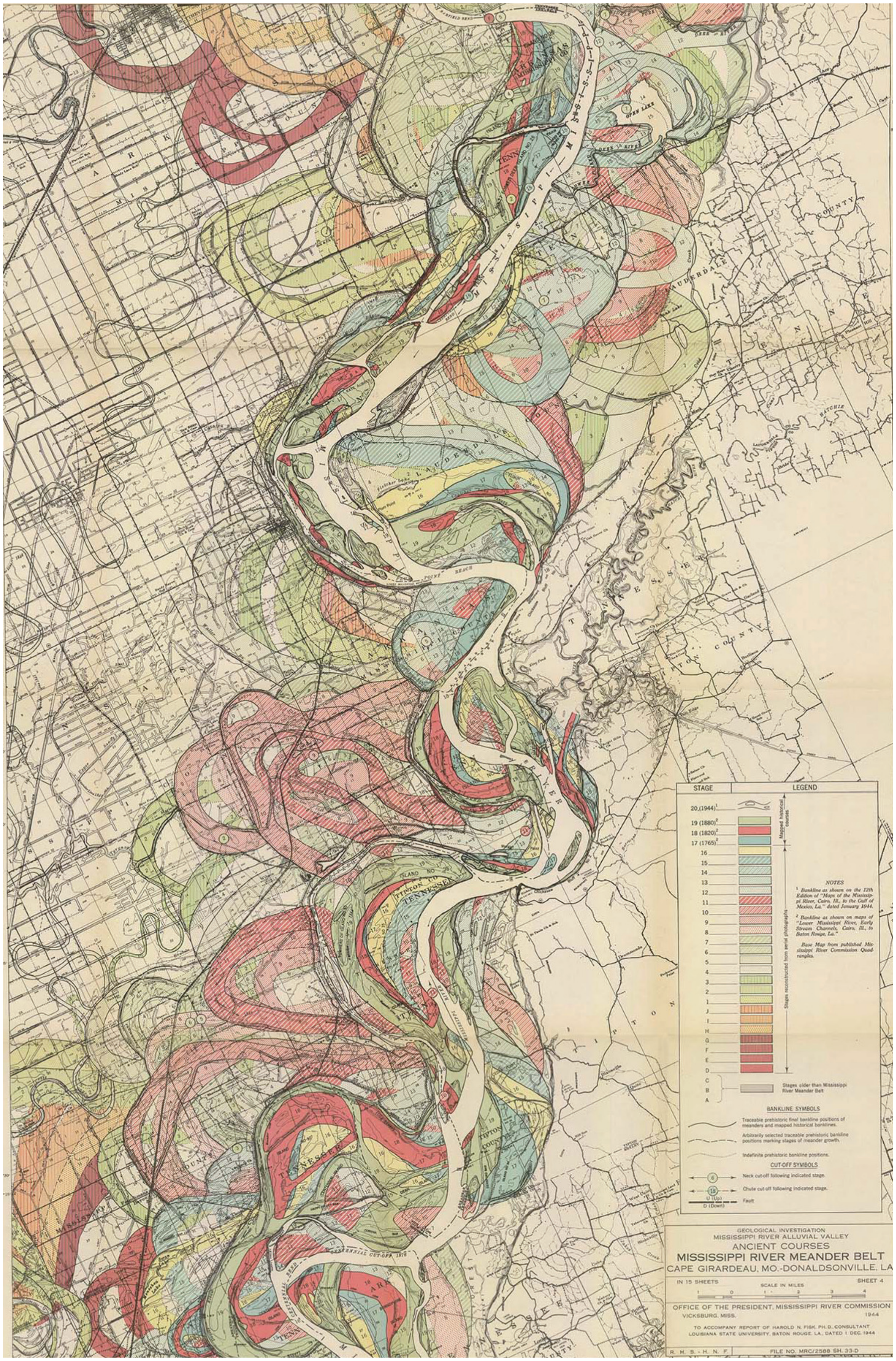
McHarg’s regional inventory is a starting point for evaluating and understanding ‘territorial resources’ (systems) and their interdependence. However, where it lacks is in its evaluation of these systems in fluctuation. The territorial changes which are taking place are pushing systems out of their steady state requiring a method beyond the static overlaying of ‘territorial resource’, instead one that considers dynamic systems. The consideration of climate uncertainty as it relates to infrastructures in watersheds can only be understood as a series of dynamic systems due to the turmoil of the coming centuries.[10] The unpredictability of flooding in river valleys exemplifies the need to construct and upgrade infrustructures to produce space that is not only resistant to flooding but also accepting of its future fluctuations. It is increasingly necessary to design flexible infrastructure instead of fixed infrastructures that are vulnerable to climate changes, as they do not evolve or respond to feedback on their own, as Gandy elaborates.

> If we consider the relationship between cities and strategic policy-making, there is a significant time lag between catastrophic events and any kind of coordinated long-term response. A mix of technical disagreements, political expediency, administrative inertia, and economic uncertainty produces a common pattern of extended delay. The process of physical reconstruction is inevitably also one of institutional reorganization, producing different constellations of power, finance and technical expertise. An accelerated rather than incremental pattern of environmental change, impelled by the “abrupt” climate change scenario could overwhelm the capacities of many cities to respond.[11]

9 Matthew Gandy, *The Fabric of Space: Water, Modernity, and the Urban Imagination* (Cambridge, MA: MIT Press, 2017), 11.

10 Susannah Hagan, *Ecological Urbanism: The Nature of the City ,* 23.

11 Matthew Gandy, *The Fabric of Space: Water, Modernity, and the Urban Imagination*, 220.



Map of ancient courses of the Mississippi River meander belt, 1944; by Harold N. Fisk from *Geological Investigation of the Alluvial Valley of the lower Mississippi River.*

The scientific consensus is that climate change is occurring and along with it, sea level rise, with Vermeer and Rahmstrof placing it between 75 – 190cm by the year 2100,[12] while the ICPP places it between 4.6 – 23.5cm,[13] and NOAA places the worst-case scenario at 250cm.[14] A 2015 article released by the Atmospheric Chemistry and Physics Discussion details that past periods of prolonged warmer temperatures, which exceeded present temperatures by just a tenth lead to between 600-900cm in sea level rise.[15] Precipitation patterns are expected to be significantly altered across the globe, with some studies attributing recent increases in wildfires, drought and cyclonic activity to climate change[16]. Regional unpredictability remains and there are overall uncertainties in the rate and location of change. Regardless of these uncertainties, in how and over what time period, watersheds and coastlines will be greatly altered. Climate change is now inevitable and unavoidable, to plan for future infrastructures without climate considerations would be a grave mistake, as current political policy trends[17] and the continued increase in the use of fossil fuels point to its continuity. It is far more likely that we are entering a period of great climate uncertainty and that the cyborg planet we have created will take many centuries to re-stabilize. This presents a challenge for the built environment as it will have to adapt to a changing context. A philosophy is needed that begins to consider the uncertainties of climate change. A solution that would allow for flexibility in the implementation and in reacting to future changes in conditions should be advanced. Cybernetics offers promise in this regard as it is flexible enough to accommodate change through time while offering an approach to systems that reaches across both the synthetic and the organic. Cybernetics recognizes that these large-scale systems are integrated and controlling the relationship infrastructure has with ecology is critical as they increasingly become one and the same.[18]

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12 M. Vermeer and S. Rahmstorf, “Global Sea Level Linked to Global Temperature,” *Proceedings of the National Academy of Sciences 106*, no. 51 (2009): 4 -5.

13 J.A Church et al., “Near-term Climate Change: Projections and Predictability,” *Climate Change 2013 - The Physical Science Basis*: 1180 - 1185.

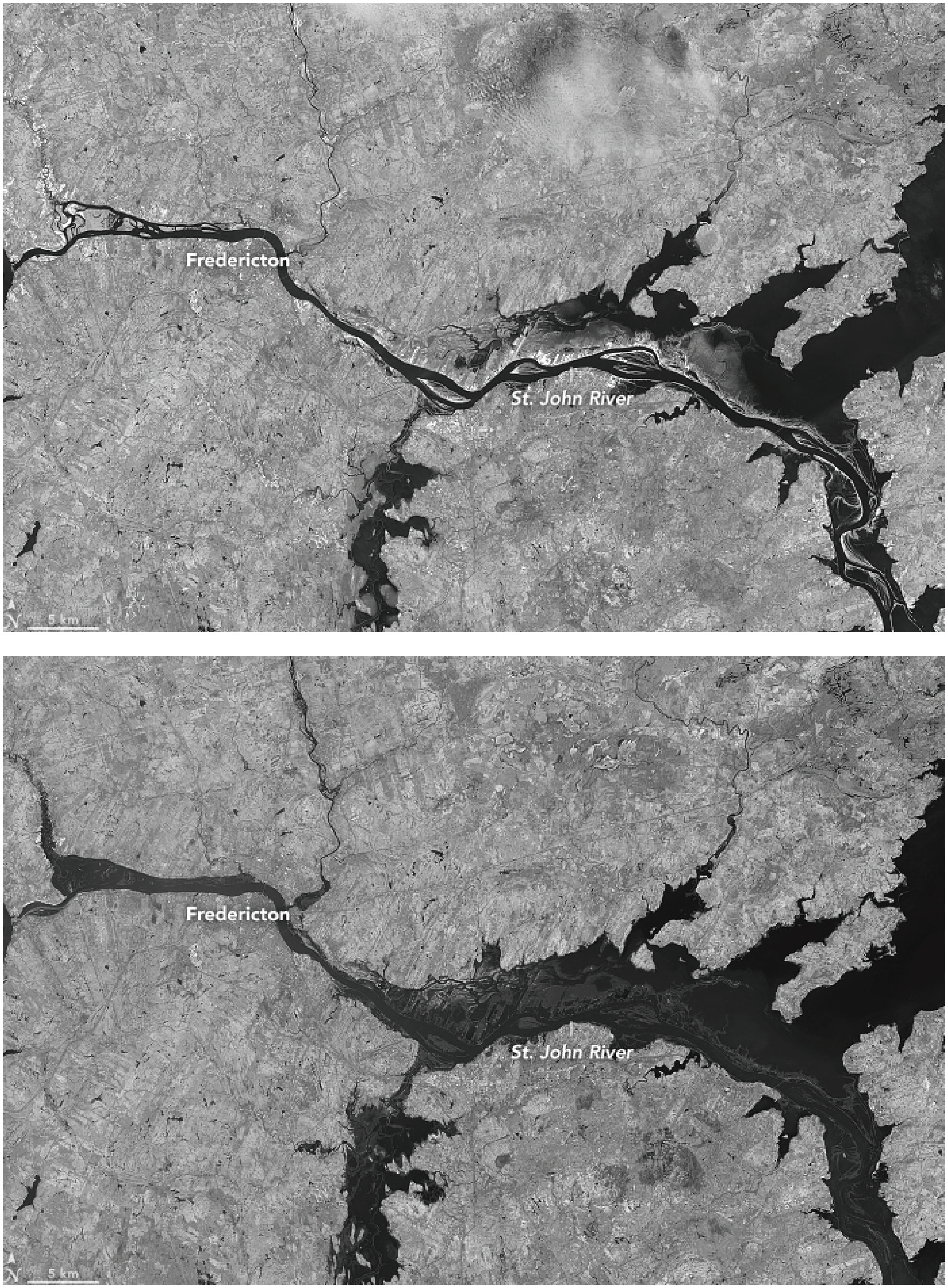
14 National Oceanic and Atmospheric Administration, “Global and regional sea level rise scenarios for the United States,” *NOAA Technical Report,*12-14.

15 James Hansen et al., “Ice Melt, Sea Level Rise and Superstorms: Evidence from Paleoclimate Data, Climate Modeling, and Modern Observations That 2 °C Global Warming Could Be Dangerous,” *Atmospheric Chemistry and Physics* 16, no. 6 (2016): 3800.

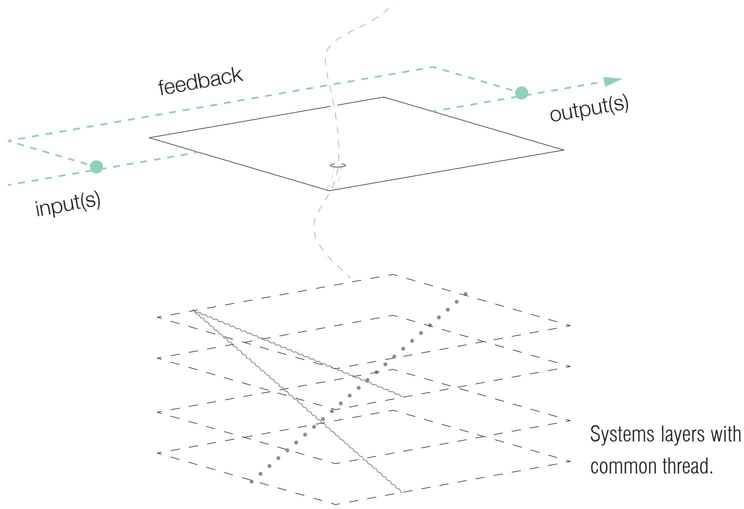
16 Oleg Smirnov et al., “The Relative Importance of Climate Change and Population Growth for Exposure to Future Extreme Droughts,” *Climatic Change* 138, no. 1-2 (2016): 41-45.

17 Tom McCarthy, Elle Hunt, and Sam Levin, “Paris Climate Agreement: World Reacts as Trump Pulls out of Global Accord – as It Happened,” *The Guardian*, June 2, 2017, https://www.theguardian.com/environment/live/2017/jun/01/donald-trump-paris-climate-agreement-live-news.

18 Paul Roncken, Sven Stremke, and Riccardo Pulselli, “Landscape Machines: Designerly Concept and Framework for an Evolving Discourse on Living System Design,” *Revising Green Infrastructure* (2014): 93-96.



NASA satellite Images comparing the devastating flooding of May 2nd 2018 (bottom) to the normal levels of the May 12th 2016 Freshet. Source: NASA Earth Observatory images by Joshua Stevens, using Landsat data from the U.S. Geological Survey.



Layered systems. Systems interelate producing systems of feedback, a cybernetic approch seeks to opporate with these wicked problems.

A Cybernetic Approach

The word cybernetics originates from kybernan, Greek for helmsman; to steer a ship. It is a trans-disciplinary approach that is interested in the circular relationship between a system and its environment across both synthetic and organic systems. It is in other words applicable to systems which through their operation cause a disruption within their environment and thus alters both the system and the environment. The helmsman of a sailboat adjusts the rudder and tightens the sheet, changing the course of the boat and cutting through the waves and wind; a relationship between the boat and its environment. Cybernetics is a way of thinking about these shifting variables, it attempts to understand the complexities of systems through their relation to feedback and disruption. Cybernetics is not artificial intelligence (AI), they differ in the scope and problem, AI is interested in solving a particular problem. Such as predictive algorithms that develop playlists on music streaming sites, their goal is very specific and focused. Cybernetics, on the other hand, is broad and interested in the interconnected nature of systems and control mechanisms across both the organic and synthetic. This is troublesome as undefined or expansive problems are difficult to solve. The notion of "wicked problems"[19], health care, economics, automation and climate change are examples of this phenomenon where immense interconnected sets of organic and synthetic systems collide. Cybernetics hopes to offer an approach to constructing tools and methods for framing these large, complex, and interrelated problems and working towards a solution.

19 Gregory Bateson and Mary Catherine Bateson, *Steps to an Ecology of Mind* (Chicago: University of Chicago Press, 2008), 474-499.

Ross Ashby views cybernetics as a useful tool across various fields to describe complex systems. His Introduction to Cybernetics outlines the principles of cybernetics as a descriptor of all possible outcomes of a system, through a construction of a set larger than that of the actual outcomes and then evaluates why a case might conform to its usual condition.[20] Further Ashby argues that cybernetics allows for a unified language to describe systems across both the organic and the synthetic, it is this language that allows for fields to intersect or systems of differing types and orientation to converge. It is, therefore, a method for attempting to understand the mechanism and machines within complex systems that do not allow for the isolation of one variable at a time.[21] Thus, the attempt to alter one factor in a complex system would lead to the disruption or alteration of other factors.[22]

Advocates for cybernetics use in architectural production essentially argue that the designer take on the systemic and relational notions of space within an ecological context. That ecological data could be the phycological user feedback of the Fun Palace or a territorial inventory, what is crucial is that there is a fusion between the organic and the synthetic. Further that the designer of systems is conscious of second-order cybernetics; that to begin to understand a designs impact on a systems the designer should understand how they are also part of these systems. It is a cybernetic approach to architecture that views systems design as the primary focus of architecture, not 'object design', even if the end goal is indeed an object. Gordon Pask argues that cybernetics might be used to formulate a general theory of the interrelations of systems within design[23], he states. "The plan will chiefly consist of a number of evolutionary principles."[24] Pask is interested in the flexibility of architecture and systems, that they might change themselves, in order that they might better serve their user's needs. To facilitate this transformation Pask develops scripts and programs that allow for space to adjust to feedback present in its context, and that this 'programing' is the main role of the architect. "The role of the architect here, I think is not so much as to design a building or city as to catalyze them: to act as they may evolve."[25]

20 W. Ross Ashby, *Introduction to Cybernetics* (New York: Wiley & Sons, 1956), 3.

21 Paul Pangaro, "Cybernetics as Phoenix: Why Ashes, What New Life?" in *Cybernetics: State of the Art*, ed. Liss C. Werner (Berlin: Universitätsverlag Der TU Berlin, 2017), 16-18.

22 W. Ross Ashby, *Introduction to Cybernetics*, 5.

23 Paul Pangaro, "Cybernetics as Phoenix: Why Ashes, What New Life?" in *Cybernetics: State of the Art*, ed. Liss C. Werner, 18.

24 Gordon Pask, "The Architectural Relevance of Cybernetics," in *Computational Design Thinking*, ed. Achim Menges and Sean Ahquist (Chichester, UK: John Wiley & Sons, 2011), 73.

25 John Frazer and Gordon Pask, "Forward," in *An Evolutionary Architecture* (London: Architectural Association, 1995), 7.

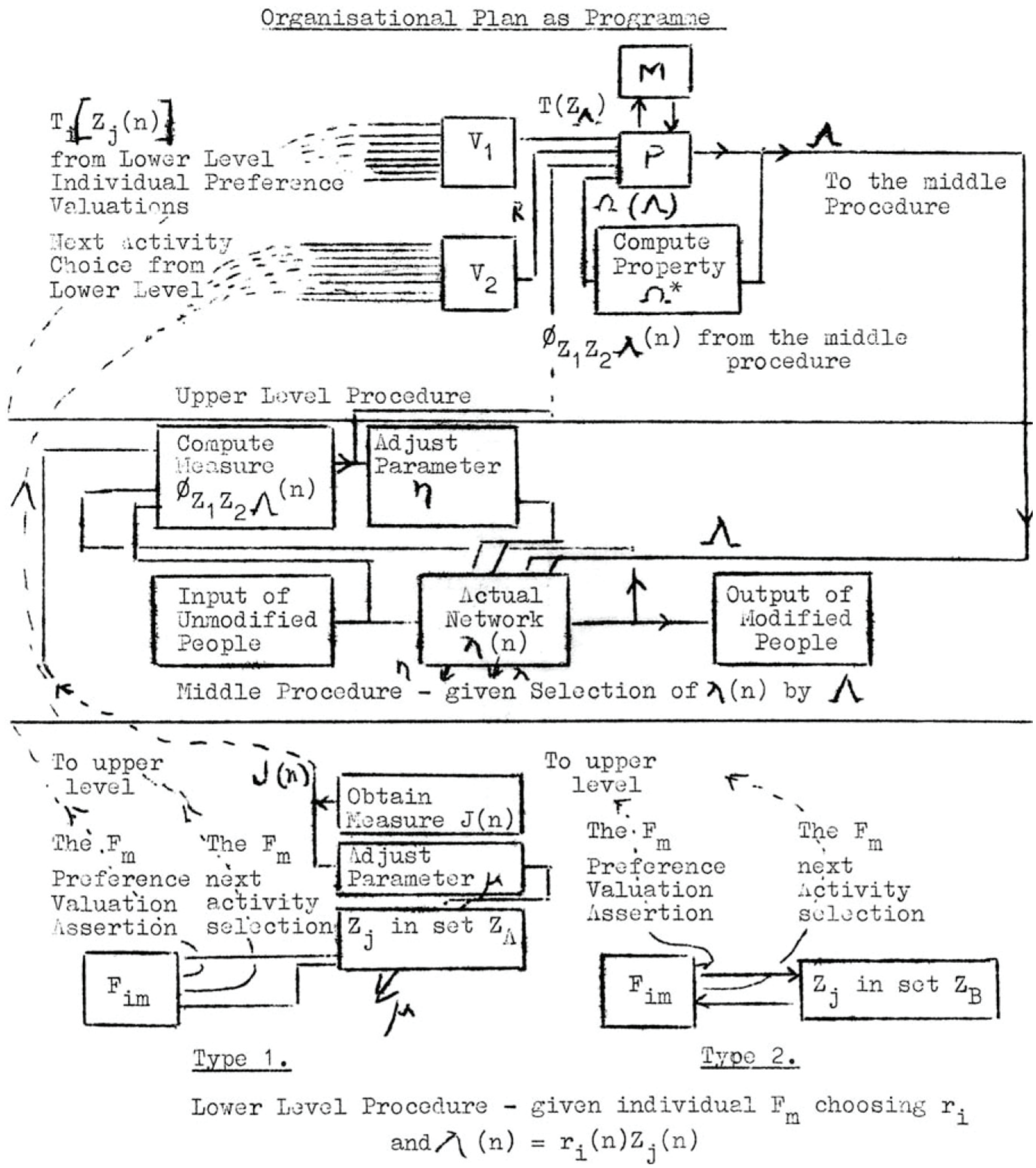
Application of Cybernetics Theory to Design in Relation to Watersheds

Given that communities in coastlines and floodplains will experience an amount of unpredictability as it relates to water levels during freshet and coastal flooding and that much of our built wealth is located in these areas, the proposition of evolutionary building is advanced as to connect ecological and synthetic systems. Not so that there might be a strict number of assemblies or programs that might dictate future evolution of space but rather a script that could begin to dictate how space might be re-arranged given changes in both organic and synthetic systems that encompass and interact with architecture. The goal being not predicting the future arrangements or experiences of space but rather laying out a set of conditions that allow for feedback between systems. This is what early cyberneticists involved with architecture wished to accomplish; allowing feedback between the user and space. Gordon Pask's work with Cedrick Price is the most prominent example of this thinking, however, it has been applied by Timothy Jachna in the context of the Pearl River Delta located in southern China.

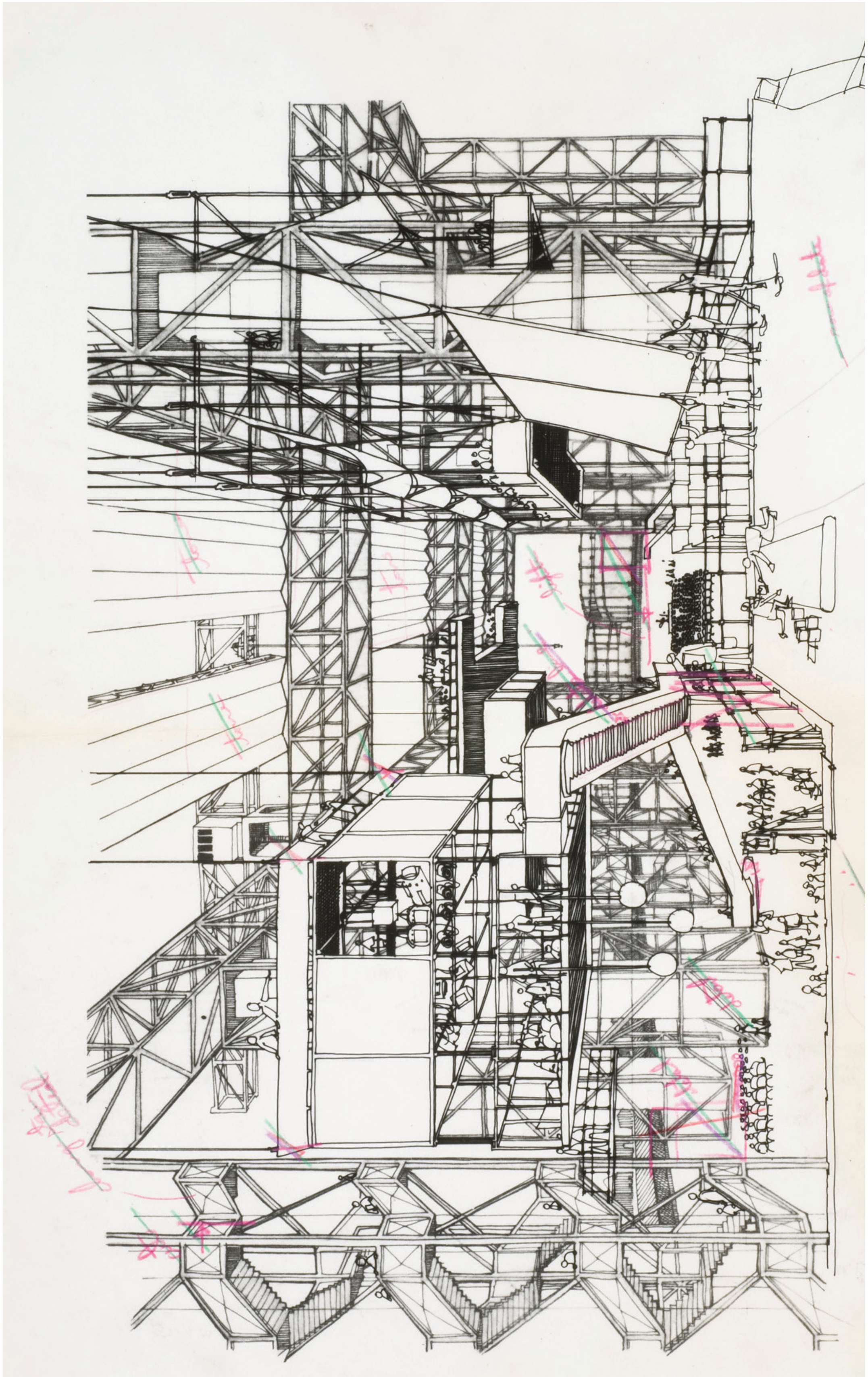
The Pearl River Delta project looks at possible scenarios of sea level rise and how the delta's metropolis might adapt. Through the process of taking into account cultural, economic and infrastructural systems important for the region, the project outlined strategies that could be employed to deal with the expected inundation. Similar to other methods which use mapping and geographic information systems to understand the potential growth areas of a city and facilitate development. The method is not predictive of development but rather lays out areas where development might occur within the set of criteria.[26] While outlining areas that might be lost or could be left un-embanked, as sea level rises in the delta. In this sense it is the predictive and planning capacity of the cybernetic methodology that considers the uncertainty in the delta as a result of climate change. It is, different from the use of cybernetics within the Fun Palace project which was to be an experiment in program arrangement thought the phycological feedback of its patrons.

The Fun Palace is considered the first building concept to be executed with cybernetic theory involved in its development. The ability for the structure to facilitate changes in a program through the mechanical re-orientation of space; user feedback was built into the operation of the building, with patrons communicating their desires directly with the built environment.

26 Timothy Jachna, "Managing (with) the Unmanageable City," *Cybernetics: State of the Art,* ed. Liss C. Werner (Berlin: Universitätsverlag Der TU Berlin, 2017), 108 – 127.



Gordon Pasks' cybernetic Diagram for the fun palace; from *Cedric Price fonds*, Collection Centre Canadien d'Architecture / Canadian Centre for Architecture, Montréal.



Cedric Prices drawing of the fun Palace, from *Cedric Price fonds* Collection Centre Canadien d'Architecture/ Canadian Centre for Architecture.

> Fun Palaces structure and enclosures ‘contribute to and emphasize the possibilities of a twentieth-century mechanized environment’… Prices imagining of ‘a three-dimensional activity framework [that enables] maximum flexibility and change in individual volumes and the whole’. Here, participation and the essential role of feedback were the agents of change, suggesting a possible role for the new discipline of cybernetics.[27]

The most striking concept developed in the Fun Palace project is perhaps the notion of spatial planning through the use of a set of options that allowed the user of the space, to re-assemble the space or participate in the space in such a way that their physical experience might be different from that of another participant. “The architecture of the Fun Palace is best described in terms of hardware – its structure and spatial ordering – and software – its operational programming and process”[28] This connection to early computational methods for spatial ordering through an evolutionary script perhaps began to link the new digital media to that of architecture. Although the project was never built, it remains a critical precedent for architects even if they do not necessarily embrace cybernetic theories; the user generated flexibility found in the Fun Palace project can be traced throughout modern architecture

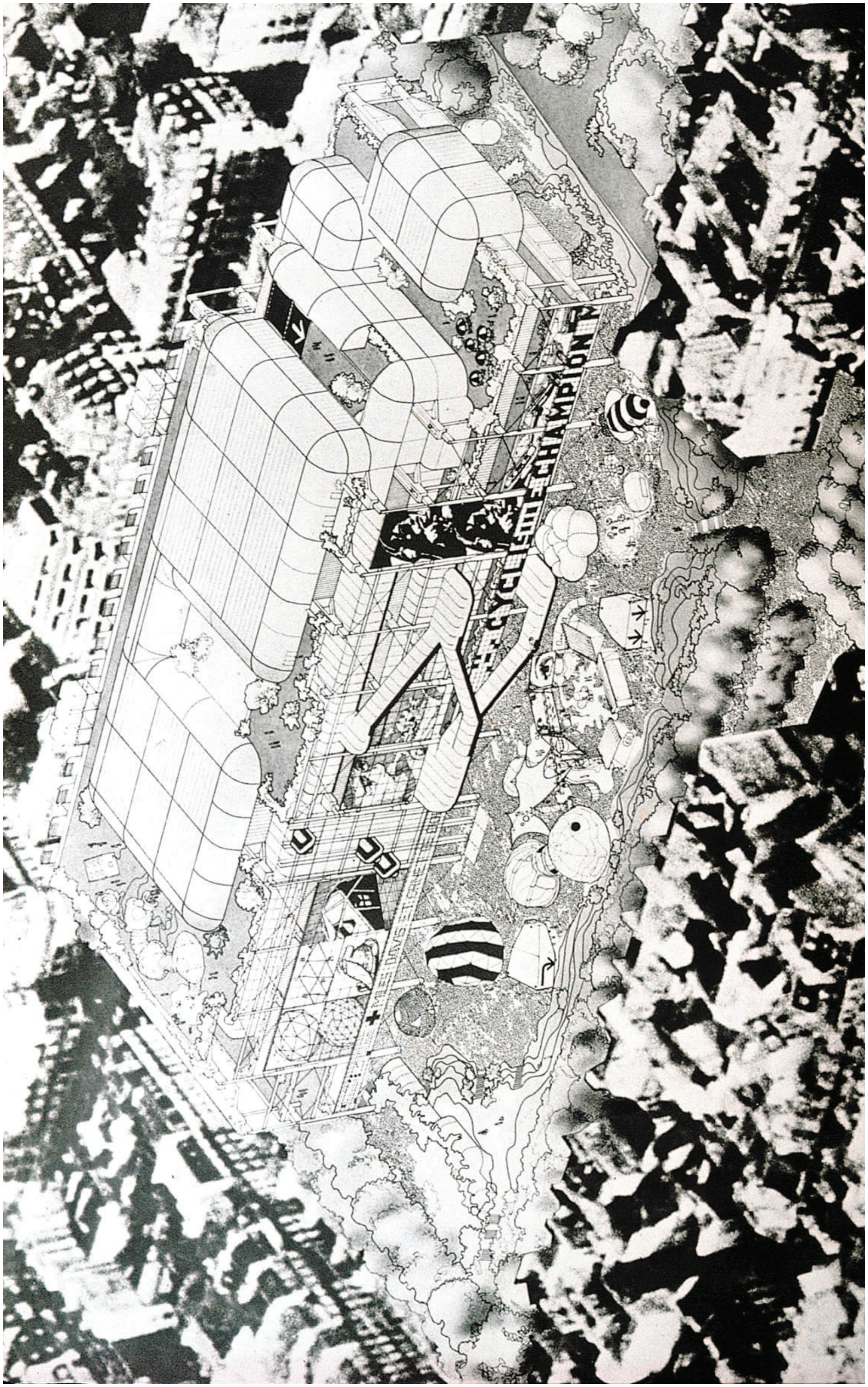
The Centre Pompidou, by Richard Rodgers & Renzo Piano is thought to be of direct descendent architecturally from that of the Fun Palace. However, it does not aspire to use an algorithm or cybernetics as a spatial constructor, it does, however, share the notion of a flexible space through the development of an open plan that uses free span elements to create flexible gallery spaces. These spaces can then be ordered by the curators of the exhibitions so that the user experience is different every time, Rodgers and Piano were not able to foresee the entirety of the activity that these spaces might generate, but rather they proposed a flexibility through their architecture.

The work of Yona Friedman is arguably the first to apply true computation to spatial planning. His Scientific Architecture pursues the notion that one might be able to propose an architecture based solely on graph theory (combination AuB) and allow for an end user to utilize this program to construct their own dwelling within a superstructure or large system. This is an architecture designed through the use of mathematical methods, which set out various typologies of units that interconnect along with rules for this connection.[29] This is similar to the Metabolists who have been endeared by Yona Friedman for drawing from his work for their

27 Cedric Price et al., *Cedric Price Works 1952-2003: A Forward-minded Retrospective* (Montreal: Architectural Association ; Canadian Centre for Architecture, 2016), 48.

28 Ibid., 55.

29 Yona Friedman, *Toward a Scientific Architecture* (Cambridge, MA: MIT Press, 1980), 1 - 45.



Centre Pompideau; by Roger Silks Harbour Partners from https://www.rsh-p.com/projects/centre-pompidou/.

theories of metabolism in architecture.[30] Capsule architecture shares this link with Friedman's use of graph theory, Metabolism however relies on biological references as a basis for evolution. However Metabolism and Friedman's Scientific Architecture, are imposing a system without any feedback mechanism, there is a growth logic within its form, but this growth is restricted by the original system.[31] Both the work of Yona Friedman and the Metabolists provide for inspirational forms and poetic methods of architectural production however where they lack is in the concept of feedback that Pask and Price provide in their cybernetic architecture.

Cybernetics as a Way to Produce Evolutionary Systems / Spaces

Today modern computing power and the proliferation of sensor devices that exist around us are reshaping the way we engage with the city. Every individual has a smartphone, is checking into a local business, triangulating their wants and needs around the city. Further, our modelling of ecological systems as they relate to synthetic systems has improved, predictions of climate, crop yields and flooding can all be considered through computation. The city is now a cyborg, the virtual network is more interconnected than that of the physical. It must be leveraged in making decisions about the programming of space.

> The increasing pervasiveness of embedded and mobile connected devices has transformed the built environment from a predominantly stable and enduring background for human activity into spaces and objects that have a more fluid behavior. These objects and environments are capable of sensing, computing, and acting in real-time; they can change their behavior in response to their own system state, histories of past actions and interactions, the behavior of humans and machines within their reach, and changes in environmental conditions.[32]

The relation of ecological and social systems to space has become possible through the proliferation of these electronic networks. However infrastructure and architecture does not dialogue dynamically with this change, instead sits in static relation. Pask sees current structures as static environments and argues for the elimination of this way of thinking as it relates to architectural development, this is fundamental because humans are continuously evolving in their needs of space. The rigid typologies that the designer forces on to other systems respond to specific needs for a specific time. What cybernetics and Gordon Pask propose is that environments might learn from their users, and other systems, on how better to arrange space. Pask argues that it is essential that the architect or designer build this evolutionary idea of space into the plans of a building. This is an

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30 Yona Friedman, *Toward a Scientific Architecture* (Cambridge, MA: MIT Press, 1980), XI.

31 Noriaki Kurokawa, *Metabolism in Architecture* (Boulder, Col.: Westview Press, 1977), 9.

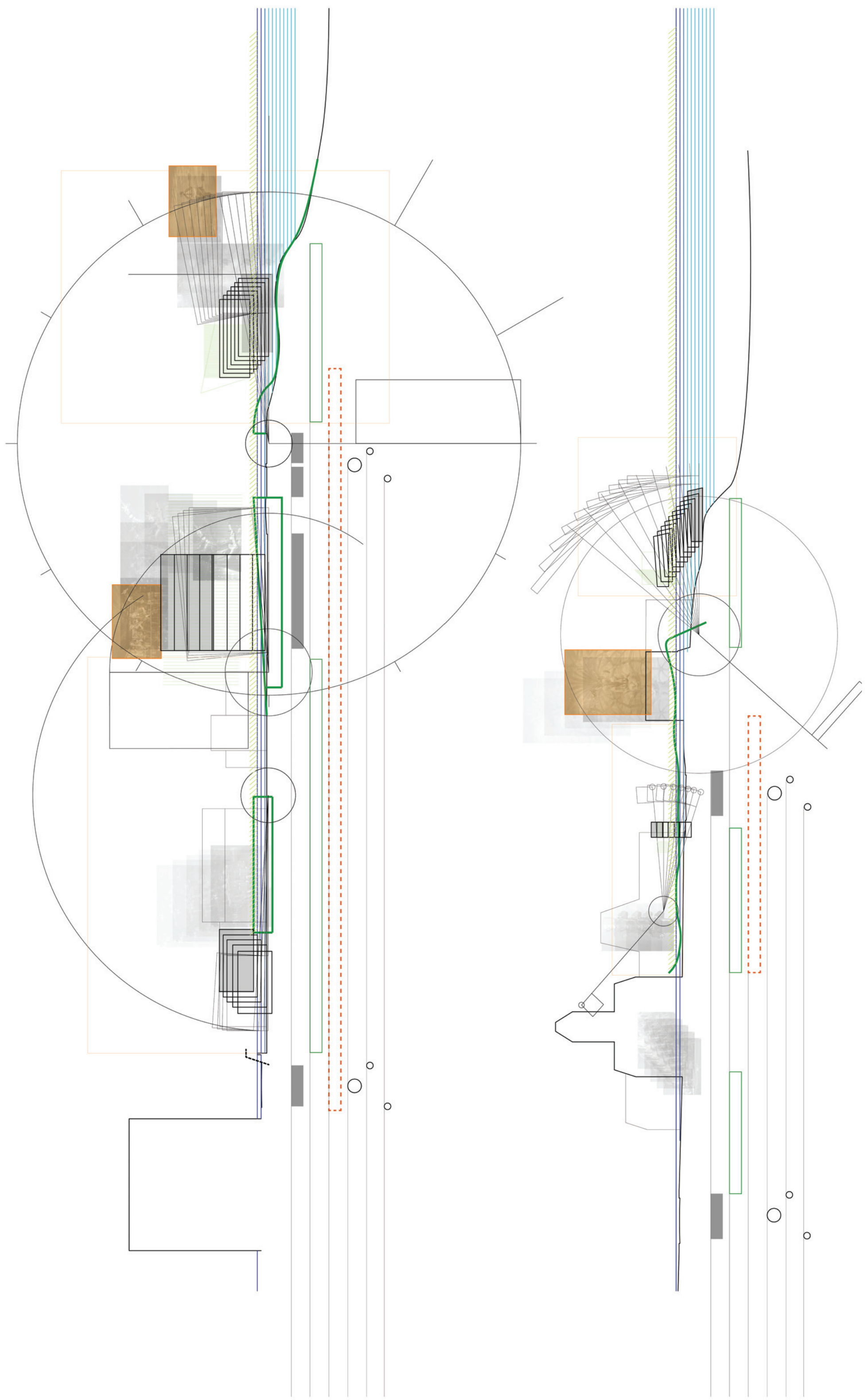
32 Kristian Kloeckl, "Open Works for The Urban Improvise" in *Cybernetics: State of the Art*, ed. Liss C. Werner (Berlin: Universitätsverlag Der TU Berlin, 2017), 150.

interesting role for the designer as they are simply designing systems and have left the final formal arrangement of space up to the users and their ever-evolving needs.[33]

In the case of floodplains, synthetic and ecological interaction take place in the complexity of watersheds, systemic consequence come to bear on communities located in these regions through the effects of land clearance, a changing snowpack and other dynamic systems in relation to infrastructures. The proposal of Pask that buildings might evolve to the changing needs of their human occupants is borrowed, and the proposal that organic systems should interconnect with our synthetic systems; that architecture and infrastructure systems should act in coordination with ecological systems is advanced. It is the interaction of these organic and synthetic systems where a convergence is needed in the floodplain as it might lead to new spatial opportunities and mitigation strategies. Buildings and infrastructures that are able to augment themselves through feedback as a means of response to uncertainty could be a valuable approach in the built environment's adaption to new climate realities, and along with changing societal conditions. Cybernetic philosophy should be applied in floodplains as it would link the urban systems into a dialog with the changing topology of a flooded landscape. Infrastructures and architectures in this sense become impacted by both the synthetic environmental demands posed by human occupation and the natural environmental systems in which they exist. This flexibility across these systems produces various spatial arrangements depending on water levels and community needs.

33 Kristian Kloeckl, "Open Works for The Urban Improvise" in *Cybernetics: State of the Art*, ed. Liss C. Werner, 154.

System Space, an examination of some of the layered systems along The Green. Information imported from *GeoNB.*



Wish Section of a cybernetic architecturealong The Green showing program activity and form in dialogue with a shifting topology.

CHAPTER 3: THE GREEN, A NETWORK OF SYSTEMS

The Green a riverside park in the city of Fredericton is a site where the confluence of organic and synthetic systems exist in flux. The park and adjacent Barracks District provide the downtown with public space, while recent construction and the city's prosed expansion of the Barracks District next to the park does not consider the possibility of 9.5m freshet.[34] This area is at the confluence of these synthetic systems of our society and the organic system of the river, they are interconnected and codependent. Cybernetics offers a way of intervening in the strategic programming of infrastructures and architectures to mitigate flooding. Implementing a more flexible solution would be beneficial as it would allow for the correlation of the river and architecture, much like the Fun Palace adapted to its users. The architecture and infrastructure along the river could adapt to change as needed, accommodating increases in water levels along with the changing of program needs throughout the year. Through the following investigation of the territory, watershed and history a design strategy that allows for this change is pursued.

A Brief History of the Saint John River System

The Saint John River runs through six different geological classifications with Fredericton situated in the lowlands between the New Brunswick Highlands and the Caledonia Highlands. This area is home to prime agricultural lands but also experiences the highest spring freshets.[35] Prior to the arrival of Europeans the Wolastoqiyik (Maliseet) nation lived along the Wolastoq (Saint John River), fished its waters and hunted throughout the watershed, the greatest resource the river offered them was that it allowed for interconnected trade with other nations.[36] The Acadians first settled the Fredericton region in what they called Saint Anne's point, they chose this site for its fertile ground. They would work the land until Robert Monckton, an officer of the British Crown lead a campaign up the river valley to expel the Acadians in 1758.[37] On July 25th, 1784 Saint Anne's point was laid out into what would become downtown Fredericton. The loyalist settlers laid out the town with its tight colonial grid connecting to the river. With places marked for institutional buildings, settlers were to build their

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34 The City of Fredericton, *Garrison District Master Plan* (Fredericton: The City of Fredericton, 2015), 1 - 62.

35 John M Henderson, *A Plan for Water Management in the Saint John River Basin: Final Report of the Saint John River Basin Board* (Fredericton, N.B.: Board, 1975), 11.

36 Ibid., 20.

37 Esther Clark Wright, *The St. John River and Its Tributaries* (Wolfville, N.S.: [s.n.], 1966), 136.

houses close to the road to leave room behind for gardens and to eliminate the threat of fires.[38] "It is during this period that settlements along the river began to expand and the watersheds natural resources started to be heavily exploited. The following paragraphs outline key developments in the watershed; the flooding along the green is the result of systemic consequences of other synthetic and natural process taking place in the watershed.

In the early history of New Brunswick logging was vital to its economic success as a colony in the British Empire but also later as an independent Province in the late eighteenth and nineteenth century. The river and its watershed were key to transporting logs, a system that would later be dammed and become a critical source of hydroelectric power in the latter half of the twentieth century. Lumbering has long been one of New Brunswick's most valuable industries with the British Navy first providing contracts in the late nineteenth century.[39] The advent of the steam engine and its increasing reliability, forced the lumber industry to switch course relying now on timber for boards and the pulp and paper industry.[40] The shipbuilding industry, the timber industries and then the pulp industry would drive New Brunswick's economy and dominate the Saint John River watershed as the main economic engine well into the twentieth century,[41] as well as result in destruction of most of New Brunswick old growth forests.

The damming of the river occurs throughout its watershed, with two main dams, The Mactaquac and the Grandfalls Hydroelectric Station having a large impact on the watershed. The Mactaquac dam represents a significant piece of infrastructure, cutting across the river and creating a large head pond.[42] Directly above Fredericton, its year-round activity has prevented the buildup of ice below the dam. The Mactaquac dam cannot be directly attributed with causing or having the ability to reduce freshet flooding, however it is regardless a critical piece of infrastructure along with the other dams and control structures along the river.[43]

38 Esther Clark Wright, *The St. John River and Its Tributaries*, 138.

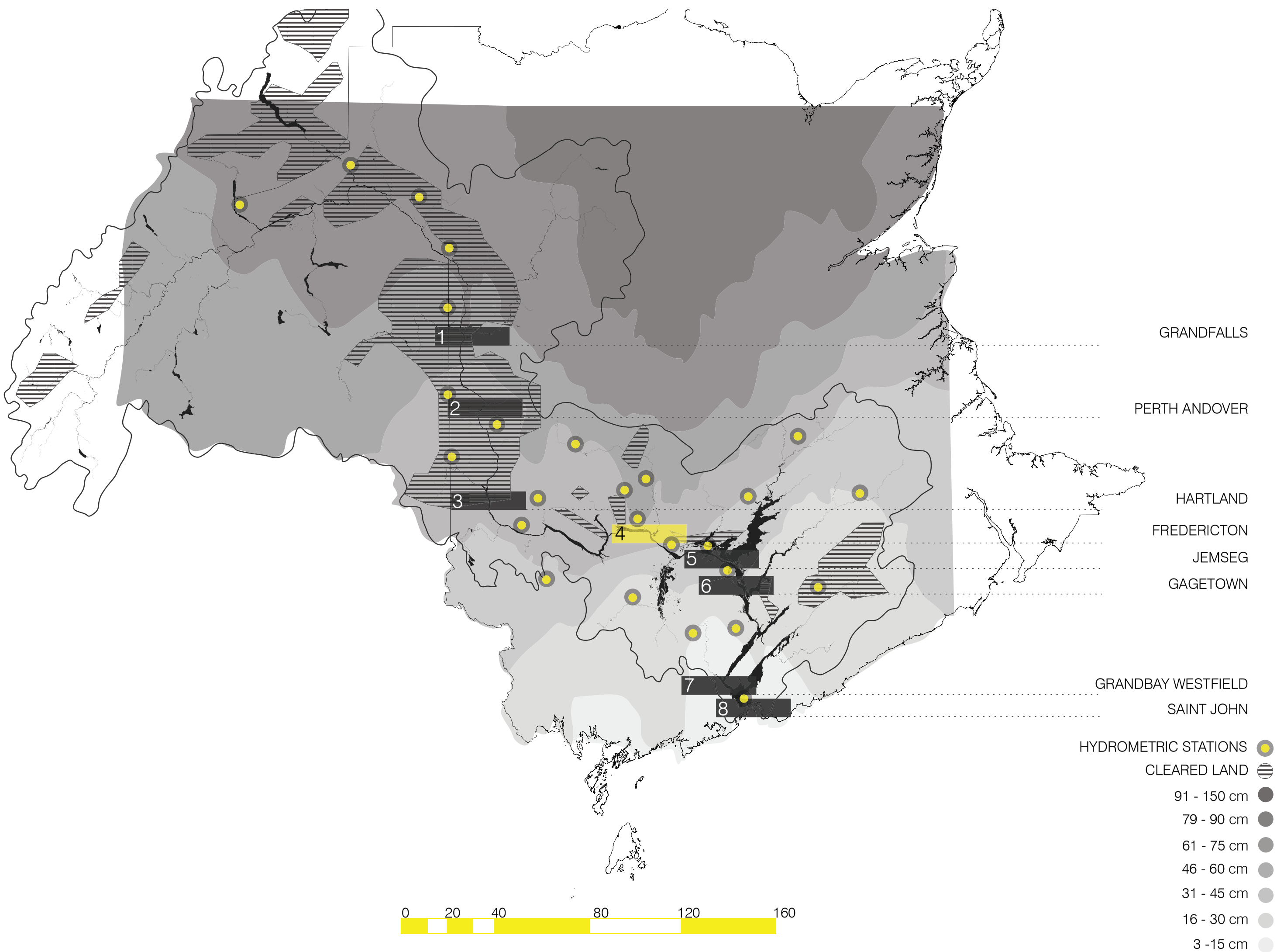
39 Carol McLeod, *Glimpses into New Brunswick History* (Hantsport, Nova Scotia: Lancelot Press, 1984), 61.

40 Scott D. Kidd, R. Allen Curry, Kelly R. Munkittrick, *The Saint John River: A State of the Environment Report*; *a Publication of the Canadian Rivers Institute Celebrating 10 Years of Science* (Fredericton, N.B.: Canadian Rivers Institute, UNB, 2011), 30.

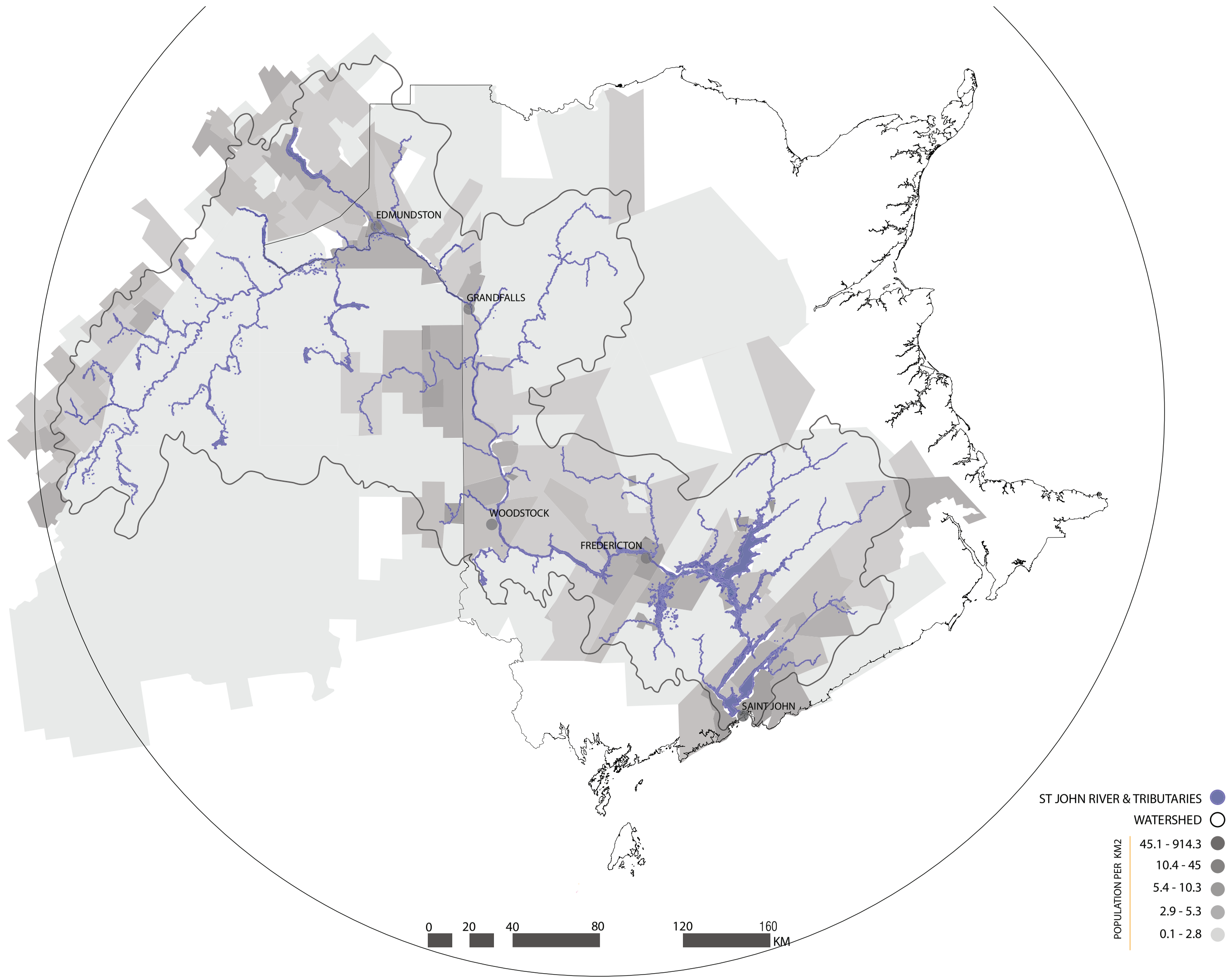
41 Carol McLeod, *Glimpses into New Brunswick History*, 62.

42 John M Henderson, *A Plan for Water Management in the Saint John River Basin: Final Report of the Saint John River Basin Board*, 241.

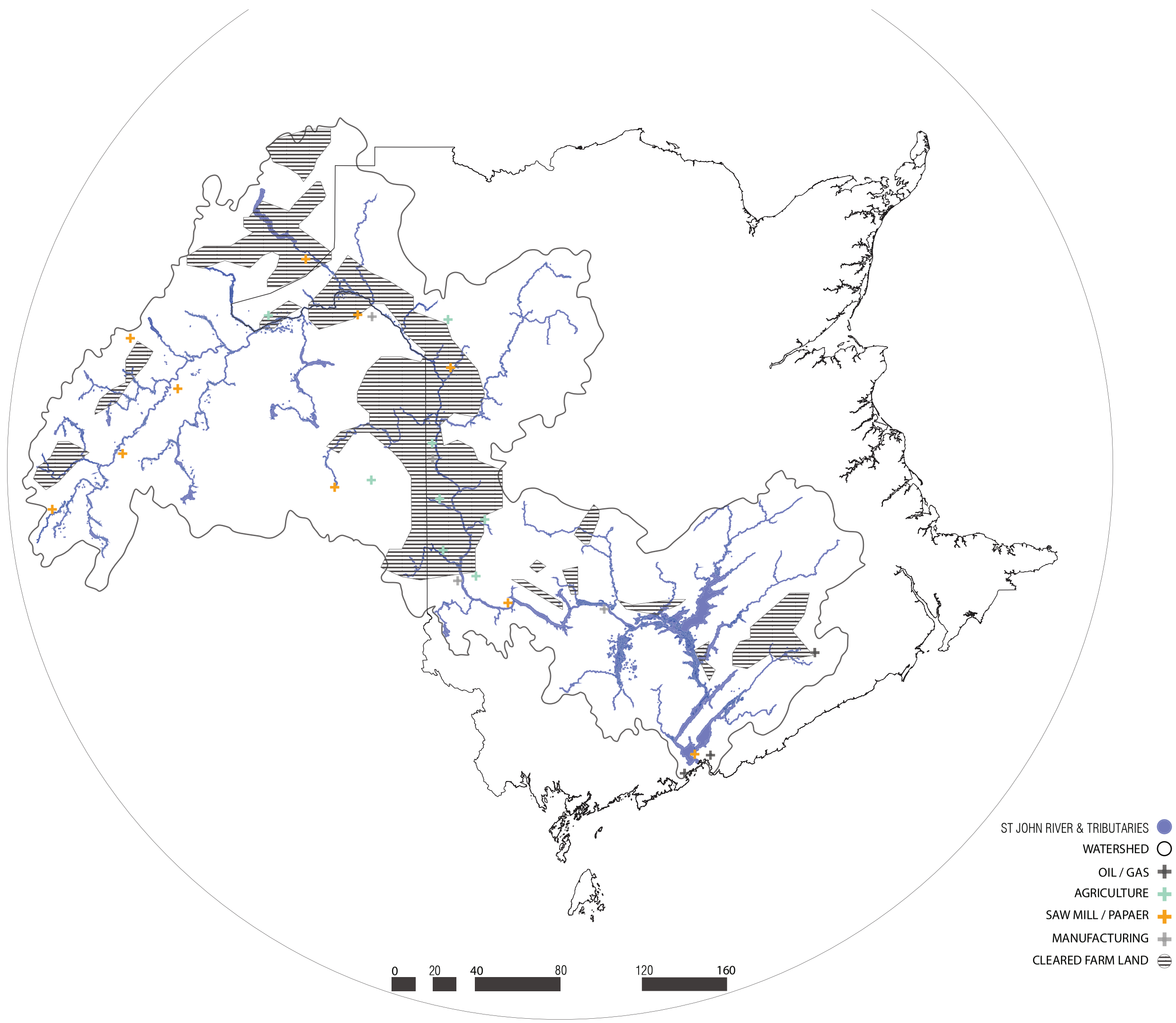
43 Scott D. Kidd, R. Allen Curry, Kelly R. Munkittrick, *The Saint John River: A State of the Environment Report*; *a Publication of the Canadian Rivers Institute Celebrating 10 Years of Science*, 34.



Watershed and snow pack levels. Information imported from *GeoNB* and *Environment Canada*.



Watershed and population levels. Information imported from *GeoNB* and *Statistics Canada.*



Watershed land clearance and industry. Information imported from *GeoNB* and *Statistics Canada.*

Most of the population in New Brunswick lives in close proximity to waterways, the Saint John River valley being one of the main rivers has several large population centers, one at Saint John where the river falls into the Bay of Funday and one just below the head of tide at Fredericton. Humans in the valley have always lived near sources of water for both transport and sustenance. "The pattern of dispersed settlement along the water, began by the Maliseets, had spread out along the entire Saint John River Valley; with very little alteration, this pattern is still evident today."[44] It is this relationship with water that has helped define the culture of the valley but also placed populations in direct conflict with freshet flooding.

Historic Flooding

Historic flooding events have occurred throughout the history of Fredericton which is situated just below the head of tide and in what is considered the New Brunswick Lowlands.[45] Flooding has never caused serious damage in Fredericton however down the river in the lowlands, along the many islands of the river and immediately across the river from The Green where The Nashwalk River enters The Saint John River it has been a significantly destructive force, with one depiction of a settlers cattle being swept away during a particularly high freshet in 1785.[46] The major floods that have caused issues historically along the green have been the result of ice jams which can significantly back up the river. As recently as 2008 and 2018, there have been perceived changes in the flooding, both instances were significant high water events which caused major disruptions in the downtown core.

Future Uncertainty

Climate change is expected to bring more precipitation to the watershed (45% more in northern and central NB) but precipitation will also be accompanied by warmer temperatures which may reduce the snowpack[47] although more study is needed in this area.[48] The impact of a one meter change in sea level was calculated in a study in the 1980s which predicted that during a 1-100 year flood an additional 20cm could be added to the

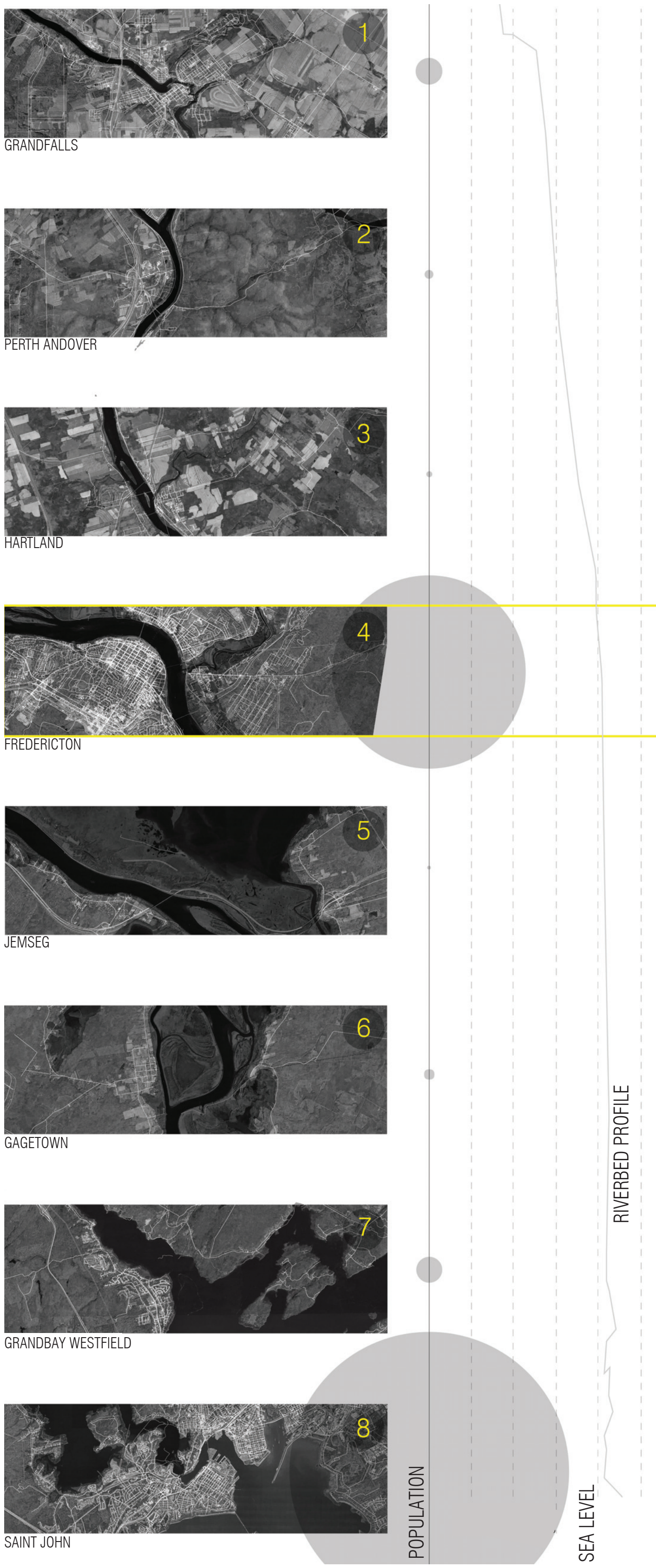
44 John M Henderson, *A Plan for Water Management in the Saint John River Basin: Final Report of the Saint John River Basin Board*, 21.

45 Esther Clark Wright, *The Saint John River* (Toronto: McClelland & Stewart, 1949), 2.

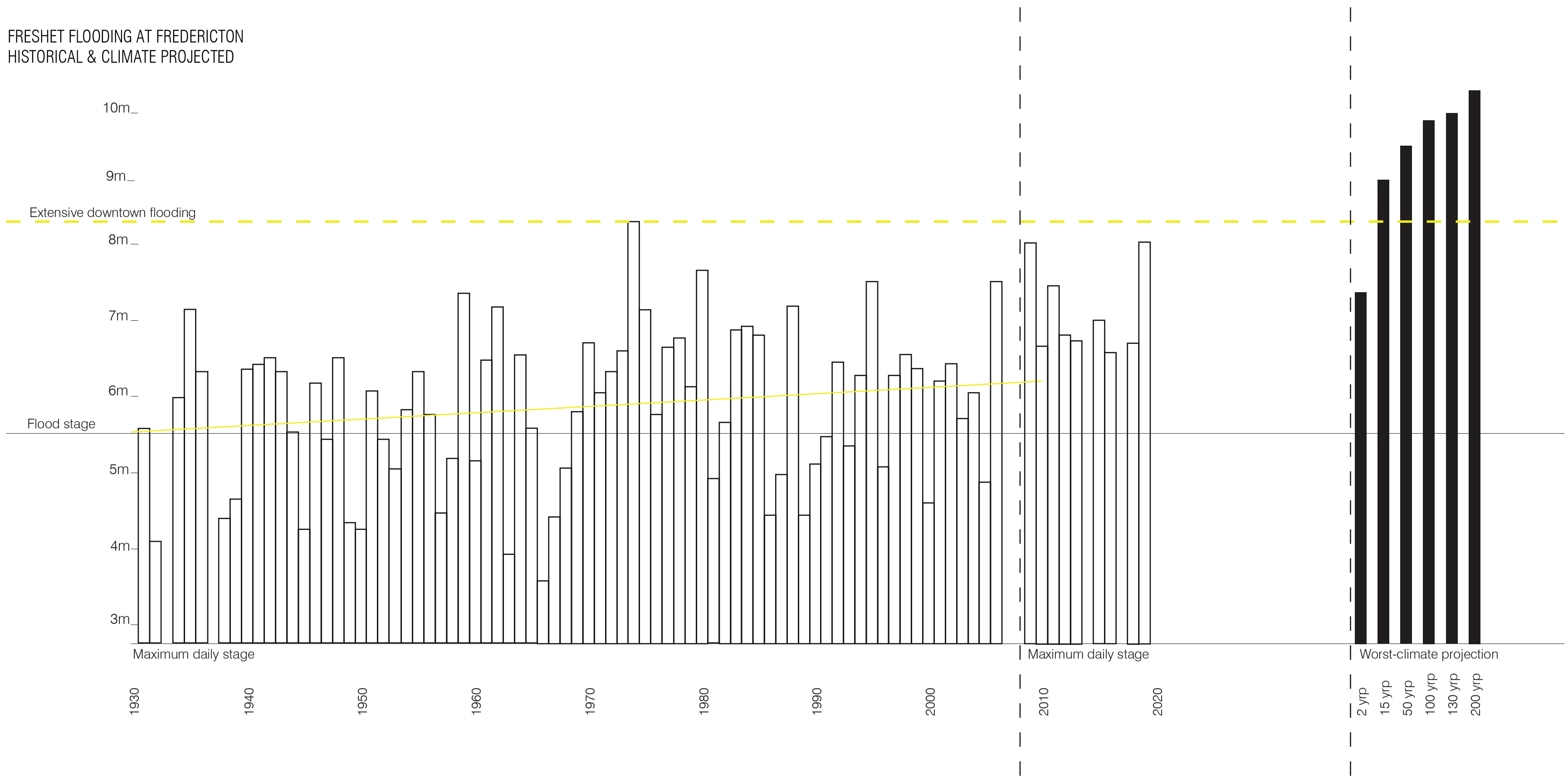
46 Esther Clark Wright, *The Saint John River*, 170.

47 E Swansburg, N. Ei-Jabi, and D. Caissie, "Climate Change in New Brunswick (Canada): Statistical Downscaling of Local Temperature, Precipitation, and River Discharge," *Canadian Technical Report of Fisheries and Aquatic Sciences* (No. 2544. Moncton, N.B.: Fisheries and Oceans, 2004), 7.

48 Ibid, x.



Flood prone communities along the saint John River valley, information imported from *GeoNB*.



Freshet flooding graphed over the past century along with projected worst case future levels. Graph constructed by author using information from: Lantz, Van, Ryan Trenholm, Jeff Wilson, and William Richards, “Assessing Market and Non-market Costs of Freshwater Flooding Due to Climate Change in the Community of Fredericton, Eastern Canada,” *Climatic Change 110*, no. 1 (2012): 347-372.

water levels as far upriver as Fredericton NB.[49] Under the worst-case scenario, the river could see a 1:100-year event increase in level from 8.76m to 9.84m while the best-case would result in the reduction of water levels to 8.68m. A 9.84m freshet event would be very costly for the city and freshet events with a lower level under the worst-case scenario would also result in significant damage. The same report places the total annual average cost of flooding in this worst-case scenario at roughly eight million dollars.[50]

The Green as Edge Condition

The Green is the principal site for the thesis, it is an edge condition between the city and the river, a historic park that through time has facilitated the community's interaction with the river. It has been used as prime agricultural land, remains an unseeded traditional territory, used as a transportation hub for steam paddle wheelers and has been extended and paved over for vehicular arteries, among many other uses. Through these transitions the natural and fluctuating river edge has been reshaped with dredging for docks, infill for bridges, roadways and, of course, the construction of buildings within this zone. As an edge condition, the green is where fluctuations in the water levels of the river are felt, the seasons change and the spring freshet inundates the edge of the city. The park is named The Green partly for its lush green grass, elm trees and other plantings which flourish with the nutrients the freshets brings. The Green meets the city's edge connecting the colonial grid with the river at an area known as The Barracks. The Barracks is a historical district consisting of mostly masonry buildings, these historic buildings and more recent institutional buildings exist in contrast to The Green. The Barracks District is home to public spaces like the library, Officers Square, City Hall, the Beaverbrook Art Gallery, and the Legislature. It is an area regarded as the cultural district of Fredericton; home to most of the city's festivals and activities. One event of note is the Harvest Jazz and Blues Festival which shuts down the district and converts it into a multi-venue concert space, using a near by theater and various temporary outdoor facilities.

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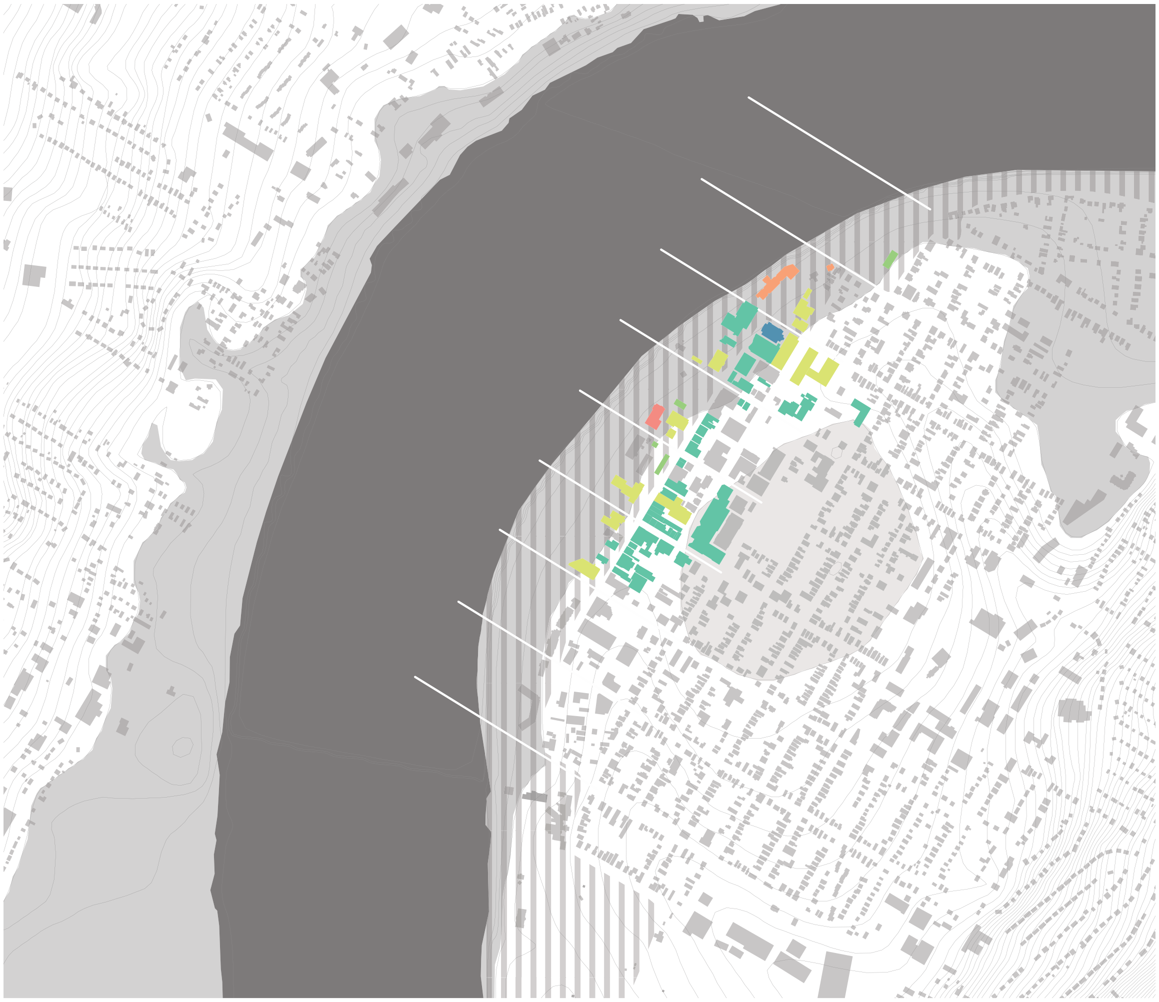
59 Martec Limited, et al, *Effects of a One Metre Rise in Mean Sea-level at Saint John, New Brunswick and the Lower Reaches of the Saint John River:* Executive Summary of the Report (CCD 87-04. Ottawa: Service, 1987), 4-5.

50 Van Lantz, Ryan Trenholm, Jeff Wilson, William Richards, "Assessing Market and Non-market Costs of Freshwater Flooding Due to Climate Change in the Community of Fredericton, Eastern Canada," 367.

1973 (top) and 2008 flood levels mapped onto Fredericton. Information imported from *GeoNB*.

9M (right) and 10M projection of freshet flooding mapped onto Fredericton.

Parks and green space (left) and aquifer pumping zones/protected areas(right). Information imported from *GeoNB* and *The City of Fredericton.*



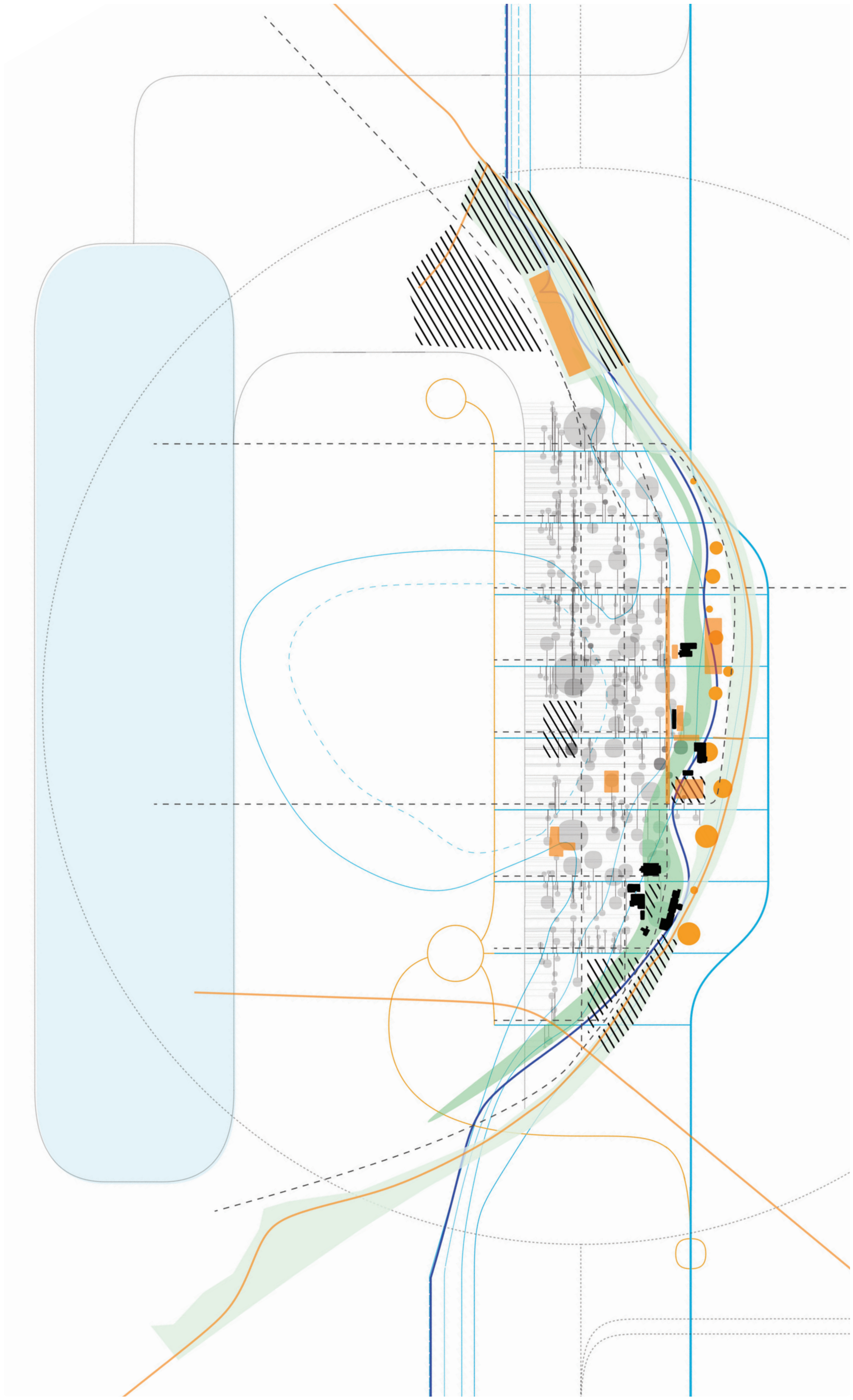
Public institutional and government buildings located along The Green.

The maps on page 32 -35 are an overview of territorial systems and infrastructure systems located along The Green overlaid with projected freshet flooding levels. They are part of an evaluation of territorial systems in relation to the dynamic system of the Saint John River. The historical flooding, projected flooding along with the categorizing of these territorial systems along The Green is the basis for the development of the urban strategy and dynamic architecture outlined in the next chapter.

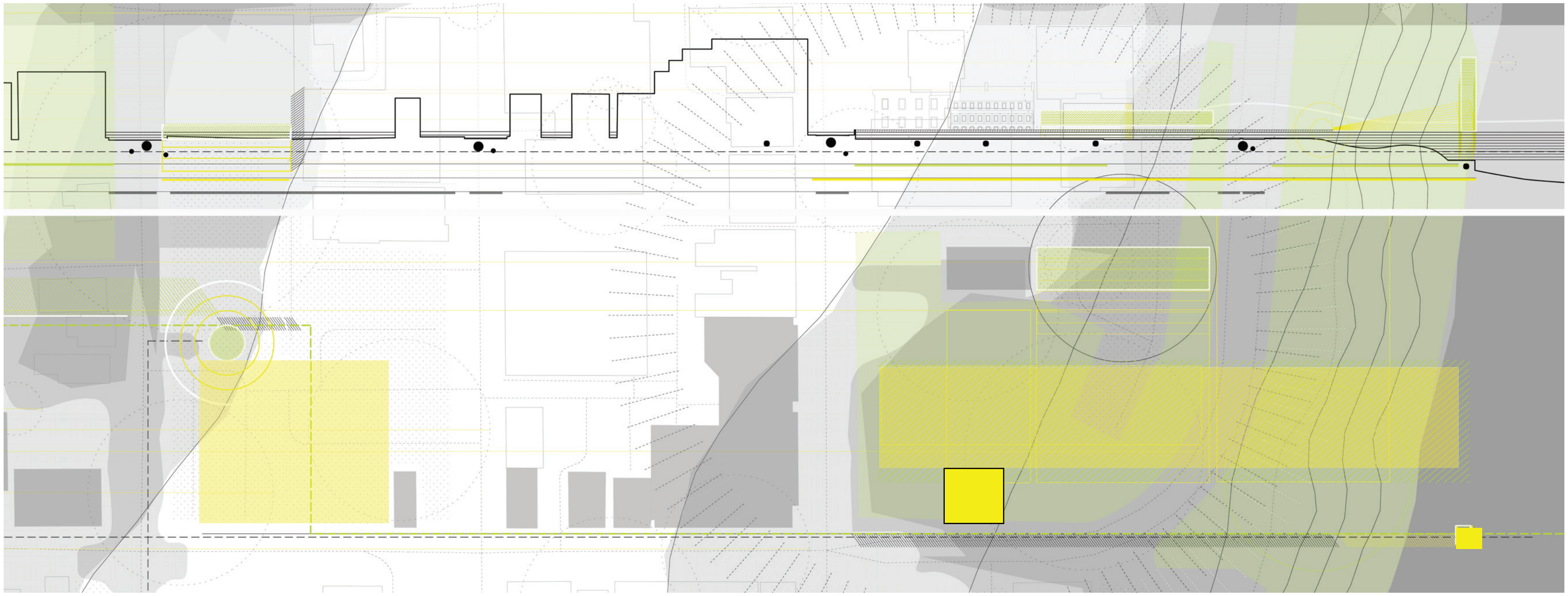
CHAPTER 4: DESIGN STRATEGY

Through the augmentation of The Greens topography where the city's grid meets the river, this thesis catalyzes systems of ecology, people and machines, while providing for flexible control of changing water levels. The Green, an interconnected surface consisting of public spaces, parks and parking lots, formed around mainly singular masonry public buildings can be designed to more effectively accommodate the flows of both people and water. A combination of topographic augmentation as well as new infrastructure and architecture proposed beyond these embankments within The Green are designed to provide for flooding, while other structures might be adapted. Architecture in this area, also considers other activities, connecting with existing local programs, while interacting with these activities, events and the river through a system of feedback. Enabling each intervention to react to the various programmatic needs as well as the forces of the river within a pre-determined script, each movement of program corresponds to a movement in the landscape. It is this changing landscape, where social, cultural and natural events facilitate the physical arrangement of form. This concept acknowledges that the landscape is in flux, not a static surface but rather a shifting topology.

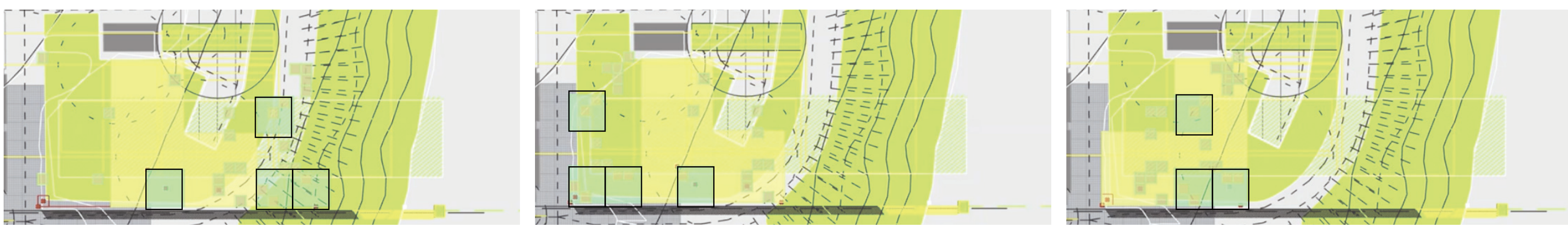
Cybernetics is viewed as the science of control across the natural and the synthetic therefore the intervention is reacting to the forces of the river within a predetermined script, each movement (or communication) corresponds to a movement (or communication) in the landscape. It is this changing landscape that facilitates the arrangement of program space and form. This concept acknowledges that the landscape is in flux, not a static surface but rather a shifting topology. Within this flexible methodology there exists some constants the design must address. 1: The flooding, by limiting the destructive potential of an extreme 8.5m-9m freshet, 2: the design should utilize The Green as a topographical solution to this flooding. 3: The design should communicate with the river, watershed and city acting as a conduit between the two. 4: Structure established beyond his augmented topography should demonstrate how to physically respond in flood plains and change given water levels. 5: The architecture should establish a relationship between the duality of programs present in both a flooded and non-flooded scenario.



Abstracted systems collage, investigating the layered and temporal nature of systems in Fredericton while speculating future water levels and edge conditions.



Process drawing image a dynamic system through The Green and into officer square.



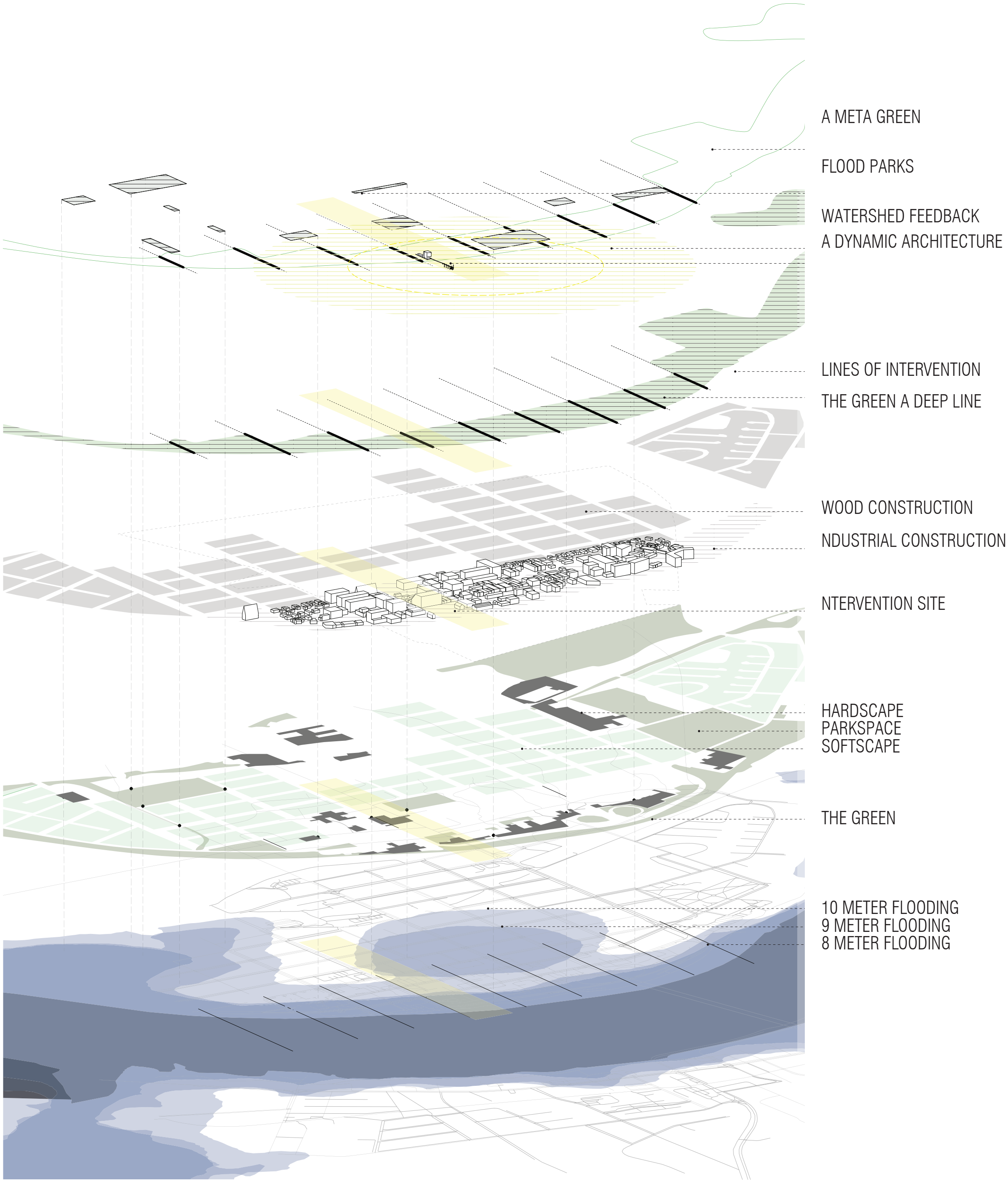
Process imags generated in Grasshopper schgemamatically illustrating programs arragments throughout The Green and into officer square.

Control Strategy ‘Meta-Green’

This project similar to how the Fun Palace produce space through occupant behaviour, produces spaces, views and topology that are the result of the communication between the Saint John River and a dynamic infrastructure and architecture. These like the Fun Palace share a memory that is processed across the synthetic and the organic. This memory is based around an event, a seasonal fluctuation, the spring freshet, This yearly event produces topological changes across the system and its unpredictability and potential increasing intensity. Each water level results in different arrangements in either view, space or surface. Of course water levels are not as complex as the human interaction present in the Fun Palace, they are none the less variable and subject to change. These connective structures also play a role communicating between the watershed and human population through a conceptual digital interface that positions spatial arrangement and social interactions based on the programmatic functions of the flood line throughout time.

Through the architectural methods of mapping, overlaying and digital modeling along with the inspirational theories of cybernetics a flood defence strategy was developed for Fredericton, a strategy of flexibility that could be applied all along the water way. The strategy includes augmenting the topology of The Green, interior flood parks, and a flexible architecture within The Green. The grid of the street is abstracted and one of these lines is picked to demonstrate the intervention although the intervention could be accomplished in some form along any of these lines. The Regent Street line was chosen for its deep connection to Office Square and its history of flooding.

Considering The Green is not as a single line but a wide area for absorption and accommodation that would allow for the interrelations of the river system and the city. Allowing for the absorption of water into the city in some zones while safe guarding other structures with a harder line of defence. In essence this ‘Meta-Green’ would begin to interface with the river in such a way that there is no obvious levee or other water infrastructure along its length. This augmented Green is the combination of; 1: a system for flood control constructed through a linking of parks, 2: The Lockhouse an example of a dynamic architecture and infrastructure, 3: The Lighthouse a poetic connection to the watershed.



Strategy drawing breaking down the logic behind a wide absorbent green and locating a series of intern flood parks.

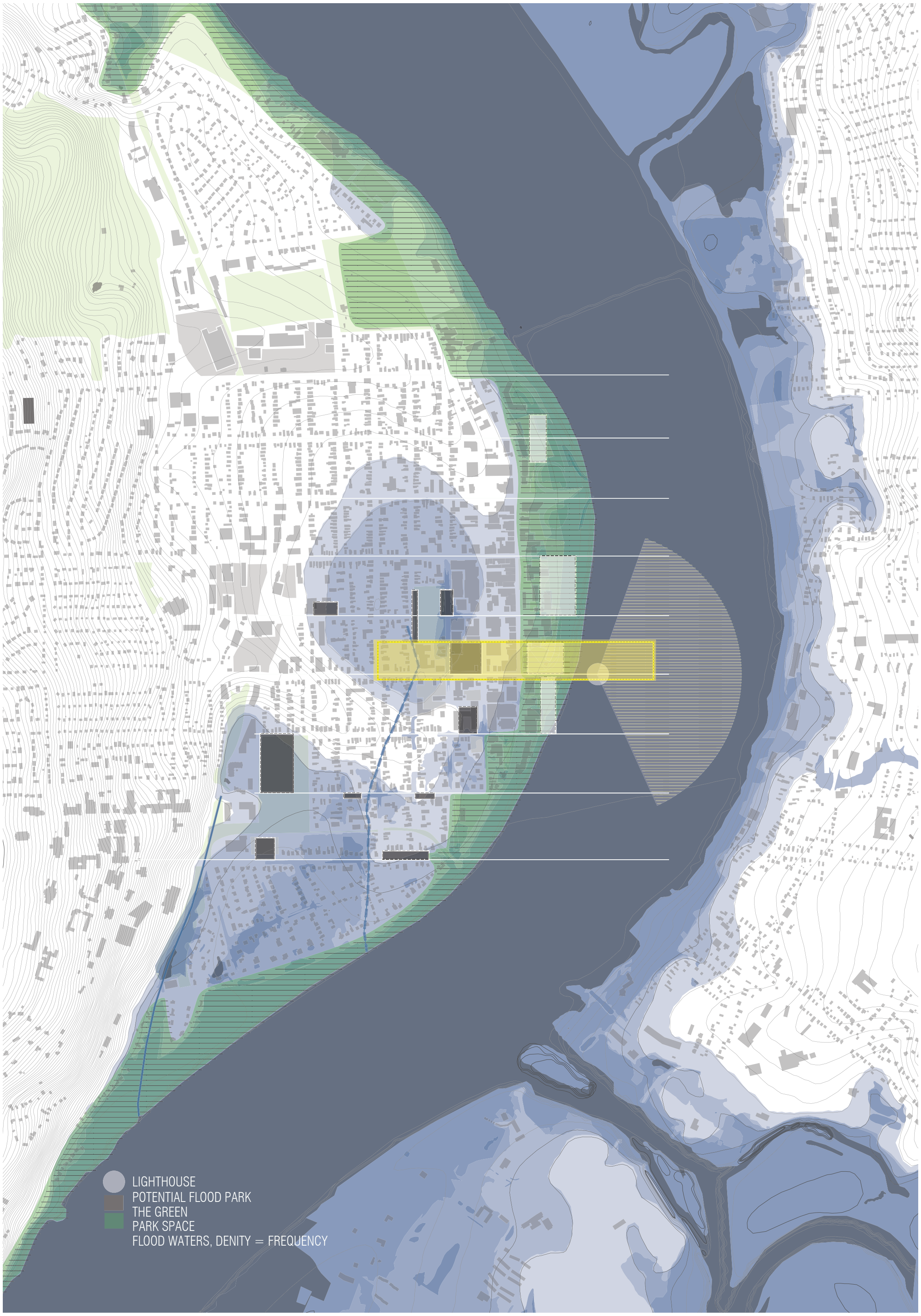
CHAPTER 5: DESIGN

The System

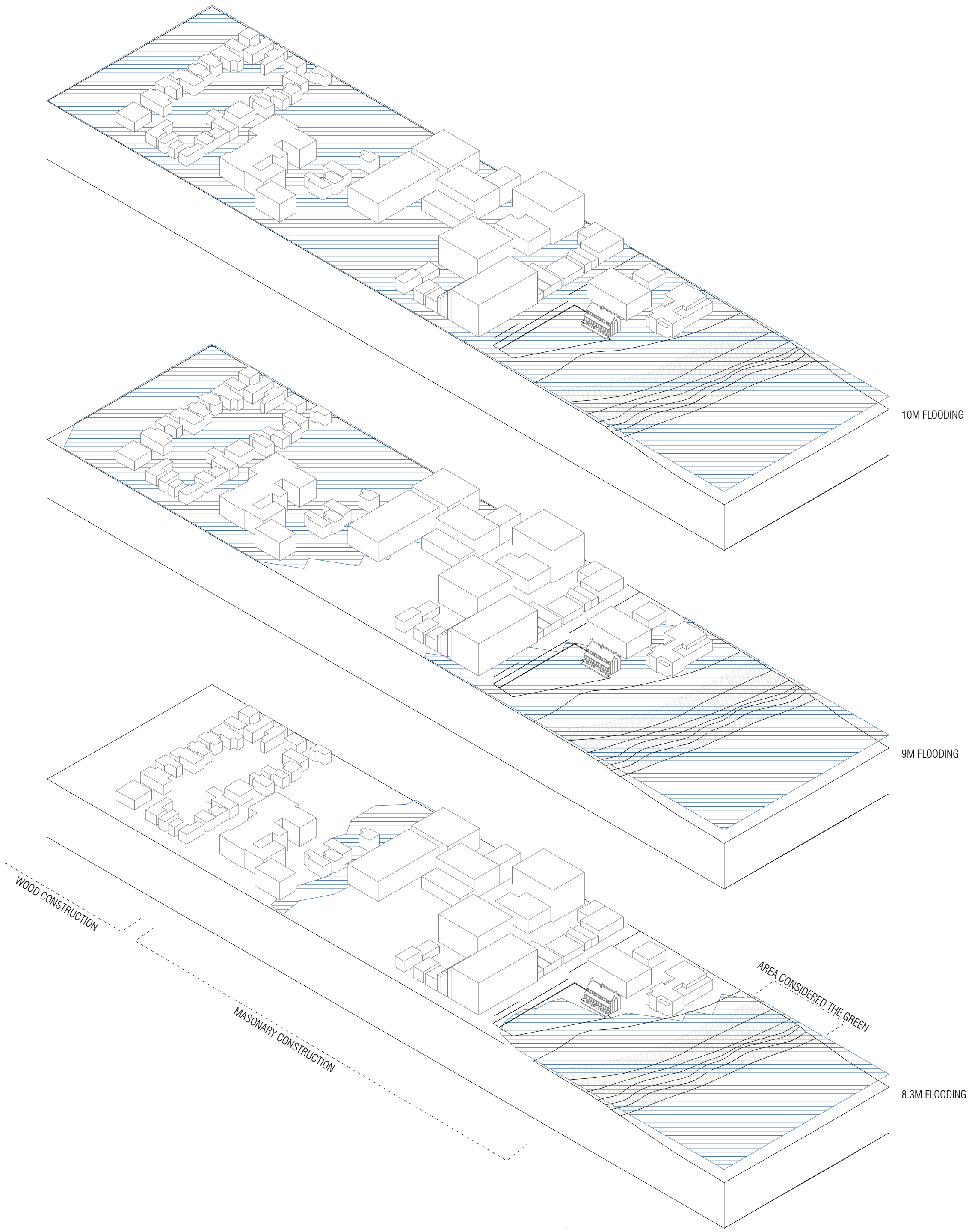
This system draws The Green into the downtown, formalizing the floodplain as part of the fabric of the city; a 'Meta-Green'. Using the green as a starting point, a flood control strategy is adopted that through an expansion of the park into the city and augmentation of its topography flooding is limited and also accommodated. Existing parks and surface parking lots are integrated and raised along its length such that it forms a continuous barrier to the flood waters. This forms a wide edge where existing buildings and new construction within the 'Meta-Green' are retrofitted or constructed such that they can accommodate high spring freshets. Behind this new expanded Green a series of flood parks are placed in areas prone to flooding from ground water or the back up of the storm water system.

The flood park's serves as a water reservoir during a flood, moving water from the street into the low areas of the park. These flood parks provide a green space that changes with the flood levels, allows for absorption during a rain event and through their plantings provide natural filtration of road run off. The park can then drain through a canal/pipe system into the river. The parks planting are salt resistant and the soil is separated from the rest of the ground water system to avoid contaminating the aquifer. Conceptually it is an extension of The Green into the city, a series of these parks work to accommodate the water. This connection of the parks not only provides physical space to store water but also provides a space where program activities can take place that are seen as risky during a flood. The canoeists who historically have taken to the flooded streets during a freshet would be able to use these parks as a space to canoe as it is safely separated from the dangerous currents present in the river during a freshet.

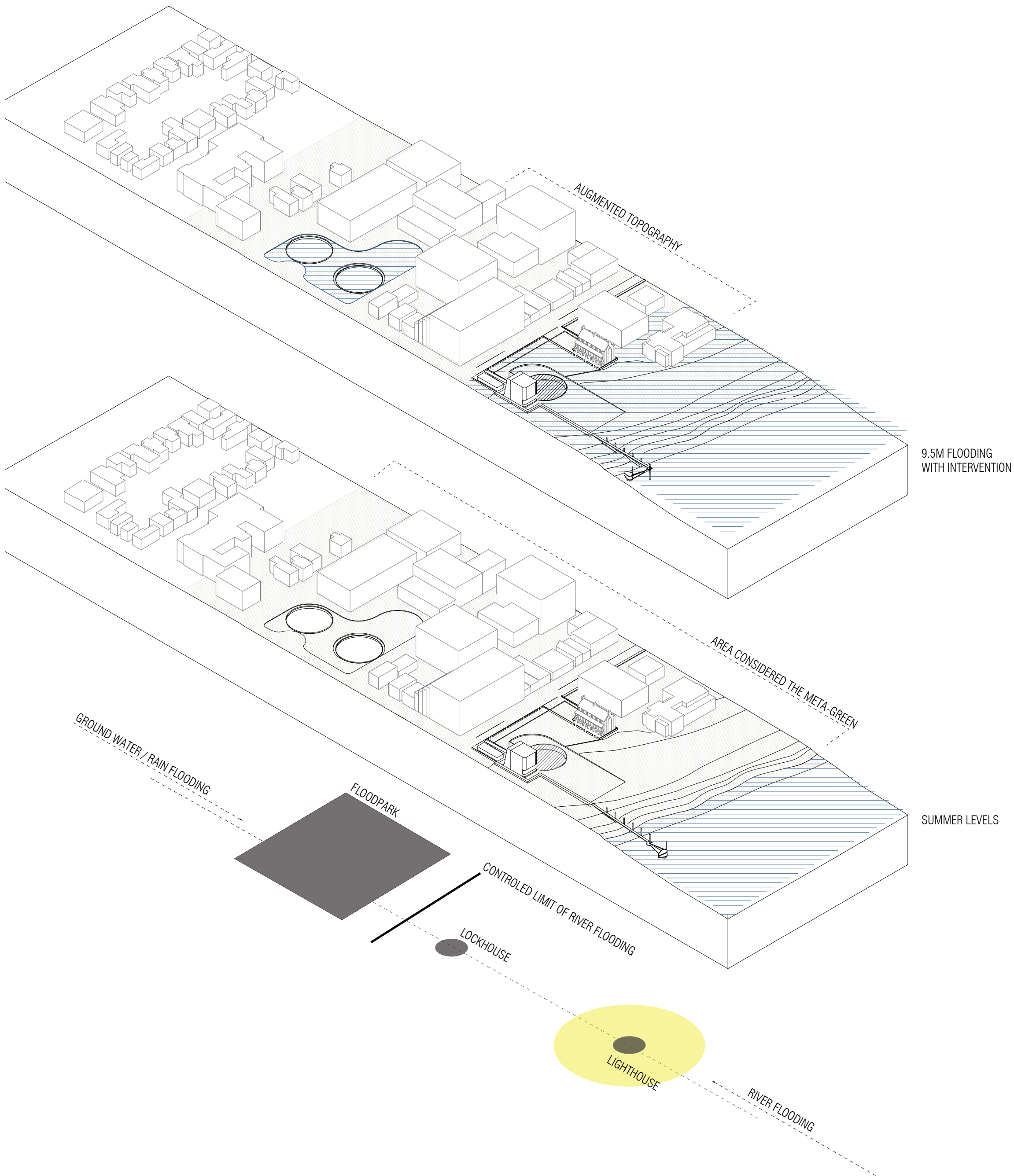
The street grid is used as a basis for the insertion and planning of the interventions, this is done because it is already where the infrastructure for storm water management is located. Regent Street is chosen for further investigation because of its historic connection to the river and its termination at Officer Square in the Barracks District. Along this line two interventions of flexible architecture are positioned along with an infrastructure serving the flood parks behind the 'Meta-Green'.



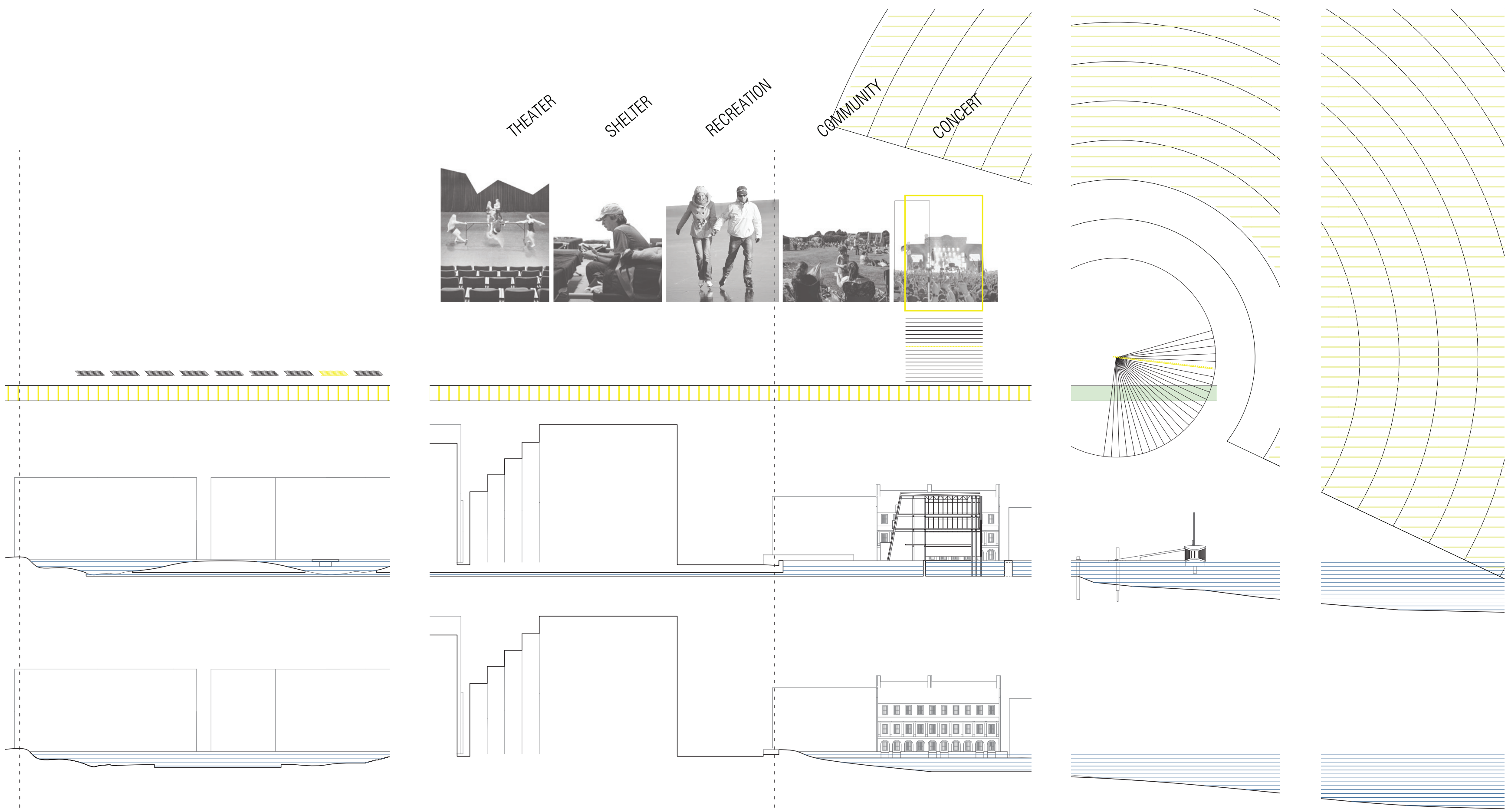
Strategy drawing articulating a strategy of a wide absorbent green along with a series of intern flood parks



Pictured, 8.3 meter flooding (bottom), 9 meter flooding (middle) and 10 meter flooding (top)



Pictured, strategy diagram (bottom), normal water levels (middle) and 9-10 meter freshet flooding (top)



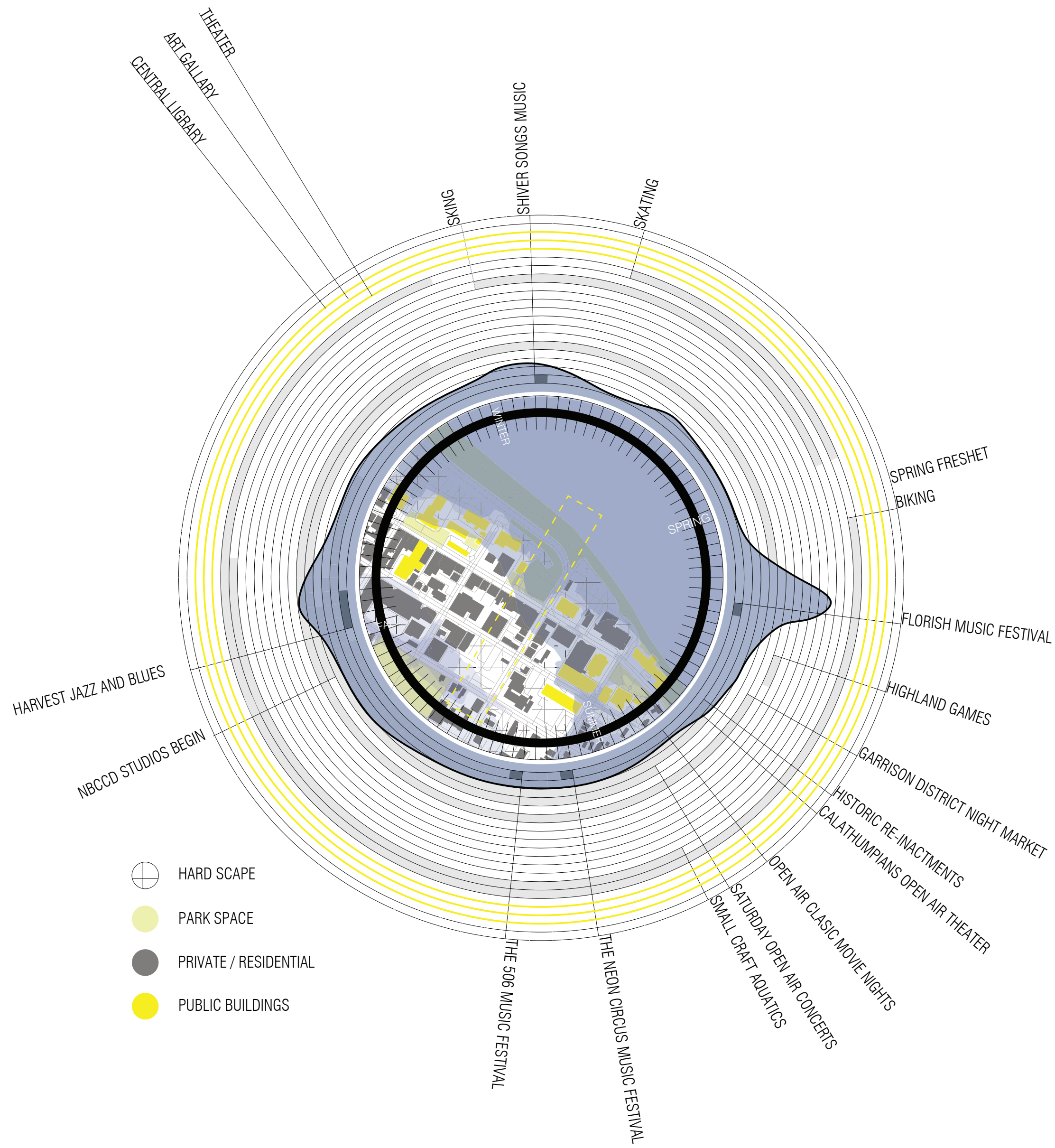
Speculative section depicting water levels, activity and connection through the line shown on page 44.

The Lockhouse

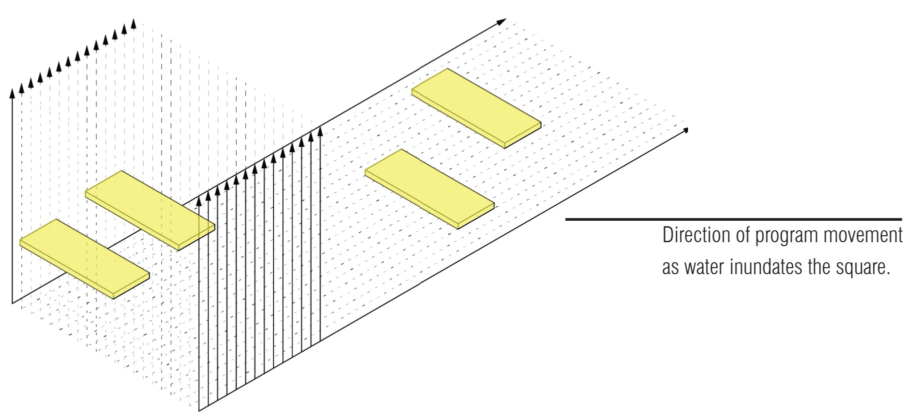
The main intervention, located along the Regent Street line where it meets Officer Square, is both a flexible theater, shelter and water gate which demonstrates a flexible and dynamic architecture within the Meta-Green, while celebrating the rivers fluctuations. During a flood its moveable floor plates can be arranged in such a way that it creates four floors of sheltered space in the flood zone. The building also serves as the lock which holds back water during the flood from entering the cities storm water system and allows parts of the park to be flooded in the winter as a skating rink. When the square is inundated with another type of flow, people, the building opens up and provides a concert stage that facilitates many of the festivals and events that take place in the square during the summer and fall. Throughout the year the structure also allows for transformation into a 100-seat theater to host intimate concerts.

The program for the lockhouse is derived through an evaluation of the seasonal activities which take place in the square as well as existing programs of the surrounding institutional buildings. The diagram on page 47 illustrates how these events and institutional buildings relate to the square. Highlighted in yellow are the public buildings, gray are the private buildings, hardscaped and softscaped spaces are also illustrated. The general water levels are also mapped onto the diagram with a large bump to highlight the spring freshet and a small one for a slight increase due to the fall rains.

The program also considered that the building would have to serve a potential changing program need in the square as new activities and events may take place. Thus the moving floor plates not only facilitate a myriad of arrangements of space within the building they also serve as elevators for the transport of program and services from the upper levels of the building down and into the square. An example of these programs and services would be the storage of tents, chairs and sound equipment.



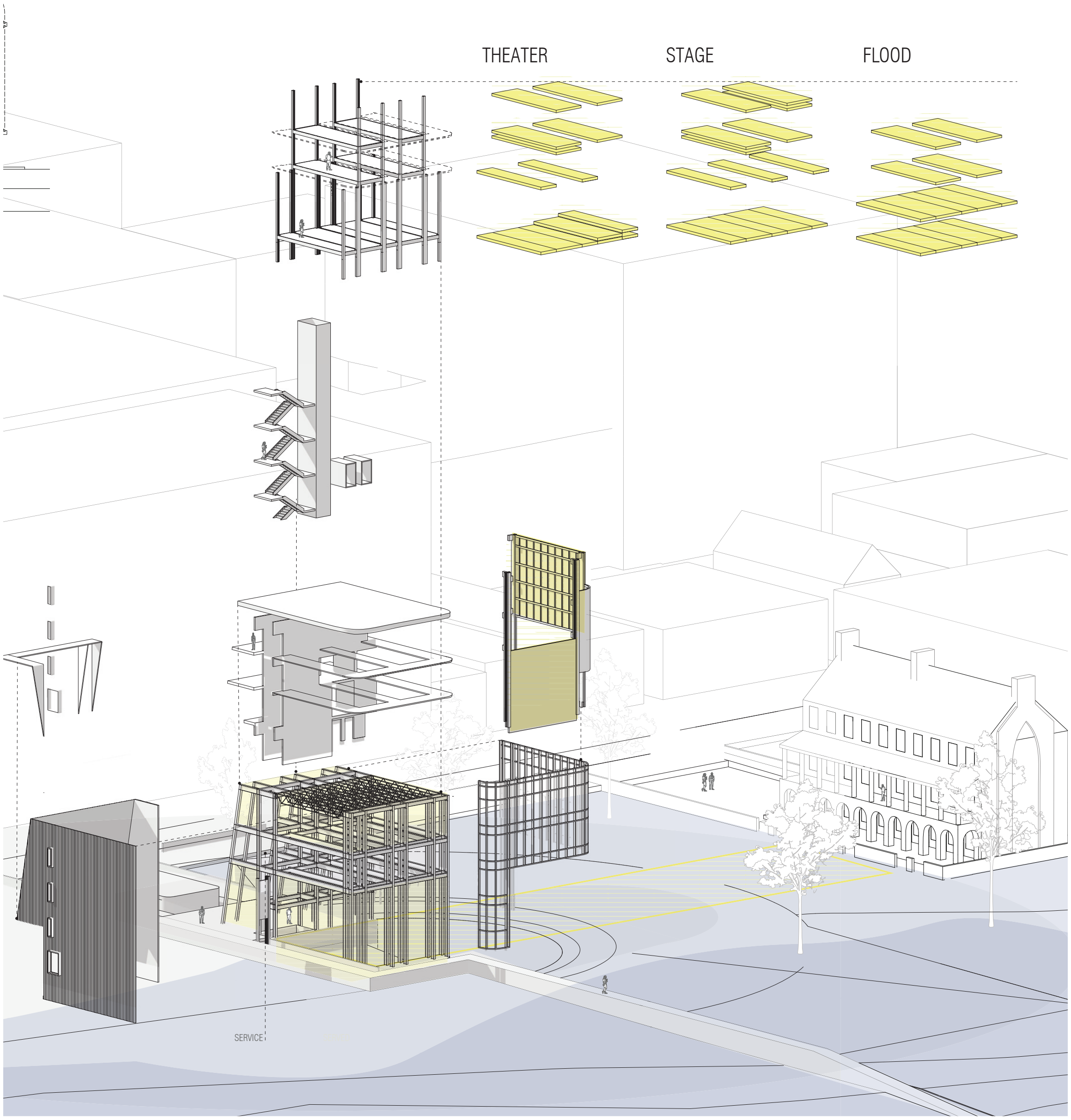
Program diagram illustrating, seasons, activities and water levels in officer square.



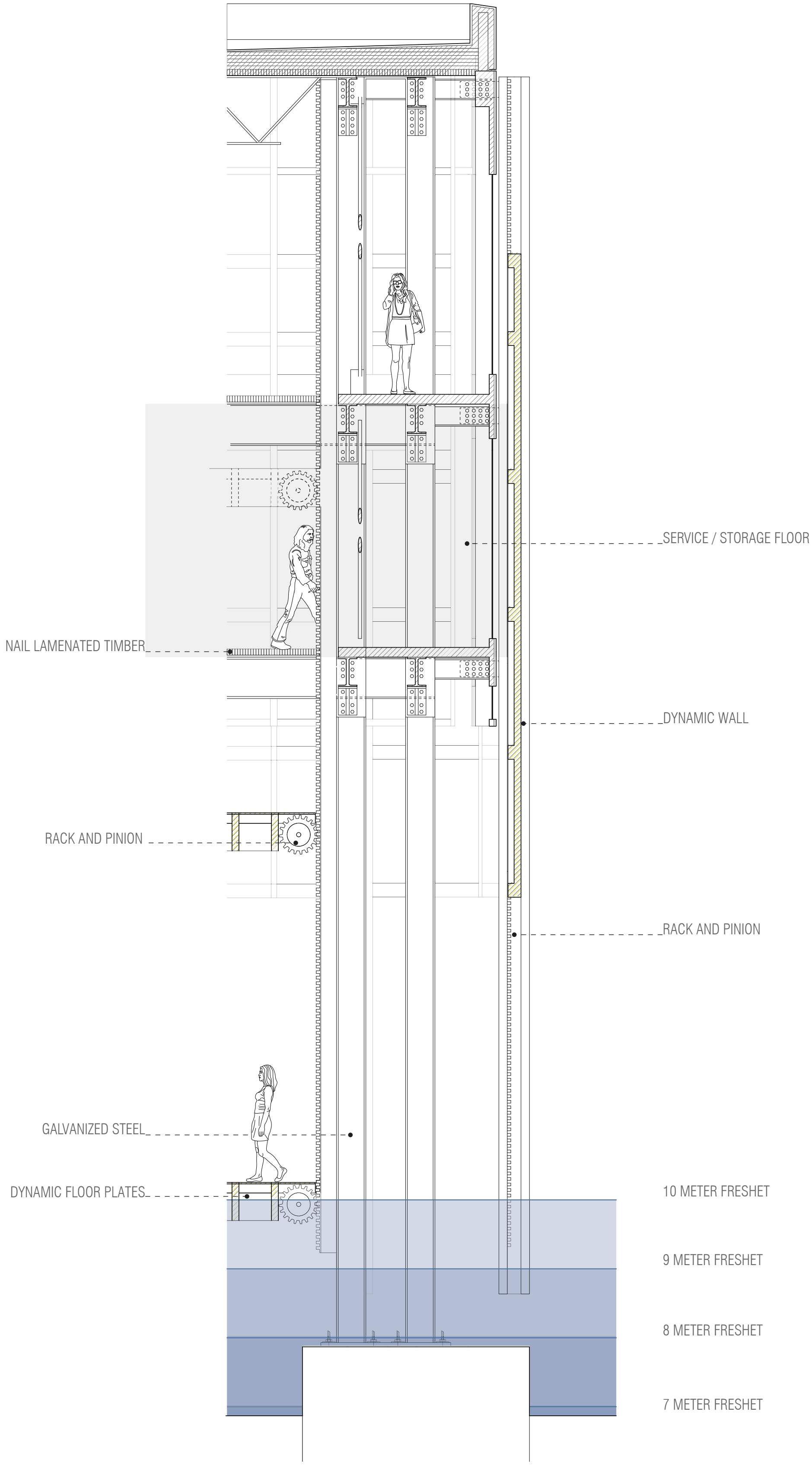
Conceptual diagram for lockhouse intervention, showing program moving out, in and up the super structure as to facilitate a dynamic program space in the square.

Considering buildings as hardware and software, materials and construction methods being the latter; the selection of materials is based on a layered approach and considers life cycle, dividing envelope from structure. Steel, wood and glass, a simple pallet that respects the systemic relationship that exists between materials and context, while aging with the building. In a changing watershed the systemic consequences of consumption is even more evident, as the effects of climate shifts are visualized in the watershed and carbon intensive building practices and materials are related globally to the changing river levels and precipitation patterns. Therefore minimal concrete is employed throughout the earthworks and architecture, used only where it is required. The buildings primary structure is steel with secondary structure and floor plates constructed of nail lam decking. Galvanized steel is used throughout the structure for its resistance to water and moisture. An aluminum curtain wall system and steel cladding provide the building envelope. Steel, wood and glass are all materials that can be recycled, or composted at the end of their respective life cycles.

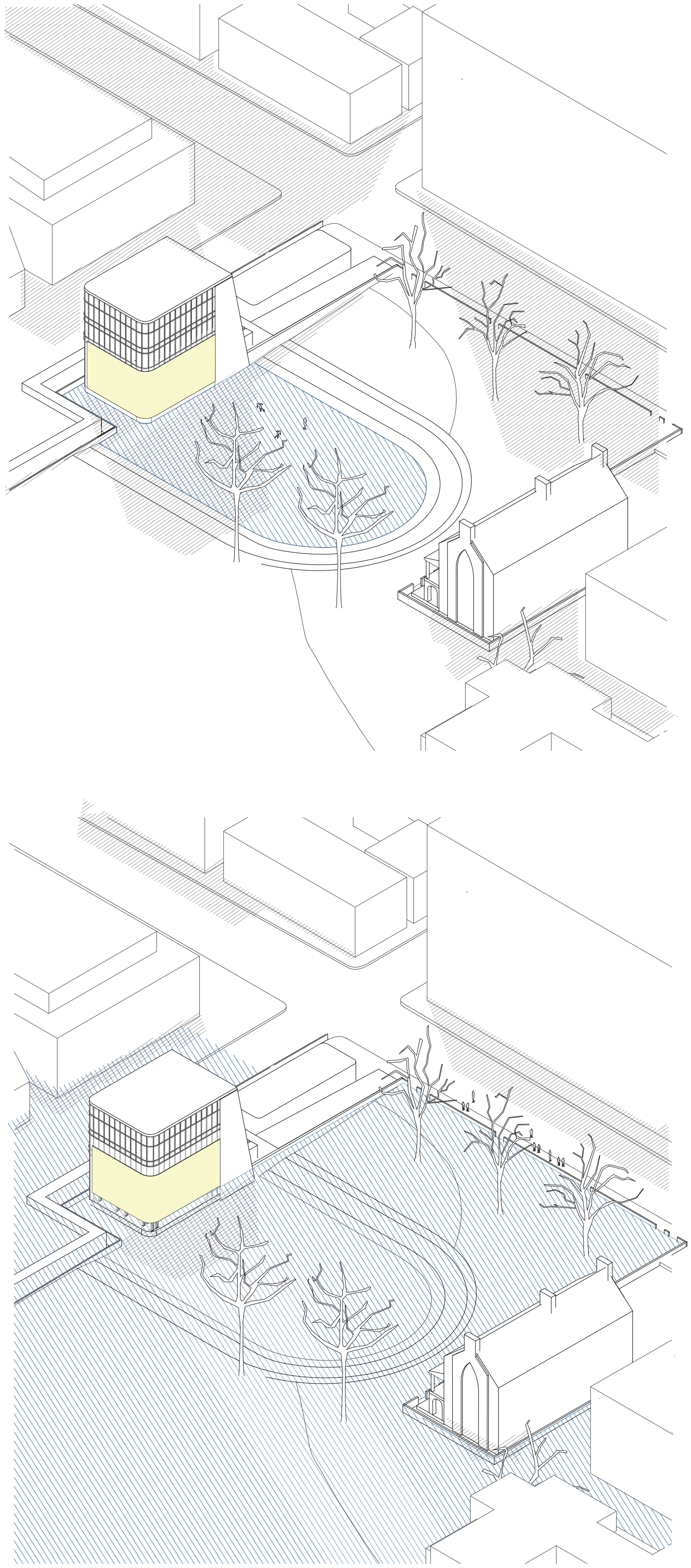
Higher quality connections and a componentization of the envelope, structure, mechanical systems increase the structures longevity while also allowing for easy disassembly at the end of life. The moveable floors are constructed of galvanized steel along with nail lam decking to span between the structural elements. The moving doors are again galvanized steel framed and clad in copper which is chosen for its patina and relationship to the material culture of the surrounding buildings along with its high value as a recyclable material at the end of its life.



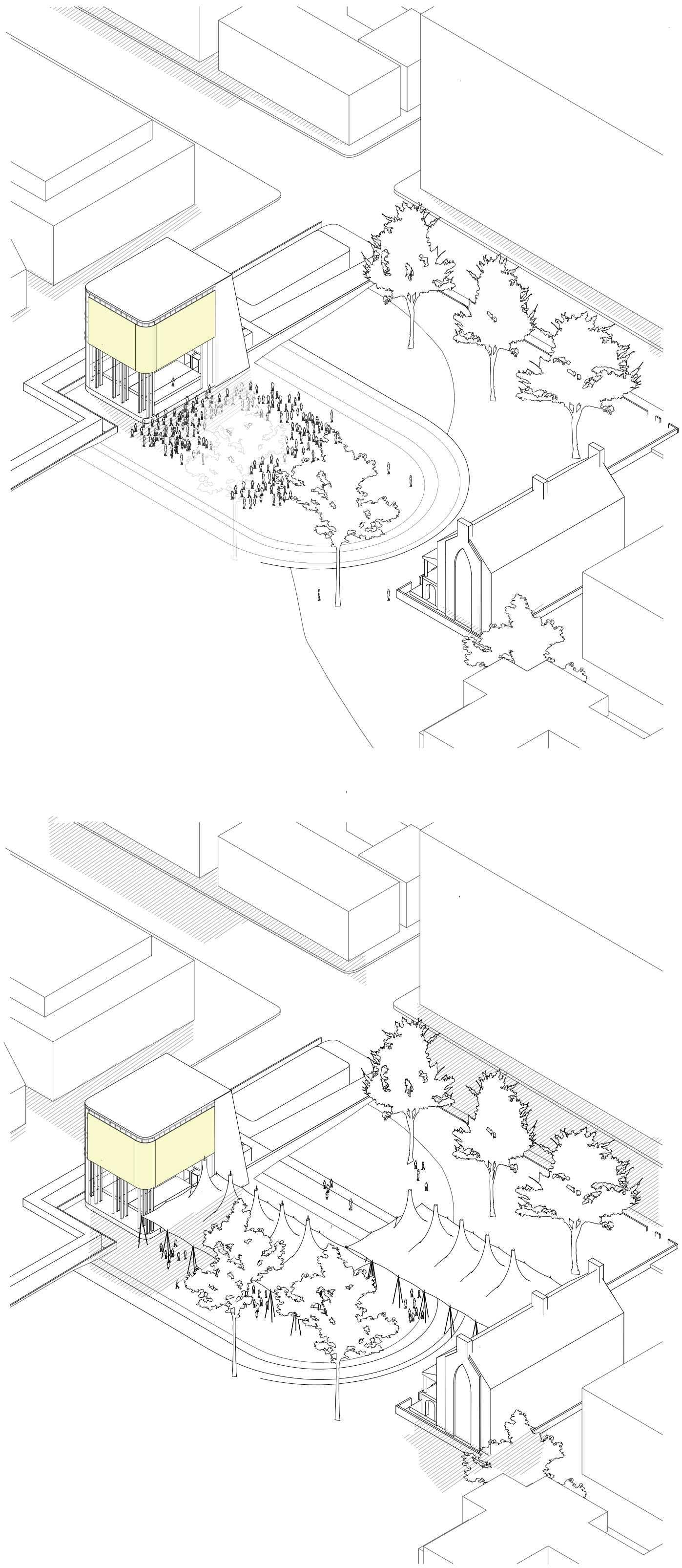
lockhouse isometric detailing major systems and their relation to the site.



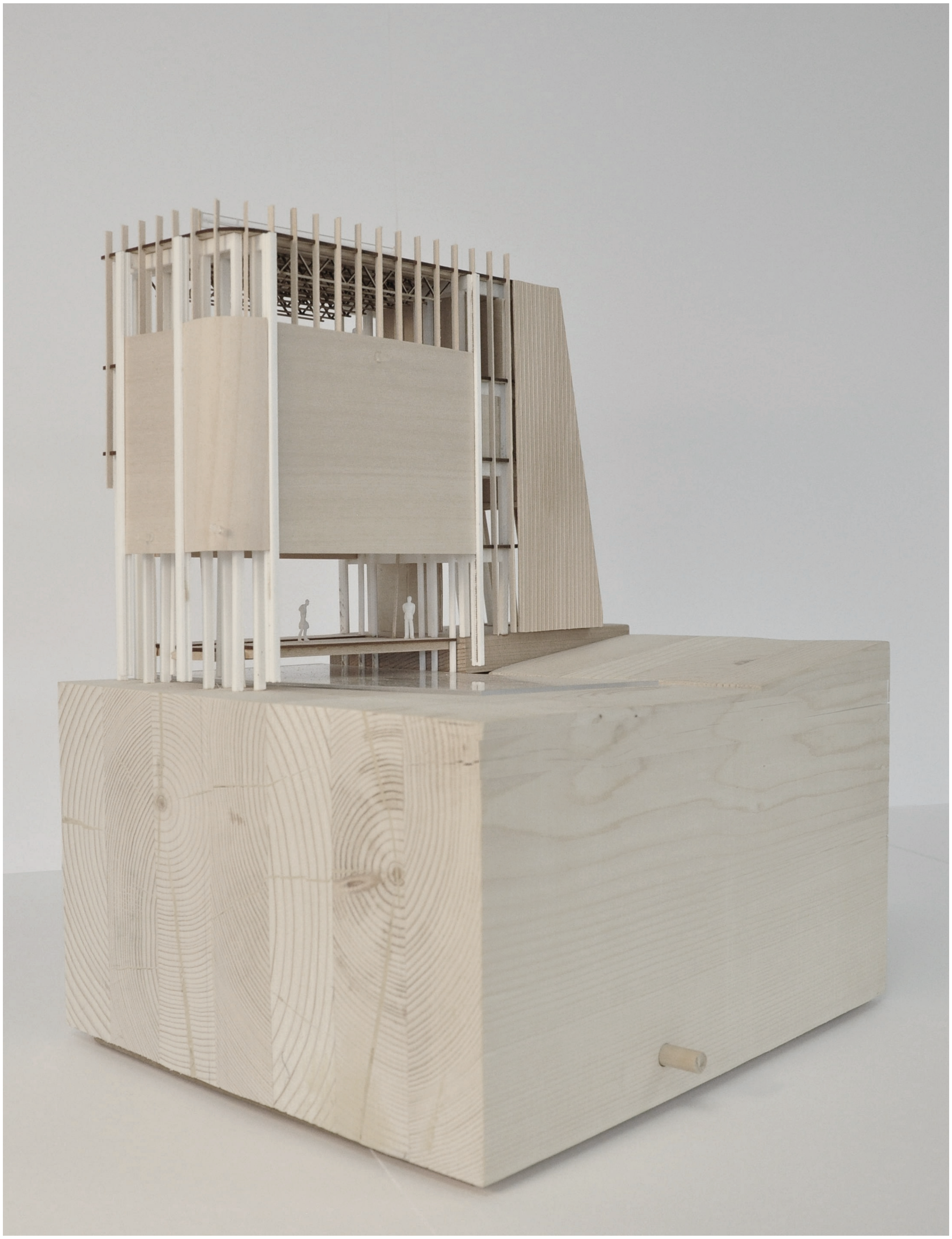
Lockhouse wall section illustrating dynamic floor and wall system.



Winter (top) and spring (bottom) Axonometric of intervention in officers' square illustrating potential water levels (bottom) and the flooded skating surface (top).



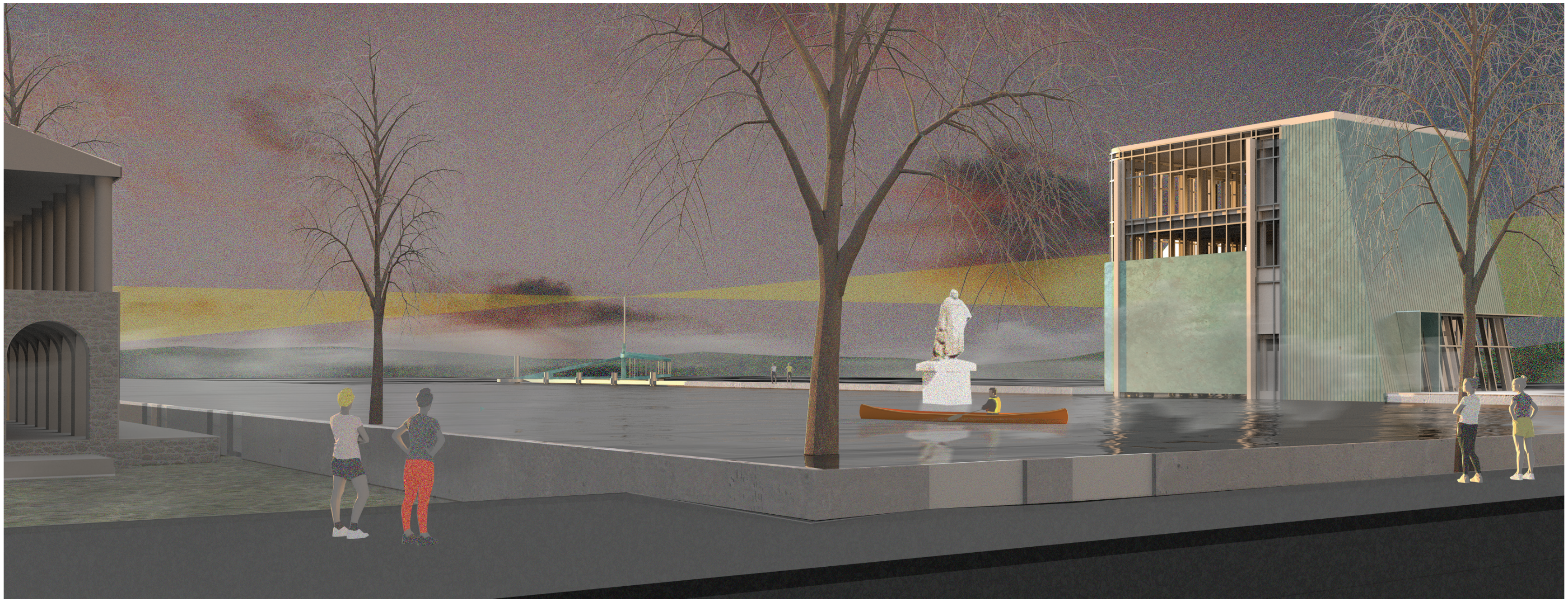
Summer (top) and autumn (bottom) Axonometric of intervention in officers' square illustrating an out concert (top) and a festival (bottom).



1-100 dynamic model of Lockhouse.

1-100 dynamic model of Lockhouse, showing moving doors.

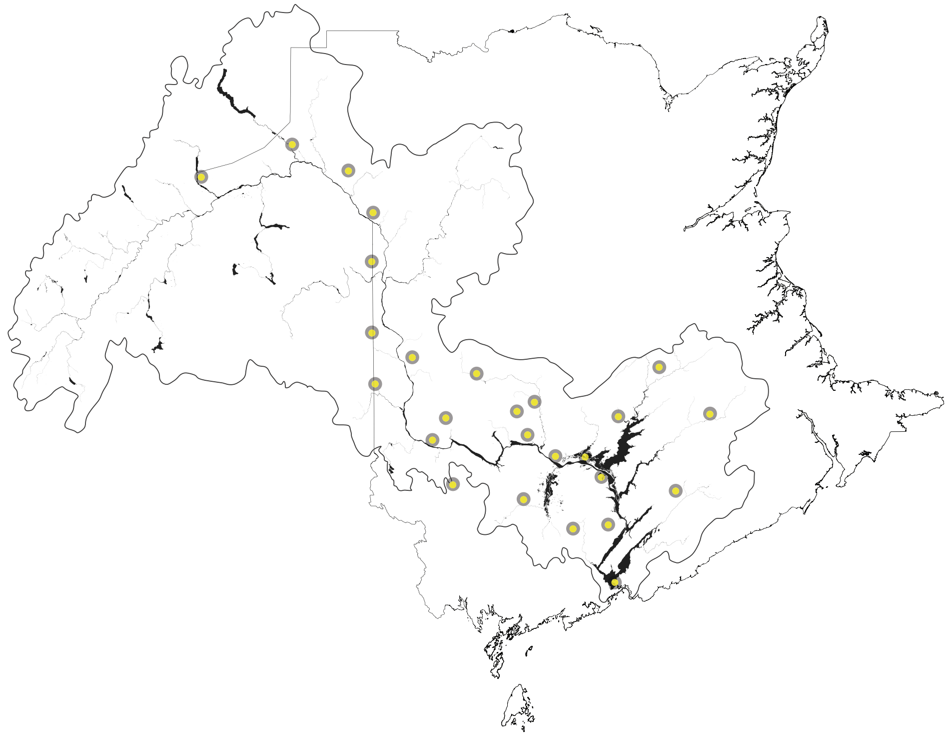
1-100 dynamic model of Lockhouse, showing moving floor plates.



Rendering of Officers Square and intervention during a high spring freshet.

Rendering of Officers Square and intervention during a concert.

Rendering from Lockhouse towards The Barracks building in Officers Square during a high spring freshet.



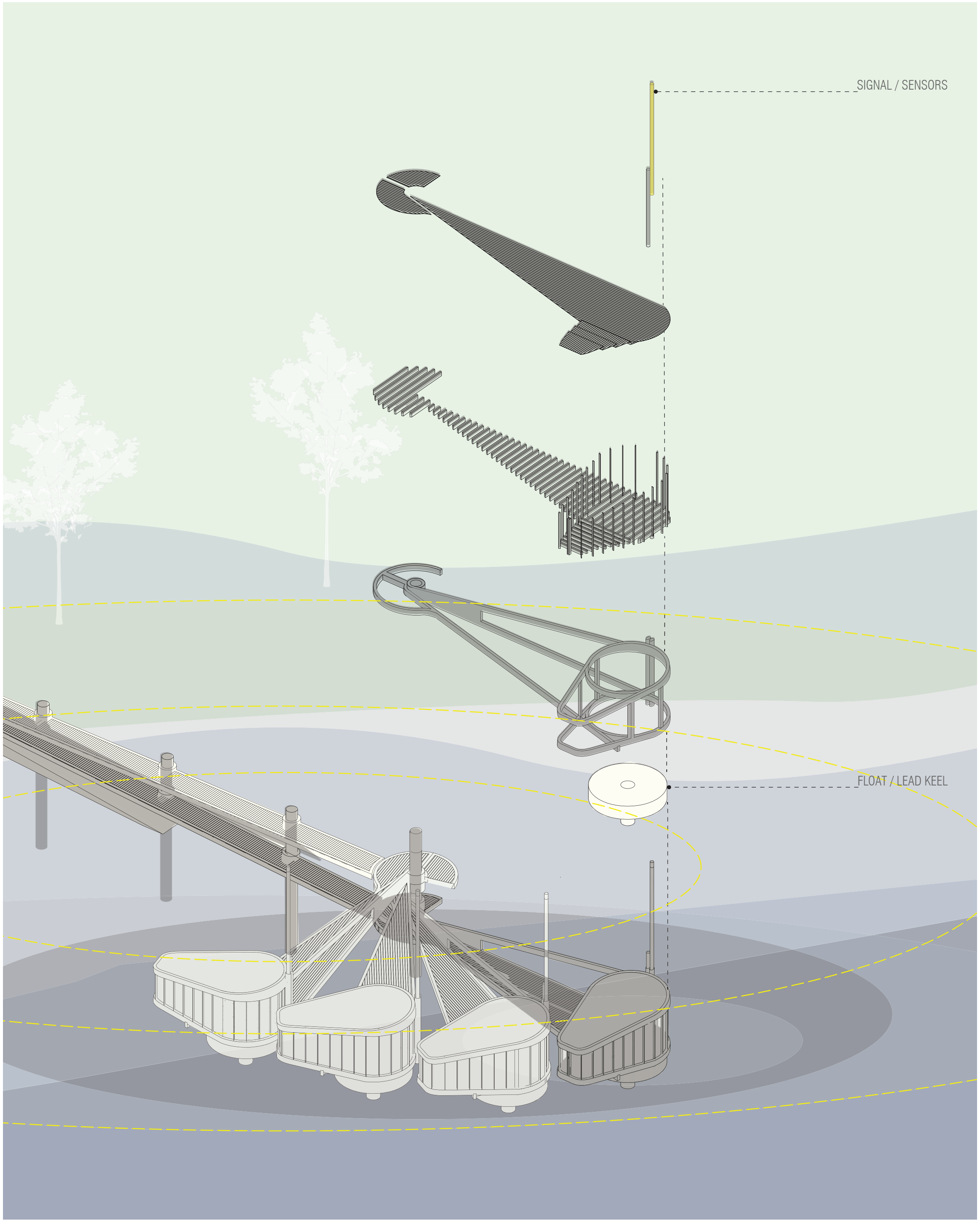
Hydrological measuring stations located in the Saint John River watershed.

The Lighthouse

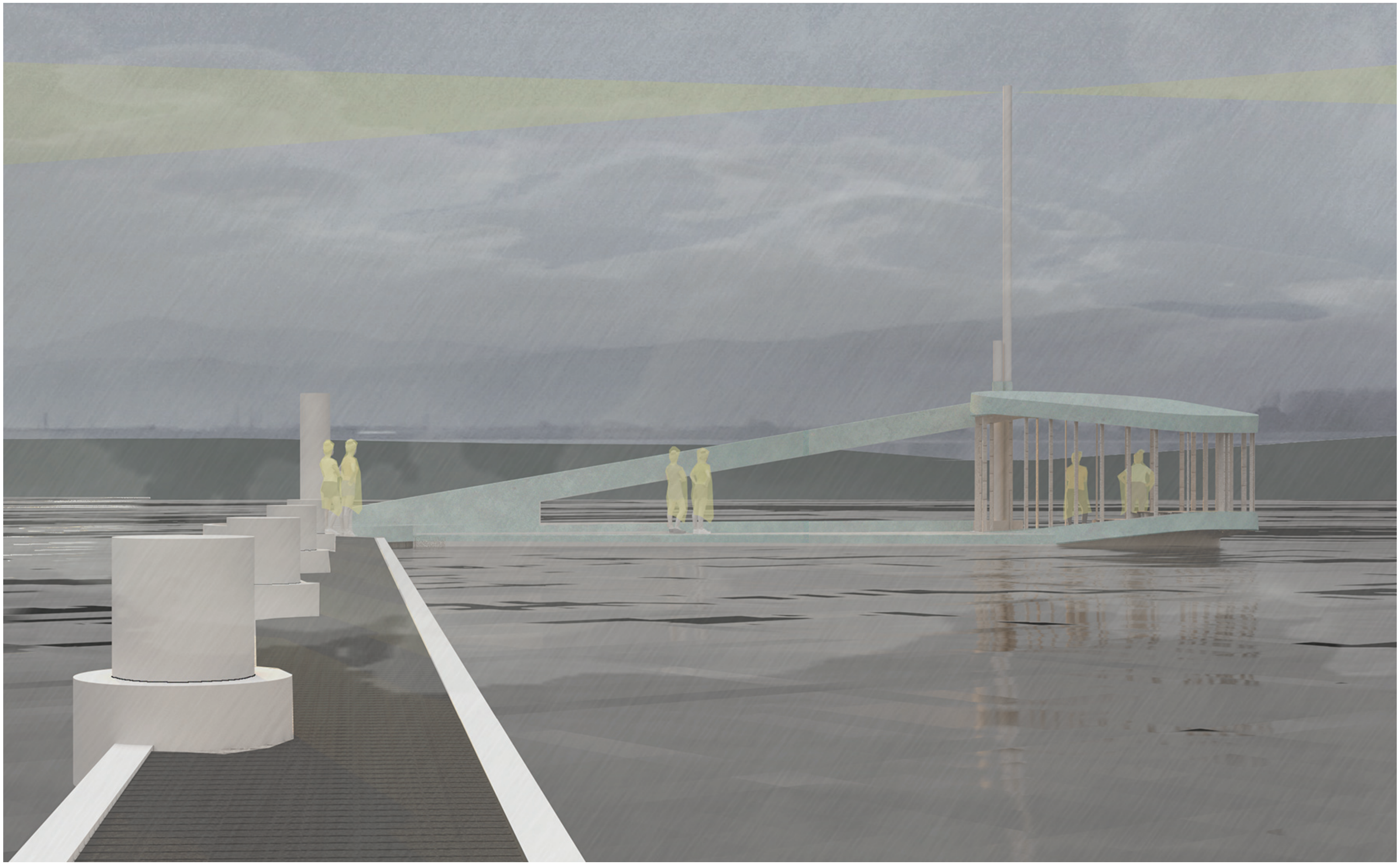
The lighthouse serves as a beacon, drawing inspiration from the inland lighthouse systems that used to guide vessels up the river, it provides a poetic connection between the territory and the city. Signaling the river system and watersheds intentions to the city through a series of lights and measuring devices which illustrate the snowpack level and flow rate from various measuring stations throughout the watershed. Finally, the pavilion raises and rotates with the water level and speed acting as a visual reference as to the intentions of the river. When the flood hits the lighthouse raises and twists framing views back into the city this view is different according to flow rate and water level. This provides not only a demarcation of the flood levels and intensity but it also a way for observation of the event.

Environment Canada maintains a network of hydrometric data sensors along water courses in Canada. These metering sensors provide flow rate and depth of the water in real time, this data is used in the forecasting of freshet flooding. In the Saint John River watershed Environment Canada has a total of twenty stream gages that are used in forecasting for the Saint John River freshet. Environment Canada also maintains snow measuring stations throughout the watershed that forecast the volume of water to be released in the freshet.[51]

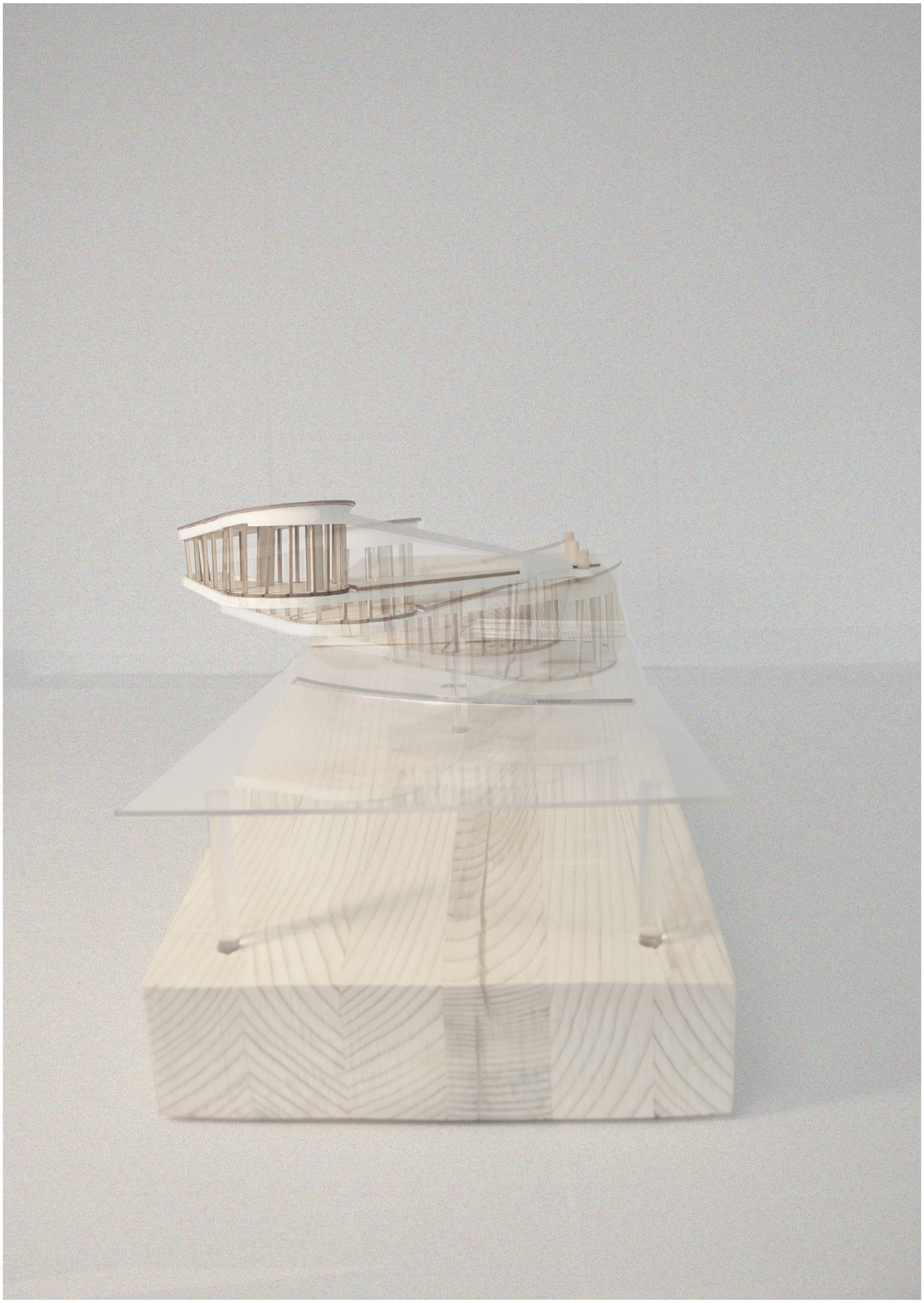
51 "Water Level and Flow," *Water Level and Flow - Environment Canada,* December 10, 2018, https://wateroffice.ec.gc.ca/index_e.html.



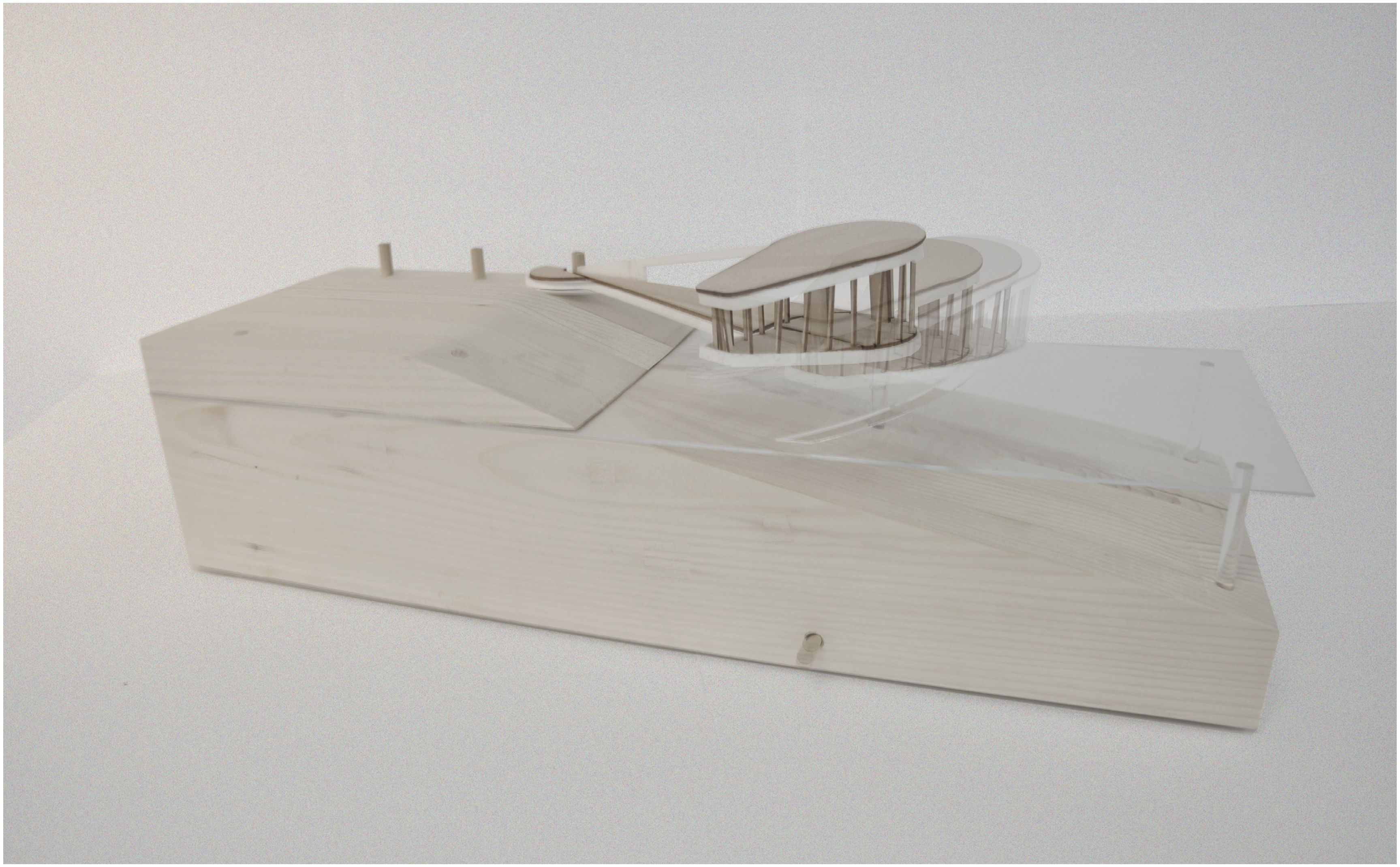
Isonometric of lighthouse illustrating movement of form and corporatization of structure.



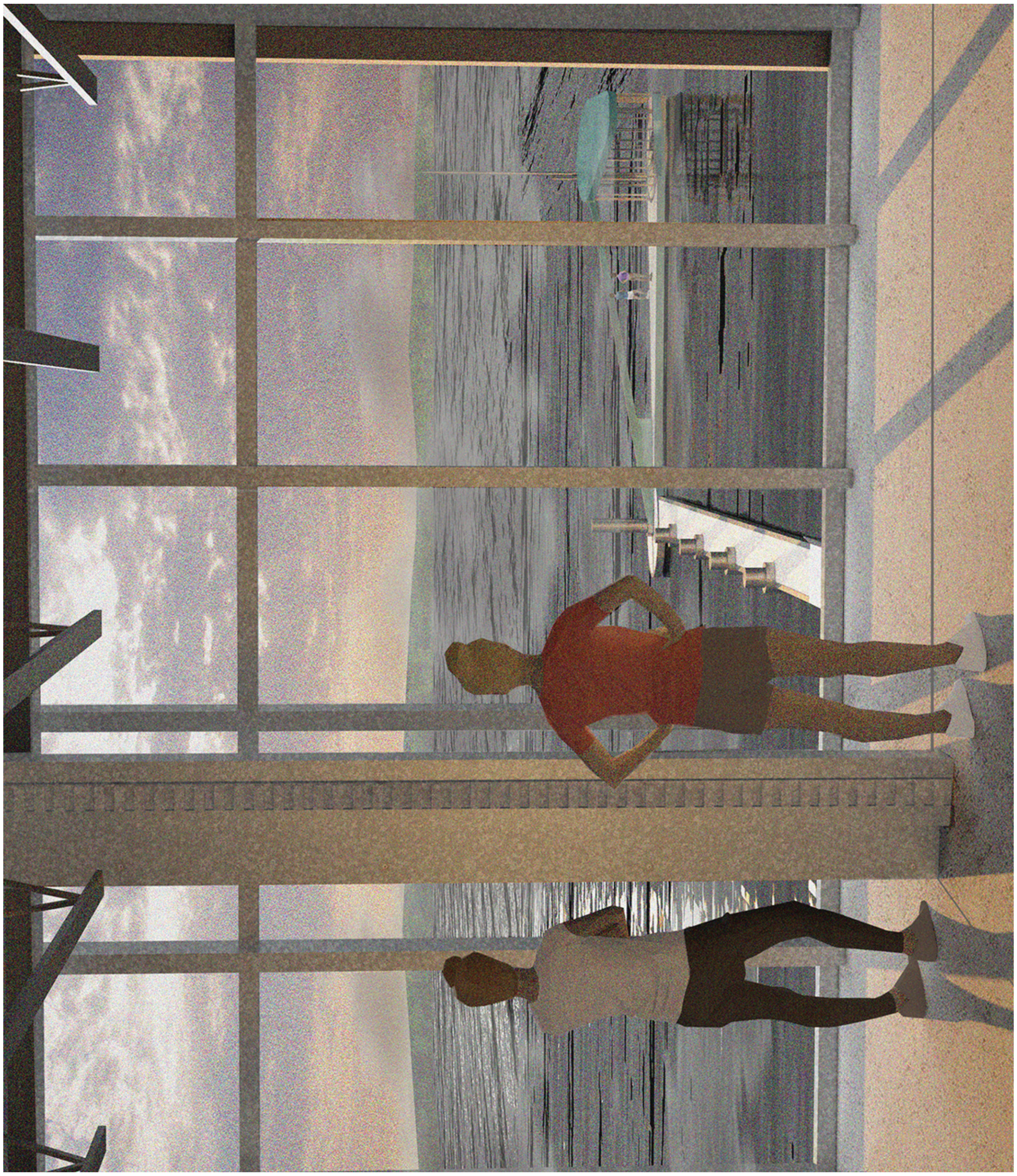
Rendering of Lighthouse during storm and high spring freshet.



1-100 dynamic model of Lighthouse, showing hifting form as the waterlevels increase.



1-100 dynamic model of Lighthouse, showing hifting form as the waterlevels increase.



Rendering from lockhouse toward lighthouse during a high spring freshet.

CHAPTER 6 CONCLUSION

Meta-Green proposes a flexible approach to freshet flooding in urban areas, drawing it's inspiration from the aspirational qualities of cybernetics while implementing river-scape designs and building logic that accommodate and control freshet flooding. The project points to a prioritizing of systems thinking in a pairing of architecture and infrastructure that is adaptive to change, not just in a watershed but any changing environment. Through leveraging the cybernetic underbelly where organic and synthetic systems are linked and ecology, people and machines can be negotiated, whether in the case of urban floodplains or a landscape prone to forest fires.

The use of flexible strategies extends beyond the Saint John River Valley, or even that of designing in floodplains. This flexibility is offered through the use of cybernetics as inspiration and method for architectural and infrastructural interventions where program exist in relation to complex natural and synthetic systems could be invaluable. An example of other sites where this strategic method could be used is along coastlines, where rising sea levels threaten existing properties. Here an architecture and infrastructure that would allow an adaptable relationship to exist between the ecological and the synthetic, such that interventions might coexists in these dynamic landscapes. Humanity is tied to these coastal and deltaic locations; generally our most valuable real estate is developed next to water and to continue this practice it will be increasingly necessary to encourage a dialogue between this infrastructure and natural systems.

While this thesis just touched upon the potential of this approach, considering the scaler relationships and linking the synthetic and organic feedback more rigorously to the architecture would further strengthen the thesis. A stronger link between parameters and how each interrelated system connected could be developed in such a way that it illustrates the communication as a set of 'evolutionary scripts', similar to those produced by Pask. An issue with this is of course time and its scaler relationship, where activities in the watershed are scaled to months, years and centuries while those of people are scaled to seconds, minutes and hours. The design of ecological elements like landscaping that control the flood could also be further investigated and linked to the architectural and systems narrative of the project. Along with strengthening the link between the respective interventions back to the watershed and the territory, through a more rigorous account of the temporal elements of the project and their relation to ecology, people and machines. While these elements were all partially addressed, a further development would strengthen the cybernetic method as it relates to interventions in any area adjacent to water and facing increasing climate uncertainty like that of the eastern seaboard of the United States, in particular Miami and southern Florida. The methodology could also extend beyond that of hydrological changes, in particular dynamic systems of drought and fire that have plagued California.

In the case of the heavily populated Florida coast line which is at risk of hurricanes that are due to become more severe with Climate Change. Miami in particular is facing rising sea levels and is home to many high valued real-estate assets, that are in direct conflict with both coastal erosion and extreme storm surges. The ground-floor and street level of these sites could begin to be thought of as a flexible space, a manufactured landscape that would allow for the inundation of tidal forces while also providing a system of space for city dwellers. Regardless of whether these changes are planned, or seen as politically popular, changes in the coastline and interior marshlands of the Florida peninsula will take place. Thus designing infrastructure and architectures that work with this change will be critical for communities to continue to thrive in these locations.

Considering the recent fires across much of California, the construction of what is called in the firefighting industry as 'defensible space' might be considered through this cybernetic lense. The landscaping of these sites, material selection and architectonics could relate directly between the natural systems of drought, and fire which are integral to these landscapes, such that buildings and infrastructure are not threatened by the fire but are in coordination with it. The use of steel and concrete board for cladding, roofs and the elimination flammable material from the construction language would go along way. A strategic landscaping of drought tolerant plants could correspond to a dynamic mechanical system for the shuttering of apertures would make architecture resistant to these extreme environments. The proposal of a dynamic infrastructure is a proposition that acknowledges environmental change and disruption and considers a multitude of arrangements, a shifting topology.

Meta-Green, a dynamic augmented system of shifting topology where organic and synthetic communicate locally and territorially, considers the Saint John River and it banks at Fredericton as a shifting topology, a system of organic and synthetic communication. A landscape ripe with systemic connections and a cybernetic underbelly that if plugged into could begin to offer solutions to the potential destruction of infrastructure brought about through a changing spring freshet all along the Saint John River watershed. The project visualized a narrative where Officer Square and The Green as a whole, would change with the seasons, climate and program requirements, through accommodating flows of people and water. In conclusion it points to the potential for Fredericton or for that matter any urban area facing ecological change to think critically about its future, that instead of working against the river or ecological change it might work with it, through considering both the organic and synthetic as one in the same.

For the synthetic and the organic are rapidly merging.

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