Transformative Materiality

Theory Development and Application in Sand, Wind, and Water

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Abstract

This thesis offers a preliminary argument for materiality as the primary medium through which landscape architecture is experienced. An original theory, Transformative Materiality, posits that landscape experience may be heightened, making people more aware of and engaged with their surroundings, if design encourages the changing of materials over time through temporal landscape processes (such as erosion and deposition). Resulting landscape phenomena may translate into passive education about the effects of naturalistic material transformation. And any gained experiential knowledge of the landscape, might, in turn, become a source of meaningful, personal connection to the landscape, potentially inspiring appreciation and stewardship. The theoretical development and argumentation for Transformative Materiality is preceded by its application in the final thesis design project, to provide a basis for common reference. The Beach Outfalls Challenge competition serves to provide a site and problem: the Mississippi commercial beach system, and stormwater management through the immediate beach environment. Three materials, sand, wind, and water, are studied in relation to landscape processes that are purposefully employed to encourage change in the landscape's material form over time. The final design is a landscape technology that harnesses material processes in order to perform environmental services of cleaning stormwater and creating new habitat, while allowing such processes to diversify material form for a range of phenomena and consequent opportunities for experiential education that may lead to a holistic understanding of the landscape as a dynamic, responsive system.

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General Audience Abstract
One may observe and learn how nature works, by noticing its transformations over time. Seeing a rock smoothed into a pebble by rushing river water, or finding a fallen tree being broken down by insects. Noticing weeds pop up from cracks in the sidewalk, or seeing a whole forest turn shades of red in the Fall. These experiences offer a passive, informal education about what nature is, what it can do, and how it works. They may be the initial experiences that spark one's curiosity, and eventually lead to a deeper connection, investigation, or stewardship of their natural environment. Seeing nature transform itself over time is the basis for a new design theory, called Transformative Materiality. With this theory, design is driven primarily by the materials in a site (rocks, soils, water, plants, etc.) and how they may interact through natural processes in the landscape. Natural processes, such as erosion, deposition, and succession allow each material to transform over time. Visitors may connect each process with its visible effects on landscape materials over time, affording a passive, informal education about nature through direct experience. The designed project, on a beach in Mississippi, uses stormwater runoff from urban areas to flow over sand, across the beach surface. Water flow to the ocean is aided by processes of sand accumulation and dune formation, which help contain the spread of water. Wooden pilings encourage processes of whirling and sand carving, to intentionally create deeper areas of water flow and collection. Introduced water helps irrigate new plant communities, which stabilize dunes, filter water, and create new insect and bird habitats. A minimalistic design framework encourages each process to work together constructively, and visitors experience a continually evolving progression of landscape transformation over time.

This book represents some of things
I have come to know. My theoretical
conclusions are not final. They have
opened up a new landscape for me --
one that will continue to transform
and change with time and experience.

Thank you to all who contributed
to this project and my education.

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Design Context and Research

1. The Beach Outfalls Challenge

The Beach Outfalls Challenge is a national competition, hosted by the state government of Mississippi or, more specifically, the Mississippi Department of Environmental Quality (MDEQ). The central problem in question is how storm water is sent into the coastal ocean, and how to reduce its degrading effects on water quality and terrestrial and marine ecologies.

The competition website, http://beachoutfallschallenge.org, is still online, as of July 30, 2017, and may be visited to learn more. The following introduction to the competition is taken from the website 'About' page (http://beachoutfallschallenge.org/about):

> The Beach Outfalls Challenge is a public prize challenge sponsored by the Mississippi Department of Environmental Quality (MDEQ). The Beach Outfalls Challenge is funded through a grant from the National Fish and Wildlife Foundation Gulf Environmental Benefit Fund (NFWF GEBF). The goal of the Beach Outfalls Challenge is to enhance Mississippi's ability to restore and maintain ecological integrity of priority bays and estuaries by providing measurable improvements to water quality and reducing significant sources of degradation. A successful Beach Outfalls Challenge could help improve water quality and benefit the ecology of the Mississippi Sound, as well as remedy harm to natural resources harmed by the Deepwater Horizon oil spill. Nutrient reduction, improvement to wildlife habitat, especially for oysters, increased production within the natural food chain, and reduced scouring and erosion along the beach are some of the benefits that Mississippi hopes to reap from the Beach Outfalls Challenge.

The competition involved an initial registration with written design intent and demonstration of site knowledge. Once passing the registration, initial design packages with four boards with plans, sections, and perspective images were to be submitted two weeks later. Twelve semi-finalists were announced two weeks after that, and two additional weeks were provided for a revised design package with a five minute explanatory video for public voting purposes. Four finalists were chosen based on a collective score of design excellence and public voting count, administered through the competition website. Three winners were finally chosen in a public showcase in Mississippi, three months after the competition began. The provided timeline is included below for additional reference:

Figure 1.1 Competition Schedule

Image provided by MDEQ

This project advanced to the semi-finalist stage, and was awarded the highest scoring project from a student at the university level. The 5 minute project video may be found on youtube at: https://www.youtube.com/watch?v=4wrPnY3Kek0.

The text from the competition registration packet describes the project prompt in more detail:

> The Mississippi Comprehensive Ecosystem Restoration Tool (MCERT), developed as part of the Mississippi Comprehensive Planning Project, has identified the beach outfalls located on the Mississippi Gulf Coast as consistent and major stressors to water quality in the Mississippi Sound, especially those outfalls located closest to marine habitats. After storm events, beach advisories are a common occurrence throughout the year because of storm water flow from outfalls into the Mississippi Sound causing increased sediment, nutrients, and bacterial levels. The potential exists to improve water quality from storm-drain outfalls located on the Mississippi Gulf Coast, which will ultimately improve the water quality in the Mississippi Sound. Outfall designs that consider ecological processes can serve to provide water quality improvement functions, and provide increased habitat for fisheries, shrimp, and crabs, as well as forage resources for birds. The State of Mississippi desires to restore and maintain the ecological integrity of priority bays and estuaries by improving water quality and reducing sources of degradation. The goal of the Beach Outfalls Challenge ("Challenge") is to enhance Mississippi's ability to restore and maintain ecological integrity of priority bays and estuaries by providing measurable improvements to water quality and reducing significant sources of degradation. Through the Beach Outfalls Challenge, the Mississippi Department of Environmental Quality (MDEQ) hopes to have competitors come up with practical, implementable eco-restoration solutions for water resource improvement. These designs need to be flexible in implementation, aesthetically pleasing, not have any unintended consequences, and be compliant with MDEQ's National Fish and Wildlife Foundation (NFWF) proposal.

In addition to the general prompt of improving water quality and ecological performance, there were several technical specifications, by which to abide in the design process. Fig 1.2 was prepared by the competition to illustrate many of these specifications in graphic form. Here is the written list:

Figure 1.2 Hypothetical On-Beach Location with Specfications Image provided by MDEQ

Technical Specifications:

a. The solution may not interfere with the 50-ft. clearance zone as measured from the edge of the seawall toward the water.

b. The solution may be installed on the beach from the edge of the clearance zone to the point where beach maintenance ends, approximately 180 feet.

c. The solution must be contained within a maximum 100-foot buffer from either side of the pipe centerline.

d. The on-beach design area extends an additional 180 feet into the Mississippi Sound; however, there are environmental compliance concerns that must be addressed.

i. Solutions cannot interfere with endangered species, such as Gulf sturgeon (Acipenser oxyrhynchus desotoi), various sea turtle species, least terns (Sternula antillarum), and piping plover (Charadrius melodus), in compliance with Section 404 of the Clean Water Act.

ii. Solutions cannot interfere with the integrity of federal US Army Corps of Engineers projects. The seawall, the beach, and the dune systems along US Highway 90 are federal projects, and all activities must comply with 33 USC 408 (commonly referred to as “Section 408”).

e. On average, the beach is approximately 230 feet wide from seawall to end of pipe.

A non-specific, hypothetical condition is provided by the competition, instead of a single specific site, or outfall instance. This is because their goal is to generate design ideas that can be deployed across multiple outfall instances, and aren’t limited to the specific site conditions of just one. As such, it may be helpful to think about the design as a landscape technology, able to be deployed within a landscape, and modified in each application to suit the needs of a specific site.

The hypothetical condition is still useful, because it is consistent across the majority of outfall instances. The beach is 230 ft wide, 50 ft of which must be preserved in the back of the beach for maintenance purposes (to let tractors drive continously along the beach). A raised seawall and road form the back edge of the beach. And the beach must continue to operate primarily as a commercial destination, limiting design strategies to 200 ft of beach length, or 100 ft on either side of the outfall.

2. Context and Site Analysis

Currently, the continuous white sand beach along the Mississippi Coastline is arrayed with pipes and channels that behave as direct conduits for storm water runoff. Rainfall begins a new life as runoff upon entering streets, parking lots, and other urbanized surface conditions, allowing for toxic pollutants and nutrients (which are harmful in excess) to mix with water. Runoff then falls into drains, pipes, and other storm water infrastructure that is designed to carry it away as quickly and efficiently as possible. The result is high volume, high velocity, polluted water entering directly into the coastal ocean via beach outfalls.

Four different types of Beach Outfalls have been constructed along the Mississippi coastline: single pipes, open channels, double pipes, and single pipes with cement bag covers (shown in Fig. 2.1). Though different in appearance, each of these strategies behave similarly. Their structures are buried underneath the beach surface for the first fifty feet of their length, allowing for large vehicles and pedestrians to maintain uninterupted travel along the back of the beach. Pipes then gradually rise out of the sand so that their bottom surface is at beach grade when it reaches the water. Open channels, instead of rising above the sand, cut down through it with large cement walls, supported by structural braces on top. The last strategy overlays cement bags on a single outfall pipe, in an attempt to form a more graduated surface for sand and water to flow over.

Each of these strategies consistently produces two major problems: (1) storm water runoff flows directly into the shallow coastal ocean, and (2) the perpendicular alignment of structure to the coast prevents the movement of sand along the beach as it is picked up by wind and water.

The first problem concerns the water itself. Runoff, as stated before, is full of toxic pollutants. These can include petroleum products leaked by cars, heavy metals, plastic debris,

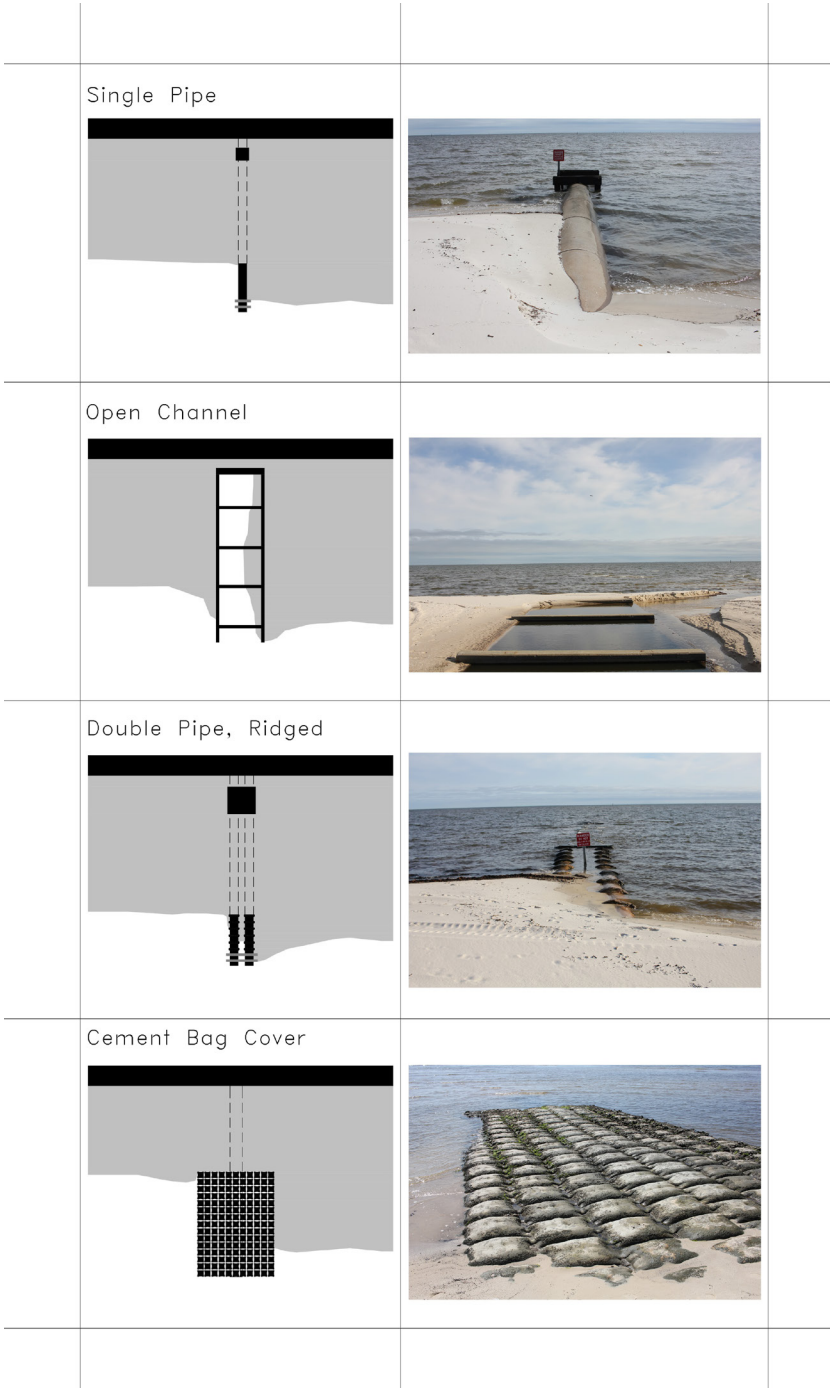


Figure 2.1 Beach Outfall Types

Photographs, Personal Collection

and other urban pollutants like cleaning products and paints. Organic nutrients, like nitrogen and phosphorous, are picked up by runoff as well. These come from fertilizer products, sewage or effluent, and any other organic matter like clipped grass or leaf debris.[i] All of these chemicals and nutrients, again, are conveyed directly into the ocean during a storm event.

Marine ecologies are made particularly vulnerable to pollution in the Gulf Coast because of shallow bathymetry (the underwater ground surface). A nautical map in Fig. 2.2 shows the project study area within the Mississippi coastline. Bathymetry between zero and five feet of depth is highlighted in blue. On average, this zone extends for a half-mile from the shoreline, making it possible to walk from the edge of the beach for ten minutes or more and still be in just five feet of water. To compare, I'm from Los Angeles, and walking straight into the water for just one minute in Santa Monica or Malibu would be too deep to stand. (The reasons for these bathymetric differences concern large-scale geologic processes, like plate tectonics, which I won't discuss here.)

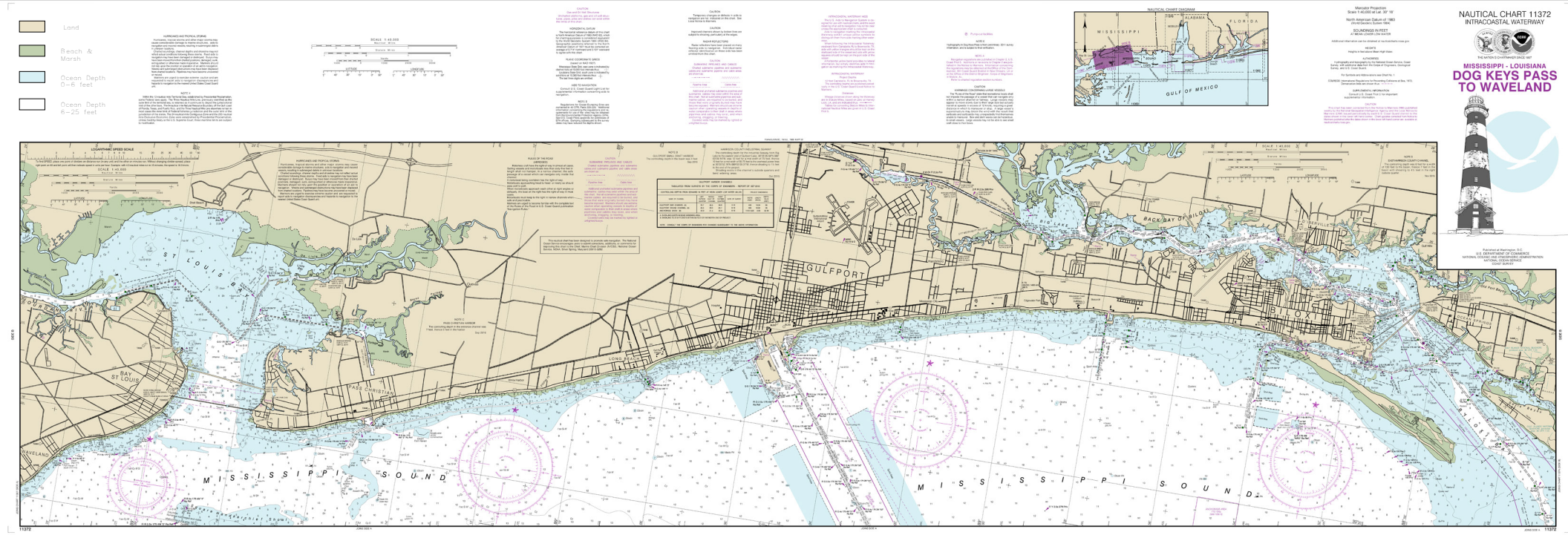
In deeper water, outfall pipes can be placed ten feet or more below the water surface. When storm water is fed into the ocean, it rises through the water column. This is because fresh water is less dense than salt water, so it floats to the top when the two are mixed. During its ascent, it becomes dispersed and diluted. And when it finally reaches the surface, pollutants are far less concentrated than they were upon their initial input.

In shallow water, however, storm water from outfall pipes cannot disperse before reaching the ocean surface. Instead, it is let out directly into the surface water. Often only one foot deep, it can fill the entire water column, affecting marine worms beneath the sand, wading birds above the surface, and everything in between.

The surface layer of the ocean has been discussed with concern because it receives the most direct sunlight in the water column. As it's commonly known, plants on land need sunlight and nutrients to grow. The same is true for phytoplankton and marine algae. When chemicals, nutrients and sunlight are abundant, algae proliferate. And when they die of naturally short life spans, marine bacteria find an abundant food source in their decay. Bacteria not only attack marine organisms (and humans), but consume oxygen in the process of decomposing organic matter. The reduction of oxygen in the water column is called eutrophication and, in extreme cases, can result in anoxic zones where no life can persist, sometimes called dead zones.[ii]

The effects of adding runoff to shallow ocean water with high amounts of sunlight are experienced by people in constant beach advisories to not swim, or even enter the water, because of high bacterial levels. Activities like fishing and shell collecting suffer from weakened ecological activity. And the sand itself looks and feels polluted with slime, and chemical sheen.

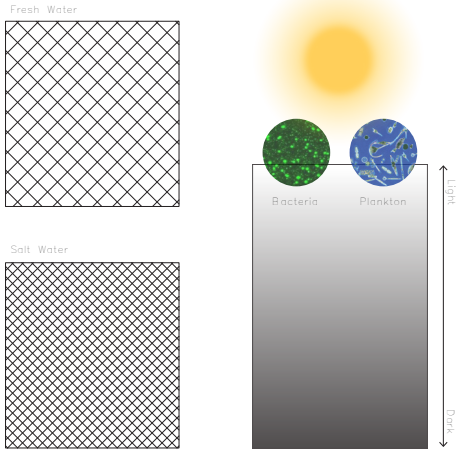
Material Form 1.
Bacterial scum layer on sand and in water.



CONCEPTS

Density differs between salt and fresh water, causing fresh water to rise when they are combined. Salt water can be so dense sometimes that people float on its very surface.

Light availability is unequal throughout the water column. Surface water that receives the most light and warmth allows for greater production of photosynthetic phytoplankton and marine bacteria.



Water Structure

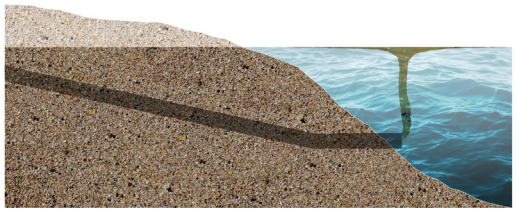
Water Column

APPLICATION

The coastal ocean along Mississippi public beaches on the Gulf Coast is extremely shallow. At low tide, it's possible to walk out 200 feet or more and still only be in 1 to 2 feet of water. This means that freshwater runoff from outfall pipes fills contaminates not just the ocean surface, but the entire water column, including important habitat on the ocean bottom, which is where most of the organisms that clean and eat detritus, like snails, worms, and barnacles, live.

MS Gulf Coast Coastline

The coastlines along northern California, Oregon, and Washington quickly descend into deep water, making it possible to place outfalls at lower depths, without extending the pipe further out. Freshwater runoff is introduced at depth, and quickly floats to the surface, becoming diluted along the way. While there are still negative consequences from runoff polution, much less of the water column is affected directly.



North Pacific Coastline

CASE STUDY

Water commonly looks brown and red, with little visibility. Large amounts of bacteria and plankton cloud and discolor the water.

Outfall pipes are positioned in shallow water, rising out of the water's surface.

Bacteria makes wet sand feel spongy and slimey. It reduces the available oxygen for important organisms that live in the sand and clean the water.

Algae and bacteria form mats on the surface and drift onto beach, staining the sand.

Exacerbating Effects of Shallow Gulf Coast Bathymetry on Water Quality

Figure 2.2 Exacerbating Effects of Shallow Gulf Coast Bathymetry on Water Quality

Map, National Oceanographic and Atmospheric Association (NOAA).

The second problem concerns the sand. Beach outfalls are large structures that run perpendicular to beach alignment. Water and wind, however, generally travel in a westward direction, parallel to the shoreline. In doing so, they pick up and move sand in the same direction. The westward migration of sand is so prevalent in the Gulf Coast that multiple barrier islands (made entirely out of sand), once off the coast of Alabama, are making their way to Mississippi. In another millenia, they could reach Louisiana and get carried away by outwash from the Mississippi River, eventually helping to form new barrier islands off the coast of Texas.

Whether a pipe rises above the sand, or a channel cuts through it, all outfalls serve to block the westward flow of sand along the beach. Along pipes, sand is halted and forced to build up along the eastern edge of the pipe. In channels, sand falls into the open cavity, or wraps around its mouth, and must fill in the channel completely before resuming transport. In all cases, sand along the western edge of outfalls continues to migrate west. Without a constant supply of sand to replace it, however, significant beach erosion occurs along the west edge of outfalls.

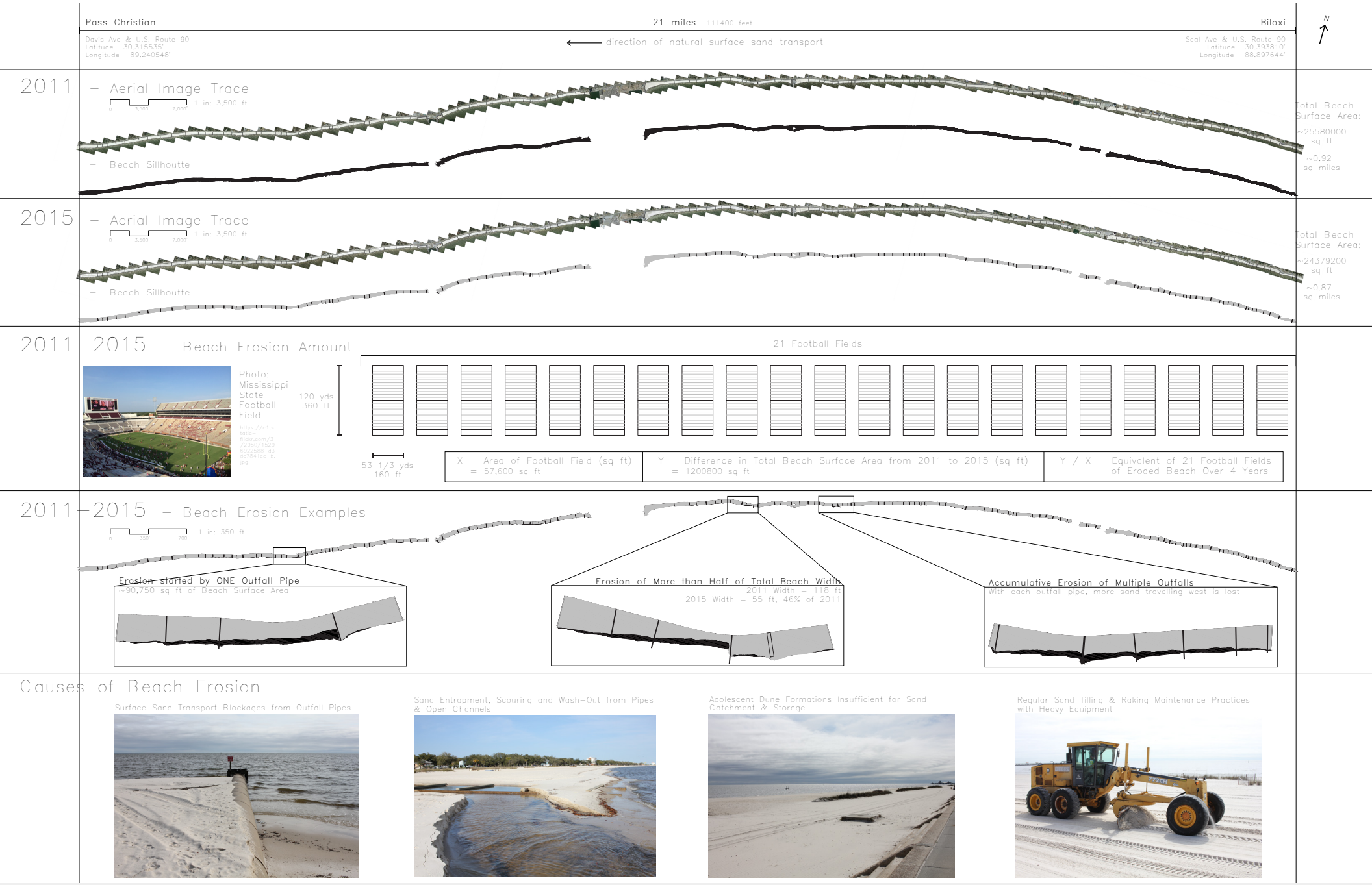
Figure 2.3 shows how this erosion affects the experience of the beach. The outfall pipes are noticeable obstacles for walks along the shoreline, demanding careful navigation around them. The difference between the east and the west side of a pipe is profound enough for many, even without knowledge of natural processes on the beach, to realize that the pipes are responsible for beach loss. They are reminders of the consequential effects of human engineering on the natural environment, detracting from a desirable prestine beach experience.

Figure 2.4 documents erosion on a larger scale: twenty one miles between Pass Christian and Biloxi, comprising 145 different beach outfalls. Comparable aerial imagery was found in the years of 2011 and 2015, and measured to study possible changes in the coastline. It was found that, over 4 years,

Figure 2.3 Beach Erosion from Single Outfall Pipe

beach outfalls had contributed to 1,200,800 sq ft of total beach loss, the equivalent of twenty one professional football fields of surface area. In extreme cases, a single outfall pipe may have contributed to the equivalent loss of almost two of those fields. Or thinned the beach to less than half of its previous width. In all cases, the points of erosion are clustered around the outfalls, and it can be determined that they are the predominant contributing factor to beach erosion.

Several secondary causes contribute to erosion as well, like the way in which plants are treated on the commercial beach. On a typical beach in the barrier islands, or a national park, where the nature is protected, plants are allowed to grow throughout the beach. Their root systems help to stabilize beach sand from shifting or migrating, and their stalks, leafs, or blades help to catch wind-swept sand in the air, depositing and retaining it instead of letting the sand get swept away.[iii] These natural strategies help beaches persist and grow over time. However, plants are prevented from establishing on the commercial beaches. Instead, large tractors comb the surface of the sand, tilling and raking to remove small plants that may have started to root. These



Beach Erosion Between Pass Christian and Biloxi, from 2011 to 2015

Figure 2.4 Beach Erosion Between Pass Christian and Biloxi from 2011 to 2015

Aerial Imagery, Google Earth.

operations are conducted five days a week, to maintain open, white sand beaches that are more valued for tourism the local tourism economy. The consequence is that sand gets swept away by the wind quite easily. (Constant driving on the beach also picks up sand in tires and sends it into the air, or carries it away.) It accumulates on roads, in parking lots, and on neighboring coastal properties, causing property damage to soils and planted landscapes. Fig. 2.5 shows a parking lot next to the beach, with medians that have accumulated so much wind-born sand, that small dunes with plant communities are starting to form in them. This is a common sight in road medians as well.

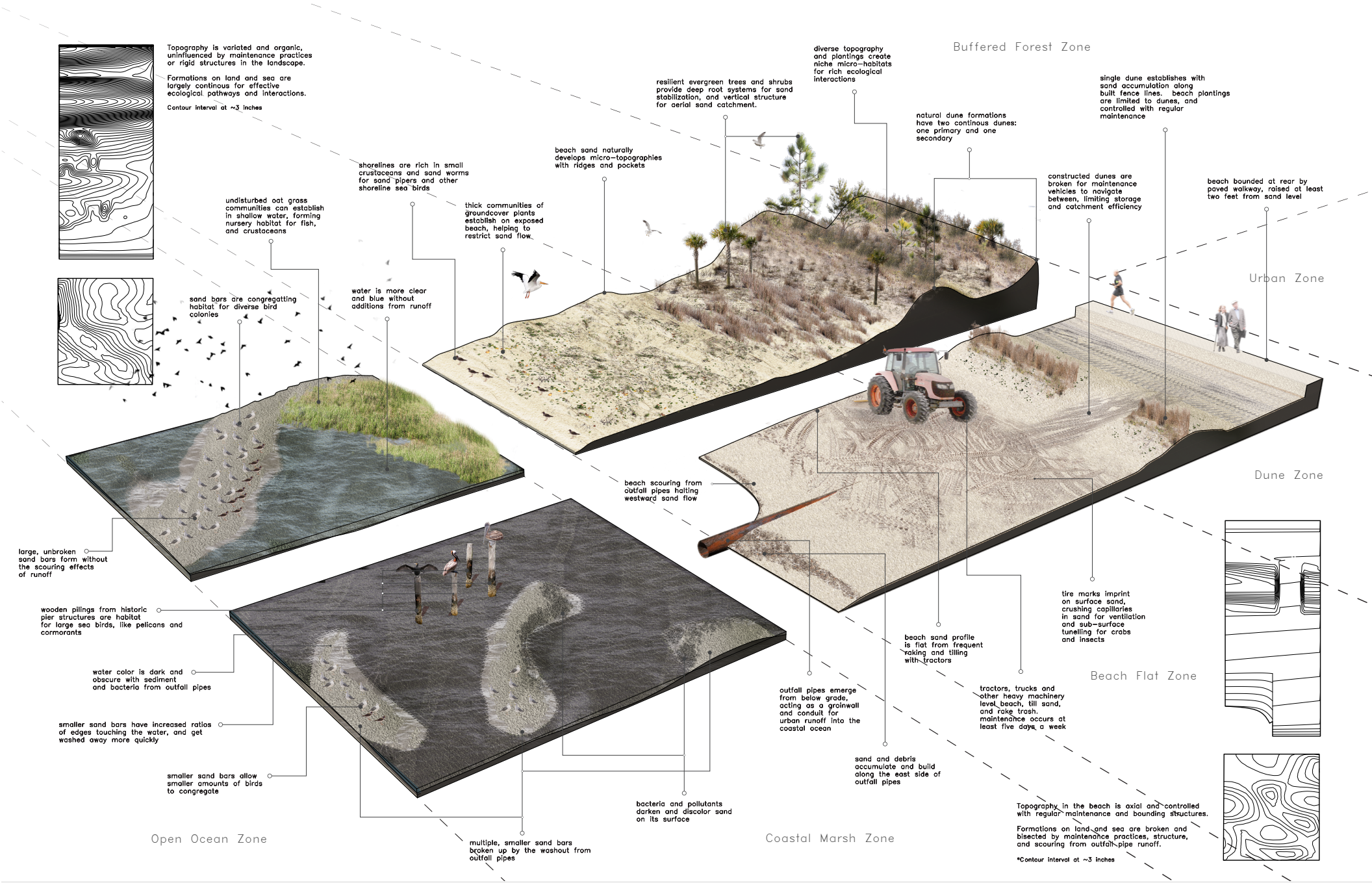
Figure 2.5 Sand in Parking Lots and Roads

In a more natural setting, dunes typically serve as the ultimate strategy to catch wind-born sand. These large vertical structures are made over time, through the gradual deposition of sand and rooting-in-place by plants. On the commercial beach, however, dunes aren't performing their function effectively. Tractor maintenance inhibits the natural building of sand formations, except in select areas along dune fences. These fences are erected to help catch sand and begin forming dunes. Unfortunately, these efforts are more of a gesture than a realistic strategy. Dune performance is severely limited by their island-

like character, with no surrounding plant material or sloped topography that could help them grow. Additionally, constructed dunes are often perforated, with large gaps in between them to allow tractors to maneuver through them while performing maintenance. Such gaps further isolate dunes from each other, preventing growth and spreading of connected plant communities.

Figure 2.6 illustrates and expands on the differences in these conditions, between a natural park setting and the commercial beach. Naturalistic conditions were observed in person, at the the large dunes opposite Miramar Park, immediately west of Biloxi, as well as in National Park Service materials about preserved beaches on Cat and Horn Barrier Islands.[iv] Of central importance is the amount of diversity in a natural setting, in terms of both plants and topographic conditions. Plants are widely varied and fill every ecological niche: spreading groundcovers, short and tall grasses, woody shrubs, and several different trees, including palms and pines. Their forms above the sand also reflect their forms below it. Fibrous, stranding root systems of grasses are complemented by large, vertical tap roots of the palm tree, all of which help to generate a range of topography.

Material Form 2.
Fibrous grass roots anchoring compacted sand.



General Comparisons: National Park Beach & Public, Commercial Beach

Figure 2.6 General Comparisons: National Park Beach & Public, Commercial Beach

In the beach flat zone, small undulations begin to develop through the shallow rooting of exposed groundcover plants. Whereas, much larger primary and secondary dune formations can develop in the back of the beach, with the help of a greater variety of larger plants. This is a cyclical, reinforcing dynamic, as the dunes, assisted by plants, then help to shelter and protect plants from sun and salt spray, which helps the plant communities become more robust. Birds and insects also benefit from the range of habitat, and assist with plant dispersal, as well as providing nutrients through the decomposition of decaying plant material.

Material Form 3.
Insect trails underneath the sand.

The commercial beach faces many obstacles for its dunes to behave as effectively in both sand catchment and ecological contribution. Tractor tilling prevents the spreading and maturing of plant communities. Their tires crush capillaries in the sand where insects live, preventing pathways for insects to assist with nutrient provision. (It often seems like there is a highway on the beach, with abundant tire tracks imprinted daily in the sand.)

And the beach outfalls cause damage to marine ecologies, which hurts shore bird populations and their ability to assist with fertilization or plant dispersal.

Material Form 4.
Tire tracks imprinted in sand.

3. Study of Site Phenomena

My design process began with an intensified study of site conditions on a smaller scale than the previous, large, ecological studies. Again, when referring to the "site," it should be interpreted as the generic condition provided by the competition.

In addition to ecological understanding, it was important to gain an understanding of how the site was used by its many occupants: plants, marine organisms, birds, insects, and people. Figure 3.1 shows these relationships as a sectional profile of the generic beach condition, starting with the elevated road and sea wall on the right, and ending in the shallow ocean to the left. The spatial ranges of each occupant group is made more obvious with colored blocks below their corresponding section. The thickness of the colored blocks also pertains to the volume of occupation -- thicker blocks implies a greater presence, and vice versa. In the last row on the bottom, these blocks have been tallied, to better discern which areas are occupied and which are left unoccupied.

The results reveal a heavy volume of occupancy near the shore, which seems to make sense. Most people who visit the beach tend to gravitate around the water, or stroll barefoot along the shore to wet their feet. Intertidal marine organisms also proliferate here, and shore birds follow as a consequence. There is, however, a gap in occupancy in the middle of the beach, or the beach flat zone. This is wide, open space that is sometimes used recreationally for activities that require such space, like flying a kite, or playing football with a group. Otherwise, this zone has little ecological activity. Further back, where dunes are constructed and there is protection from tractor tilling, plants like grasses and small pine trees may begin to establish. This attracts insect communities and small nesting birds too. The clearest opportunity for strengthening ecological connections, thus, exists in the beach flat zone.

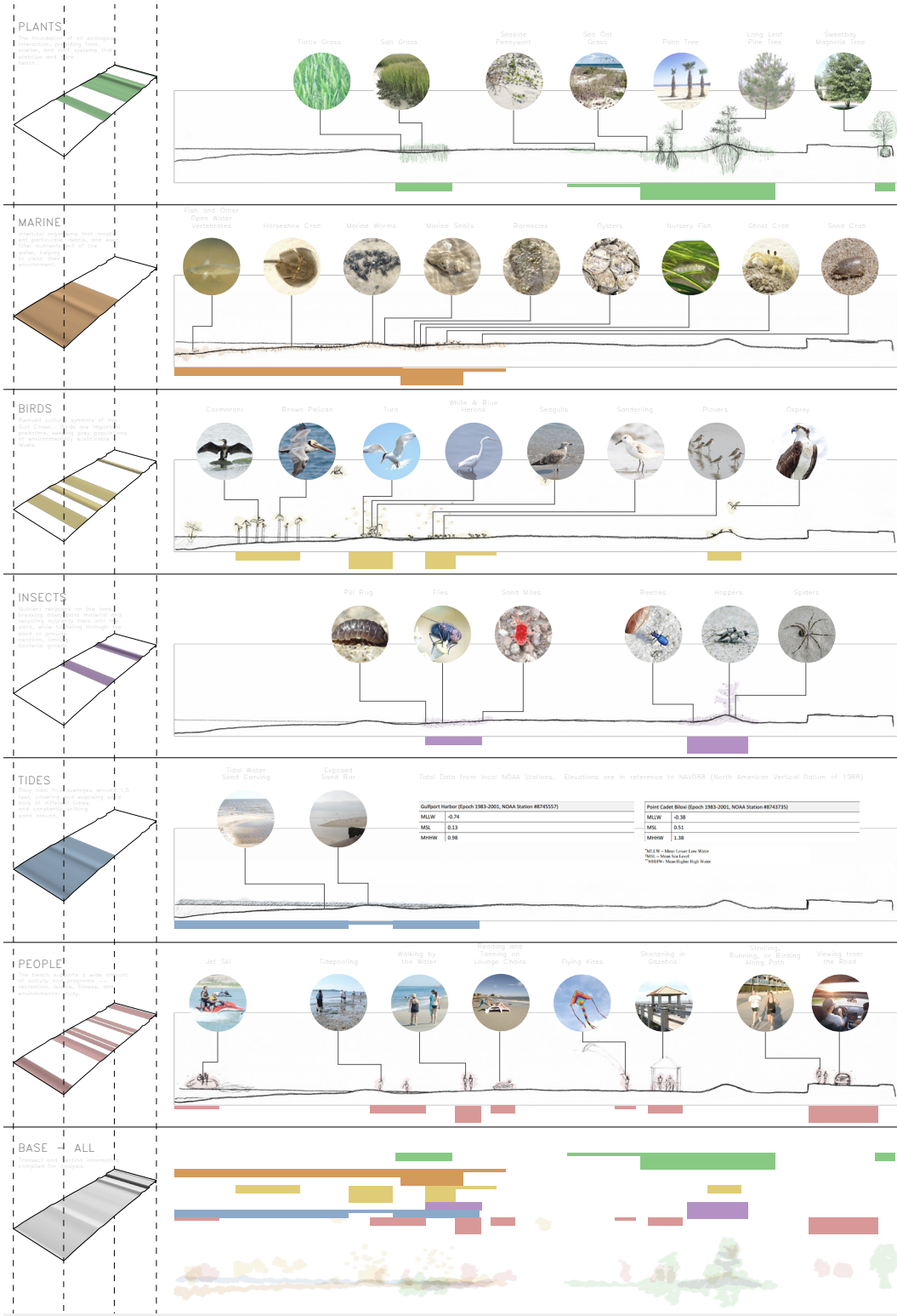


Figure 3.1 Observed Spatial Framework of (Ecological) Surface Interaction

Material Form 5.
Smooth wet sand along shore.

Material Form 6.
Wide open beach with wind-formed ridgelines in sand.

Beyond knowing where a possible intervention might best occur, it was also necessary to learn how the site and its predominant material components -- sand, wind, and water -- might react to possible interventions. As mentioned earlier, sand moves constantly around the site. This is because the grains of sand on this particular beach are extemely small. They stick to skin without effort, and are even light enough to float on water! Wind and water can easily move sand with such small granules, making the sand form differently on the beach every single day.

Material Form 7.
Sand floating on calm water, casting shadows beneath the water.

Existing interventions, like the beach outfalls, endure this dynamic interaction in mostly negative ways. Because of their design, sand is either forced to impede on the functioning of the outfall, or the outfall is forced to disrupt sand flows and cause erosion. On regular land, made of soil, it wouldn't be as large of a problem to construct a wall or pipe. Soil shifts and moves over time, but generally much slower and requires greater amounts of force from wind and water. Sand, however, could not be thought about in the same static manner. Predicting and

integrating its constant movement, as assisted by wind and water, was considered a primary factor in the success of a possible intervention.

While visiting the Mississippi beaches in person, I documented different phenomena on the beach, in order to better learn about sand behavior. A phenomenon may be defined as something that is able to be observed or experienced.[v] My reference of phenomena will concern the observation or experience of change in natural environments over time. This should be distinguished from natural processes, which create change. For example, the process of erosion may involve water removing or scouring sand from a particular area. The phenomena of erosion is the observed change that results from that process, which can be experienced by a person over time. In less words, process is the physical interaction, and phenomena is the observed experience of it. Several phenomena have already been presented in the 'Material Form' photographs. While these images don't show active processes, they offer evidence of the process, and how it may be experienced through changes in sand appearance.

Sand behaviors and characteristics were documented in the form of time series drawings, in plan and section. The surface of the sand is depicted in contour lines, which represents a half-foot or six inches of change in elevation. So the distance between two parallel contours is the distance that it takes for the beach surface to rise or fall six inches. This cartographic tool makes it possible to read a two-dimensional drawing as a three-dimensional form.

Figure 3.2 shows how sand typically responds to the introduction of a single outfall pipe. In box 1 (top left), the pipe has been inserted into a stable beach condition. Box 2 (top right) shows the sand beginning to build and accumulate along the eastern side of the pipe, as the pipe prevents its westward flow. Conversely, sand on the western edge becomes depleted and the

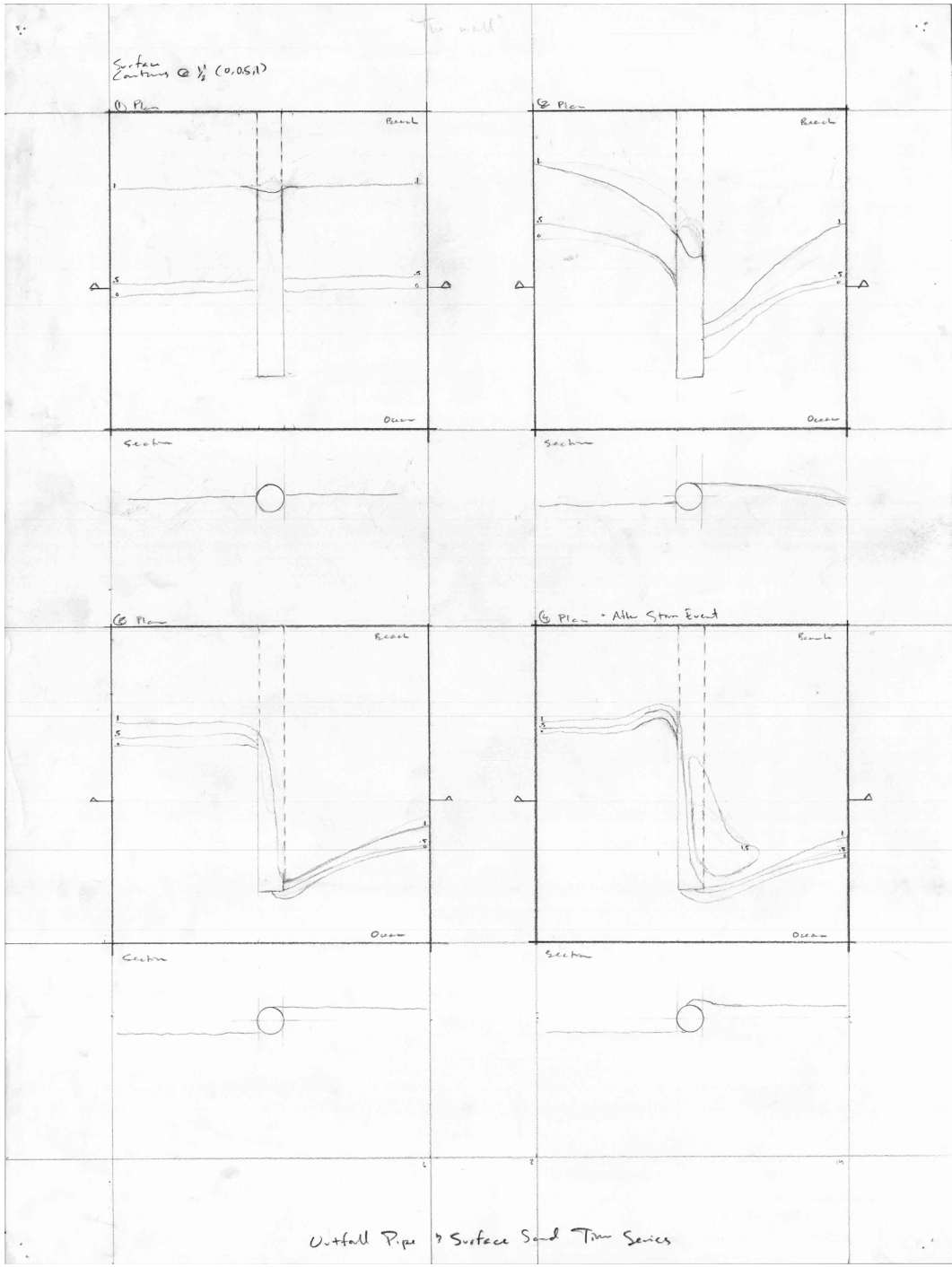


Figure 3.2 Outfall Pipe and Surface Sand Time Series

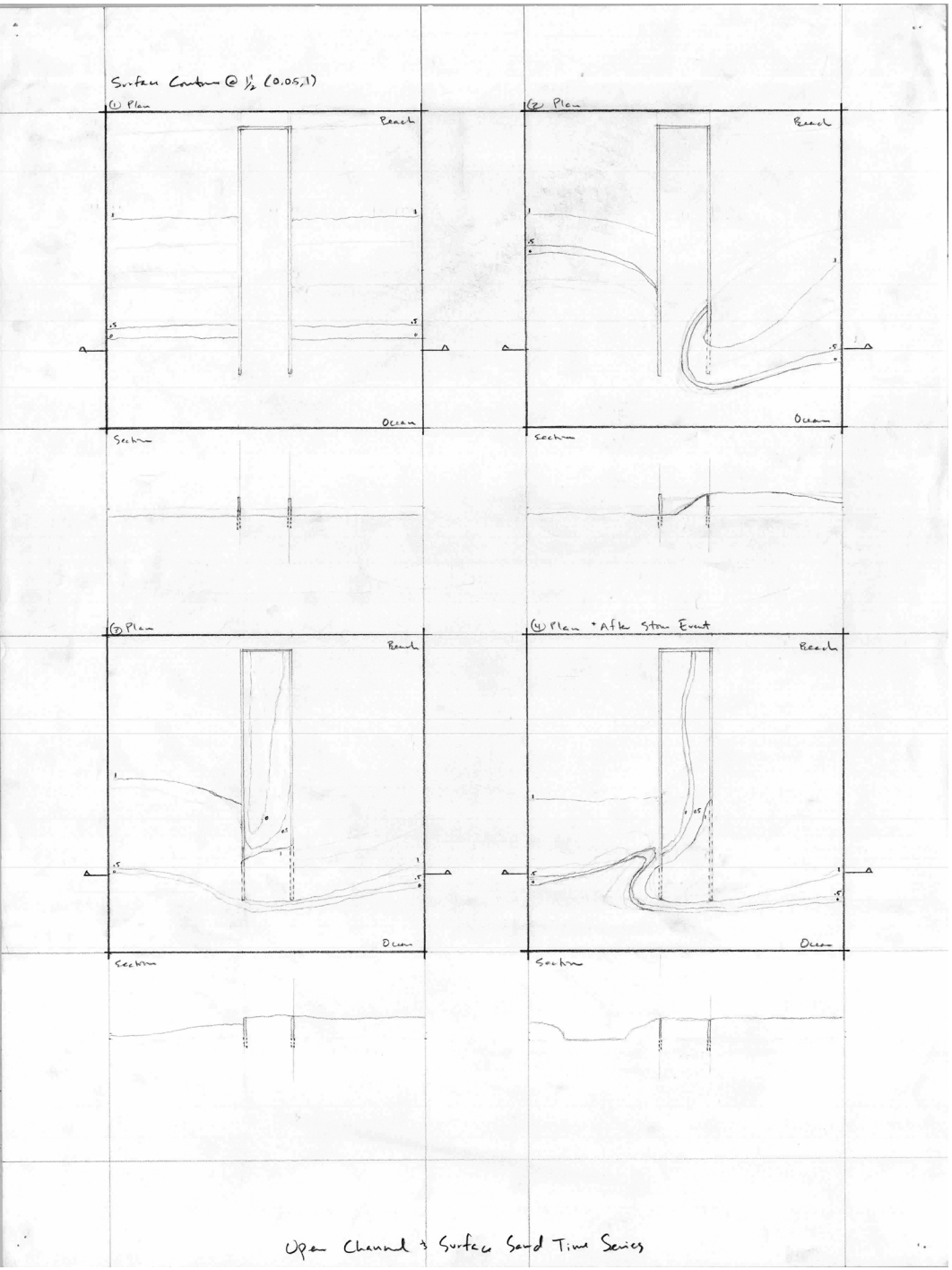


Figure 3.3 Open Channel and Surface Sand Time Series

beach begins to erode. Box 3 (bottom left) is a new stable condition, where sand has fully eroded to the point at which the pipe rises out of the sand and begins to obstruct flow. Box 4 (bottom right) depicts a heightened condition after a storm event, where the force of water increases from tides and outflow discharge, causing further scouring along the pipe's west side. Again, conversely, an increased sand load is deposited on the east side, where it may build along the pipe ridge, or wrap around into the pipe mouth. Sand that enters the outfalls may be trapped there, contributing to overall beach loss, until expensive dredging operations are conducted to clear the outfalls of all debris and blockages.

Whereas pipes behave as vertical wall-like structures towards the sand, open channels, shown in Figure 3.3, are vertical depressions, and behave more like small canyons. Sand can still build along the hard edge of a channel, but its concrete walls are easily overcome, usually extending less than six inches above the sand. After a short time, sand builds enough to begin spilling into the new cavity. Eventually, the sand completely clogs the opening of the channel, by spilling over and wrapping around its mouth. During a storm event, the clog can be so thick, that water isn't able to cut through it, and must breach the channel in order to keep moving. It carves new streams through the beach (as seen in box 4), eroding portions of the beach that were previously in tact. At high tide, the ocean may also enter into these new streams, helping to erode further, sometimes carving vertical cliffs in the sand.

Figure 3.4 shows the effects of outfall pipes underwater. Contours that have negative values indicate that they are below water level, which is at zero feet of elevation. As a starting condition, the near-shore slope is relatively gradual and uniform from consistent tidal action. Sand bars result from the dual forces of tides pushing sand onto the shore, and also removing sand from the beach. They're large and continous, which allows for congregations of sea birds to rest safely and forage for food. Box

Material Form 8.
Meandering scour patterns from streams of outfall discharge.

Material Form 9.
Vertical cliffs in the sand from constant tidal erosion.

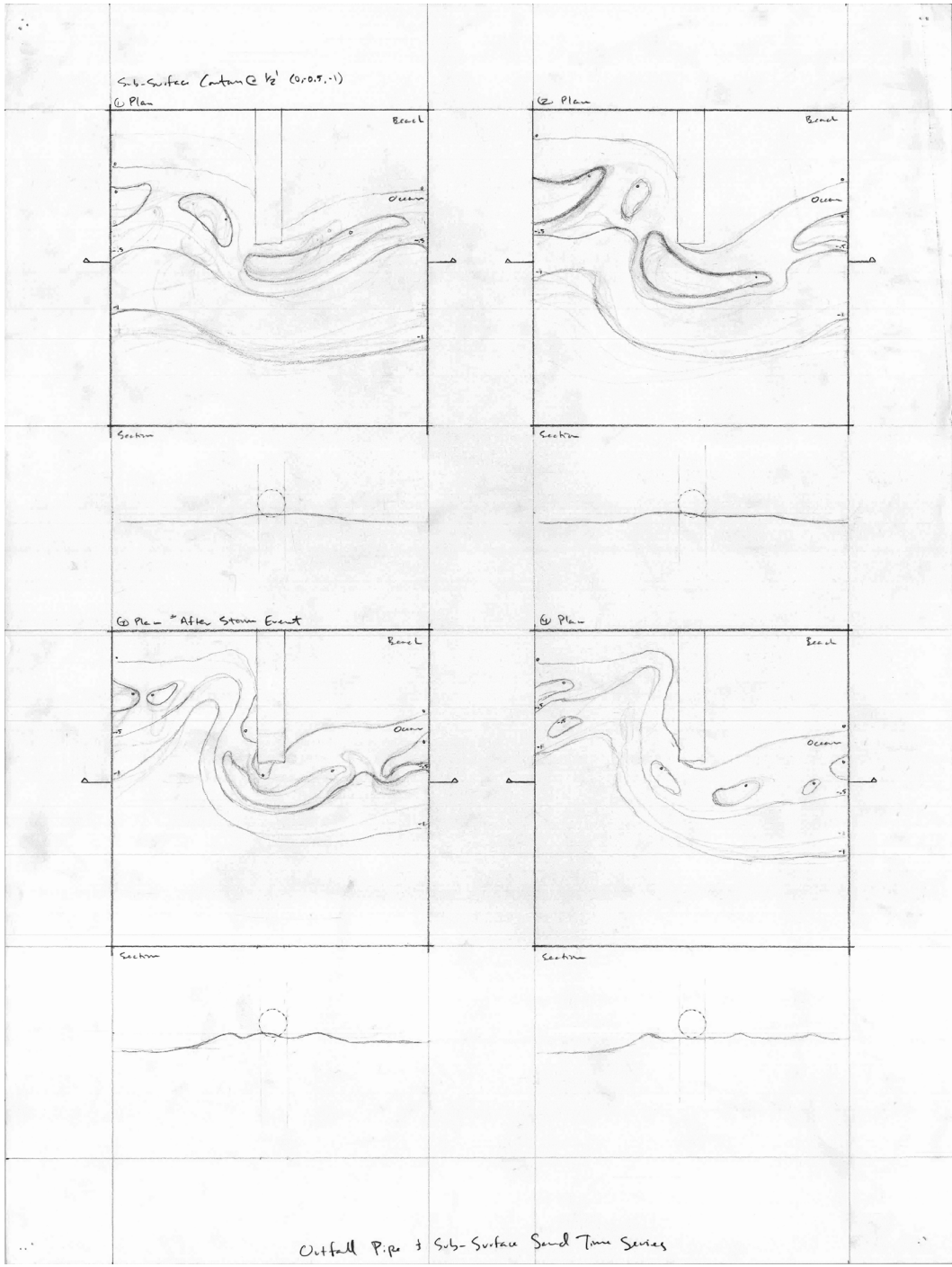


Figure 3.4 Outfall Pipe and Sub-Surface Sand Time Series

3 shows how a storm event can re-shape these bars by thinning and carving with high velocity discharge from outfall pipes. Once their integrity is weakened, tidal action continues to cause erosion. The result is many small, disconnected sand bars that perform less effectively as habitat for birds and intertidal marine organisms.

Material Form 10.
Underwater sand ridges from consistent tidal action.

Pipes and channels may have produced unintended consequences for sand accumulation and erosion, but dune fences are constructed to intentionally encourage a specific behavior: the building and accumulating of sand. By slowing the flow of air and reducing its energy, or capacity to move sand, fences allow wind-swept sand to drop and begin accumulating along their edges. Resulting dunes are undisturbed by tractor tilling, and naturally seeded plants may begin to establish and grow, helping to capture and retain more sand. Figure 3.5 shows a typical fence in the process of building a dune, which will completely envelope the fence over time. Figure 3.6 shows the time series of this process, and how fences may be constructed with multiple kinds

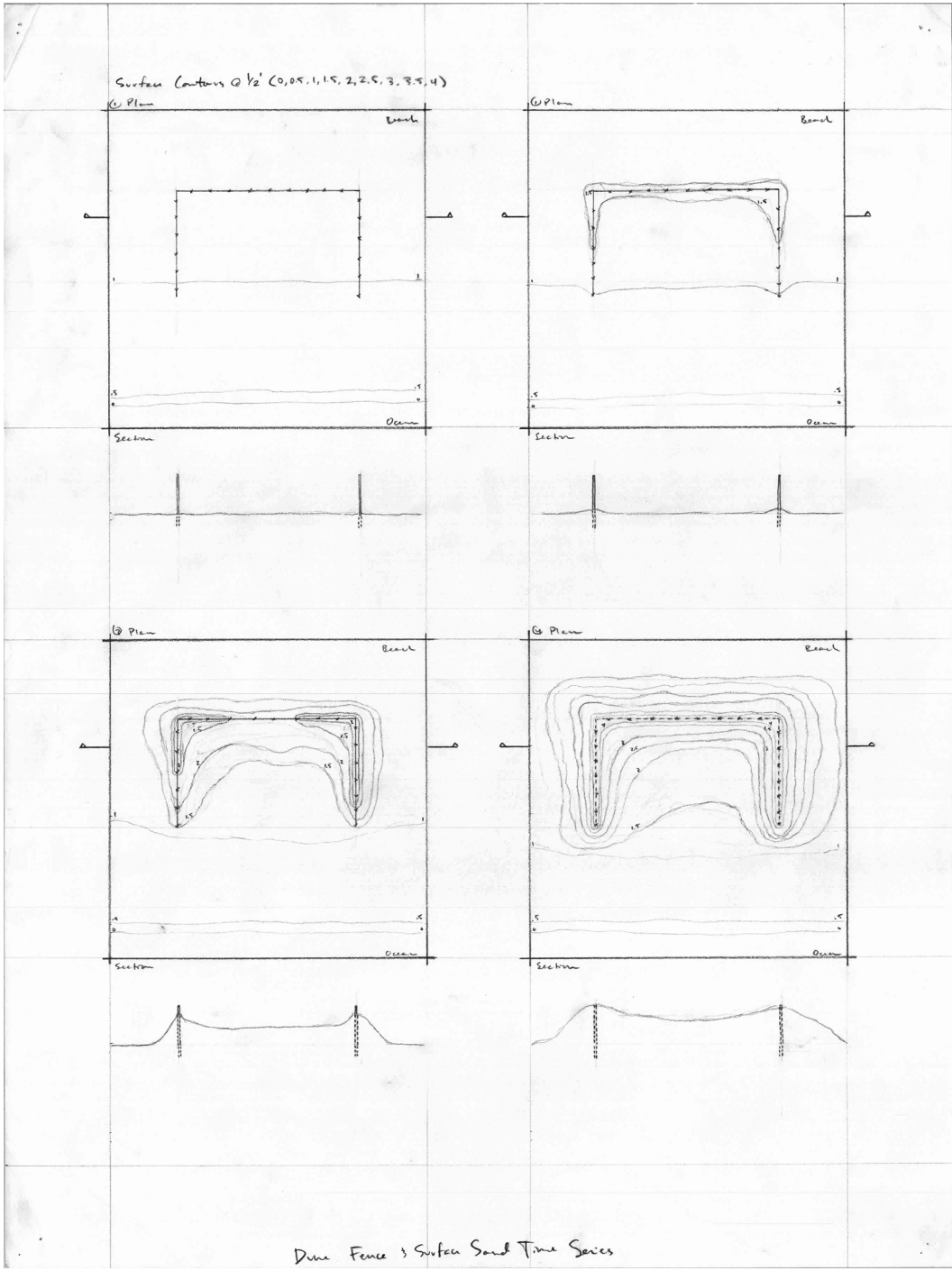


Figure 3.6 Dune Fence and Surface Sand Time Series

of configurations and orientations.

Figure 3.5 Dune Fence with naturally seeded plantings.

Figure 3.7 and 3.8 show hypothetical postulations of what might happen if water from outfalls is allowed to flow through the beach, instead of being conveyed directly into the ocean. If the slope is relatively uniform, water may meander towards the shoreline in a direction suggested by the beach slope. Its uninhibited meandering path results from a lack of hard material to restrict or influence flow.

If the slope is not uniform and there is a widened flat area, it may be possible for water to spread out and eventually form a pool or lagoon condition. This phenomena was observed during my visit to the site as an accidental product of open channel clogging. Water was forced out of the channel and onto the beach, where the beach slope was gradual enough to let it run for a few hundred feet before forming a small lagoon. Trapped water eventually percolated or evaporated, leaving behind a sun-dried crust of dead algae and bacteria in the sand. (Dessecation and prolonged sun exposure are guaranteed strategies for killing aquatic bacteria.)

Material Form 11.
Speckled, compacted sand from dropping and spalling.

Material Form 12.
Saturated, encrusted sand from dried lagoon.

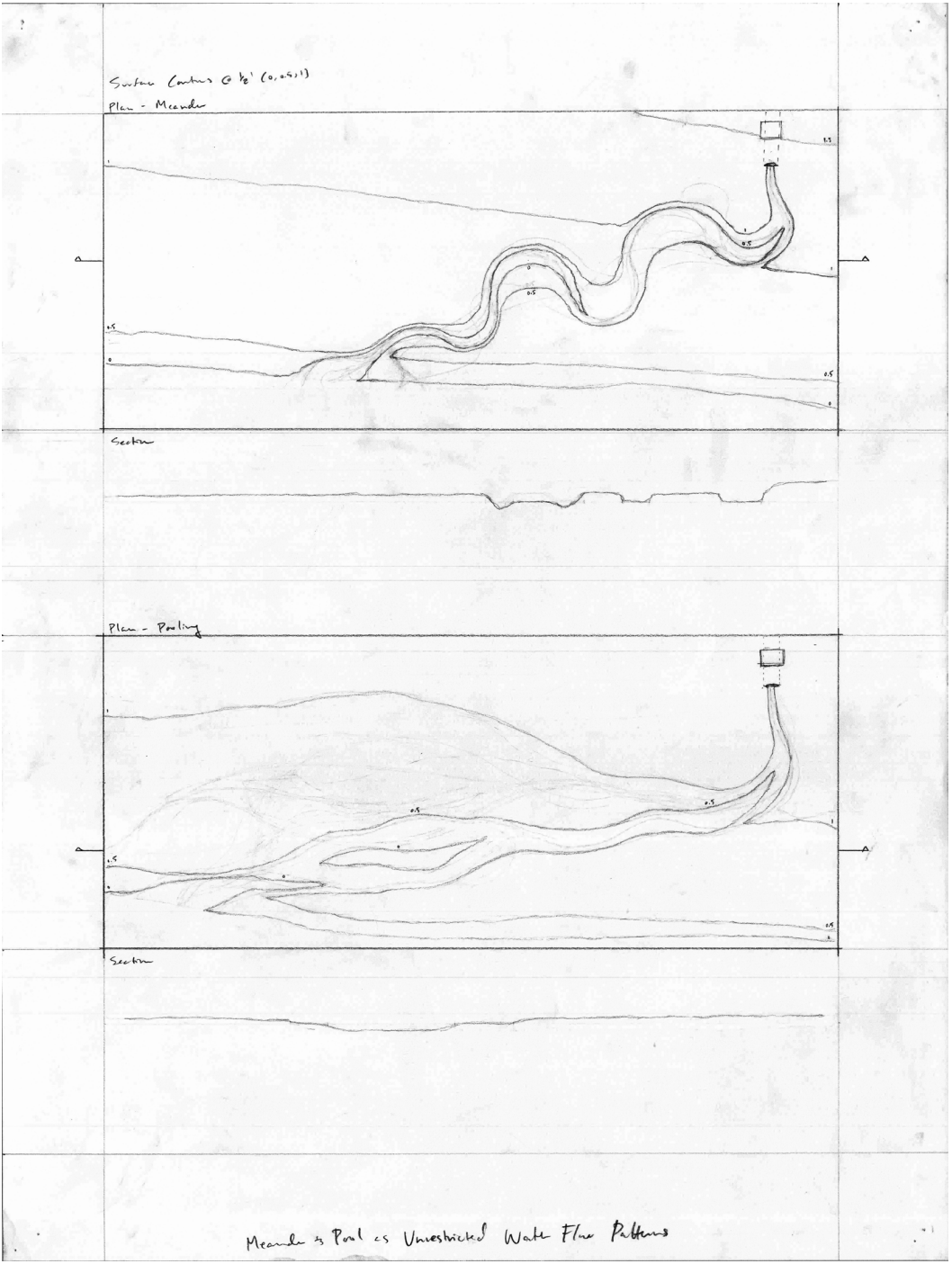


Figure 3.7 Meander & Pool as Unrestricted Water Flow Patterns

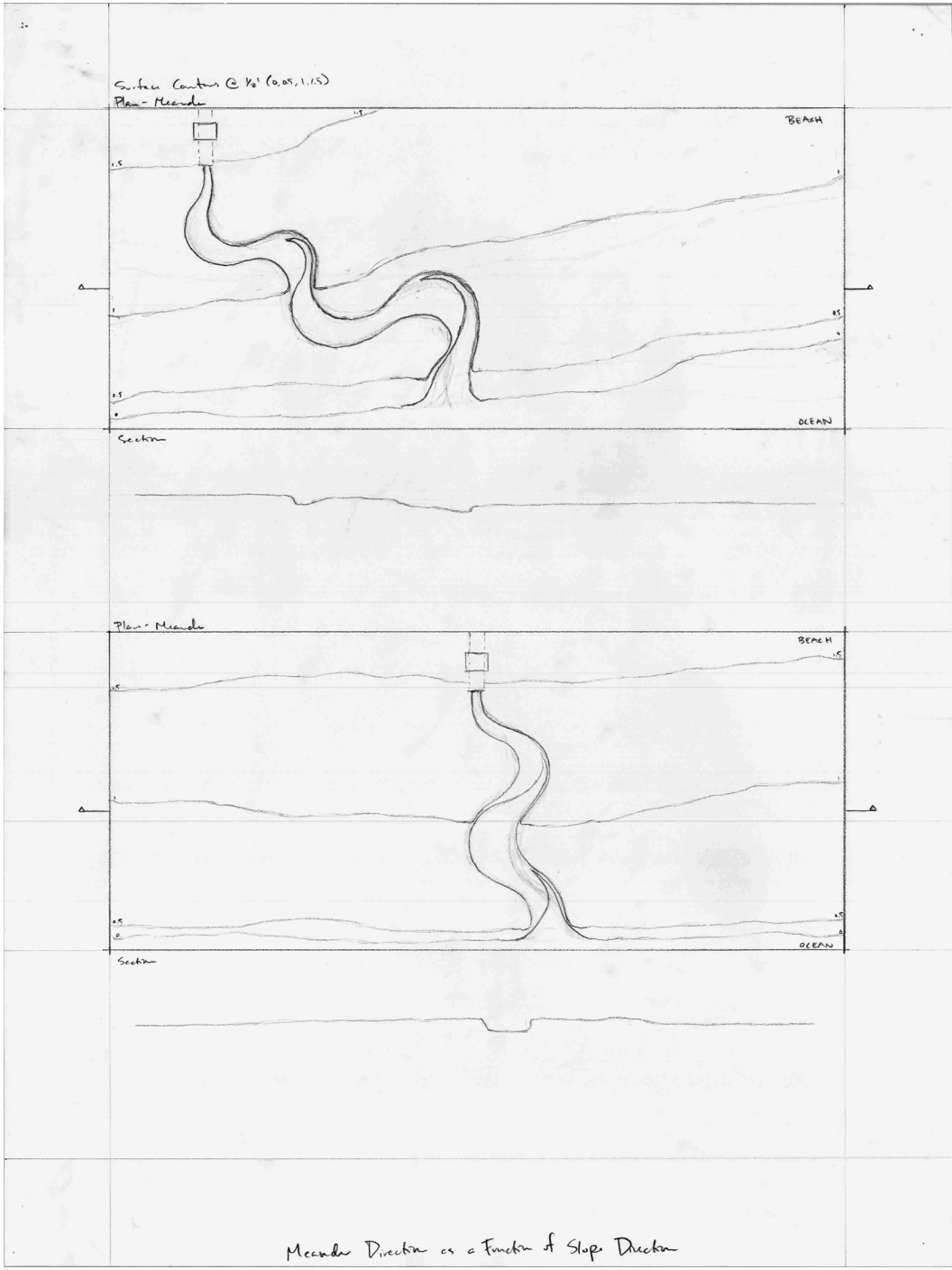


Figure 3.8 Meander Direction as a Function of Slope Direction

Final Thesis Design

4. Design Component Descriptions

The final design, shown in plan in Figure 4.1, attempts to resolve the aformentioned problems with existing outfalls, and establish a framework for natural processes to fully influence the landscape in constructive, visible ways. The design is represented as a set of infrastructural interventions. However, these are only half of the design. Each type of intervention, or part of the design, enables a different natural, material process, allowing nature itself to continually contribute to the design over time. Each part will be clarified in detail, in order to understand how it affects a singular process. In the end, the set of processes may function together to form an interconnected system of processes.

The top of the plan is the back edge of the beach, where it meets the elevated seawall and highway. The bottom is the shoreline and coastal ocean. The intervention largely occupies the beach flat zone, which was identified in Chapter 3 as the part of the beach with the greatest opportunity for improvement. Additionally, it is compliant with the project area limit set forth in the competition, maintaining a fifty foot buffer from the sea wall, and staying within two-hundred feet of total beach length. The immediate shoreline is also preserved as open, commercial beach, as it's already the most successful part of the beach for both people and ecologies, and it's important to maintain a continuous pathway to walk along the shore.

The initial design move is to remove the outfall pipe from the immediate shoreline. Outfall pipes currently extend to the shore, or beyond into the water by 5-30 feet. The majority of the this pipe length is cut off, creating a new pipe mouth or outlet 60 feet from the seawall, approximately 170 feet from the shoreline. The new 60 foot pipe length incorporates a 500 foot maintenance buffer zone along the back of the beach, as well as 10 extra feet

of allowance for maintenance structures that may need to be built behind the pipe mouth.

Natural, ecological spaces are also encouraged to develop behind the pipe opening to help enclose the project area in continuous "green" borders. Blending effects are taken into consideration to avoid one side of the project area that is only infrastructure, and other sides that are only natural, which would create highly noticeable, undesirable, contrasting edge effects.

The ultimate reason for cutting the pipe is to let storm water runoff flow through the beach, using the width of the beach to begin slowing and cleaning the water before it finally enters into the ocean. As seen in Figure 3.7 and 3.8, however, unrestricted flows of water through the beach may be destructive, carving large, erosive streams and encroaching on valuable commercial beach space. In order to combine storm water with the beach in a constructive relationship, the water needs to change in two ways: (1) it must be slowed to prevent excessive carving, and (2) dispersed into many smaller streams to decrease the chances of a single, major point of erosion from developing (as seen in current outfalls).

Smaller, separate volumes of water may not carve stream beds as easily. Unable to carve clear pathways through the beach, they will have a greater chance of splitting and thinning out over the beach surface, which may increase evaporation and percolation while continuing to slow water velocity. The sand alone cannot resist and disperse water flow in such ways, however. A second infrastructural intervention is needed.

The second move is to construct a detention basin, which is a type of infrastructure designed to capture, slow, and release water in intentional ways. This is different from a retention basin, which is designed to capture and hold water without releasing it again. A retention strategy is not chosen because the volume of runoff is too high to fully contain within the provided project

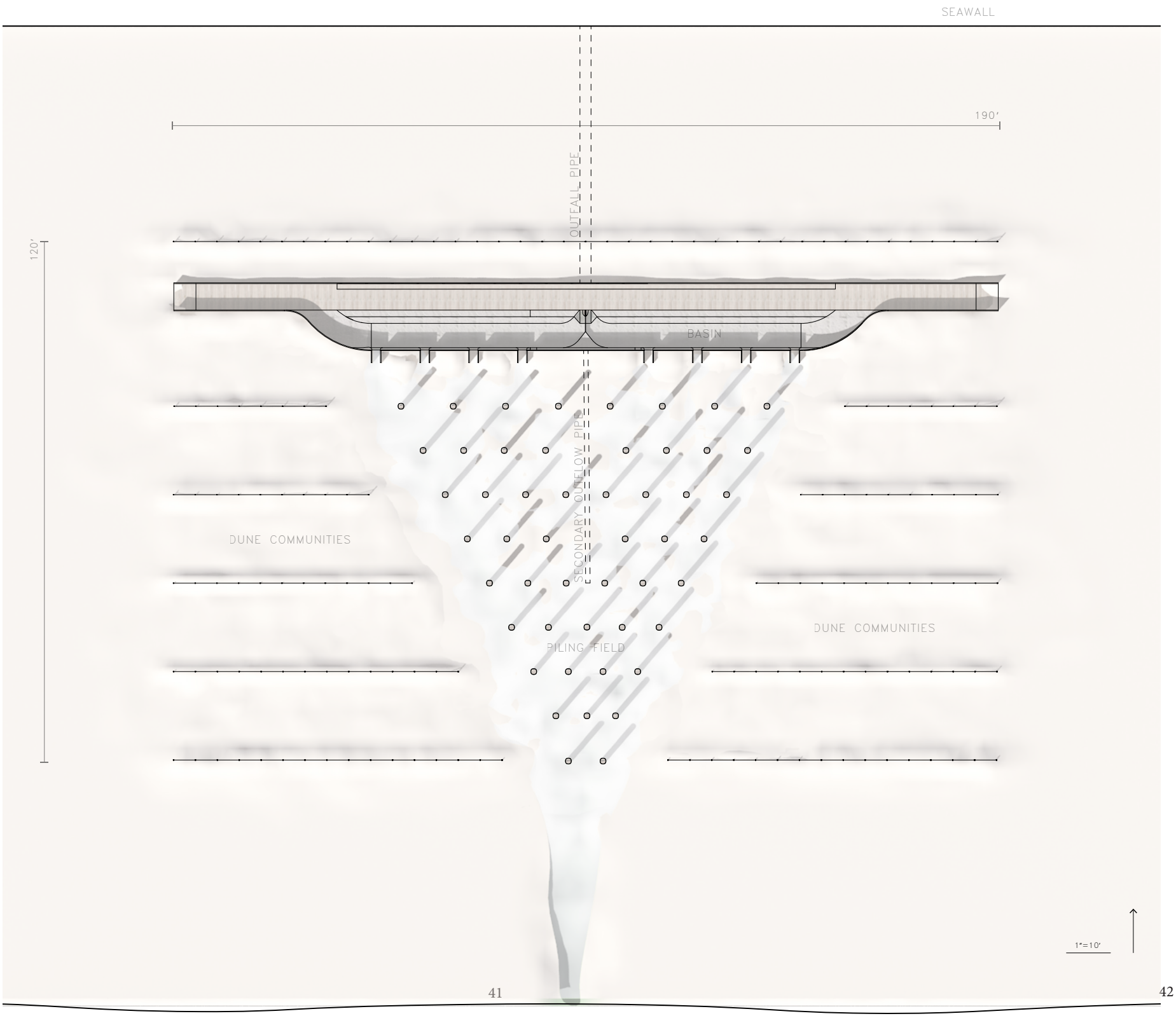


Figure 4.1 Plan of Final Design

area. Additionally, runoff water is not enjoyable if left standing. It contains trash, debris, and pollutants that discolor and odorize water. Thus, the developed detention strategy is to hold the smallest amount of water required to slow and disperse runoff onto the beach. Instead of holding water for gradual percolation and evaporation, it is preferred to run water through the beach, where sand and plants can contribute to slowing and filtering processes.

In order to understand how much water would need to be captured, a watershed analysis was performed over a 2.5 mile length of beach with four outfall pipes. By including four different pipes, each with their own sub-watershed, variation in water volume between pipes is better revealed. This variation informed potential flexibility in basin design to accomodate a range of conditions. A slope analysis of the land area between the Sound and Mullet Lake, shown in Figure 4.2 helps to reveal the extents of the full watershed.

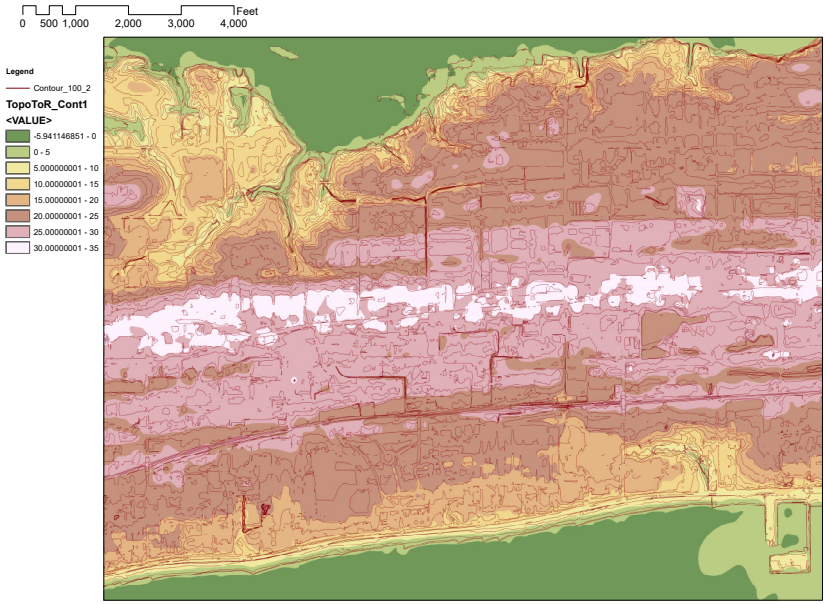


Figure 4.2 Watershed Slope Analysis

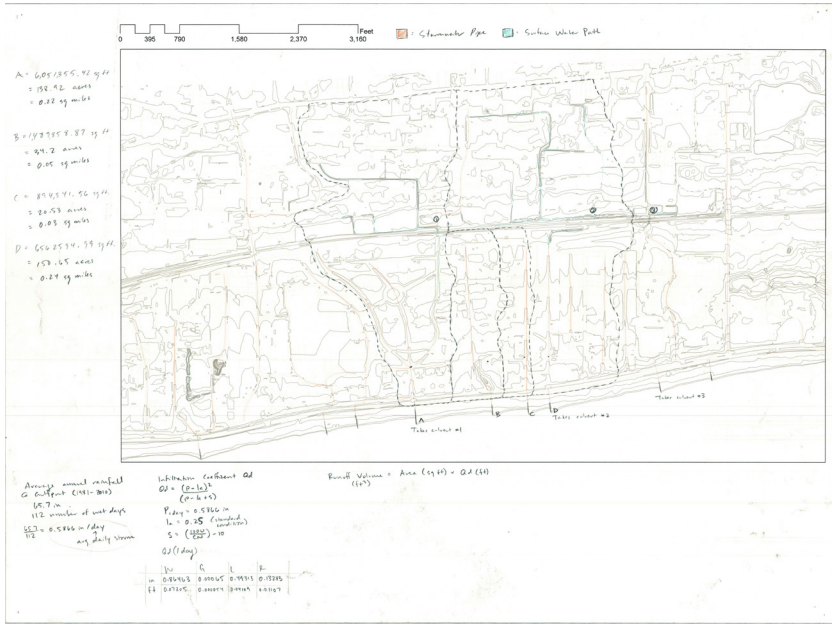


Figure 4.3 Sub-Watershed Delineation

Figure 4.4 Ground Condition Analysis for SCS Method Calculations

Figure 4.3 shows only land that drains into the Sound. The sub-watersheds for each pipe are labelled A, B, C, and D.

In order to determine the volume of water that is captured in each sub-watershed and sent to the outfall pipes, the SCS (Soil Conservation Service) Method, a standard method for calculating storm water runoff in large drainage areas, is used. This method takes into account different ground conditions and how much runoff they produce. Ground conditions include fully paved surfaces, forested woodland, and other mixed conditions.

Figure 4.5 shows final figures for runoff volume in each sub-watershed, during each level of storm severity. To interpret such large volumes, they are divided by an initial basin volume in order to see how many times a storm may cause a detention basin to fill and spill out onto the beach (Figure 4.6). It is found that even the smallest storm in the smallest sub-watershed is capable of filling the basin several times. This means that there are no obstacles to basin design from water supply alone. Instead, other goals such as detaining as little water as possible, and spreading water throughout the beach in many smaller streams, can become primary design drivers.

The final designed basin and all of its feature components are shown in Figure 4.7. The best overview may be seen in box 2. A wooden boardwalk, placed six inches above the sand, is entered by visitors on the sides via small wood ramps. Once inside, the entire perimeter of the basin, except for the 6-foot-wide entrances, are lined with 3-foot solid wood sand fences, to keep the basin from filling with sand on the first day of its installation! Any sand that becomes trapped in the basin can be cleaned out with routine maintenance. Box 4 shows a concrete ramp into the basin, from the wooden boardwalk, in order for small maintenance vehicles, like golf carts and bobcat tractors to enter into the basin. Once there, mechanical sweeping and manual trash collecting can be performed. The debris is loaded onto the maintenance vehicle and carried away. On the exterior

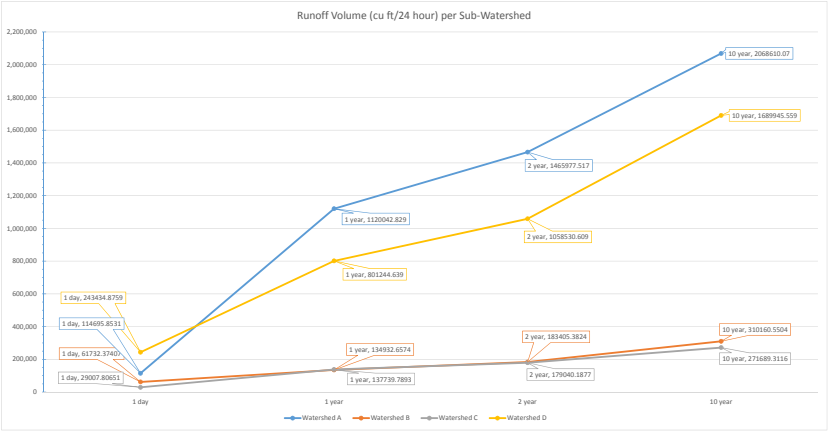


Figure 4.5 Total Runoff Volume for each Sub-Watershed

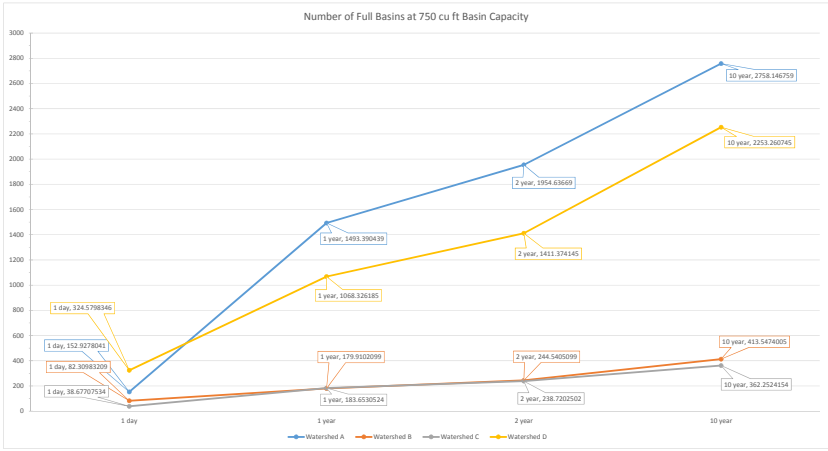
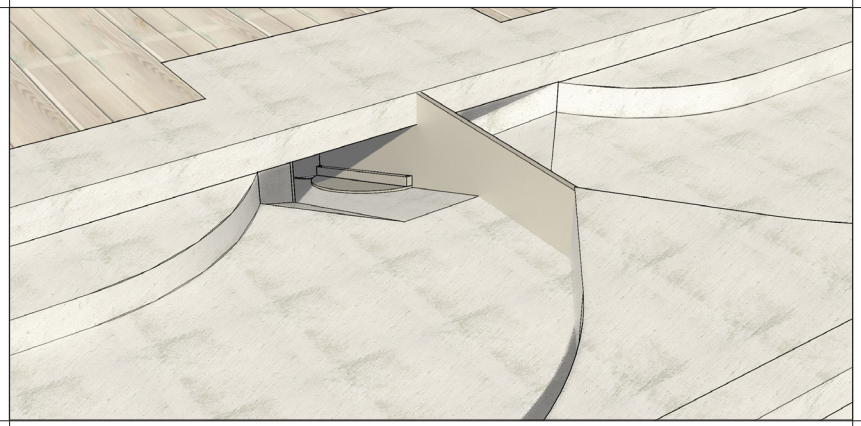


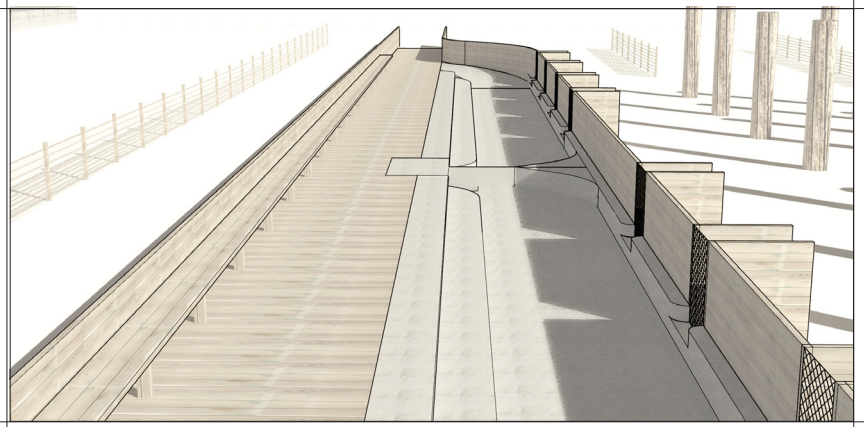
Figure 4.6 Number of Basins Filled During Each Storm Severity Level

side of the fence, sand is allowed to accumulate and build one-sided dunes. Over time, this will help the design blend into the new, naturalistic recovery landscape, all but dissapearing among the other dunes and plantings, both in front and behind the basin.

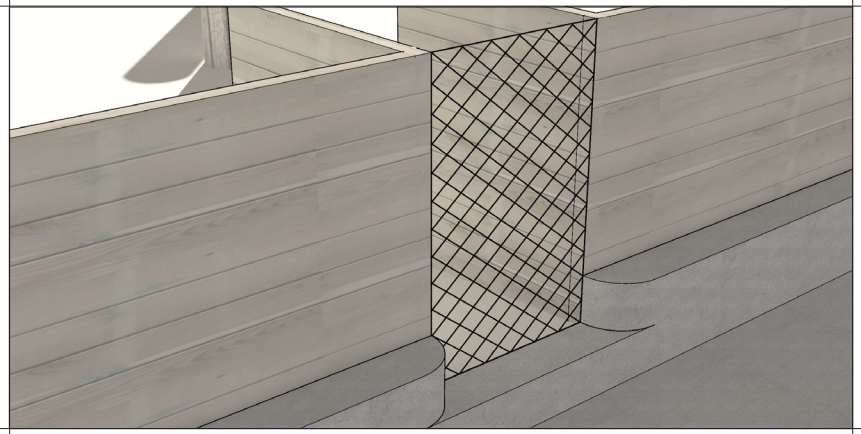
1. New Beach Outfall Mouth in Basin, with Steel Flow Divider Board, and Secondary Release Pipe Cap



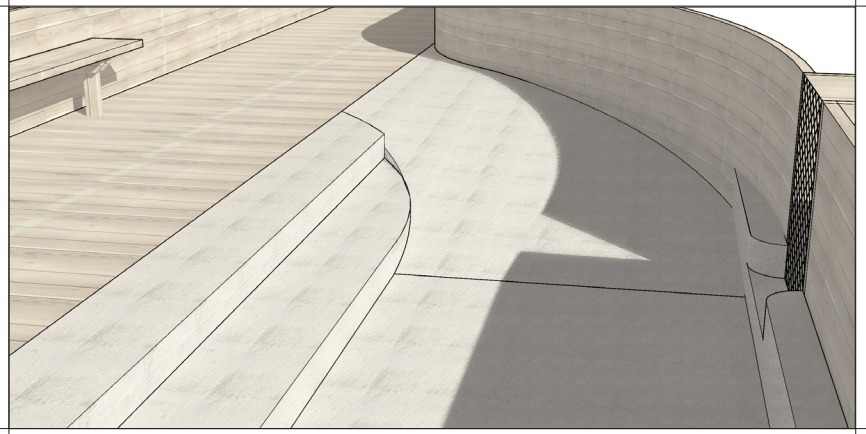
2. Solid Wood Dune Fence Lining of Basin Perimeter



3. Steel Fence Debris Catchment at Flow Release



4. Small Vehicle Service Ramp for Maintenance



Basin Feature Board

Figure 4.7 Basin Design Feature Board

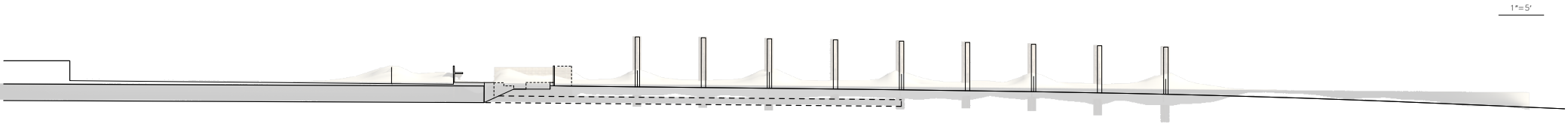


Figure 4.8 Design Section, from Street and Seawall to Ocean

As mentioned, stormwater is full of debris, which is caught in the basin via small metal grates at basin outlets, shown in box 3. Instead of allowing trash to spill onto the beach and into the ocean, an attempt is made to capture it entirely within the basin, where it can be cleaned quickly, all in one place. Currently, methods of maintenance include driving the entire coastline with a pick up truck, stopping periodically to pick up plastic bottles and other debris that may be floating or presenting itself in other obvious ways. This isn't efficient or effective. A central point of collection is preferred by the environment and beach staff.

Water enters the basin via a small ramp, shown in box 1. The shortened outfall pipe mouth is still buried underneath the beach surface, and must be brought up to the level of the beach in order to interact with the beach surface for filtration, percolation, and dilution. Upon leaving the pipe, water builds up to a level where it spills into the basin. This accumulation is fast, with the incredible amount of stormwater supply talked about earlier. Water arrives with a velocity and force that must be slowed, even before entering the basin. The catching and building of water accomplishes this initially. Secondly, at entering the basin, water is met with a steel board which divides flow into the peripheries of the basin. Instead of crashing into the basin walls directly, and flowing backwards into the pipe, water flow is directed out in a fluid manner that avoids structural damage.

The basin itself is only six inches deep -- a minimum amount of water was targetted for collection, so as to allow for maximum storm water input onto the beach, and to reduce resting water within the basin that is polluted and unnatractive. After filling to six inches in depth, water is released into the beach in selective openings in the dune fences, accompanied by steel grates. The openings are small enough to have not permitted a great deal of sand accumulation, and the water is volumous enough to engage in positive erosive action to clear sand away and provide clear channels for release. This is one instance in which beach erosion is encouraged!

Figure 4.9 shows this process happening step-by-step, as a time series in plan and section. Water first accumulates within the pipe, until it builds to the point of entering the basin. Once it builds to the height of the basin outlets, it is released through the fence openings. Water that was previously channelized into a single, high volume, high velocity stream, has been slowed initially, and dispersed into several smaller streams that can be introduced directly onto the beach without the consequence of massive beach erosion.

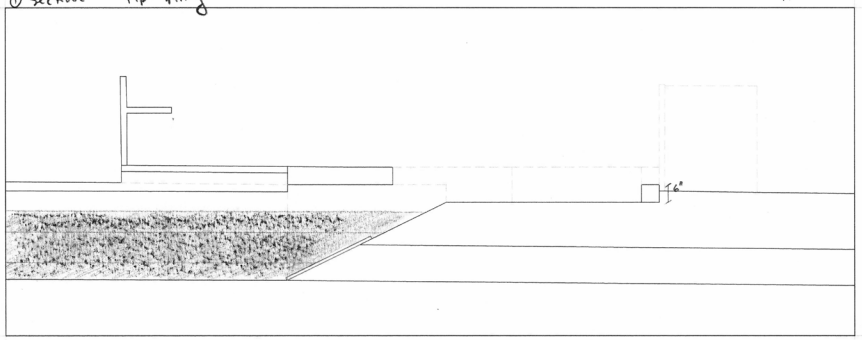
Once the storm has passed, and there is no further stormwater input into the basin, there will remain a 6 inch layer of water within the basin, as well as the additional backed-up water within the outfall pipe below. Figure 4.7, box 1, shows a release cap on the basin water ramp, which can be opened to release remaining water. Opening the cap, allows water to enter into a secondary pipe below the beach surface. This is also shown in Figure 4.1, to see it in plan view. Figure 4.9 illustrates it best in section. The third and final phase is the secondary release. Water isn't released at full speed onto the surface. Instead, stagnant, backed-up water is released very slowly (at the rate of percolation) into the sand column below the beach surface, via perforations in the pipe. These perforated openings may also have micro-mesh protections to prevent sand from infilling the pipe. Plant root systems are engaged to absorb new groundwater input.

The final designed features of the basin are simple commodities for public engagement. A simple bench lines the rear dune fence, built with 2x4 construction that replicates bench construction techniques already used on the site. This ensures that the bench isn't a financial or aesthetic concern for the stakeholders and public visitors. The basin itself is built with two concrete steps, which engages the 10 foot wide concrete pad as a public space that is useable when it's drained and dry. People may inspect the system, and make mental connections about the flow of water onto the beach, seeing the input, the divider, the

Scale @ 1" = 2'

① Section - Pipe filling

N ←



Scale @ 1/16" = 1'

② Plan - Pipe filling

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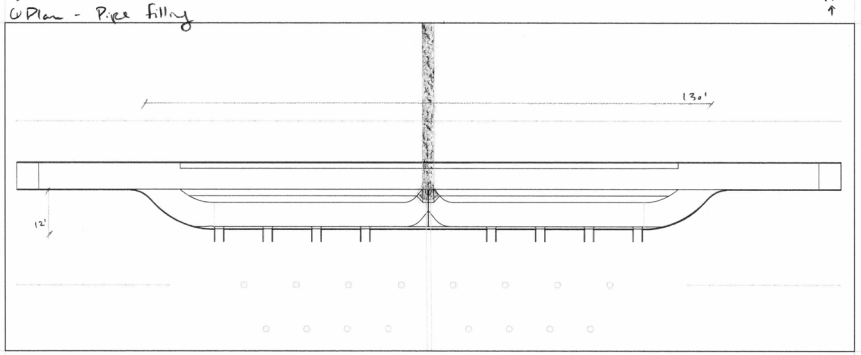
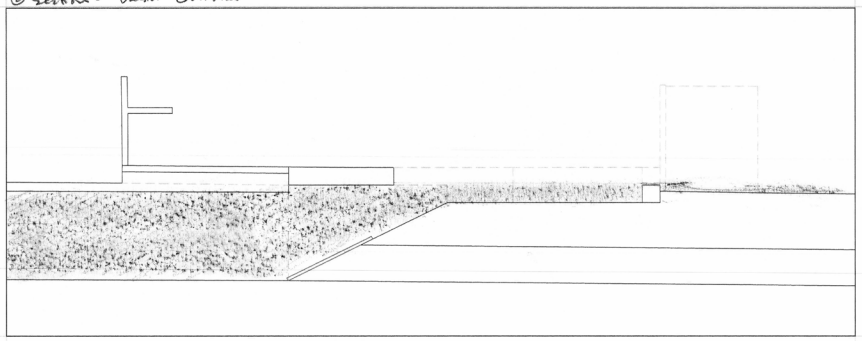
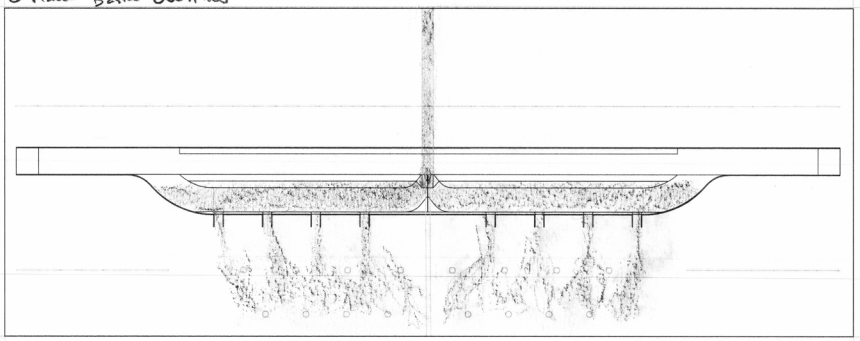


Basin Capacity @ 450 cu ft + Held Pipe Volume @ 500 cu ft

④ Section - Basin Outflow



⑤ Plan - Basin Outflow



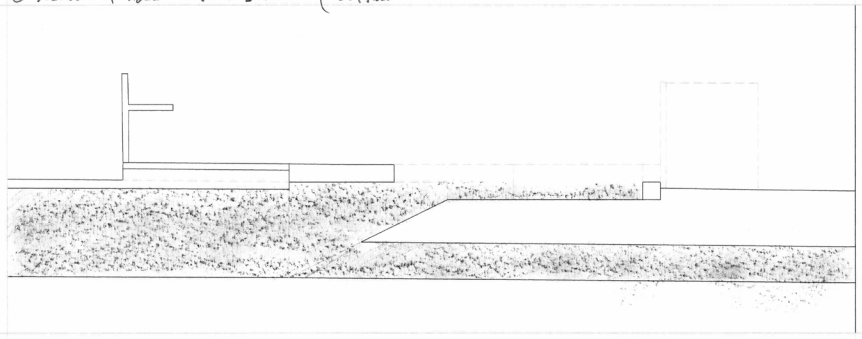
Runoff Volume

	24 hr daily	24 hr 10 yr
Smallest Watershed	29,000 ft³	270,000 ft³
Largest Watershed	245,000 ft³	2,070,000 ft³

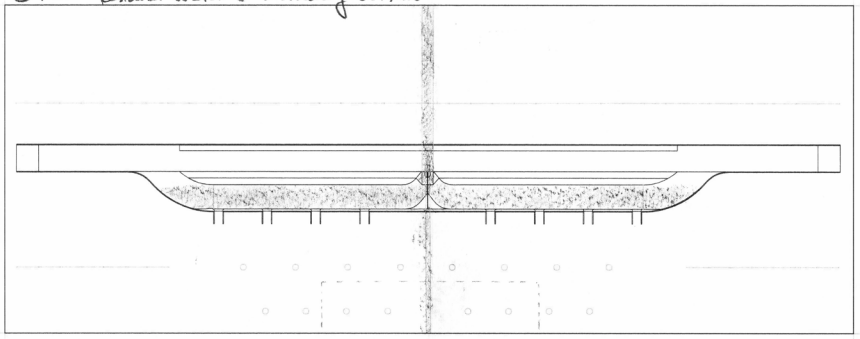
Basin Fill Amount

	24 hr daily	24 hr 10 yr
Smallest Watershed	30 times	285 times
Largest Watershed	250 times	2170 times

③ Section - Residual water & Secondary Outflow



⑥ Plan - Residual Water & Secondary Outflow



Total Volume @ 950 cu ft.

Total Spaced @ approximate 6" depth = 50' × 40' Field

Phenomena of the Basin- Water from Storm Runoff

Figure 4.9 Phenomena of the Basin, Engaging Water from Storm Runoff

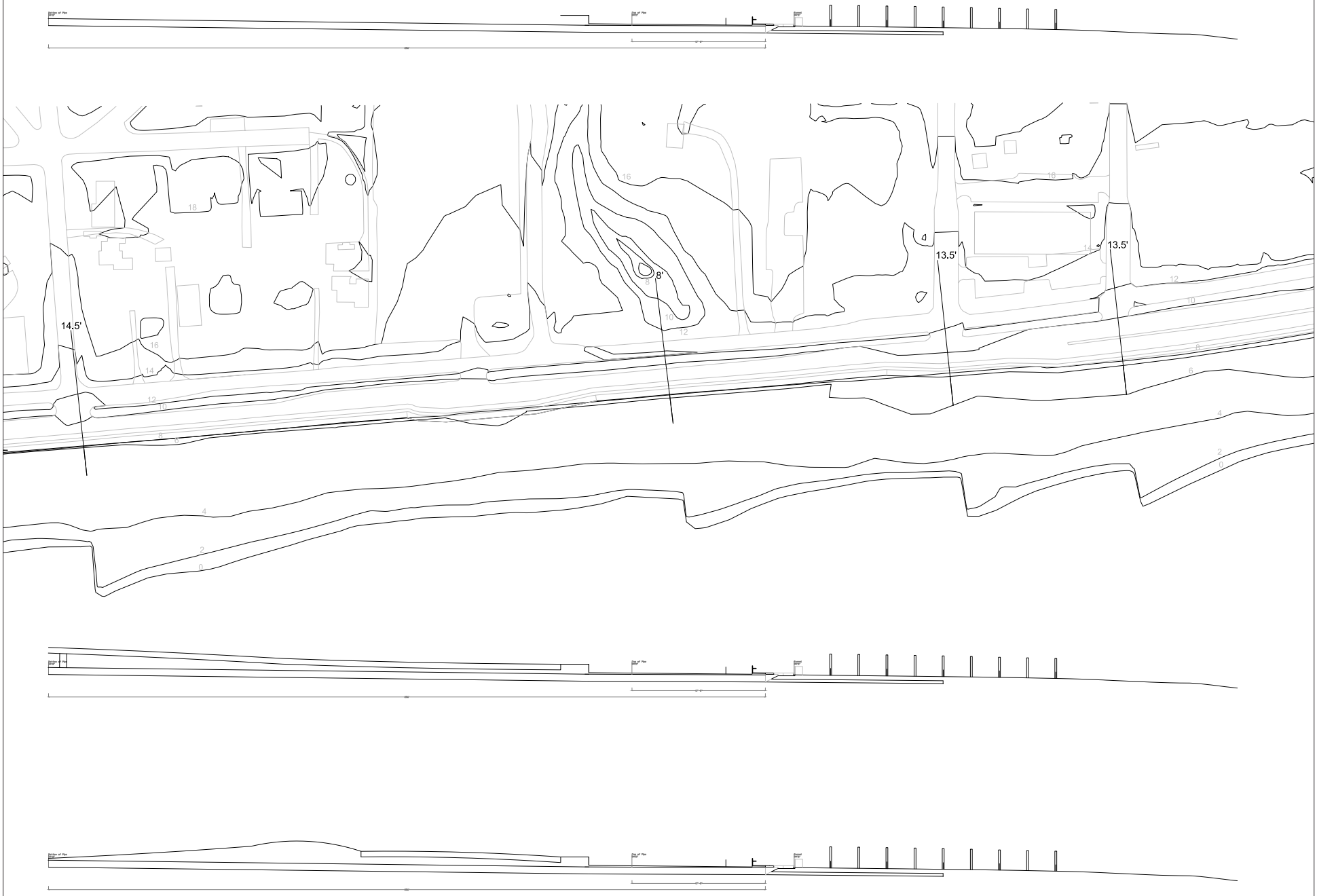


Figure 4.10 Topographic study of water back-up within outfall pipes

fence outlets, and the final beach surface stained with water. While standing inside the basin, dunes come up to meet you on the other side of the dune fences, offering an experience of being closer and "inside" the dunes.

The basin relies fundamentally on water's capacity to build within the pipe and eventually breach the beach surface. This is made possible because of unique topographic conditions on the site. The studied portion of the Mississippi coastline is entirely engineered, including the beach, in order to resist the destructive effects of hurricanes. The beach is actually an erosion control measure to protect the seawall. The seawall, highway, and receding land have all been raised three feet above the beach surface, where they meet. With the pipe buried underneath the beach, this means that water levels would have to rise more than four feet before coming out on the highways and neighborhoods. As the system is designed, water only builds about one foot before breaching the beach surface. No water is released back into the city, where it is initially captured.

A study of topography in Figure 4.10 shows the same four representative outfall pipes, with detailed sections concerning water levels. Two sections on the bottom show differing scenarios: the outfall pipe fed by streets, and the outfall pipe fed by a swale, or topographic depression that collects water. In both cases, there are close to ten feet of gain between the street inlet, where the pipe is initially fed, and the new outlet in the basin. Water has no escape, except for out of the basin, ensuring a single directional flow onto the beach. If the topography wasn't so unique, and the beach was more at grade with adjacent streets, this situation would not be possible.

Once water is let out onto the beach, it needs to be channeled or contained in some way, so as to not spread out and cause erosion or ruin the clean, commercial beach experience for the public. Engineered, hard wall solutions cause problems like sand build up and consequent beach erosion. And after some

time, they can be buried completely, becoming disfunctional and dangerous to the public. Instead of engineered solutions, the beach topography itself was seen as the most resilient, adaptable solution. Beach topography develops naturally, in dune formations, which cause water to meander and ravine through the beach, finding low points in between the ridges of accumulated sand. On a commercial beach, dunes can be encouraged to build along dune fences, which slow wind and allow sand to drop.

Figure 4.11 shows how sand can build along a dune fence, in both plan and section time series. Fences interrupt wind flow, which causes sand and moisture content in the air to drop. This compacted, shaded sand forms ideal conditions for plants to establish quickly. Small grasses and shrubs form root systems, which, in turn, help to lock sand into place, preventing accumulated piles from being swept away by wind. The continual, re-enforcing cycle of sand droppage, and plant anchoring, creates a system in which sand builds over time and eventually overtakes the dune fence completely. A mature dune is filled internally with layers of compacted sand and roots that extend throughout its entire sectional profile.

The last technology employed in the design are simple wooden pilings. Historic pilings from old fishing pier structures litter the Mississippi coastline, in a beautiful way. They stick out in the water, providing a poetic hint of geometry and history in an otherwise flat and expansive water line. Pelicans, cormorants, and other sea birds have come to rely on them, as well, for resting habitat in between fishing endeavors. Snails, clams, and worms all make their homes by borring small holes in the soaked wood. They, in turn, provide a nice food source for sand pipers, sea gulls, and other smaller shore birds.

Of principle importance is the way that pilings interact with sand. As the tide rushes in and out, water is forced to flow around the pilings. Wind does the same thing, when the piling is out of water (at low tide). Because the piling is a perfect circle,

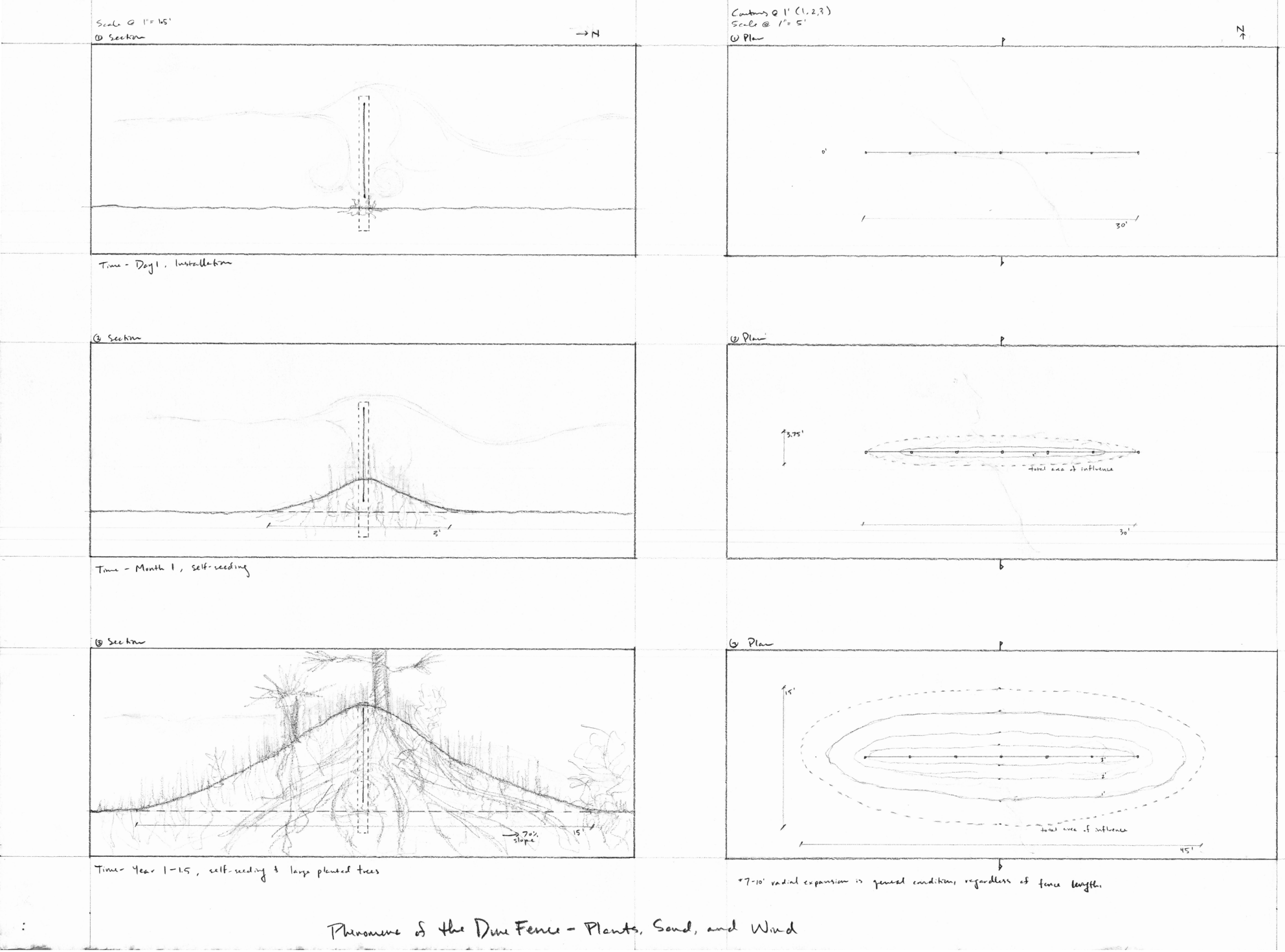
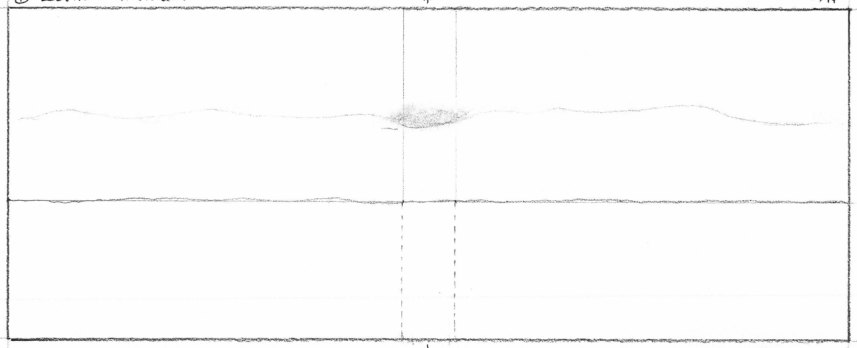


Figure 4.11 Phenomena of the Dune Fence - Plants, Sand, and Wind

Scale @ 1" = 1.5'

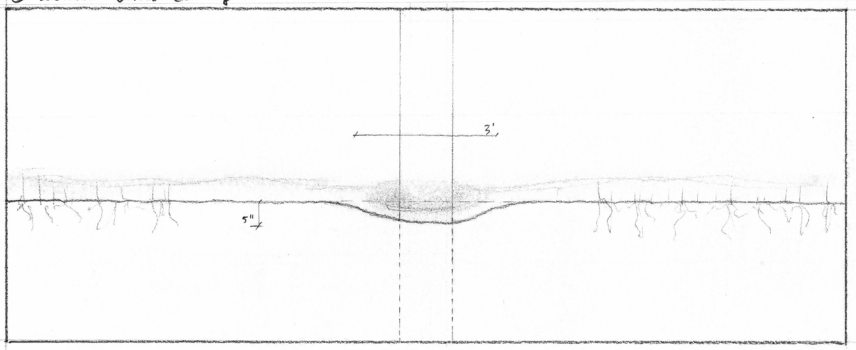
① Section - Installation



Total piling length @ 12 - 13'
- 8' above ground
- 4-5' below ground

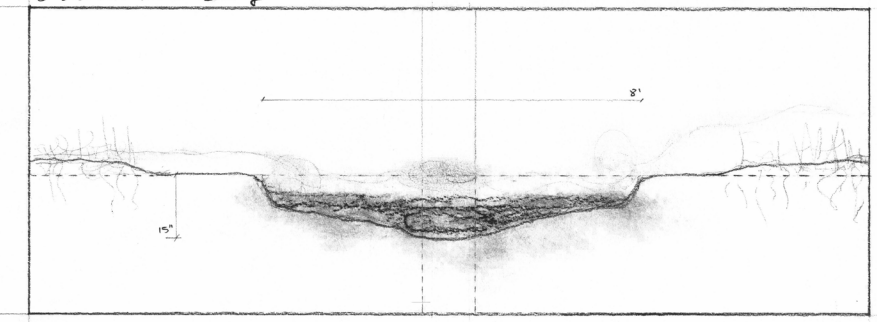
2' Foundation may extend up to 5' below ground level

② Section - Wind Carving



Planter may establish on open beach

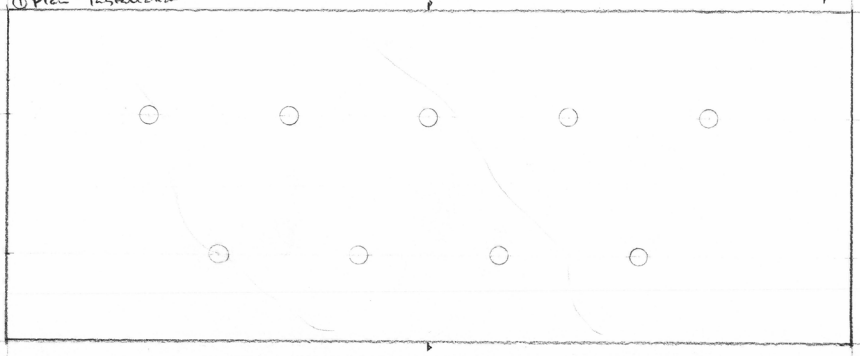
③ Section - Water Carving



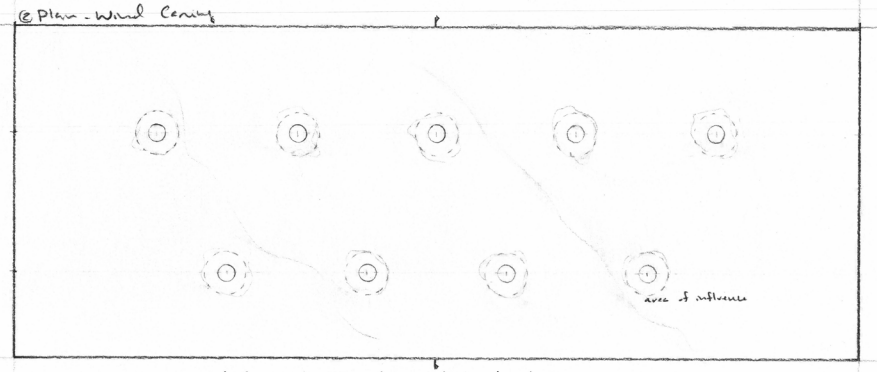
*Final depth and width of scouring from water is completely dependent on water volume & flow rate.
Results shown approximate a one-year storm.
Established plants may contribute to the formation of new micro-topographies.

Scale @ 1" = 5'

① Plan - Installation

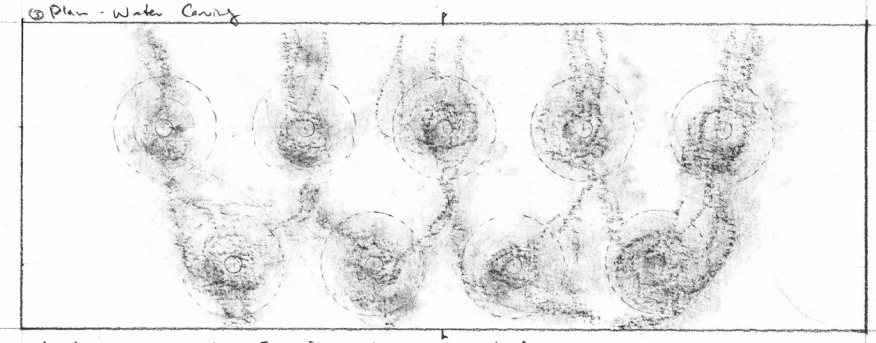


② Plan - Wind Carving



Irregularities are accounted for wind coming from multiple directions.

③ Plan - Water Carving



Meanders are approximations. Exact flow patterns are result of interaction between amount of water volume, sand microtopography, plants, and pilings.

Phenomena of the Piling Field - Wind, Water, & Plants

Figure 4.12 Phenomena of the Piling Field - Wind, Water, and Plants

wind and water wrap around it, instead of bouncing off of it, or turning away from it. The result is a pattern of scouring at the piling base.

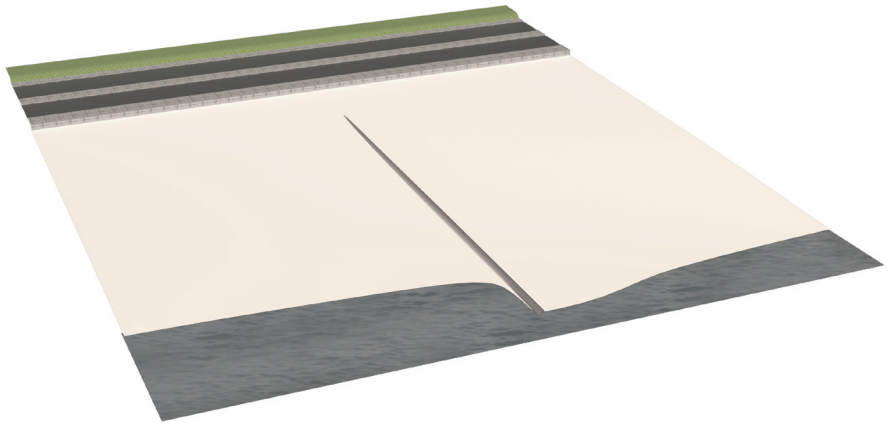
Figure 4.12 shows the time series of this set of processes involving pilings. After their installation, wind begins to carve at the beach surface around the base of pilings, creating several small topographic depressions. Water, which always seeks the lowest point in its travels, finds these depressions, and wraps around the pilings, further scouring and digging the beach surface. Small pools around the pilings are formed. In this way, the water is encouraged to scour and dig its own path through the beach. A balance is achieved between inevitable sand accumulation in the beach outfall zone, and intentional scouring to help stormwater find its way out. When combined with the building of sand in the dunes, natural processes that engage wind, sand, and water are able to contain and direct water flow. The exact flows of water through the piling field are not pre-determined or channelized, however. Pilings are placed in offset rows, so that there is a piling in between the gaps of the ones in the previous row. This method ensures that water is caught and slowed, as well as contributing to positive scouring processes. But is not prescriptive of its exact path.

Figure 4.13 shows the effects of the combination of these landscape technologies. Natural processes involving wind, sand, and water are engaged on the beach, creating a holistic system in which the beach builds and continually manages stormwater runoff. The first step is to remove the outfall pipe to 60 feet from the seawall. Afterwords, the design can be installed in one day. Subsequent invitations are made towards sand, wind, water, and plant communities to finish building the design after that. And because the design engages processes over time, time only makes it perform better. Dunes get bigger, plant communities become more robust, ecologies of birds, plants, insects and mollusks expand, which help to till, clean and fertilize.

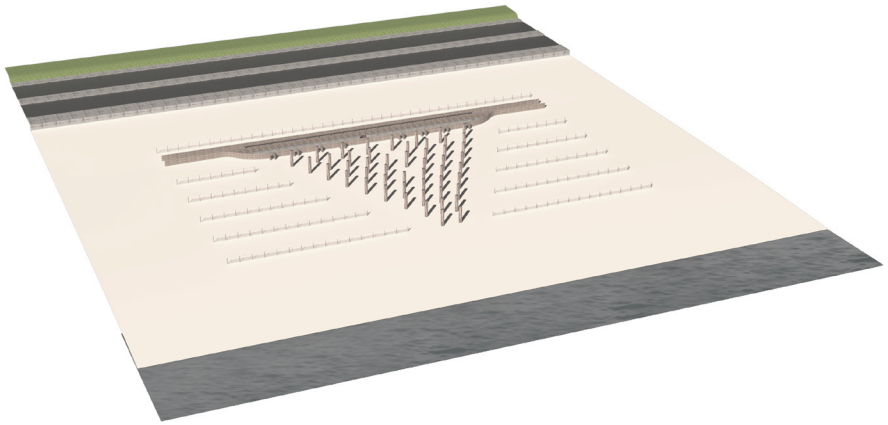
Throughout the entire life of the project, from installation to climax ecological performance, people are allowed to witness change in the beach. The beach outfall zone is never roped off, preventing people from enagaging with the design. Signs may be posted that describe the potential hazards of the water flowing through the project, and the sensitivity of establishing ecologies. Even if people feel uncomfortable exploring the dunes and piling fields, the basin boardwalk offers a safe vantage point of the entire design, from the initial input all the way down to the coastline. A new environment is created, which adds diversity and interest to the beach-going experience. And reveals how much nature is laying dormant within the beach, waiting to be engaged in a way that people can understand and translate for themselves.

The final solution is a repeatable technology, able to be deployed throughout the beach as a general outfall solution. As it's currently designed, the ranges of conditions that it can tolerate are immense (as demonstrated in the watershed study). If necessary or desired, every aspect of the design can be scaled up or down -- the length of the basin, or dunes, as well as the height of the pilings. The demonstrated version may be considered as a standard version, from which all other applications may deviate if desired.

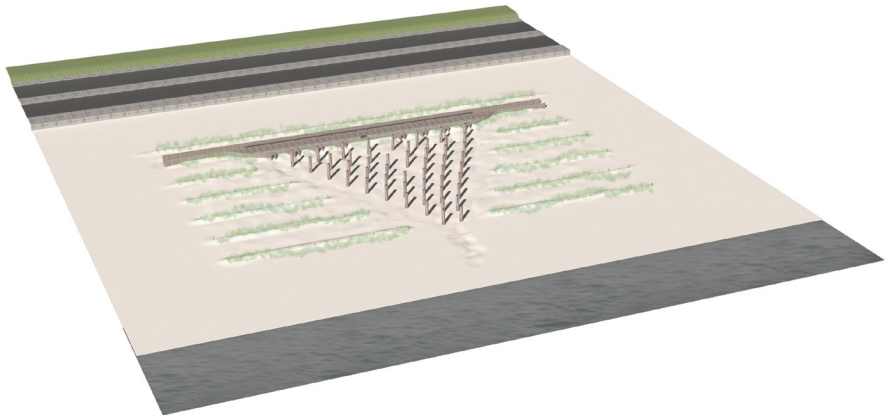
1. Existing Condition, Outfall Pipe



2. Remove Outfall Pipe Length, and Install Design Infrastructure: Basin, Dune Fence, Piling Field



3. Passive Dune Fence building, and recruitment of initial plant communities



4. Mature dune planting communities and fully contained outflow field

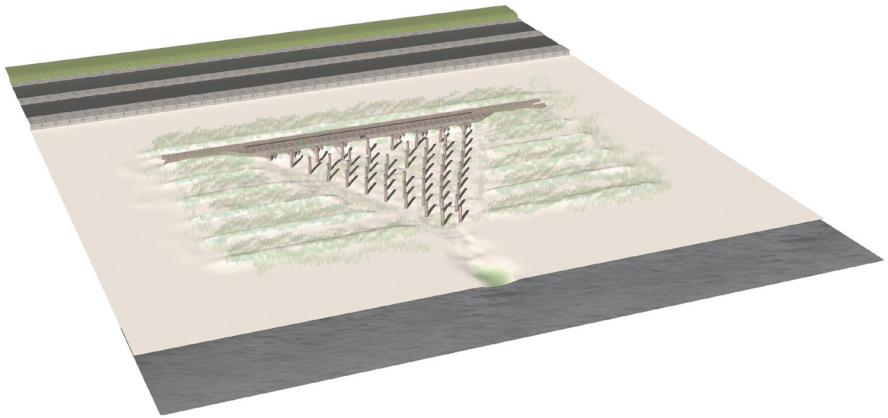


Figure 4.13 Phases of implementation of new Beach Outfall Zone

5. Design Experience

When the design is first installed, excavation is required for the basin, dune fences and pilings. The amount of sand that is excavated forms a supply for initial construction of dunes along fences, at 10 feet long and 1.5 feet tall. Small grasses may also be planted on these new dune mounds, in order to ensure their structural survival. Finally, large palm trees may be planted in between dunes, along the edge of encouraged water travel, in order to help build natural sand mounds and recruit planted ecologies to those areas more quickly.

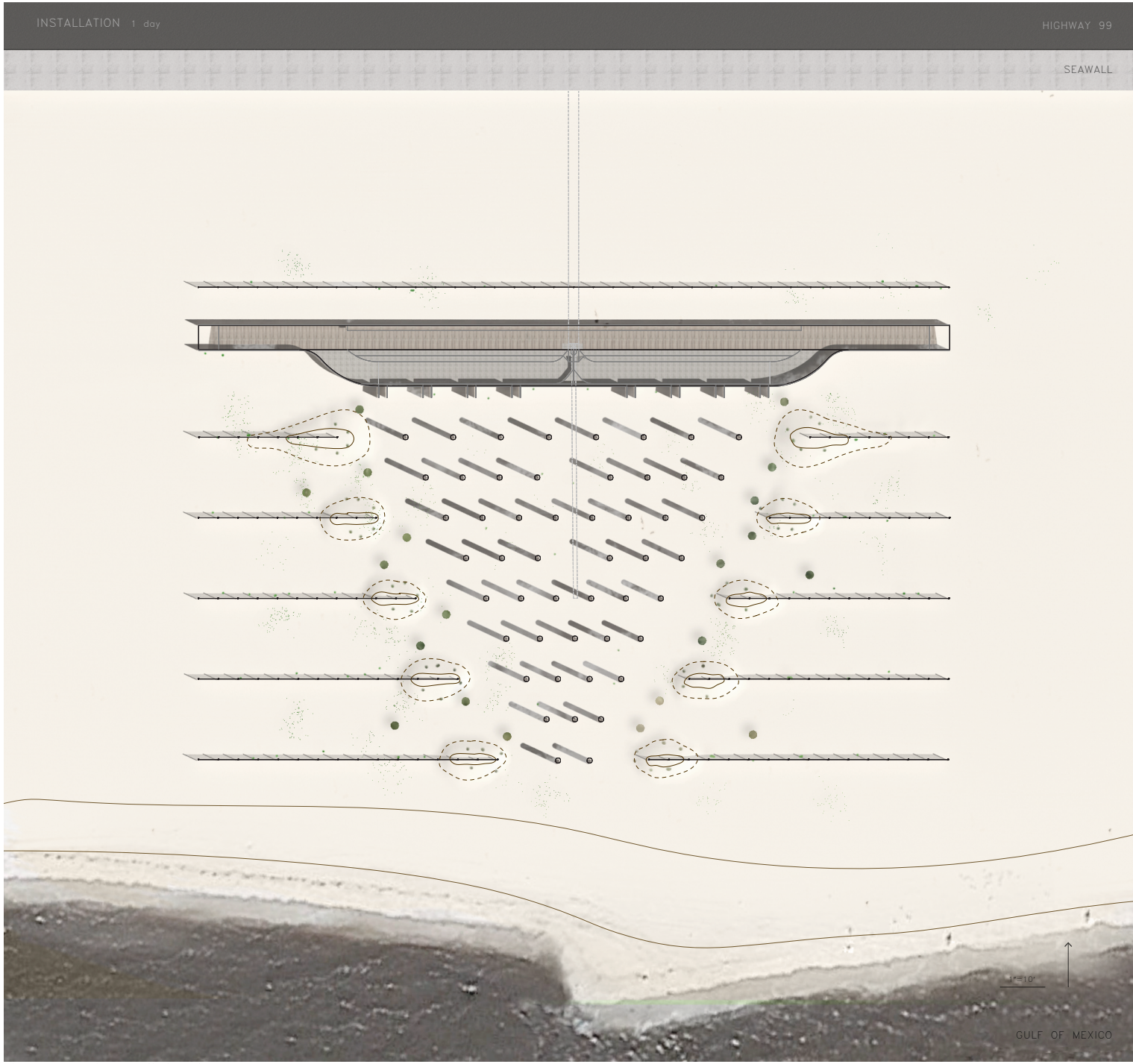


Figure 5.1 Design Installation Plan

Figure 5.2 Design Installation Perspective

The installed landscape is intriguing and begs for exploration. Spaces in between dunes become hiding places for kids to huddle and play. The pilings are enchanting in their repetition, and chain of cast shadows. Run through them. Lean on them. String hammocks between them. Get lost in them.

Just as there is not a prescribed path for the water, there is no prescription for public engagement. People can let their mind and bodies wander, figuring out how they fit into this new stormwater system.

Dunes continue to build along sand fences, while the first storm arrives. Immature plant and dune communities aren't able to channel water entirely, allowing some water to escape between them. This is fine. Sand will rebuild the beach over time, covering previously carved water channels, while making dunes more resilient for the next storm. The only area that is not restored completely is the piling field, because of the ever-present erosive interaction between the pilings and wind. The high points get higher, and the low points stay low. Natural processes are engaged in a topographic symphony, each part complementing the others.

With the pipe removed, the coastline starts to reform itself, and the dunes become critical repositories for sand replenishment.

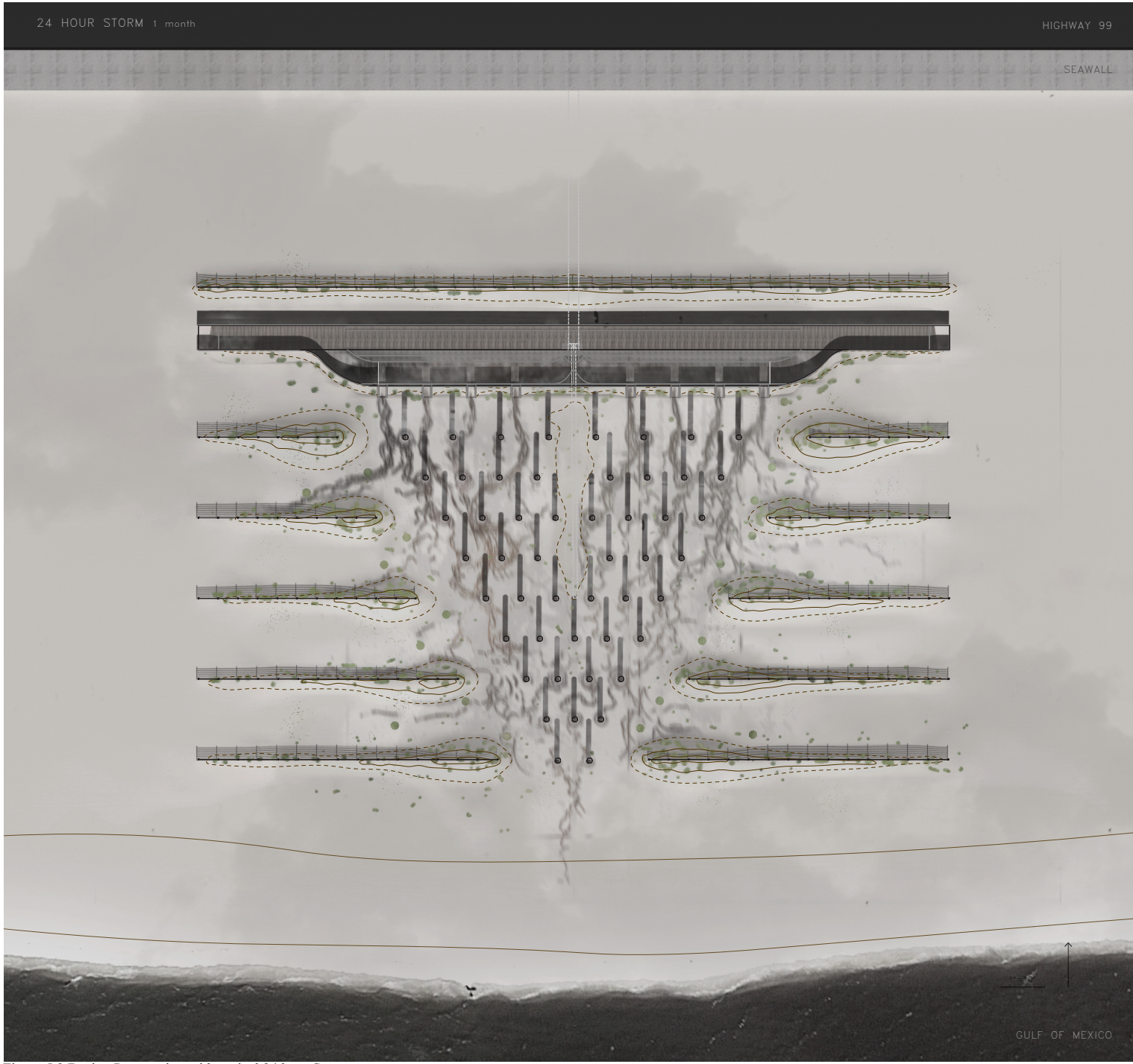


Figure 5.3 Design Progression with typical 24 hour Storm event

Figure 5.4 Design Progression and Storm Event Perspective

Instead of avoiding the beach during a storm, the beach becomes a destination. Storms are weathered, in order to sit on the boardwalk with an umbrella, and see the water rushing from the city into the beach. As each piece of debris is caught, people feel proud about protecting the beach, and may even volunteer to pick up some of the trash. Water roaring out the basin, carves out sand, giving plants and pilings a sense of agency, as if they're fighting the tides. Water is observed flowing around the pilings to the low points, and away from the dunes and high points. The system is understood intuitively, and people develop a sense of nature's resiliency and fragility at the same time.

The beach continues to be tilled and combed by tractors outside the beach outfall zone, ensuring a commercial white-sand experience. Inside the outfall zone, however, the beach is wild. Micro-topographies are fully developed, and the beach surface is rich with undulations and pockets. Dunes are mature and big, completely covered with thick, interweaving layers of grasses, shrubs, and coastal pine trees. The basin itself has disappeared into the dunes, and its discovery is a surprise.

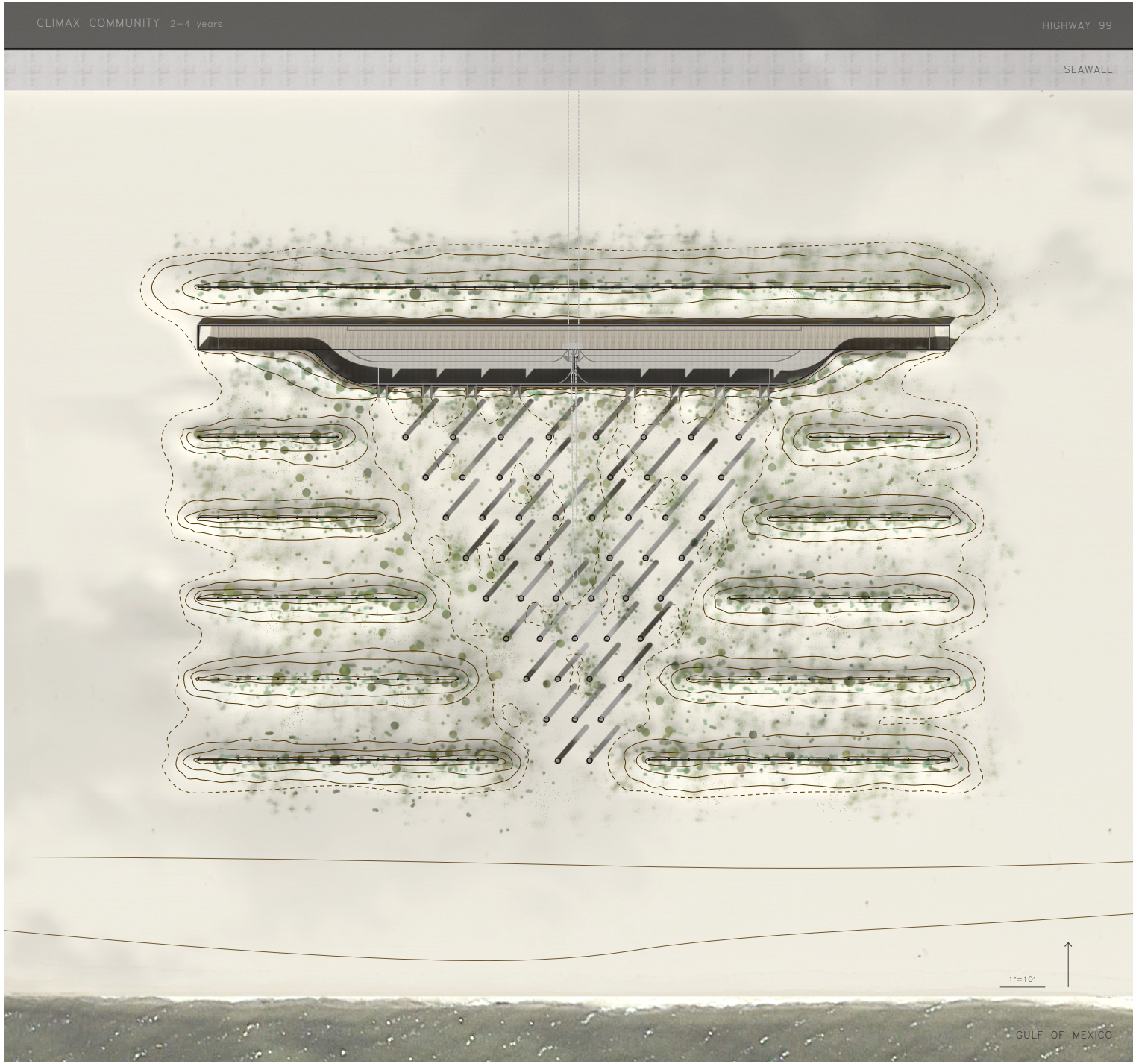


Figure 5.5 Climax Design

Figure 5.6 Climax Design Perspective

Transformative Materiality

6. Context and Development

Transformative Materiality is an original theory I developed during my thesis year, before beginning the final design project. It concerns materials, which may include rocks, plants, soils, water, wind, light, and other physical manifestations. And it concerns their transformation, which is the process by which a form is changed into a different form. It may be helpful to reiterate some definitions:

- Natural: that which exists and was not created by humans.
- Form: the singular or collective shape of an object or grouping of objects, respectively, in three dimensions.
- Material: the kind of matter that composes a form, and informs its distinguishable qualities, such as taste, touch, visible appearance, smell and sound creation.
- Process: a temporal event, in which a singular material and its associated form change at all, so that they are no longer exactly the same as they were, and can now be considered a different material and form.
- System: The combination of multiple processes to produce change in more than one material and form. Systems are predictable and repeatable, such that if the same set of processes occur to the same set of materials and forms, the resulting change will be the same.
- Visible: able to be directly observed with sight by a person over time.
- Phenomenon: 1. a fact, occurrence, or circumstance observed or observable. 2. an appearance or immediate object of awareness in experience.[vi]

As an example application of these definitions, imagine a cube. The cube has a three dimensional shape, which is its form. Its material can vary widely, and have profound implications on how the cube is able to be transformed. Take a knife to the cube. If it's made out of cheese, it will slice. If it's made out of steel, the knife might need to be re-sharpened. Materiality has total influence over what processes may change a form, and how that change occurs over time. A system is a combination of processes. Imagine a frozen cube of cheese that needs to be thawed before being sliced. Slicing cannot work without thawing, and so an interrelated system of processes is created to produce familiar, consistent outcomes.

In a landscape, the consequences of materiality are much more prevalent than how hard it is to slice a block of cheese. (Although, that can be very concerning in the moment.) Indeed, materiality in the landscape, and its propensity for change, shapes our very conception of nature itself. Imagine a stream, whose shores have been fortified with large rocks, called rip-rap. The shores will never change their shape, as the rocks may resist further soil carving action by the stream. Imagine the same stream without those rocks, after a huge storm. Whole sections of the banks might have failed, collapsing trees, and greatly expanding the width of the stream channel. No moral significance or preference should be given to either scenario – neither is right or wrong. Instead, significance should be given to the different ways in which materiality affects one's experience of nature – how each one allows for or deprives the phenomena of natural material interaction.

The philosophical problem with which Landscape Architects are confronted today, is not one of budgets or timelines. It is a more fundamental, popular conception that nature is supposed to be contained and perfect. It should look amazing on day one, immediately after the installation, and look exactly the same on day one-thousand. This is a picturesque sensibility, and its consequences are profound. Idealized nature requires heavy

and continual maintenance. It requires resources, sometimes beyond the capabilities of a local region. And it continues to reinforce the conception that nature is primarily aesthetic. It's always there, always looking great, always the same, year after year. Nature, through this lens, becomes a commodity for personal enrichment, a service to the public.

It is my contention that a popular view of nature needs to shift in order to meet the challenges ahead, such as global pollution, ecosystem destruction, and climate change. If people are allowed to see natural phenomena, if they can observe the processes by which nature evolves over time, they may learn through passive observation that nature is not an unchanging, aesthetic commodity, but is an ever-changing, complex and responsive system of interrelated, dynamic processes. They may learn that actions and changes to the environment by men have catalytic effects. And that nature requires an active stewardship in order to be grown and preserved. The design of nature in cities is responsible for popular conceptions about nature. I seek to design nature in ways that allows it to change itself over time, if landscape architects are going to inspire people and spur them into stewardship on an individual level. The challenges ahead require everyone to move forward as a culture and civilization, and they require this change among many.

Materiality is the chosen medium for the encouraging of dynamic landscape phenomena. A medium is a form of communicating ideas or thoughts. Other art forms appropriate this term commonly. For example, one's experience of seeing (or inhabiting) professional photography is understood as being provided through the medium of a photograph, hung on a wall, in a room. In the landscape, there is more than one medium. James Corner, a leading theoretician and landscape architect, offers three different media that are unique to landscape architecture: spatiality, temporality, and materiality. Each one is critical to understand. However, not all of them are equal in landscape experience. Spatiality and temporality are not able to be

experienced directly – they require materiality as a measure of their change, as experienced by humans (the target demographic for this paper). It becomes important to explain these distinctions further. The following are preliminary explorations, mini-essays, on each medium, to establish a common framework for discussion.

Spatiality

> Unlike paintings or novels, there is very little opportunity to wander or turn away from the experience of landscape. Spatially, it is all-enveloping and surrounds us, flooded with light and atmosphere. Irreducible, the landscape controls our experience extensively; it permeates our memories and consciousness, and enframes our daily lives.[vii]

Corner's depiction of spatiality is one of complete immersion. But it's not clear what one is immersed in. Corner continues, "Landscape [spatiality] is a highly situated network of associations and relationships." This reveals two aspects of space: (1) it has boundaries which are situated and defined, and (2) those boundaries are determined by the spatial relationships of things.

Martin Heidegger, a 20th century German philosopher, presents a similar understanding of spatiality in his essay, Building Dwelling Thinking:

> Analytic-algebraic relations… make room for the possibility of the construction of manifolds with an arbitrary number of dimensions. The space provided for in this mathematical manner may be called "space," the "one" space as such. But in this sense "the" space, "space," contains no spaces and no places. We never find in it any locations, that is, things of the kind of a bridge. As against that, however, in the spaces provided for by locations there is always space as interval… [There is] the possibility of measuring things and what they make room for, according to distances, spans, and directions, and of computing these magnitudes. [viii]

Thus, a space may be defined by the locations or things that bound it and bestow upon it a finite shape or manifold in three dimensions. To understand this concept better, one can model it with an empty table surface. When the surface is completely empty, there is only openness. This form of space is the "one" space, a theoretical anti-space in which there are no defined spaces. However, three small objects may now be placed onto the empty table surface. Those objects can represent trees, buildings or other things in the landscape; they become locations. The locations serve as finite boundaries, enclosing and defining a space between them, which can be measured. This set of constructed relationships of measurable distances is a defined space. (If your tables are as cluttered as mine, it might be fun to visualize all of the tiny spaces created between the clutter.)

George Dodds, professor and landscape architect, offers an interesting example of defined space in a traditional Chinese garden.[ix] These gardens are enclosed with walls that form their immediate boundary, and block out undesirable views of the landscape beyond. However, distant mountains are still high enough to see, and views of them are purposefully borrowed, or used to extend the space. The wall becomes a tool to modify defined space, essentially skipping over large amounts of land in order to create a more immediate relationship between two distant locations.

Merleau-Ponty, a 20th century French philosopher, adds to the complexity of this situation, in saying that space may not be limited to what is immediately in sight. He would also engage memory in spatial experience.

> I do not identify the detailed object which I now have with that over which my gaze ran a few minutes ago, by expressly comparing these details with a memory of my first general view. When, in a film, the camera is trained on an object and moves nearer to it to give a close-up view, we can remember that we are being shown the ash tray or an actor's hand, we do not actually identify it. This is because the screen has no

> horizons. In normal vision, on the other hand, I direct my gaze upon a sector of the landscape, which comes to life and is disclosed, while the other objects recede into periphery and become dormant, while, however, not ceasing to be there.[x]

Going back to the traditional Chinese Garden, one can imagine sneaking around the wall and viewing the landscape below, which was previously hidden. Upon returning to the Garden, inside the confines of the wall, the hidden landscape, even though unseen, remains a part of one's spatial definition, because they know it to be there from memory. Space, thus, is not confined to the present moment, but exists throughout time.

Temporality

> Meaning, as embodied in landscape, is also experienced temporally. There is a duration of experience, a serialistic and unfolding flow of befores and afters. Just as a landscape cannot spatially be reduced to a single point of view, it cannot be frozen as a single moment in time.[xi]

Corner's description of temporality involves the comparison of multiple moments, a before and after. Accordingly, one's ability to perceive and experience landscape temporality may rely on their ability to remember their previous experiences and compare them with current ones. This is very similar to spatial experience, and one's ability to imagine spaces of previous viewing. Temporal experience differs, however, in that it may occur within a single location or object. Merleau-Ponty explains further:

> I contemplate the house attentively… It is true that I see it from a certain point in my 'duration', but it is the same house that I saw yesterday when it was a day younger… It is true, moreover, that age and change affect it, but even if it collapsed tomorrow, it will remain forever true that it existed today… Each present permanently underpins a point of time which calls for recognition from all the others, so that the object is

seen at all times as it is seen from all directions.

Walter Benjamin, a 20th century German philosopher, phrases this more succinctly, "The experience of landscape takes time; it is an accumulation of everyday encounters."[xii] Landscape temporality may not be a set of individual, unrelated experiences. Rather, it is an additive, accumulative experience that grows more robust with each encounter.

Merleau-Ponty further explains that temporal experience may be relative: "Time is not a datum of consciousness but rather consciousness deploys or constitutes time. Time arises from my temporal relationship to things."[xiii] Instead of time being a universal constant, it is created uniquely through one's singular experience. This allows every person to have a different concept of time in the landscape, based on their experience. A very simple example is the number of times one visits a landscape; the more visits, the more change they will observe over time. If only one visit is ever made, there can be no accumulation of experience, and no developed concept of time in that place.

However, the strength of temporal experience is not always limited to the number of experiences one has in a landscape. If the landscape does not change, then the number of times it's visited becomes redundant. Indeed, many Landscape Architects strive to design landscapes that are timeless. This is most obvious in preserved landscapes, like those at Monticello and Mount Vernon, which may seem as though they are "unchanged" from when they were first constructed. These efforts regard landscape as an art, similar to painting or photography, in which a single moment is captured and preserved. Corner, again, helps to explain how landscape differs from other mediums:

> Landscape is a living biome that is subject to flux and change of natural processes operating over time… erosion, deposition, cold, heat, growth, decay, shifting, sinking, rising, blanketing, and burning.[xiv]

Corner lists different processes to describe the dynamic quality of landscape. Even with excellent maintenance and curation, landscapes are always changing, if only discretely, in how these processes affect their material form. The strength of one's temporal experience may then, in fact, rely on materiality, and the processes and interactions that are allowed to unfold in the landscape.

Materiality

> Matter is the raw brutish stuff from which things are made. It is what constitutes material properties, which are understood through the tactile, bodily perception of things. Materials radiate sensory stimuli, like aroma, humidity, dampness, intensities of light and dark, and heat and cold.[xv]

Corner describes how an object's materiality bestows on it the qualities that are experienced in that object. On a desk, for example, there might be a computer screen, a photograph, and a metal lamp shade. All three of these objects are similar in their ability to reflect light, and yet they are still recognized as different materials. This is because of their other significant qualities like texture, shape, hardness, thickness, etc, which produce a unique experience for each one.

Materiality in the landscape may include the rocks, and how they might shine or dampen light, have striations, or be smooth or jagged; soils may be dark or light, dry or wet, compacted or porous, smelly or odorless; water may be fast with waves and ripples, or slow and dark; plants can tower above or cling to the ground, and have any multitude of colors; wind can whip, causing leaves to make fill the air with rustling sounds, or it can rest in thickness; light may batter an open field all day, or be captured by trees and formed into smaller beams with intricate shadows in between.

To better understand material experience, it may help to

return to the three objects on a table, as discussed in the section on spatiality. Again, they may be thought about as trees or buildings. It can now be considered, however, that not all trees are the same. The specific kind of matter that composes a tree's woody tissue (roots, trunk, and branches) has slight differences between species and even between organisms of the same species. Thus, each individual tree's growing pattern and resulting form will be unique. Buildings also vary considerably. A steel and glass building might be very tall, blocking out the sky, but allowing people to see into it. A brick building might be shorter, leaving a more open skyline, but completely blocking views of its interior. Material qualities, thus, have direct effects on the form of landscape objects (or locations), which, in turn, may influence the spatiality defined between them. It is then possible to claim that spatiality is derived from the material realities of a place.

Returning to the table one more time, each metaphorical object, now imagined with specific materials, will have different durations. Trees do not all grow at the same rate, lose their leaves at the same time, or live for the same amount of time. Imagine the difference in experienced time, if one goes to the same park for their entire life, either seeing the growth and death of three trees, or being outlived by just one! Additionally, certain building materials, like glass, may collect dirt quickly and noticeably, or break easily. Others, like bricks, are slower to show discoloring and are capable of enduring many hundreds of years. Noticing the clarity of a glass panel on a daily basis is a more active experiencing of temporality than the gradual noticing of dirt accumulating on a brick façade. Landscape temporality, as the experience of registering and remembering change, thus, may be directly influenced by materiality.

7. Theory

I have come to believe that materiality is the interface through which the experiences of spatiality and temporality are realized. If that is true, then the way in which materiality is deployed, controlled, or allowed to change is significant for all aspects of landscape experience. Materiality may be considered the primary medium or factor in all landscape experience. Allowing materials to change over time, thus, also changes one's perceptions about space and time around them. All of landscape experience is amplified and more perceptible, external phenomena are heightened as well as one's internal awareness of those phenomena.

Returning to the designed thesis project, recall the material forms. All images were of sand, and yet all of them were dramatically different from each other. The same material, having different forms. In fact, all materials have within them the capacity to change and take on different forms – they have varying propensities for change. Water, for example, is virtually unrestricted in its application as a material in the landscape. Its speed can vary from a jet to completely stagnant; it may tolerate any amount of sunlight or shade, given that its volume is great enough; and it may flow over and through soil mixtures of any acidity. Beyond withstanding a limitless range of site conditions, however, water is also versatile in its form. Fountains, pools, waterfalls, ice skating rinks; such landscape features are only a few potential forms that water may take in built designs. Designers may also exercise control over larger, more natural water bodies, such as rivers, lakes, bays, and even the coastal ocean. And for all forms of water, there exist ways to alter its properties, such as color, reflectivity, speed, temperature, acoustics, and dissolved chemical composition.

With so many possibilities for material application, and so many experiential consequences of material design, the application and design of materiality in a site is paramount.

Louis Kahn, a 20th century architect, shared what has become and remains perhaps the most well-known material philosophy in the architectural disciplines, the idea of material integrity. He says in five words, "A brick is a brick."[xvi] A brick is not glass; it is not steel. To design with a brick is to know its unique qualities. Kahn continues by writing a fable, in which he speaks to a brick. He asks, "Brick, what do you want to be?" The brick responds, "I like an arch [because an arch is the way that bricks work together to span an opening]." It's material qualities, like shape, structural strength, jointing techniques, and more, have translated into behavior. Now, the brick knows what it is made out of, and also how it should best be applied to suit its particular character. And the architect merely listens to the material. He serves the materials, instead of bending them to his will. Try to make a straight spanned opening? Don't force the brick. Instead, wood or steel will work much better. A material's integrity must be honored in its design application.

Kahn's approach is a helpful starting point, in order to recognize an inherent logic in material design. In a landscape, would it make sense to place a boulder in a tree? It's an interesting hypothetical but, ultimately, it would hurt the boulder and tree, and confuse viewers of the combination. Thus, a material integrity may inform initial material application and placement. However, the longevity of materials to remain in a single stagnant form needs to evolve, particularly within landscape architectural design. A new longevity is needed, which is one of cultural and environmental vitality, it is a psychological longevity of connection between humans and nature. In order to do this, it becomes pertinent to reveal nature and its materials – rocks, soil, water, wind, light, plants – in a diversity of forms afforded by local landscape processes. Nature may be experienced, not as rigid and durable, but as dynamic and constantly changing with its context.

The resulting philosophy is a Transformative Materiality. One form of materiality may not be preferred over another.

Instead, the range of all of a materials forms are to be engaged, as much as possible within a single site, as afforded by the existing natural processes that may act upon that material to change it over time. In the thesis design, one form of sand is not given preference. Wind, water, plants, insects, birds, and intertidal ecologies, are all activated in order to freely change the sand as much as possible. Walking through the site is walking through a mosaic of colors, textures, highs, lows, entropy, calm, etc. In doing so, it becomes possible to link each material form with the process that created it, and develop a holistic understanding of the natural operations within that system. Nature is dynamic and ever-changing, and its effects can be seen anew every single day.

Within the larger framework of process-based operations of cleaning stormwater, the design tries to not be prescriptive of material forms. Dune fences are erected, but do not inform exactly how the dunes will develop over time. Their shape, texture, and recruited plant communities, all establish dynamically and uniquely. Pilings are driven, but do not create determined pathways for water. They offer water a greater opportunity to drive out sand, and find its way to the ocean, should the two meet. Water is free to meander and wander wherever it wants, within the piling field, or even outside of the outfall zone. If that were to happen, one could determine why. Was there a dune that failed? Were the plants on that dune not well established? The system contains within it an ability to read nature, and determine why and how materials interact to produce their forms. In engaging natural, material processes over time, the design also engages people, allowing them to witness change around them and constantly learn more about the environment.

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