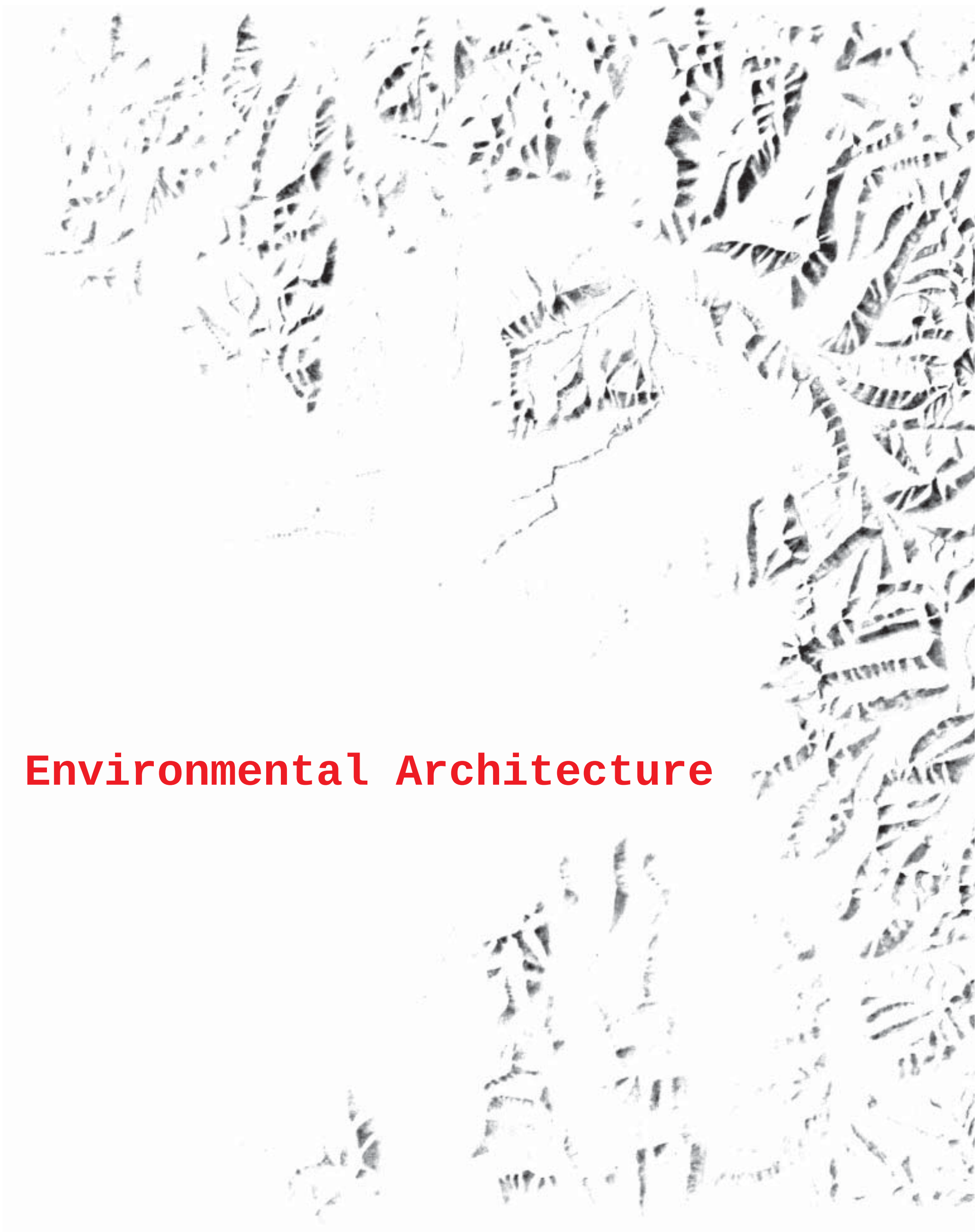

Environmental Architecture

ENVIRONMENTAL ARCHITECTURE

by

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A thesis submitted in partial fulfillment
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APPROVAL

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Charles Evan Franklin

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ABSTRACT

An unbalanced relationship currently exists between man and nature. However, humans are beginning to realize if this uneven relationship continues, it will mean the ultimate demise our world as we know it. This investigation seeks to produce architecture which is in balance with nature. To do this the architecture must act as a living system in diverse ecological environments. If architecture can organize as a living system it will no longer exist as an object on the landscape, rather the architecture will be experienced as an interrelated process essential to the functioning whole. When natural living processes and cultural and social processes combine, a truly environmental architecture may arise.

To explore the idea of environmental architecture, a project is proposed as testing grounds. The Midway Thermal Laboratory and Interpretive Center is this project. The site is the Midway Geyser Basin of Yellowstone National Park, WY. The results have produced architecture which is both interactive and responsive to its unique local environment. The architecture provides not only a functional lab space, but also allows the user to experience dynamic space in a dynamic environment.

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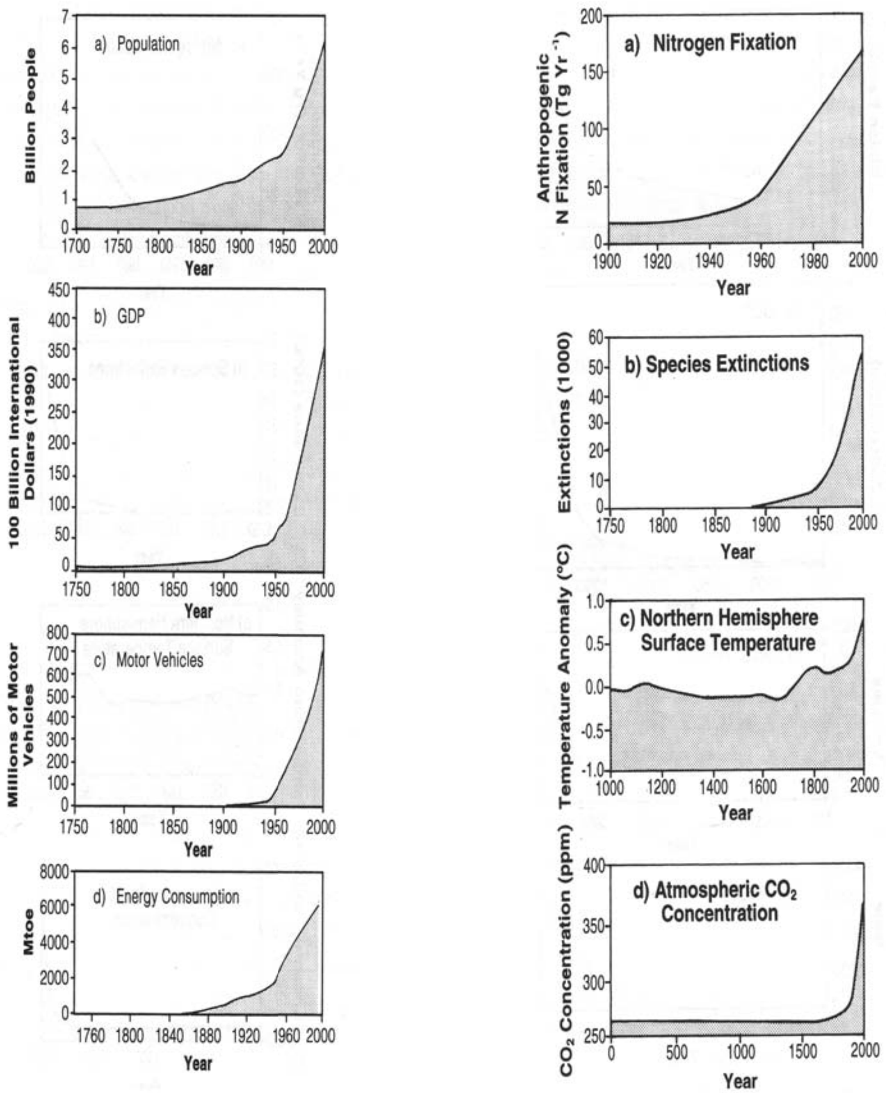
Chapter 1

Of Nature

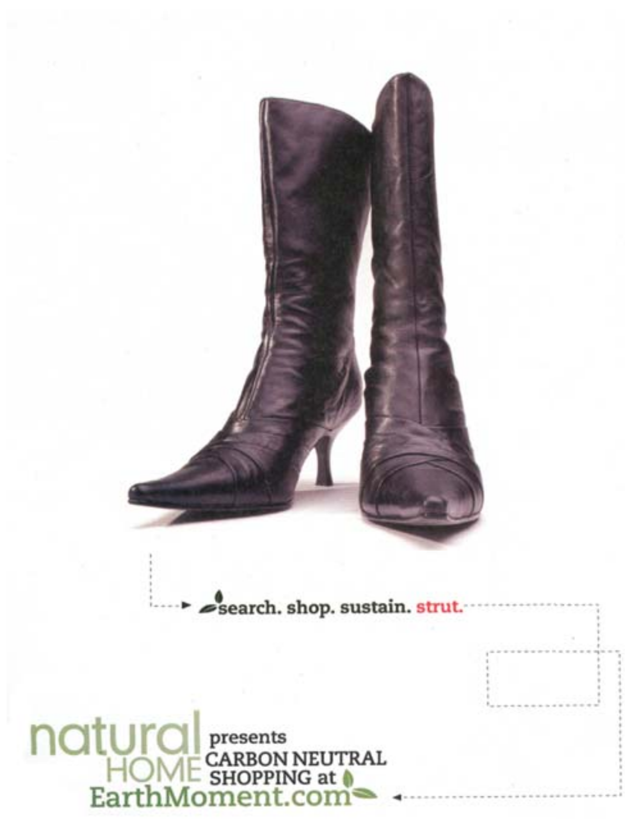
The earth is currently operating in a no-analogue state. In terms of key environmental parameters, the earth system has recently moved well outside the range of natural variability exhibited over at least the last half million years. The nature of changes now occurring simultaneously in the earth system, their magnitudes and rates of change are unprecedented. (Steffen, et. al. 17)



Graphical depiction of our human-nature relationship. Figures on the left show human impacts, and figures on the right show eco-responses.

What are we to do?

How can architecture make a difference?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Modern American culture is beginning to become aware of the unbalanced relationship which exists between man and nature. The term “green” or “eco-friendly” has infiltrated society, and has almost become ubiquitous. There are green buildings, eco-cleaning products, green carpets, green light bulbs, eco-cars, etc… the list is endless. I began this investigation wondering what it truly means to be “green”. I soon came to realize the question is not how can we be “green”, or how we can minimize our impact on the natural world. Rather, the question is how can we make a more radical shift and come to live as a contributing member within the natural environment and not just as a pilferer of natural resources.

Nature has been comodified. The proliferation of consumer goods since the industrial revolution has produced a human-nature relationship which is unbalanced. The well-being of the earth has been ignored while man has continually exploited the earth's resources to satisfy our insatiable appetite for the newest products, or a contemporary life-style. Recently a shift has begun to take place in which man is seeking to restore a balanced relationship with the natural world. But, balance requires give and take. Therefore, to conceptualize this balanced relationship we must see our world as a system of interrelated components which are constantly striving to maintain stability. The *web dictionary of cybernetics and systems* defines system as, "a set or arrangement of entities so related or connected so as to form a unity or organic whole." This definition allows us to see the earth system as a unity. Humans are a component of this whole and therefore our creations also belong within this

Architecture reflecting the image of nature, but can we do more?

whole. Now we can ask: what role does architecture play in helping to restore balance within the earth system?

In architecture and many other fields the term “sustainability” has come into fashion as a way to minimize our impact upon the natural world. But is “sustainability” enough? Is it possible to produce architecture, or a way of thinking, which will allow our creations to exist as an active partner within an active system?

There is no doubt our social and environmental systems are experiencing rapid change. The climate is changing at an alarming rate. The way we communicate is changing and speeding up through the advent and proliferation of digital technologies such as computers and the internet. Architecture must change as well in order to effectively communicate and form systemic relationships with people and with the environment in which it exists.

Chapter 2

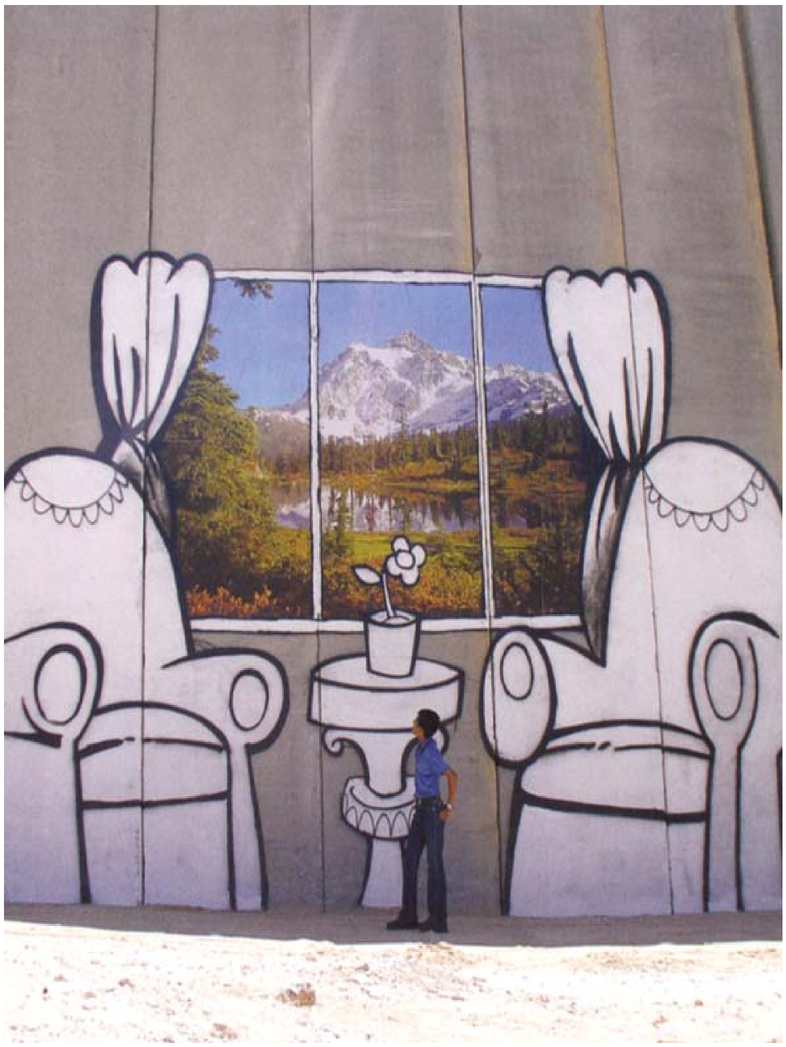
Relationships

> “The taste of the apple…lies in the contact of the fruit with the palate, not in the fruit itself: in a similar way: poetry lies in the meeting of the poem and reader, not in the lines of symbols printed on the pages of a book. What is essential is the aesthetic act, the thrill, the almost physical emotion that comes with each reading.” -Jorge Luis Borges

Ours is a world of relationships, or communication systems, that are constantly interacting with each other. Borges states that it is not the apple that contains the taste of itself, nor the palate that contains the taste of the apple, but the interaction, communication, or relationship between the two which results in the ultimate taste of apple. In the apple, as well as the palate, lies the potential for taste which may or may not be realized. The taste of the apple is only revealed when a series of actions take place, inevitably leading to an interaction between the apple and the palate. Taste may therefore be described as the communication between two systems, the apple system and the palate system.

Borges has shown us taste lies within the relationship or interaction between the apple and the palate. But, this is not the end of the story. Speaking of poetry, Borges states, “What is essential is the aesthetic act, the thrill, the almost physical emotion that comes with each reading.” Poetry has the ability to be reborn with each reading. Architecture, as an aesthetic act, may also be able to be reborn with each experience of it. In this short passage Borges has laid the foundation for relational architecture which, much like taste, exists between nature(the apple)and man(the palate), and like poetry is capable of regeneration.

Borges analogy represents a process, or a sequence of events. Valentin Turchin, a cybernetic



philosopher and computer scientist, has defined process as “an action which we see as a sequence of constituting sub-actions. The states of the world resulting from sub-actions are referred to as stages of the process. Thus we see a process as a sequence of its stages.”(1991) Process becomes known when a sequence of stages is evident. Many events in our lives can be seen as a process. For example, learning to ride a bicycle starts with a tricycle or a big-wheel, and progresses through training wheels, and finally to the two wheel bicycle. Like learning to ride a bike, most of our learning is process based. For instance, we likely would be lost in calculus if we had never learned algebra. Our world is full of natural and cultural processes which are reflected in things such as growth and learning.

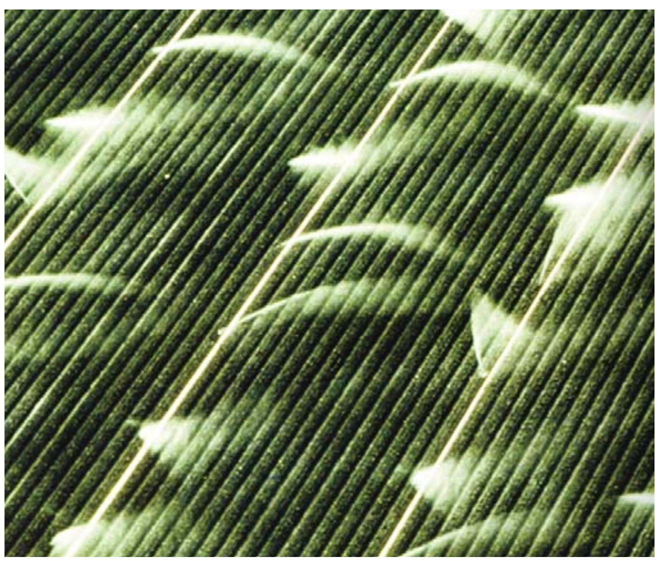
Batel Dinur, in *Interweaving Architecture and*

Ecology, has argued, “A truly environmental architecture will begin to happen only when architecture will emerge as a result of integration between natural living processes and cultural and social processes.”(Dinur, 2) Therefore, to find a relational architecture between man and nature, we must focus on processes.

Much of recent architecture has become image based. Salingaros, a mathematician and architectural theorist has stated,

> “It turns out that there is a basic confusion in contemporary architectural discourse between processes, and final appearances. Scientists study how complex forms arise from processes that are guided by fractal growth, emergence, adaptation, and self-organization. All of these act for a reason. Jencks and the deconstructivist architects, on the other hand, see only the end result of such processes and impose those images onto buildings.”(Stalingaros, 2004: 45)

To continue to design architecture as an image of a process is not enough. This way of thinking will result in a continuation of man’s unbalanced relationship with nature. An environmental architecture must do more with available resources. This means taking advantage of cultural processes by employing new materials and digital technologies in architecture. It also means designing architecture not as an image of a process, but as a process in which a sequence of stages becomes evident. In order to gain some understanding of how this is possible, my investigation will continue as we look first into “natural living processes” and secondly “cultural and social processes”.

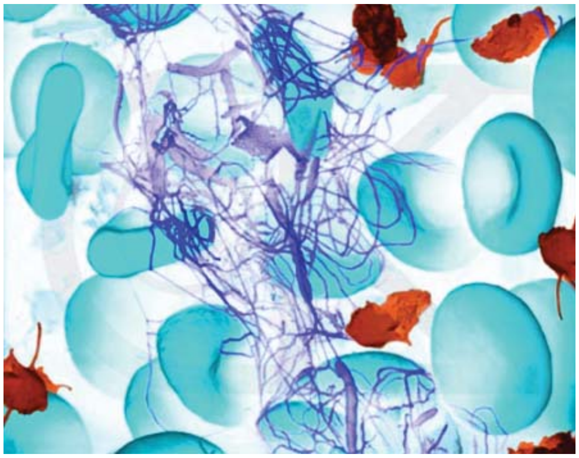


Chapter 3

Ecology

Ecology is the study of “the relations between living organisms and their environment.” (Neufeldt, 189) In other words, ecology investigates “natural living processes” or the composition of living systems. Living systems emerge from relationships between individuals in which the whole presents itself as something different than its parts. An example of this can be seen in human biology. People are made up of millions of individual cells. Groups of cells come together to form tissues, and tissues form organs. Organs in turn assemble to form a person. In each one of these levels of organization we can see that the whole is always something different and more complex than the sum of its parts.

Architecture acts in a similar way to living systems. In architecture; individual building components such as studs, drywall, and fasteners, come together to form assemblies such as a wall,



roof, or floor. These assemblies, which exist on differing scales if thoughtfully assembled, create architecture. Therefore, we may consider architecture as a system consisting of various sub-systems and components, which may be organized according to the same principles of a living system.

Central to understanding living systems is the concept of organization. Living systems organize in order to achieve goals; the ultimate goal being survival. Dinur has shown three principles of ecology: fluctuations, stratification, and interdependence allow us to understand the organization of living systems, and thus the processes which keep them living. This knowledge can then be applied to suggest possibilities for the design of architecture.

Part 1: Fluctuation and Autopoiesis

Fluctuations are changes in the system. Fluctuations can be internal to the system or external to the system. An external fluctuation, such as a rise atmospheric temperature, may cause an internal fluctuation such as sweating to regulate the internal temperature of the body. Internal fluctuations are responses to external fluctuations of the environment commonly called disturbances to the system. Living systems are constantly striving to be in a state of equilibrium; as a result, they must continually fluctuate in response to environmental disturbances. Internal fluctuations in the living system allow the system to maintain internal equanimity or organization.

It is essential for the living system to be able to self-organize. This ability is called autopoiesis or,

> The process by which a system recursively produces its own network of physical components, thus continuously regenerating its essential organization in the face of wear and tear…the autopoietic system is open to the exchange of matter and energy with its environment, but it is autonomously responsible for the way these resources are organized. (Heylighen, 2001: 11)

The consequences of autopoietic organization have been stated by Humberto Maturana and Francisco Varela in their book, *Autopoiesis: The Organization of the Living*. The following three points suggest a correlation between autopoietic organization and the organization of architecture.

One, “Autopoietic machines (living systems) are autonomous; that is, they subordinate all changes to the maintenance of their own organization, independently of how profoundly they may otherwise be transformed in the process.”(H. Maturana & F. Varela, 80) Point one suggests an architecture which is centered around the internal organization of its functional components regardless of the “external appearances” this organization may manifest. Autonomy is attained through mechanisms which allow the architecture to intelligently fluctuate based on external disturbances.

Two, “Autopoietic machines have individuality; that is, by keeping their organization as an invariant through its continuous production they actively maintain an identity which is independent of their interactions with an observer.”(ibib ,80) Point two allows us to conceive of architecture which, after its initial construction, is not dependent upon human intervention to maintain its essential organization. This can be realized today through new technologies in the computer/software realm and the material sciences which allow intelligent architecture. Individuality is attained through environmentally specific fluctuations in the system.

Three, “Autopoietic machines are unities because, and only because, of their specific autopoietic organization: their operations specify their own boundaries in the processes of self-production.” (ibid, 81) Architecture must be seen as a unity of components which is goal driven. Point three establishes the idea that we may know the disturbance triggering fluctuation in a living system, but we cannot always predict what the outcome will be. Autopoietic architecture then can only be seen as an evolving process, and not as an image or static object.

Part 2: Adaptation, Stratification, and Downward Causation

The autopoietic system is able to self-organize in order to maintain homeostasis. But, a living system is always effected by and involved in changing environmental conditions. Therefore, the system must adapt. “for a complex system, to endure is not enough; it must adapt itself to modification of the environment and it must evolve. Otherwise outside forces will soon disorganize and destroy it.” (Rosney, 1997; 2)

Living systems are constantly in a state of fluctuation as they react to their surrounding environment. As the environment changes a living system must learn from internal and external fluctuations and adapt accordingly. Continual adaptation to changing external and internal conditions allows a living system to survive. Hierarchical organization allows a system to exhibit a larger range of flux thereby increasing the chances of survival. Hierarchical organization leads us to Dinur's second principle of ecological organization, stratification.

Stratification in geology occurs when rock or sediments form layers. Living systems also form layers, or strata, in order to maintain organization. The strata of living systems organize in a hierarchical manner. The smaller components organize together to form the next higher level of organization, which in turn organizes to form the next higher level, and the next.

> So, the system self-organizes itself in a structure of stratified order – multiple levels, so that each level can have its own organization. It is important to distinguish that the stratified order is necessary for the organization of complexity. Since the various systems levels posses differing complexities, the stratified order makes it possible to use different descriptions for each level. (Dinur 5)

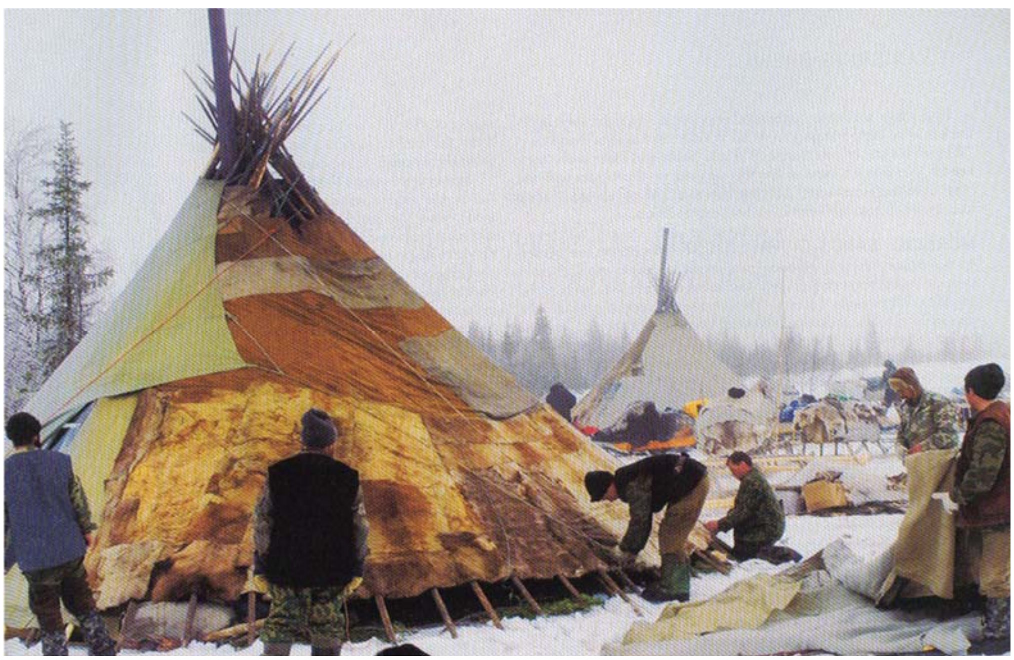
For example, the human body stratifies into cells, tissue, organs, etc. in order to effectively operate. The stratification of living systems also

allows fluctuation and communication to take place on various levels within the system. Therefore the system is able to make changes of differing scale in order to maintain organization. Stratification then increases the chance of survival for a living system by providing multiple communicating levels on which to make changes.

Central to the principle of stratification among living systems is downward causation. Downward causation explains how control is handled in a living system. Properties which occur due to the interaction between components in a system are called emergent properties. Downward causation occurs when higher level emergent properties constrain lower level components. “This influence of the higher levels on the lower levels helps to maintain the order within the systems as a whole and to make sure that the system will achieve its goal of self-maintenance and evolution.”(Dinur 5,6) Stratification allows us to see living systems organized hierarchically. Lower level components interact with lower level components. For example, cells interact with cells. This organization forms a level, or strata, in the system in which the whole must be greater than the sum of its parts, i.e. tissues. Tissues exert control over the cells to serve their needs, and this is downward causation, or the constraining of lower level components by higher level systems.

In architecture, downward causation may be utilized for forming hierarchical organization within the components, sub-systems, and systems within architecture. This is not a new realization within the field. In the construction of architecture it is common for certain systems to exert control over lower level systems. For example, most buildings start with a structural system and all other systems (enclosure, finishes, HVAC, pluming, etc.) are constrained by it, or have to “fit” with it. What architecture can learn from downward causation, in terms of living systems, is that the importance of components can fluctuate based on environmental conditions. This means, for example, that at times enclosure may be essential to the organization of space, and at other times enclosure may not be needed. What is important is for the building to be able to recognize the conditions when certain functions are important and respond accordingly.

Downward causation in architecture allows for large scheme functions to be handled by multiple sub-systems and components, thereby increasing the overall flexibility of the system.



Nomadic shelters demonstrate the power of flexible systems.

Part 3: Interdependence: Communication through Feedback

The third principle in understanding how living systems are organized is interdependence.

> When components are joined together to form a complex system, properties emerge that cannot be explained except by reference to the functioning whole. Actually the connectivity drives the system: in order to create the whole, the connections grow and proliferate, using the components as anchoring nodes for a coherent network. (Salingaros,2004: 48)

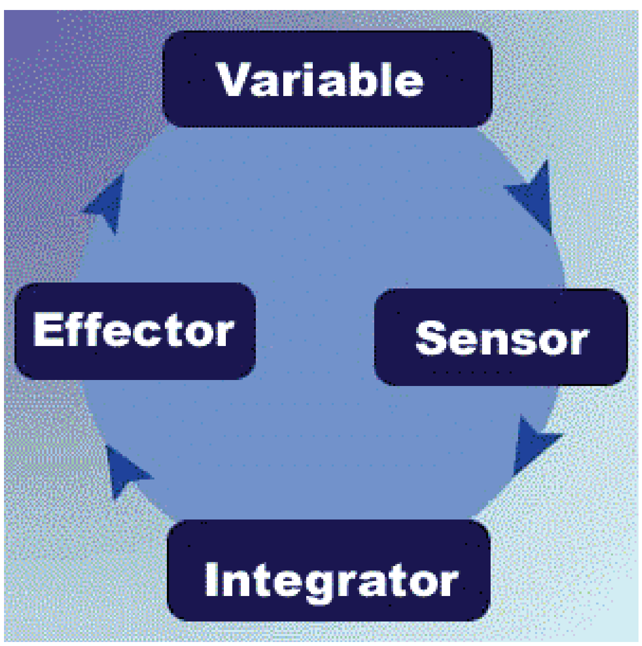
Salingaros reminds us of the importance of the connections between individuals in a system. It is these connections which maintain and allow the system to evolve. These connections also make the system interdependent. Interdependent systems must communicate. So, we may ask, what mechanism allows communication to take place between components in a living system?

Communication within the living system occurs through feedback cycles. Materials, energy and information flow through non-linear pathways connecting the components and levels. Change in one component effects changes in the other components. These effects are then fed back to the original component as reflected through the overall changes to the system. Feedback loops can be positive or negative. Heylighen explains,

> Feedback is said to be positive if the recurrent influence reinforces or amplifies the initial change. In other words, if a change takes place in a particular direction, the reaction being fed back takes place in that same direction. Feedback is negative if the reaction is opposite to the initial action, that is, if change is suppressed or counteracted, rather than reinforced. Negative feedback stabilizes the system, by bringing deviations back to their original state. Positive feedback, on the other hand, makes deviations grow in a runaway, explosive manner. It leads to accelerated development, resulting in a radically different configuration. (Heylighen, 1997:10 from Dinur:7)

Both positive and negative feedback allow a system to communicate effectively with itself. When a change in the systems environment occurs, the system must respond. Feedback loops allow the system to make changes and then learn from those changes. Therefore, communication between the components of a system is essential if the living system is to achieve its ultimate goal of survival.

Graphical depiction of a feedback loop



Interdependence, and subsequently feedback loops, are an essential part of an environmental architecture. Feedback allows architecture to actively communicate with its relational environment. Through sensory technology systems, architecture can, and must enter in to the feedback cycles of its surroundings. This means, not only should architecture respond to external environmental conditions and learn from them, but it should also be an active member of the overall system. Architecture ought to contribute to the survival of the system as a whole. We will call this overall system an ecosystem, and architecture's goal should be to positively affect the ecosystem in which it resides. Communication between the ecosystem and architecture becomes critical and feedback loops allow effective communication to take place between the two systems.

Part 4: Living Systems and Architecture

Living systems may influence the way we design architecture in multiple ways. First, it is essential to overcome the tendency to objectify architecture. Living systems are processes. We cannot continue to simply represent the processes in architecture. Antithetically, the architecture itself must be experienced as a process. How can this happen? Architecture should respond to the environment in such a way as to become a functioning component within the larger system. Through the mechanisms of autopoiesis, downward causation, and feedback loops, architecture may begin to organize in the same way living systems organize. If architecture is able to organize as a living system it will no longer be an object on the landscape, but an integral component of the landscape, which demonstrates the same ecological processes as a living system.

Furthermore, we must recognize architecture as part of an interconnected system. This means that architecture must constantly be adapting to environmental conditions, and also to interaction with the users of the architecture. Gregory Bateson has said, “Man is only a part of larger systems, and the part can never control the whole.” (Bateson 1972) Architecture must also be seen as a part of an interconnected whole. Through the study of living system organization we have come to see how architecture can embody natural living processes, and become a functioning component in its environment.

Chapter 4

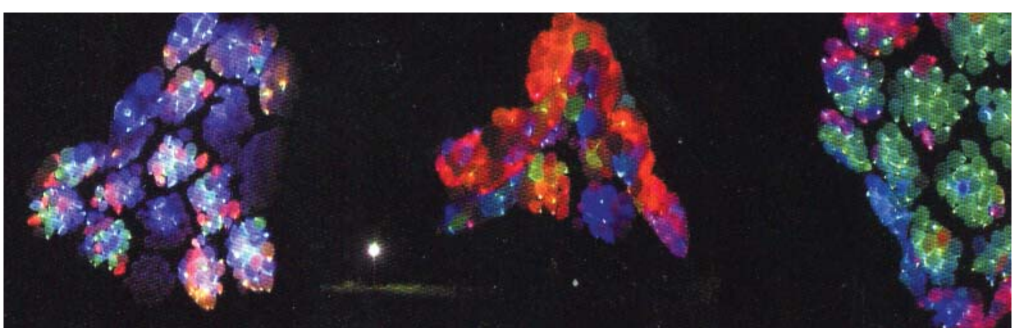
Art and Architecture: The Cultural Component

Cultural and social processes are the second ingredient to “environmental architecture”, and now we will turn our investigation to this component of the whole.

> The domain of architecture has been transformed by developments in interaction research, wearable computing, mobile connectivity, people-centered design, contextual awareness, RFID systems and ubiquitous computing. These technologies alter our understanding of space and change the way we relate to each other. We no longer think of architecture as static and immutable; instead we see it as dynamic, responsive, and conversant. -Usman Haque

Usman Haque of Haque Design and Research speaks of a transformation of architecture largely driven by technologies which allows architecture to become interactive and responsive to its ecological and cultural environments. We have already investigated ecological organization and seen how architecture may begin to act as a living system. In this section, we will be looking at cultural and social processes as reflected through art and architecture. We will examine several case studies to exemplify art and architecture as cultural and social processes which reflect the fundamental characteristics of living systems. These case studies consist of: two “low-tech” projects which employ only stones and feet to illustrate unity within a system, a “middle-ground” project which introduces the architectural element of verticality into a horizontal landscape, and two “high-tech” projects which embrace sensory technology and computer systems to create interactive and reflexive architectural environments.

Sky Ear by Usman Haque



Part 1: Environmental Art

Art is not the components from which it is made, rather it exists as a stage in the process from whence it came.

The first example of “low-tech” art exemplifies process through interaction with the environment. Richard Long’s “A Line Made by Walking” appears as a simple line in the grass; however, the piece reveals communication between Long and his environment: that particular section of turf on that particular day. The piece becomes all about the interaction between the artist and his environment, where the grass, which most of us take for granted, is transformed into a work of subtle clarity. Through the repetition of walking a line, Long has entered into communication or a relationship with the landscape. Long’s presence in the environment is communicated by repeatedly flattening the grass as he walks. The environment responds by providing positive feedback; encouraging Long to continue to walk on the same

A Line Made by Walking   Richard Long

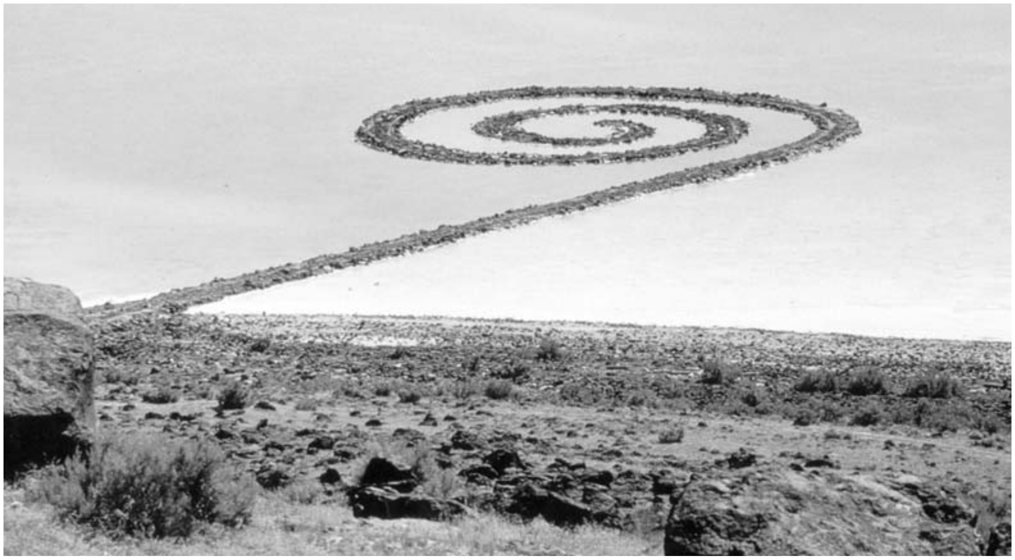
straight line. The piece of art would not exist if their systems (Long and the landscape) had not interacted on a physical and subliminal level. Long and the grass existed as separate entities until they came together much like Borges apple and palate. This artwork illustrates an interaction between two systems which produced an aesthetic act, not as a line in the grass, but as a process of communication between Long and the environment.

In 1970 Robert Smithson produced *Spiral Jetty* out of 1500 linear feet of black basalt and limestone rocks. *Spiral Jetty* is a piece in which the landscape communicated with Smithson.

> About one mile north of the oil seeps I selected my site. Irregular beds of limestone dip gently eastward, massive deposits of black basalt are broken over the peninsula, giving the region a shattered appearance. It is one of the few places on the lake where the water comes right up to the mainland. Under shallow pinkish water is a network of mud cracks supporting the jig-saw puzzle that composes

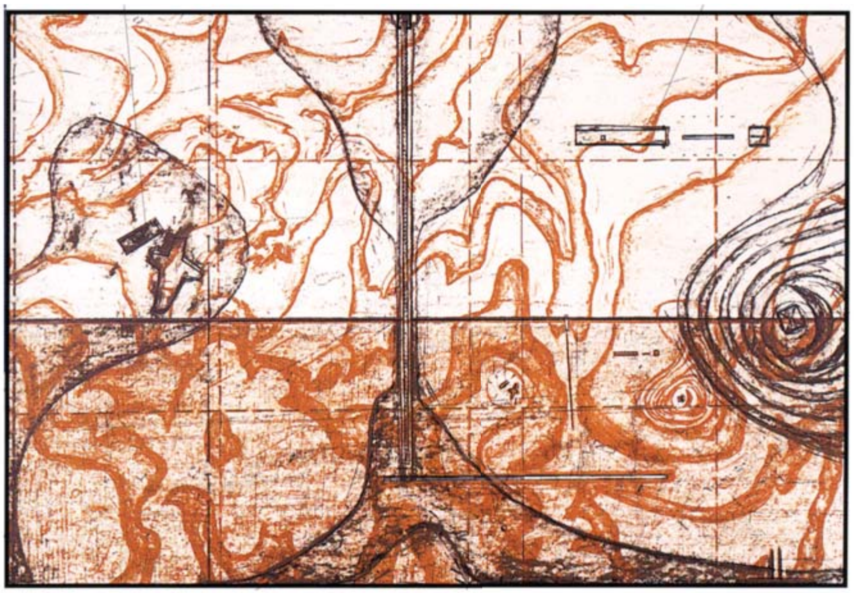
the salt flats. As I looked at the site, it reverberated out to the horizons only to suggest an immobile cyclone while flickering light made the entire landscape appear to quake. A dormant earthquake spread into the fluttering stillness, into a spinning sensation without movement. This site was a rotary that enclosed itself in an immense roundness. From that gyrating space emerged the possibility of the *Spiral Jetty*. - Robert Smithson (Beardsley 22)

Robert Smithson’s Spiral Jetty



How does the *Spiral Jetty* resemble a living system? Is it more than just a pile of rocks? The most important part of this piece, and how it may begin to influence an environmental architecture, is reflected in the interaction between Smithson and the site. Smithson describes a process of observation in which two systems collide resulting in an aesthetic act, or the *Spiral Jetty*. It is important to note that his observation is not objective, but rather subjective. Through this process of subjective observation, Smithson and the *Spiral Jetty* enter the feedback loop of the environment, and his work becomes an active part of the landscape. In the *Jetty*, the rise and fall of the Great Salt Lake is recorded by the residual salt crystals embedded on the rock. The *Spiral Jetty* is a work in which a dialog can begin take place between the visitor and the surrounding environment; each learning from one another. The *Spiral Jetty* generates awareness of communication and the relationship between man and his environment. This is where the power of the piece lies, and why it is important for our discussion of cultural and natural process.

In the middle of the Texas prairie, Mark and Peter Anderson, and Cameron Schoepp, have created *The Prairie Ladder* project. This project seeks to explore the notion of horizon, a prevalent element in the Texas landscape. However, the project does more than just focus your attention on this horizontal middle ground. The creators of the project are interested in the relationship which exists between people and the landscape, or cultural and social processes and environmental processes. People inhabit this middle ground between earth and sky; therefore, it is the crossroads of culture and nature.



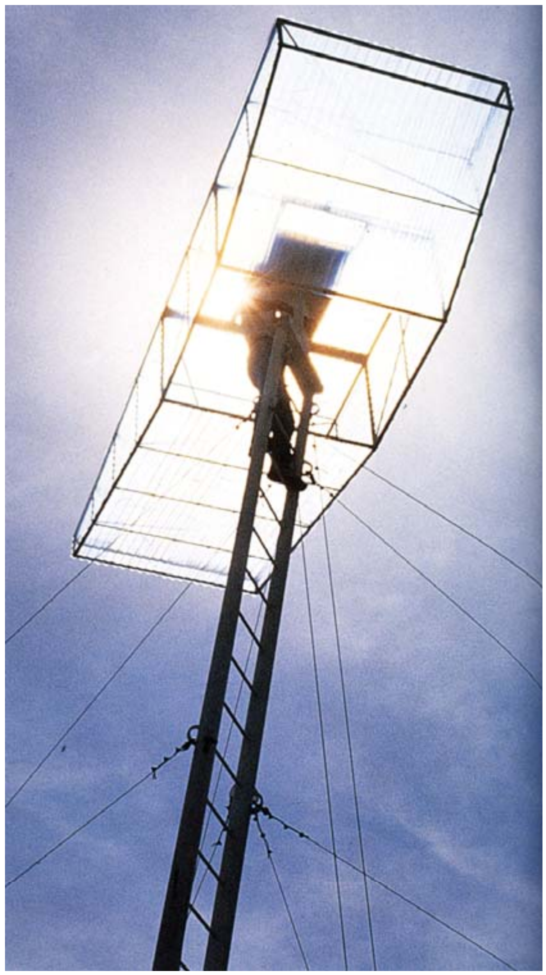
Prairie Ladder project site plan at two different scales

We became intensely interested in this fundamentally American landscape in which human beings have no particular place, where physical and conceptual space can only be understood as a line between the sky, which is no home for human beings, and the belowground, which is no home for human beings. The selection of the ladder as an element common to each of the works introduces a vertical axis, marking a departure from the natural horizontal axis of the prairie. The ladder also provides a human scale and proclaims human defiance of the horizontal limitations of the earth. This real or implied activity of vertical

> movement on the prairie, whether up into the sky or down into the earth, it the defining characteristic of place making – of human settlement or intervention in the existing primal environment. (Anderson and Anderson, 21)

Earth Plane/Sky Barge emerges from this discourse with the natural environment. It is an important part of *The Prairie Ladder* project because like a living system, it is in a constant state of flux as it reacts to a changing environment: the shifting winds. The project also allows the visitor to interact with it, or become part of the system.

> The transparent Sky Barge points into the wind and provides for the climber an oculus focused on the horizon from whence the winds of memory and aspiration blow. Earth Plane cuts open the freshness of the earth and places the inhabitant at eyelevel with the ground plane. Buried, the viewer is one with the horizon. These vehicles of imagined flight are arrested by the empathetic ladder, which interrupts their flowing motion across the placeless prairie. (Anderson and Anderson, 22)



Sky Barge

Part 2: Interactive and Reflexive Answers

The *Earth Plane/Sky Barge* project considers a key component to environmental architecture, the notion of interactivity. We have seen that successful living systems are constantly involved in communication networks or feedback loops. Interactive space allows people to enter these feedback loops, ultimately influencing their experience. In the 1960's Cedric Price asked, "What if a building or space could be constantly generated and regenerated?" At the time this must have seemed like a fairly radical proposition. Today however, technology has progressed to a point where this idea is attainable. Through sensory technology, mobile communications, RFID systems, and advances in computers and software, we can now design architecture as an active process. Interactive architecture allows this thought to manifest through the ability to fluctuate and adapt to its cultural environment.

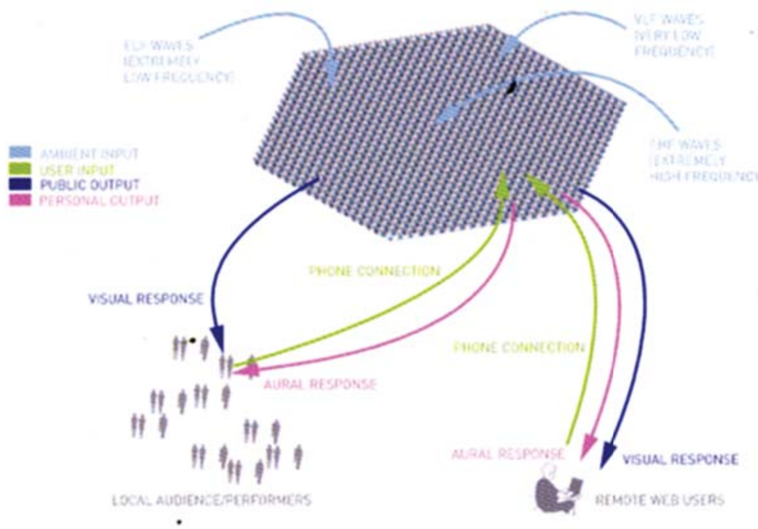
Antonino Saggio, in his article *Interactivity at the Center of Avant-Garde Architectural Research*, states

> Interactivity places at its center the subject (variability, reconfigurability, personalization) instead of the absolute nature of the object (serialization, standardization, duplication). Interactivity incorporates the fundamental feature of computer systems, namely the possibility of creating interconnected, changeable models of information that can be constantly reconfigured. And finally, interactivity plays in structural terms, with time, and indicates an idea of continuous spatial reconfiguration that changes the borders of both time and space that until now have been consolidated. (Bullivant, 23+24)

Interactive cultural processes allow an experience of architecture to fluctuate, or become customizable, for the user. The user becomes an integral part of the unique feedback cycles of the system, thereby affecting further flux in the system. Interactive space is one way in which architecture can become more like a living system.

Usman Haque has created a project which explores this notion of interactivity, the *Sky Ear*. *Sky Ear* is an assemblage of helium filled balloons which react to electromagnetic waves. The balloons change color, via LEDs, based on electromagnetic radiation detected by electromagnetic sensors and mobile phones. The piece becomes interactive “When an audience member uses a phone during the cloud flight, they are not using it just as a remote-control device: the cloud is actually responding to the electromagnetic fields created within it by the phones,” says Haque. (Bullivant, 9) The balloons not only communicate with people via cell phones, but they also communicate between themselves “via infrared, creating patterns across the surface of the cloud. Feedback within the sensor network created ripples of light similar to rumbling thunder and flashes of lightning.”(Bullivant, 9)

The *Sky Ear* project allows us to see characteristics of living systems displayed in an architectural manner. The *Sky Ear*, much like a living system,

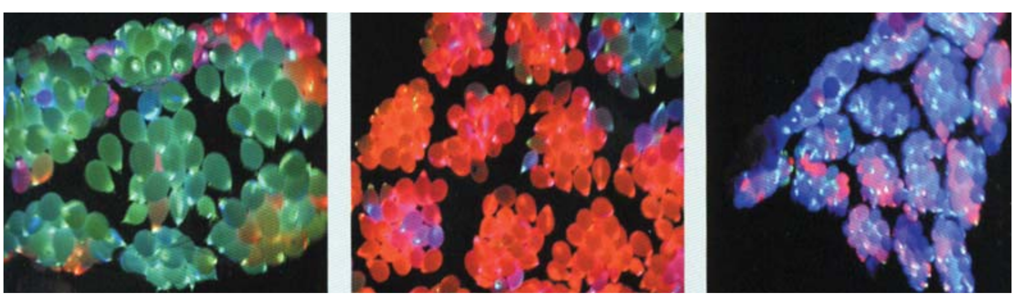


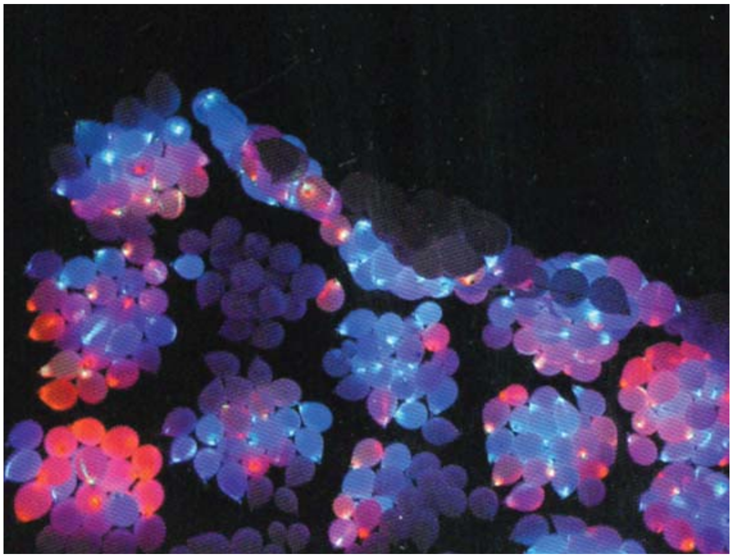
Sky Ear’s communication diagram

Sky Ear before flight

responds and adapts to its electromagnetic environment. Electromagnetic waves, accruing naturally in the environment, and caused artificially by people using cell phones, are reflected in the changing colors of the Sky Ear's balloons. Further, *Sky Ear,* through infrared sensors communicates with itself much like a biofeedback mechanism. Changes in electromagnetic waves effect changes of color which in turn effect more changes in color patterns. In this manner, *Sky Ear* clearly demonstrates feedback cycles and fluctuations allowing it to adapt to its environment in electromagnetic space.

Reflexive architecture is similar in spirit to interactive architecture. However, it differs by





Sky Ear reacting to electromagnetic fields

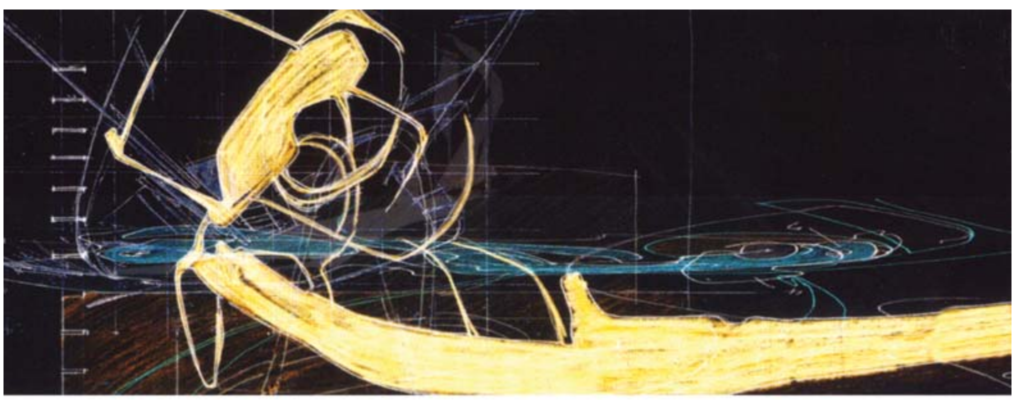
putting the environmental communication as the primary catalyzing element of change within an architectural system as opposed to interactive architecture, which responds primarily to human communication with the system. The *Sky Ear* project could be considered both interactive and reflexive as it responds to human communication and environmental communication.

A project which exemplifies the reflexive approach is the *Archulus Flood Structure* by Shaun Murray.

This work creates a new landscape at the delicate intersection of a local river and the sea at Aldeburgh, Suffolk, England. The project seeks to find a solution to a dissolving spit of eroding land. When this spit disappears the coastline will flood. Murray describes,

> The proposition creates a series of almost cocked and loaded pieces that suddenly at the moment and point of breach explode into action. This landscape creates a new surface for plant and animal colonization. The flood shields resonate in the territory of harpooning landscapes linked to each other through an enchanted tectonic loom embroidering and weaving spaces. Through the transitional territories of user – reader – space, *Archulus* explicitly injects its own agendas. The movement of waves, tidal imbalances and currents shape the ever changing *Archulus* profile. (Murray, 91)

Harpooning Landscapes



Murray also describes how this architecture is derived,

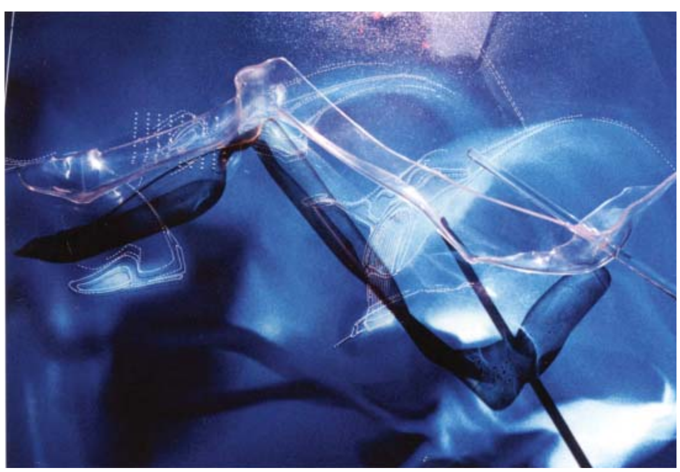
> A model is constructed between the environment and the drawing by using a set of derived values from the landscape [temperature, humidity, salinity levels, etc…] of the real world and from data and processes of the virtual world. Also from numerous techniques of capturing the real and casting it into the virtual. The model is fed time-based data through which the form becomes animate, the architecture vacillating.”(Murray, 91)

In this construction, Murray allows the structure to organize, fluctuate, and stratify according to local environmental conditions much like a living system in this setting would.

There are many parts to the *Archulus* flood structure, each of them adapting to the variable conditions of the site, and reacting in appropriate ways. For example, the flood-control structure consists of shields which run the length of the coastline and shift at varying time scales according to the archaeological, geomorphological and diurnal processes acting on the site. These shields rapidly reconfigure after flood tidal conditions.

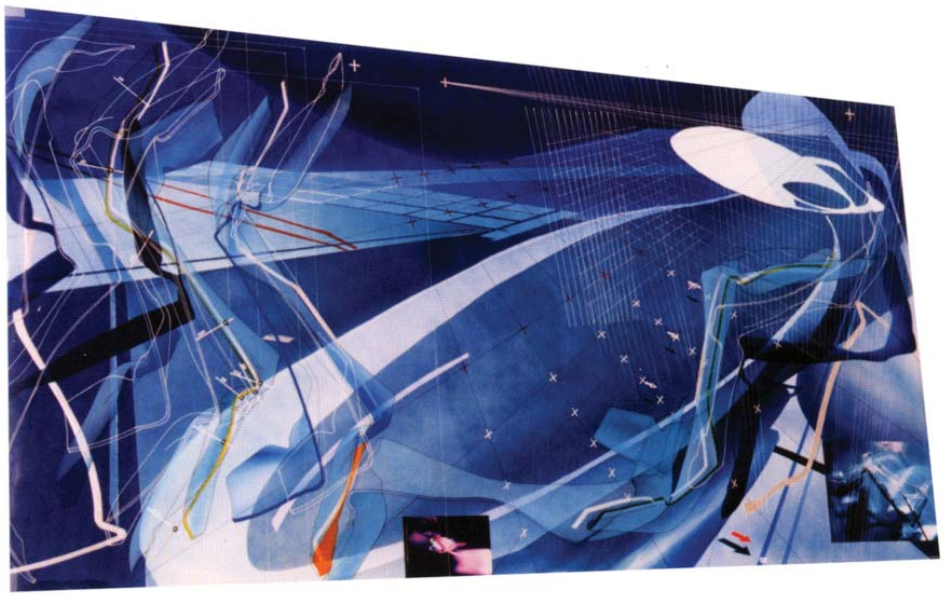
> This reflex results in a catalytic task space which consists of a series of dynamic frames and shifting horizons in between the flood shields… These flood control structures are sensitive guides in a dialogue with the ever changing coastline. They act as the arms of this enchanted loom, working with the natural phylum through the mechanic to enable the flood control structure user to be a part of the environment through the readings of its pristine positioning in space.(Murray, 96)

Model of Flood Control Structure



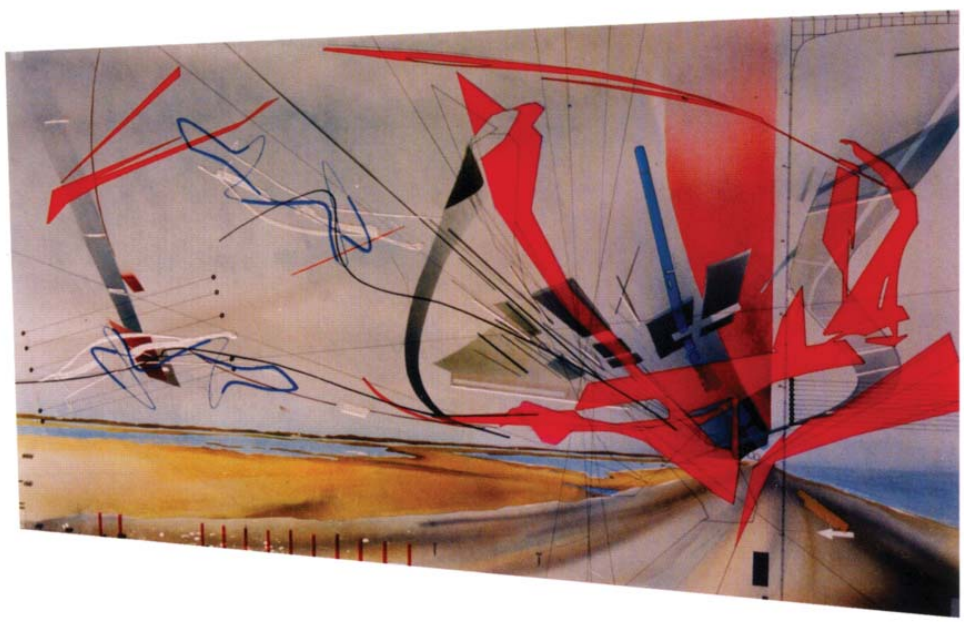
The turbulence voids are submersible devises which scan the seabed with sonar technology for archaeological remains. As the turbulence void ascends the data collected is mathematically mapped and re-created in a virtual archive. The turbulence voids also serve the purpose of a harpoon mechanism. When structure is experiencing flood conditions, the turbulence voids are fired out into the sea providing an anchor for the flood-control structure to shunt forward, exposing the new hyper polder.

Turbulence Void as Harpoon mechanism

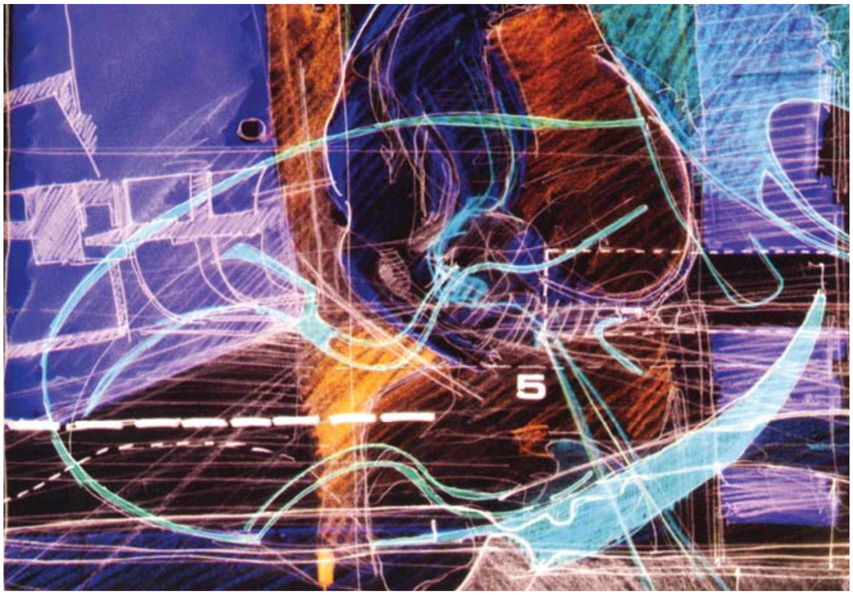


Low slung perspective through Hyper Polder

This shunting of the sea bed produces the hyper polder that was once a part of the seabed, and creates a new landscape for colonization of flora and fauna. The hyper polder is encoded with a complex external skin which acts as a filter for future harsh climates. The hyper polder is also able to deform according to stimuli captured from the environment thereby creating a, near infinite series of changing permutations, which overlap continually, drifting in and out of sequence. Topological deformations render the surface a programmed landscape that not only has the capacity to fulfill the smooth functioning of the major programs of aquaculture framing but also to foster the emergence of new and unanticipated configurations of space.(Murray,102)



Sectional perspective through Flood Control Structure



Sectional perspective through Flood Control Structure

What matters most in the architecture is not ideas as such but their resonances and suggestions, the drama of their possibilities and impossibilities. It becomes an architecture in search of a physical form, but derived and controlled by the physical stimuli of this unique local environment. The work becomes the intermeshing of differentiated local stimuli in various natural environments, as control factors for the construction of architectural environments. (Murray, 102)

Chapter 5

A Proposal

Part 1: Yellowstone National Park

"In this tract of about 3000 square miles, there are manifestations of force so enormous that its mathematical expression could convey no idea to the ordinary mind. Nothing but the imagination can grapple with the problem, but the imagination most simulated and exuberant carries one but a little way on the road to truth." – *Harper's Weekly*, 1893

Yellowstone National Park, with its abundant wildlife and majestic scenery, is a place that once could only be realized in the imagination. Today, the park attracts over three million visitors a year to view its splendor. People come from all over the world to experience nature in its most wild manifestation. But this is not the whole story.

Yellowstone, throughout its history, has danced the line between development and conservation. From its early days, much of park policy has been driven by the will of concessioners whom cater to the ideology of the tourists that they serve. This is evident in the types of facilities that have been constructed in the park over the last 130 years, as well as the services offered to the visitors of the park. Yellowstone's image has constantly been redefined to fit within the popular belief of the visiting public. For years the Park was seen as "national pleasuring ground" in which anyone's desires could be met. From luxurious accommodations complete with French cuisine, to adventurous curiosities, Yellowstone is a place in which the environment (man-made or "natural") is constantly shaped to present the idea of what the Park should look like according to popular demand. Concession owners as well as the NPS spent millions to feed the paying publics desire to experience "nature" as what they believed "nature" should be. In recent years, it is not this tradition of constructing nature that has changed, it is the public's ideology which has

led to Yellowstone being seen as the last “wild” place. Therefore, Yellowstone National Park has become a place which should be preserved, studied, and presented from an ecological standpoint. What constitutes nature, or wilderness, in this context is debatable. However, if we see Yellowstone for what it is, a truly magnificent landscape where wildlife and wild native plants thrive, the argument for ecological preservation is agreeable.

Yellowstone exemplifies the intermingling of natural living processes and cultural and social processes. In this framework, Yellowstone presents a perfect opportunity to explore the construct of environmental architecture whose goal is to become an integral contributing member to the cultural and ecological system in which it exists. This is not a project in search of ultimate truth in terms of the “right” thing to do. Rather, the project is a suggestion towards designing architecture which is an active member of an active ecosystem.

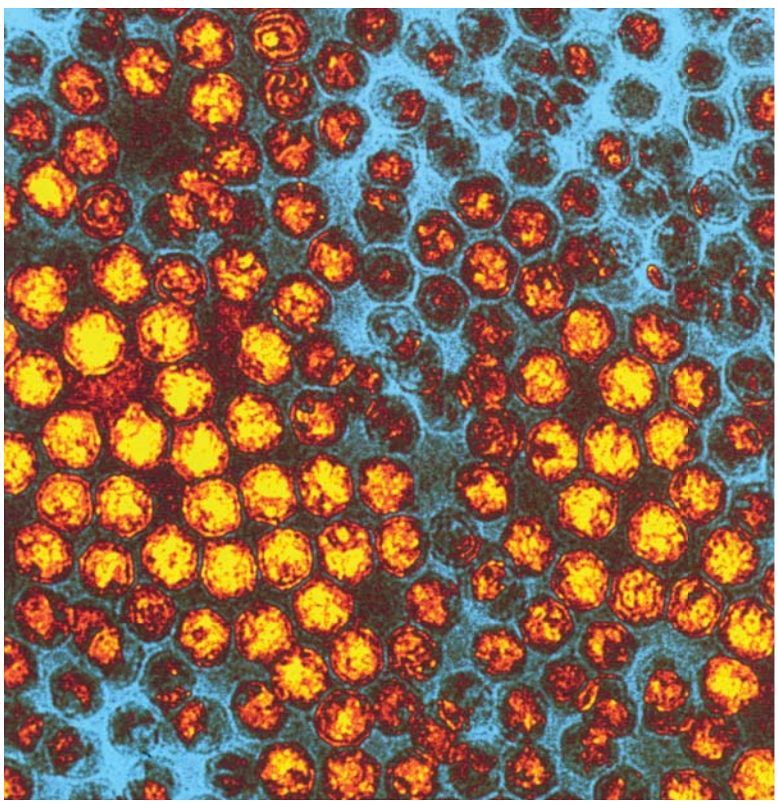
Part 2: Program and Site

Water and Fire: Thermophiles

Yellowstone, because of its unique position over a hot spot in the earth’s crust, is home to the more geothermal features than any other place on earth. Over 300 geysers in the park compromise two-thirds of all the geysers in the world. In addition, Yellowstone contains approximately 10,000 thermal features (Reid, 1). Geysers, hot springs, mud pots, and fumaroles make up the geothermal features of the park, and create very unique living environments for a group of microorganisms called extremophiles.

Extremophiles get their name because they are organisms which thrive in extreme environments. Some examples of these extreme environments are: freezing

Electron microscope image of virus particles isolated from *Sulfolobus*, a hyperthermophile that lives in very hot and acidic springs



water, boiling water, and highly acidic water. The most common extremophiles in Yellowstone are called thermophiles and hyperthermophiles, because they thrive in extremely hot water. If you have ever wondered what makes the intense colors of Grand Prismatic Spring change from deep blue to green, to orange and yellow, it is partly due to the presence of different thermophiles thriving in particular temperature ranges of hot water.

The program proposed for Water and Fire will consist of two design challenges. The first is to create a research laboratory which envelops scientists in the ecosystems of thermophiles. The second challange is to introduce the visiting public to the ecology of thermophiles in Yellowstone National Park through interactive gallery space. Thermophiles exist in complex ecological networks. The architecture of Water and Fire must embody this complex system of interconnected relationships. As such, the program will harness natural phenomena and modern technology

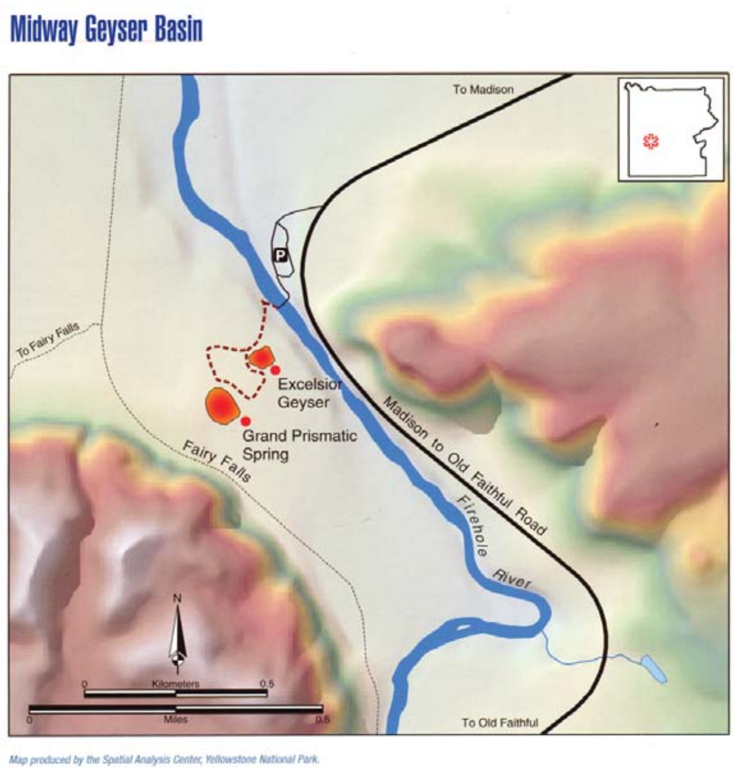
Grand Prismatic Spring’s bacterial mats

in order to create architecture which is self-regulating, interactive, and reflexive; resulting in effective communication between the visitor and the environment. The program will be capable of adaptation and transformation enabling the architecture to become an active member within the active ecosystem in which it exists. Simultaneously the visitor will become an integral component of the system, capable of influencing the system and being acted upon by the system. The performance of the building will completely submerse the user into the extreme environment of thermophiles. The architecture will create a data base of remote ecological information from different sites throughout the park. This information will be used for scientific research and as an effective means to allow the visitor to experience, in real time, multiple locations and diverse ecological factors in the extreme environments of thermophiles. The goal of the project will be to synthesize ecological processes and cultural and social processes into architecture which exists as an active partner within an active relational environment.

The site chosen for the project is on the northeast side of the Firehole River, across from the Midway Geyser Basin. This collection of thermal features is located midway between the Upper Geyser Basin and the Lower Geyser Basin. Midway Geyser Basin is

GALLATIN
NATIONAL FOREST
M O N T A N A
Gardiner
North Entrance
Mammoth
Cooke City
Silver Gate
GALLATIN
NATIONAL FOREST
Tower-Roosevelt
Norris
Canyon
West Yellowstone
West Entrance
Madison
YELLOWSTONE
NATIONAL PARK
Fishing Bridge
Lake Village
Bridge Bay
East Entrance
Pahaska
Yellowstone Lake
Old Faithful
West Thumb
Grant Village
Island Park
CARIBOU-TARGHEE
NATIONAL FOREST
SHOSHONE NA
Bechler Ranger/ Entrance Station
South Entrance
Flagg Ranch
BRIDGER-TETON NATIONAL FOREST
W Y O M I N G

a favorite tourist stop on the road between Madison Junction and Old Faithful, which insures public exposure, and provides existing infrastructure for the project.



Pedestrian bridge crossing Firehole River leading to Midway Geyser Basin

Excelsior Geyser runoff providing thermophile habitat

The “hard” program of the project will consist of:

1) Research Laboratory: 6000 sf

2) Water Gallery: 2000 sf

3) Fire Gallery: 2000 sf

4) Office/Support space: 1000 sf

5) Public Restrooms: 250 sf

6) Parking: 25 additional spaces added to existing

Total square footages are approximate and will be subject to fluctuations in response to environmental conditions. The total will be somewhere around 11,250 square feet.

The Research Laboratory will be an interactive and reflexive environment, enabling scientists to effectively study thermophiles through the created Remote Data Base, and through on-site observation. The Research Laboratory will be open to the public as an interactive learning environment.

Part 3: Research Lab

Essential to the Water and Fire program is the Research Laboratory. This space must not only serve the needs of resident biologists, but it also must fully engage with the surrounding environment to produce an architecture which is interactive and reflexive. To understand better the requirements of a Biological lab, we will first look at some design requirements from Daniel Watch's book Building Type Basics for Research Laboratories. Secondly, we will look at a case study from the Bocas del Toro region of Panama which finds a solution for a facility of this type in a complex and fragile ecosystem.

Seven design basics for biological labs:

1) Biological labs are wet labs, meaning they require sinks, piped gases, and fume hoods. A wet lab requires chemical-resistant countertops and 100% outside air.

2) Fume hood and biosafety cabinets

3) Space for incubator, refrigerators, and freezers of various sizes

4) Bench and storage space for equipment and research materials

5) High-quality water at the sink

6) Cabinets for chemical and flammables storage

7) Adjacent prep, storage, and equipment supply to support efficient use of the laboratory.

Further, the biological lab should be flexible to accommodate the various research activities of resident and visiting scientists. Some examples of support spaces commonly required in a biological lab are: vivarium facilities, greenhouses, tissue culture areas, environmental rooms, incubators, growth chambers, glass washing areas, darkroom areas, instruament rooms, storage and shops. Plant and animal specimen storage and display rooms should be located in close proximity to the lab. (Watch, 73)

Bocas del Toro Laboratory

At Colon Island in Panama ‘s Bocas del Toro region in the Caribbean, STRI (Smithsonian Tropical Research Instiute) has established a site for education and research, providing scientists and students with access to an extraordinary diversity of marine and terrestrial biota. This station is situated among areas of undisturbed forest, a remarkable coastal lagoon system, and numerous islands and reefs.

On Isla Colon in Bocas del Toro province, STRI built

a center for a comprehensive program in research and education, focused on both marine and terrestrial environments.

Bocas del Toro is a complex region of islands, mainland bays, rivers and forested mountain slopes on the Caribbean side of the Panamanian isthmus. The very high diversity of marine and terrestrial ecosystems makes Bocas an ideal area to study natural environments. However, Bocas is also a socio-politically complex setting—a site with fisheries, growing tourism, agriculture and a significant population of endangered sea turtles and manatees. In short, Bocas comprises a model region for working on the important issue of sustainable multiple use.

Additionally, Bocas del Toro offers an ideal setting for conducting paleoecological studies to answer important questions about the history of the Isthmus of Panama. The rocks and fossils around Bocas hold the key to understanding when and where the Isthmus began rising, and when and where it closed, separating the Atlantic and Pacific Oceans. Pinpointing the time sequence of this division, which triggered the formation of the Gulf Stream, among other major natural events, has huge ramifications across varying fields of scientific inquiry as diverse as evolutionary biology and climatology. (above info from www.stri.org)

Overview

- Location: Bocas del Toro, Panama
- Building type(s): Laboratory, Higher education
- New construction
- 7,530 sq. feet (700 sq. meters)
- Project scope: a single building
- Rural setting
- Completed October 2003

The Smithsonian Tropical Research Institute (STRI) is a renowned world leader in research on the ecology, behavior, and evolution of tropical organisms. Their new research station is located at a former sawmill, on a sensitive coastal site next to a mangrove swamp, on an island off the Caribbean coast of Panama.

The building's main functions — labs for resident and visiting scientists, teaching labs, a conference room, and support spaces — occupy a string of volumes on a raised platform shaded by an overhanging pitched roof. The main laboratory building was designed to minimize its environmental impact while providing an exemplary scientific facility.

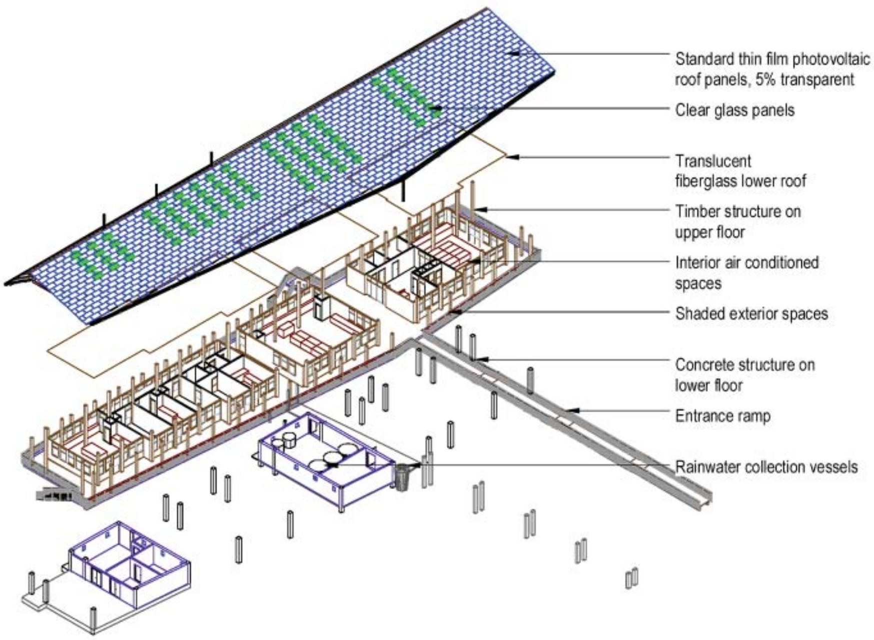
Environmental Aspects

The guiding principle of the design was that it be “net zero impact,” collecting its own water, treating its own waste, and generating its own energy.

The form of the building itself affords great energy savings. Interior volumes are shaded by the large photovoltaic roof, which minimizes direct heat gains. The narrow plan, together with the space between the two roofs, allows cross ventilation to keep the building cool while providing daylight and views. The translucent lower roof, along with the partially transparent photovoltaic roof, admits an optimum 5% of daylight into the interior rooms for daylighting. The 38-kW photovoltaic upper roof produces approximately 75% of the building’s energy needs, while doubling as the rainwater collector.

Raising the entire building on concrete piers helps to catch prevailing breezes for passive cooling, and also provides a measure of flood protection and minimizes the lab’s impact on the site. Air conditioning is zoned so that individual rooms can be cooled separately.

Materials were chosen for environmental reasons, and, where possible, were left without additional finish. Sustainably harvested local hardwood was used for the upper structure and siding of the building.



Owner & Occupancy

- Owned by Smithsonian Tropical Research Institute, Federal government
- Typically occupied by 6 people, 40 hours per person per week; and 40 visitors per week

Building Programs

Indoor Spaces: Laboratory (26%), Classroom (19%), Conference (11%), Other (10%), Mechanical systems (10%), Office (6%), Electrical systems (6%), Circulation (5%), Lobby/reception (4%), Restrooms (3%), Data processing (1%)

Outdoor Spaces: Restored landscape (38%), Wildlife habitat (28%), Garden—decorative (20%), Drives/roadway (5%), Shade structures/outdoor rooms (5%), Pedestrian/non-motorized vehicle path (3%), Parking (2%)

The Bocas del Toro Research Lab offers many insights into a sustainable design approach. The building provides a comfortable work environment for researchers, and also effectively harvests natural energy from its environment. The architecture minimizes its impact upon the ecosystem in which it exists. However, environmental architecture must do more. The architecture must fully engage the ecosystem to become an active entity in its environment. Living systems are not passive. Environmental architecture therefore, cannot be passive.

The research lab for Fire and Water must create an effective work environment for the scientists who will be using the facility. The lab also must become an active member within the ecosystem of Midway Geyser Basin contributing to that ecosystem in the same fashion as a living system. The architecture must enter the feedback cycles of the site and affect change within the ecosystem as well as within the architectural system.

The Water Gallery and the Fire Gallery will create an interactive and reflexive environment, which will allow the visitor to experience the thermal ecosystems of Midway Geyser Basin.

Part 4: Site Analysis

Quick Facts on Yellowstone’s Ecosystem

Location

96% in Wyoming

3% in Montana

1% in Idaho

Size

3,472 square miles

2,219,789 acres

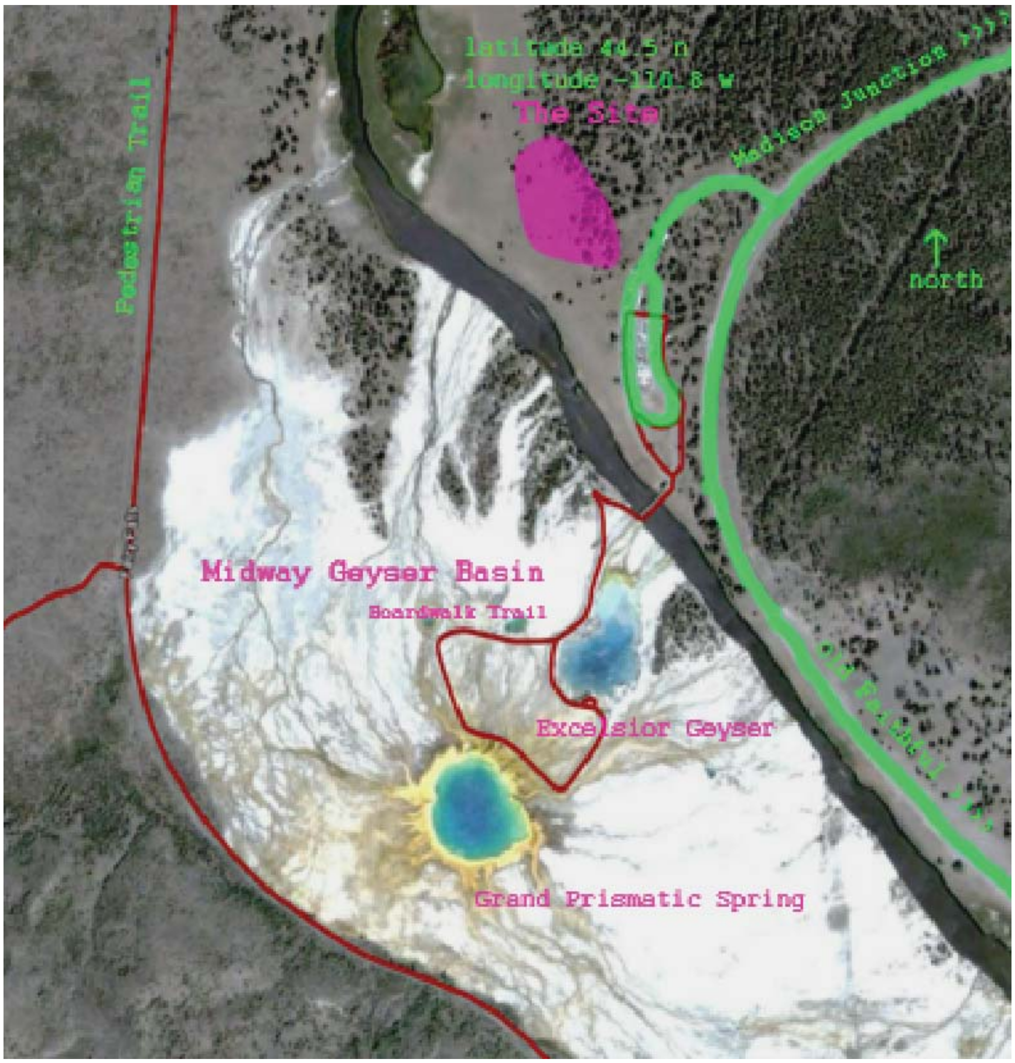
63 miles north to south

54 miles east to west

Geography

Highest point: Eagle Peak 11,358ft above sea level

Lowest point: Reese Creek 5,282 ft above sea level


latitude 44.5 n
longitude -110.8 w
The Site
Madison Junction
north
Pedestrian Trail
Midway Geyser Basin
Boardwalk Trail
Excelsior Geyser
Old Faithful
Grand Prismatic Spring

Wildlife

7 species of native ungulates: Elk, Bison, Moose, Mule Deer, Whitetail Deer, Pronghorn, Bighorn Sheep

2 species of bear: Black Bear, and Grizzly Bear

Approx. 50 species of other mammals

311 recorded species of birds

18 species of fish (6 non-native)

6 species of reptiles

4 species of amphibians

5 species protected as “threatened or endangered”:

Threatened: Bald Eagle, Grizzly Bear, Lynx, Grey Wolf

Endangered: Whooping Crane

Flora

8 species of conifers

Approx. 80% of forest is comprised of Lodgepole Pine

More than 1,700 species of native vascular plants

More than 170 species of exotic plants

186 species of lichens

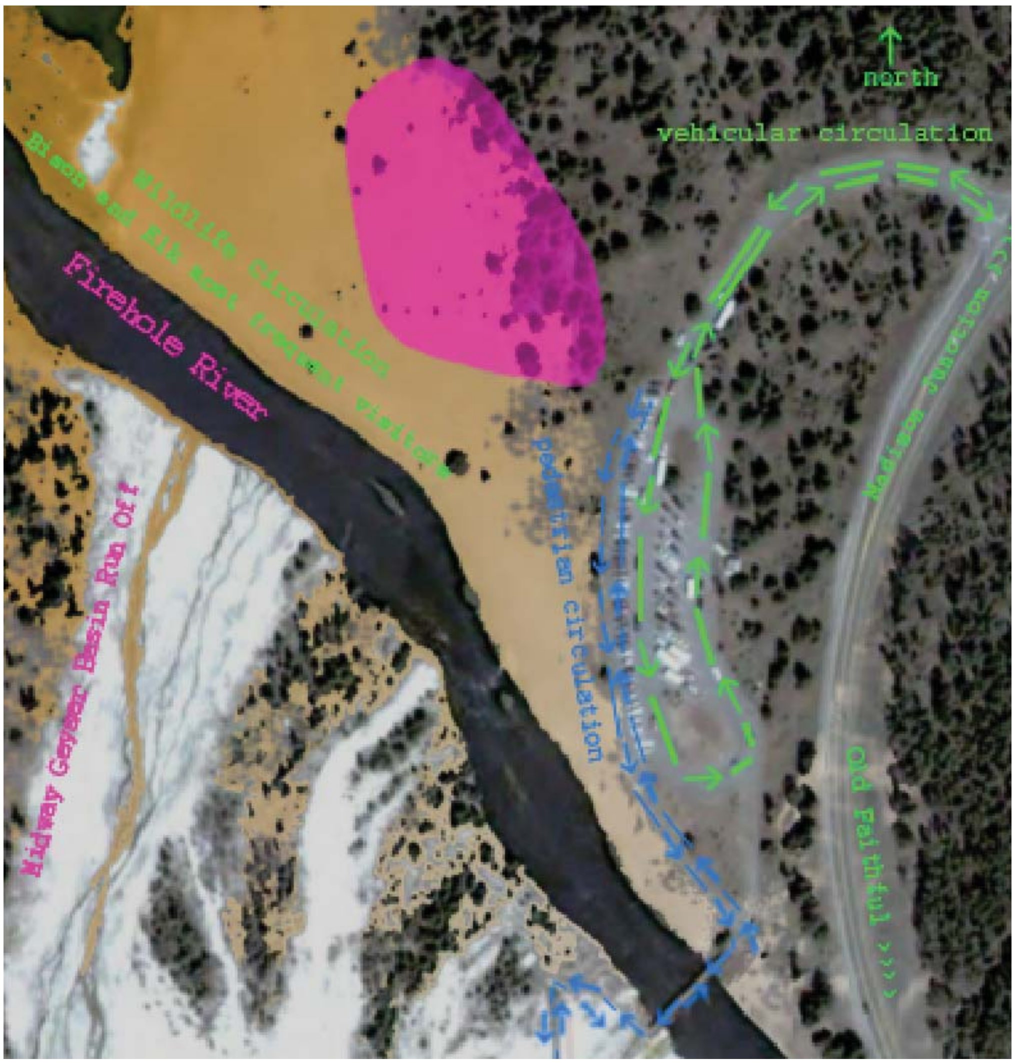
Geology

Approx. 2,000 earthquakes annually

Approx. 10,000 thermal features

More than 300 geysers

Approx. 290 waterfalls, 15 ft or higher flowing year round


north
vehicular circulation
Wildlife Circulation
Firehole River
pedestrian circulation
Midway Geyser Basin Run Off
Old Faithful >>>

Tallest waterfall: Lower Falls of the Yellowstone River: 308 ft.

Roads and Trails

5 park entrances: North entrance at Gardiner, MT; Northeast entrance at Cooke City, MT; East entrance 53 miles west of Cody, WY: South entrance 64 miles north of Jackson, WY; West entrance at West Yellowstone, MT.

466 miles of roads

950 miles of backcountry trails

97 trailheads

287 backcountry campsites

Visitation

Approx. 3 million annually

Winter visitors approx. 140,000

Facilities

9 visitor centers and museums

9 hotel/lodges: 2,238 hotel rooms/cabins

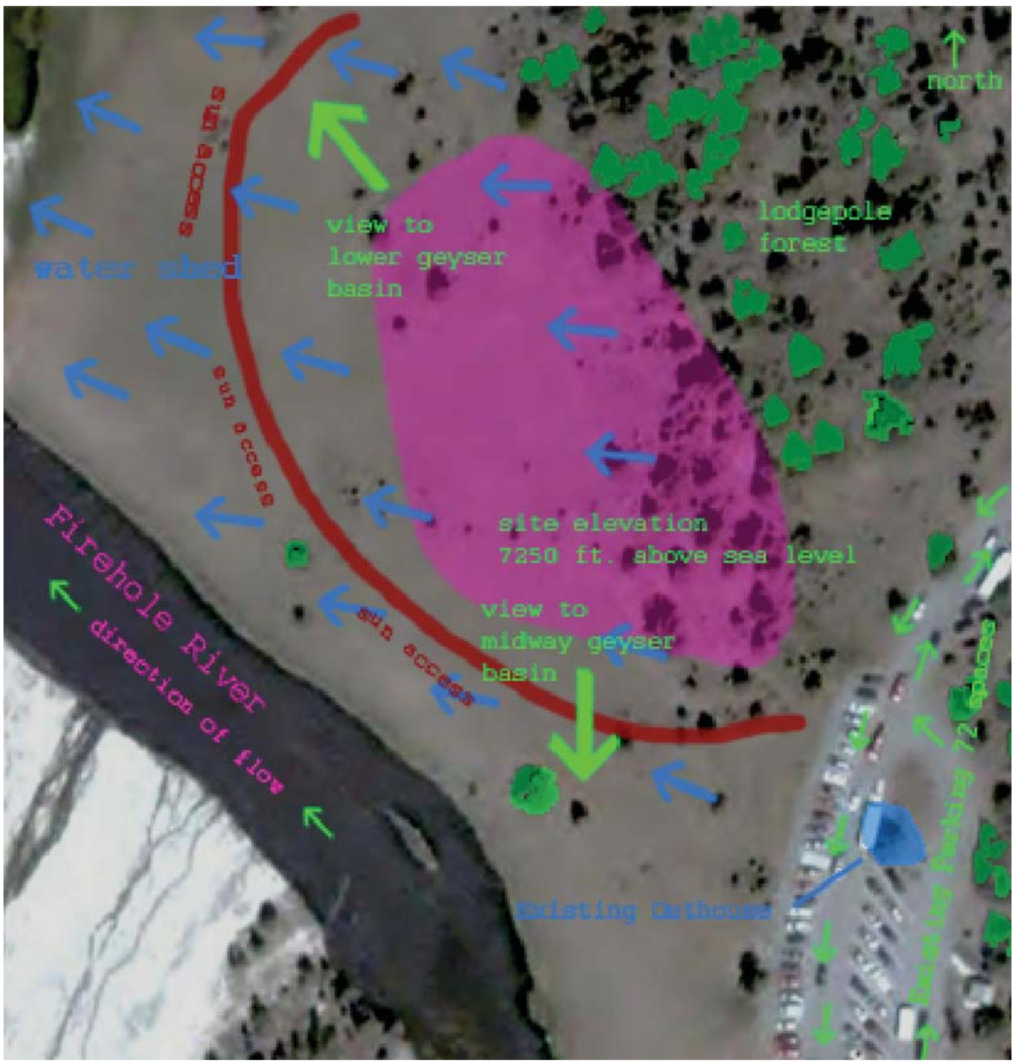
7 NPS-operated campgrounds: 454 sites

5 concession-operated campgrounds: 1,747 sites

2,000 + buildings (NPS and concessions)

49 picnic areas

1 marina


north
lodgepole
forest
view to
lower geyser
basin
water shed
sun access
sun access
sun access
site elevation
7250 ft. above sea level
view to
midway geyser
basin
Firehole River
direction of flow
Existing Outhouse
Existing Parking 72 spaces

Midway Geyser Basin is home to Excelsior Geyser and Grand Prismatic Spring. These two thermal features are among the largest in the world, provide a home to billions of thermophiles, and present a unique on-site research environment.

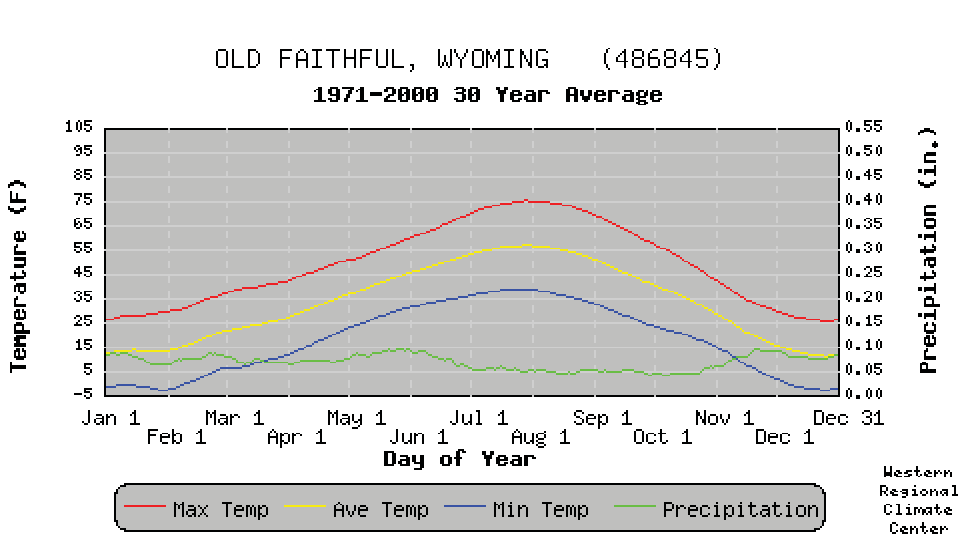
Excelsior Geyser of the Midway Geyser Basin measures 276 feet by 328 feet, and has a temperature of 199 degrees Fahrenheit. Excelsior was once the world’s largest geyser, erupting up to 300 feet high. The last of these mega-eruptions occurred during the 1880’s. Because Excelsior is no longer producing eruptions, it is considered a thermal spring. Excelsior discharges over 4000 gallons of hot water into the Firehole River every minute. (Reid, 137) The most visible thermophiles exist as the water cools and empties into the Firehole River. Photosynthetic bacteria form in distinct temperature zones along the runoff channel. Thermophiles also thrive in the Firehole River as a result of Excelsior’s discharge.

Grand Prismatic Spring of the Midway Geyser Basin is the third largest hot spring in the world measuring 250 feet by 380 feet, and over 120 feet deep. The water temperature varies from 147-188 degrees Fahrenheit.(Reid 135) The Grand Prismatic Spring gets its name from the rainbow of colors which shift from deep blue to green to orange to red as the water temperature varies and different types of hyperthermophiles and thermophiles take up residence forming mats. The mats in the Grand Prismatic Spring are made from photosynthesizing bacteria such as *Chloroflexus* and *Synechococcus*. (Sheehan, 37) The water from the Grand Prismatic Spring spills out over the sides in all directions at a rate of 560 gallons per minute.

View of site from Midway boardwalk

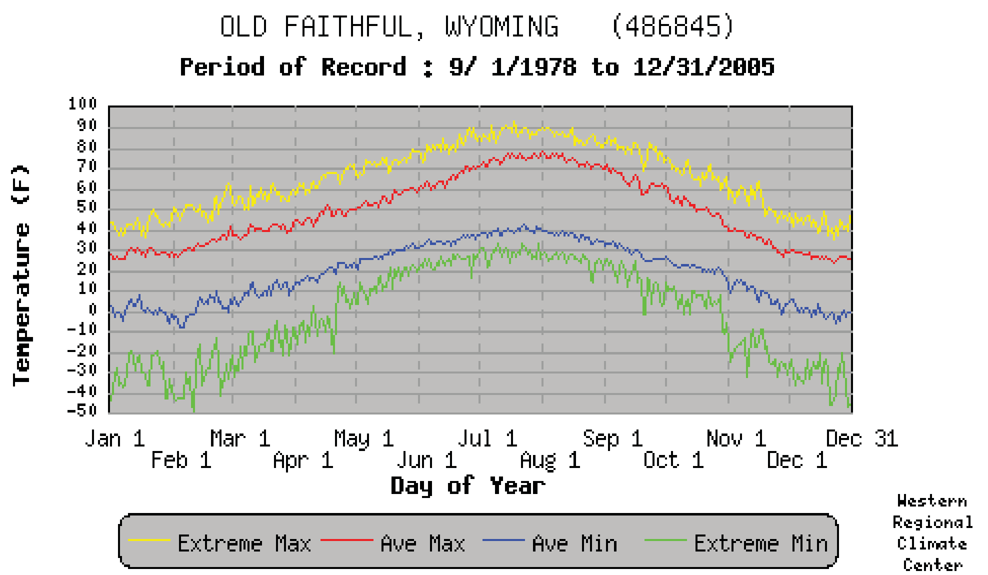
View from site looking west

Climate data from Old Faithful provides the most accurate description for the Midway Geyser Basin. Only approximately 8 miles separate the two. This information is from the Western Regional Climate Center.

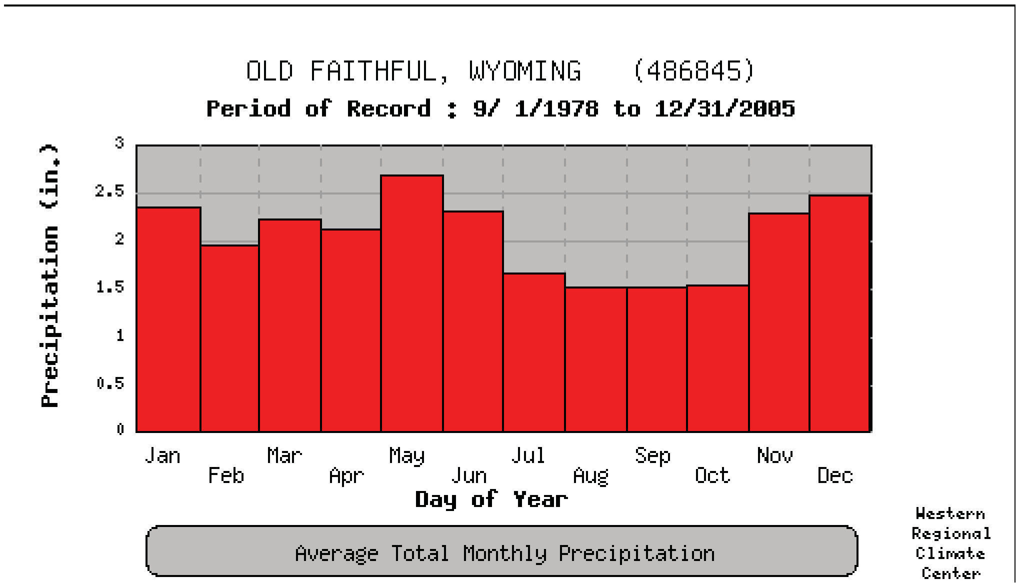


Data is smoothed using a 29 day running average.

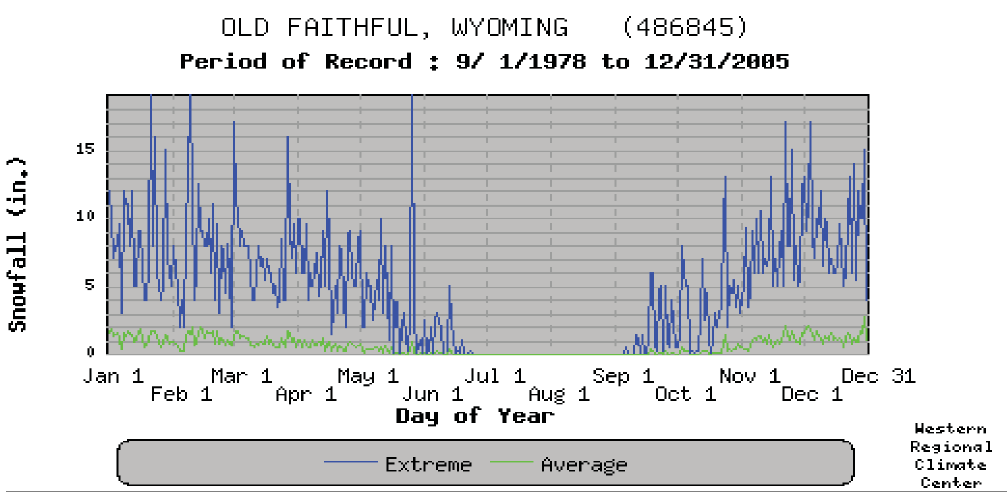
POR - Daily Temperature Averages and Extremes



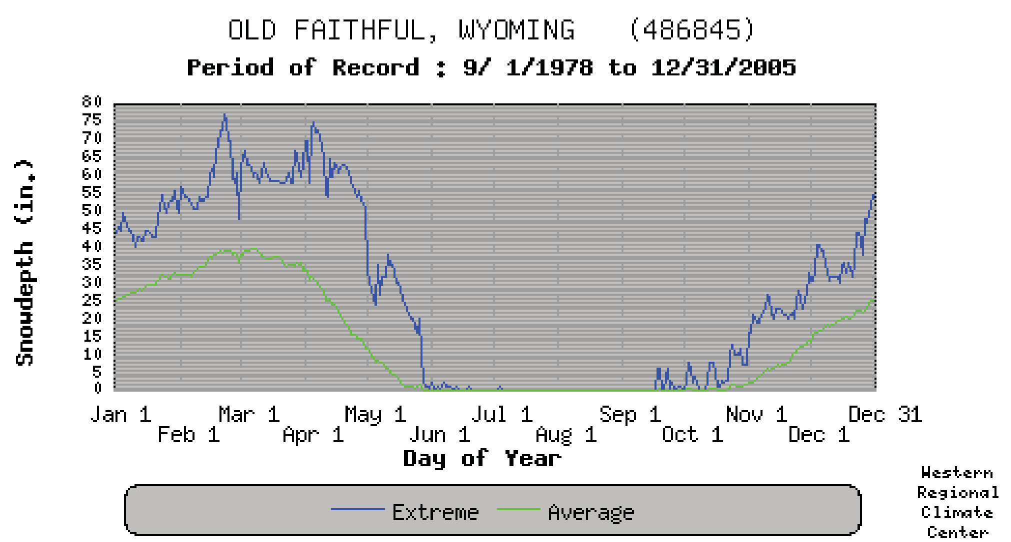
POR - Monthly Average Total Precipitation



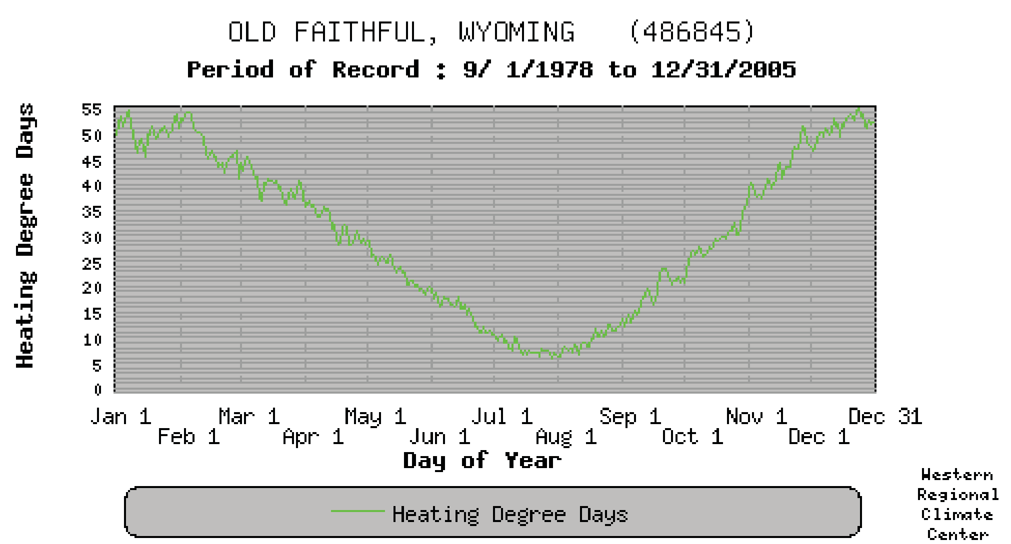
POR - Daily Snowfall Average and Extreme



POR - Daily Snowdepth Average and Extreme

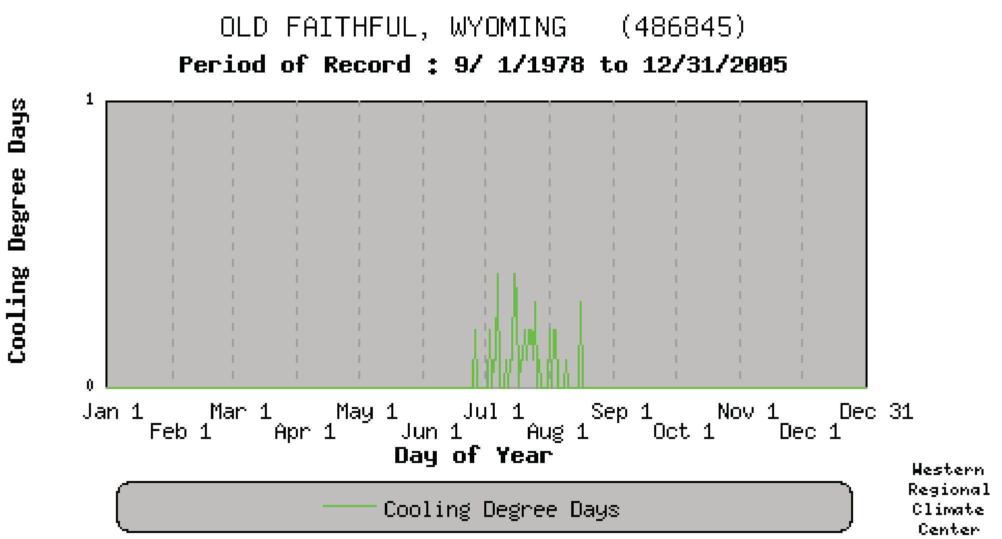


POR - Heating Degree Days (Base 65)



- Average of all heating degree day units recorded for the day of the year.

POR - Cooling Degree Days



- Average of all cooling degree day units recorded for the day of the year.

OLD FAITHFUL, WYOMING (486845)

Part 5: Code Analysis

Applicable codes: IBC 2006, IEC 2006 intl. electric code, IFC 2006 intl. fire code.

Occupancy: Gallery space A-3, section 303.1

Research Lab E

Occupant load: Table 1004.1.1

Assembly w/out fixed seats; unconcentrated

Gallery: 15 sf/occupant = 267 total occupants

Fixed seating in Research Lab. = 30 total occupants

Total occupancy = 297

Construction Requirements:

Construction type A-3 ocupancy: type V-A, section 602.5

Maximum allowable height 2 stories,

Table 503

Maximum allowable floor area per story 11,500 sf, Table 503

Construction type E occupancy: Type v-A, section

602.5

Maximum allowable height 1 story

Table 503

Maximum floor area per story 18,500 sf,

Table 503

Table 601 Fire resistance rating for building elements

Type V-A

Structural frame: 1 hr.

Bearing walls exterior: 1 hr.

Bearing walls interior: 1 hr.

Nonbearing walls exterior: 0 hr.

Nonbearing walls interior: 0 hr.

Floor construction: 1 hr.

Roof construction: 1 hr.

*1 hr. ratings may be dropped with sprinkler

Accessibility:

ADA compliances:

Section 1104 Accessible Route

Minimum 36” path of travel

Section 1105 Accessible Entrance

At least 60% of all public entrances

accessible

Section 1010 Ramps

Slope of ramp must not exceed 1:12

Provide 60” landing per 30’ of ramp

Minimum 36” width

Table 1106.1 Accessible parking

Minimum required: 1

Table 1108.2.2.1 Wheelchair spaces in fixed seating

Minimum required: 2

Section 1007.1 Accessible means of egress

Minimum required: 2

Section 1109.2 Toilet facilities shall be accessible

Table 2902.1 Plumbing fixtures:

Total occupancy = 148 male 148 female

2 male water closets

3 female water closets

1 male, 1 female lavatory

1 drinking fountain

1 service sink

Egress requirements:

Section 1008:

32” minimum door width

Doors shall swing in the direction of

travel

Section 1015.2.1:

2 exits no greater than 1/3 of the diagonal of the space apart if sprinkled

Table 1016.1 Exit access travel distance

No greater than 250 feet with sprinkler

Section 1006.1 Illumination required

The means of egress, including the exit discharge, shall be illuminated at all times the building space served by the means of egress is occupied

Section 1006.2 Illumination level.

The means of egress illumination level shall not be less than 1 foot-candle (11 lux) at the walking surface level.

Section 1006.3 Illumination emergency power.

The power supply for means of egress illumination shall normally be provided by the premises’ electrical supply.

In the event of power supply failure, an emergency electrical system shall automatically illuminate the following areas:

1. Aisles and unenclosed egress stairways in rooms and spaces that require two or more means of egress.

2. Corridors, exit enclosures and exit passageways in buildings required to have two or more exits.

3. Exterior egress components at other than the level of exit discharge until exit discharge is accomplished for buildings required to have two or more exits.

4. Interior exit discharge elements, as permitted in Section 1024.1, in buildings required to have two or more exits.

5. Exterior landings, as required by Section 1008.1.5, for exit discharge doorways in buildings required to have two or more exits.

The emergency power system shall provide power for a duration of not less than

90 minutes and shall consist of storage batteries, unit equipment or an on-site generator. The installation of the emergency power system shall be in accordance with Section 2702.

Part 6: Conclusion

Environmental architecture consists of two components: natural living processes as well as cultural and social processes. We have seen how architecture can embody both of these components to become an active member with in a relational ecosystem. From Borges to Yellowstone National Park we have explored our world of interconnected relationships, and seen how architecture can change in order to become an essential component in the active system which is our world.

Part 7: The Project

SYTHESIZING ECOLOGIES

MIDWAY GEYSER BASIN

THERMAL LABORATORY

YELLOWSTONE NATIONAL PARK, WY

STATEMENT OF INTENT:

An unbalanced relationship currently exists between man and nature. However, humans are beginning to realize if this uneven relationship continues, it will mean the ultimate demise of our world.

This is a project which seeks to produce architecture that is in balance with nature. To achieve this the architecture must act as a living system in diverse ecological environments. If architecture can organize as a living system it will no longer exist as an object on the landscape. The architecture will be experienced as an interrelated process essential to the functioning whole.

Yellowstone, because of its unique position over a hot spot in the earth's crust, is home to more geothermal features than any other place in the world. The Midway Geyser Basin is a collection of thermal features located on the Firehole river, 8 miles north of Old Faithful.

Midway Geyser Basin is home to Excelsior Geyser and the Grand Prismatic Spring. These two thermal features are among the largest in the world, and provide a home to billions of micro organisms which thrive in this extreme environment.

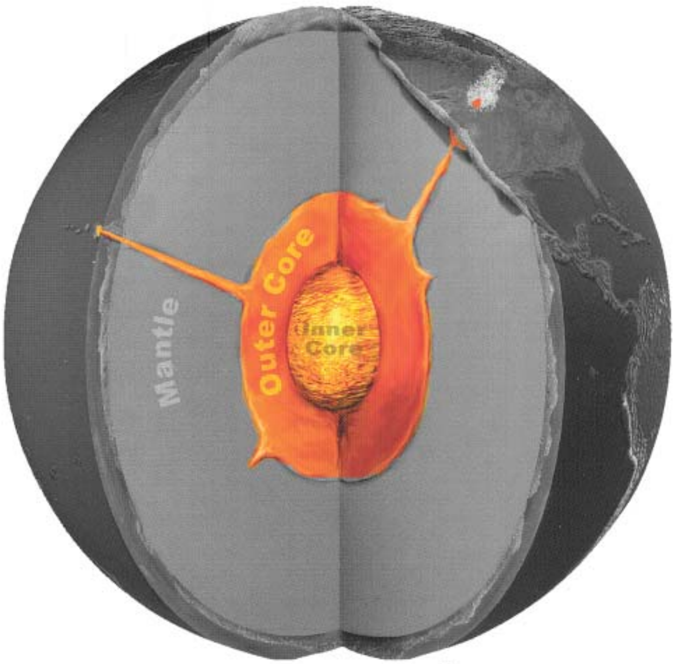
The program is tailored to this unique system.

5000 sf of research laboratory
5000 sf of interpretive space
2000 sf of support space
12,000 sf total.

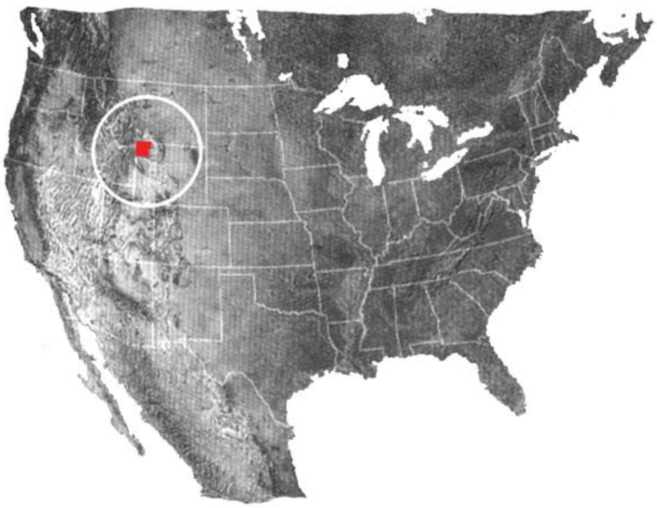
PROJECT DESCRIPTION:

The project gathers its organization from the unique local environment inwhich it exists. GIS maps were used to form the site plan. This allows the architecture to engage the environment and produce purposeful space. As one travels through the architecture unique changes in eye level, enclosure, and stability awaken the senses and promote a deep connection to place.

The architecture lives within this environment and thrives. Dynamic changes in space occur correlated with the suns movement and the presence of visitors. The Laboratory's massive earth wall opens to visitors. The digital gallery unfolds with the sun. Energy is harvested through a tracking pv array. The dynamic skin opens for ventilation.

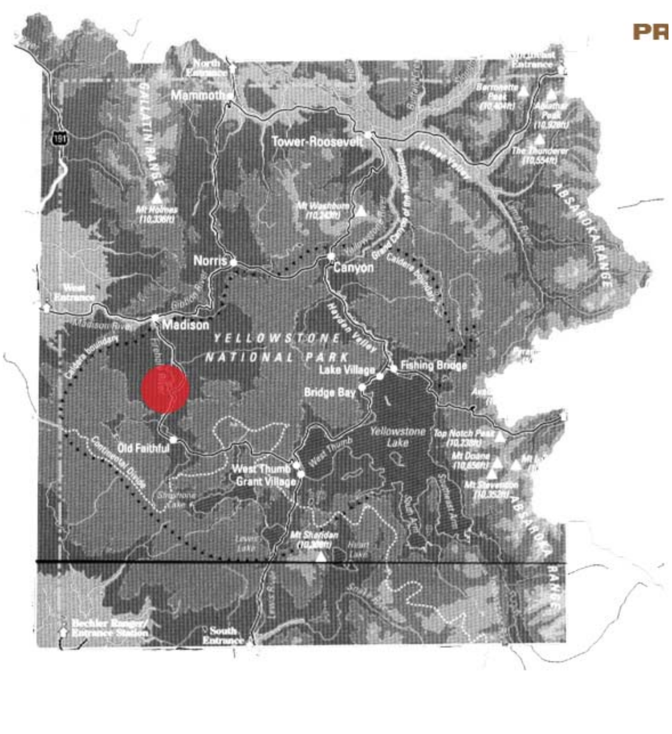


YELLOWSTONE HOT SPOT

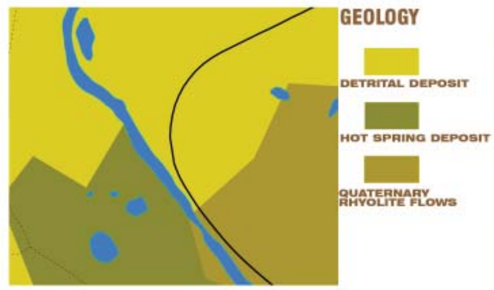


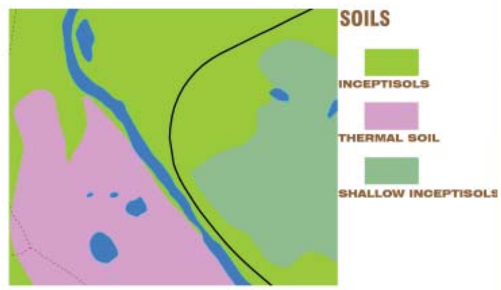
SITE LOCATION MAPS

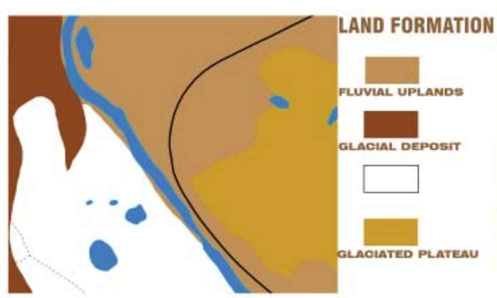
PR



GIS Maps are used to create a composite site plan. connecting the architecture directly to the unique local environment.

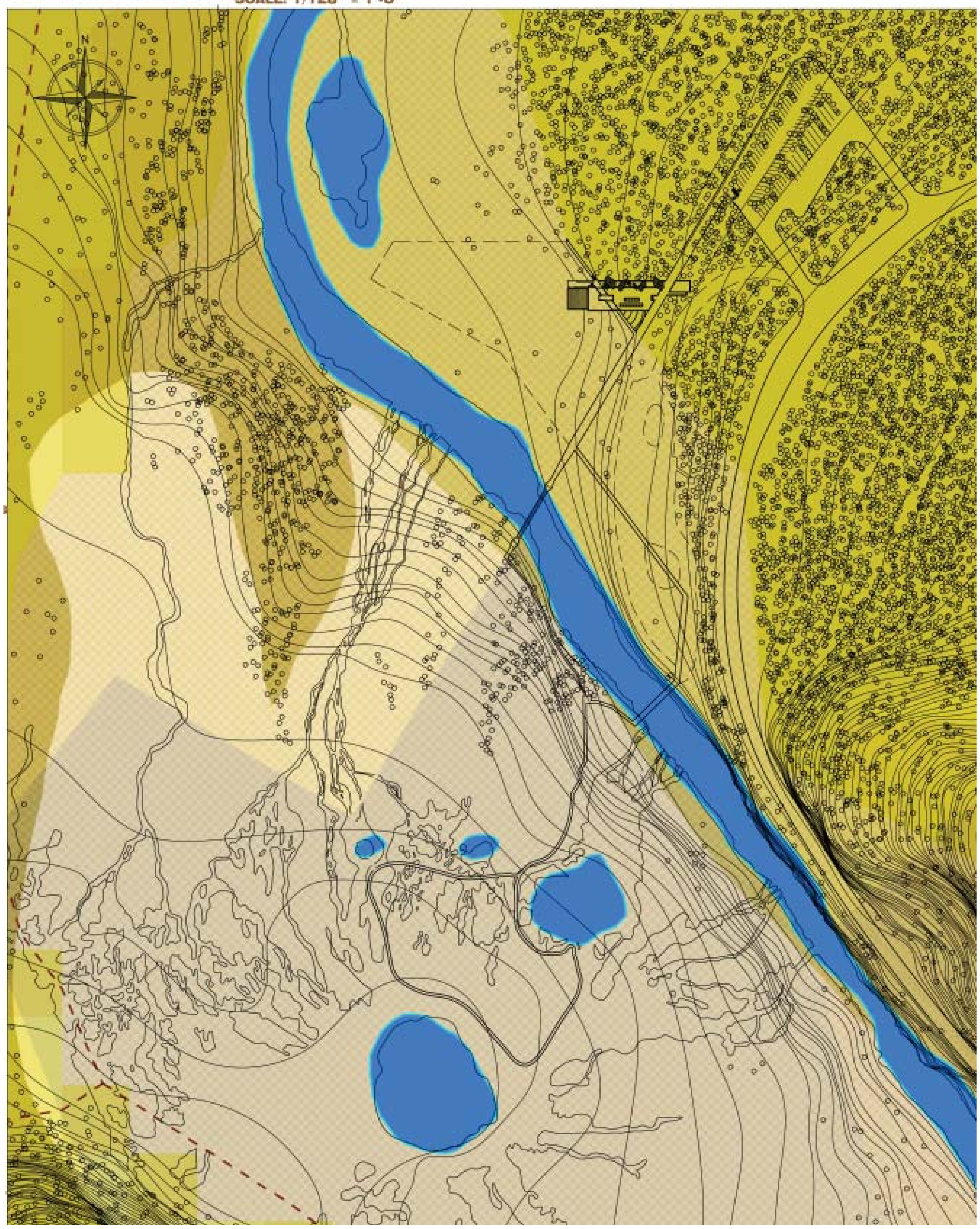




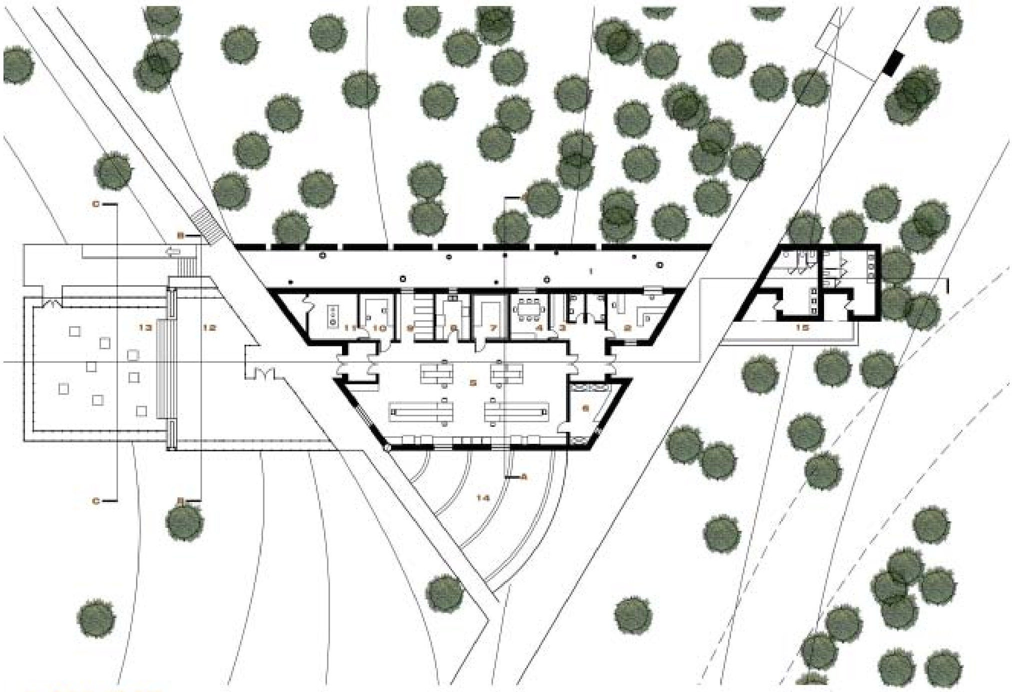


COMPOSITE SITE PLAN

SCALE: 1/128" = 1'-0"



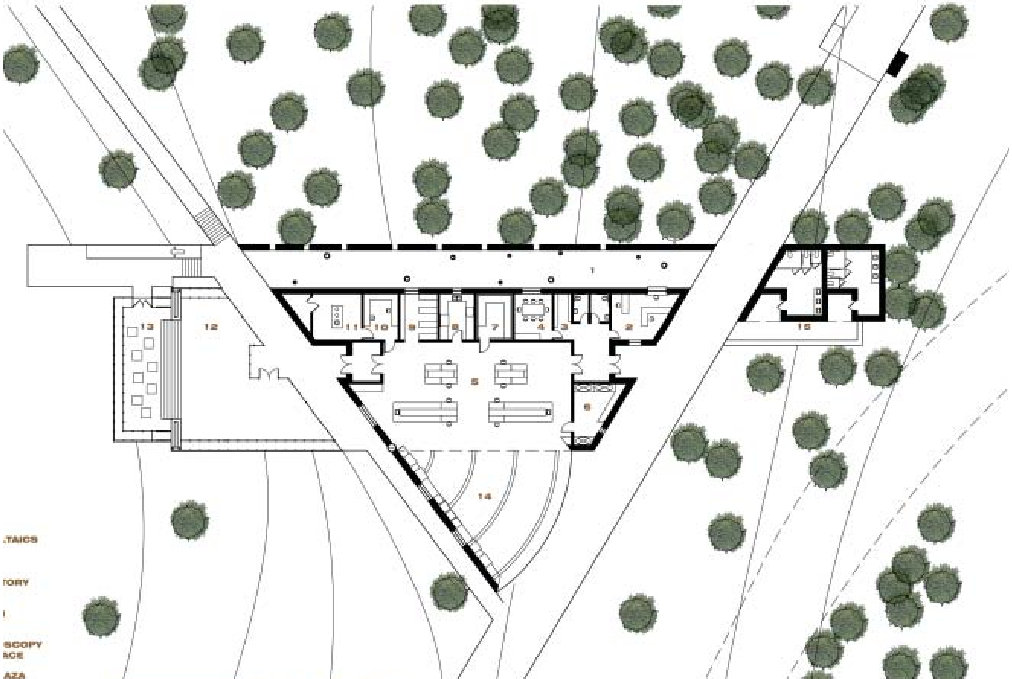
DYNAMIC SPACE IN



FLOOR PLAN
SCALE : 1/16" =1'-0"

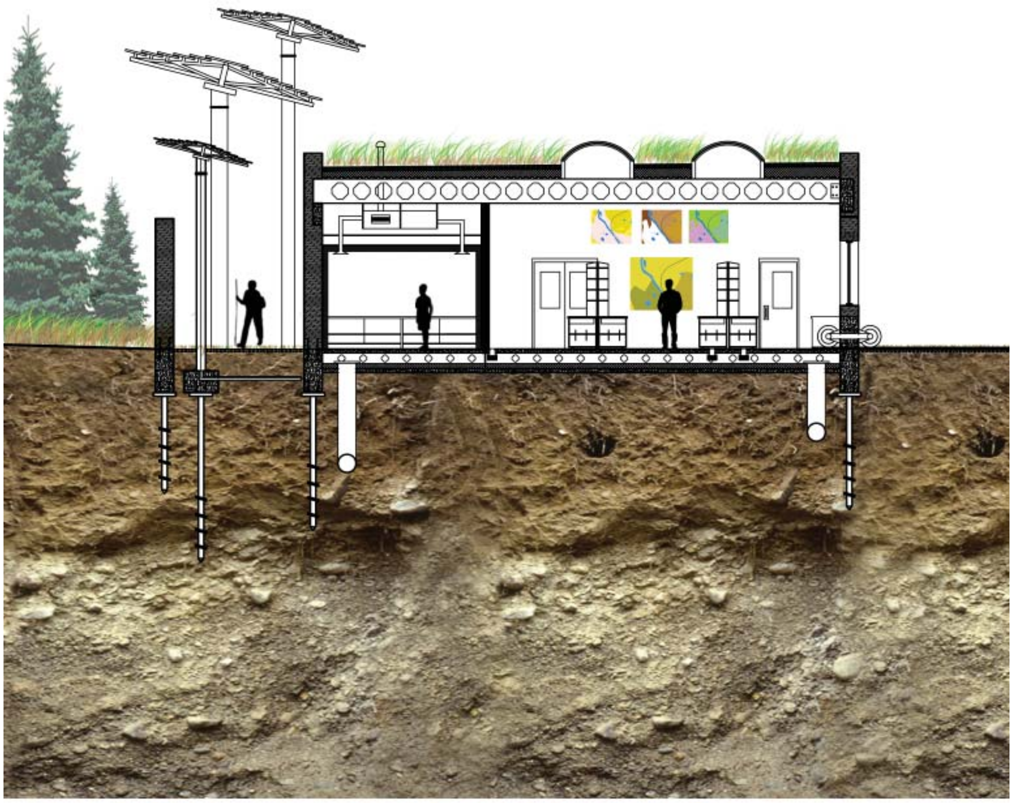
EXPANDED SECTION
SCALE : 1/16" =1'-0"

A DYNAMIC ENVIRONMENT

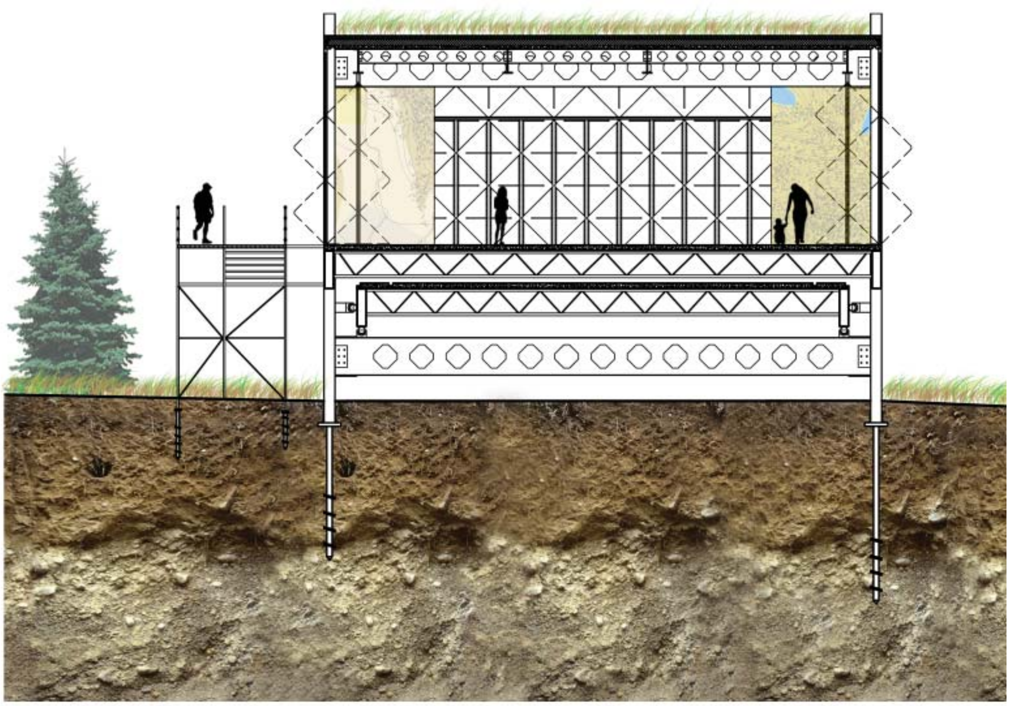


MOVEMENTS FLOOR PLAN
SCALE : 1/16" =1'-0"

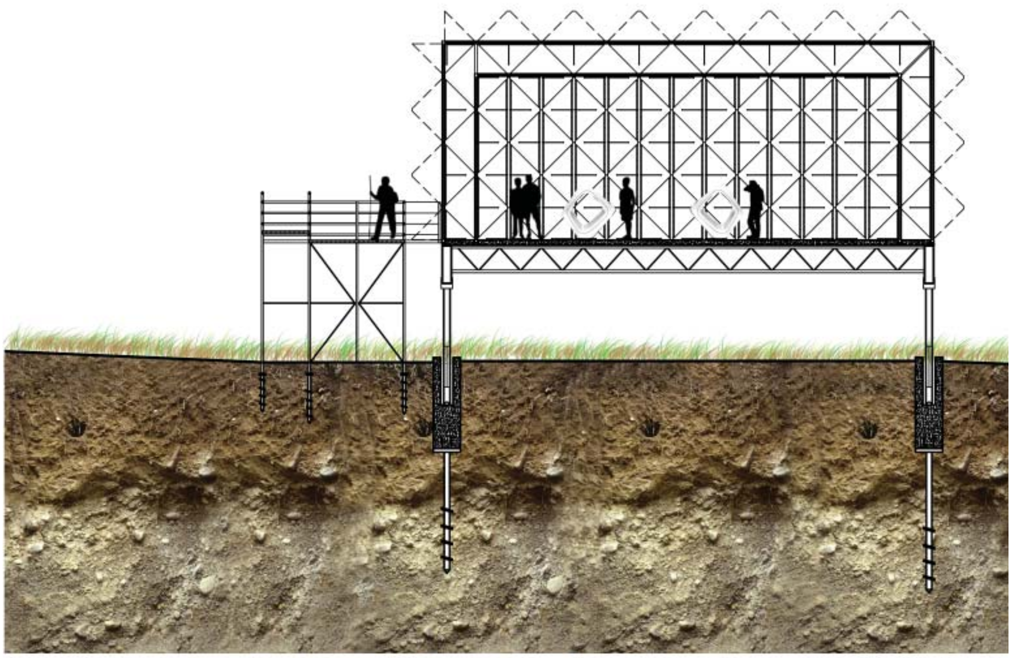
CONTRACTED SECTION
SCALE : 1/16" =1'-0"



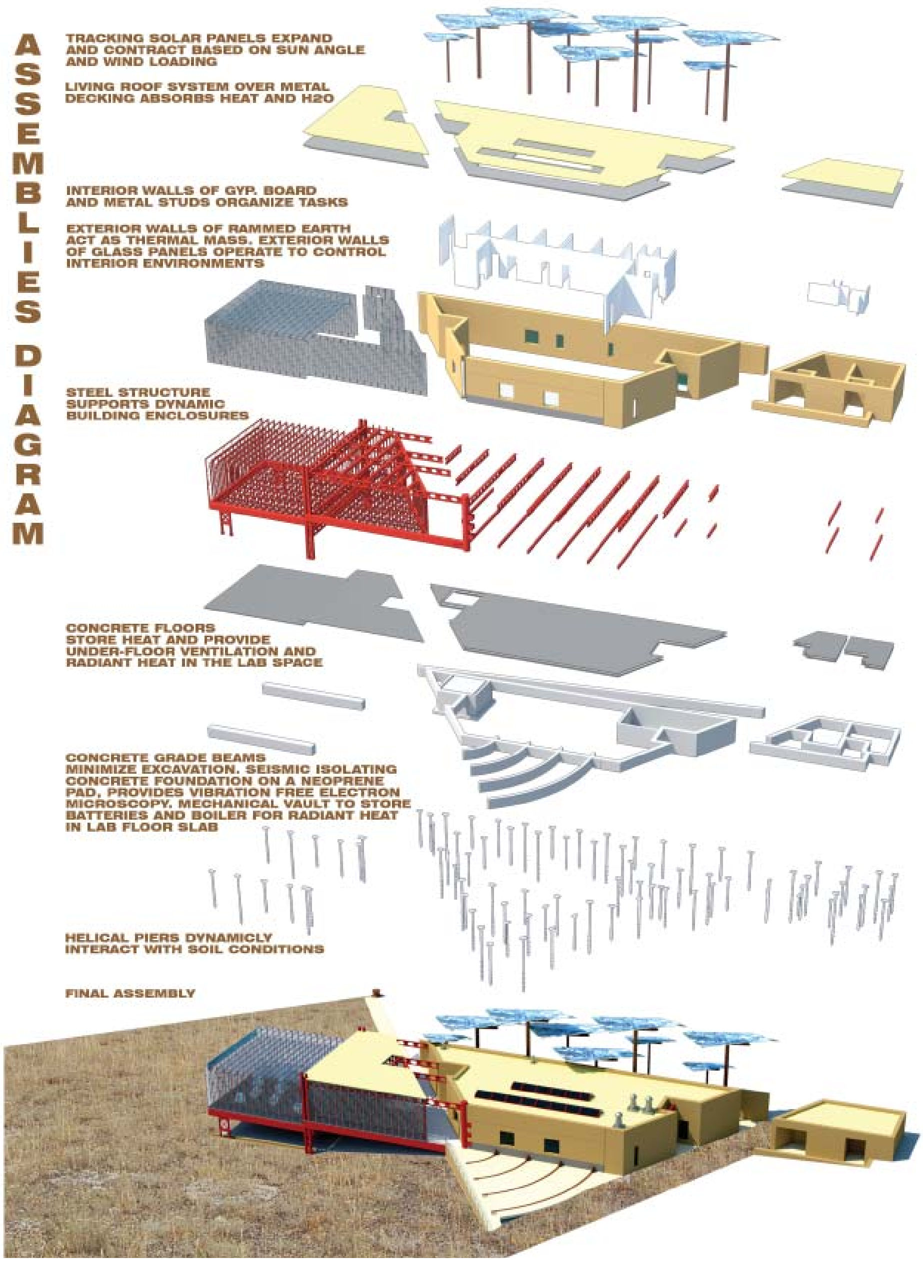
SECTION A : THERMAL LABORATORY
SCALE : 1/8" =1'-0"

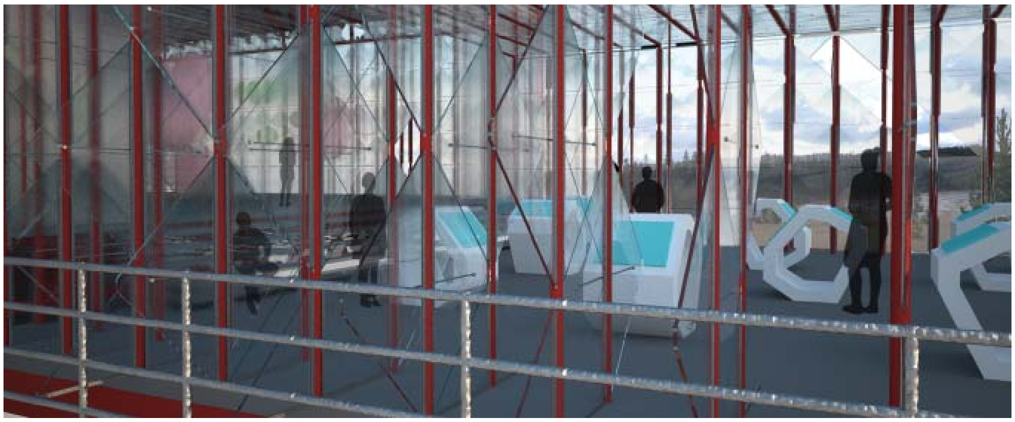


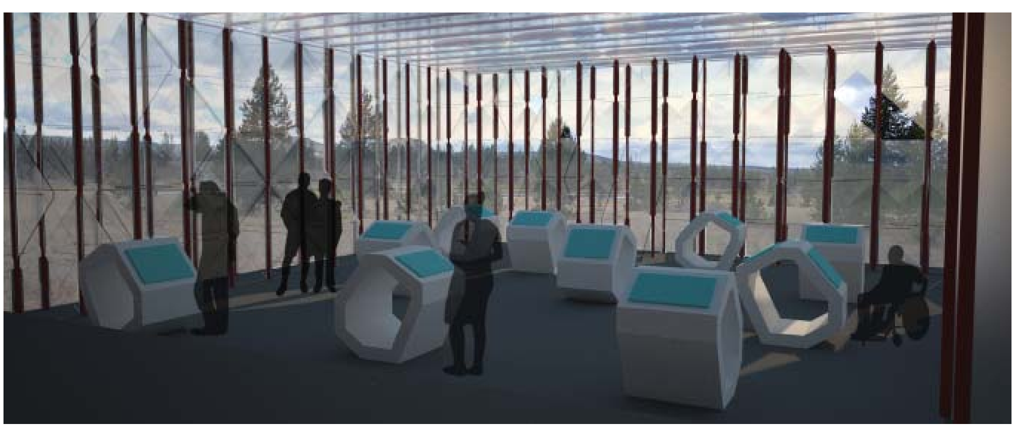
SECTION B : INTERPRETIVE SPACE
SCALE : 1/8" =1'-0"



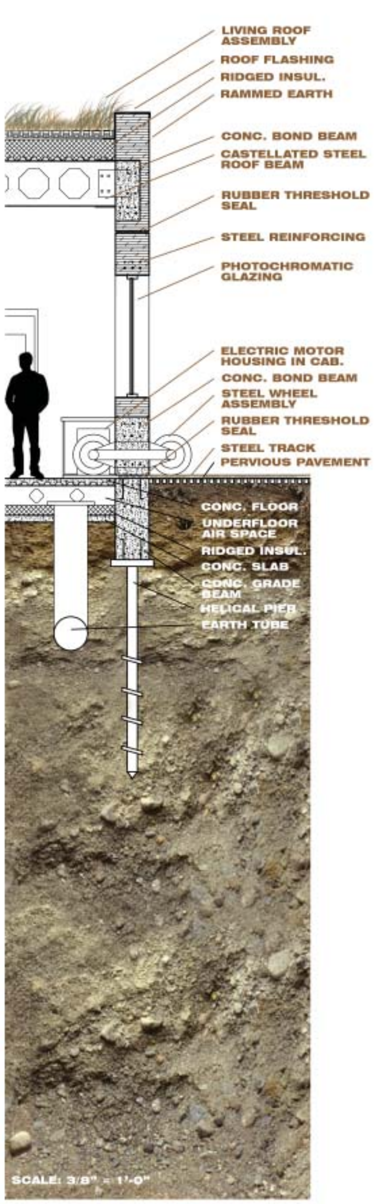
SECTION C : DIGITAL GALLERY
SCALE : 1/8" =1'-0"


ASSEMBLIES DIAGRAM
TRACKING SOLAR PANELS EXPAND AND CONTRACT BASED ON SUN ANGLE AND WIND LOADING
LIVING ROOF SYSTEM OVER METAL DECKING ABSORBS HEAT AND H2O
INTERIOR WALLS OF GYP. BOARD AND METAL STUDS ORGANIZE TASKS
EXTERIOR WALLS OF RAMMED EARTH ACT AS THERMAL MASS. EXTERIOR WALLS OF GLASS PANELS OPERATE TO CONTROL INTERIOR ENVIRONMENTS
STEEL STRUCTURE SUPPORTS DYNAMIC BUILDING ENCLOSURES
CONCRETE FLOORS STORE HEAT AND PROVIDE UNDER-FLOOR VENTILATION AND RADIANT HEAT IN THE LAB SPACE
CONCRETE GRADE BEAMS MINIMIZE EXCAVATION. SEISMIC ISOLATING CONCRETE FOUNDATION ON A NEOPRENE PAD, PROVIDES VIBRATION FREE ELECTRON MICROSCOPY. MECHANICAL VAULT TO STORE BATTERIES AND BOILER FOR RADIANT HEAT IN LAB FLOOR SLAB
HELICAL PIERS DYNAMICLY INTERACT WITH SOIL CONDITIONS
FINAL ASSEMBLY

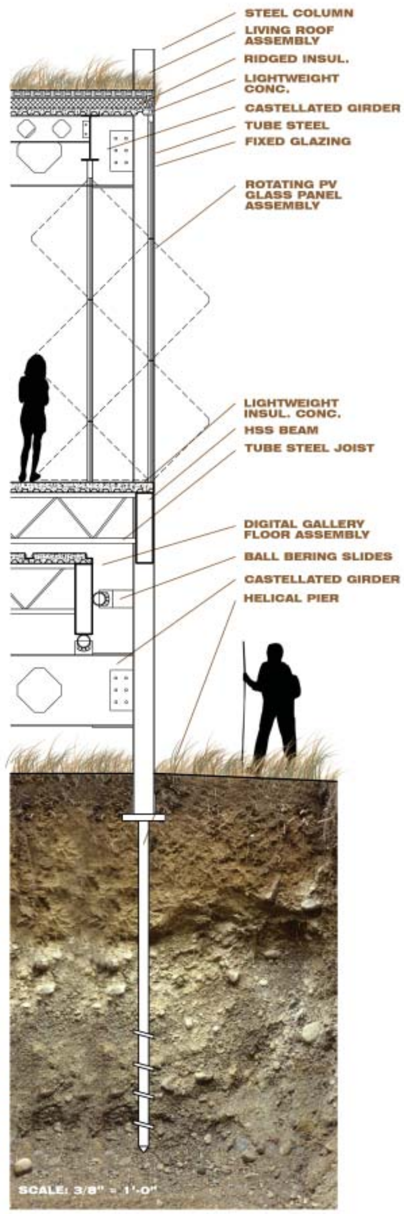




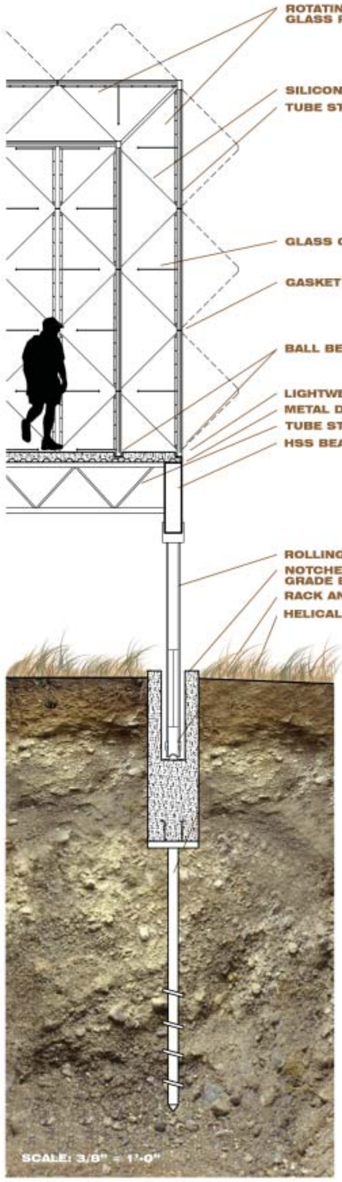
WALL SECTIONS AND DETAILS



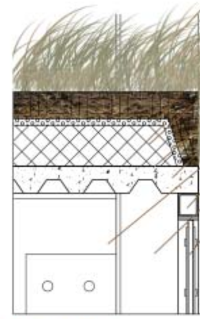
LABORATORY WALL



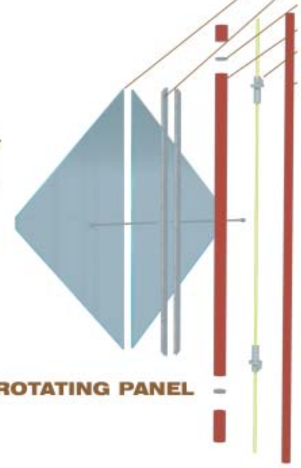
INTERPRETIVE SPACE WALL



DIGITAL GALLERY WALL



LIVING ROOF
SCALE: 1 1/2" = 1'-0"



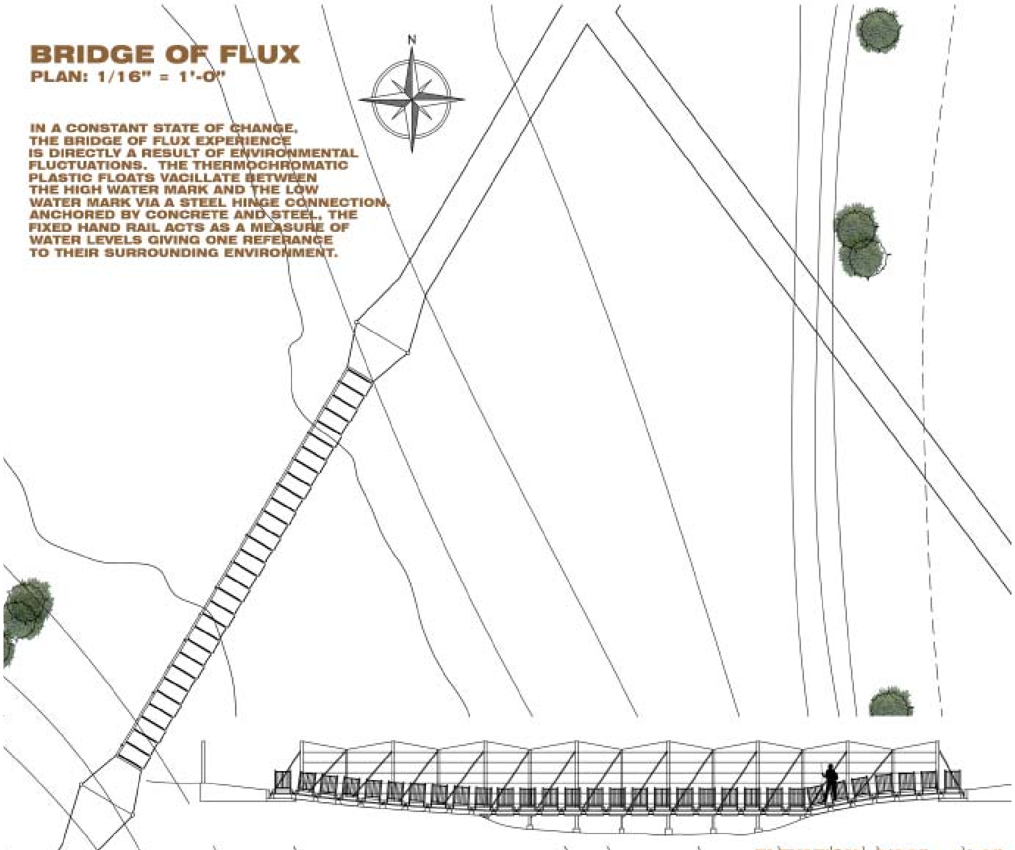
ROTATING PANEL

PERVIOUS PAVEMENT

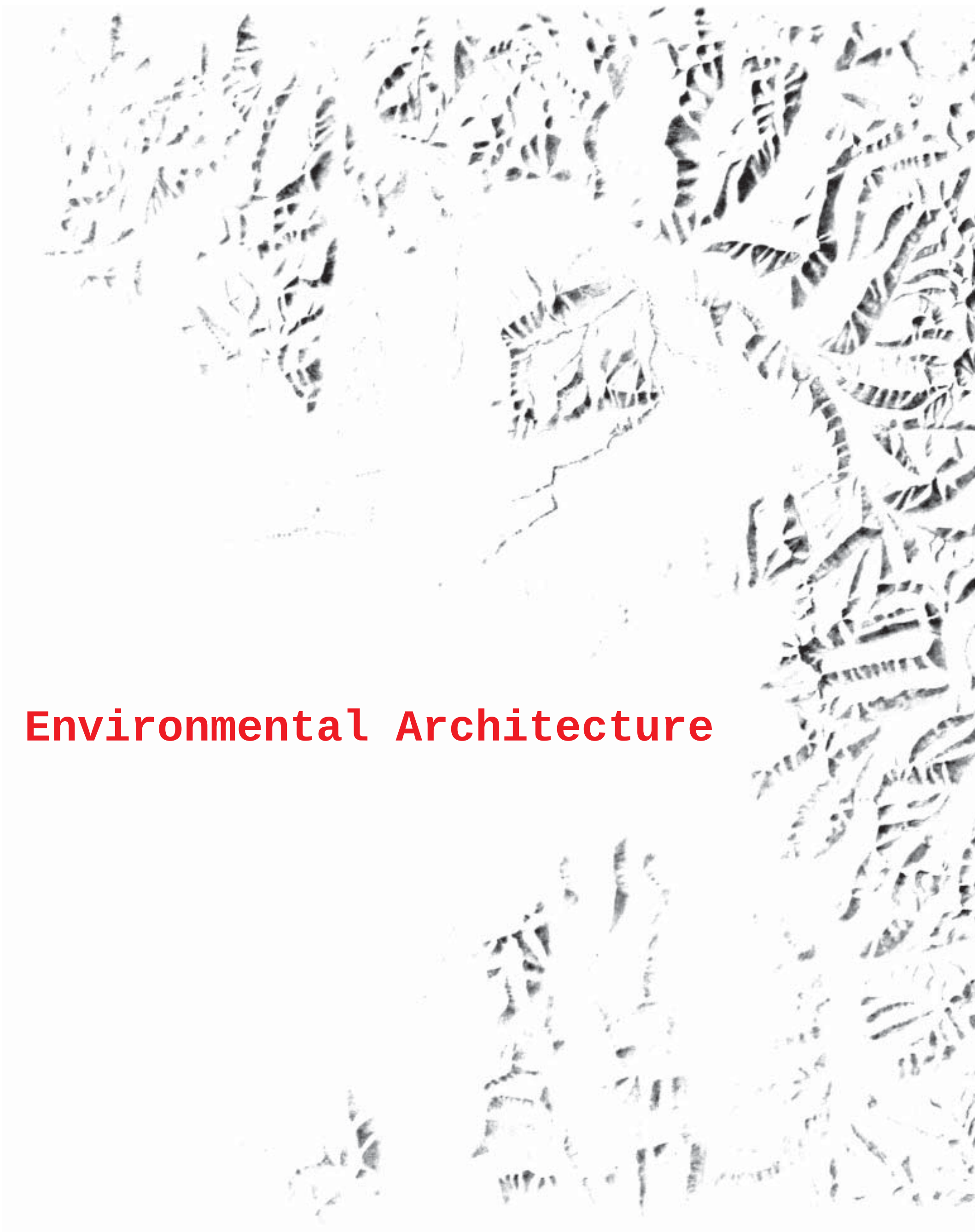
BRIDGE OF FLUX

PLAN: 1/16" = 1'-0"

IN A CONSTANT STATE OF CHANGE, THE BRIDGE OF FLUX EXPERIENCE IS DIRECTLY A RESULT OF ENVIRONMENTAL FLUCTUATIONS. THE THERMOCHROMATIC PLASTIC FLOATS VACILLATE BETWEEN THE HIGH WATER MARK AND THE LOW WATER MARK VIA A STEEL HINGE CONNECTION. ANCHORED BY CONCRETE AND STEEL, THE FIXED HAND RAIL ACTS AS A MEASURE OF WATER LEVELS GIVING ONE REFERANCE TO THEIR SURROUNDING ENVIRONMENT.



ELEVATION: 3/32" = 1'-0"



Environmental Architecture

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