The Re-Exploration of a Mine Site – A Solar Bathhouse and Passive Water Treatment System in the Desert

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I would also like to thank my family and friends. Without their support, this could not have been possible.

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1 INTRODUCTION

The story of the mining industry has been one of success, failure, joy, sorrow, and above all, controversy. It is a dangerous trade in which death is a real possibility for those who partake in its operations. It is an industry that extracts land from the earth and moves it elsewhere, often times displacing vegetation and wildlife. In the past, little consideration was given to the consequences of mining. However, in the 1970's, new regulations were passed in order to help alleviate the harm that mining does to the environment. Now, in the twenty-first century, mining little resembles what it was just forty years ago. The overall process is the same, however, there is now heavy focus placed on maintaining the landscape and environment during mining operations. This presents the topic of reclamation – the process of returning a landscape back into its original character. Exploring a thesis that is framed within a mine site offers numerous opportunities in the relationship between architecture, the landscape, the environment, and humans.

Thesis Statement

There are currently over five hundred thousand active and abandoned mine sites throughout the western United States, and it is projected that by the twenty-third century there will be over one hundred thousand square miles of post-mined landscape. There are many opportunities to explore new, innovative ways to reclaim and re-use these modified landscapes. The Lone Tree mine, an open pit, hard rock gold mine located in the Great Basin Desert in Northern Nevada, is one such landscape with its operations ceasing in 2006. The open pit, a hole roughly one and one-quarter miles long by one-half of a mile wide, and one thousand feet deep, is now filling up with ground water. Due to the mining operations, this ground water becomes acidic when it comes into contact with the surface of the pit wall making it unsafe for animals and humans.

The current acidity of the water is inhibiting the site from having any meaningful use. Remediating the water decreases its negative impact on the local ecosystem, while also allowing human interaction with the site. Creating a destination that explores innovative water reclamation in the context of a decommissioned mine provides an educational opportunity for visitors that encourages interaction with the landscape. This project acknowledges the significant role mining has played in Nevada's history, while acting as a precedent for creative post-mine land use.

By utilizing the inherent features of Nevada, and in particular, this site, this project introduces a system to neutralize the acidic lake water, and draw people into the site to gain a better understanding of the relationship between the land, water and the sky. This project is an opportunity to re-imagine what post-mining land reclamation can be. It uses land reclamation as an opportunity to integrate a functional design into the landscape, while simultaneously mending that landscape.

This thesis explores the relationship of land, water and sky – all of which are uniquely present on this site – it examines ways in which the architecture can reinforce these relationships, as well as isolate each of these elements. Earth isolated; sky isolated; water isolated; earth's relationship with water; earth's relationship with the sky; sky's relationship with water – are all explored.

2 SCOPE

There are four primary phases in the surface mining process: exploration, extraction, milling and processing, and reclamation. Each of these phases plays a key role in the mining process, and are present in almost every mining operation. The first phase, exploration, encompasses all the actions a mine takes to find new gold deposits. This can include drilling for core samples, examining soil samples, and estimating potential deposits based on existing deposits, usually with the aid of computer modeling.

The next phase, extraction, is probably the largest phase in terms of scale and production. Extraction methods can vary from site to site, but generally consists of removing waste rock material, drilling and blasting, and the moving of the gold-rich ore to the milling and processing facilities. With surface mining, the gold deposits are typically microscopic and invisible to the naked eye. Retrieving this gold requires the removal of a large amount of earth as the gold is scattered throughout the ground. Often times, there is a large amount of waste material – earth that contains little to no gold – present above the gold deposits. This material must first be moved to another location before the drilling and blasting of the gold-rich material can be done. Once the waste material has been taken care of, hundreds of holes are drilled in a specific pattern, loaded with an explosive, and then detonated in order to break up the earth into manageable pieces that can be moved by excavators and haul trucks. The large scale shovels scoop up the ore and place it into large haul trucks, which then transport the material from the open pit to the milling facilities.

The milling and processing phase can vary widely, and includes the most steps. There are two primary methods: one for high-grade ore, or material with a high concentration of gold; and one for low-grade ore, or material with a low amount of gold, that contains enough gold that it is economically feasible to retrieve it. For the high grade ore, this phase consists of crushing and milling the material, mixing the material with water to create a slurry, introducing cyanide to extract the gold from the host material, retrieving the gold from the cyanide solution, and finally refining the gold for use in the open market.

When the ore arrives at the milling and processing facilities, the rock ranges from gravel-size to boulder-size. In order to maximize the recovery of the gold, this material must be milled down to a fine powder. The first step is to crush the material into pieces about the size of a basketball. Then, the material enters into a series of ball mills which are large steel drums filled with various sized steel balls. There are typically three ball mills: the first mill takes the basket-ball-sized rocks and turns them into gravel-sized; the next mill grinds the gravel-sized material into the consistency of sand; and the last mill turns the material into the consistency of talcum powder. After the milling stage, the powder is mixed with water and a dilute cyanide solution is introduced (BCS Incorporated 7-3 – 7-4).

The cyanide leaches the gold particles from the host rock material. Next, the cyanide solution containing the gold enters into the carbon in leach (CIL) circuit. The CIL circuit consists of multiple large tanks that mix the gold-rich solution with small pieces of carbon. The porous carbon absorbs the gold particles from the solution, and this carbon is placed into a carbon elution chamber, which removes the water. Caustic soda and cyanide are then passed through the chamber to remove the gold from the carbon resulting in a solution with a high concentration of gold, called the pregnant solution. Next, the pregnant solution is moved to electrowinning cells, in which an electric current is passed through the solution causing the gold to coat steel cathodes that are immersed in the solution. The cathodes are then rinsed, and the gold is collected and taken to the refinery to be smelted and poured into gold bars. Throughout this process, the water, cyanide, carbon, and other components are recycled and reused whenever possible (BCS Incorporated 7-4 – 7-9).

The low grade ore is taken to the heap leach pad, which is a contained area where the material is dumped to create a tiered hill. A dilute cyanide solution is sprinkled over this hill, and as the cyanide passes through the material, it leaches the gold from the host material. It then joins the gold-rich cyanide solution from the high-grade ore process that is described above (Heinen et al. 7-9).

The final stage of mining – reclamation – is one of the primary focuses of this thesis and will be discussed in great detail.

Post-Mining Land Use and Reclamation

> "Man can actually improve on nature. In my opinion, the human use of natural resources and of technology is compatible with ecological health, and can indeed bring out potentialities of the earth which remain unexpressed in the state of wilderness."
>
> -Rene J. Dubois (Cole 8).

Reclamation is an integral part of the mining process, and one that is a process itself. There are many different variations on the definition of reclamation. The State of California Department of Conservation defines mine reclamation as the "process of maintaining water and air quality, minimizing flooding, erosion and damage to wildlife and aquatic habitats caused by surface mining. The final step in this process is often topsoil replacement and re-vegetation with suitable plant species" ("Mine Reclamation"). In his book, *Landscape and Surface Mining: Ecological Guidelines for Reclamation*, Gerhard Darmer states that "the concept of reclamation combines all measures needed to make surface mined landscapes productive and visually attractive again" (1).

This notion of reclamation is most often economically engineered and focuses solely on the environmental issues of the site. Often times mines develop some sort of concurrent reclamation plan in which the reclamation process is carried out in areas of the mine that are no longer active while operations are still going on elsewhere on the site. For open pit mines, the reclamation will include the filling in of the pit, grading of any man-made hills that were a result of the mining operations, resolving any water drainage issues so as to not negatively impact the new landscape, and adding a new layer of topsoil for the reintroduction of natural vegetation. What has just been discussed is the most basic and essential form of mine reclamation, and is traditionally the route that most mine sites take. There are, however, instances when the use of a mine site has gone beyond the scope of basic reclamation.

Alan Berger is a leading scholar and facilitator on the topic of design and reclamation. He is an Associate Professor of Landscape Architecture in the Graduate School of Design at Harvard University. He is also the founder and director of the Project for Reclamation Excellence, also known as P-REX, at Harvard University. P-REX is a collaboration between designers, researchers, environmentalists, and scientists on the topic of design's role in reclamation. This project's goal is to raise awareness of the rising amount of post-mined landscapes that exist in the world, as well bring attention to the multitude of opportunities that lie in these altered landscapes.

In his book, *Designing the Reclaimed Landscape*, which is a collection of articles by various individuals ranging from landscape architects, engineers, environmental researchers, mining professionals, scientists, and the like, Alan Berger recognizes the need for design professionals to address the scarred landscapes created by the mining process, establishing a connection between post-mining land reclamation and design. There are over five hundred thousand active and abandoned mines throughout the western United States scattered over millions of acres of land. Based on current production rates, a majority of the currently active mines will cease operations by the twenty-third century resulting in an enormous amount of land that has been disturbed by mining activity. In fact, it is predicted that there will be around one hundred thousand square miles of post-mined landscape at this time (Berger xvii).

This means that there is a great amount of opportunity for the design industry – landscape architects and architects alike – to explore new ways of utilizing and reclaiming this altered land. Alan Berger believes in this notion saying that "reclamation, design, and the environment could mutually benefit one another" (xvii). He goes onto say that "reclamation is not solely a 'landscape' or 'engineering' issue. It is a large-scale design issue that affects environmental systems and the life supported by them. Most importantly, reclamation can act as a laboratory for experimentation" (xvii). Mined landscapes present unique opportunities for architectural exploration and discovery, as well as opportunities to explore the relationship between the architecture, landscape, and the environment.

The current reclamation plan for the Lone Tree mine site is that of the more traditional method. It consists of allowing the open pit to naturally re-fill with water, re-grading the man-made hills to make them more hospitable for the wildlife, and re-introducing natural vegetation. This site possesses unique qualities and opportunities that the current reclamation plan does not take advantage of. The landscape that the mining process has formed offers insights into the mining process and the land itself.

The carving away of the ground in this particular site has created a condition in which the relationship between land, water, and the sky become extremely apparent. Land was removed, water was removed, the site's profile against the sky was manipulated and changed; and now with the mining operations ceasing, the water is filling this large void resulting in the creation of a lake. A new relationship between earth, water, and sky is being formed, slowly over time, as the water reclaims its natural state on this site.

There have been many examples of unique uses for decommissioned open pit mine sites. Some examples include turning the mine site into a botanical garden, boy scouts church, a lumber production facility, a rainwater runoff control facility, an amusement park, a land fill, a mining museum, a model airplane airport, a motorcycle park, a municipal water supply facility, a history museum, a prehistoric animal museum, a sanitary landfill, a sewage sludge disposal facility, ski slopes, a sportsman's clubs, a storage facility, a summer camp, tourism, a vegetable garden, and a vineyard. (Meyers 15).

As has just been illustrated, there have been organizations and people in the past that have developed creative visions for an old mine site. Some of them are more practical and linear in their conversion from a mine site to a landfill or sewage disposal facility, for example; and, some of them have been much more creative, such as using the site as a ski slope or vineyard.

Figure 1: Image of Pit Lake from the West

The Relationship between Landscape, the Environment, and Design

> "Man is a singular creature. He has a set of gifts which make him unique among the animals: so that, unlike them, he is not a figure in the landscape – he is a shaper of the landscape. In body and in mind he is the explorer of nature, the ubiquitous animal who did not find but has made his home in every continent."
>
> -Jacob Bronowsky (Kastner 11)

There is one truth when examining the landscape, environment, and humans. Humans, since the beginning of time, have had a unique relationship with the land and environment. The land provides the resources necessary for survival; it provides the wood, rock, and metals to build shelters, and supplies the water and food that maintains human life. Humans take away from the land, and also add back to it in the form of structures, by way of manipulating the landscape to create water reservoirs, or form some sort of protection. They *design* the landscape. This is still the case today. Humans continue to change the landscape they interact with. The land is taken away or added to as needed and the sky is re-formed by structures, and each of these interventions begins to redefine the surrounding environment.

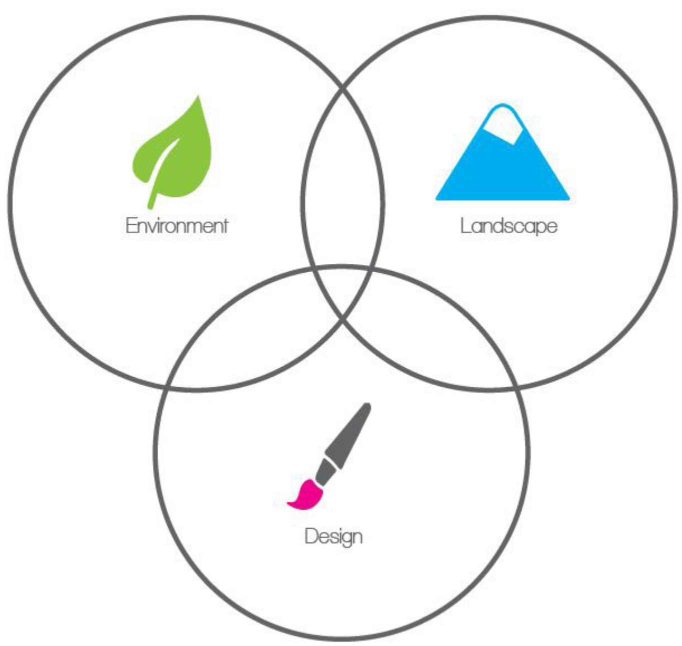


Figure 2: Relationship between Landscape, the Environment, and Design

All of these elements – the landscape, the environment, and design – are integrally related (see Figure 2). The Lone Tree mine site is a prime example of this relationship, and a place that would serve as a great example, of how this relationship can become championed and better understood. This site has undergone a significant amount of change in the last few decades. A hole one and one-quarter miles long, one-half mile wide, and 500 feet deep was created, and the material that was pulled from the ground was used to create new man-made mountains.

Additionally, with the high water table in this area, hundreds of thousands of gallons of water were pumped from the area and used for processing or directed off-site. Now that the mining activity has ceased in the open pit, the water is re-assuming its place, filling up the pit. Humans have done a great amount of designing to this landscape. Now, it is time to re-design this landscape to return the harmony between its various elements. There have been numerous examples in which various types of art have been placed in the landscape to help improve the environmental condition of the land. These are interventions that serve multiple purposes: first, they exist as art in the landscape, and second they serve some environmental end.

> Humans have created forms in honor of the land and as an act of defiance against it. They have made objects to place within the sweeping vista and recreated its patterns in isolation from it; invented images variously designed to document, idealize and vilify the sometimes gentle, sometimes violent and always oblivious charms of the natural environment.
>
> -Brian Wallis (Kastner 11)

One project that exemplifies many of the ideas discussed above is a large scale sculpture called Roden Crater by the artist James Turrell. Roden crater is a 600 foot tall cinder cone that is being turned into a "monumental work of art" ("About Roden Crater"). It is located in the San Francisco Volcanic Field outside of Flagstaff, Arizona near the Grand Canyon and Arizona's Painted Desert. This project is slowly transforming the tall cinder cone into a "naked eye observatory… [it] will bring the light of the heavens down to earth, linking visitors with the celestial movement of planets, stars and distance galaxies" ("About Roden Crater").

The Roden Crater project involves the large scale design of a unique natural landscape, and is tackling many of the same issues that this thesis is examining. Specifically, it is exploring ways in which a large scale site can be developed using smaller scale, more human-measured interventions. Despite the fact that the site covers many acres, and is 600 feet tall, Turrell is attempting to create spaces for human interaction with the metaphysical – a very lofty goal, but one that is worth investigating in light of this thesis. He is doing this by creating spaces that explore how a place can influence or direct a person's visual perception ("About Roden Crater"). He is essentially creating rooms that direct the visitor's attention in some way – to the sky, to the distance, or to what is near – and he using light and space to do so (see Figure 3).

Figure 3: Images of Roden Crater

Acidic Water Treatment and Neutrilization

There are numerous methods for the treatment of acidic water, some passive and some active. Additionally, there are many things to take into account when determining the appropriate method for treating acidic water such as the water's pH, acidity, alkalinity, and metal content. pH measures the amount of free hydrogen ions in water, and is represented on a scale from 0 to 14. Water with a pH of 7 is considered neutral and is neither basic nor acidic. Water with a pH lower than 7 is considered acidic, while water that has a pH above 7 is basic. Acidity measures the capacity of water to neutralized alkalinity, and alkalinity is just the opposite – it is the capacity of some solution to neutralize acidity. Metals that are commonly found in water that has come into contact with a mined landscape are iron, manganese, and aluminum (Schmidt and Sharpe 3). The chemical makeup of the water will determine the measures that must be taken in order to effectively neutralize the water so that it can be safely used by humans and animals.

In order to address water that has a high acidity level, the alkalinity must be increased. This is most commonly done by dissolving substances with high levels of calcium carbonate, such as limestone into the water. Methods for addressing the acidity of a body of water, i.e. raising alkalinity levels and pH, include watershed liming, in-stream limestone sand, wetland liming, limestone diversion wells, and anoxic limestone drains (ALD) (Schmidt and Sharpe 3-11). Watershed liming is the process of dispersing calcium carbonate, in the form of limestone, on the surrounding land of a water source thereby neutralizing the water as it drains into the body of water. Studies have shown that this form of passive acidic water treatment is suitable for treating lakes (Schmidt and Sharpe 5).

In-stream limestone sand is a method in which limestone sand is distributed directly into the stream, or other body of water. The limestone dissolves and is carried downstream resulting in higher pH and alkalinity levels throughout the stream or other body of water. Wetland liming is somewhat similar to watershed liming; it is the mixing of fine limestone sand with the topsoil layer of wetlands in riparian areas. The lime-rich soil helps to neutralize the body of

Figure 4: Image of Acidic Water Treatment

Figure 5: Image of Acidic Water Treatement

water directly, as well as neutralize water runoff that is entering the body of water. Limestone diversion wells are most often used for the treatment of streams. A limestone diversion well is typically a large round concrete well that is embedded into the ground near a stream. Upstream, a small dam is constructed in order to create an elevation difference between the intake valve and well. Water moves from the dam, through the diversion well where it comes into contact with the limestone, and then gets released back into the stream. The limestone that is located within the well is slowly dissolved providing neutralization for the stream for an extended period of time (Schmidt and Sharpe 6-9). The last method to be discussed are the use of anoxic limestone drains, which are "buried trenches of limestone that receive acid mine drainage and convert net acidic water to net alkaline water under anoxic conditions" (Schmidt and Sharpe 10).

The exact makeup of the water located on this site is unknown at this point. There is documentation available, and I am waiting to acquire a copy of this information. Based on conversations with an employee who is familiar with the Lone Tree mine site, the following preliminary information has been established. The natural groundwater in this area is naturally acidic and contains small amounts of mercury. As this groundwater comes into contact with the walls of the pit, it becomes even more acidic; it also leaches certain metals from the wall's surface. Many of the methods discussed above can be utilized to treat the acidic water contained in the pit lake. It is this thesis' goal to take these methods and apply them in an innovative and creative way.

A project that demonstrates how a passive water treatment system can be implemented in the context of a mine site is the Vintondale Reclamation Park by D.I.R.T. Studio. This project, located in Vintondale, Pennsylvania, was a collaboration between D.I.R.T. Studio, environmentalists, scientists, artists, and the community. The team took on the task of remediating an abandoned mine located next to a creek. The creek was being contaminated by the remnants of the mining activity that was once going on at the site ("D.I.R.T. Studio").

One of the primary goals of this project was to demonstrate the remediation process of acidic water. This was achieved by creating a park that the public could interact with, and see the transformation of the water from “toxic orange” to clean, clear water (“D.I.R.T. Studio”). The design of this park consists of a series of eight ponds. The toxic creek water enters the system, and slowly moves from basin to basin, which neutralizes the water more and more until it is clean (see Figure 6).

Figure 6: Site Plan and Image of Vintondale Reclamation Park

3 SITE

The site for this thesis is the Lone Tree mine, which is a decommissioned gold mine that ceased mining operations in 2007. It lies just southwest of I-80 in northern Nevada between Winnemucca, NV and Battle Mountain, NV (see Figure 7). There are a number of small, rural communities located along Interstate 80 near this site. Figure 8 shows the population numbers for the significant towns and cities located along Interstate 80, and Figure 9 breaks down the population levels based on their distance from this project's site. Within a 25 mile radius of the site, there are just under 15,000 people, and within a 100 mile radius there are nearly 57,000 people.

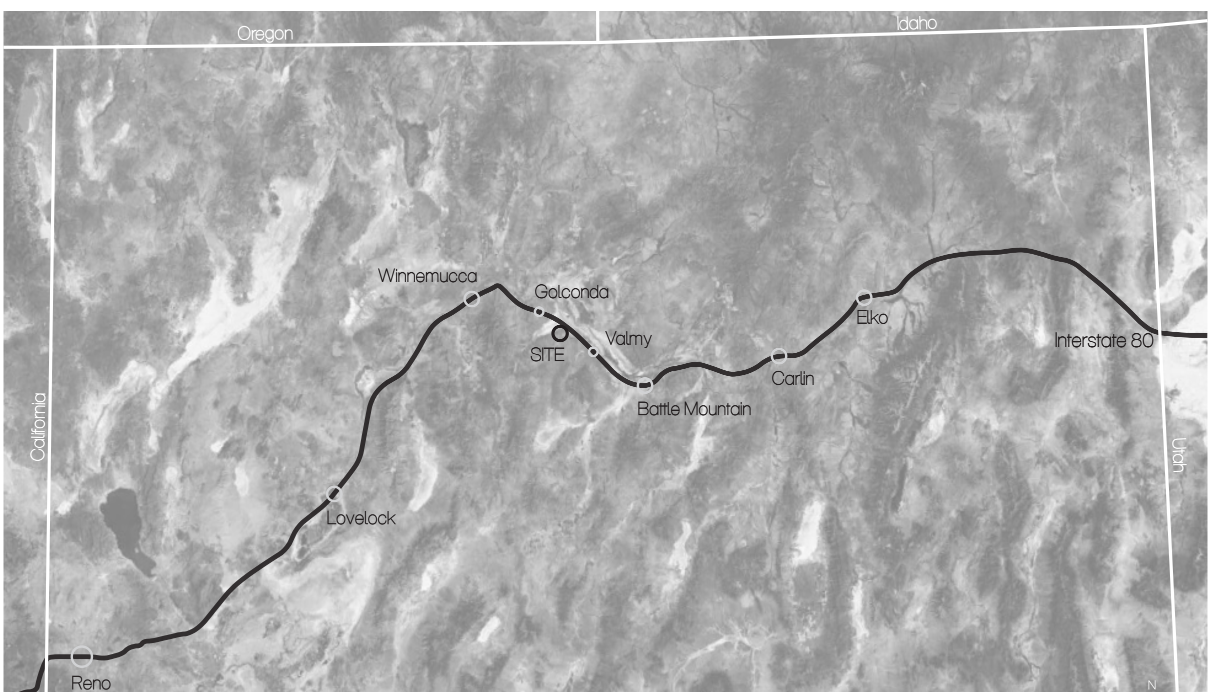


Figure 7: Vicinity Map

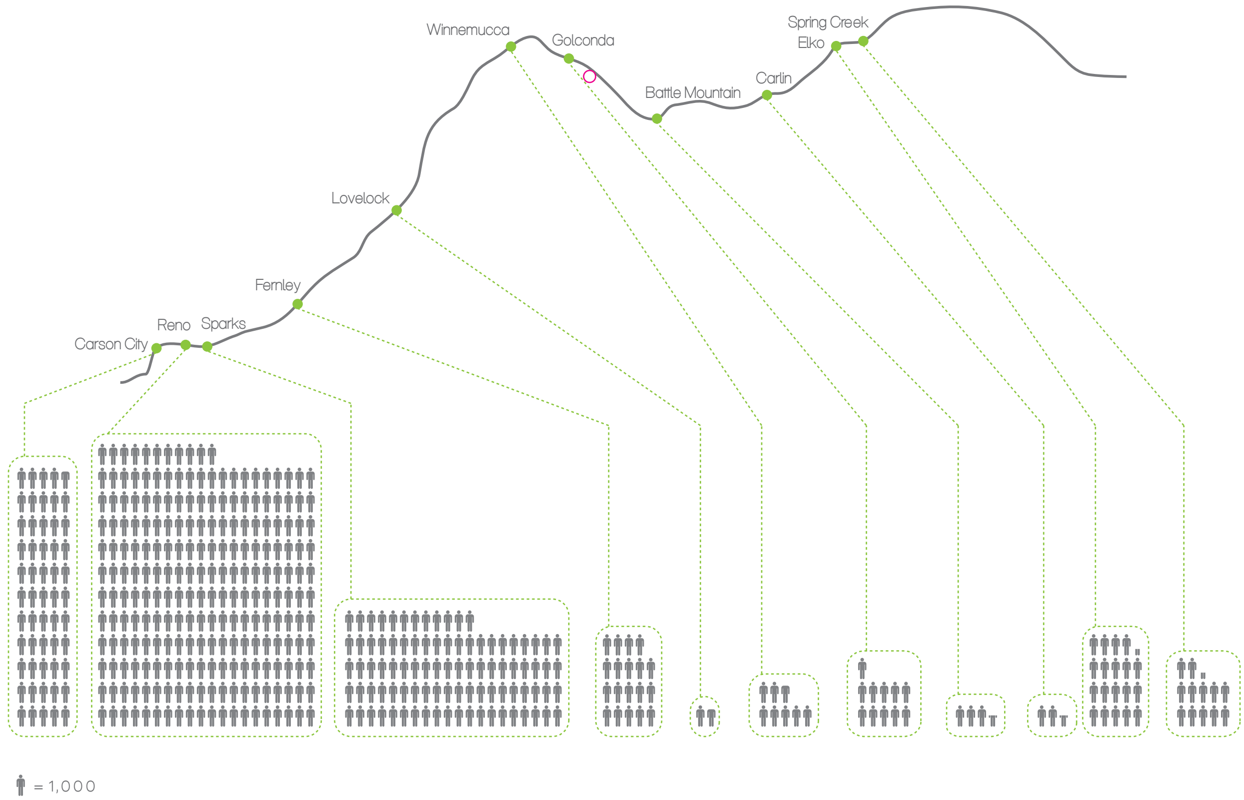


Figure 8: Population Diagram by City

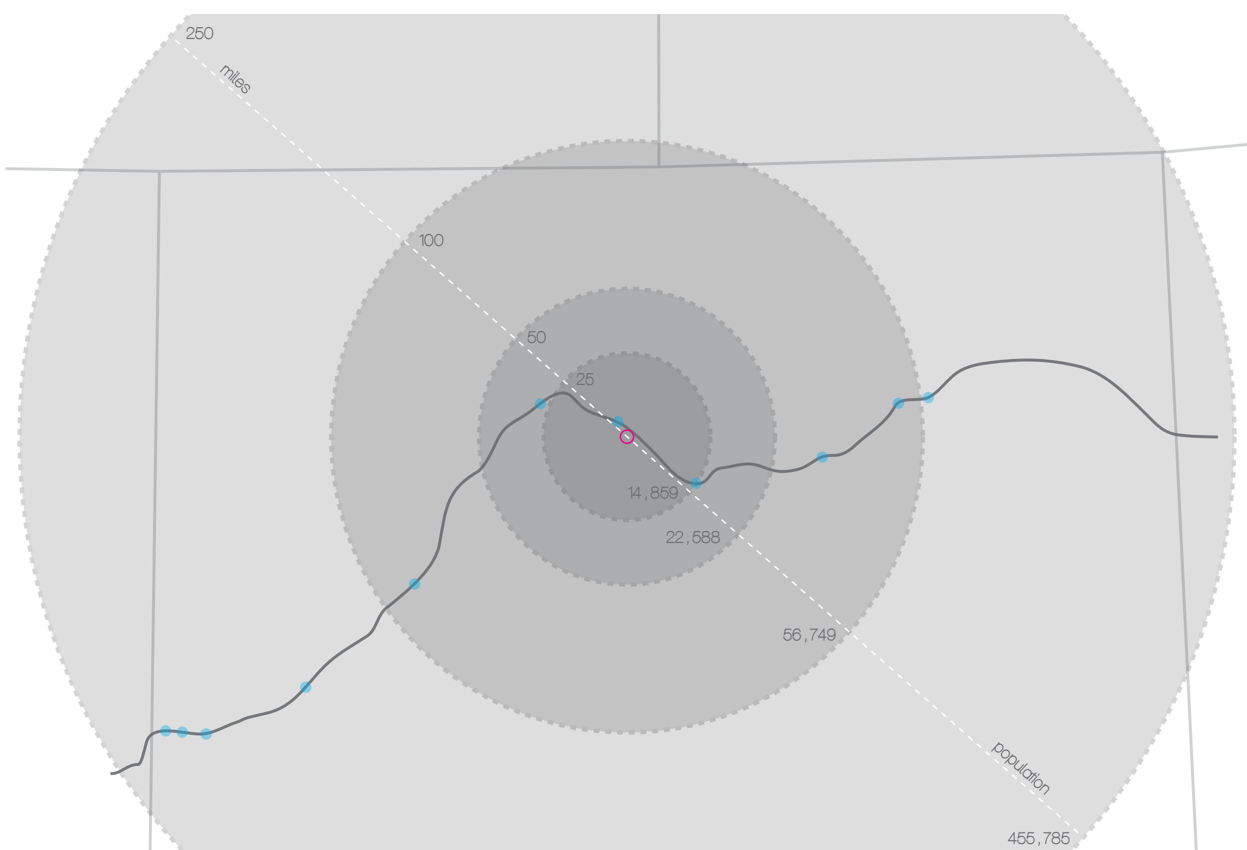


Figure 9: Population Diagram Based on Relative D istance from Site

Interstate 80 is not only the backbone for these communities, it is also a highly active avenue that connects the entire state, and even country, from east to west. As such, Interstate 80 has a very high volume of daily traffic, and Figure 10 breaks down the traffic flow for numerous stretches of I-80.

Two of the most significant elements of the site for this thesis project are the fact that it was once an extremely active gold mine, and the presence of water that is becoming more and more apparent as the pit lake fills up. Gold mining is a very important and prominent industry in the northern Nevada area; there are currently over thirty active mine sites in the area (see Figure 11). Figure 12 maps the significant bodies of water that are located along Interstate 80; the currently forming pit lake located on this site will be a new edition to this map once it has completely filled up.

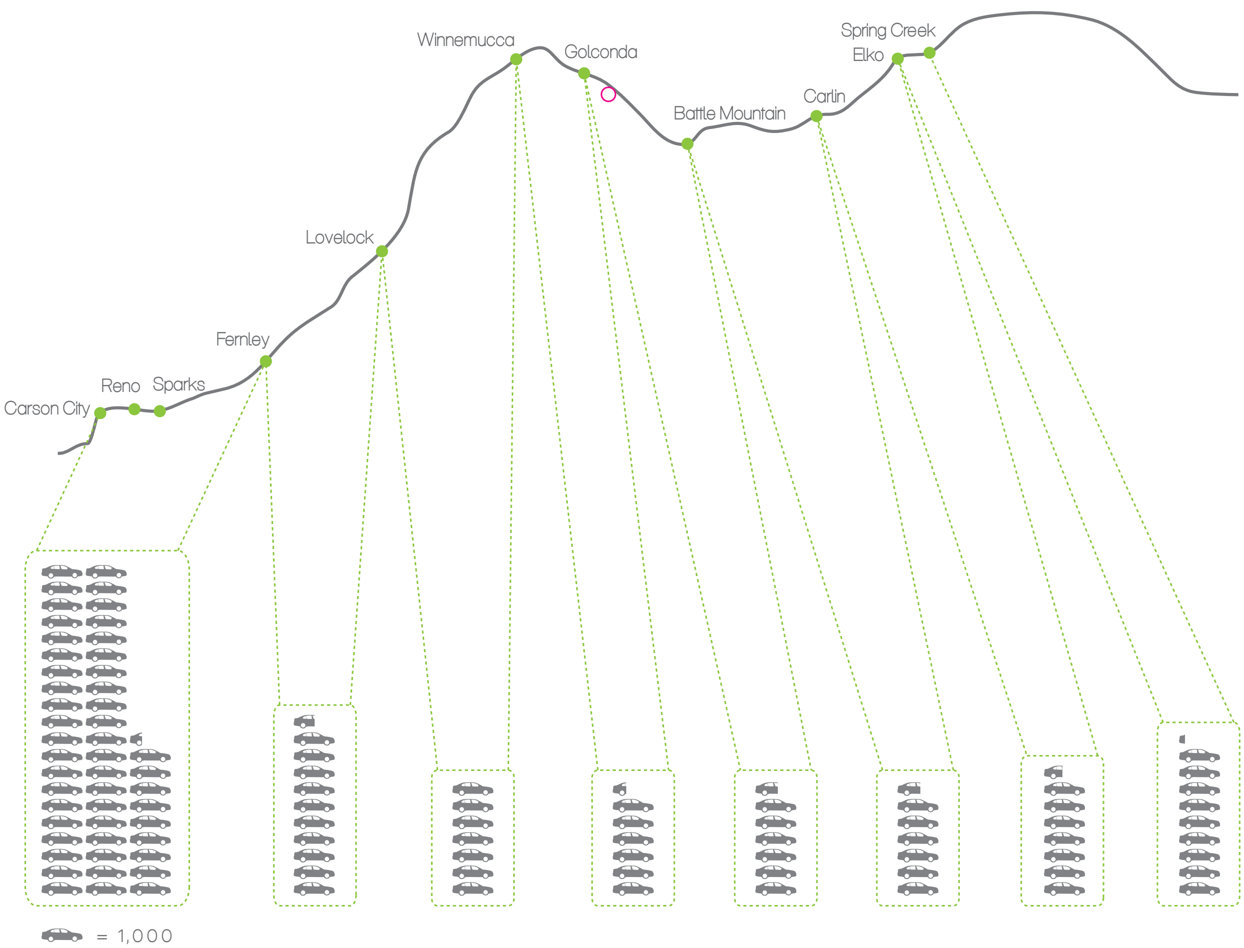


Figure 10: Traffic Flow on Interstate 80

Figure 11: Active Gold Mines in Northern Nevada

Figure 12: Significant Bodies of Water along Interstate 80

On this site, over the past two decades, hundreds of thousands of tons of earth have been removed and placed elsewhere – it has been changed by man every single day during this time. There are many distinct features about this site; central to it is the open pit, which is now filling up with water to form a relatively large lake (see Figure 13). The water table in this area of Nevada is very high, which is the cause for the filling up of the pit with water. The ground water that is present in this area is naturally acidic, and when this water comes into contact with the pit wall, the water's acidity level increases, and some metals are leached from the surface of the pit walls.

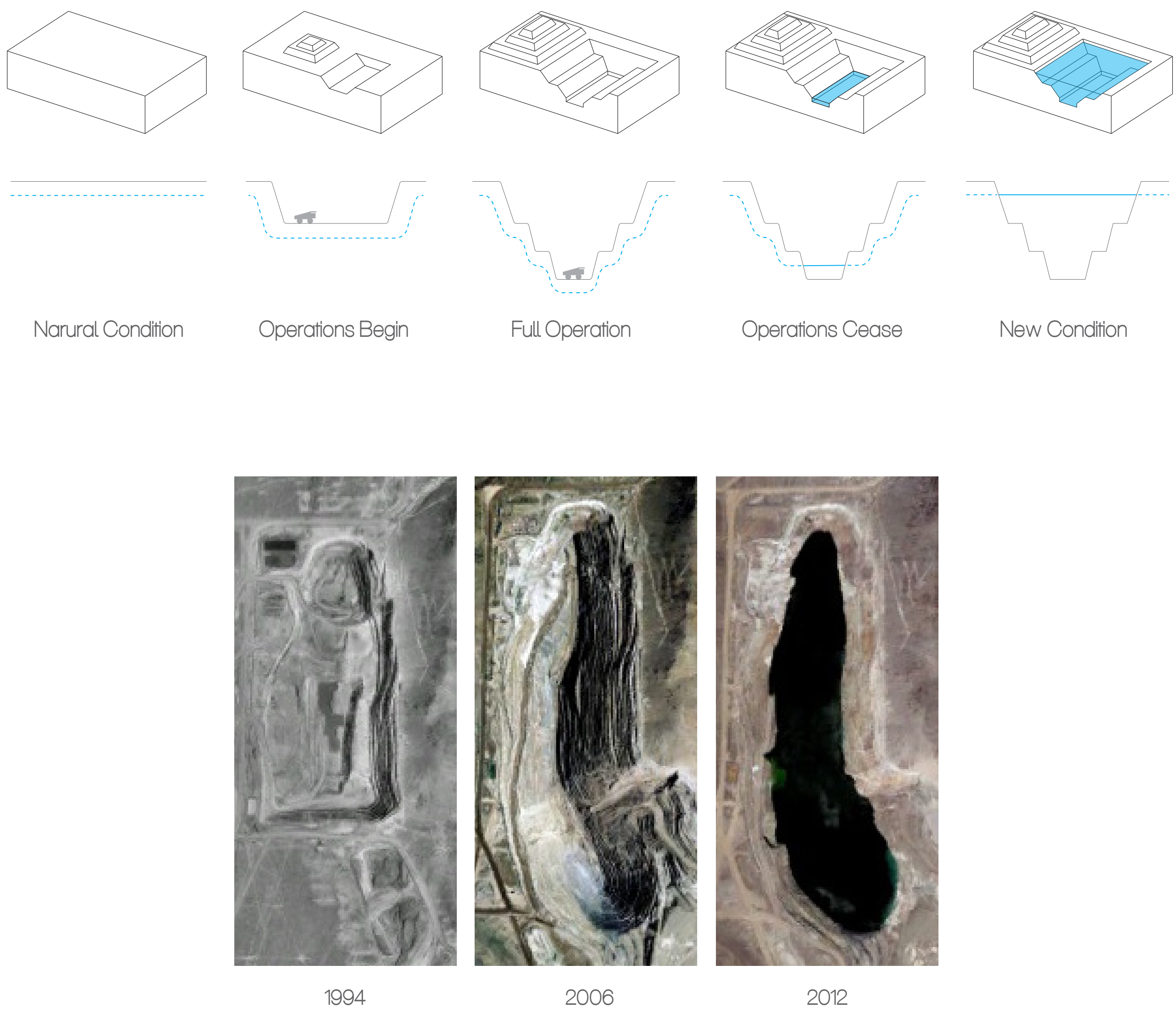


Figure 13: Life of Mine Diagram with Aerial Images of Open Pit Over Time

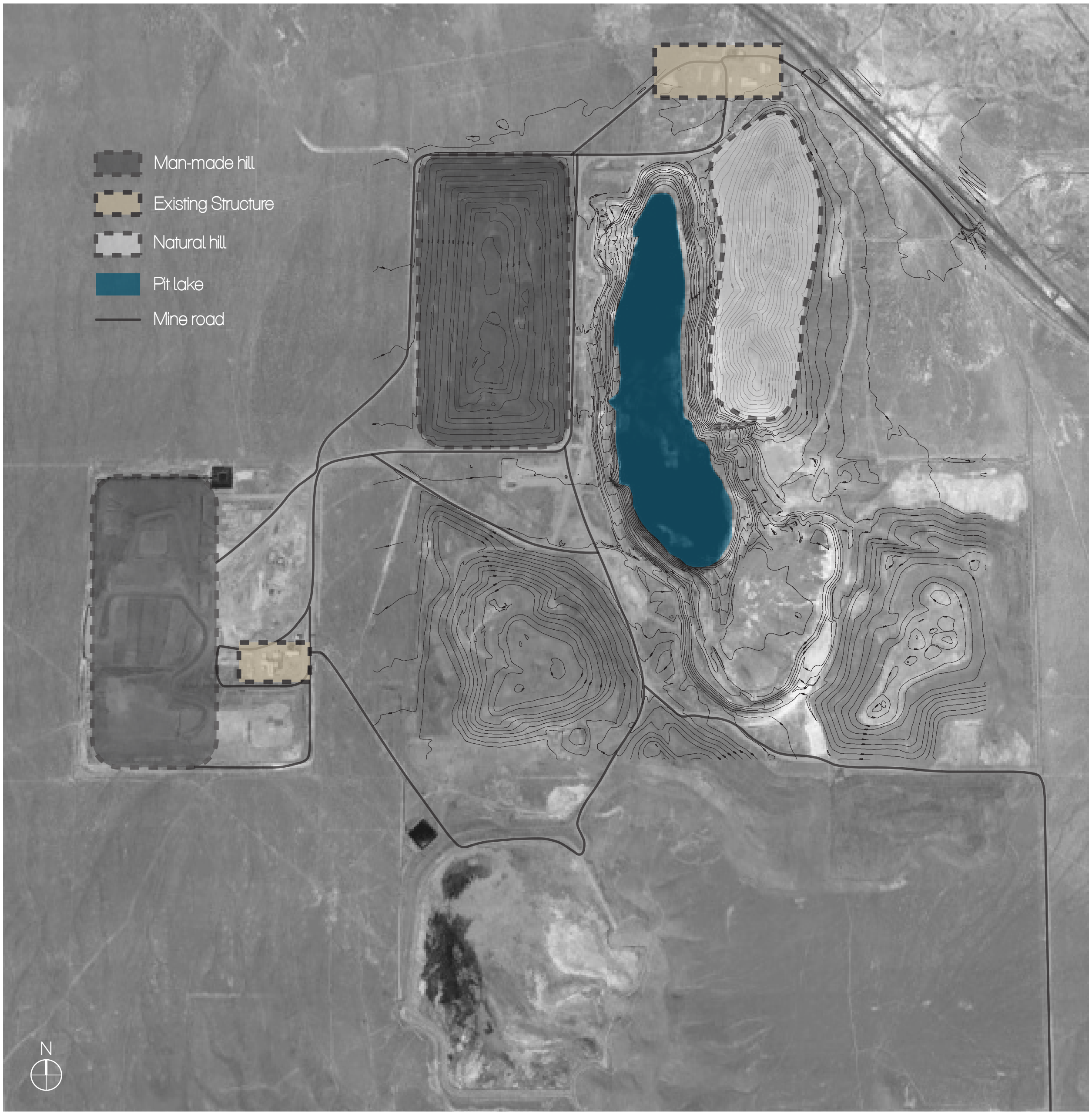


Figure 14: Site Map

Just to the east of the pit lake is a small natural hill; the west face of this hill extends down into the pit lake. To the west of the pit lake is a large man-made hill that was created using the overburden from the open pit. There is another similar man-made hill to the southwest that is a heap leach pad where low-grade ore from the pit is processed. In this same area lies the processing facilities which include a handful of structures housing the different machinery and equipment used for the milling and processing of the ore. Other architecture that is existing on this site includes the maintenance shop and administration buildings located north of the pit lake. Parts of these buildings are still in use today, although it is unclear for how long. The last element of the existing features on this site are the mine roads that wind around and connect the various components of the site. Figures 15 shows a panoramic view, looking east, of the entire pit lake. The natural hill can be seen across the lake, and the line where the natural hill ends and the terraced benches begin can clearly be seen. Figure 16 is an image of the pit lake looking south; the natural hill is located on the left side of the lake.

Figure 15: Panorama of Pit Lake

Figure 16: Image of Pit Lake

Northern Nevada possesses a unique climate. It makes up a large portion of the Great Basin Desert that spans between western Utah and eastern California. This area is classified as a high desert due to its high elevation, which is just over 4,000 feet above sea level. This area of Nevada experiences all four seasons including 100 plus degree summers, below freezing winters, and receives only around 8 inches of precipitation per year (see Figures 17 and 18). Additionally, this area of Nevada receives 227 days of sun per year, so 68% of the year there is sunshine ("Average Weather In Nevada"). Sun path and wind direction information are displayed in Figures 19 and 20. On this site, the wind blows primarily from the south and west.

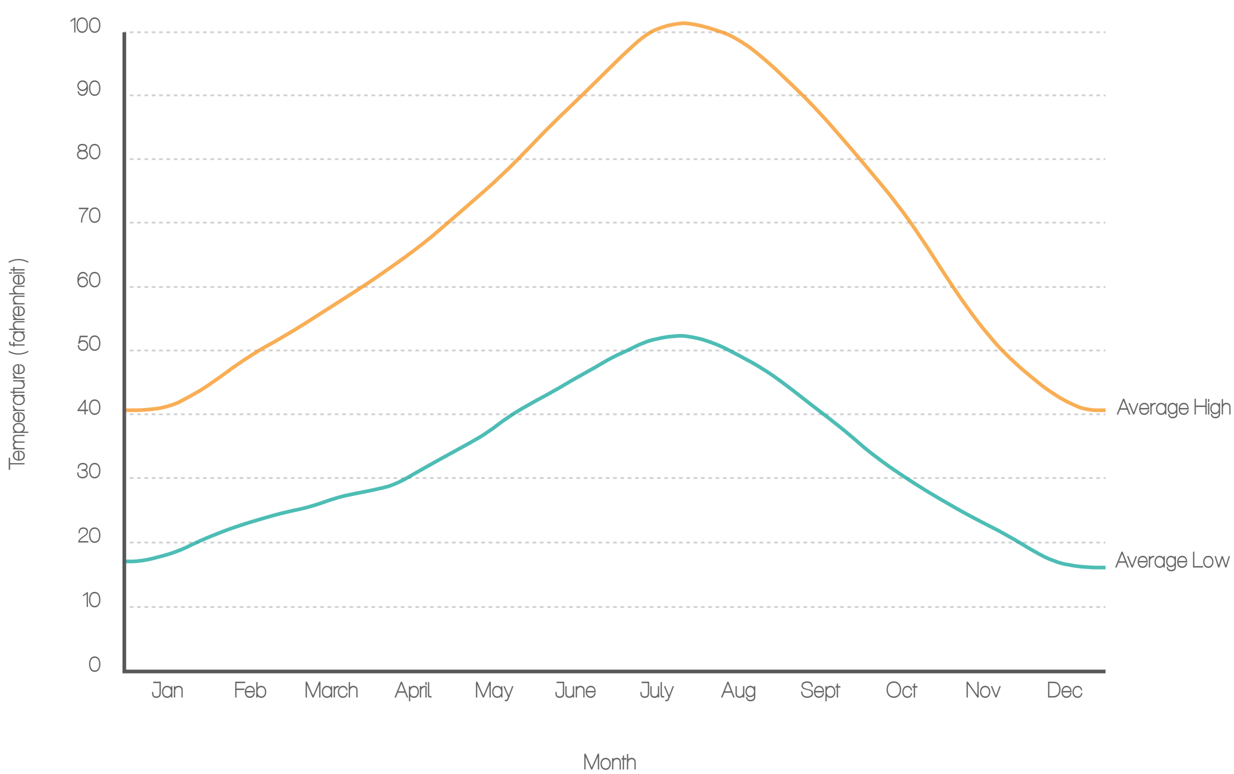


Figure 17: Average Temperature for Site by Month

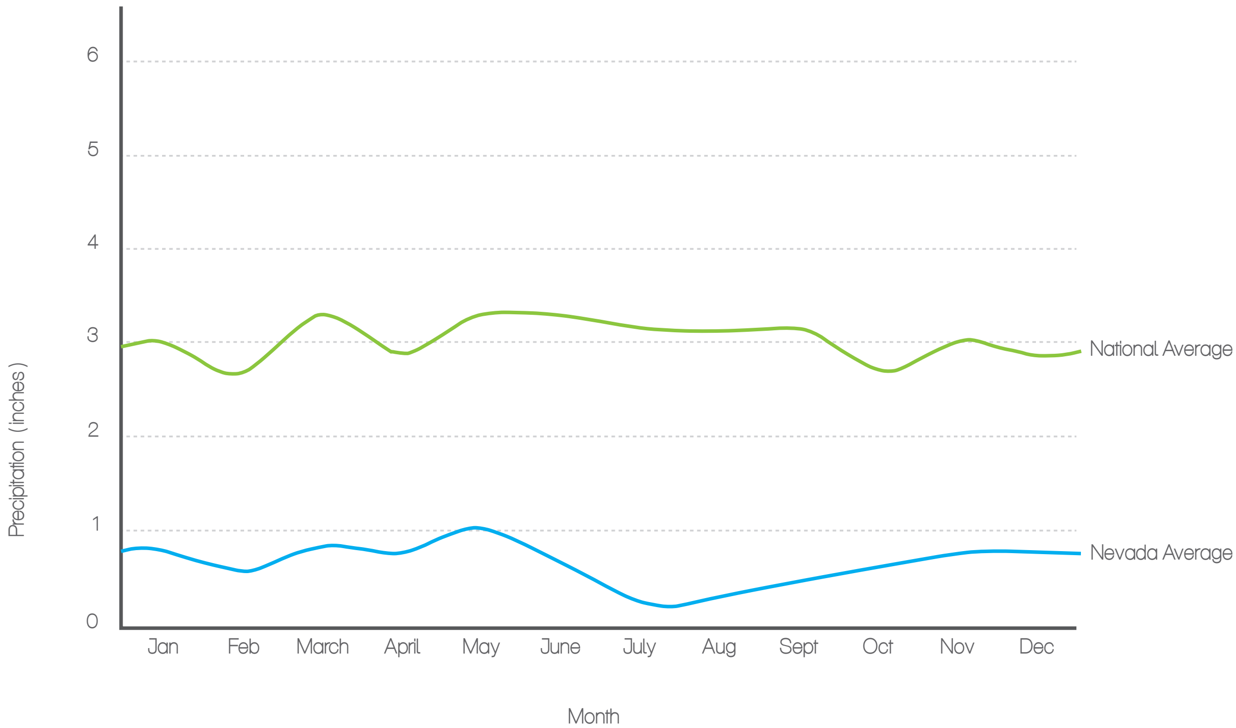


Figure 18: Average Precipitation for Site by Month

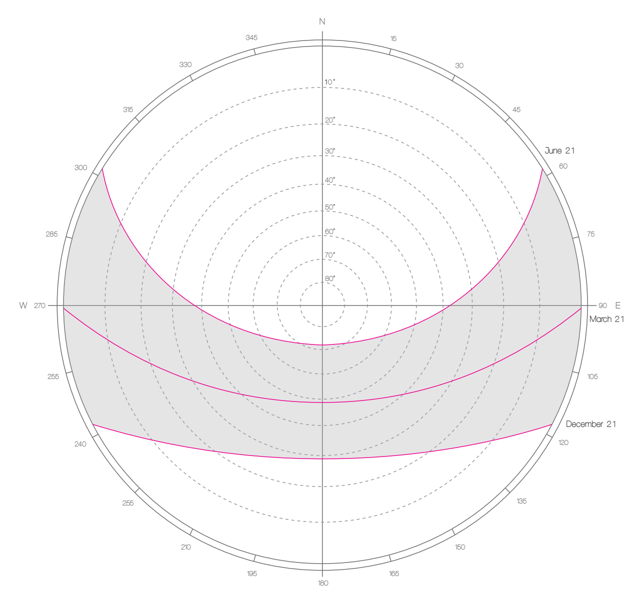


Figure 19: Sun Path Diagram

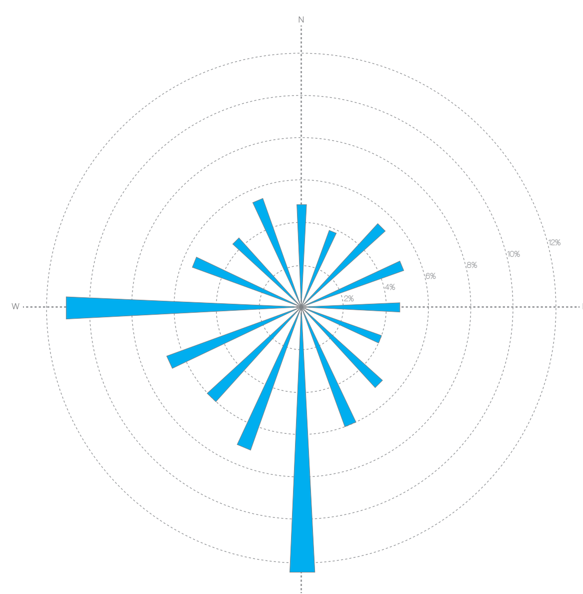


Figure 20: Wind Rose

As has been mentioned, the open pit is slowly filling up with water. As of 2012, the water level is at about 680 feet deep. By 2092, the water is projected to be 872 feet deep, which is about 95% of the pit's full capacity (see Figure 21). As the water comes into contact with the surface of the pit walls, it becomes acidic. The pH levels for the newly forming lake have varied greatly due to a number of factors, including weather, the seasons, and the measures that have been taken to neutralize the water. In fact, pH levels vary between the north end of the lake and the south end of the lake (see Figures 22 and 23). Developing a system for addressing this acidic water is a primary component to this thesis.

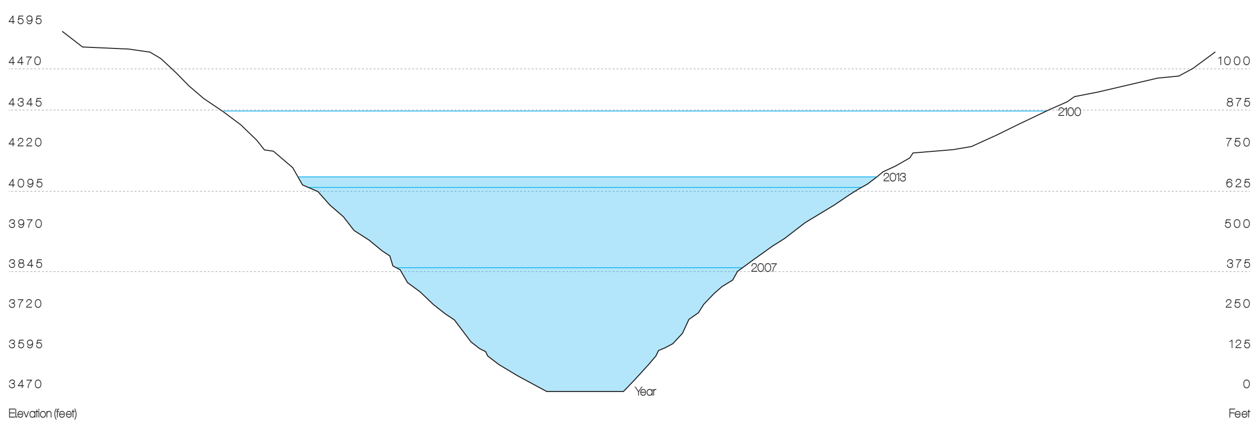


Figure 21: Diagram of Pit Lake Water Level (observed and projected)

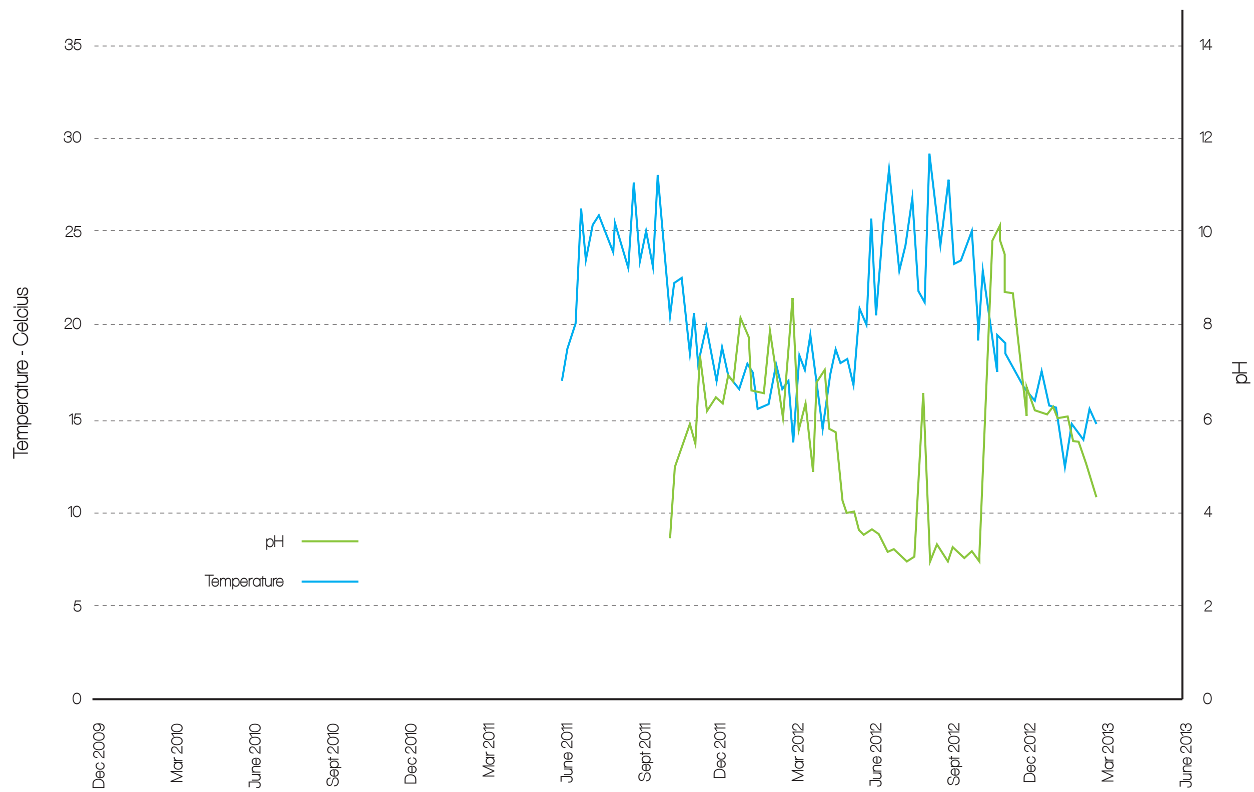


Figure 22: Pit Lake (North) Water Temperature and pH

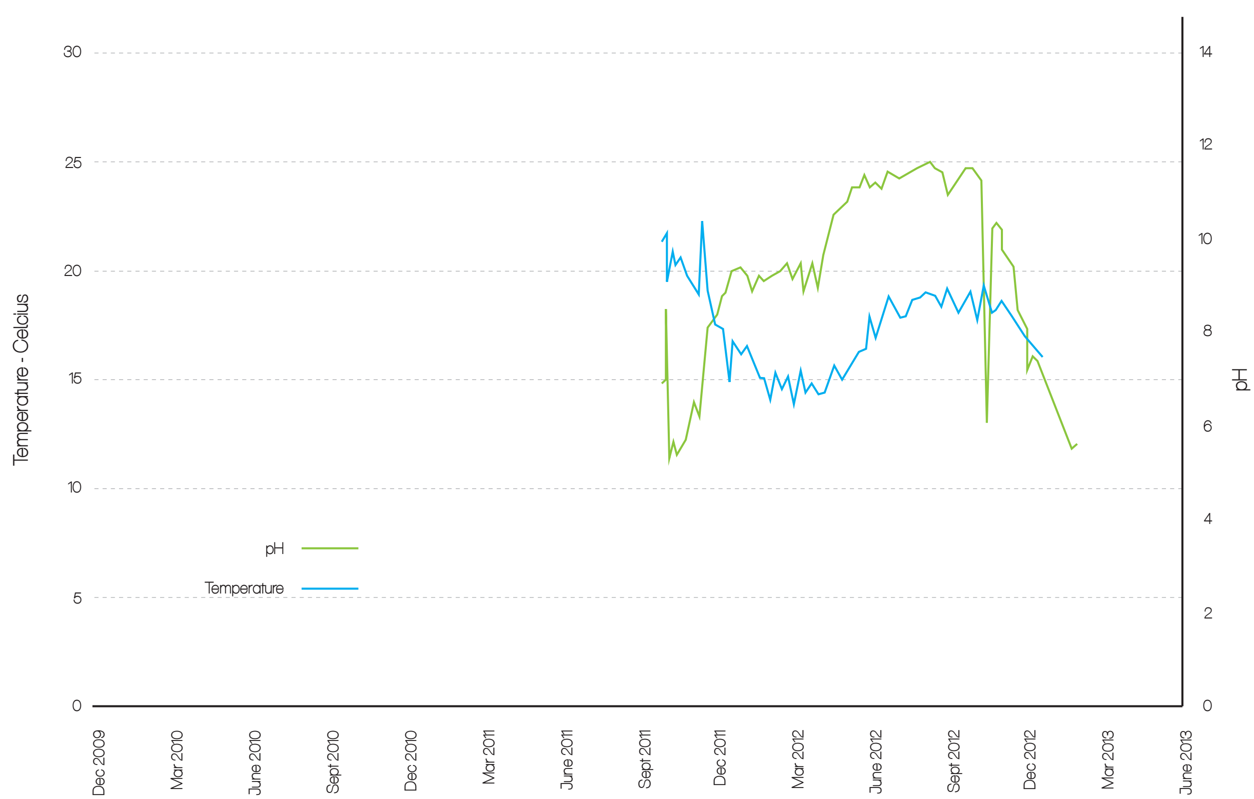


Figure 23: Pit Lake (South) Water Temperature and pH

4 PROGRAM

There are two general user groups for this project: the local communities and residents that live near to the site, and the people traveling on Interstate 80 which runs right next to the site (see Table 1). Each of these user groups have a set of needs, some of which overlap, and others that are unique to that group. Within each of these groups are subgroups, which include families (parents and children), groups of individuals, and individuals. This distinction is made here to include the needs of children – both in the local communities and those traveling with their family.

The first general group, the local communities, require a place that they can return to again and again, so the program includes elements that the visitors can play in and/or explore. They need a place to park, explore, change clothes, bathe, and eat. The second general group, the travelers, require a place to park, explore, change clothes, bathe, eat, and rest. The children require a place to play in and interact with the water. This takes the form of a series of outdoor pools that are separated from the main bathhouse pools.

The primary programmed space is the solar bathhouse. The bathhouse includes several bathing rooms including a hot water bath, warm water bath, cold water bath, an indoor/outdoor pool, an indoor lap pool, restrooms, café, and changing rooms. The other major programmatic element is the passive water treatment system which is composed of a series of remediation ponds, and circulation paths that lead the visitor from their vehicle to the bath house. These

Figure 24: Image of Boat on Pit Lake

ponds and paths act as an interpretive and educational experience that reveal to the visitor what is currently going on at this site. As they move through the water remediation process with the water, they gain a better understanding of the water remediation process that is occurring on this site. Additionally, throughout the paths, there are points of rest that reveal information about the mining process, and history of the mine site. Tensile photovoltaic fabric is used to create shading structures that cover a majority of the paths and ponds to help reduce the amount of evaporation, and heat gain visitors will experience in the summer time.

The overall process that is introduced on to the site is as follows: water is pumped from the lake to the top of the natural hill where it is stored in the acidic water holding pond. The water will then be passively neutralized by passing through a series of limestone-cladded ponds that are embedded into the landscape before it arrives at the bathhouse where visitors can enjoy a cleansing experience. After the water is used in the bathhouse, the water returns back to the lake (see Figure 25).

Two precedents that have influenced the development of the program, among other things, for this thesis are the Therme Vals by Peter Zumthor, and the Nk'Mip Desert Cultural Center by HBBH Architects. Bath houses have played a key role in the public life of society for thousands of years. Traditionally, bath houses were one of the primary stages for personal interaction. People came to them to cleanse themselves, interact with their fellow citizens, and share stories and knowledge. The Romans turned the bath house into an architectural feature; they were often times one of the largest and most important buildings in the city.

One of the most popular contemporary bath houses is the Therme Vals designed by Peter Zumthor. This bath house is sited on a hillside in Graubunden Canton, Switzerland. It is built on a naturally occurring thermal spring, and was added to an already existing hotel complex. The primary building material for this project was Valser Quartzite, which was a locally quarried material. It became a driving inspiration for the design of the project. Zumthor discusses his project: "mountain, stone, water – building in the stone, building with the stone, into the mountain,

Users	Users' Needs a place ...	Program	sq. ft.
		Solar Bathhouse	13,000
Local Communities / Residents Families Groups Individuals	to play to explore and learn to bathe to eat to gather that they can return to again and again	hot water bath	300
		warm water bath	500
		cold water bath	300
		indoor/outdoor pool	1500 / 2500
		restrooms	250
		changing rooms	1500
Travelers on I-80 Families Groups Individuals	to play to explore and learn to bathe to eat to rest	cafe	1000
		lobby/entrance	1000
		Pump House	
		Passive Water Heater Field	
		Photovoltaic Panel Field	
		Passive Water Treatment Sculptural Field	
		Paths throughout Site	

Table 1: Users and Program

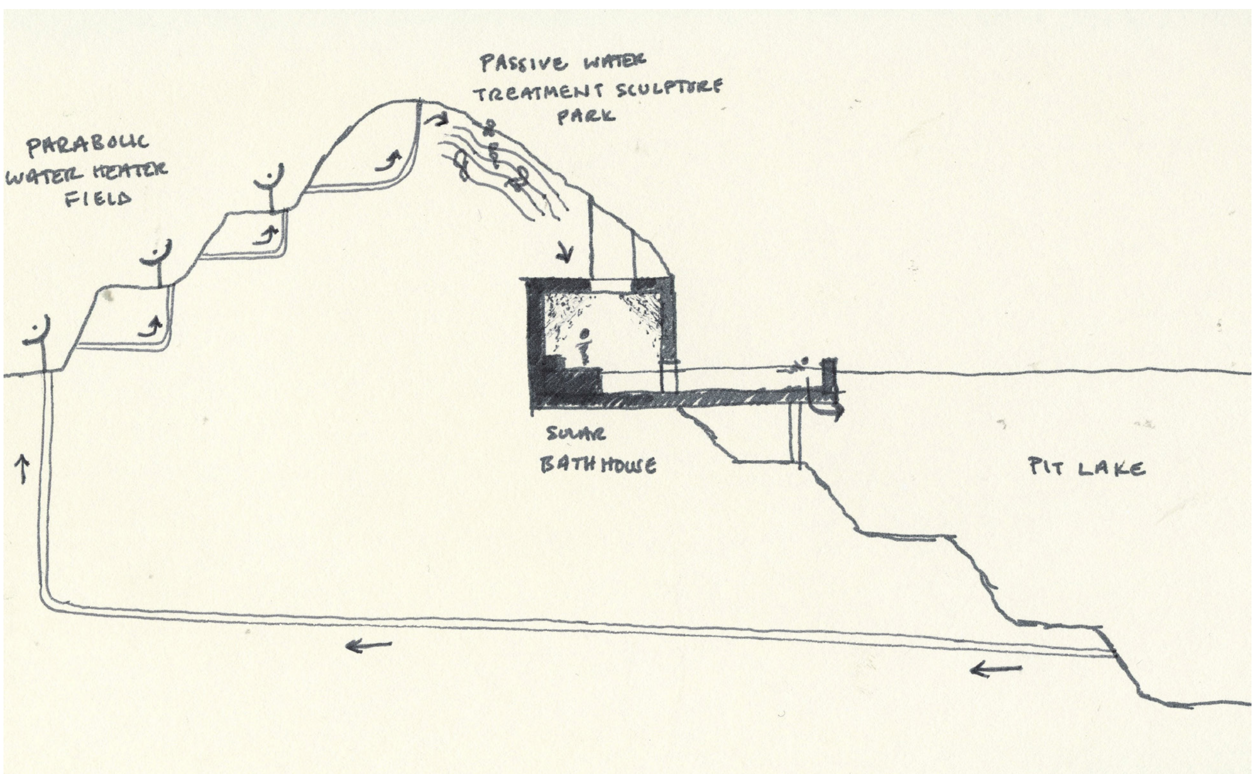


Figure 25: Diagram of Passive Water Treatment and End Use

building out of the mountain, being inside the mountain – how can the implications and the sensuality of the association of these words be interpreted, architecturally?" (The Therme Vals). On a broader scale, this project explored the architectural implications of designing and building with a material that is harvested from the same mountain the architectural intervention is placed within. Questions of materiality, place, and site were investigated both individually, as well as in relation to one another.

Just as materiality and place were strong design drivers, so too was the idea of creating a unique experiential journey. Zumthor writes, "hollowing out the blocks, assigning, seeking and finding bathing experience, inventing hollow shapes and matching uses for the delight of the bathers – all these thoughts played a vital role in the design process" (Zumthor 88). One element of the project that took on a heavier and heavier role as the project moved along was "the delight in experiencing water at different temperatures and in different spatial situations" (Zumthor 88). This project investigated creating spaces that varied in climate, color, material, sound, light, and even scent. The goal being that the user "[immerses] oneself in water for relaxation, as a ritual. Purification. Peace. Serenity. No noisy attraction, no intrusive stimulation, only the sensation of one's own body undergoing subtle change" (Zumthor 88).

Notable program elements for the Therme Vals includes changing rooms, showers, restrooms, an indoor bath, outdoor bath, sound bath, fire bath, cold bath, and multiple rest spaces (see Figure 26).

The desert possesses many unique features, and the northern Nevada desert is no exception. It is an extremely dynamic place with diverse wildlife and extreme weather. From freezing winters to triple-digit summers, the desert of northern Nevada is a harsh and intriguing environment. So intriguing, that many Desert Interpretive and Cultural centers have been established to better connect people to this awesome environment. The Nk'Mip Desert Cultural Centre in Osoyoos, British Columbia was created to do just that.

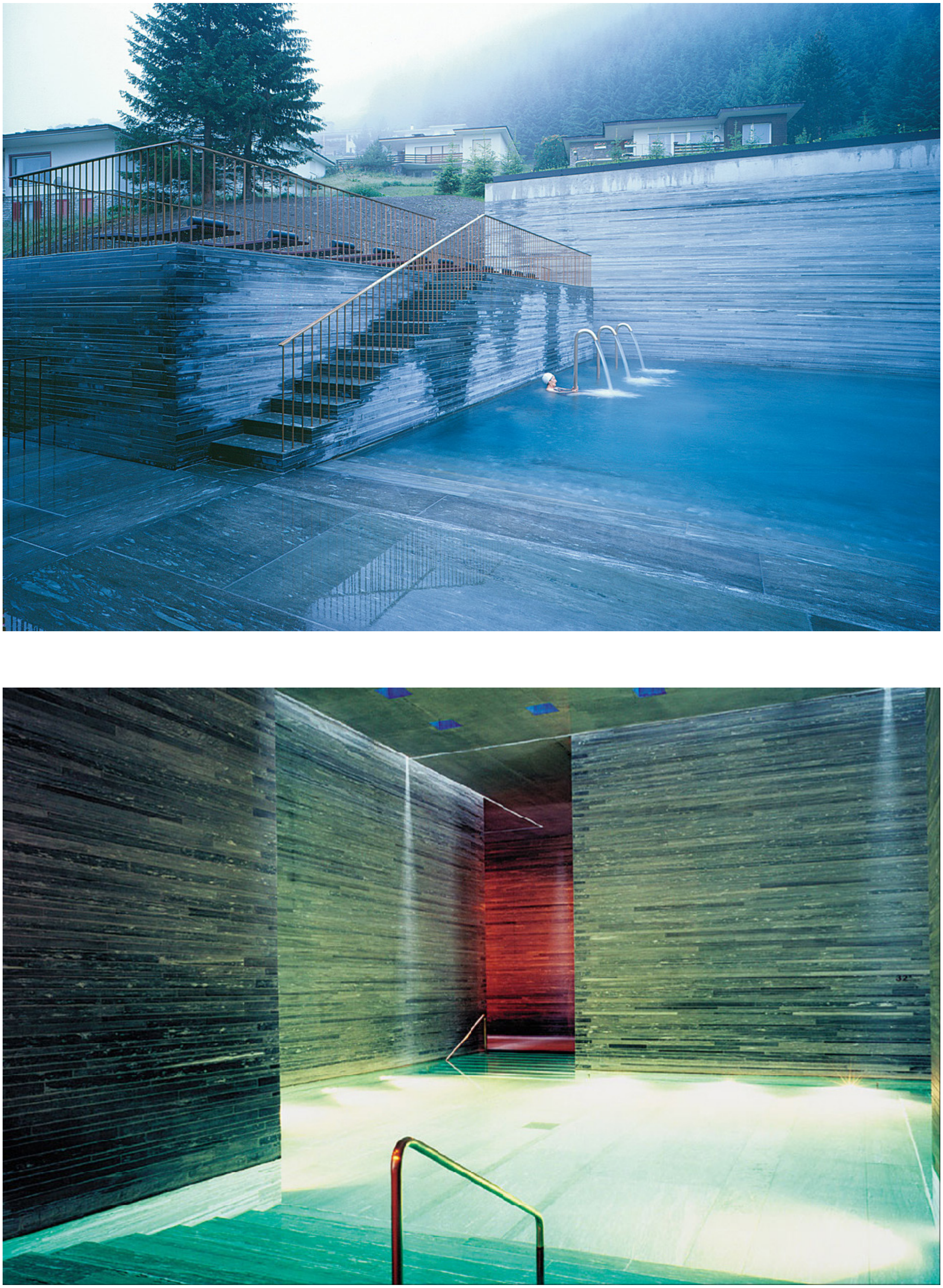


Figure 26: Images of Therme Vals by Peter Zumthor

Designed by Hotson Bakker Boniface Haden (HBBH) Architects, this desert cultural center "celebrates [the Osoyoos Indian Band] culture and history, and respects their relationship with the land" (The Nk'Mip Desert Cultural Centre). It is designed to be a "specific and sustainable response to the building's unique context-the unusual Canadian desert found in... British Columbia" (Nk'Mip Desert Cultural Centre – HBBH Architects). The cultural center consists of a number of elements, the most significant being the lecture and performance theater, stage, exhibit gallery, animal habitat display, demonstration area, outdoor amphitheater, outdoor interpretive area, retention pond, and animal habitat. Also included in the program are offices, restrooms, a gift shop, workshop, and storage areas (see Figure 27).

This cultural center is examined for its approach to desert design and use of materials, and less so in terms of its program. The interpretive qualities that have been integrated into the design of the cultural center and its spaces is the primary reason why this particular project has been examined in the context of this thesis project.

Figure 27: Images of Nk'Mip Desert Culturual Centre by HBBH Architects

5 METHODS

"We live at a time in which the world, i.e. our environment, can be experienced from new dimensions. Satellites enable us to observe the earth from an extra-terrestrial viewpoint directly or indirectly via photographic reproduction. A highway seen from a height of 3,000 meters loses its purely functional character, it becomes a human intervention in the landscape. It is now time that we realize that every grave that is dug, every road that is constructed, every field that is converted into a building-site, represents a formal change in our environment, whole implications transcend by far their purely practical, functional meaning."

-Gary Schum (Kastner 284)

Design is much more about the process than the end product. The design process can be applied to projects at any scale, from the expansive urban scale to the smaller furniture scale. The same principles of concept and iteration apply in order to arrive at an appropriate design. When it comes to designing at a larger scale, such as developing a master plan for a large site, there are many components that make up the larger whole. Each of these elements presents opportunities to further reinforce the overall design approach, concept, and ambitions. The various pieces of architecture, furniture, and art act in two capacities – first as its individual element, and second in its relationship with the other smaller elements and its role in the greater scheme.

This thesis began with a site, and the site has been the driving force in determining the direction of this project. It was, and is, the catalyst for the design and development of this thesis. My approach to this site is to begin at a larger scale and explore how to handle each of the unique elements of the site. How do they relate to each other? What is unique about each of them? What does each of them offer to the user's experience?

The desert, and my site specifically, possess a unique set of circumstances regarding earth, sky, and water. The earth is prominently formed with the repetition of peaks and valleys. Water is scarce, and therefore its presence makes it become a highlight and feature of the landscape. The desolate nature of the northern Nevada desert, and its series of peaks frame the sky – making the sky become a figure itself. Additionally, the desolate nature of the desert draws your eyes to the horizon – where sky meets earth.

These concepts are one of the major driving forces for the design of my architectural intervention. The land is unique in the sense that it has been modified by humans. This human intervention is apparent in many forms. Rock and dirt have been removed from the earth and placed elsewhere to form new mountains. This removal has resulted in the exposure of ground water to the sky. The large pit is slowly filling up with water, revealing the hidden existence of the water on this site – making it become an extremely prominent feature of the landscape. Sunlight interacts with the water in many ways. There is the reflection of the sunlight by the water, the filtering of the sunlight by water, and an exchange of energy between the sun and water in the form of evaporation (see Figure 28). These are relationships that were brought into the design of the water remediation ponds, path, and bath house.

My architectural intervention in this landscape reinforces the natural relationships this site inherently demonstrates between earth, sky, and water (see Figure 29). This is one of the driving forces behind my program. The water on the site is unusable in its current state. Therefore, introducing a passive water treatment facility allows this water to be used by both animals and humans. By creating a bath house, it allows people to directly interact with the water, and by understanding the process by which this water arrives at the bath house, they are exposed to the unique relationship the water has with the land on this site.

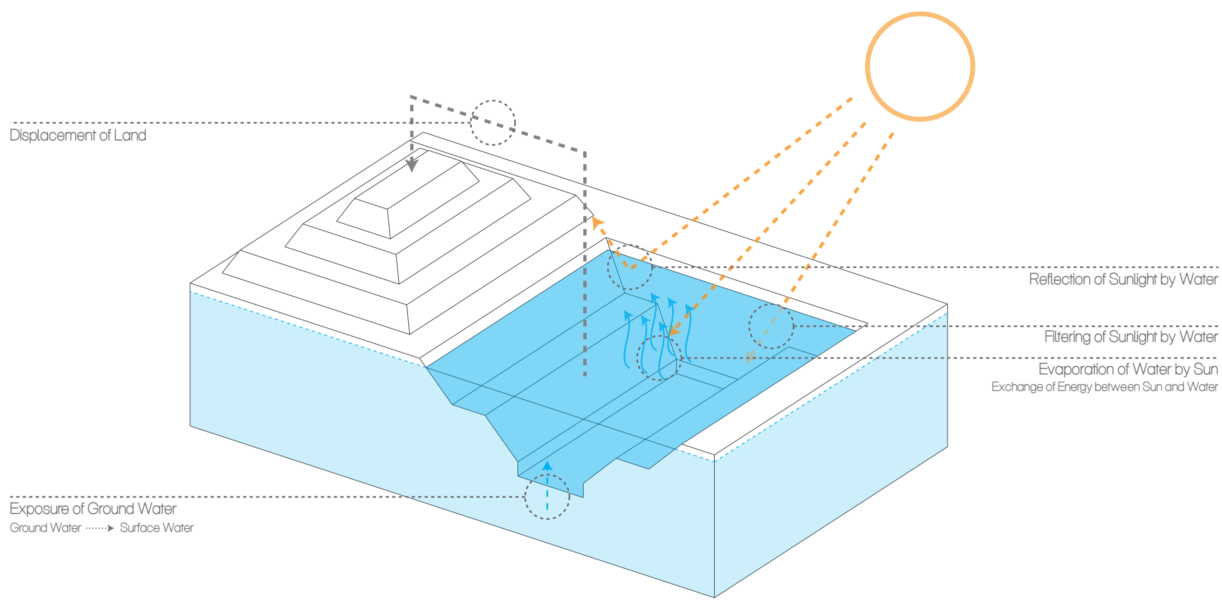


Figure 28: Relationship Between the Land, Sun, and Water Diagram

Figure 29: Image of Pit Lake

6 DESIGN RESPONSE

Water Remediation Process

The acidic water remediation process was one of the initial jumping-off points for the design of this project. The water remediation process to neutralize the acidic lake water on this site is a rather straightforward and simple process. The acidic lake water is pumped from the pit lake to the top of the natural hill where it arrives to the large acidic water holding pond. This is the first step in the passive water treatment process. The water slowly moves between a series of ponds embedded in the natural hill. Each remediation pond is lined with limestone, and as the acidic water contacts the limestone it begins to raise the pH until the water becomes neutralized, and safe for human use. Once the water has been neutralized it is either heated or cooled before entering the bath house for use in the various baths and pools. Once the water has been used in the bath house it is then returned back into the pit like.

The amount of water that is moved through the passive water treatment system is much more than is required for the baths and pools in the bath house. Only some of the water will actually enter into the bath house; the remaining water that is not diverted into the bath house is sent directly back into the pit lake. The goal is that over time, the entire lake will become neutralized (see Figure 30).

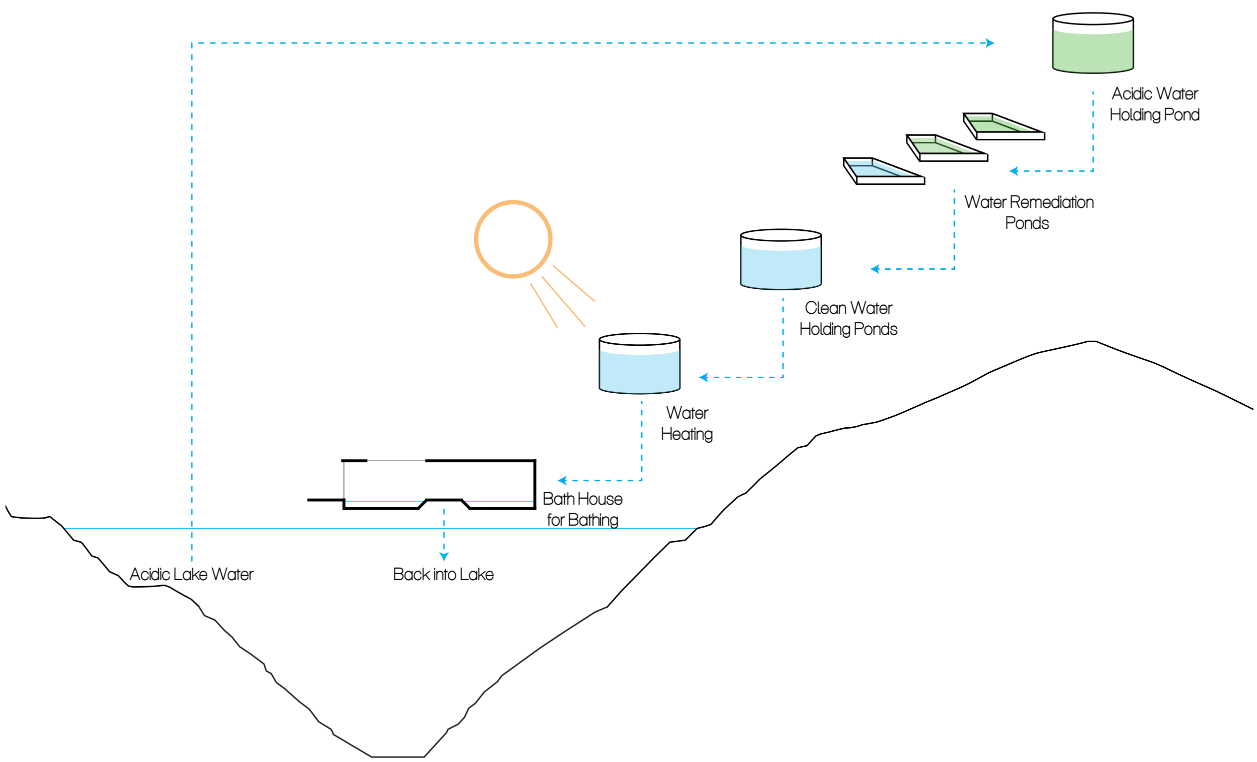


Figure 30: Water Remediation Process Diagram

Traversing the Site

In order to remediate a large amount of acidic water it must be sent through a series of limestone-lined ponds. Because of the nature of the site with its slope, these ponds have been broken up into a series of smaller terraced pools. These smaller pools have been offset to the side of one another to allow for a path to be placed along them to provide circulation for people. The form that these ponds take is reminiscent of the existing formal stepped bench language that the mining operations utilized when they carved out the open pit (see Figures 31 and 32).

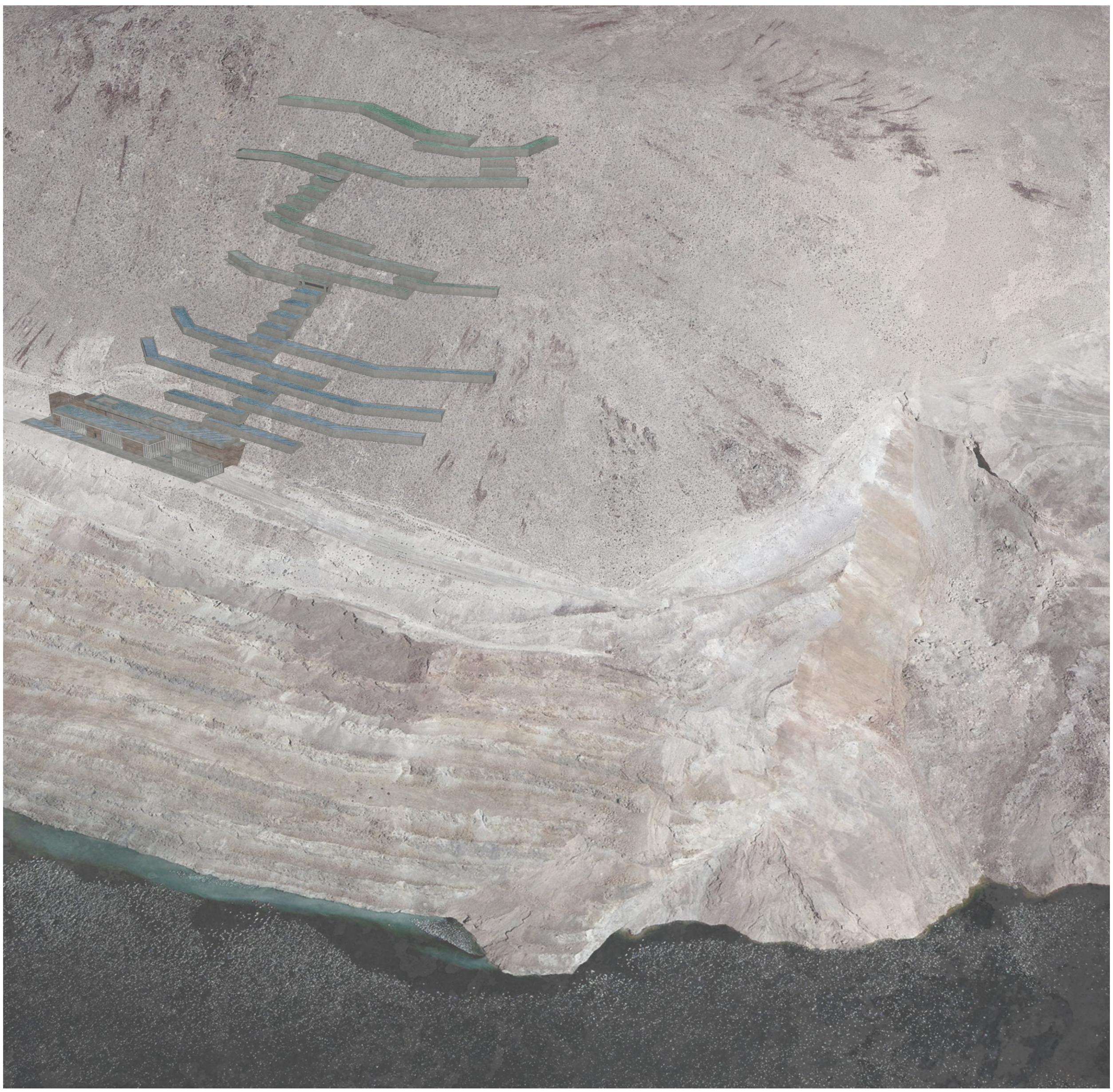


Figure 31: Bird's Eye View Perspective

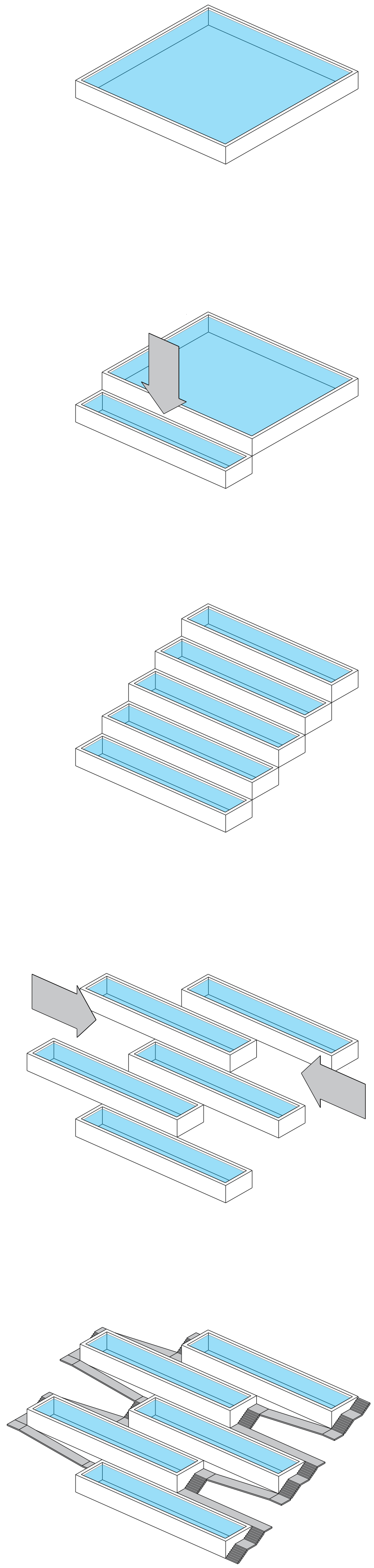


Figure 32: Landscape Ponds and Path Diagram

Site Design

The overall design of this project began with the water remediation process, and its relationship with the landscape. As mentioned above, in order to remediate a large amount of the water within the context of such a steeply sloped site, the ponds needed to be broken up into a series of narrower, stepped ponds. Once this was established, the circulation paths were introduced into the design in a very careful way. The movement of the water and the movement of the visitors on this site go hand in hand. They are constantly connected in one way or another; reinforcing what is happening on this site (see Figure 33 and 34).

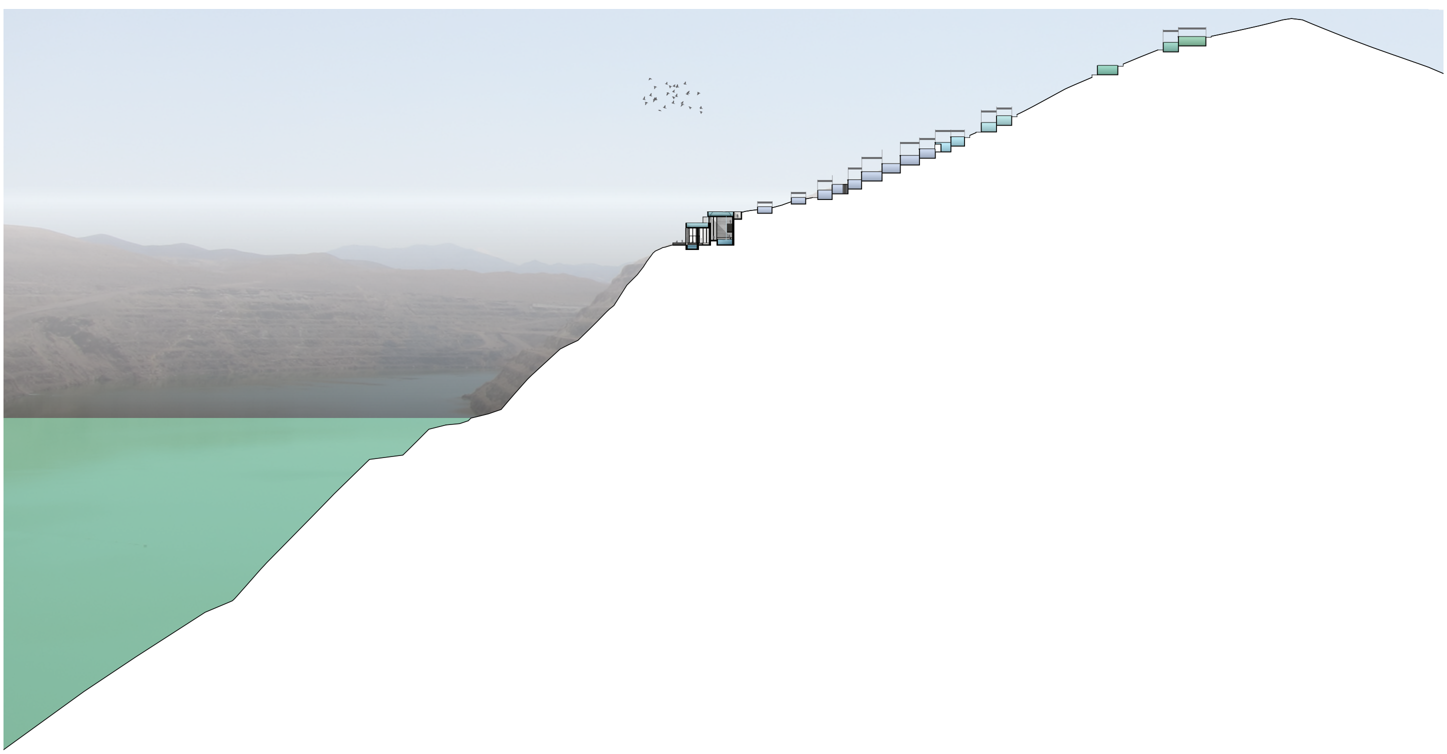


Figure 33: Site Section (Looking North)

Figure 34: Site Plan

Water is pumped up from the lake where it begins it neutralization journey. There are essentially three zones in the water remediation process, and each influences the relationship the path, and ultimately the visitor, has with the ponds and water. In the first zone, the water is rather acidic, and therefore the visitor is somewhat removed from the water, and cannot interact with it (see Figure 35). In the second zone, the water is becoming less acidic and some interaction with the water is okay. The path begins to carve into the ponds creating a tunnel framed on one side by the pond wall, and on the other the cascading water moving from one pond to the next (see Figure 36). Visitors can begin to engage the water if they choose. In the last zone of the process, the water is neutralized, and the path dissolves into the pools becoming a set of stepping stones. The visitors can fully immerse themselves into the water, if they choose (see Figure 37).

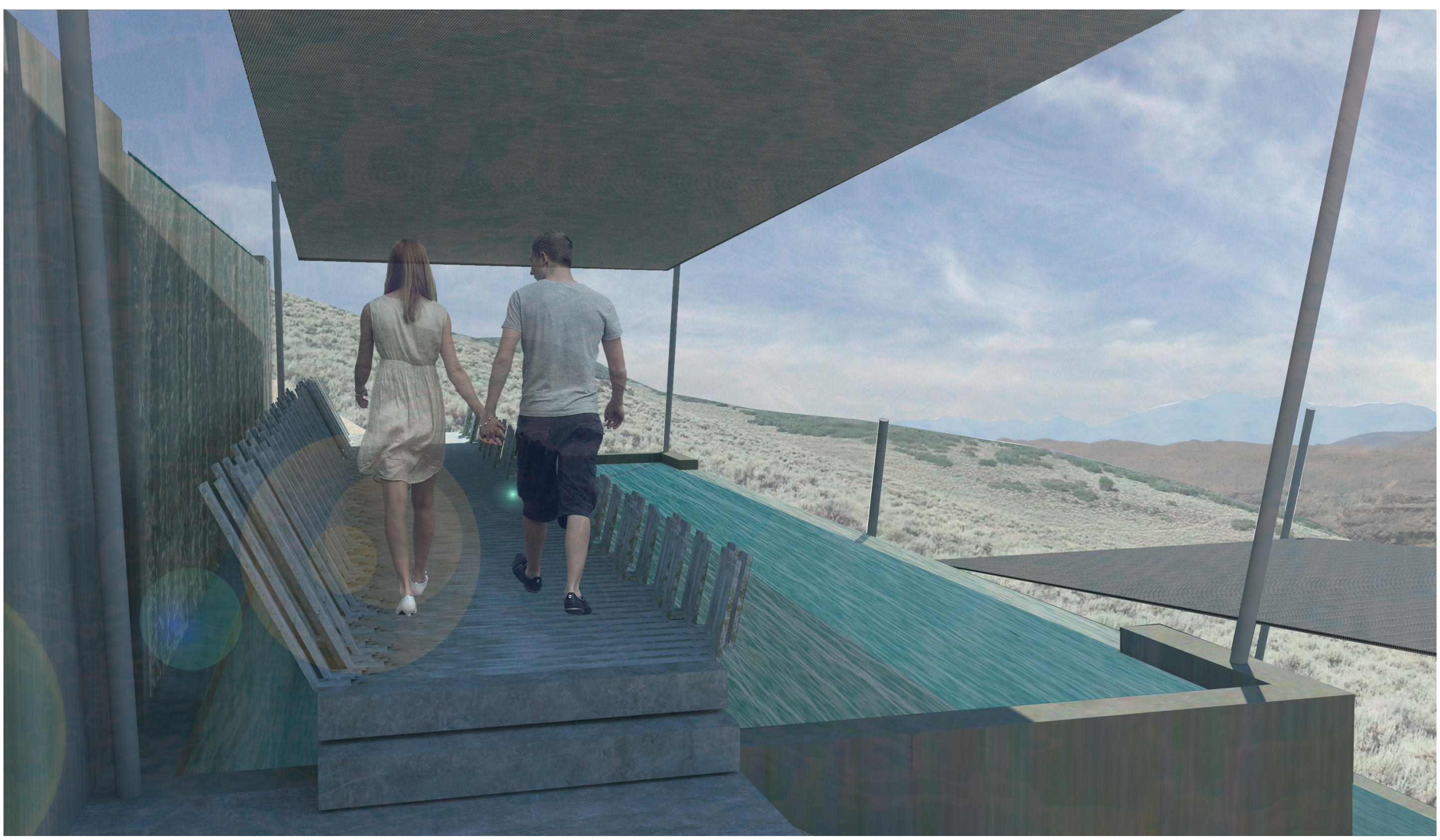


Figure 35: Path Perspective - Bridge

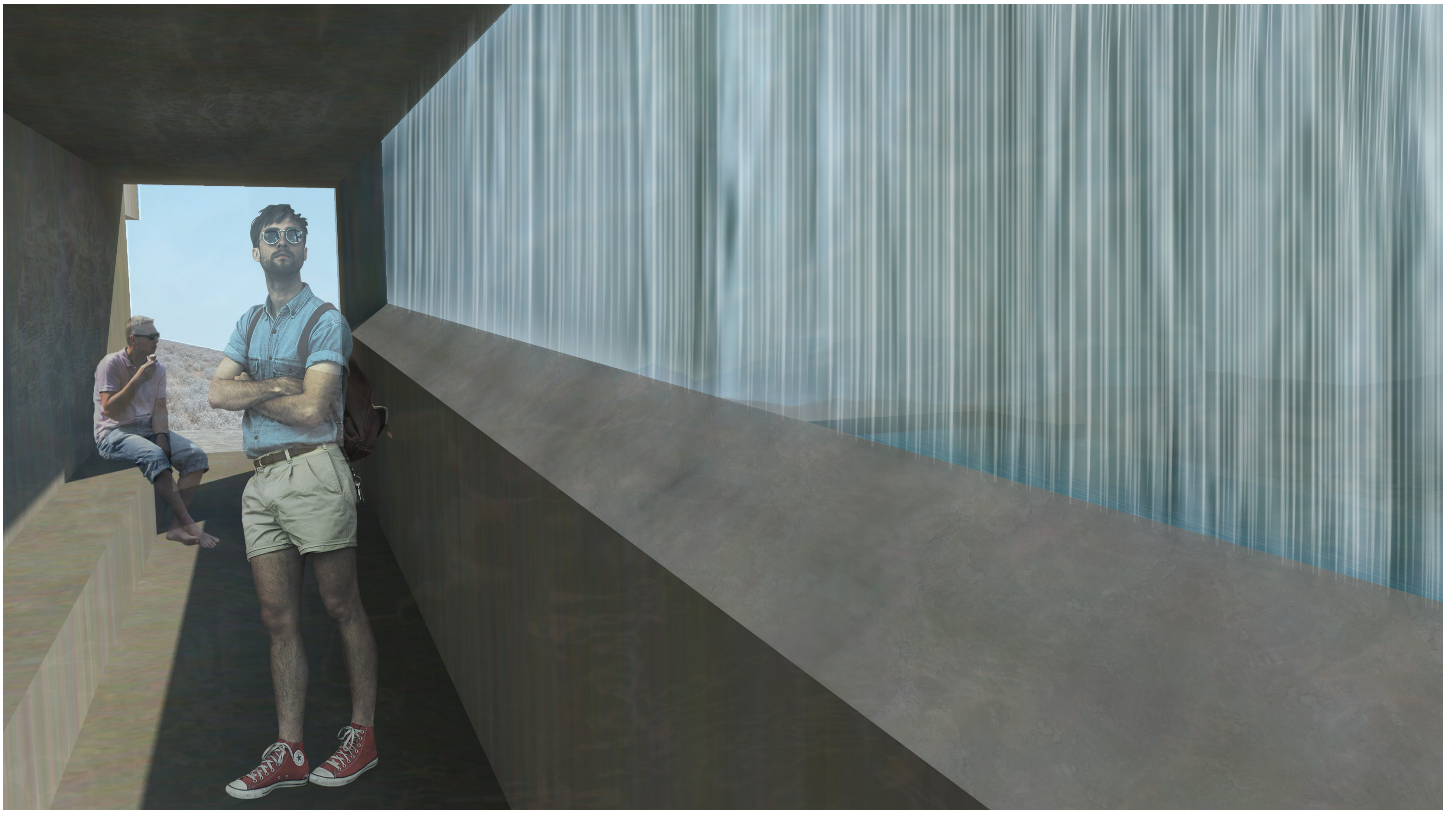


Figure 36: Path Perspective - Tunnel

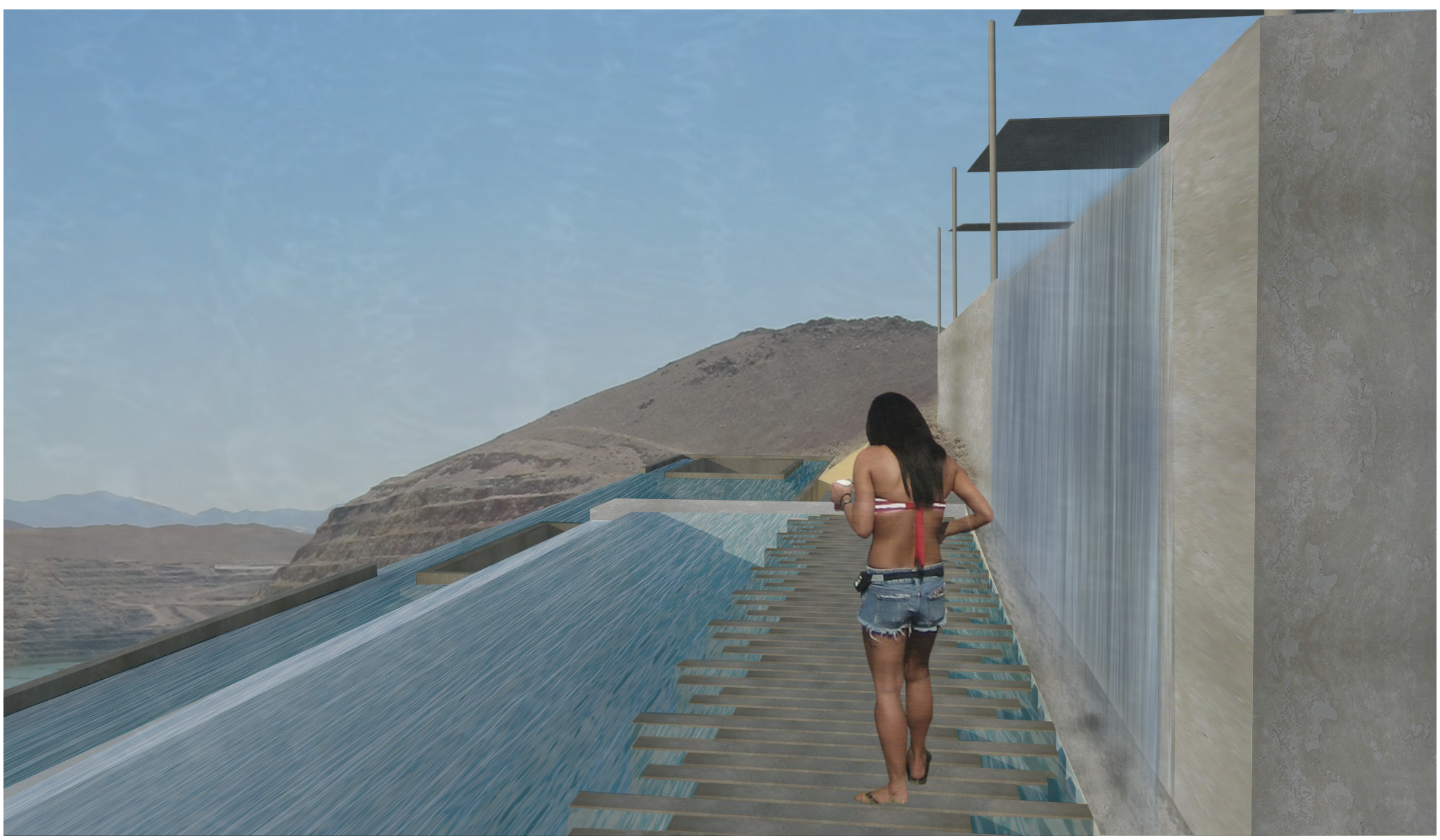


Figure 37: Path Perspective - Stepping Stones

Bath House Design

The circulation within the bath house is an extension of the exterior path. The back and forth design of the path in the landscape continues into the bath house. The visitors descend down into the earth via a long ramp until they reach the main entrance of the bath house. Maintaining the integral relationship that has been established between the path that the water and people take, the point of entrance for both the visitors and the water is the same. Water enters the bath house through a long slot located at the bottom of the large roof pond; the water cascades from above landing in the indoor pool. This is the first scene visitors encounter when they enter the bath house; their view out to the exterior is filtered through the waterfall falling from above. Continuing into the bath house, visitors descend down a large limestone stairway into the lobby and entry space. There are great views out onto the pit lake and site.

After visiting the changing rooms and showers, the visitor continues their procession through the bath house. The long indoor lap pool introduces the visitor to the idea of being in the water. This water cascades down into the indoor-outdoor pool, which then cascades into the warm bath. The hot bath and cold bath are the final two spaces in the bath house – each with a direct relationship to the exterior. The hot bath is located along the west side of the bath house and the exterior space. The cold bath extends to the exterior courtyard (See Figure 38).

The idea of hot and cold has been an integral part of the bathing ritual in many cultures since they were first created. Most often, it is believed that moving from a hot environment and then immediately to a cold environment, and vice versa, had favorable health benefits for the body and spirit. This scenario is created in two ways: first, by moving between the hot and cold baths; and second, by moving from the baths to the exterior. The bath house was designed to integrate the extreme weather conditions that this part of Nevada experiences. In the summer time, the extreme heat can be experienced in conjunction with the cold bath; and in the winter time, the freezing cold can be experienced in conjunction with the hot bath.

Just as the interior circulation patterns act as an extension of the exterior paths, the lan-

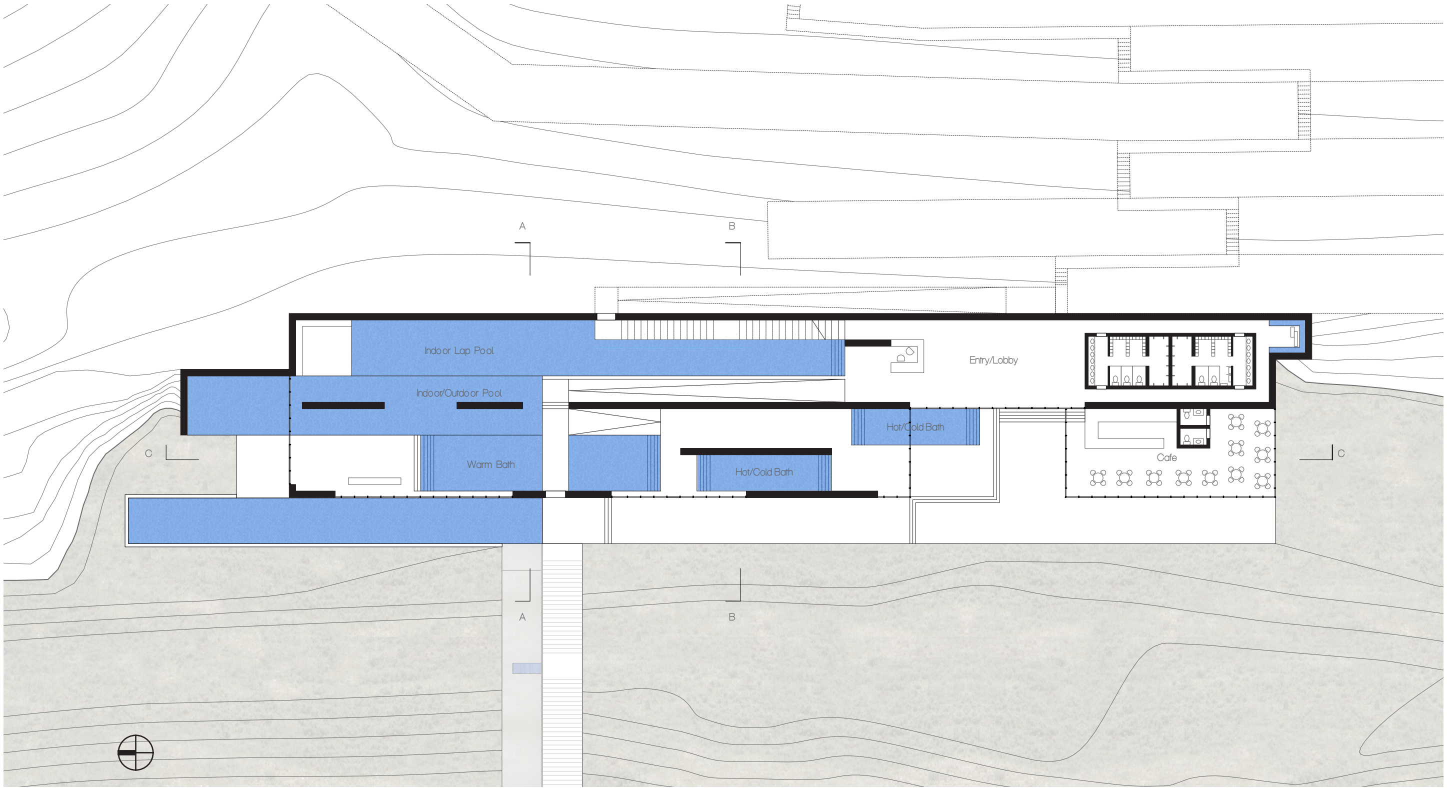


Figure 38: Floor Plan

guage of the terraced pools from the exterior landscape ponds are carried into the bath house. This is illustrated in the three sections taken through the bath house. Section C, the longitudinal section, is taken north-south and cuts through the warm bath, hot bath, exterior courtyard, and café. In the background, the terraced pools can be seen in elevation with the cascading waterfalls. On the left side of this section, in the interior portion, this same cascading can be seen, occurring between the indoor lap pool, indoor/outdoor pool, and warm bath (see Figure 39).

Sections A and B, two transvers sections taken east-west, show the terracing of the interior pools, and varying levels of the floors throughout the bath house. Section A, moving from right to left, cuts through the indoor lap pool, the indoor/outdoor pool, warm bath, exterior return pool, as well as the water shoot that returns the treated water back the pit lake. Additionally, this section shows the skylight above the indoor lap pool, and the relationship between the cascading water moving from one pool to the next and the windows. Section B, moving from right to left, cuts through the exterior entrance ramp, entrance staircase, indoor lap pool, hot bath, and exterior patio space (see Figures 40 and 41).

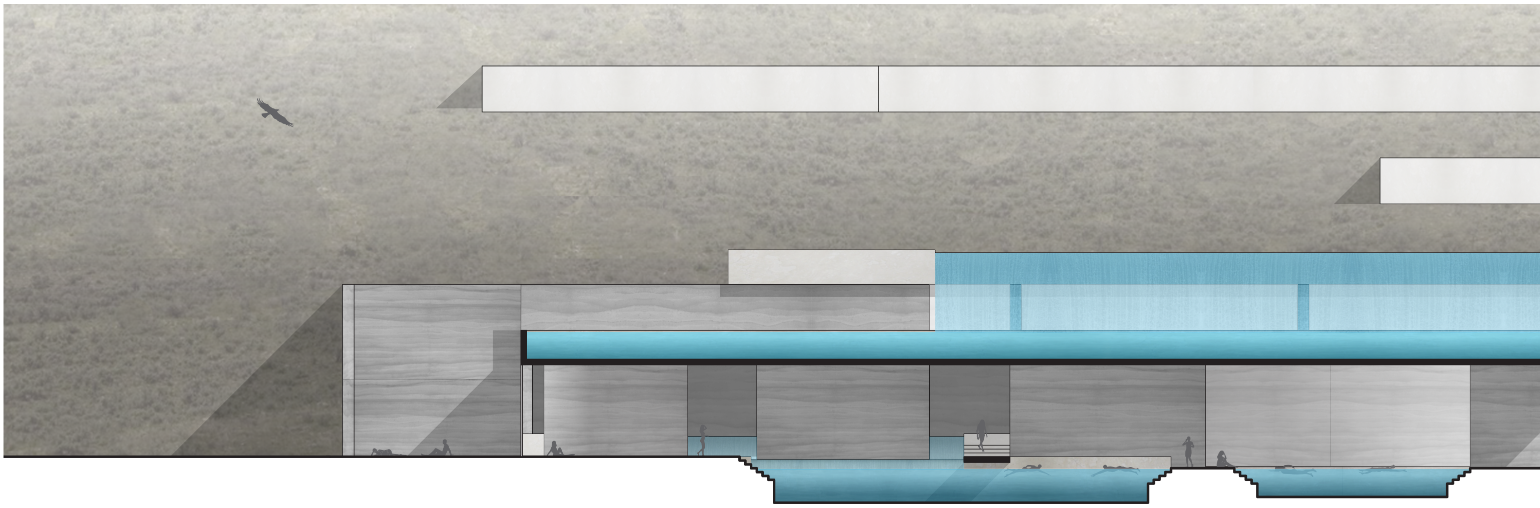


Figure 39: Section C (Longitudinal)

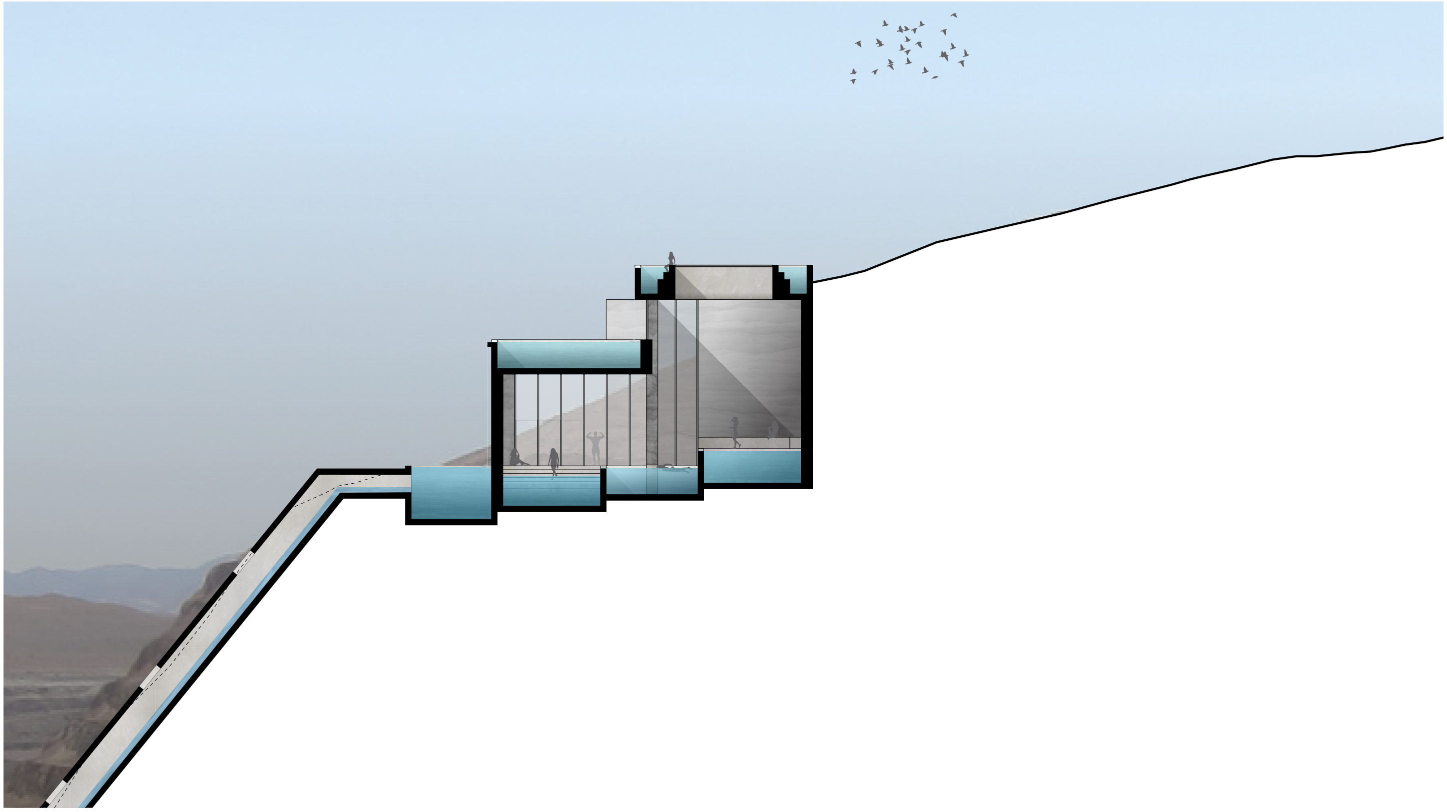
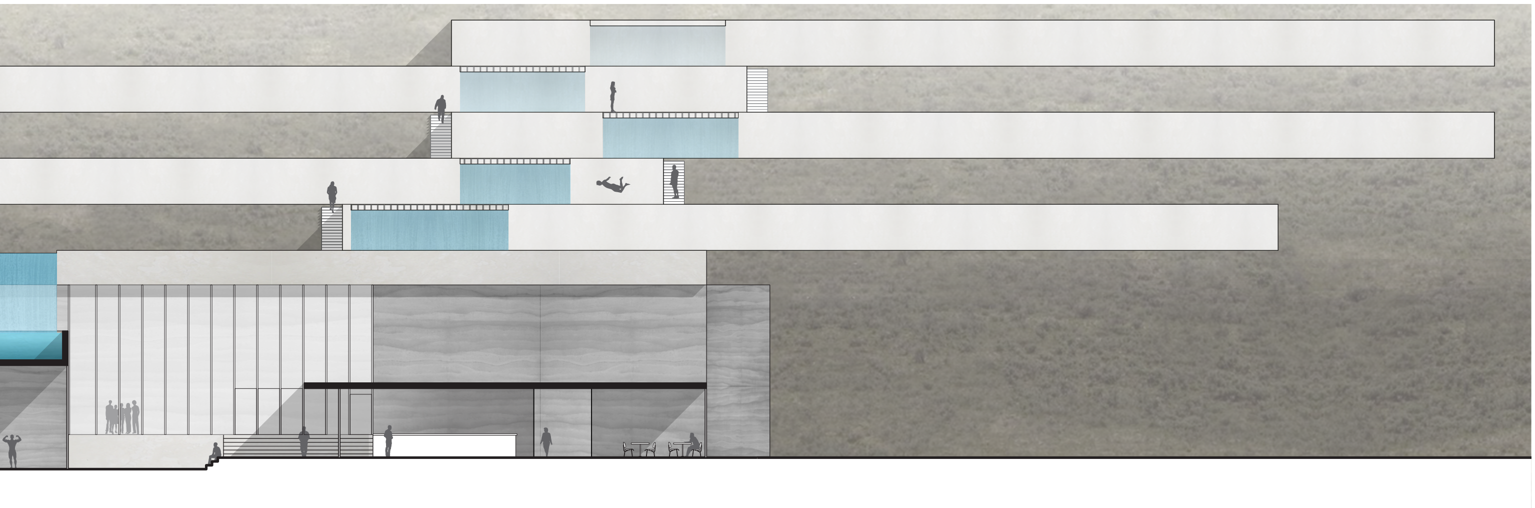


Figure 40: Section A (Transverse)



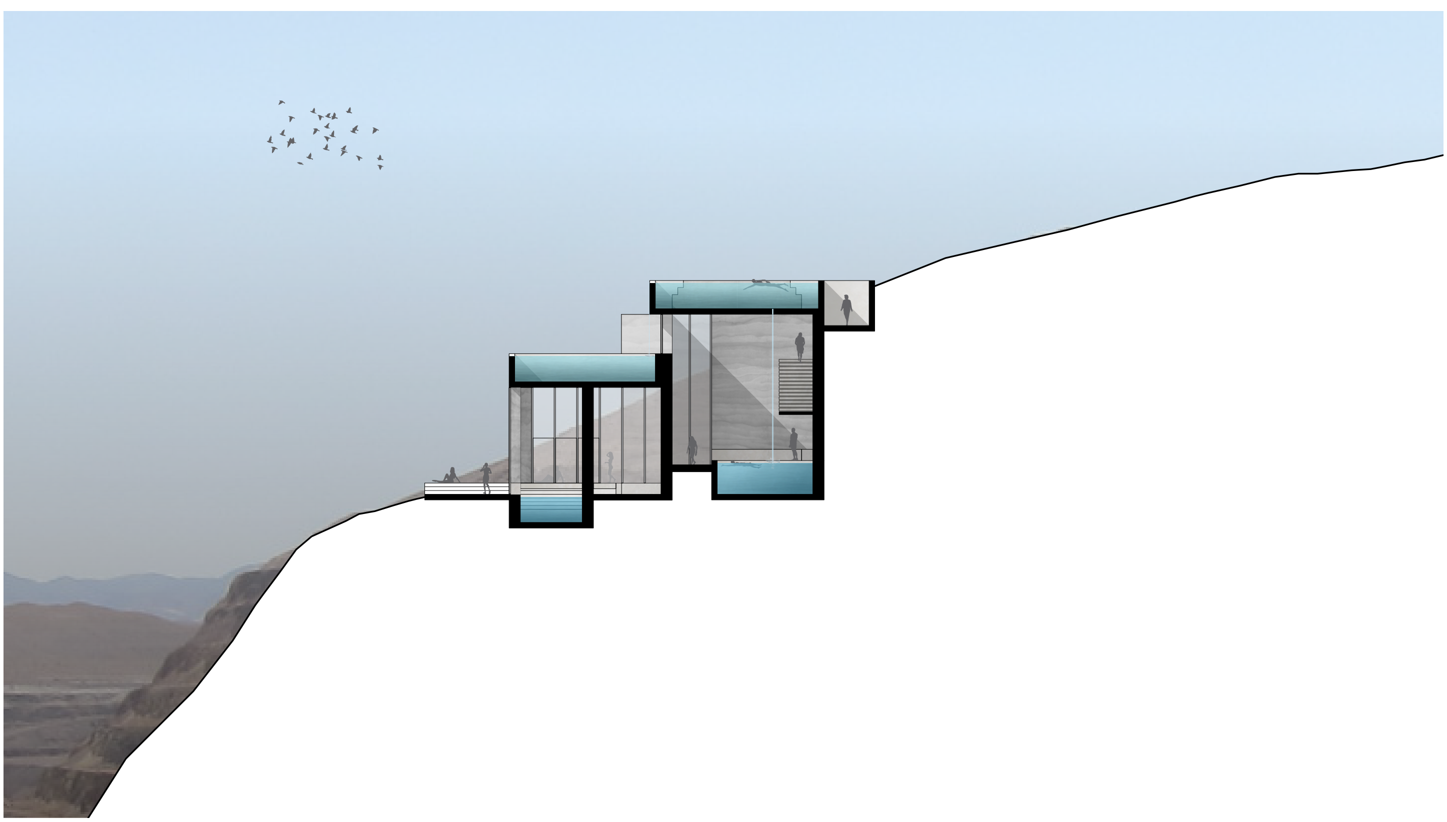
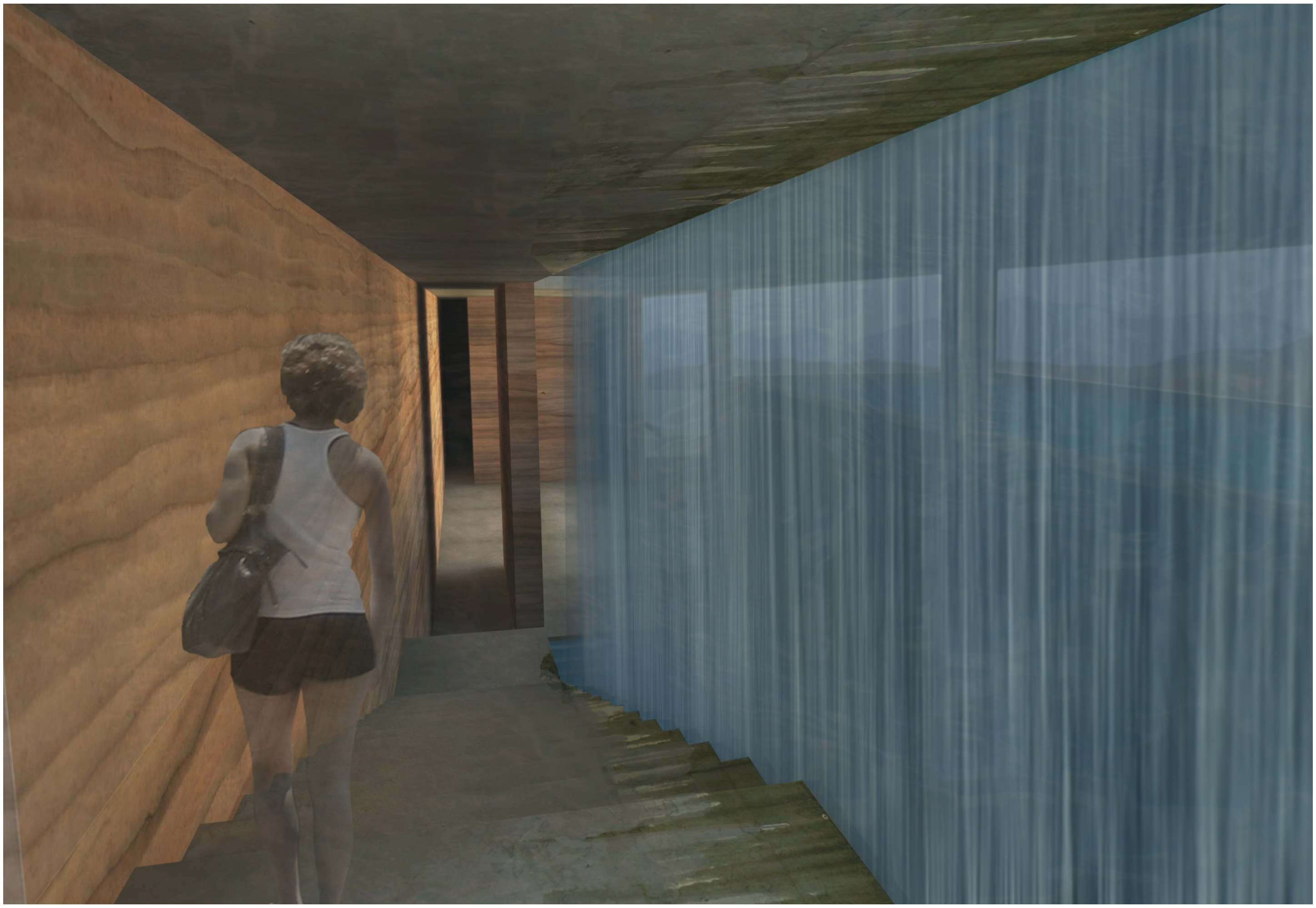


Figure 41: Section B (Transverse)

Upon entering into the bath house, the visitor is immediately met with the sound and view of a twenty six foot tall waterfall. This is the point of entry for both the visitor and the remediated water. The water falls from a fifty foot long slit located on the ceiling of the bath house (floor of the roof pool) into the indoor lap pool. The visitor has filtered views (filtered by the waterfall) to the exterior as they descend down the stairway into the lobby and entrance space (see Figure 42).

The lobby and entrance space have expansive views of the greater site to the west, as well as a large skylight above. The entrance is large, open, and bright and provides comprehensive information on the site's history, the history of mining, as well as extensive information on the current reclamation efforts that are occurring on the site (see Figure 43).

The east side of the bath house, which consists primarily of the long indoor lap pool, is embedded into the earth, and is naturally lit by two large skylights as well as clerestory windows. This space focuses the visitor's attention to the sky above, and the sunlight's interaction with the falling water from above. All of the solid walls of the bath house are made of rammed-earth, a building material and method that is almost exclusively found in desert climates. The use of rammed earth reminds the visitor of the 'place' in which this bath house is embedded – the desert (see Figure 44).



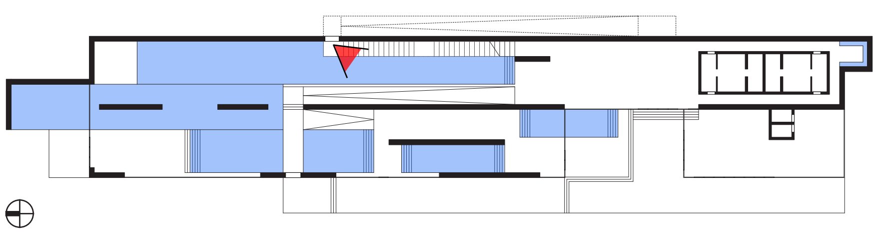


Figure 42: Entry Perspective

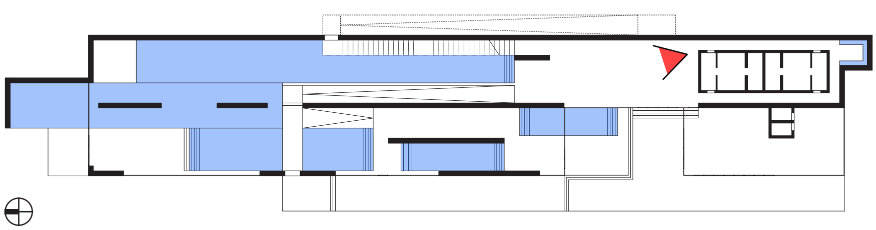
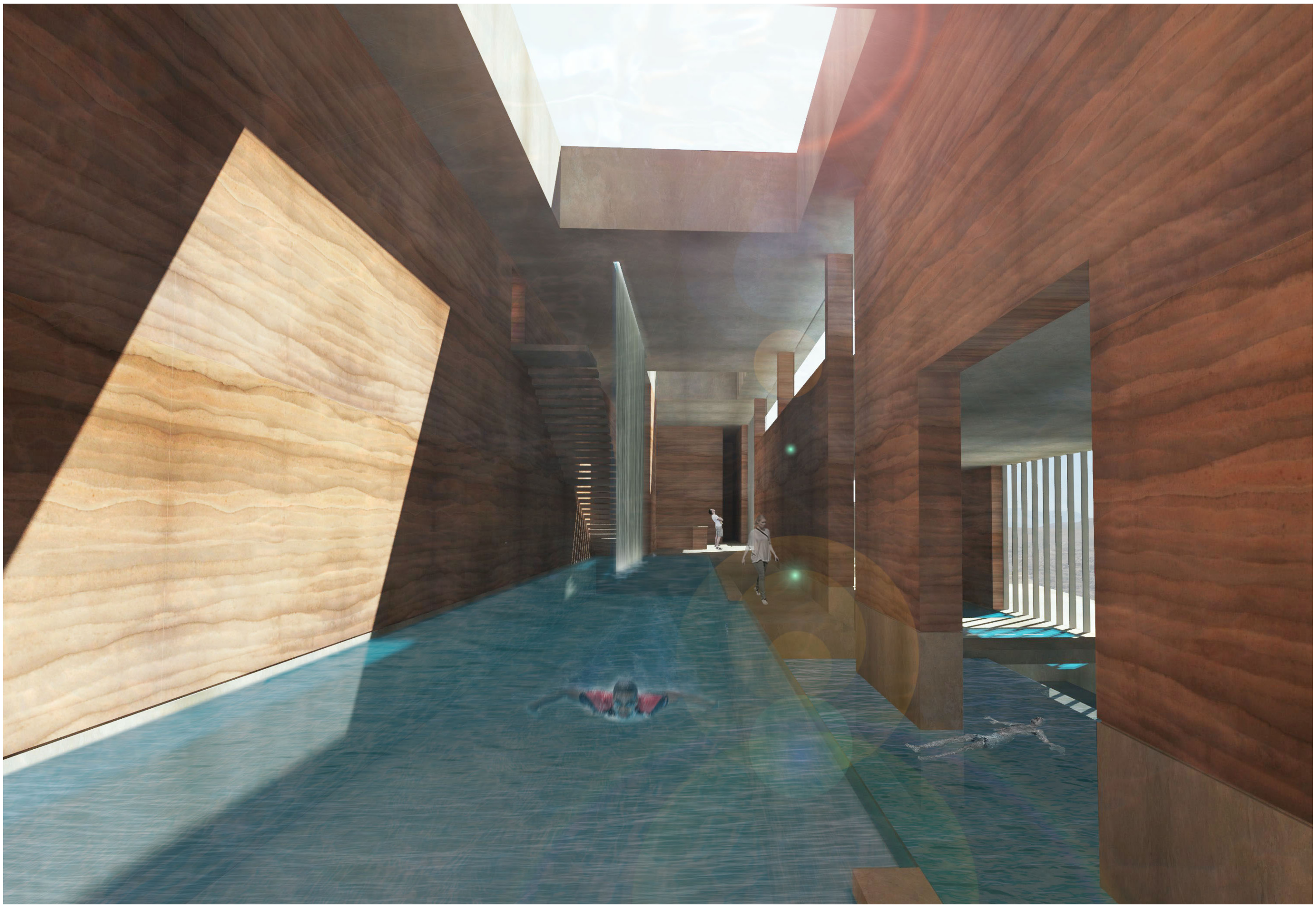


Figure 43: Perspective of Lobby and Entrance Space



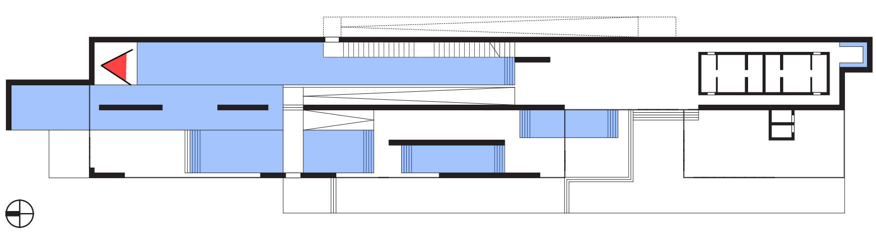


Figure 44: Perspective Looking South toward Indoor Lap Pool

The other primary building material is limestone, the same limestone that is used in the acidic water neutralization process, which lines all of the pools and provides the base of which the rammed earth walls rest upon. Figure 45 shows the view from the warm bath looking south toward the hot and cold baths, and exterior courtyard beyond. The west side of the bath house is entirely side lit with floor-to-ceiling glazing offering great views of the pit lake and overall mine site.

Figure 46 is the view looking north from the warm bath to the indoor/outdoor pool, and exterior patio space on the north side of the bath house. Again, there are expansive views to the exterior that include views down to the pit like, as well as views out to man-made hills and distant mountain ranges.

This project's site is located in a climate that receives all four seasons, and although many of the design decisions were made in response to the hot summer days, many decisions were also made with the cold winter climate in mind. Figure 47 shows a view of the exterior courtyard space in the winter time, which portrays this project in a new light – one that reinforces the interior-exterior relationships that are established between the interior hot and cold baths, and exterior, environmental climate.

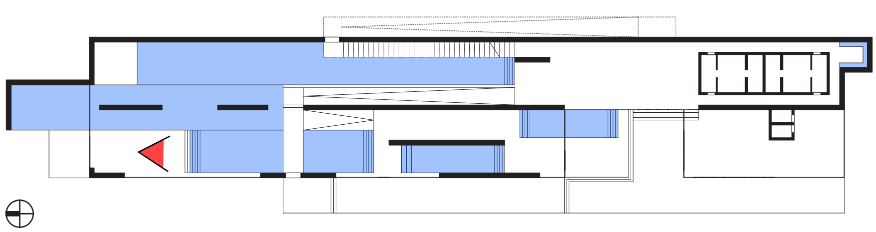


Figure 45: Perspective Looking South toward Warm Bath

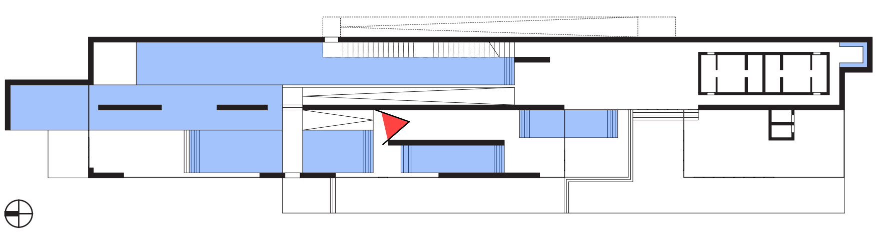


Figure 46: Perspective Looking North toward Warm Bath

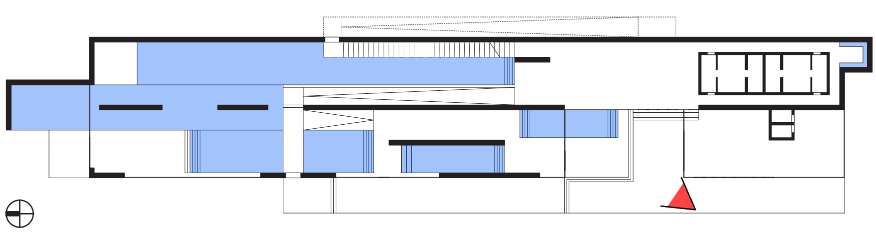


Figure 47: Exterior Perspective of Courtyard Space in the Winter

7 CONCLUSION

This project began with a site; a site that I had strong personal ties to, and a site that belongs to an industry that has supported my family for three generations. I spent two summers working at, exploring and thinking about this mine. At the time, I had no idea just how significant this place would become to my studies, but as I worked my way through graduate school thinking about what I wanted to do for my thesis, this site always came to mind. It was such a dramatic and dynamic landscape that brings with it so many opportunities and challenges, and brings to light many pertinent issues. Namely, what should, or could, be done with a mine site once all of its resources have been extracted, and to what extent should a mine sight be reclaimed?

Over the past three or four decades the mining industry, as a whole, has made leaps and bounds on the topic of reclamation. They have placed a large emphasis on the need for responsible clean up and creating a sustainable plan to rehabilitate the land the mining operations have altered. However, there is still a large amount of room for improvement, and this thesis project was an attempt to challenge the traditional forms of mine reclamation, and an exploration into what role architecture and design have in this subject.

It is this project's goal to demonstrate that design and architecture can play a key role in the efforts to bring a sick landscape back to health. This project integrated many disciplines

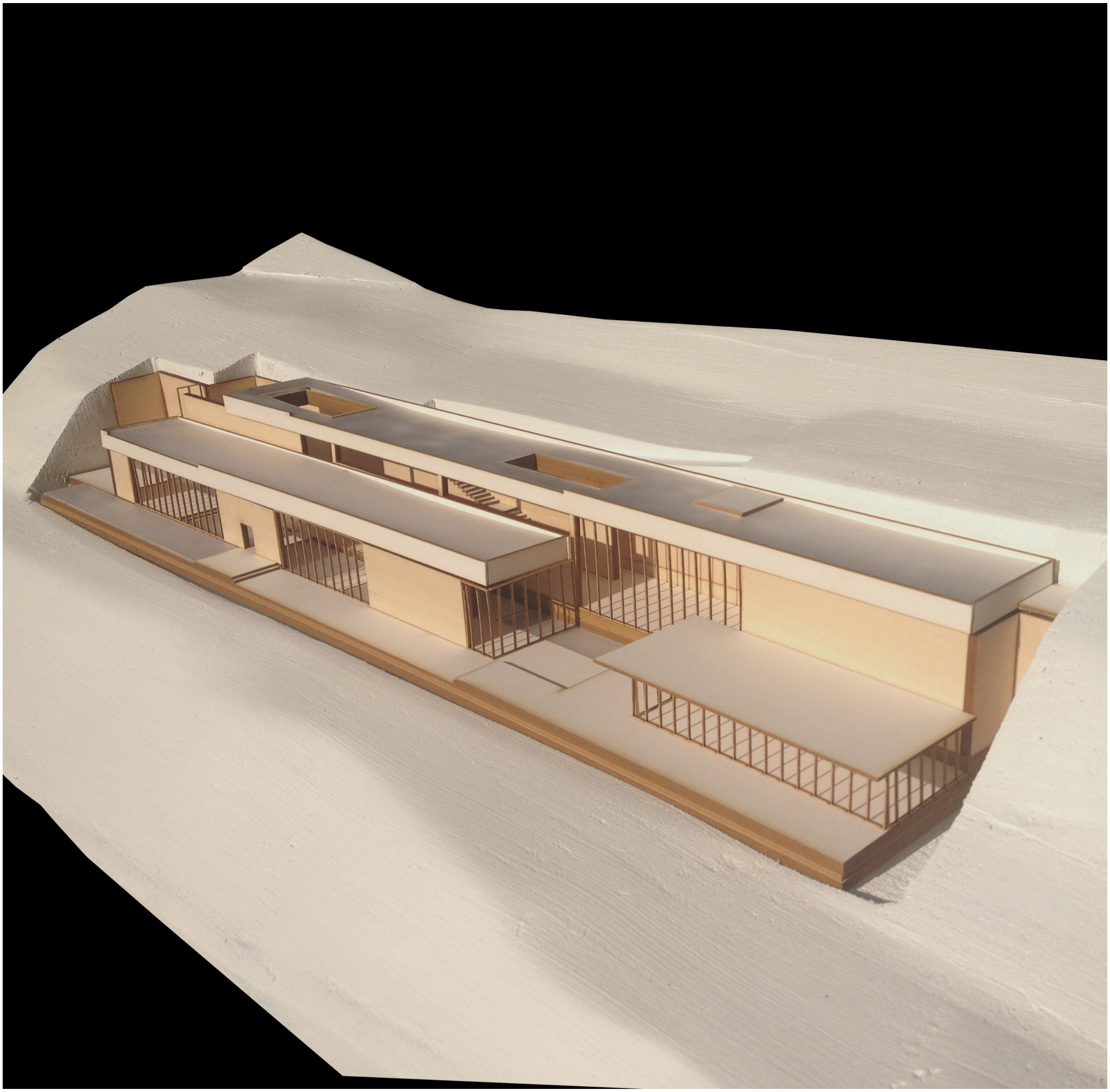


Figure 48: Model Photo

including design, environmental reclamation, science, and engineering in an effort to find a solution for what to do with a decommissioned mine site. Of course, this project has many shortcomings. One of which was addressing the issue of scale; more specifically, looking at the amount of water this project proposes to treat versus the amount of water in the pit lake that needs to be treated. There are billions of gallons of water in the pit lake, and this project's series of pools can only treat around three million gallons at one time. This project was designed as a system, the goal being that over time this system would treat a significant amount of water, but the topic of scale was one important issue that this project could have handled differently.

Another element to this project that could have explored in more detail, in regards to the design of the bath house itself, was that of the sun patterns throughout the year on this site, and how they could influence the design. In more general terms, the sun path was kept in mind when designing the bath house, however, this project was unable to really test out the different design solutions, and use the results of those tests to inform subsequent design iterations. With more time, this process could have occurred, and the design solution would have been even stronger.

This thesis served as a great exercise to test the problems that were posed at the beginning of this experience: what should be done with a post-mined landscape, and what role can architecture and design play in this discussion. This design solution demonstrated that architecture can be the driving force behind a project that is rooted in environmental reclamation. This project showed that not only can architecture devise a practical solution to a practical problem, it can become a solution for many problems. This project creates a destination that explores innovative water reclamation in the context of a decommissioned mine site, acts as a precedent for creative post-mine land use, provides an educational opportunity for visitors that encourages interaction with the landscape, and reinforces the natural relationship between the land, water, and the sky.

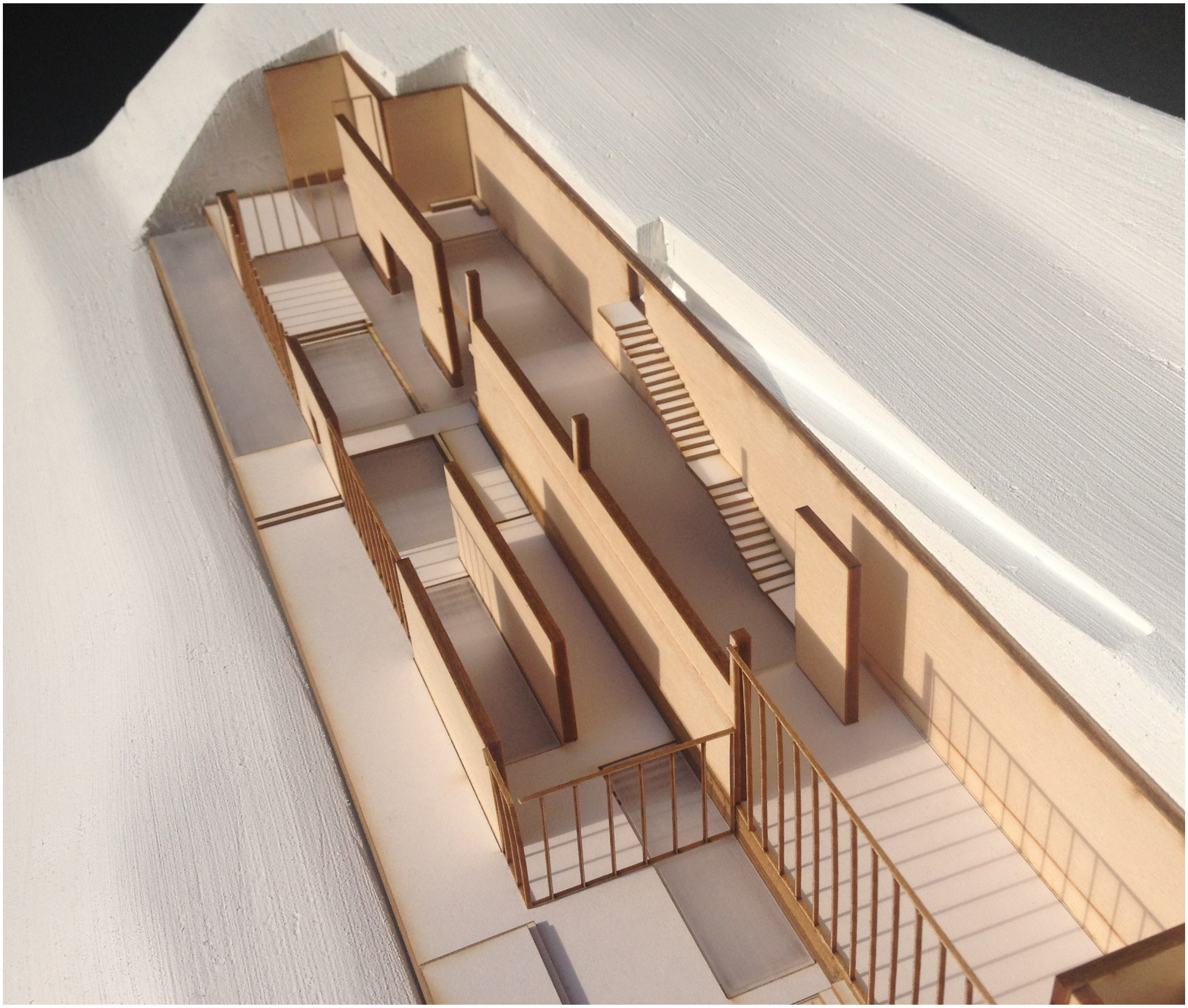


Figure 49: Model Photo

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Figure 3

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Figure 6

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Figure 13

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Figure 14

Aerial image taken from Google Earth; diagram produced by author

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Data collected from Autodesk Ecotect; diagram produced by author

Figure 20

Data collected from Autodesk Ecotect; diagram produced by author

Figure 21

Data collected from Hagar, Charlie; diagram produced by author

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Figure 22

Data collected from Davis, Andy; diagram produced by author

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Figure 26

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