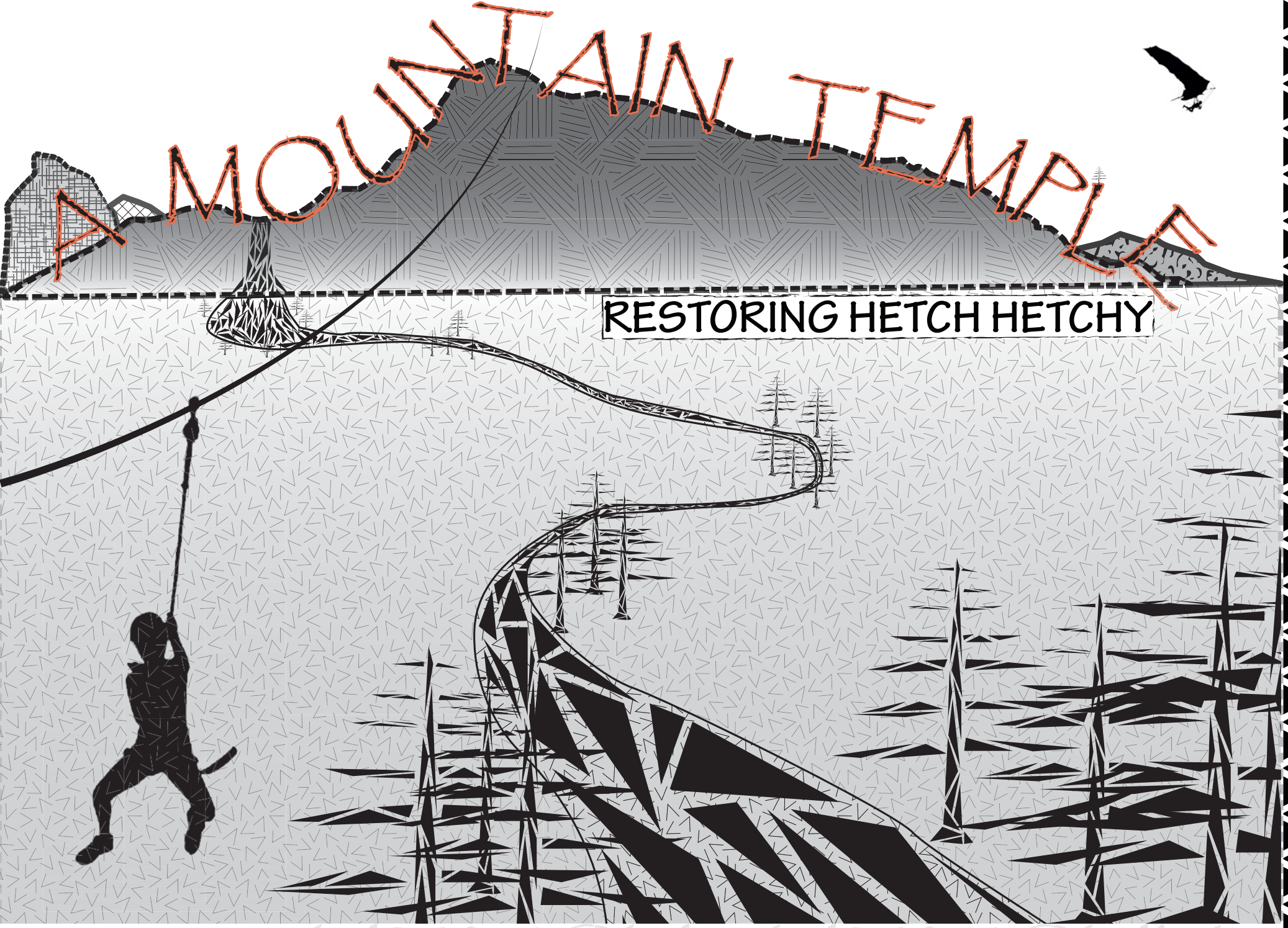
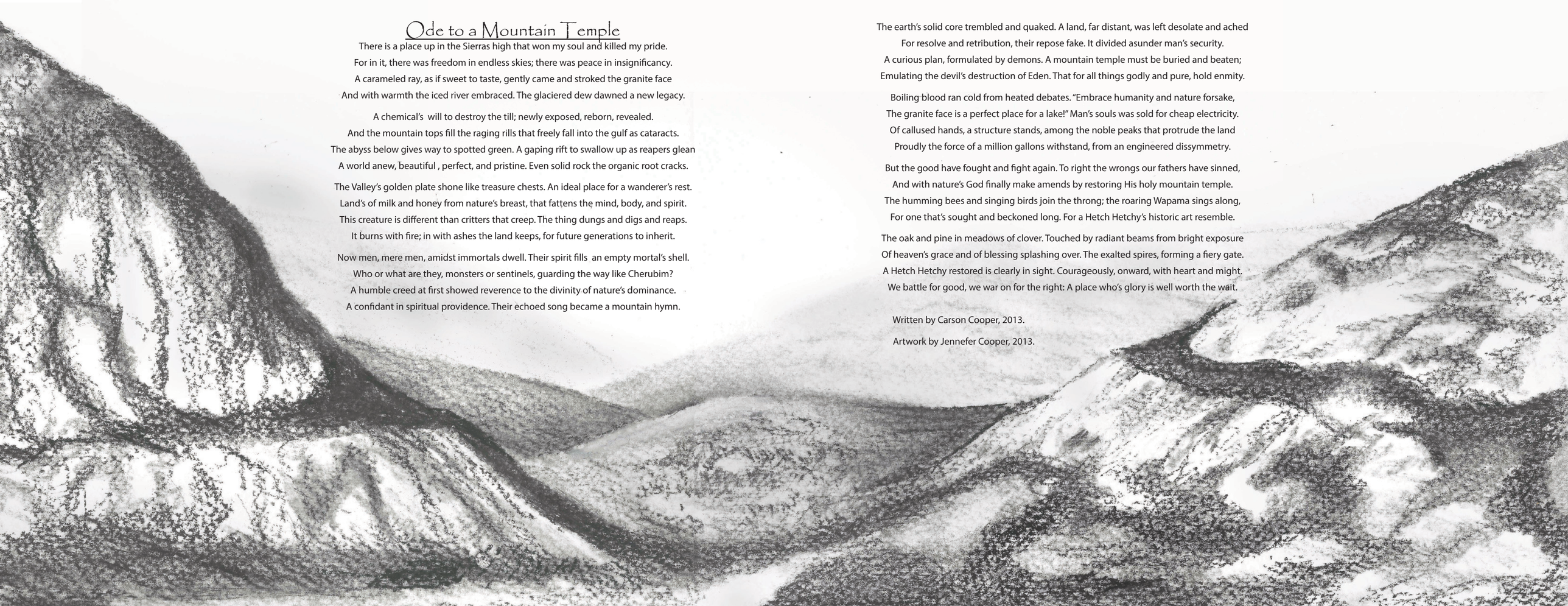
A MOUNTAIN TEMPLE

RESTORING HETCH HETCHY



HETCH HETCHY

CARSON DAVID COOPER



Ode to a Mountain Temple

There is a place up in the Sierras high that won my soul and killed my pride.
For in it, there was freedom in endless skies; there was peace in insignificancy.
A carameled ray, as if sweet to taste, gently came and stroked the granite face
And with warmth the iced river embraced. The glaciered dew dawned a new legacy.

A chemical's will to destroy the till; newly exposed, reborn, revealed.
And the mountain tops fill the raging rills that freely fall into the gulf as cataracts.
The abyss below gives way to spotted green. A gaping rift to swallow up as reapers glean
A world anew, beautiful , perfect, and pristine. Even solid rock the organic root cracks.

The Valley's golden plate shone like treasure chests. An ideal place for a wanderer's rest.
Land's of milk and honey from nature's breast, that fattens the mind, body, and spirit.
This creature is different than critters that creep. The thing dungs and digs and reaps.
It burns with fire; in with ashes the land keeps, for future generations to inherit.

Now men, mere men, amidst immortals dwell. Their spirit fills an empty mortal's shell.
Who or what are they, monsters or sentinels, guarding the way like Cherubim?
A humble creed at first showed reverence to the divinity of nature's dominance.
A confidant in spiritual providence. Their echoed song became a mountain hymn.

The earth's solid core trembled and quaked. A land, far distant, was left desolate and ached
For resolve and retribution, their repose fake. It divided asunder man's security.
A curious plan, formulated by demons. A mountain temple must be buried and beaten;
Emulating the devil's destruction of Eden. That for all things godly and pure, hold enmity.

Boiling blood ran cold from heated debates. "Embrace humanity and nature forsake,
The granite face is a perfect place for a lake!" Man's souls was sold for cheap electricity.
Of callused hands, a structure stands, among the noble peaks that protrude the land
Proudly the force of a million gallons withstand, from an engineered dissymmetry.

But the good have fought and fight again. To right the wrongs our fathers have sinned,
And with nature's God finally make amends by restoring His holy mountain temple.
The humming bees and singing birds join the throng; the roaring Wapama sings along,
For one that's sought and beckoned long. For a Hetch Hetchy's historic art resemble.

The oak and pine in meadows of clover. Touched by radiant beams from bright exposure
Of heaven's grace and of blessing splashing over. The exalted spires, forming a fiery gate.
A Hetch Hetchy restored is clearly in sight. Courageously, onward, with heart and might.
We battle for good, we war on for the right: A place who's glory is well worth the wait.

Written by Carson Cooper, 2013.

Artwork by Jennefer Cooper, 2013.

SIGNATURE PAGE
SENIOR THESIS

CARSON COOPER -- JUNE 15, 2013

Presented to the faculty of the Landscape Architecture Department of the University of California, Davis, fulfilling the necessary requirements for a Degree of Bachelors of Science in Landscape Architecture.

Accepted and Approved By:

Stephen Wheeler, Senior Project Faculty Advisor

Steven Greco, Committee Member

Brett Milligan, Committee Member

Spreck Rosekrans, Committee Member

ABSTRACT

"Hetch Hetchy is a grand landscape garden, one of nature's rarest and most precious mountain temples..."

John Muir, ***The Yosemites.*** 1912

A new era of dam decommissioning has commenced. Few dams are built and even fewer are justifiable because of the egregious environmental damage they cause. Destroying a dam and draining a reservoir might be considered victories for restoring our world to a resilient future; however, as the water recedes, a new obstacle emerges-- the newly exposed valley floor. Typically, these reclaimed landscapes are in terrible condition because the soil is low in nutrients, microbial activity, moisture availability, and usually does not have a consistent soil profile. These factors, and others, hinder natural succession of native plants which leaves the new landscape vulnerable to exotic species invasion.

In the glorious mountain tops of the Sierras and within the boundaries of Yosemite National Park, there is a place called **Hetch Hetchy**. It was once a beautiful and thriving valley that bountifully provided food, raiment, and shelter for the **Miwok Indians**. Hetch Hetchy Valley was considered to be one of the most diverse and unique ecosystems in the world. John Muir described it as "one of nature's rarest and most precious mountain temples" (Muir, 1912). However, in 1913, the pure and precious Toulumne River was dammed. The resulting reservoir buried the prosperous, beautiful, and ancient valley with three hundred thousand acre-feet of water. The water retained became an integral part of an aqueduct system that provided San Francisco and neighboring cities both water and power. For decades heated discussions of politics and environmental ethics concerning Hetch Hetchy have reverberated city halls and city walls throughout the world. Although many people are being informed about the complexities revolving around Hetch Hetchy and their opinions are molded into instruments of action, the discussion is truly just beginning.

This senior thesis is intended to be a tool and instrument in the discussion. It develops a master plan, through intensive analysis, for a newly exposed Hetch Hetchy Valley once the **O'Shaughnessy Dam** is obsolete and breached. This thesis considers the extreme complexities bounded within the historical context of the project and explores, lightly, the analysis involved in justifying the removal of the dam and the support pushing for **restoration**. It investigates the processes involved in restoring a newly drained reservoir through theoretical approaches as well as through case studies and precedence. It develops appropriate design programming that will highlight the beauty of the historical landscape while offering new and exciting recreational opportunities for all types of visitors; all the while maintaining the integrity of the National Park initiatives and the serenity that should exist within a mountain temple.

Through the restoration of the Hetch Hetchy Valley, a new and viable ecosystem can be created for both wildlife and humans to experience. This project might also be used as a tool in the building up of resilient principles for our future and an instrument in the dam decommissioning movement. There is no better way to foster human health and to promote the goals of the National Park Service than restoring an ancient "mountain temple" that will manifest the handiwork of both God and humanity.

DEDICATION

To John Muir:

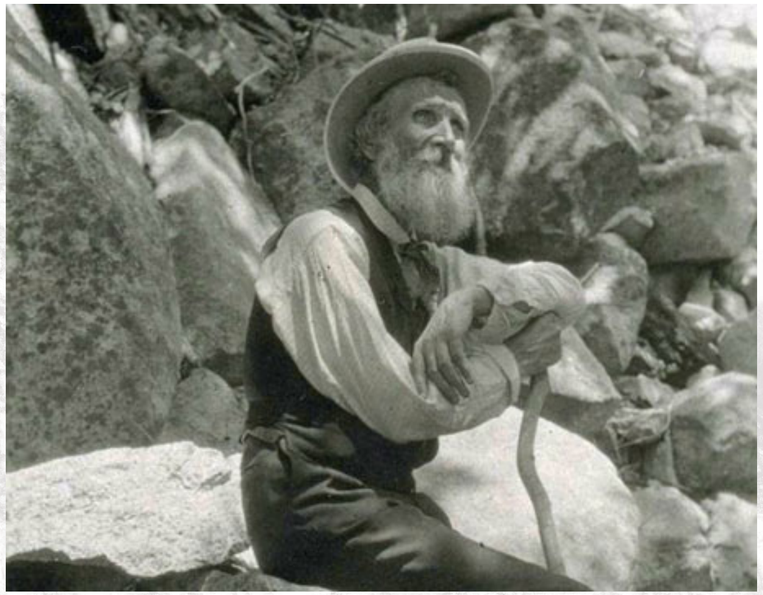


***FIGURE 0.1**: John Muir seated in Yosemite. Francis M. Fritz, 1907. Courtesy of The Sierra Club*

May you soon rest in peace.

ACKNOWLEDGMENTS

I would like to thank and acknowledge:

Committee Members

- Steve Greco for helping me figure out how to use ArcGIS effectively and for helping problem solve many issues I had with data, or the lack thereof.
- Brett Milligan for patiently teaching me how to effectively use many crucial and powerful computer programs as well as your critiques and experience with dam decommissioning.
- Spreck Rosekrans for opening the door to public insight and grassroots knowledge concerning Hetch Hetchy.

Faculty and Staff

- Stephen Wheeler in developing the process by which I found the topic for my Senior Thesis.
- Gayle Totton for editing and critiquing my work.

National Park Service

- Scott Gediman for taking much of your time for an excellent and useful interview.
- Jay Shields for the private tour of Hetch Hetchy and O'Shaughnessy Dam.

Family

- Jennefer Cooper, my beautiful wife, for giving me the time needed to complete this project as well as help in graphic clarity, document layout, and artistic implementation of my documents and posters.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS

5. Momentum (Cont'd)

6. Site Analysis

7. Design

LIST OF ILLUSTRATIONS/TABLES

7. Design (Con'td)

TABLES

1. Introduction

2. History

6. Site Analysis

7. Design

1. INTRODUCTION

Dams are marvelous wonders of engineering. Dams have been constructed for thousands of years and some might argue that dams have been one of the most important structures in mankind's development and growth. The earliest known dam was the Jawa Dam in Jordan which dates back to 3000 BC (Helms, 1975). It is not a coincidence that all of the major civilized world powers built dams. Whether it was the early Mesopotamians, Ancient Egyptians, Romans, Indians, Chinese, or Europeans, dams were built to irrigate prosperity and to power innovation. Since we have been constructing dams for so long, we have reached an incredible competency and skill to dam just about any river or stream. We also have increased their utility with the invention of hydropower turbines. Dams in our day and age have been built or are being built for three main purposes: water supply and retention, hydropower and flood control. Although not every dam satisfies all three purposes.

Within the boundaries of the United States resides 8,100 major dams. These dams are at least fifty feet tall with a water holding capacity of 5,000 acre feet or more (Major Dams in the United States, 2009); although, most of these dams far exceed these minimums. Some of the most prominent and distinguished dams (due to their height, size, and importance) are: Oroville Dam, Hoover Dam, Glen Canyon Dam, Shasta Dam, and New Don Pedro Dam ("List of the Tallest Dams", 2013).

Figure 1.0: *Remnants of Jawa Dam Schnitter. Courtesy of A.A. Balkena*

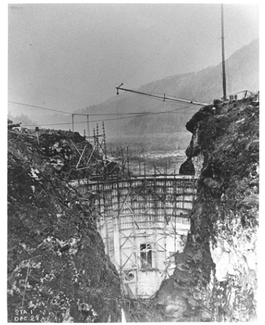


Figure 1.1: *Elwha Dam under construction Paul. 2013.*

Dams have had profound impacts on human development. The ability to retain water for irrigating crops even in dry years has increased food production and security as well as made more land suitable for agriculture. The power obtained from the hydroelectric dams have sparked industrialism and city expansion throughout the whole country. Nevertheless, despite these advances, dams have wrought havoc on the ecosystems, habitats, and rivers that drive ecosystem services we need for our survival. Many keystone species, like Salmon, have been drastically affected and their populations are plummeting.

There has always been opposition and scrutiny of dam building. Dams are becoming more and more controversial, especially with the arrival of new water management techniques, farming practices, and alternative power sources. They have become the main topic of debates and discussions in city halls, congresses, and rallies because of the threads in which dams have interwoven politics, agriculture, and the environment into a complex blanket that warms some while smothering others. The paradigm of political, environmental, and public controversy over dam building was, and still is, Hetch Hetchy.

John Muir described the Hetch Hetchy Valley as "one of nature's rarest and most precious mountain temples". It also was considered one of the most unique and diverse ecosystems in the world (Muir, 1912). Sculpted by glaciers, the nine mile long valley is located in the northwest corner of the Yosemite National Park. Hetch Hetchy is considered to be a twin sister of the infamous Yosemite Valley.

In 1913, the Raker Act was passed by congress which allowed the construction of the O'Shaughnessy dam.

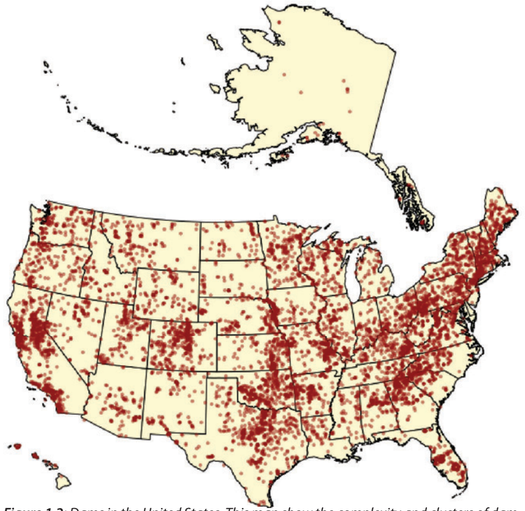


Figure 1.2: *Dams in the United States. This map show the complexity and clusters of dam location in the United States. National Atlas of the United States. 2009*

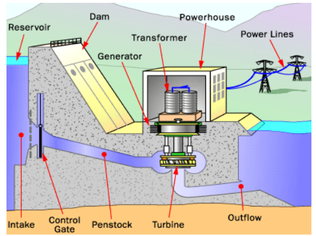


Figure 1.3 and 1.4: *Hydroelectricity. 1.3: This graph shows diagrammatically how Hydroelectric dams work. 1.4: Shows a real hydroelectric turbine. Kevin Bonsor. 2013*

INTRODUCTION

Consequently, the dam created a deep, finger-like reservoir. Currently, the reservoir is the least visited site within the National Park. (Philp, 2004). Nevertheless, the Hetch Hetchy Reservoir is an integral part of a complex aqueduct system that consists of multiple reservoirs, transport pipes, hydropower stations, and most importantly, water rights. This system provides a reliably clean source of water and power for millions of resident in the San Francisco Bay area.

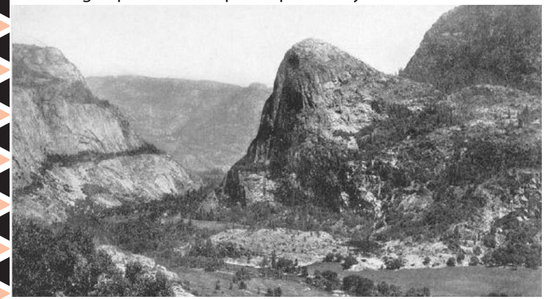


Figure 1.5: Pre-dam Hetch Hetchy. *Hetch Hetchy Valley was a beautiful and thriving destination for visitors and a home for the Miwok Indians. Hetch Hetchy Valley, Sierra Club.*

Figure 1.6: Post-dam Hetch Hetchy. *Hetch Hetchy Valley now lies 300 feet below the waterline of the Hetch Hetchy Reservoir. Mountainproject.com, 2013*

There have been heated debates over the last twenty years regarding the removal of the O'Shaughnessy Dam and emptying the reservoir to "daylight", once again, the Hetch Hetchy Valley. Justifying the dam's removal has been analyzed for years and there exists some persuasive arguments of why it is not only economically feasible and environmentally necessary, but socially approved (Null, 2006). It is also part of the discussion that instead of removing the dam completely, which would be extremely expensive, it can be strategically breached and the remaining structure can be re-purposed for additional use (See Chapter 7: Design).

Once the dam is removed, what are the submerged issues that lie at the bottom with regard to future development and/or restoration? How do you plan and design the Hetch Hetchy Valley once the O'Shaughnessy Dam is removed? What are the major restorative implications that must be addressed to mitigate for a hundred years of complete inundation?

METHODOLOGY

A sufficient understanding of the history, geology, ecology, politics, and current conditions of the site is paramount to begin a successful master plan. The majority of the research will be qualitative and rely heavily upon previous case studies and precedents. Due to the lack of sufficient data supporting the theoretical approaches to a drained reservoir valley, case studies like the Condit and Elwha Dam removal projects have been explored fully to measure their successes and failures and how they might be relate to the conditions at Hetch Hetchy.

Other forms of research included an intensive site analysis of current and historical conditions. Historical data such as maps, quotes, political debates, congressional legislation, and time-lines also elucidated the extreme complexities surrounding Hetch Hetchy. The history of Hetch Hetchy inspired an approach towards its restoration that pays tribute to the unconquerable devotion of activists and supporters of this great cause.

Interviews were conducted with the park Superintendent of Public Affairs, Scott Gediman and Mather District Ranger, Jay Shields of the National Park Service. The interviews focused on identifying current issues surrounding Hetch Hetchy (maintenance, likability, transportation, access, revenue gain/loss) and what kind of amenities the National Park Service deems important for future growth and development. Furthermore, identifying the successes and failures of Hetch Hetchy's "twin", Yosemite Valley, will greatly contribute to the master planning and programming of Hetch Hetchy Valley.

The quantitative data collected were mainly statistics and GIS data. The datasets included information on endangered species, ecological processes, and land cover types and quantities. Statistical analysis also provided data like popularity, past survey results, and percentages of pervious/impervious ground cover that aided in the design process.

Qualitative Research	Quantitative
Case Studies	Past Survey Results
Site Analysis	Statistical Analysis
Historical Data	Historical Timelines

Table 1.0*: Methodology Research. This table illustrates the main research techniques used for information gathering and analysis.*

2. HISTORY

Hetch Hetchy: The Twin

"Nature is not so poor as to have only one of anything..."

John Muir. 1912

Hetch Hetchy Valley was once an amazing landscape of cascading waterfalls, seasonal meadows and grasses, ancient granite sculptures polished by glaciers, and was inhabited by the Miwok Indians. Considered as the "twin sister" of Yosemite Valley, Hetch Hetchy had its fair share of natural wonders. At the base of the valley floor ran the Toulumne River, a clear and clean source of mountain water that consistently flowed from cataracts within the Grand Canyon of the Toulumne to the meandering, snake-like channel within the valley.

Positioned along the south wall is a bold and picturesque face called Kolana Rock. At 2,300 feet high, it's compared to the beautiful Cathedral Rocks of Yosemite in position and form. Upon the northern slopes just opposite of Kolana Rock is the Hetch Hetchy Dome, which is the counterpart of Yosemite's El Capitan in its rigidity and splendor. In the northern wall is a waterfall that is only comparable to the great Yosemite Falls-- the Wapama Falls. Although Wapama Falls doesn't reach the same heights as Yosemite, it has a greater volume during early summer months, causing it to be a spectacular visual display (Muir, 1912). All throughout Hetch Hetchy Valley are incredible spectacles of nature's art and divinity. At the center of all of these incredible site features lies a lush and productive valley floor. The meadows were well depicted by Muir when he suggested that we "imagine [our]selves in Hetch Hetchy on a sunny day in June, standing waist-deep in grass and flowers..." (Muir, 1912). Hetch Hetchy Valley was full of meadows and riparian areas spotted by groves of giant Black Oaks and forests of Yellow Pines. It made a perfect place for habitation.

The Miwoks (and some claim the Paiutes as well) had lived there for over six thousand years and used many of the

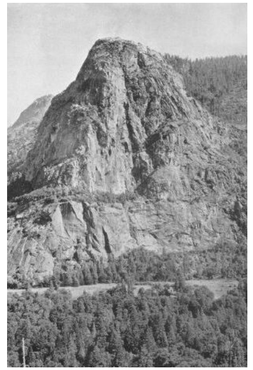


Figure 2.0: Kolana Rock. *The Kolana face is a spectacular sight. The Sierra Club.*

Figure 2.1: Wapama Falls. *The powerful and strong Wapama Falls. The Sierra Club.*

natural resources for food, water, shelter, medicines, baskets, and much more. The native people were ecosystem engineers. They modified the landscape to be more hospitable for themselves and the things they ate; namely: acorns, bulbs, deer, and edible grasses. In the Miwok tongue, "hatchhatchie" means "edible grass". Although the Miwok people do not inhabit the Valley anymore, many descendants still have rights to use the park for access to milkweed, deer grass, bracken fern, willows, and many other plants for basket weaving, medicines, and strings (www.nps.gov, 2013).

The first non-Native American to enter into the Valley was Joseph Screech in 1850 (Muir, 1873). Many more travelers came in subsequent years searching for opportunity and work. Charles F. Hoffmann conducted the first survey in 1867 for the California Geological Survey (Hoffman, 1868). John Muir first visited Hetch Hetchy in 1871 and this first visit elicited a lifelong devotion to its preservation and grandeur. His writings were very influential in aiding in visualizing the majestic and awe-inspiring views in Hetch Hetchy (Muir, 1912). He helped establish Yosemite National Park in 1890, to protect and preserve the amazing landscapes found within its boundaries, mainly, the Hetch Hetchy and Yosemite Valleys.

Figure 2.2: The Falls. *The Tueeulala and Wapama Falls neighbored by the Hetch Hetchy Domes create an amazing backdrop for the Valley Floor. The Sierra Club*

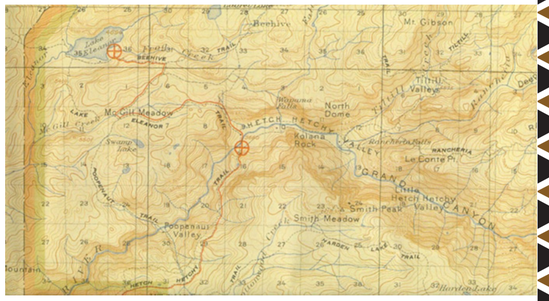


Figure 2.3: 1909 USGS Quadrangle Map. *One of the only maps available that shows the contours of the valley floor before dam construction. National Park Service. www.nps.gov*

The Damn Dam Damnation

"...Is it not a fact that if a beautiful dam is put there, as is contemplated...it will be more beautiful than it is now, and give more opportunity for the use of the park?"

Congressman John Raker.

After the devastating earthquake and fire in 1906, fierce debates over water supplies and security began. James Phelan, the Mayor of San Francisco at the time, was seeking water permits for Hetch Hetchy and, although denied, sparked an increasing interest for water security in the San Francisco Bay area (www.sierraclub.org, 2013). Because of the1906 earthquake and fire, and the obvious need for more water security, the debates grew more in favor of damning the Tuolumne River and creating a reservoir in the Hetch Hetchy Valley. Mayor Phelan later said during the congressional debate, "To provide for the little children, men, and women of the 800,000 population... San Francisco Bay is a matter of much greater importance than encouraging the few who, in solitary loneliness, will sit on the peak of the Sierras loafing around the throne of the God..." (Phelan, 1913).

In the end, San Francisco won the debate, and ultimately, the rights to a piece of public land that resides within a National Park. In 1913, Congress passes the Raker Bill which gave the City of San Francisco rights to begin constructing a dam in the Hetch Hetchy region. Immediately, San Francisco funded the development of an immense project that would retain 360,000 acre-feet of water, create an aqueduct that spanned hundreds of miles, and build two hydroelectric plants to create energy for the Bay Area (www.sierraclub.org, 2013).

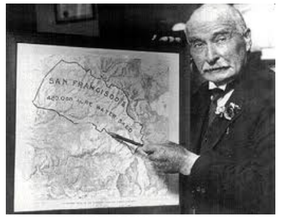


Figure 2.4: Michael O'Shaughnessy. *A perfect place for a dam. foundsf.org, 2007*

The Chief Engineer of San Francisco, Michael M. O'Shaughnessy, was hired to develop the plans for the a 227-foot-high, curved gravity dam. The dam was completed in 1923. The need for added storage capacity was evident when, within 10 years, they increased the dam height to its current height of 312-feet-high. In 1934, the newly raised dam and the Hetch Hetchy Aqueduct

(a gravity-driven, 167-mile long network of dams, reservoirs, tunnels, and aqueducts that delivers 31,900,000 cubic feet of water per day) were completed ("Hetch Hetchy", 2011).

The reservoir is roughly seven miles long, half a mile wide, and approximately three hundred feet deep. Hetch Hetchy reservoir is a moderately small reservoir at roughly 360,000 acre-feet. Due to the surrounding watershed and natural filtering systems in the neighboring granite cliffs, the water needs very little filtration and treatment (www.HetchHetchy.org, 2013).

Figure 2.6: The O'Shaughnessy Dam. *At 312-feet-high, millions of gallons of pristine mountain water are retained for the citizens of the Bay Area. Aquafornia. 2008*

Figure 2.5: The Hetch Hetchy Aqueduct. *Stretching over 167-mile. This gravity-driven network of pipes delivers 31,900,000 cubic feet of water daily to S.F. Aquafornia, 2008*

Figure 2.7: James Phelan. *As the mayor of S.F., he fought for water. foundsf.org, 2007*

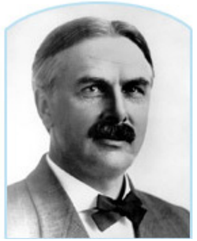


Figure 2.8: John Raker. *The lead politician in support of a lake. bausca.org, 2013*

"Dam Hetch Hetchy! As well dam for water-tanks the people's cathedrals and churches, for no holier temple has ever been consecrated by the heart of man."

John Muir. *The Yosemite*. 1912

Hetch Hetchy: The Lake

"I am aware that in certain quarters one who contends for the practical value of natural beauty is considered a "crank," and yet the love of beauty is the most dominant trait in mankind."

Robert Underwood Johnson. 1913

After ninety years of inundation, the beauty and serenity of the Valley has been forgotten. While many of the natural site features like Kolana Rock, Wapama Falls, and Hetch Hetchy Dome are still visible and magnificent, they have become the ghosts of the past, haunting each visitor of what might have been. There are still attractive views, beautiful trails, and rigorous hikes to enjoy at Hetch Hetchy, and during certain times of the year, these recreational opportunities are sought out by many. Nevertheless, the disparity amongst visitors and their common routines of visitation within the twin valleys draws out remarkable conclusions.

With over four million visitors a year, Yosemite National Park is one of the busiest and popular parks in all of the world. Visitors come to see the waterfalls, the sheer granite edifices like Half Dome and El Capitan, and the Giant Sequoia. In The National Park Service's Summary Guide for the Merced Wild and Scenic River Draft Comprehensive Management Plan and

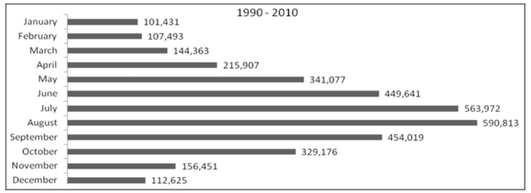


Table 2.0: Average Park Visitation by Month. *This data was collected from averages over twenty years. The summer months are by far the busiest. NPS. MWSRD. 2013*

Environmental Impact Statement (MWSRD.) they have reliable data showing park visitation, demographics, survey analysis, and site attractions. The data shows that annually, ninety five percent (3.8 million) of all visitors go to Yosemite Valley and surrounding locations while only one percent (50,000) go to Hetch Hetchy (NPS, 2013).

Scott Gediman, Assistant Superintendent for Public and Legislative Affairs, stated that it [Hetch Hetchy] is the least visited place because people don't equate it with Yosemite Park due to the strict rules of protection regarding visitor behavior at or near Hetch Hetchy Reservoir (Gediman, 2013). Visitors are not allowed

to swim, drink, or boat in the reservoir; however, relaxing along the shore, boating, and swimming were ranked within the top five activities to do in Yosemite Valley (NPS, 2013). In a recent survey of Yosemite's most popular sites, Hetch Hetchy ranked last, even ranked behind "other" (Philp, 2004).

Entrance Station	May		June		July		August		September	
	Total	%	Total	%	Total	%	Total	%	Total	%
Arch Rock	44,950	32	56,213	29	59,327	22	54,471	21	44,896	23
Big Oak Flat	40,870	30	60,856	32	75,667	29	66,429	25	50,263	26
Hetch Hetchy	5,312	4	6,475	3	5,360	2	3,892	1	3,194	2
South	47,396	34	54,693	29	76,212	29	69,499	27	49,486	25
Tioga Pass	0	0	13,200	7	48,050	18	66,650	26	48,000	24
Total	**138,528**	**100**	**191,437**	**100**	**264,616**	**100**	**260,941**	**100**	**195,839**	**100**

Table 2.1: Monthly Inbound Vehicle Traffic Volumes. *This data was collected at entrance stations during 2011. Visitors to Hetch Hetchy are the smallest in the park. NPS. MWSRD. 2013*

Since the majority of visitation occurs within Yosemite Valley, current surveys show that up to eighty percent of respondents felt overcrowded while doing an activity. The biggest concerns for overcrowding revolve around transportation: Driving Roads (90%), Finding Parking (99%), and Riding Shuttles (83%) (MWSRD, 2013). Scott Gediman noted that Yosemite Valley needs to consolidate amenities that work and to extirpate all the ones that don't (Golf courses, swimming pools, tennis courts) to improve traffic flow. Furthermore, he thinks that the biggest need is for more lodging opportunities, whether that is by more hotel rooms or campground sites (Gediman, 2013).

Every year the campgrounds within Yosemite Park are sold out several months in advance, causing visitors to either stay for the day (losing revenue) or to camp outside of the Valley (increasing vehicular dependency and traffic). Consequently, the summer months are those with the highest day-use park visitation (MWSRD, 2013). This data infers the reality that many people do not stay due to overcrowding and a lack of adequate lodging.

Visitor Destinations	Percent of Visitors
Yosemite Valley	70%
Yosemite Falls	59%
Bridalveil Fall	52%
El Captain Meadow	43%
Wawona	33%
Vernal Fall	28%
Half Dome	22%
Indian Cultural Museum	13%
Pioneer Yosemite History Center	12%
Little Yosemite Valley	8%
Yosemite Wilderness	5%
High Sierra Camps	3%

Table 2.2: Percentage of Visitors at Common Locations. *Hetch Hetchy Valley doesn't even make the list for common destinations. NPS. MWSRD. 2013*

"It has become a no-man's land... for some-man's water."

Carson Cooper. 2013

3. PROCESS

RESTORING A WASTELAND

How do you restore a wasteland? The bottom of any lake bed is in an extreme anaerobic condition due to the lack of oxygen. Anaerobic conditions foster certain types of microbiology, but not the kinds desired for vegetative growth. Once a reservoir is drained, what remains is a large, open, barren wasteland. There is low soil biology due to few soil microbes, standing snags, and residual live plants. Therefore, the soil is usually low in nutrients and the soil profile is unpredictable and may be unsuitable for plant growth. Furthermore, due to the lack of vegetative cover, sun and wind exposure increase evaporation and sediment transport that decreases moisture availability ("Elwha River Restoration", 2011). All of these variables can cause an epic failure for large or small scale restoration efforts.

Figure 3.0: Owens Lake. *Plagued with low moisture, poor soil structure, and anaerobic conditions. Mavin's Photoblog, 2011.*

RESTORATION OBJECTIVES

Restoring a drained reservoir is possible with appropriate measures. The success of the project is dependent on the quality and effectiveness of the restoration goals and objectives. Goals must drive decision making and phasing implementation but also must be adaptable to ever changing ecosystem dynamics (Clewell et al. 2005). Minimizing exotic and invasive species, restoring ecosystem processes, and establishing native forest stands are all necessary over-arching goals. Smaller and more specific objectives should be derived for full success, such as: determining time lines for invasive management regimes, creating lists of exotics that are primary or secondary species of concern, instigating natural processes through extreme care, and monitoring natural succession. Project objectives drive the length of each goal whether they are short term or long term goals.

EXPECTED CONDITIONS

It is crucial to understand the full scope of expected conditions of the project to drive goal setting. Due to the nature of inundation and its effect on soil biology, it must be expected that the quality of the soil will be drastically different than the surrounding landscapes. Since the landscape will have no biological legacies, circumstances and conditions for restoration are considered to be more closely related to primary succession (similar to the aftermath of extreme disturbances like volcanic eruptions and glacier retreat) ("Elwha River Restoration", 2011).

Rates of primary succession tend to be slow in large, dry and infertile landscapes and areas in the middle of the valley would take longer to naturalize because the distance between the surrounding landscapes is far and will not allow for quick seed dispersal, microbiological movement, and organic matter circulation (Walker and del Moral 2003). Woody debris, erosion factors of course and fine sediments, and native establishment amongst the sediment types must be considered ("Elwha River Restoration", 2011).

ACCESS FOR RESTORATION

Decommissioning and destroying a dam is no easy feat. Great amounts of debris and litter will need to be transported away. Getting the proper machinery necessary for demolition and transport near the project site might require the creation of temporary access roads. When considering road allocations, alternative uses for these roads after demolition must be taken into account. These access roads can be converted back into natural areas, they can be used for new public roads for better access into the project site, or they can become private service roads for emergency vehicles and rangers. It is often suggested that the most cost effective form of debris removal is via conveyor belt. Alternative uses for the conveyor belt after demolition and removal might be to retrofit it into a gondola or passenger lift. Either of these alternative uses can increase visitor transport and likability while creating opportunities for revenue gain.

Figure 3.1: Condit Dam Removal. *All the water needs is a way of escape. Dave. 2011.*

DECOMMISSIONING

Removing the dam structure is an expensive and time-intensive approach. When removing the structure for full restoration efforts, licensed engineers must develop the most effective, sustainable, and low-impact approach. Due to the costs for structure removal, it is becoming a popular notion to keep the structure after the reservoir is empty. A professionally placed explosive at the bottom of the dam structure would puncture a hole sufficient enough to drain the reservoir quickly and safely without compromising the integrity of the structure ("Condit Hydroelectric Project", 2011). The remaining structure can be

retrofitted to have other purposes, especially for recreational and public art opportunities. It may be considered as a monument to incredible feats of engineering. The structure can be used for viewing platforms and instigating other forms of wildlife watching. It might also be retrofitted to be a zip line platform that would be the beginnings of a zip line system to the valley floor. The smooth concrete surface could become a large canvas for public art and murals. Sections could be partitioned for graffiti artists for a small fee. Sections can also be retrofitted to support extreme climbing walls (See Chapter 7: Design). Moreover, any form of public use should go through a robust public process to determine which types of activities and use would be ideal and most appropriate.

SEDIMENT REMOVAL

Coupled with removing the dam, the need for removing coarse, but mainly fine, sediment that has accumulated on the lake bottom is an expensive and timely process. Depending on the watershed upstream, the age of the reservoir, and human activities, the amount of sediment deposition could be a huge obstacle. Dredging can take place either before or after the water is drained on a case by case basis. Typically, the quickest and most cost-effective way to lose the sedimentation load is to let it get driven downstream by the power and force of the natural water source. For example, the Condit Dam Hydroelectric Project blew a large hole at the base of the Condit Dam and let all of the water flow downstream. After the water was fully drained, the power and force of the Salmon River slowly reformed the river channel-- moving any of the sediment within its desired course ("Condit Hydroelectric Project", 2011). It should be taken into consideration the full effects the change in water depth, speed, clarity, and temperature has on the downstream watershed.

San Clemente	Elwha	Glines Canyon	Matilija
85 feet	108 feet	190 feet	163 feet
7,070 c.y.	26,000 c.y.	15,000 c.y.	47,825 c.y.
2,000 af	2,480 af	8,678 af	3,660 af
Unknown	$ 182.5 Million in 2004		$110 Million
3 Years (Dam removal & mechanical sediment transportation)	2 Years (Dam removal only Natural river transport for sediment removal)	3 Years (Dam removal only Natural river transport for sediment removal)	2 Years (Dam removal & slurry of fine sediments) Alt. 4B

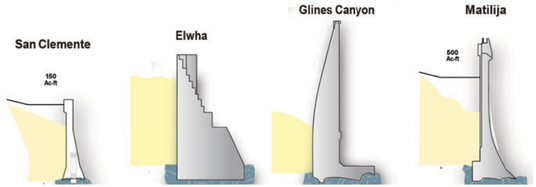


Figure 3.2: Dam Removal and Cost Considerations. *This graphic depicts the types of sediment accumulation and the costs of removal. Hetch Hetchy Restoration Study. 2006*

BANK STABILIZATION

Depending on the amount of sediment loss, velocity of the river, and time of year, bank stabilization must be implemented. The type of stabilization should be dependent upon the factors listed above. However, new research has discovered more economic, effective, and natural ways of bank stabilization. These methods include, but are not limited to, brush packing, brush layering, hydro-drilled live staking, mulching, and constructed log jams. All of these methods use vegetation as the means for stabilization, more specifically, willows and cottonwoods. These are more efficient and ecosystem friendly than concrete siding, gabion walls, or rip-rap, all of which are expensive, difficult to construct, and need heavy machinery. Furthermore, once the plants are established (within a couple of years), they will create a natural succession of bank stabilization that require little to no management while promoting habitat.

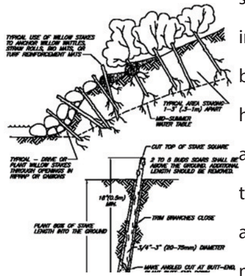


Figure 3.3: Live Staking. *Alternative bank stabilizing methods. Condit Hydroelectric Project. 2011*

SITE ASSESSMENT

A full post-dam site assessment must commence immediately for accurate information to drive many of the goals and objectives previously determined. Topographic surveys are necessary to delineate contour intervals and slopes and how they match the previous bathymetric data. Surveys should also define the project's extents, large debris, large boulders/stones, and other unpredicted objects. An assessment of the new river channel should imply stability and rate of change through natural river geomorphology. This should determine wetland delineation as well as other possible habitat types which will elucidate areas for re-vegetation. Assessment should be done regularly of exotics invasion into the landscape and locations of greatest invasion ("Condit Hydroelectric Project", 2011).

Figure 3.4: Elwha River Assessment. *Post-dam site assessment is necessary to implement the correct procedures for optimal restoration success. Joel Rogers. March 16, 2012*

RE-VEGETATION PHASING

There are four stages or periods of re-vegetating for this form of landscape restoration, namely: Pre-dam Removal, Dam Removal, Installation, Post-Installation. Each phase should be reviewed by professional biologists, ecologist, horticulturist, and any other important professionals. Where applicable, collaboration with the native indigenous people is vital because they have developed over centuries Traditional Ecological Knowledge (TEK) that will greatly benefit restoration efforts.

1. Pre-dam Removal: Before the dam is removed, native seeds and saplings should be gathered from surrounding landscapes and then propagated in nearby greenhouses/ nurseries. These will later become the plants available for installation.

2. Dam Removal: As the dam is being decommissioned, the reservoir banks will slowly be exposed to the dry environment. Propagation should continue in the greenhouses. Invasive weed control should be implemented immediately once a surface becomes exposed. This is an appropriate time for experimental plantings along the newly exposed bank to see which type of stabilizing methods are most effective and which plant palettes are most successful in any given condition.

3. Installation: Once the dam if fully removed and the water is drained, then comes the time of full re-vegetation installment. The main areas of focus would be the terraces in the valley bottom zone and the upland landforms in the valley wall zone. Depending on the circumstances, the floodplain can be left to natural processes during this time.

4. Post-Installation: This becomes the time for intense monitoring to ensure the survival of the planted species and the control of undesirable exotics. During this stage, re-vegetation should occur where necessary, especially along the floodplain once the river channel is more established ("Elwha River Project", 2011).

Figure 3.5: Fallen Log. *A safe haven for new plant growth. Elwha River Project, 2011*

ADAPTIVE MANAGEMENT

Adaptive management and monitoring strategies are crucial for the success of the project and ultimately saving money. It is important to locate sites expected to have the capability of regenerating naturally without any assistance or threat of invasive species. Consolidating areas of concern can focus efforts to the places that need the most help. For example, sites within 160 feet (50 meters) of intact forests are expected to regenerate naturally (Chenoweth et al. in prep).

Assisting natural recovery processes can also aid in the speed and recovery of the landscape. Strategies like manipulating woody debris to encourage regeneration can increase habitat suitability. Constructing log jams can increase channel complexity, capture sediment, provide habitat, and raise the water table (MWSRD, 2013). Some other artificial recovery methods might include planting, seed broadcasting, or soil mitigation. The only need to implement the artificial methods is if the natural recovery is not expected to occur quickly enough to prevent exotic invasion and/or increase habitat suitability (Elwha River Project", 2011).

> "... [goals] require measurements of innumerable parameters that are constantly subject to change on account of ecosystem dynamics"
>
> A. Clewell., 2005

MONITORING PERFORMANCE

Quality data and analysis pertaining to dam decommissioning methodology and implementation is lacking. Therefore, it is essential every project documents closely the performance of each method used and finds opportunities for experimentation and data collection. Research and data collection can be paired with educational tools for the general public via information kiosks, signage, volunteer efforts, and school participation. Every effort to increase the pool of knowledge concerning dam removal and restoration is incredibly important and valuable for generations yet to come.

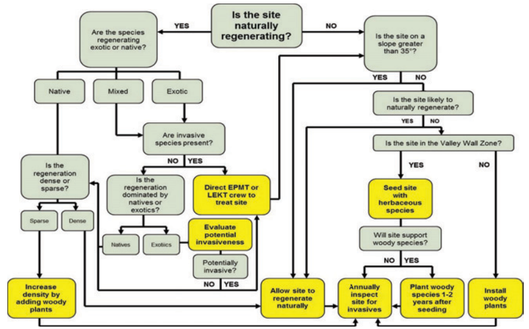


Figure 3.6: Planting Strategy Flow Chart. *This chart may help monitor performance through an adaptive management approach. Elwha River Project, 2011*

4. EXAMPLES

ELWHA RIVER PROJECT:

Purpose: To remove the Elwha and Glines Canyon Dam, access the valley conditions, commence experimental plantings, and then restore the entire valley floor to viable habitat. The leading concern was restoring the salmon population that had been dwindling by creating an unobstructed river channel that had pockets of naturalized spawning grounds.

Where: The Elwha River Restoration project was in Olympic National Park, a distinguished National Park in the State of Washington.

When: The project commenced in 2011 and will be completed in 2013.

Figure 4.0: *These hug cedar trunks have been preserved at the bottom of the lake and now shine a brilliant gold. Atop is over 100 years of stratigraphy, or of sediment deposition. Nathan Dipietro. May 5, 2012*

Impact Summary: The Elwha River Restoration Project is the largest restoration effort in the United States history. It was not the size of the dam nor reservoir that made the restoration efforts extreme, it was the incredible amounts of sediment deposition. An estimated18 million cubic yards of sediment lied behind the two dams and thus, releasing all the sediment at once would had drastically affected the downstream watersheds. Experimental approaches were necessary to see how they might create a slow draw-down of the valley floor by relying on the force and power of the Elwha River.

Funding: Many private, public, and governmental agencies such as Olympic National Park, Bureau of Indian Affairs, Department of the Interior, National Business Center, and National Park Service, were involved in the construction, funding, and research (www.nps.org/olym, 2011).

Main Strengths:

- They used a variety of agencies for research funding and information gathering
- They used a system of "awarding contracts" so they could pick the agency with greatest competence.

Main Limitations

- Slow Process of Restoration: bad soil, too much sun and wind exposure, low soil biology
- Conform to Federal Regulations and Bureaucracy
- Focused on Endangered species only instead of an holistic approach

Applications for Hetch Hetchy

- Plant Propagation Techniques: seed banking and minimizing invasive species
- Restoring ecosystem processes
- Defines accurate steps for ecosystem restoration
- The use of webisodes to adequately frame problems and solutions
- The process of re-vegetation
- Proper goal and objective setting
- Using Adaptive Management and monitoring
- Implementing Traditional Ecological Knowledge from the Native Miwok Tribes

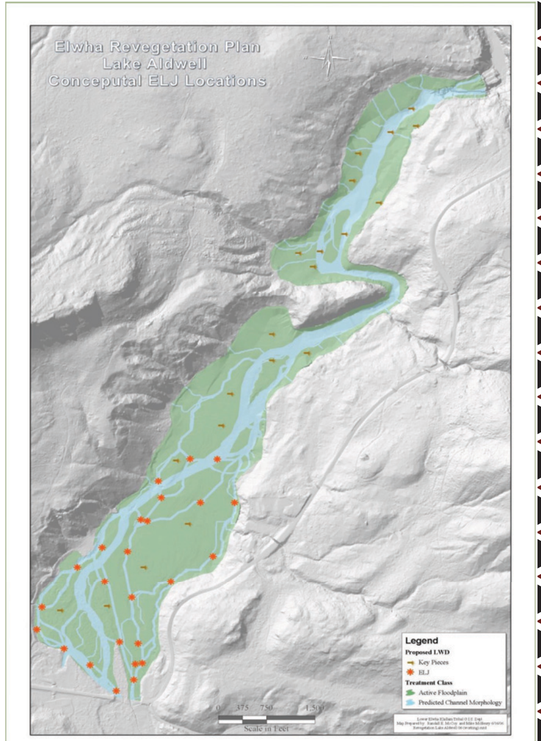


Figure 4.1: Conceptual Plan for ELJ Construction. *This map was intended to help in the visualizing of the post-dam valley. The River complexity and dynamics improves salmon habitat. Elwha River Project, 2011*

CONDIT HYDROELECTRIC PROJECT:

Purpose: Condit Dam was first built in 1913 for hydroelectric power generation. It was determined to decommission the dam because of increased environmental costs. Salmon do not have direct migration routes upstream of the dam. Washington State Fisheries required the municipalities to have a fish hatchery instead and to spawn salmon and steel head. The hired construction firm, Kleinfelder, provided the construction drawings, the site assessments, management measures, and other plans for the public to view. The construction drawings provided an example to what types of maps, drawings, and information are important to specify and include in an actual project. (Green Works, 2011).

Where: The Condit Restoration Project was another dam removal project in Washington and focused more on the process of restoration.

When: The dam was intentionally breached in October of 2011. The dam removal and initial restorative measures were completed ten months later. It was the largest dam to be removed in its time, but that only lasted until the Elwha River Project commenced and was subsequently completed.

Impact Summary: There was immediate controversy among local agencies who had assets and constituents firmly founded in the aesthetics of a lake and the habitat it provided. After a year of the initial breach, many of the lake front properties were now adjacent to a "dust river" and they argue that the value of the home has dropped (King, Date unknown). Furthermore, it has been noted that steel head have returned to the White Salmon River and salmon populations have increased.

Figure 4.2: The Lake front Homes. *After the breach in the Condit Dam, the reservoir drained five hours faster than anticipated. Due to the immense sedimentation, the White Salmon River cuts huge gorges into the landscape. These home owners most likely opposed the dam removal. www.columbian.com, 2013.*

Main Strengths:

- It is a completed project. The documented process, progress, successes, and failures are documented
- The plan is much more specific to habitat types and the acreage that will be restored. Also plant lists are available to get a feel for quantity.
- Accessible data shows crucial information for a real project

Main Limitations:

- Fairly new project so it might be difficult to identify any failures or successes.
- Many of the construction drawings are for structure removal and are intended for engineers and contractors. Not much information on site enhancement through designed elements.
- No information regarding landscape architects contributions.

Figure 4.3: A River Cuts Through It. *Much of the channel restoration was given to natural processes: using the force of the river, gravity, and properties of water allowed the river to makes its own channel. www.columbian.com, 2013.*

Application for Hetch Hetchy:

- Much of the maps and data collection they analyzed are beneficial for Hetch Hetchy
- The Management Measures can be emulated in other places with the slight addition of indigenous species to the High Sierras.
- The need for monitoring and photo documentation is crucial.
- The process of seed banking, slope stabilization, and re-vegetation areas can be applicable.

JUSTIFYING A CHANGE:

The debate on whether the O'Shaughnessy Dam is still necessary for supplying both power and water to San Francisco and the Bay Area has continued throughout the years, both in the political and environmental arenas. The Board of Directors of the Sierra Club first issued a statement that demanded the removal of O'Shaughnessy Dam in 1970. In 1987, the Secretary of the Interior, Donald P. Hodel, revitalized the idea of a restored Hetch Hetchy by stating that the restoration is possible.

The National Park Service (NPS) asked the U.S. Bureau of Reclamation (USBR) to do a full scale report on water replacement scenarios that might justify dam removal (USBR, 1987). However, several agencies discredited the replacement scenarios offered by the USBR and concluded that further investigation into Hetch Hetchy is unlikely and unnecessary (Null, 2006). In 1994 and 2004, Republicans in Congress and in the Presidency (George W. Bush) proposed bills that would increase the "rent" San Francisco currently pays to maintain water rights within a National Park from $30,000 to the maximum of $5 million. Both proposals were killed by opposing party members within congress (www.sierraclub.org, 2013).

In 2003, Jay Lund (professor) and Sarah Null (graduate student) at the University of California, Davis assessed the current Hetch Hetchy Valley water supply and analyzed alternative water storage options that may satisfy San Francisco's water and power needs. The economic benefits are also examined on behalf of O'Shaughnessy Dam and are measured in terms of quantity of water, economic costs, and hydropower generation. These factors were measured in an economic-engineering optimization model and computer aided programs like CALVIN (California Value Integrated Network).

Conclusions are provided which show that most of San Francisco's water needs may be met if the Hetch Hetchy aqueduct is connected to the much larger New Don Pedro Reservoir without any compromise to water quantity. However, the quality would be reduced and thus would create a need for a new and expensive water treatment facility. A need for a facility could increase water prices for the residents in the Bay Area to current state averages.

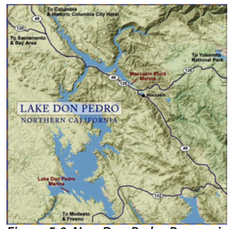


Figure 5.0: New Don Pedro Reservoir. *As an alternative source of water, Don Pedro has five the capacity of Hetch Hetchy. Foreverhouseboats.com, 2009*

Null also concluded that a substantial amount of energy revenue will be lost from two hydrological power plants, the Moccasin and Kirkwood plants (Null, 2006).

In 2004, Arnold Schwarzenegger's Secretary of Resources announced that the state would perform an intensive study on Hetch Hetchy to determine whether restoring Hetch Hetchy was even possible. Two years later, the report declared that restoring the Valley is both feasible and practical without harming San Francisco's power and water. However, little change is brought into fruition despite all the facts and well-documented debates; the people of San Francisco continue to vote down any proposition in favor of the restoring Hetch Hetchy (www.sierraclub.org, 2013). Those with voting power might not realize all of the factors within the debate or be fully educated on all the variables involved. The current politicians continue to use strong jargon to persuade their constituents to maintain rights to Hetch Hetchy.

> "I called it stupid...[and] I still think it is."
>
> **San Francisco's Mayor, Ed Lee in response to Measure F (to restore Hetch Hetchy). http://blogs.kqed.org 2012**

Figure 5.1: Gravity-propelled Aqueduct. *The Hetch Hetchy Aqueduct pays homage to man's innovation and engineering, but at the price of ruining a beautiful mountain side. This is a part of the aqueduct coming from Cherry Lake. Carson Cooper, March 24, 2013.*

ORGANIZING FOR CHANGE:

Many non-profit organizations have publicly endorsed the restoration of Hetch Hetchy. The "Restore Hetch Hetchy" organization is a sister off-shoot of the Sierra Club that completely focuses on the issues involving Hetch Hetchy. Its purpose is to be a local (to San Francisco) activist group to lobby for Hetch Hetchy as well as start a grassroots campaign to educate the citizens of the Bay Area so that they, through their voting power, may begin the tides of change for Yosemite National Park (www.HetchHetchy.org, 2013). Other organizations like the Sierra Club and Environmental Defense Fund have publicly endorsed restoration efforts and will evaluate restoration plans for the valley (Null, 2006).

Figure 5.2: Restore Hetch Hetchy. *A grassroots organization that is trying to increase public awareness and knowledge about Hetch Hetchy. There main office is located in San Francisco. Yosemiteblog.com, 2010*

The idea of a restored Hetch Hetchy is beginning to be more prominent within the media. New York Times advocated that there must be a feasibility study done and the conclusions of such a study should be the deciding factor to the fate of Hetch Hetchy (www.sierraclub.org, 2013). The Sacramento Bee published fourteen articles entitled "Hetch Hetchy Reclaimed." The articles delved deeper into the impacts of the reservoir within the National Park. It states that Hetch Hetchy is the least visited and least popular site within Yosemite National Park. The articles also elucidate the contradictions within the sustainable and environmental initiatives San Francisco is proclaiming to follow and its firm grip on keeping a reservoir within a National Park (Philp, 2004).

For example, San Francisco prides itself on being a world leader in implementing environmental legislation and initiatives, namely: carbon taxing, endorsing bicycle commuting, requiring urban agriculture, and improving some aspect of storm water management ("SF Environment", 2013). The City's environmental agenda spans the globe; all the while they keep a rare glacial Valley that resides within a National Park hundreds of miles away locked and covered with 300 feet of water (Philp, 2004).

> " By investing in state-of-the art recycling, conservation, and groundwater systems, S.F. can eliminate the use of Yosemite National Park as a water storage facility."
>
> Superintendents of Yosemite

This notion has sparked serious dialogue within the San Francisco community and throughout the world. The series of Bee articles later won the 2005 Pulitzer Prize for Editorial Writing (www.sierraclub.org, 2013).

Polls in 2010 have shown that most of the residents within San Francisco and the neighboring communities would vote in favor of restoration if it doesn't raise water and power rates. Much of the feasibility tests have shown that it would be difficult to provide the same amount of adequate water and power at the same cost they currently have. Cost would rise because the water would come from less clean sources and require increased sanitation treatment.

In 2012, the citizens of San Francisco had the opportunity to vote for a local ballot proposition, Measure F. If Measure F would have been passed, it would have allowed for a two part study to evaluate how to drain Hetch Hetchy and restore it. Unfortunately, Measure F was voted down by double digit percentage points (www.sierrclub.org).

Yet there are more opportunities for lower water and energy costs other than through reservoirs. For example, increasing areas for "banking" groundwater for future use and replenishing deep wells are alternatives. San Francisco only utilizes 2.5 million gallons of the nearly 2 trillion gallons of rainwater it receives annually. Expanding waste water recycling and improving water conservation efforts could amount to huge savings in water needs. Los Angeles recycles 198 million gallons per day while San Francisco recycles a mere 1 million (www.hetchhetchy.org, 2013).

Figure 5.3: Calera Creek Water Recycling Facility. *This plant, located in Pacifica just south of San Francisco, offers positive precedents for the bay area. It recycles million of gallons a year while generating a substantial amount of energy. Julie Littman, 2010.*

RESTORING THE CHANGE:

Restoration Plans have been developed to show the steps needed for a full ecological restoration of Hetch Hetchy and how to best maximize the valley's potential. A feasibility study, written by Dr. Gerald Meral in 2005, delves into the actual problems associated with the restoration of Hetch Hetchy. Also included in the study, theoretical design elements that would contribute to a "successful" restoration strategy are given.

The study also confirmed much of the data analysis from other sources about Hetch Hetchy's unpopularity within the park, statistical data about visitors, usability, and desirability. Furthermore, the study identifies many of the preliminary opportunities and constraints that the unique environment of Hetch Hetchy would provide. Problems like mining scars, a "bathtub" ring, re-contouring the ground, re-vegetation schemes, and invasive exotics all were prominent. The study also gave an estimate cost of a project of this scale and included possible revenue the new valley would make (Meral, 2005).

Dam Name	O'Shaughnessey	San Clemente	Elwha	Glines Canyon	Matilija
Dam Height	312feet	85 feet	108feet	190feet	163feet
Concrete Volume	662,605 c.y.	7,070 c.y.	26,000 c.y.	15,000 c.y.	47,825 c.y.
Sediment Volume	Unkown (minimal)	2,000 af	2,480 af	8,678 af	3,660 af
Total Project Cost	Unknown	Unknown	$ 182.5 Million in 2004		$110 Million
Dam and/or Sediment Removal Time	Unknown	3 Years (Dam removal & mechanical sediment transportation)	2 Years (Dam removal only Natural river transport for sediment removal)	3 Years (Dam removal only Natural river transport for sediment removal)	2 Years (Dam removal & slurry of fine sediments) Alt. 4B

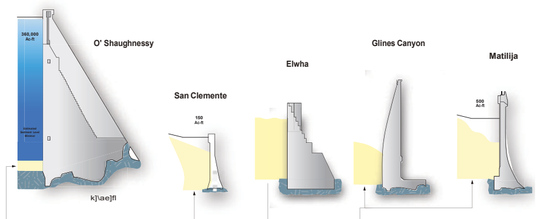


Figure 5.5: Dam Removal Differences. *It is striking to note that although the Elwha Dam is the largest dam to have been removed so far, the size and scope of the structure itself is relatively small compared to O'Shaughnessy. Hetch Hetchy Restoration Study. 2006*

Another document illustrates three different alternatives for restoring Hetch Hetchy Valley. The document starts off with an in depth description of automatic assumptions of the project scope with regard to restoration. Things like soil organism re-colonization, plant and animal habitation, sedimentation, river morphology, and soil toxicity. These assumptions manifest quick possible design solutions and/or opportunities for the specific site (Riegelhuth, Richard, Steve, 1988).

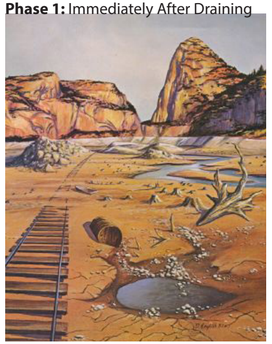
The process of removing the dam must be in compliance with engineered decommissioning data and plans. However, the lower one hundred feet of the dam will remain to prevent massive erosion of the lower valleys (Philp, 2004). It has been proposed to leave the structure in order to save on expenses and

deem the project more feasible. The structure may be used to other aspects involved within the park.

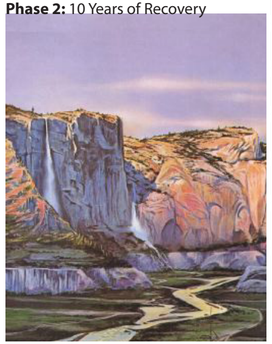
Restoring the valley to its historical and natural form might not be as hard as predicted. Due to the unique granite rock of the Tuolumne watershed, there has been very minimal sedimentation deposition (www.HetchHetchy.org, 2013). In 1991, it is predicted that only one inch of sediment is on the reservoir floor and the historic river channel most likely remains (Philp, 2004). Due to both of these unpredicted findings, it is believed that the aquatic ecosystem can return to pre-dam conditions relatively quickly and with little cost.

It is recommended to use Willow posts and seed carpeting to mimic native terrain. An aggressive replanting plan would be initiated immediately to ensure the growth of desired plants. The planting plan would follow a rigorous schedule of vegetative succession that mimics natural processes. Incorporating Traditional Ecological Knowledge provided by the Miwok Indians, an intensive fire ecology could suppress conifer encroachment and a take-over of exotic grasses (www.HetchHetchy.org, 2013).

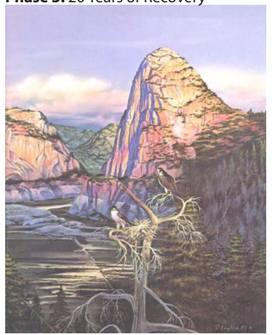
Phase 1: Immediately After Draining



Phase 2: 10 Years of Recovery



Phase 3: 20 Years of Recovery



Phase 4: Fully Recovered Valley

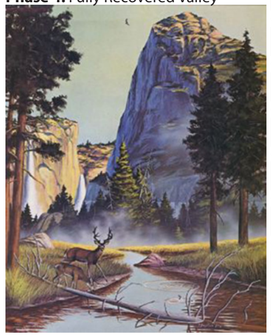
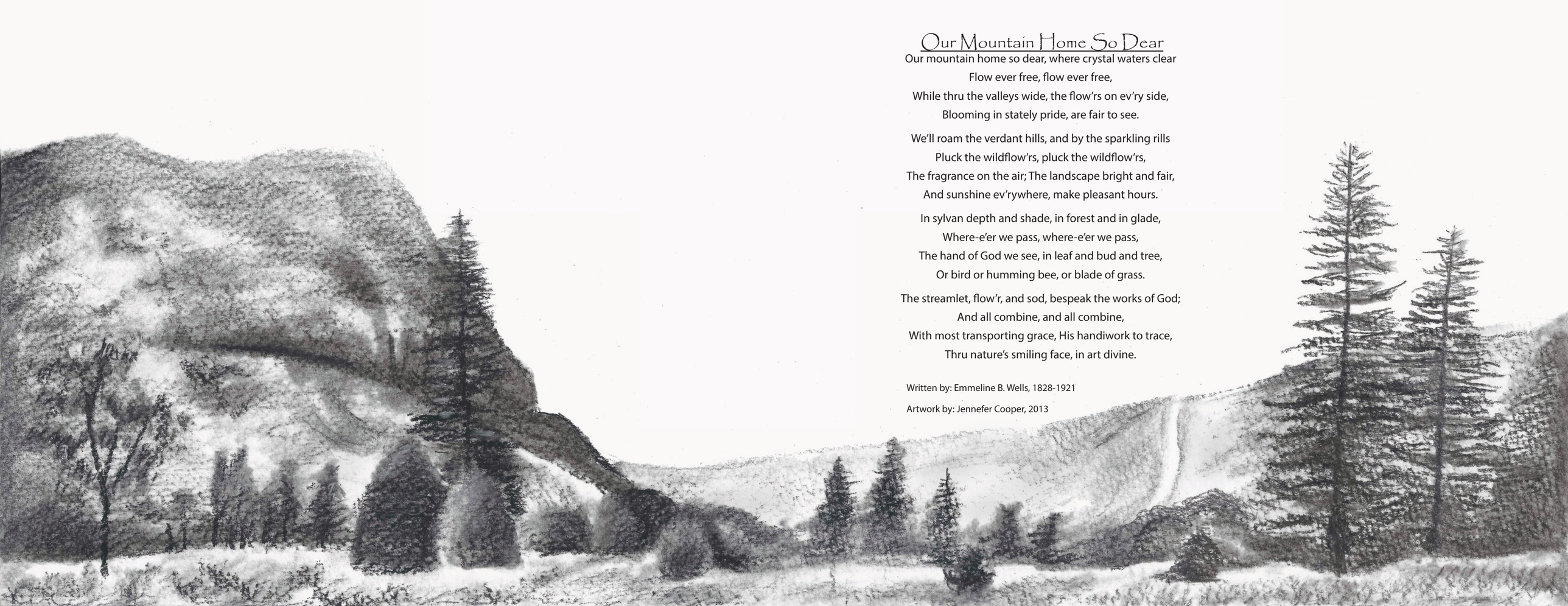


Figure 5.6: Artistic Renditions of Hetch Hetchy. *These paintings are an artist's depiction of a restored Hetch Hetchy. Daved English painted these four pieces to illustrate the unique and dramatic phases during restoration over a 100 year period. These paintings were used as posters for Muir's March fund raisers to gain support and awareness. Daved English, Sierraclub.org, 2013.*



Our Mountain Home So Dear

Our mountain home so dear, where crystal waters clear
Flow ever free, flow ever free,
While thru the valleys wide, the flow'rs on ev'ry side,
Blooming in stately pride, are fair to see.

We'll roam the verdant hills, and by the sparkling rills
Pluck the wildflow'rs, pluck the wildflow'rs,
The fragrance on the air; The landscape bright and fair,
And sunshine ev'rywhere, make pleasant hours.

In sylvan depth and shade, in forest and in glade,
Where-e'er we pass, where-e'er we pass,
The hand of God we see, in leaf and bud and tree,
Or bird or humming bee, or blade of grass.

The streamlet, flow'r, and sod, bespeak the works of God;
And all combine, and all combine,
With most transporting grace, His handiwork to trace,
Thru nature's smiling face, in art divine.

Written by: Emmeline B. Wells, 1828-1921

Artwork by: Jennefer Cooper, 2013

THE SITE BOUNDARIES:

Hetch Hetchy Valley is located within Yosemite National Park. It is roughly 15 miles north of Yosemite Valley and resides in Toulumne and Mariposa Counties. The valley consists of a long, finger-like form that stretches three and half miles long and varies from half to a quarter mile wide.

To maintain integrity and include all necessary components of appropriate analysis, the site boundaries extend beyond the shape of the Valley itself. The site boundaries were adopted by using the two USGS Quadrangle maps that incorporate all of Hetch Hetchy and its neighboring amenities, Camp Mather, and Cherry and Eleanor Lakes that reside on the northern boundaries as the project extents.

Although Camp Mather isn't located within Yosemite National Park, it still is an important place for park visitation and revenue. It is a San Francisco family camp and brings lots of visitors to Yosemite Park from the city of San Francisco. Camp Mather is considered to be the gateway to Hetch Hetchy.

The extent of the boundaries help identify circulation routes with access roads, trails, and equestrian paths. It also helps show key attributes and site elements that surround the Hetch Hetchy Valley and provides a sense of place and identity.

Figure 6.0: USGS Quadrangle Maps. *The o37119h6 and 037119h7 maps. CalAtlas, 2013.*

Figure 6.1: Camp Mather Entrance. *The gateway to Hetchy Hetchy. Gennarelli, 2011*

REFERENCE MAP: YOSEMITE NATIONAL PARK

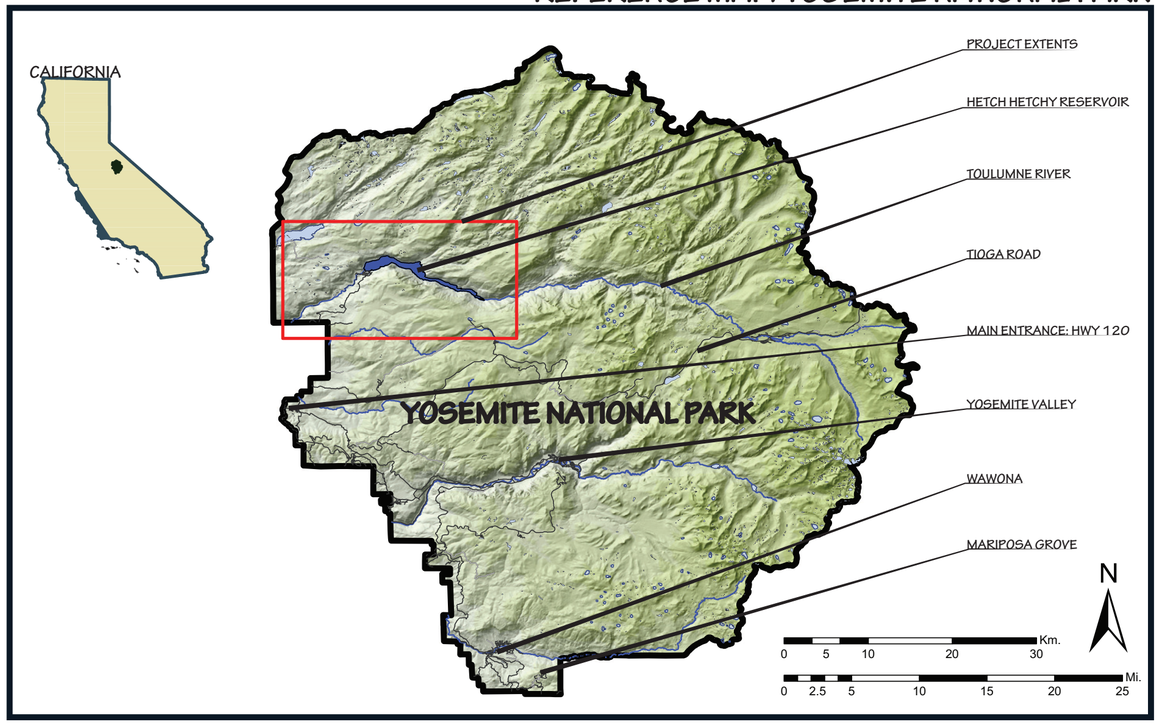


Figure 6.2: Yosemite National Park. *There is a lot to see and do in one of the most popular parks in the world. Located in the High Sierras, Yosemite National Park was one of the first National Parks in the United States. The most visited location in the park is the Yosemite Valley. Although Hetch Hetchy had many of the same great features that makes Yosemite so popular, it is the least visited location. Hetch Hetchy is located in the northwest corner.*

SITE INVENTORY MAP: HETCH HETCHY AREA

Figure 6.3: Site Inventory Map. *This map illustrates the various activities available to do in the Hetch Hetchy region. A majority of the hikes and trails available lead to a specific destination that is considered a natural wonder or place worth the effort.*

SITE INVENTORY:

Hetch Hetchy Valley, just like Yosemite Valley, is surrounded by granite cliffs that rise thousands of feet-- almost vertically-- into the sky. There are five major waterfalls along the cliffs surrounding the Valley. The most prominent are the Tueeulala and Wapama Falls.

The watersheds surrounding the valley all empty into the valley floor through rivers and small streams, each usually cascading down a cataract that are spectacular sights during the spring. Meandering along the valley floor is the Toulumne River, which is purer and cleaner than the Merced River of Yosemite Valley.

The Toulumne River runs into the Valley from the east through the Grand Canyon of the Toulumne and exits the valley on the west into the infamous Poopenaut Valley. Natural site amenities in the project boundaries include: Hetch Hetchy Dome, Kolana Rock, Smith Peak, Tiltill Valley, Poopenaut Valley, Grand Canyon of the Toulumne, a handful of various waterfalls such as: Wapama Falls, Tueeulala Falls, and Rancheria Falls, and several neighboring mountain lakes like Cherry Lake, Eleanor Lake, and Laurel Lake.

Project Amenities and Attractions	
Lakes and Reservoirs	
Hetch Hetchy Reservoir	Cherry Lake
Lake Eleanor	Laurel Lake
Lake Vernon	Harden Lake
Mountains and Ridges	
Kolanah Rock	Hetch Hetchy Dome
Smith Peak	Grand Canyon of Toulumne
Le Conte Point	Mt. Gibson
Meadows and Valleys	
Poopenaut Valley	Miguel Meadows
Tiltill Valley	Smith Meadows
Rivers and Creeks	
Toulumne River	Rancheria Creek
Tiltill Creek	Cottonwood Creek
Waterfalls and Cataracts	
Wapama Falls	Tueeulala Falls
Rancheria Falls	Cottonwood Falls
Scenic Areas and Attractions	
Poopenaut Valley	Grand Canyon of Toulumne
O'Shaughnessy Dam Administration Area	

Table 6.0: Site Inventory of Amenities and Attractions. *This table shows the most prominent types of attractions located within a 5 mile radius of Hetch Hetchy Valley.*

Figure 6.4: Half Dome. *The amazing Half Dome that looms over Yosemite Valley stands as a testament to the strength and durability of Yosemite Granite.* Carson Cooper, 2013.

GEOLOGY AND SOILS:

Most of the High Sierras, where Yosemite National Park is located, is made up of granite. However, in Yosemite, the granite is called Yosemite Granite and is the strongest of all granites. The strength and durability of this magnificent stone, along with thousands of years of glacier wear, has been the main factor for the extreme uniqueness of the mountain ranges within the Yosemites. Ancient glaciers cut away the unique shape of Hetch Hetchy Valley, inevitably leaving behind glacial till. Through processes of chemical and physical weathering, the glacial till became an ideal landscape for primary succession. Hetch Hetchy Valley was a very rich and prosperous valley due to the uniqueness of soil and historic geology.

TOPOGRAPHY/ BATHYMETRY

The Hetch Hetchy Valley is roughly around 3,600 feet above sea level. The tallest cliffs along its perimeter are range from 5,500 to 6,500 feet. As the cliffs reach the bottom of the valley their slopes soften to a near 3:1 slope ratio until they hit the valley floor.

The valley floor is nearly flat with an average of 1% cross-slopes directing all run-off to the Toulumne. Finding current bathymetric data proved difficult because it either is not public knowledge or the National Park Service has not accumulated this data. In order to achieve the likely bathymetry of the valley, geo-referencing the old 1909 USGS Quadrangle Map that predated the dam allowed for digitizing the contour lines within the reservoir boundary.

Although the topography might not fully match the true conditions, they are close enough to hypothesize and develop design solutions. After the reservoir is completely drained, a full scale assessment of current topographic analysis must be completed and reviewed with the projected site planning.

ELEVATION ANALYSIS WITH GRAPHS

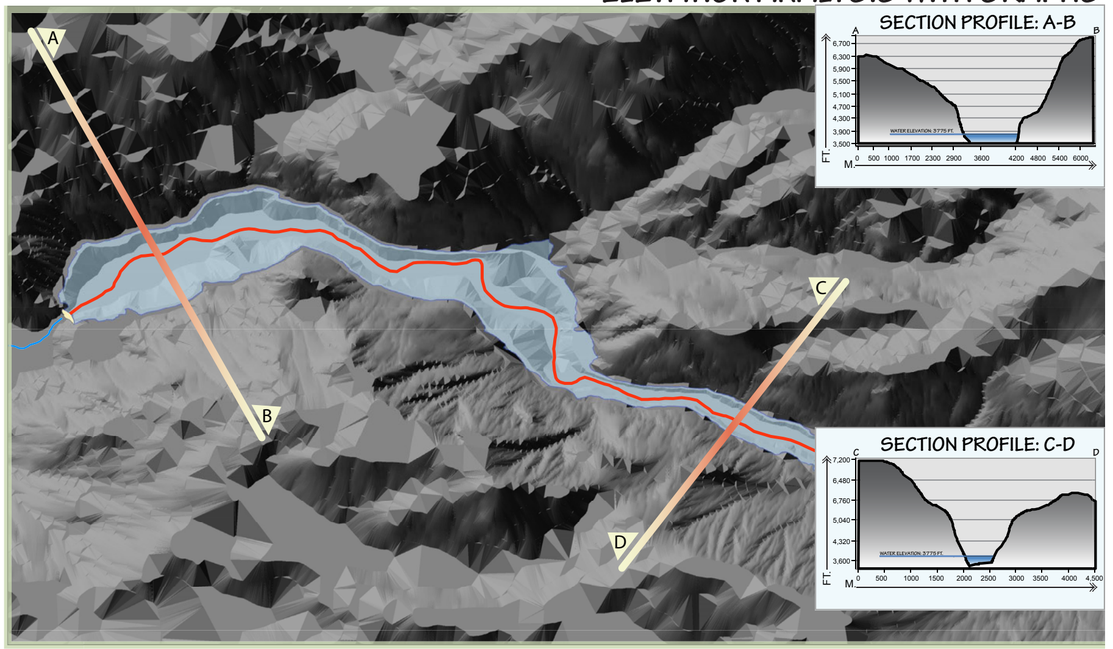


Figure 6.5 : TIN Model and Graphs. *The TIN model and associated graphs help to illustrate the drastic elevation changes around Hetch Hetchy.*

HYDROLOGY AND FLOODPLAIN:

There are ten watersheds within the project boundaries and a majority of them eventually flow into the Toulumne River. The watersheds surrounding the valley that empty into the valley floor through rivers and small streams usually cascade down a steep face at some point, creating waterfalls of all shapes and sizes. Typically, the larger the watershed, the greater the volume of water it will accumulate and larger the waterfall.

It is nearly impossible to know the exact floodplain along the valley floor without precise bathymetric data or post-dam assessments. The average floodplain width for a 10-year flood event is three hundred feet in Yosemite Valley. Therefore, a 300-foot buffer was designated outward on each side from the river channel and no major development will occur in these areas. During an unusual 100-year flood event, almost all of Yosemite Valley was inundated and its inferred that Hetch Hetchy would be as well.

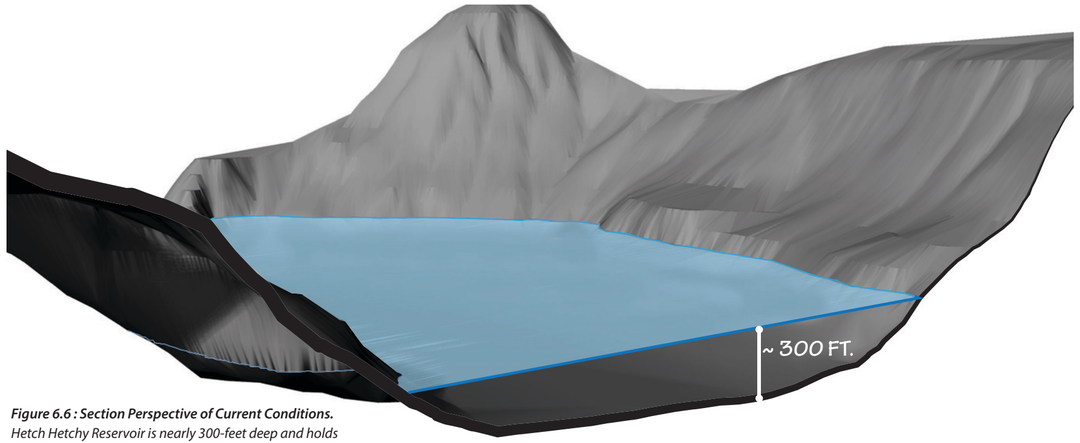


Figure 6.6 : Section Perspective of Current Conditions. *Hetch Hetchy Reservoir is nearly 300-feet deep and holds 360,000 acre-feet of water.*

WATERSHEDS OF THE TOULUMNE

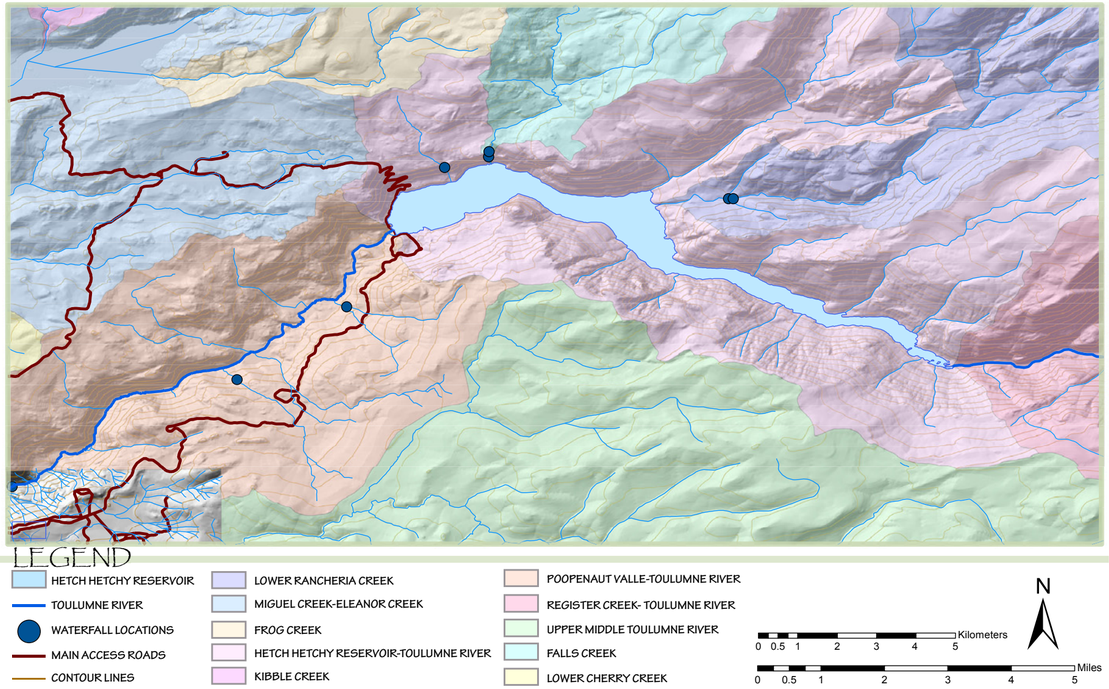


Figure 6.7: Watershed Map. *Each watershed typically drains into a distinguished waterfall at some point. The waterfalls of Hetch Hetchy are highly regarded.*

VEGETATION:

There are seventeen major habitat types within the project boundaries. They vary from lower oak woodlands to upper-montane chaparral. However, through the process of determining habitat suitability, only seven of them would actually be suitable for the Hetch Hetchy Valley.

From the writings of John Muir and other settlers along with the Traditional Ecological Knowledge obtained by the Miwoks, we know that some habitat types are more dominant than others, namely: Meadow, Black and Live Oak Woodlands, Ponderosa Pine, and Foothill Conifer. Since several restoration guides have already been published, this thesis will not focus on habitat allocations or placement but more focus on usability and integrating human involvement without degrading the restoration efforts.

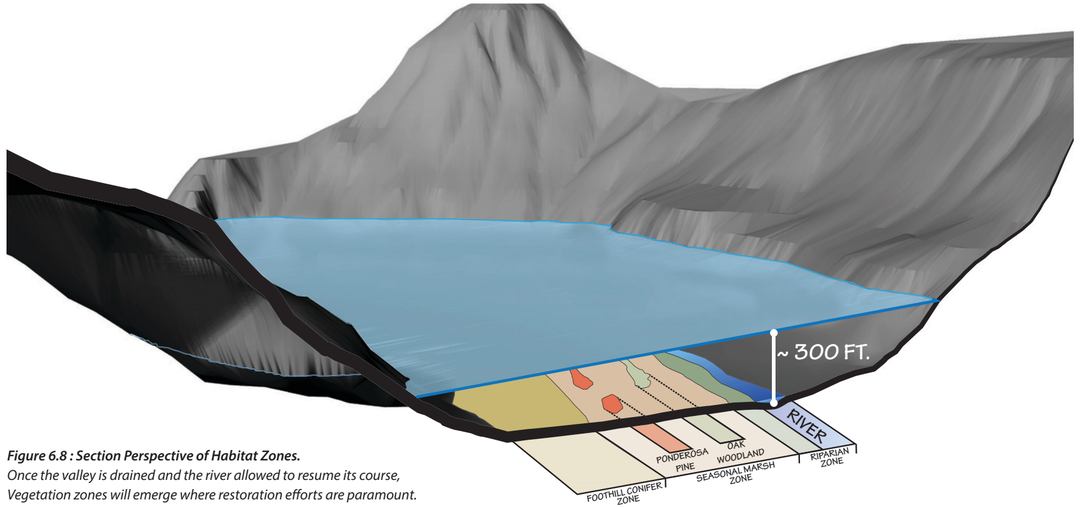


Figure 6.8 : Section Perspective of Habitat Zones.
Once the valley is drained and the river allowed to resume its course, Vegetation zones will emerge where restoration efforts are paramount.

DOMINANT HABITAT MAP

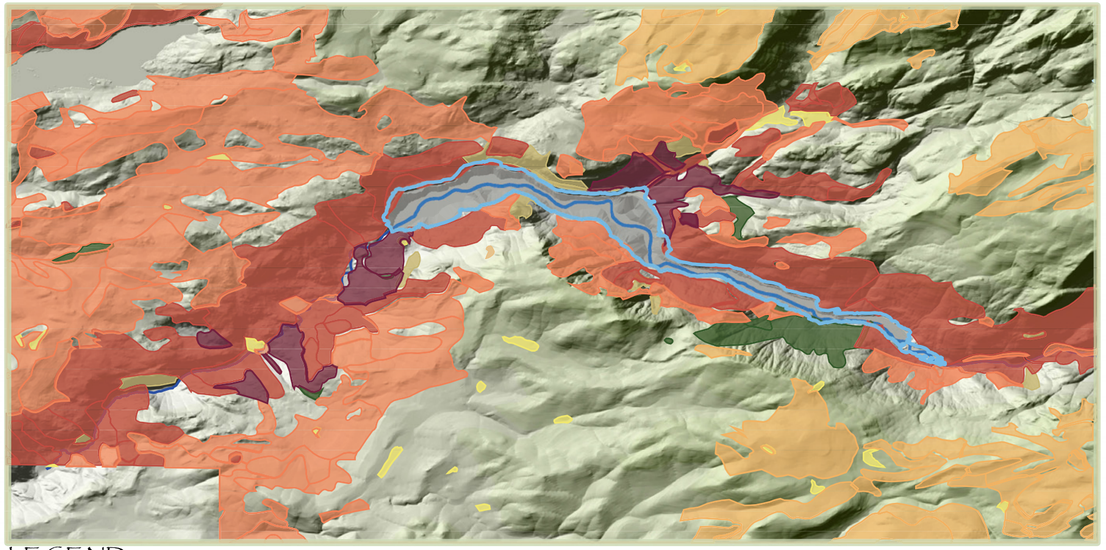


Figure 6.9: Dominant Habitat Types Map. *This map shows the habitat types that would most likely be aiding restoration efforts through seed dispersal. Each habitat's proximity is a key factor in primary and secondary succession.*

WILDLIFE AND HABITAT:

Home to a variety of fauna, Hetch Hetchy is a great wilderness. Home to deer, beaver, bear, amphibians, and birds. Many notable species that would be common to a restored Hetch Hetchy are: the Golden Eagle, the Bald Eagle, the Peregrine Falcon, and the Great Gray Owl. Within all of Yosemite National Park are certain keystone species that are of a special concern to either California government, the Federal Government, or both. Not every special status species will find residence in or around the Hetch Hetchy area but there are some influential species that will inhabit the restored valley (See Table 6.1).

Tailoring restoration efforts to create suitable habitat for endangered species is crucial for developing a healthy ecosystem. Understanding ecosystem dynamics is important in developing restoration plans suitable for accurately mimicking nature. Table 6.1 is a list of species that should be considered as focal species. In other words, restoration and re-vegetation efforts should be tailored to provide for each species life cycle.

Scientific Name Common Name	Listing Status: Federal/State/CNPS	General Habitat	Potential to Occur in Study Area Segment
Amphibians			
Rana sierrae Sierra Nevada yellow-legged frog	FC/CT CSC	Inhabits high mountain lakes, ponds, tarns and streams at elevations ranging from 4,000 to 12, 500 feet; rarely found more than 3 feet from water.	Moderate/High
Birds			
Aquila chrysaetos Golden eagle	CFP	Forages in open terrain such as grasslands, deserts, savannahs, and early successional stages of forest and shrub habitats; nests in canyons and large trees in open habitats. In the Sierra Nevada, golden eagles favor grasslands and areas of shrubs or saplings, and open-canopied woodlands of young blue oaks.	Extremely High
Haliaeetus leucocephalus Bald eagle	FD/CE/CFP	Nests in tall trees, usually over 100 feet in height, or on cliffs, usually near water. Favor lakes and rivers with abundance prey (mostly fish).	Moderate/High once vegetaion is established
Falco peregrinus Peregrine falcon	CFP	Nests on vertical cliff habitat, with large potholes or ledges, that is inaccessible to land predators. Hunts in a wide variety of habitats including meadows, woodlands, marshes, and mudflats.	High/ Extremely High
Strix nebulosa Great gray owl	CE	Entire California population of this species is restricted to the Yosemite region. Breeds in mixed conifer/red fir forests bordering meadows. Winters in mixed conifer down to blue oak woodlands.	High/ Extremely High
Empidonax traillii Willow flycatcher	CE	Breeds in moist, shrubby areas, often with standing or running water. Winters in shrubby clearings and early successional growth. Deciduous trees and shrubs interspersed with open areas enhances the quality of foraging habitat.	High/ Extremely High
Mammals			
Martes pennanti pacifica Pacific fisher	FC, CSC	Dens and bears young in the cavities of large trees or snags and strongly associated with mid-elevation mature and late successional coniferous or mixed forests. Generally found in stands with high canopy closure, large trees and snags, large woodlarge wood, large hardwoods, and multiple canopy layers.	Moderate/High once vegetaion is established

STATUS ABBREVIATIONS:
FE = Federal Endangered
FT = Federal Threatened
FC = Federal Candidate
FD = Federal Delisted
CT = California Threatened
CCE = California Candidate Endangered
CFP = California Fully Protected Species
CSC = California Species of Concern CE = California Endangered

Table 6.1: Hetch Hetchy Focal Species. *Each of these species are of special status. It is paramount that restoration efforts are tailored to the thriving of these animals. Data Collected from the Nation Parks Service's MWSRD.*

MIWOK CONSIDERATIONS:

The Sierra Miwok Tribes have inhabited the Hetch Hetchy Valley for over six thousand years. They were industrious and knew the land well. They knew the right time to plant, pluck, eat, preserve, and share all of the local flora and fauna. Since the Miwok Indians know the land extremely well, it would behoove restoration efforts to include Traditional Ecological Knowledge (TEK). Restoring the valley to its pre-dam condition would be restoring it back to how the Miwoks managed it for thousands of years. The Hetch Hetchy Valley's pre-dam condition is not pristine, and such an effort to restore it to its "natural" and "pristine" state would compromise the site's historical integrity.

The Miwoks managed the land to be desirable for many of the animal species they ate as well as animals that had cultural and spiritual value. They had sacred rituals and burial grounds throughout the valley. The exact locations of the sacred lands and burial grounds are unknown. Further outreach with the Miwok Tribe would be crucial to preserve and sanctify these locations. It is estimated that there are at least eleven of these locations spotted along the valley floor. Post-dam assessment must include culturally significant sites.

Figure 6.10: Miwok Umacha Tee-pee. *Umacha Tee-pees were the main form of lodging for the native Miwok Indians. Yosemite Research Library, 1925.*

Figure 6.11: Miwok Dancing. *The Miwok Indian's culture was full of traditional dancing for worship, rituals, and entertainment. Tony, 2006.*

Figure 6.12: Miwok Sacred Grounds. *Places like this are extremely important to the history of the Miwok Indians and such should be preserved. Avant-Gardenist, 2008.*

CURRENT CIRCULATION:

The most accessible way to get to Hetch Hetchy is to take the Evergreen Pass off of Highway 120. The route spans roughly twenty six miles of narrow roads with several cut-backs and elevation changes. The road is relatively narrow and offers very little leeway if two cars pass each other. It isn't completely secure either because there are many places where there is no guard rail, even near high cliff drop-offs. Even with a map, it is difficult to navigate a clear route to Hetch Hetchy; therefore, way-finding and signage should be improved.

Once you arrive at Hetch Hetchy Reservoir, there is limited parking and the two way street turns into a one way round-about that goes along the edge of the O'Shaughnessy Dam. There are few service roads that go around the reservoir, so access is currently very limited. Some access roads do provide connectivity to other ecological features like Cherry and Eleanor Lakes.

Existing trails of different lengths and difficulty surround the reservoir. The trails are intended to highlight site amenities and natural features and most of the them start on top of the dam.

Figure 6.13: Parking at Hetch Hetchy. *Due to the lack of high visitation rates and vehicular traffic, Hetch Hetchy only offers a few parking options. Carson Cooper. 2013*

Figure 6.14: Hetch Hetchy From Afar. *This picture was taken from Evergreen Road. It is evident of the spectacular views available on your way to Hetch Hetchy. Imagine the views once the valley is restored! Carson Cooper. 2013*

CIRCULATION MAP

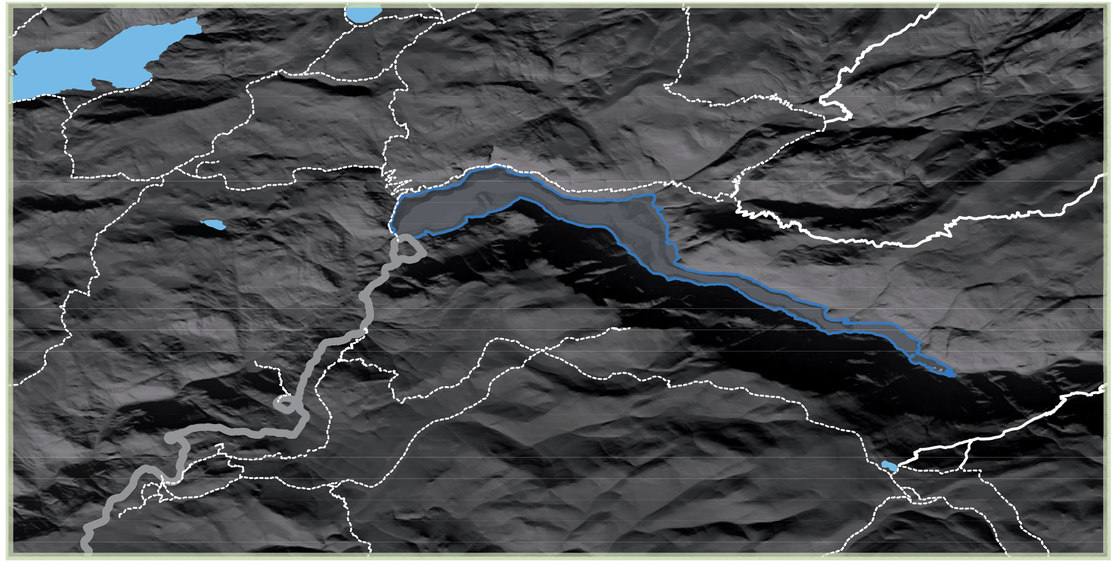


Figure 6.15: Circulation Map: *Adequate trail connectivity is an ideal recreational feature for a National Park. The more trails that can accommodate different users, the less crowding each will be during the summer months.*

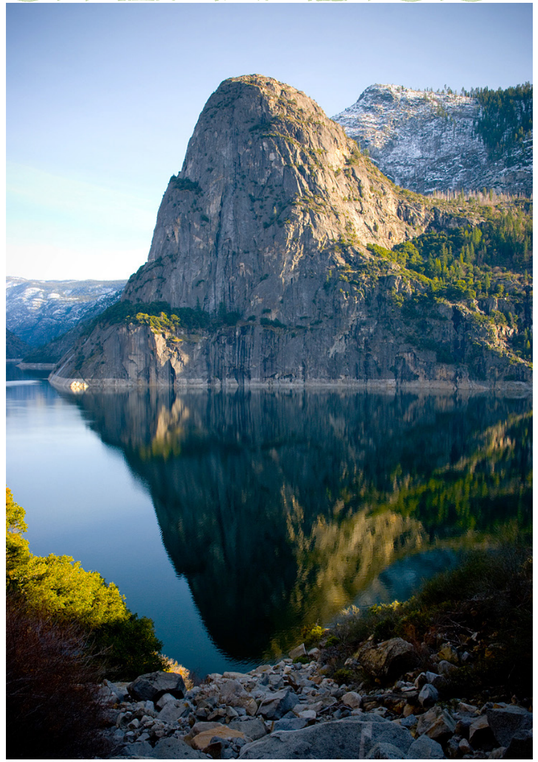


Figure 6.16 : Kolana Rock Reflections: *One of the highest regarded attractions is Kolana Rock. Although it is visible from almost anywhere within the valley, it also obstructs views to and from neighboring attractions. Kristel Balmet, 2012.*

Sight Line Analysis:

Along the Hetch Hetchy Valley are locations ideal for viewing a diverse array of natural features. Considering a majority of visitors come to Yosemite for sightseeing and relaxing, identifying those locations of highest sight-seeing value would be paramount. The areas with the greatest ability to see the largest variety of site amenities is considered the most valuable.

The sight lines are drawn with elevation, ridge lines, natural features, and proximity all in mind. Locations where the most sight line polygons overlap will become areas of greatest importance for site programming and design feature placement. Considering the view from O'Shaughnessy Dam also extends over the vast Poopenaut Valley to the west, it is prudent that the analysis included areas within the Poopenaut Valley.

> [The] trends, sculpture, physical structure, and general arrangement of the main rock-masses... has excited the wondering admiration of every observer.
>
> John Muir. *The Yosemites.* 1912

SITE LINE ANALYSIS MAP

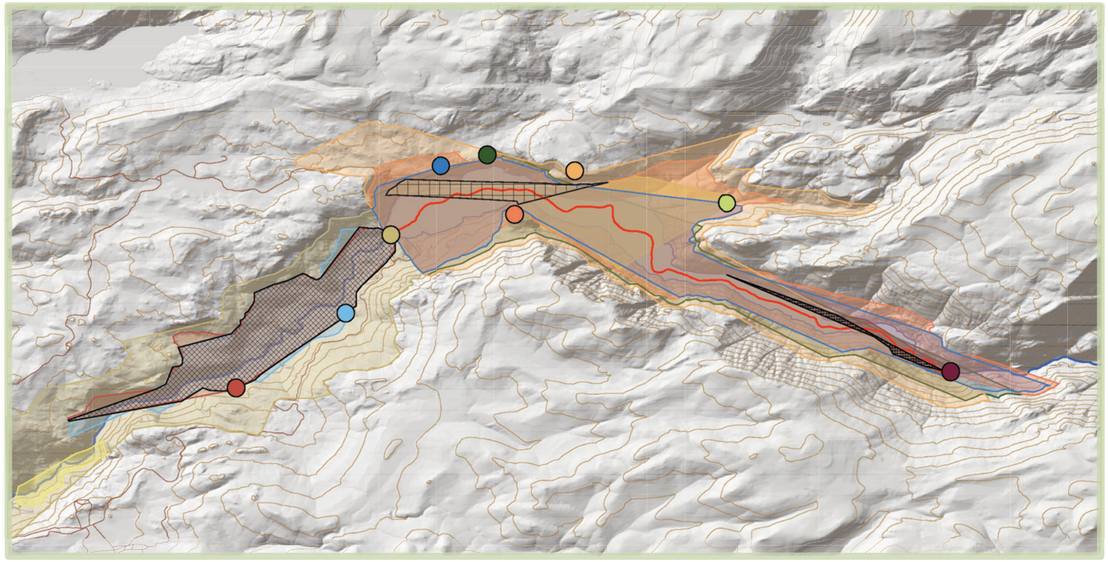


Figure 6.17: Site Lines Analysis Map: *This map identifies key areas where a visitor may see the most natural attractions at the same time.*

SUITABILITY ANALYSIS:

Through an in-depth analysis of the slope, proximity to the river, proximity to natural site amenities, and the floodplain buffer, specific locations for design programming were identified. The most suitable locations would be ground with a slope no greater that 3%.

Being close to important features like the Toulumne River for access as well as being in close proximity to the natural site attractions is ideal. Areas that are found closest to many of the site features were given higher value. Areas located nearest the Toulumne river were also given a higher value.

Through various tools like the model builder in ArcGIS, the most suitable areas for development and site intervention were extrapolated. These areas are considered suitable development sites for project programming. Not every one of these locations would need or require development; therefore, further analysis must be taken into consideration for appropriate site planning.

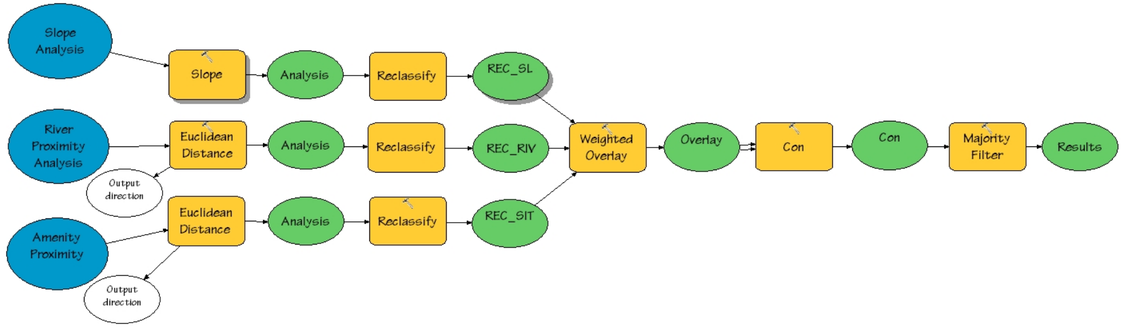


Figure 6.18: Model Builder in ArcGIS: *The model builder tool in GIS aids in complicated analysis of different variables and their relationships with one another.*

SUITABILITY ANALYSIS MAP

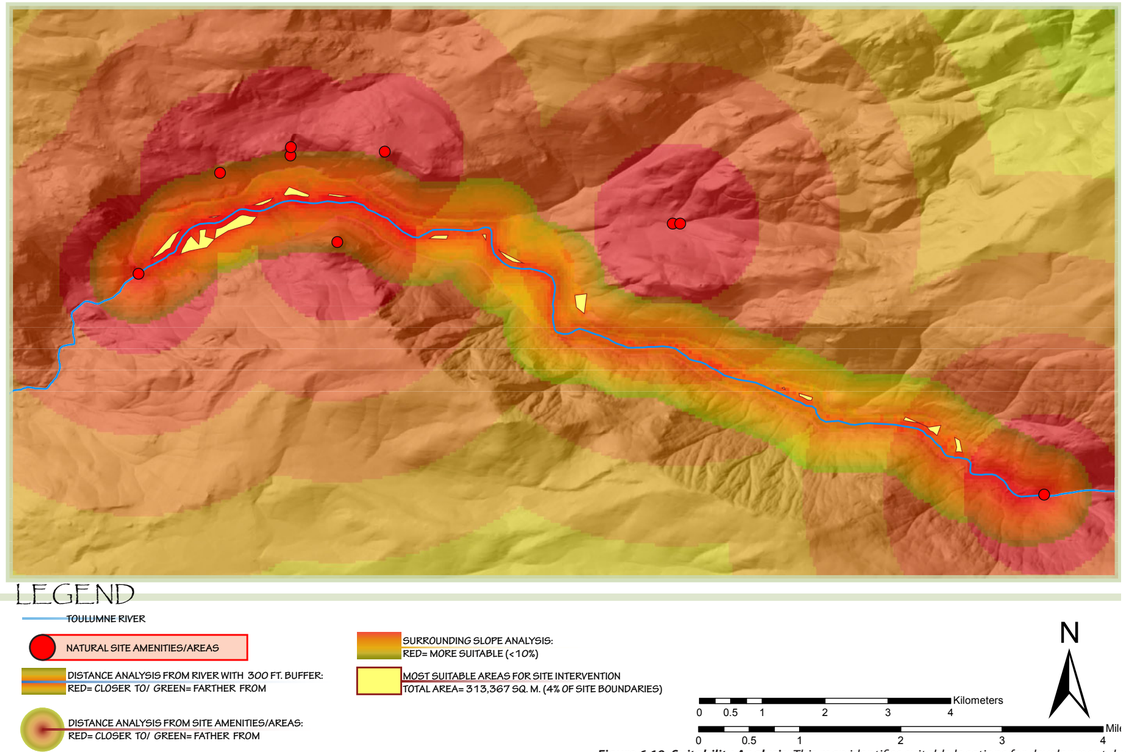


Figure 6.19: Suitability Analysis: *This map identifies suitable locations for development due to their slope and proximity to the river and other features.*

OPPORTUNITY ANALYSIS:

Results from the Sight Lines Analysis and the Suitability Analysis were then analyzed together. Layering the two data sets manifested the optimal design sites. The delineated areas are considered the optimal development sites for project programming. These sites are taken into special consideration for their unique proximity, views, and suitability features when developing the master plan.

The most appropriate types of design intervention will weigh form and function, and then create a space that most visitors can use without overcrowding. Possible types of intervention might include viewing platforms, a visitor's center, campgrounds, and recreational activities.

There are a variety of different areas spread across the entire Hetch Hetchy Valley that are optimal development sites but each has a different shape and size. The sites' shape, size, and location were the deciding factors for which type of site intervention would be included.

Site #	Area in Acres	Possible Design Element
1	2.25 acres	Viewing Areas, Information Kiosks, Campground
2	6.50 acres	Campground, Visitor's Hub
3	1.25 acres	Viewing Areas, Information Kiosks
4	.75 acres	Viewing Areas, Information Kiosks
5	1.50 acres	Campground

Table 6.2: Optimal Sites. *Each of these sites were identified as having the best conditions for development; however, due to their size and location, many types of site programming are not possible.*

Table 6.20: Wapama Falls. *Three of the five optimal sites are near Wapama Falls. It is considered an equal counterpart to the great Yosemite Falls. Pete Jackson, 2006*

OPPORTUNITY ANALYSIS MAP

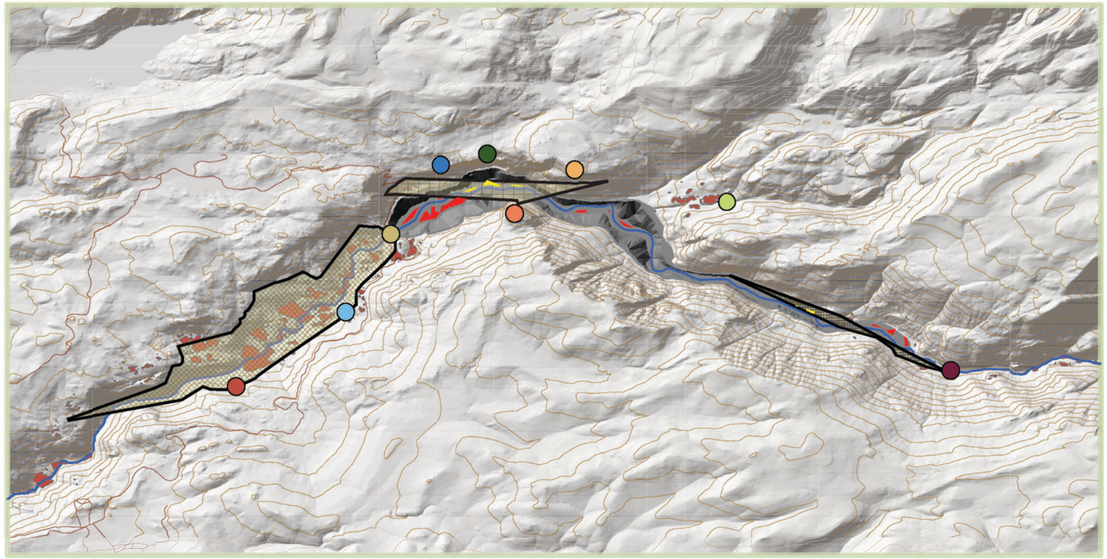


Figure 6.21: Opportunity Analysis Map: *Through layering analysis of previous research, it is possible to locate the optimal design sites for master planning.*

HYPOTHESIS:

1. The overall Master plan and site programming will have limitations because the project resides within a National Park.
    - o Tools and Design Processes used might be limited

2. Attempting to restore the valley floor will be a very intensive and long process.
    - o Vegetation succession time lines will need to be instituted and followed with best management practices.
    - o Volunteer groups and non-profit organization will need to collaborate for the maintenance, up-keep, and weed removal.
    - o Research and studies will need to be implemented to ensure proper record keeping and to elucidate many facts regarding reservoir valley restoration.
    - o Professionals of various fields of study should be employed for future decision making and to evaluate the successes and failures of the restoration efforts

3. The valley will never be restored completely back to its original form before O'Shaughnessy dam was commissioned.

4. The restored valley will revitalize Yosemite National Park and increase revenue.
    - o Reach an even more global clientele
    - o Will enhance the visitor experience which will warrant a longer stay, more paid tours, more lodging revenues, more accessory and memorabilia sales

5. The restoration effort will be an example to a global market and be a catalyst for removing dams worldwide.

Figures 7.0: The Hetch-Hetchy Valley. *Albert Bierstadt was a member of the Hudson River School who courageously embarked on the Westward Expansion expeditions to bring to life the "new world". His paintings illustrate the beauty of Hetch Hetchy. Albert Bierstadt, 1830-1902.*

SITE PROGRAMMING:

Appropriate programming for the Hetch Hetchy Valley should reflect the project goals in their entirety. Not everything proposed in this document are necessary for a complete and successful restoration effort; however, through the previous analysis hitherto accomplished, the program elements are noteworthy and should be highly considered for implementation. The ultimate fate for Hetch Hetchy Valley will be decided by the National Park Service with thorough public involvement.

The project goals proposed for Hetch Hetchy are: 1. Increase visitation; 2. Increase public awareness and likability; 3. Improve vehicular and pedestrian circulation; 4. Moderate overcrowding through design and accessibility; 5. Create lodging and camping opportunities; 6. Prevent human encroachment in sensitive restoration areas; and, 7. Develop a variety of recreational activities for all types of visitors.

PROJECT GOALS
Increase Visitation
Increase Public Awareness and Likability
Improve Vehicular and Pedestrian Circulation
Moderate Overcrowding Through Design and Accessibility
Create Lodging and Camping Opportunities
Prevent Human Encroachment in Restoration Areas
Develop a Variety of Recreational Activities

Table 7.0: Project Goals. *Goals will help drive production and maintain focus. Goals are essential pieces to any successful project. The National Park Service will finalize and approve all of the project's goals.*

1. Hetch Hetchy should be the "shy twin sister" of Yosemite Valley, meaning that it is just as beautiful and wonderful to visit but not have the same amount of negative impacts on the natural world. However, increasing visitation is incredibly important for the future of Hetch Hetchy. Not only would increased visitation alleviate many of the problems Yosemite Valley faces with overcrowding and poor circulation, it will increase the diversity of activities to do within Yosemite National Park. Relieving the touristic burden would enhance overall visitor experience. Ultimately, this goal is achieved when all of the other goals are met.

2. Educating visitors is an important aspect of restoration management. Throughout the site there would be interpretive signs that inform visitors of the many wonders within Hetch Hetchy. Informing visitors about Hetch Hetchy's complex geomorphological and political history, the flora and fauna within the park, the unique features around Hetch Hetchy, and

more. These signs should be clear and concise with attractive graphics. The National Park Service will dictate where the signs should go and their content.

3. Providing options for travel helps the overall visitor experience. Creating many paths that lead to the same destination would mitigate major traffic and any accidents. Having a variety of pedestrian travel throughout Hetch Hetchy, especially in the areas proposed to have the highest amounts of visitation (O'Shaughnessy Dam Recreational Area), is ideal. It is proposed that there be a main access road for vehicular use, but the access roads can also serve as larger pedestrian corridors. Also, the plan will have a variety of trails, paths, and boardwalks that spread throughout the valley, bypassing any sensitive areas.

4. Moderating large crowds would be crucial in protecting restoration efforts and user likability. One way overcrowding might be minimized would be to control access into Hetch Hetchy. It is proposed that all visitors must travel into Hetchy Hetchy via passenger buses that make periodic trips from Camp Mather. However, the bus routes would be limited to one-way travel for safety and easier travel. The one-way travel would create a longer waiting times in between bus circulation and thus, minimize the amount of visitors at any one time. During peak business months, many buses can travel in the same direction at once. The buses should be free to park visitors.

5. A major issue Yosemite Valley faces year after year is the inability to accommodate overnight users. In direct response, Hetch Hetchy Valley could have four campgrounds of various sizes and locations. All the proposed campgrounds are identified as "hike-in only". In total, 275 new campsites would be added. This would greatly increase the Park's capacity to accommodate overnight use and increase revenue (See Table 7.1).

6. Clustering development according to program elements would create designated boundaries that could tolerate human influence while also continuing to maintain isolated natural areas for unhindered restorative efforts. Fencing and appropriate signage would also aid in this effort.

Name	Number of Sites	Acreage	Reservations?	Running Water	Fire Pit
Poopenaut Campground	65	9	No	Yes	Yes
John Muir Campground	125	30	Yes	Yes	Yes
Wapama Falls Campground	50	6.5	No	Yes	Yes
Canyon's Feet Campground	35	6	No	No	No

Table 7.1: Hetch Hetchy Campgrounds. *Campgrounds are an essential part of the Hetch Hetchy experience.*

There will be certain facilities located throughout the valley. Restrooms would be located according to daily use patterns as well as adequate vehicular access. Storage facilities for park rangers are also located appropriately for maintenance equipment and materials.

Larger facilities like a visitor's center, museum, grocery store, and hostel should be designed to have minimal impact on the environment by including eco-friendly building techniques like "vegitecture", alternative power accumulation and the use of native materials.

7. Hetch Hetchy should explore a variety of recreational opportunities (some of which Yosemite Valley does not offer), without harming the natural environment and without distracting other visitors. Recreation activities might include, but are not limited to, white water rafting, zip lining, hang gliding, dam and rock climbing, fishing, swimming, mural art, and hiking. Although some of these activities are considered "extreme" recreation and sport, their impact on the environment is minimal and their capability to disrupt visitation is small.

Boardwalks and Signs

Melissa M., 2012

Dam Climbing

Thrillseekersanonymous, 2012

Hang Gliding

Roger Baker, 2013

Hike-In Campgrounds

Tom Stienstra, 2013

Low Impact Center

Inhabit.com, 2013

Split-rail Fencing

firewoodonline.net, 2013

Zip Lining

Bridge Day, 2012

Information Kiosks

FWS.gov, 2013

White Water Rafting

imperfectspirituality.com, 2011

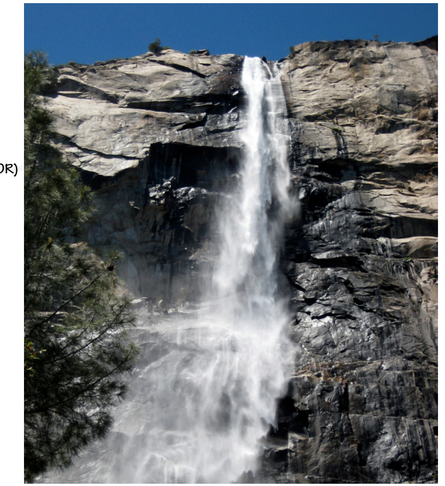
Figures 7.1- 7.9: Programming Elements. *Hetch Hetchy will incorporate many of the successful elements that are found in Yosemite Valley like white water rafting, fencing, and boardwalks. Furthermore, it will also include extreme recreation activities, low impact facilities, and hike-in campgrounds. Various Sources- See List of Illustrations.*

PROJECT BASE MAP LEGEND

- TOULUMNE RIVER
- PROJECT STREAMS AND CREEKS
- PEDESTRIAN TRAILS
- HETCH HETCHY/ EVERGREEN ROAD
- LOCAL ROADS
- 100 FT. CONTOUR INTERVAL
- 1500 FT. CONTOUR LINE (1000 FT. ABOVE VALLEY FLOOR)

- NEARBY WATER FALLS
- NEARBY WATER BODIES (LAKES/RESERVOIRS)
- SUITABLE LOCATIONS FOR SITE INTERVENTION
- THE OPTIMAL LOCATIONS FOR SITE INTERVENTIONS
- <2.5% SLOPE AREAS

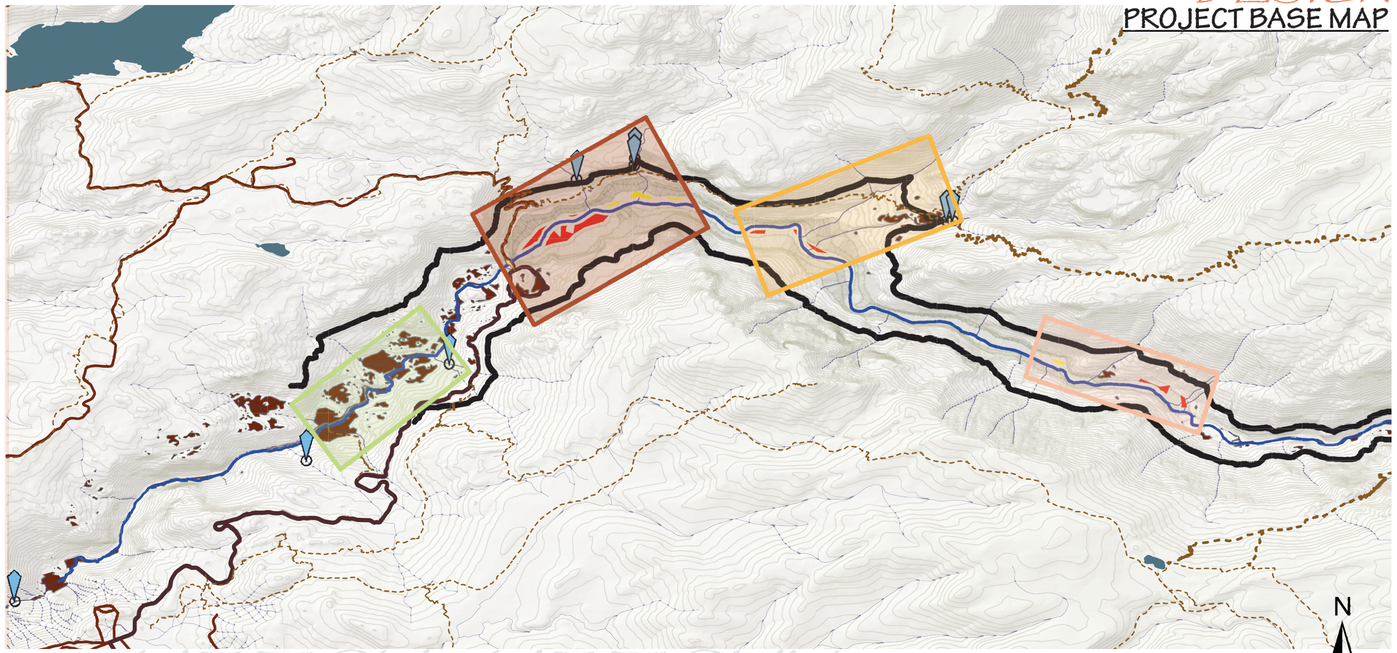
- VIEWPORT 1: GRAND CANYON AREA
- VIEWPORT 2: RANCHERIA SLOPES
- VIEWPORT 3: RECREATION HUB
- VIEWPORT 4: POOPENAUT VALLEY



Figures 7.10 (Top): Tueeulala Falls. *Tueeulala Falls was regarded by John Muir as one of the most beautiful waterfalls in all of Yosemite National Park. It is usually in the same view as Wapama Falls, but the two are considered opposites in their volume, intensity, and nature. summitpost.org, 2013.*

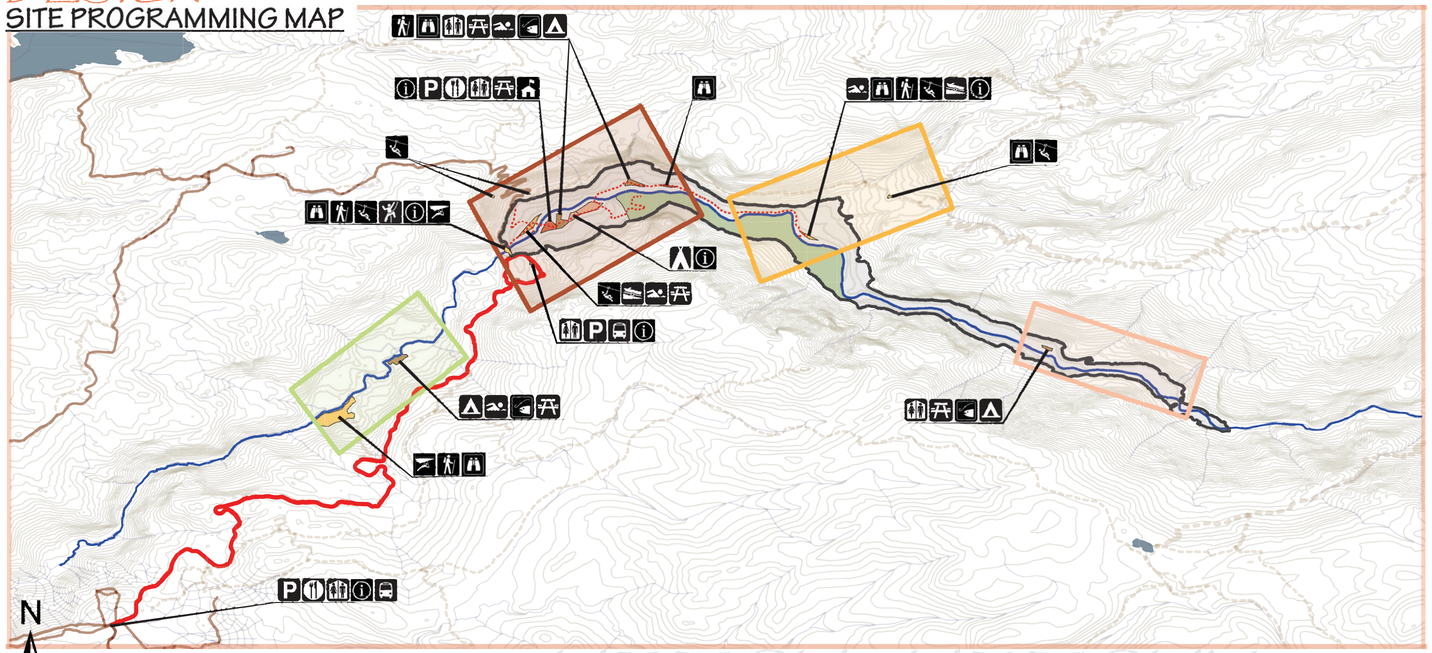
Figures 7.11 (Opposite): Project Base Map. *The Base Map is intended to clearly show the results found through the vigorous site analysis. Viewports were also included to highlight important areas of greatest site interventions. The viewports will be investigate further later in the document.*

PROJECT BASE MAP



DESIGN

SITE PROGRAMMING MAP



DESIGN

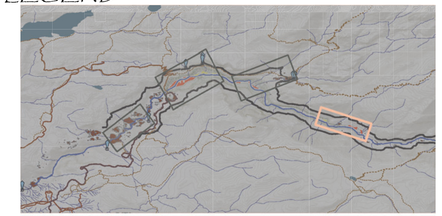
SITE PROGRAMMING MAP LEGEND

- TOULUMNE RIVER
- ROUND TRIP BUS ROUTE
- LOCAL ROADS
- VEHICLE ACCESSIBILE ROADS
- SURROUNDING WATER BODIES
- HETCH HETCHY BOUNDARY
- MIWOK RESERVE (2 SQ. KILOMETERS)
- DESIGNATED RECREATIONAL AREAS
- DESIGNATED CAMPGROUNDS
- DESIGNATED COMMERCIAL AREAS
- MIWOK CULTURAL AREA
- VIEWPORT 1: GRAND CANYON'S FEET
- VIEWPORT 2: RANCHERIA SLOPES
- VIEWPORT 3: O'SHAUGHNESSY DAM
- VIEWPORT 4: POOPENAUT VALLEY
- PARKING ACCESS
- RESTAURANT/DINING
- RESTROOM ACCESS
- INFORMATION CLUSTERS
- BUS STATION CENTERS
- HANG GLIDING ZONES
- FISHING ACCESS
- TRAIL HEADS
- SIGHT SEEING AREAS
- HIKE-IN CAMPGROUNDS
- SWIMMING ACCESS
- VISITOR'S HUB: CENTER, HOSTEL, GROCERY, AND MUSEUM
- MIWOK CULTURAL AREA: MUSEUM AND EXPERIENTIAL GARDENS
- ROCK CLIMBING ZONES
- BOAT DOCKS
- ZIP LINE ZONES
- PICNIC/ EATING AREAS

Figures 7.12 (Opposite): Site Programming Map. *This map illustrates the broad areas of intervention and keeping a general theme throughout each specified area. To minimize negative interactions between visitors and sensitive areas, most of the program elements are clustered together. Viewport three is where the majority of the design elements will be located.*

GRAND CANYON'S FEET MAP LEGEND

- TOULUMNE RIVER
- WATERSHED STREAMS
- 100-FOOT CONTOUR LINES
- HIKING/ PEDESTRIAN TRAILS
- AUXILIARY PEDESTRIAN TRAILS
- VIEWPORT EXTENTS
- POOPENAUT RECREATIONAL AREA
- HIKE-IN CAMPSITE#1: POOPENAUT CAMPGROUND
- BUILDING FOOTPRINT: PUBLIC/PARK FACILITIES
- FOOT BRIDGE LOCATIONS: NOT TO SCALE
- VIEWING PLATFORM LOCATION: NOT TO SCALE
- HANG GLIDING LANDING: NOT TO SCALE

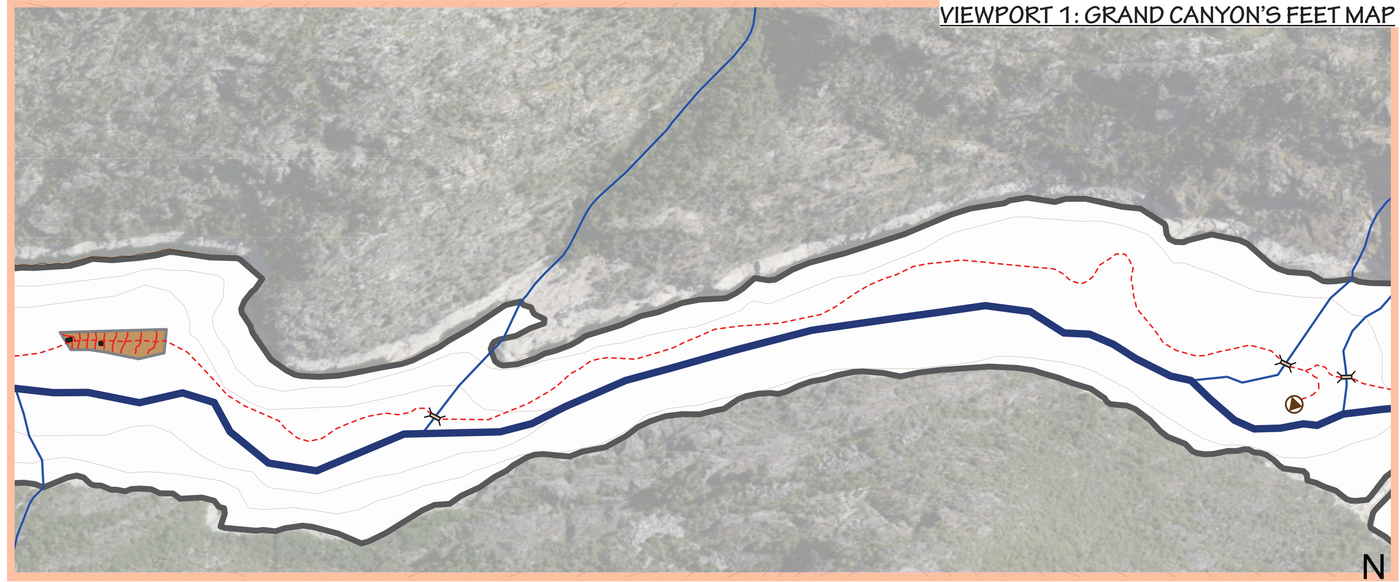


Viewport 1 Reference Map

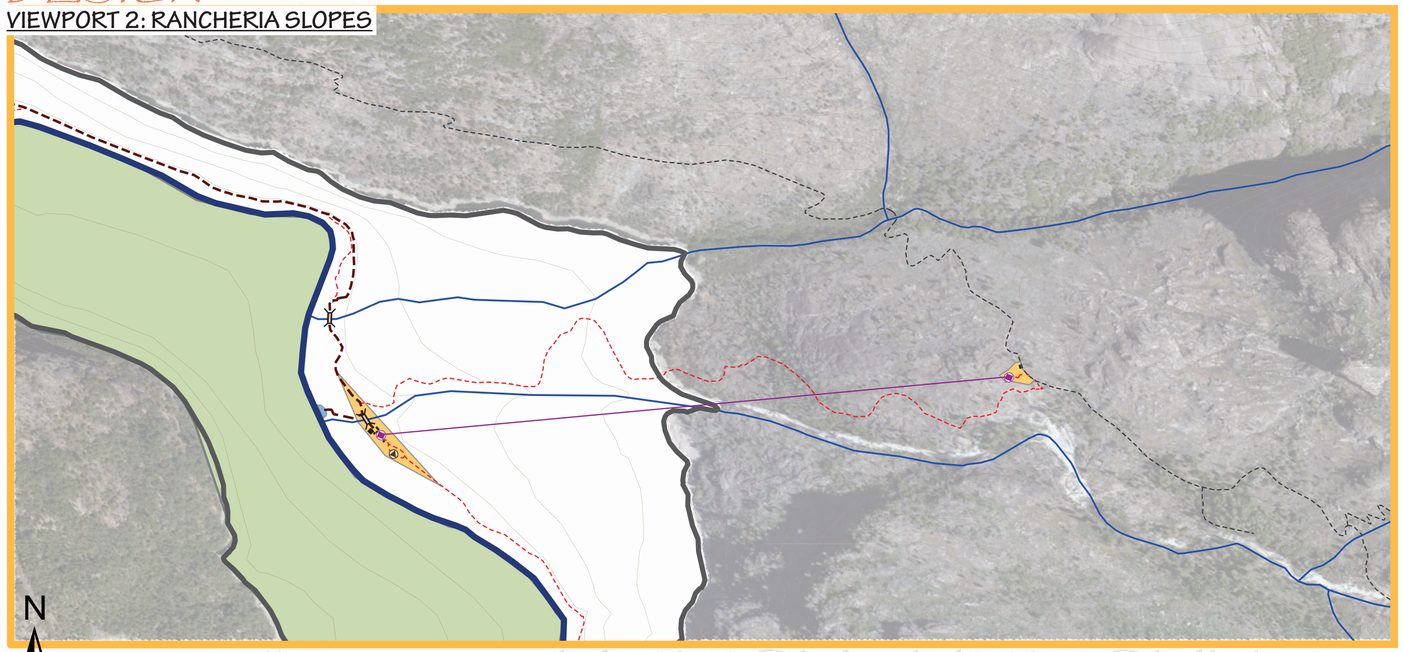
Figures 7.13 (Opposite): The Grand Canyon's Feet Area. *The Grand Canyon Area is the furthest destination from the main Recreation Hub; therefore, it is remote and undeveloped area with one campground that provides minimal amenities.*

Figures 7.14: The Grand Canyon of the Toulumne. *Looking into the magnificent cliffs of the Toulumne River's grandest canyon. Many viewing areas are proposed near the canyons to maximize views and inspire awe. Christopher Ryerson, 2010.*

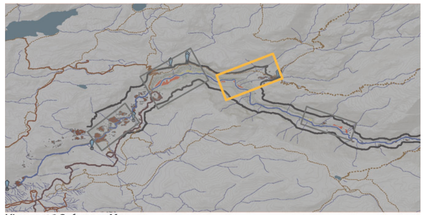
VIEWPORT 1: GRAND CANYON'S FEET MAP



VIEWPORT 2: RANCHERIA SLOPES



RANCHERIA SLOPES MAP LEGEND



Viewport 2 Reference Map

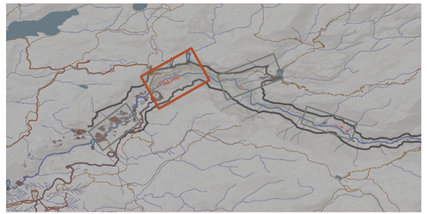
- TOULUMNE RIVER
- WATERSHED STREAMS
- 100-FOOT CONTOUR LINES
- HIKING/ PEDESTRIAN TRAILS
- SERVICE ROADS
- EXISTING TRAILS
- ZIPLINE RUN

- RESERVOIR BOUNDARY
- VIEWPORT EXTENTS
- MIWOK RESERVE (2 SQ. KM.)
- RANCHERIA RECREATIONAL AREA
- RIVER ACCESS/BOAT DOCK
- BUILDING FOOTPRINT: PUBLIC/PARK FACILITIES
- FOOT BRIDGE LOCATIONS: NOT TO SCALE
- VIEWING PLATFORM LOCATION: NOT TO SCALE
- ZIPLINE PADS: NOT TO SCALE

Figures 7.15 (Opposite): Rancheria Slopes: *The Rancheria Slopes area is located at the base of the Rancheria Falls and takes advantage of the shallower slopes. This area will be a recreation area. This would be the starting point for white water sports and tours. Also included at the Rancheria Slopes is a zipline that rivals others for being the longest is the United States (almost a mile long!)*

O'SHAUGHNESSY DAM RECREATIONAL AREA MAP LEGEND

- TOULUMNE RIVER
- WATERSHED STREAMS
- 100-FOOT CONTOUR LINES
- HIKING/ PEDESTRIAN TRAILS
- SERVICE ROADS
- BOARDWALKS
- EXISTING TRAILS
- ZIPLINE RUNS
- EVERGREEN ROAD/ENTRANCE



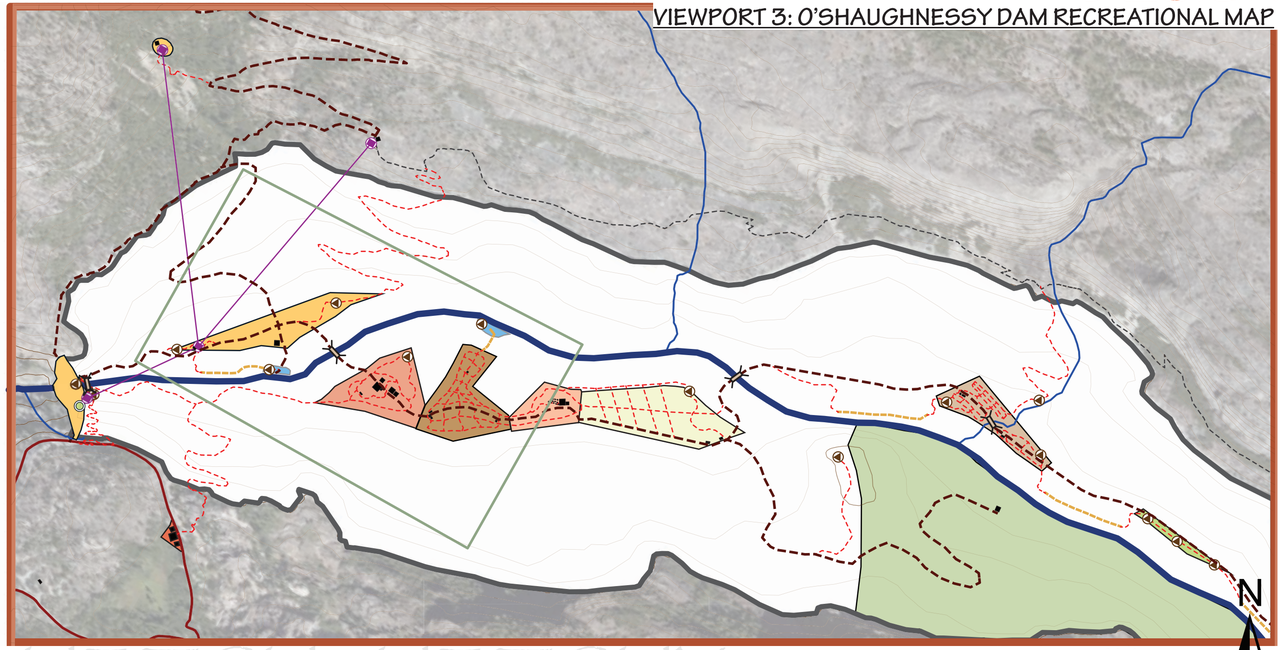
Viewport 3 Reference Map

- MIWOK RESERVE (2 SQ. KILOMETERS)
- O'SHAUGHNESSY RECREATION AREA
- HIKE-IN CAMPSITE #2: JOHN MUIR CAMPGROUND
- HIKE-IN CAMPSITE #3: WAPAMA FALLS CAMPGROUND
- VISITORS HUB: CENTER, HOSTEL, GROCERY
- MIWOK CULTURAL AREA
- MIWOK EXPERIENTIAL GARDENS
- KOLANA VISTAS: VIEWING AREA
- BUILDING FOOTPRINT: PUBLIC/PARK FACILITIES
- RIVER ACCESS/BOAT DOCK

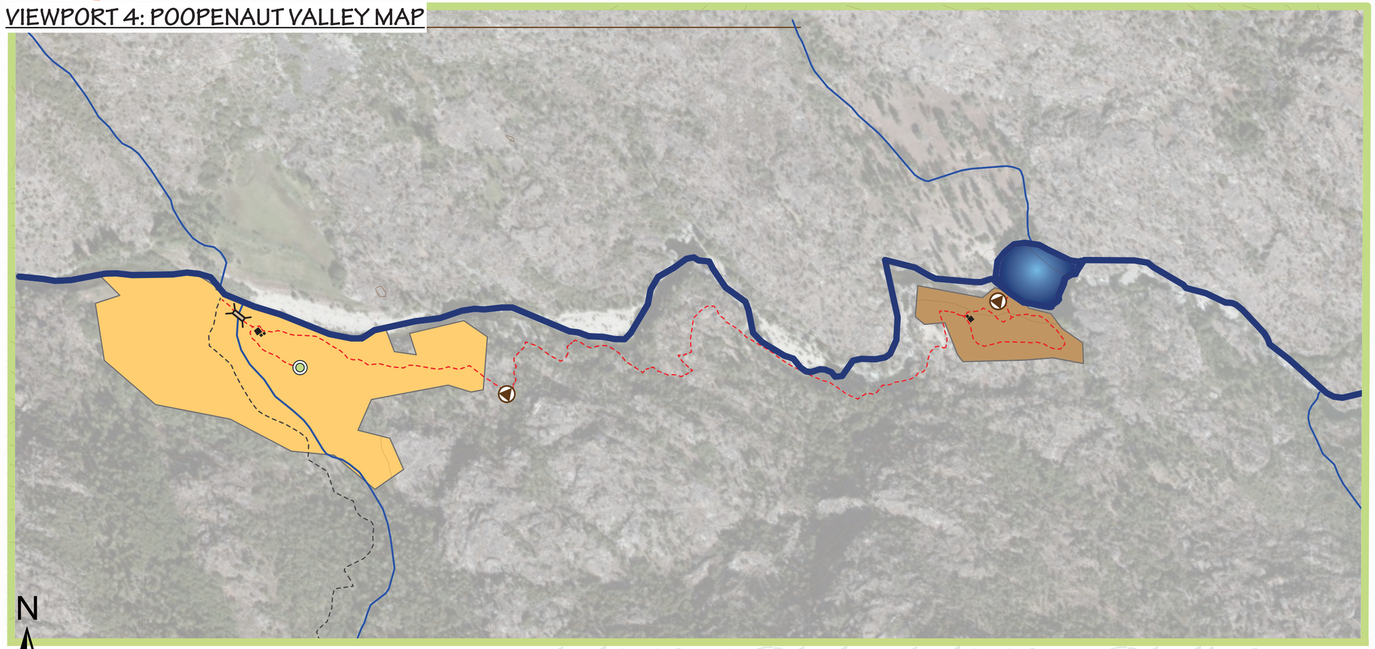
- VIEWPORT EXTENTS
- RESERVOIR BOUNDARY
- MASTER PLAN EXTENTS
- FOOT BRIDGE LOCATIONS: NOT TO SCALE
- VIEWING PLATFORM LOCATION: NOT TO SCALE
- ZIPLINE PADS: NOT TO SCALE
- HANG GLIDING PADS: NOT TO SCALE

Figures 7.16 (Opposite): O'Shaughnessy Dam Recreational Area: *The O'Shaughnessy Dam Recreational Area clusters the majority of activities and amenities in the Hetch Hetchy Valley. It will be where the Visitor's Hub, Miwok Cultural Area, and majority of extreme recreation are found. Also located here are two of the larger campgrounds: John Muir and Wapama Falls Campgrounds.*

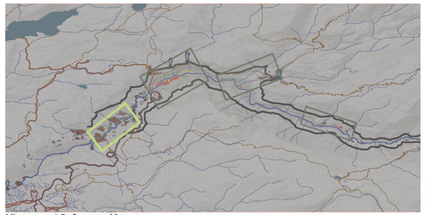
VIEWPORT 3: O'SHAUGHNESSY DAM RECREATIONAL MAP



VIEWPORT 4: POOPENAUT VALLEY MAP



POOPENAUT VALLEY MAP LEGEND



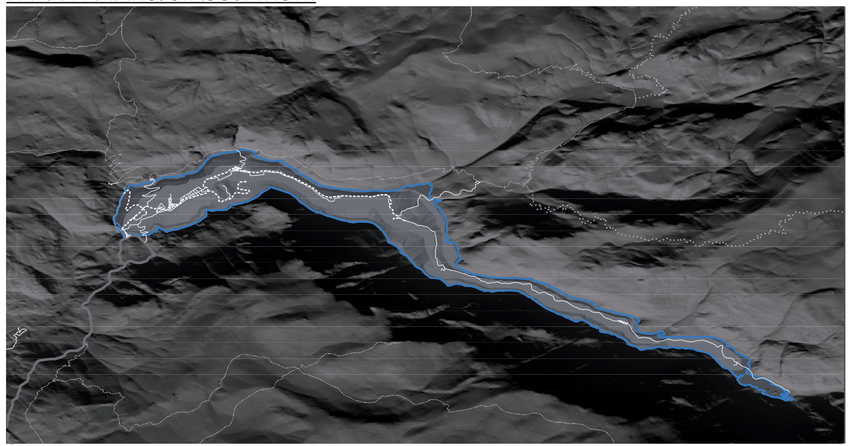
Viewport 4 Reference Map

- TOULUMNE RIVER
- WATERSHED STREAMS
- 100-FOOT CONTOUR LINES
- HIKING/ PEDESTRIAN TRAILS
- VIEWPORT EXTENTS
- POOPENAUT RECREATIONAL AREA
- HIKE-IN CAMPSITE#1: POOPENAUT CAMPGROUND
- BUILDING FOOTPRINT: PUBLIC/PARK FACILITIES
- FOOT BRIDGE LOCATIONS: NOT TO SCALE
- VIEWING PLATFORM LOCATION: NOT TO SCALE
- HANG GLIDING LANDING: NOT TO SCALE

Figures 7.17: View of the Valley: *The Poopenaut Valley is part of the Toulumne River Scenic Area. It is an attraction unto itself. This picture was taken from the O'Shaughnessy Dam looking west. Carson Cooper, 2013.*

Figures 7.18 (Opposite): Poopenaut Valley Area: *Poopenaut Valley is renowned for its seasonal meadows and perennial wildflower display in spring. There are several unique waterfalls that have created deep pools that are perfect for swimming. This area will most likely serve Camp Mather the most. Connectivity to the rest of Hetch Hetch is difficult due to topography and terrain. In this area will be a landing pad for hang gliding tours.*

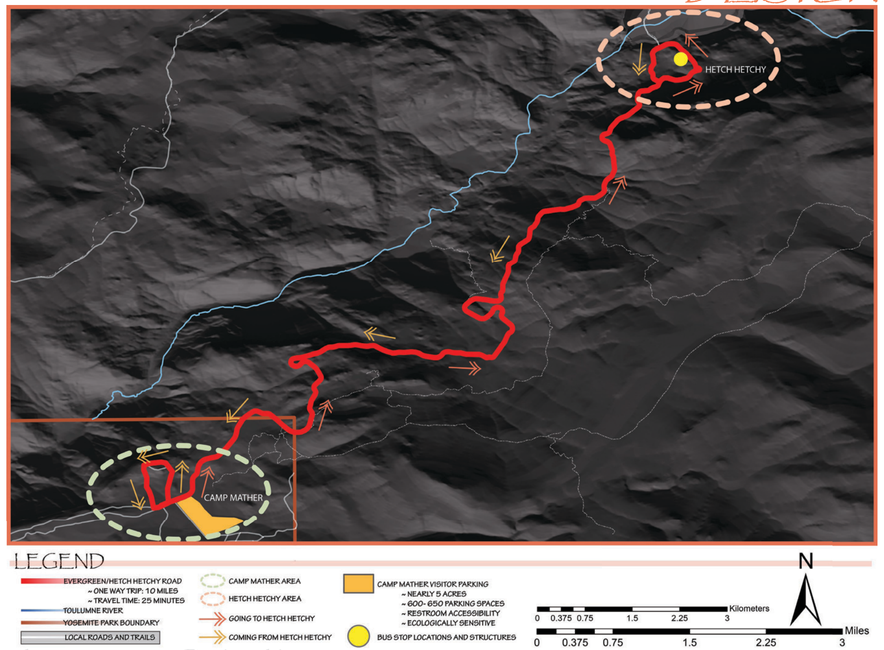
PARK TRAFFIC/CIRCULATION:



Figures 7.19: Project Circulation: *Throughout the Hetch Hetchy Valley, circulation has been greatly improved. Vehicular access in the valley has increased for park rangers, emergency vehicles, and for commercial trucks. These roads are limited to private use at the Park's consent. Due to the small amount of vehicular traffic, the service roads will most likely act as large pedestrian corridors. Paths and boardwalks also increase connectivity.*

The most distinct way to limit human impact on the environment and prevent overcrowding is to control circulation and traffic. Hetch Hetchy should not be plagued by concrete and impervious pavements like roads and parking lots. To accomplish this, it is proposed that the Hetch Hetchy Valley can only be experienced on foot. It would be considered "hike-in only." This would minimize the width of roads and paths and the materials used (can use an impervious material like gravel or decomposed granite instead of asphalt).

It is highly recommended that to access Hetch Hetchy a visitor must travel into Camp Mather and from there take a public and free eco-friendly bus. Round-trip bus routes from Mather to Hetch Hetchy will accommodate all the needs for travel without creating congestion. It would take approximately 25 minutes to travel from Camp Mather to Hetch Hetchy. In consequence, trips to Hetch Hetchy would only take place every hour. However, several buses can load and take passengers at the same time if they travel together in a single line. Doing this will dismiss the need for wider roads and increase the safety of the bus (since no one is coming the other way, it can take wider turns).



Figures 7.20: Hetch Hetchy Bus Routes. *An intricate bus system will be instituted to maximize access and alleviate long wait times for travel. However, because the buses will run one-way trips, it will cause a slight delay for visitors. Ideally, several buses would leave at once and follow each other in the same direction. Due to increased wait time, alternative recreational opportunities and commercial retail stores could occupy visitors and increase park revenue.*

DESIGN

O'SHAUGHNESSY DAM RECREATIONAL AREA MASTER PLAN LEGEND

- O'SHAUGHNESSY RECREATION AREA
- JOHN MUIR CAMPGROUND
- VISITOR'S HUB
- MIWOK CULTURAL AREA

1 O'SHAUGHNESSY RECREATION AREA:
O'SHAUGHNESSY RECREATION AREA IS THE MAIN RECREATIONAL HUB IN THE VALLEY. TO ACCOMMODATE VISITORS OF ALL AGES AND EXTREMES, A LARGE VARIETY OF ACTIVITES ARE AVAILABLE DURING MOST OF THE YEAR; SUCH AS: ZIPLINING, HANG GLIDING, WHITE-WATER SPORTS, ROCK AND DAM CLIMBING, HIKING, BICYCLING, SWIMMING, AND MUCH MORE!

2 TOULUMNE RIVER:
THE UPPER PORTIONS OF THE TOULUMNE RIVER ARE PRISTINE AND PURE BECAUSE THEY ARE FED BY SNOW-MELT AND RUN-OFF OF THE HIGH SIERRAS. THE MAJORITY OF THE WATERSHEDS SURROUNDING HETCH HETCHY VALLEY THAT EVENTUALLY DRAIN INTO THE TOULUMNE ARE IN THE HIGHER ELEVATIONS OF SOLID YOSEMITE GRANITE.

3 RIVER ACCESS/ BOAT DOCK
THIS AREA OF THE TOULUMNE IS DEDICATED TO RECREATIONAL WATER ACTIVITIES. IT IS ALSO INTENDED TO BE THE LAST PORTION OF THE RIVER WERE ALL WHITE-WATER SPORTS ARE PERMITTED. THIS AREA IS CONSIDERED TO BE A PART OF THE O'SHAUGHNESSY RECREATION AREA.

4 MEADOWS AND SEASONAL MARSHES:
THE MAJORITY OF THE VALLEY FLOOR CONSISTS OF MEADOWS, WETLANDS, AND SEASONAL MARSHES. THESE HABITATS ARE CRUCIAL FOR A HEALTHY ECOSYSTEM. WHEN APPROPRIATE, BOARDWALKS SHOULD BE CONSIDERED WHEREEVER A PATH MIGHT COMPROMISE THE INTEGRITY OF THE HABITAT VALUE.

5 SERVICE/ACCESS ROADS:
THROUGHOUT PARTS OF THE VALLEY, THERE WILL BE SERVICE ROADS FOR VEHICULAR ACCESS. THESE ROADS ARE INTENDED SOLEY FOR NATIONAL PARK RANGERS, EMERGENCY VEHICLES, AND SMALL TRUCKS (FOR COMMERCIAL USE). THE NATIONAL PARK AUTHORITIES WILL DICTATE WHAT TYPES OF MATERIALS (IE. GRAVEL, ASPHALT, DECOMPOSED GRANITE) WILL BE USED.

6 BRIDGES AND RIVER CROSSINGS:
THERE ARE NINE BRIDGES SPREAD OUT ACROSS THE VALLEY. THE SIZE OF THE BRIDGE SHOULD REFLECT THE SIZE OF THE WATERWAY AND ITS SEASONAL FLOODING DYNAMICS AS WELL AS THE TRAFFIC TYPE (VEHICULAR OR PEDESTRIAN). EACH BRIDGE SHOULD BE CONSTRUCTED TO ALLOW FOR A SIZABLE FLOODPLAIN.

7 VISITOR'S HUB:
THE VISITOR'S HUB WILL CLUSTER ALL THE ELEMENTS ANY VISITOR WOULD WANT DURING THEIR STAY. THE MAIN PUBLIC FACILITIES WILL BE: A VISITOR'S CENTER, A HOSTEL THAT CAN ACCOMMODATE UP TO SIXTY PEOPLE, A MARKET FOR GIFTS AND GROCERIES, AND A MUSEUM. THE HUB WILL ALSO HAVE A PAVILION FOR PICNICKING, VIEWING PLATFORMS, BATHROOMS, INFORMATION KIOSKS, AND INTERPRATIVE SIGNS.

8 JOHN MUIR CAMPGROUND:
THE JOHN MUIR CAMPGROUND IS THE LARGEST CAMPGROUND IN THE VALLEY AND WILL CONTAIN UP TO 150 CAMPSITES. THERE WILL BE RESTROOMS LOCATED THROUGHOUT THE CAMPGROUND. EACH CAMP SITE WILL HAVE A FIREPIT, PICNIC BENCH, AREAS FOR TENTS, AND A BEAR-PROOF STORAGE CONTAINER FOR FOOD. EVERY CAMPGROUND IN HETCH HETCHY VALLEY WILL BE ACCOMMODATE"HIKE-IN" USERS ONLY, UNLESS CHANGED BY THE NATIONAL PARK SERVICE.

9 RIVER ACCESS:
AS AN EXTENSION OF THE JOHN MUIR CAMPGROUND, THIS AREA IS FOR ACTIVITIES LIKE SWIMMING, DIVING, AND PICNICKING. THERE IS NOT BOAT ACCESS; THEREFORE, CROWDING AND CONFLICTS BETWEEN BOATERS AND SWIMMERS WILL BE MINIMAL.

10 MIWOK CULTURAL AREA:
AS AN HOMAGE TO THE INDIGENEOUS PEOPLE THAT INHABITED HETCH HETCHY VALLEY FOR MILLENNIA, THE MIWOK CULTURAL AREAIS INTENDED TO EDUCATE VISITOR'S ABOUT THE MIWOK CULTURE AND THEIR AFFECT ON THE DYNAMICS OF HETCH HETCHY ECOLOGY. THE CULTURAL AREA WILL HAVE A MUSEUM THAT DISPLAYS THE ARTISTRY, INDUSTRY, AND CULTURE OF THE MIWOK INDIANS. THERE WILL ALSO BE EXPERIENTIAL GARDENS THAT WILL MANIFEST THE UNIQUE LAND MANAGEMENT THE MIWOK'S INITIATED. THE GARDENS MAY ALSO GROW PLANTS THAT IMPORTANT TO THEIR LIFESTYLES, RITUALS, AND SURVIVAL.

N

0 25 50 100 150 200 Meters

0 125 250 500 750 1,000 Feet

Figures 7.21: Master Plan. The new Hetch Hetchy will have something for everyone.

PERSPECTIVES:

Figure 7.22: Zip Lining Into the Valley. *Not only are the views excellent on the mountainside, you can experience Hetch Hetchy like never before-- flying through the treetops!*

Figure 7.23: The "Extremers". *Looking down the side of O'Shaughnessy dam, a visitor might be surprised by what they see. At the bottom is the tunnel that breached the dam.*

Figure 7.24: The Meadows. *A prominent habitat type in the restored Hetch Hetchy Valley is the meadow. John Muir said that in the spring the grasses grew tall enough to be above a man's waste. Add perennial and annual wildflowers with the incredible back drop of the Wapama Falls, and every visitor will be touched by divinity in this mountain temple. Phu. Blog, 2013.*

Figure 7.25: The New O'Shaughnessy Dam. *With its original purpose futile, a renovated and refurbished structure will have new opportunities emerge. As a hot spot for sight seeing and the main platform for many of the extreme sports like dam climbing, hang gliding, and zip lining. Other opportunities might include opportunities for mural and graffiti art.*

CONCLUSION:

Amazing things have happened in the history of mankind. With each generation there is knowledge that advances our understanding, technology, and culture. Although many of the intentions of the past were of a good cause, the execution, in hindsight, were damaging. We have come to understand that many of the past feats mankind has accomplished in the interest of economic gain, now have become major environmental issues. Once these concepts are presented and common understanding obtained, we can start making the changes necessary to maintain all the economic benefits gained while mitigating any environmental damage.

Hetch Hetchy is a perfect place to start. Hetch Hetchy is not an object on an auction block to the highest bidder nor is it a captive servant restrained from its full potential by the weight of a million gallons. No, Hetch Hetchy is a sanctuary were people may go and commune with something greater than themselves. Humans, so small and so imperceptible amongst the rigid slopes and high arches of the Sierra Nevada; and yet, can do big things to drastically affect their fate. Times have changed. Many have already been changed when encircled about by shimmering granite cathedrals and embraced by the freedom of exalted skies. Is there a change for Hetch Hetchy? Can we still do big things? Let's hope so.

Figure 7.26: The New Hetch Hetchy. *Many artists have voiced their opinion on the subject of a restored Hetch Hetchy through the paintings, photographs, and murals. This historic photograph pays homage to the "mountain temple" John Muir described so eloquently. Phu. Blog, 2013.*

The Wintry Day, Descending to Its Close

The wintry day, descending to its close,
Invites all wearied nature to repose,
And shades of night are falling dense and fast,
Like sable curtains closing o'er the pasts.

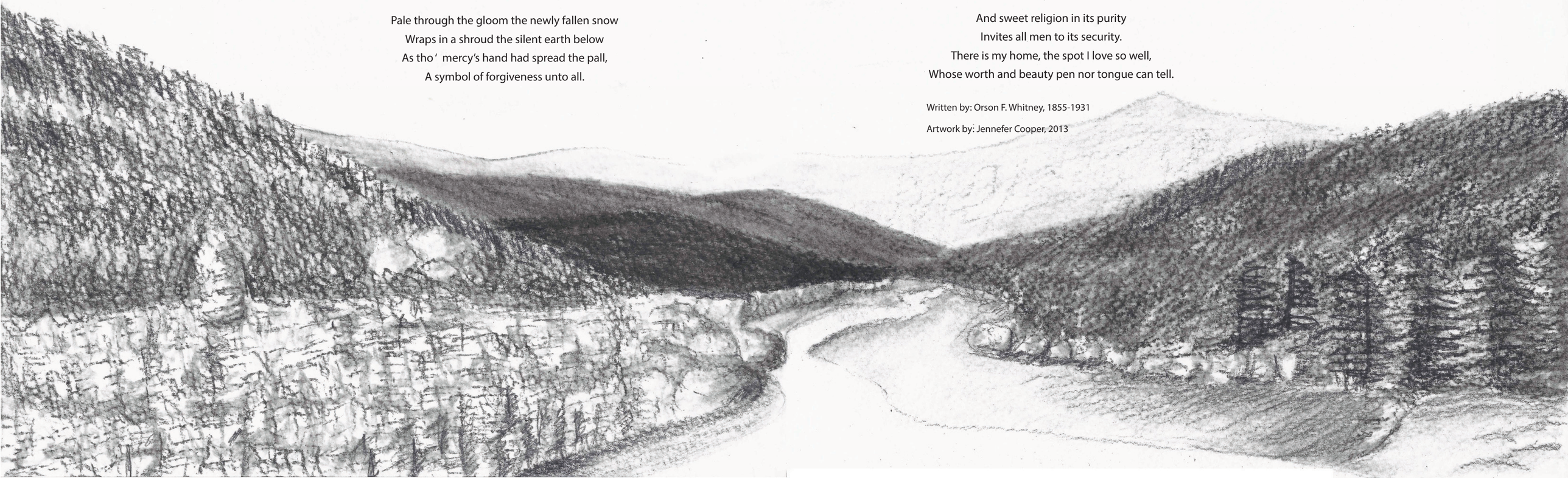
Pale through the gloom the newly fallen snow
Wraps in a shroud the silent earth below
As tho' mercy's hand had spread the pall,
A symbol of forgiveness unto all.

The wilderness, that naught before would yield,
Is now become a fertile, fruitful field.
Where roamed at will the fearless Indian band,
The templed cities of the [people] now stand.

And sweet religion in its purity
Invites all men to its security.
There is my home, the spot I love so well,
Whose worth and beauty pen nor tongue can tell.

Written by: Orson F. Whitney, 1855-1931

Artwork by: Jennefer Cooper, 2013



REFERENCES/BIBLIOGRAPHY

- Chenoweth, J. 2007. Predicting seed germination in the sediments of Lake Mills after removal of the Glines Canyon Dam on the Elwha River. Master's thesis. University of Washington, College of Forest Resources. Seattle, WA
- Cooper, Carson. 2013. Poetic Writings. Bachelor of Science in Landscape Architecture, UC Davis. Master Candidate in Landscape Architecture. Spartacusgardens.cooper@gmail.com
- Cooper, Jennefer. 2013. Works on Hetch Hetchy: Variations of a Theme. Charcoal on paper. Jenneferg@gmail.com
- Clewell, A., J. Rieger, and J. Munroe. 2005. Society for Ecological Restoration International Guidelines for Developing and Managing Ecological Restoration Projects, 2nd Edition. http://www.ser.org and Tuscon: Society for Ecological Restoration International. December.
- Elwha River Restoration. 2011. National Park Service. www.nps.org/olym
- Gediman, Scott. 2013. Personal Interview. Interviewed by Carson Cooper. March 26th, 2013
- "Hetch Hetchy". 2011. San Francisco Utilities Commission. www.sfwater.org
- Hoffmann, C.F. 1868. " Notes on Hetch-Hetchy Valley," *Proceedings of the California Academy of Sciences* (San Francisco: CAS, 1868), series 1, 3:5, pp. 368-370. Digitized by Dan Anderson, July 2005.
- Johnson, Robert. 1913. Letter to the House Committee on the Public Lands, *Hetch Hetchy Dam Site,* 63rd Cong., 1st sess. (25–28 June 1913; 7 July 1913), (Washington D.C.: Government Printing Office, 1913) 235–38.
- King, Mark. White Salmon Conservation League, Environmental Jewel to be Sacrificed to 'Dam Removal God, http://community.gorge.net/wsalmoncl/History/history.html
- Muir, John. 1873. *Hetch Hetchy Valley,* in *Overland Monthly,* July, 1873, pp. 42-43.
- Muir, John. 1912. The Yosemite. New York; Century Company.
- Meral, Gerald H. Restore Hetch Hetchy: Feasibility Study. 2005. Restore Hetch Hetchy, Sonora, California
- National Park Service. 2013. Summary Guide For the Merced Wild and Scenic River Draft Comprehensive Management Plan and Environmental Impact Statement (MWSRD). U.S. Department of the Interior. January, 2013.
- National Park Service: U.S. Department of the Interior. www.nps.gov. 2/28/2013

- Null, Sara E., Lund, Jay R. 2006. Reassembling Hetch Hetchy: Water Supply Without O'Shaughnessy Dam. Journal of the American Water Resources Association. April, 2006.
- Phelan, James. 1913. House Committee on the Public Lands, *Hetch Hetchy Dam Site,* 63rd Cong., 1st sess. (25–28 June 1913; 7 July 1913), (Washington D.C.: Government Printing Office, 1913) 235–38.
- Philp, Tom. "Hetch Hetchy Reclaimed." Sacramento Bee. Articles 1-14. 2004
- Raker, John. 1913. House Committee on the Public Lands, *Hetch Hetchy Dam Site,* 63rd Cong., 1st sess. (25–28 June 1913; 7 July 1913), (Washington D.C.: Government Printing Office, 1913) 25–29.
- Restore Hetch Hetchy: Yosemite National Park. www.HetchHetchy.org. 2/13/2013
- Re-vegetation and Wetland Management Plan: Condit Hydroelectric Project Decommissioning (FERC Project No. 2342). Prepared by Green Works, KleinFelder, JR Merit. March 15, 2011
- Riegelhuth, Richard. Botti, Steve. Keay, Jeff. Alternatives for Restoration of Hetch Hetchy Valley Following Removal of the Dam and Reservoir. National Park Service. February 1988, 18 pp.
- SF Environment. 2013. Department of the City and County of San Francisco. http://www.sfenvironment.org/climate-change/policy
- Sierra Club. www.sierraclub.org. 2/27/2013
- Milhalic, D., Griffin, BJ., Binnewies, B. Superintendants of Yosemite. www.restorehetchhetchy.org
- U. S. Bureau of Reclamation. Hetch Hetchy: A Survey of Water and Power Replacement Concepts. Sacramento. 1987.
- Walker, L.R. and R. del Moral. 2003. *Primary Succession and Ecosystem Rehabilitation*. Cambridge, UK. Cambridge University Press.
- Wells, Emmeline B. 1828-1921. Our Mountain Home So Dear. Hymns of The Church of Jesus Christ of Latter-Day Saints, Hymn #33.
- Whitney, Orson F. 1855-1931. The Wintry Day, Descending to Its Close. Hymns of The Church of Jesus Christ of Latter-Day Saints, Hymn #37.
- Wikipedia. 2013 *List of the Tallest Dams in the United States*. Retrieved from http://en.wikipedia.org/wiki/List_of_the_tallest_dams_in_the_United_States