#poop2potable

Re-envisioning Water Cycles in the Sacramento Valley

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Abstract

#poop2potable: Re-envisioning Water Cycles in the Sacramento Valley

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Architecture

Chronic water shortages affect all corners of the planet as the rate of water use grows twice as fast as the world population. It is estimated that about twenty percent of the world's population lives with constant water shortage and that by 2025, "1.8 billion people will be living in countries or regions with an absolute water scarcity, and two-thirds of the world population could be under stress conditions." This is especially apparent in California where the demands of a burgeoning population, the naturally arid climate and severe drought have made water scarcity a predominant issue that requires attention and action.

The immediate effects of California's water shortage, caused in part by a miniscule snow pack, an ongoing drought, and increasing temperatures exacerbate strains on all aspects of water access. Currently, underground water reservoirs are being depleted without recharge in order to meet the water needs to sustain agriculture irrigation. While the importance of agriculture to the state of California and to the rest of the country is not in question, there is an imminent and critical need to challenge the way we use and consume water.

The long-standing practices of water treatment, potable consumption, and unabated usage are in dire need of reassessment and fundamental change. This thesis investigates a prototypical venture that marries complex elements of today's water climate in the California Central Valley by proposing new networks and relationships that adjust the way we use water. The proposed design is a synthesis of sustainable agricultural water use and full cycle water treatment that promotes black water recycling; it suggests a prototypical model that could be replicated at larger scales throughout the Central Valley and in other localities that are economically, socially, and traditionally dependent on agriculture. The overarching goal of this thesis is to bring people closer to the water cycle, both natural and technological, by providing a place for positive spatial experience, intimate participation and education.

to rick and alex	*for wisdom*
to andrew and opie	*for love*
to mom and erin	*for encouragement*

...for water

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prologue: the statement

"We never know the worth of water till the well is dry."

-Thomas Becker

East Porterville is located in central California. Currently, the town of 7,500 is suffering through the worst drought in the state's history. The 1,000 wells that previously supplied water to this town are now running dry, leaving residents to struggle with everyday tasks such as bathing, cooking, and cleaning. Nearly half of East Porterville's residents are completely without running water. The remainder is surviving on failing wells or is dependent on the county supplied 5,000-gallon emergency tank of non-potable water for flushing their toilets and washing their clothes.[1]

Low-income residents qualify for government aid; the state supplies these individuals with eight cups of water per person per day, which is miniscule when compared with the average total water usage of a California resident at 150-200 gallons a day. A pastor from a local church hands out cases of water in the church's parking lot while a community volunteer affectionately nicknamed the "water angel" delivers bottled water to the homes of the most desperate. [2]

While many of California's residents, particularly the poor, are struggling to survive without water, agribusiness has continued to consume a large majority of the diminishing supplies. From 2008 to 2014, the production of almonds, one of the most water intensive crops to cultivate, increased by a fourth in California. This augmentation in production has also occurred in the past few years for many of the most profitable and water consuming crops, such as alfalfa, walnuts, and grapes.[3]

In an effort to reduce water consumption, Governor Brown mandated a 25 percent reduction in urban usage, effective statewide in 2015. However, this cutback does not pertain to agriculture, which accounts for 80 percent of the total potable water usage in California. Historically, California growers have fed the country; its farmers produce a third of the nation's vegetables, two-thirds of nation's fruit, and forty billion pounds of milk a year. In total, the state's agribusiness accounts for $14 billion in exports, and employs nearly 3 million residents.[4] While the importance of agriculture to the state of California and to the rest of the country is not in question, it is imperative that the current attitudes and practices regarding water usage for agriculture and human consumption and water treatment are challenged and re-envisioned.

There is an imminent and critical need to rethink the way we use and consume water. Agricultural techniques used in the last century cannot be sustained under the current conditions of increasingly limited water supplies. Additionally, the long-standing practices of water treatment, human consumption, and unabated usage are in dire need of reassessment and fundamental change. This thesis investigates a prototypical venture that marries complex elements of today's water climate in the California Central Valley by proposing new networks and relationships that adjust the way we use water.

There are many towns facing the same critical shortages and municipal shortcomings that challenge East Porterville; the number of communities in crisis will only increase with continued drought and unsustainable resource use. The fundamental objective of this investigation is to change the way people think of water cycles and to encourage stewardship by proposing new networks of use between treatment, human and agricultural water distribution.

This project proposes a demonstration facility that will promote innovative water strategies for recycling and agricultural usage, and encourage conservation of one of our most vital resources. The proposed architectural intervention will integrate multiple aspects of water use such as augmenting diminishing drinking supplies, amending unsustainable agricultural methods, implementing closed-loop recycling technologies, practicing conservation, and foremost, educating the public about imminent and necessary change via agrotourism.

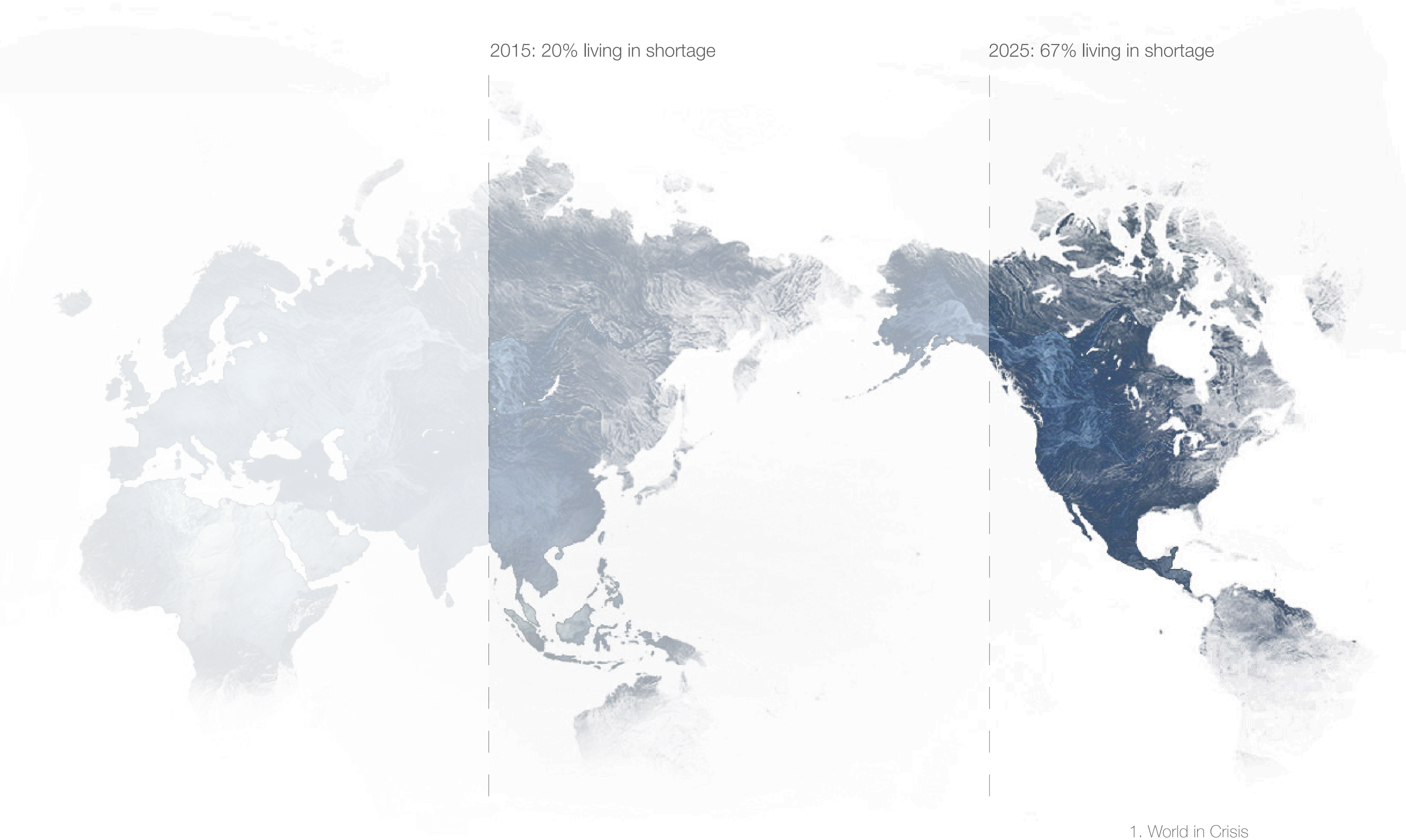
chapter 1: introduction

"Of all of our natural resources water has become the most precious. By far the greater part of the earth's surface is covered by its enveloping seas, yet in the midst of this plenty we are in want. By a strange paradox, most of the earth's abundant water is not usable for agriculture, industry, or human consumption because of its heavy load of sea salts, and so most of the world's population is either experiencing or is threatened with critical shortages. In an age when man has forgotten his origins and is blind even to his most essential needs for survival, water along with other resources has become the victim of his indifference."

- Rachel Carson, Silent Spring

Throughout the twentieth century, and in particular the later half, the demands of growing populations coupled with the increased occurrence of drought have resulted in water shortages that plague a multitude of users ranging from those living in urban city centers to agricultural heartlands.

Chronic water shortages affect all corners of the planet as the worldwide rate of water use grows twice as fast as world's population. It is estimated that currently about 20 percent of the world's population lives with constant water shortage and that by 2025, "1.8 billion people will be living in countries or regions with an absolute water scarcity, and two-thirds of the world population could be under stress conditions."[5]



1. World in Crisis

2. Nasa satellite images depicting change in California over the course of one year due to drought.

January 2013

January 2014

The lack of water access is particularly problematic in densely populated regions with naturally arid climates. In the summer of 2015, the National Oceanic and Atmospheric Administration (NOAA) declared that 30 percent of the contiguous United States was experiencing “moderate to exceptional drought.”[6] This is especially apparent in California where the demands of a burgeoning population, the naturally arid climate and severe drought have made water scarcity a predominant issue that requires immediate attention and action.

In January of 2015, Governor Edmund Brown of California proclaimed a state of emergency due to an ongoing, multi-year drought.[7] The immediate effects of the water shortage, caused in part by a miniscule snow pack, the ongoing drought, and increasing average temperatures exacerbate strains on all aspects of water access.[8] Currently, underground water reservoirs are being depleted without recharge in order to sustain irrigation. Over-drilling and pumping of wells has caused water tables to decrease by as much as fifty feet and depleting underground water reservoirs without recharge may cause irreversible damage including surface level cracking and sinking.[9]

California has already implemented many water saving and recycling initiatives. At present, recycled water in some form is used for 46 percent of the state’s irrigation needs including municipal, recreational, and agricultural.[10] This is significant considering that California agriculture accounts for 80% of the state’s entire water usage.[9]

Desalination and recycling efforts exist all over the state. The largest desalination treatment plant in the nation is under construction in San Diego; at a cost of one billion dollars, by its slated completion in 2016 it will treat fifty million gallons of water day at a cost of two thousand dollars per acre foot (approximately double the cost of recycling wastewater). Fifteen additional desalination operations are planned for the California Coast.[11] Recycling efforts in the state are led by the Edward C. Little Water Recycling Facility of El Segundo, California. This operation is the only treatment facility worldwide to process and treat “five distinct types of ‘designer’ recycled water,” meaning that several different criteria and processes of treatment are used in order to produce different types of water specific to the intended use such as irrigation, urban, landscaping features, industrial cooling, and groundwater aquifer recharge. For example, water intended for industrial cooling is only treated to that standard, and only released for that specific purpose.[12]

Despite innovative and aggressive conservation and reclamation efforts, none of these agencies integrates a holistic, full-cycle water-recycling program, i.e. waste to potable. Moreover, most of the technological processes are unknown to the populations who depend on them. While the majority of citizens are generally in favor of water recycling efforts for purposes such as irrigation, agriculture, and industry, there is far less support for water recycling for human consumption, both indirect and direct.

Indirect and direct reuse approaches involve a "proactive decision to transform treated wastewater into drinking water."[13] Indirect potable reuse entails the injection of treated recycled water into an existing, naturally occurring water source, such as an underground aquifer or a surface level lake. The existing water source acts as an environmental buffer, where reclaimed water mixes with "natural water," and both are ultimately sent through another level of treatment in order to achieve drinking water standards. Water intended for direct potable reuse entails the treatment and purification of wastewater that is then introduced directly into the municipal drinking water system.[13]

The "disgust comes from intuitive concepts of contagion,"[14] as the association of sewage and drinking water is hard to overcome in the collective consciousness despite rigorous methods of treatment and filtration. Dr. Carol Nemeroff of the University of South Maine, who coauthored *The Psychology of Water Reclamation and Reuse: Survey Findings and Research Road Map*, states that tantamount to pure necessity, "one of the best ways to get past it is perceptual cues…if you can see sparkling fresh, clear water, and taste it that helps to overcome the concept ... the contagion type thinking decreases with familiarity."[15] Public acceptance and support of reclaimed water usage is imperative for the future of California.

In order to promote an unconditional acceptance of water reclamation, we must create and foster a connection between people and new processes in the water cycle in a way that is both humanly relatable and accessible. Making a direct and physical connection between place, climate, and agriculture with water treatment can create an educational experience that uses cultural and economic synergies to underline the importance of water recycling in the health of California's cultivation traditions and their future continuance.

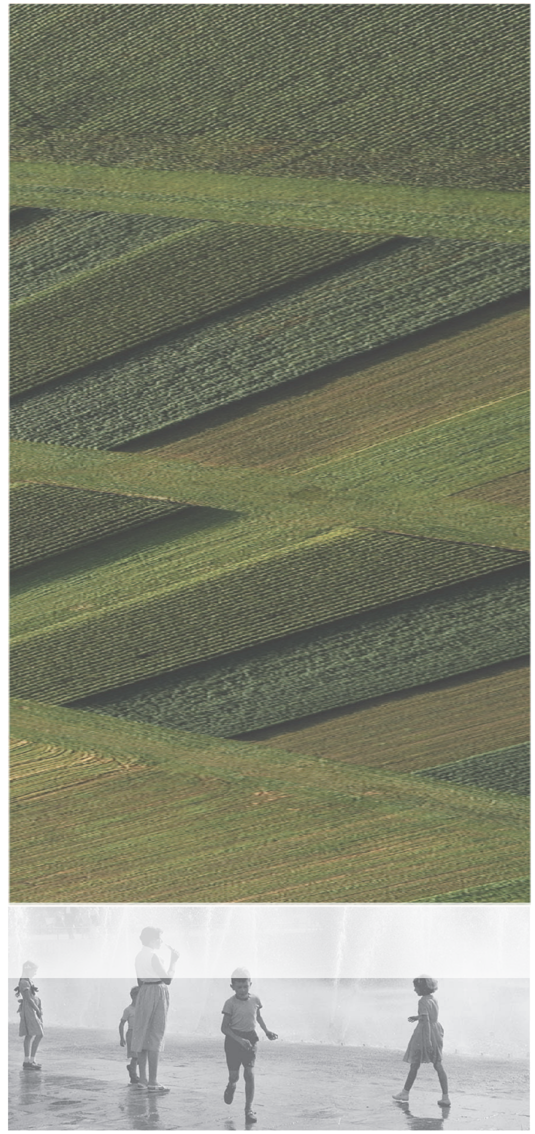
Agriculture, an integral aspect of California's history, socioeconomic character, and culture, has been significantly affected by drought. It is estimated that this year, farmers in the state will leave one million acres of land fallow due to water shortage, double that of last year which resulted in 2.2 billion dollars in losses for the growing economy.[8] California's agricultural production provides over 400 different commodities and accounts for half of the nuts, fruits, and vegetables grown in the United States.[16] These considerable production outputs require an immense quantity of resources; the state's agribusiness accounts for eighty percent of the usage of surface water available for human consumption. In lieu of draining all natural water resources such as groundwater, snowpack and surface sources, recycling and reclamation efforts can help provide the water that is so greatly needed.

Emphasizing the important and necessary role that water reclamation practices play in the continued health of the state's horticultural identity can greatly increase public acceptance of recycling wastewater. Architecture can serve as a medium in which the public is directly able to participate in the relationship of water treatment and California's rich cultivation traditions, providing a platform for learning and experience.

The purpose of this thesis is to explore an architectural project that can simultaneously integrate efficient and innovative water treatment technologies while connecting people directly to the water cycle. A large disconnect exists between the realities of water accessibility, treatment, use, distribution, politics, and/or the functions and populations that depend on it. Despite a drought and a shortage crisis, many of the populations who would benefit most from water recycling are resistant to it.

This thesis postulates that populations reluctant to accept holistic water recycling technologies can be better educated and connected to the processes through thoughtful architectural insertions that closely tie the horticultural traditions of the state to new water recycling initiatives.

The project proposal is for a closed loop integrated system of a water-reclamation facility and small-scale demonstration farm located in California's Central Valley. The program elements will provide the public, whether passing by in a short term capacity or participating in a longer term farm-stay, to fully explore the symbiosis of water security and procurement with the rich cultivation heritage of the region. This facility will also incorporate methods of conservation and efficient irrigation techniques in order to demonstrate sustainable practice.

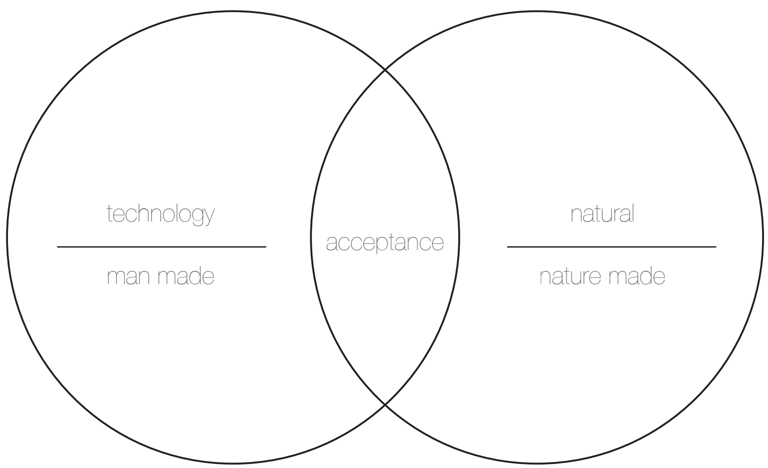


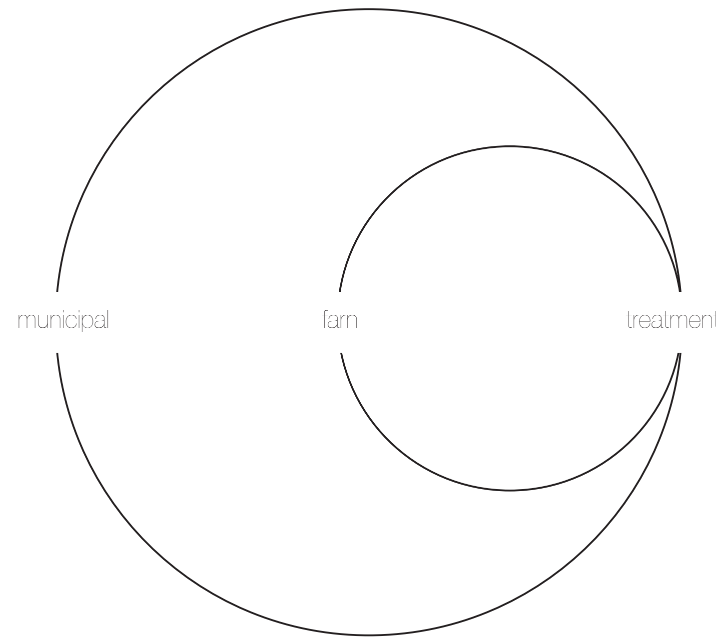
3. Water usage by percentage in California

agriculture: 80%

reduction in urban use: 25%

urban : 20%





4. Project Network Diagrams

Moreover, this design proposal reimagines how a partnership between municipalities and agriculture can create synergies and rethinks current water infrastructure. A local municipality without an incorporated water utility that depends on well water and septic tank waste storage can augment onsite water capture with a steady source of water intended for tertiary treatment. Water treated on-site may be piped back into the municipality for a dependable source of clean potable water and also used directly on site for the project's agricultural and programmatic needs.

This thesis aims to emphasize and illustrate the symbiotic relationship of the technical aspects of water treatment with familiar, and human uses of water. This arrangement can ease the existing suspicions and rejection of water recycling, and potable water recycling specifically. By integrating the agricultural and horticultural landscape with both the technical and anthropological programmatic elements, architecture can be used to connect the public with the importance of full circle water recycling. The goal is to bring people closer to the water cycle, both natural and technological, by providing a place for intimate participation and inquiry. Implementing the objective of this thesis requires investigation of the complexities of the California drought's causalities, the human disconnect and resistance to water recycling for consumptive purposes, and the role of growing to the regional economy, culture, and existence.

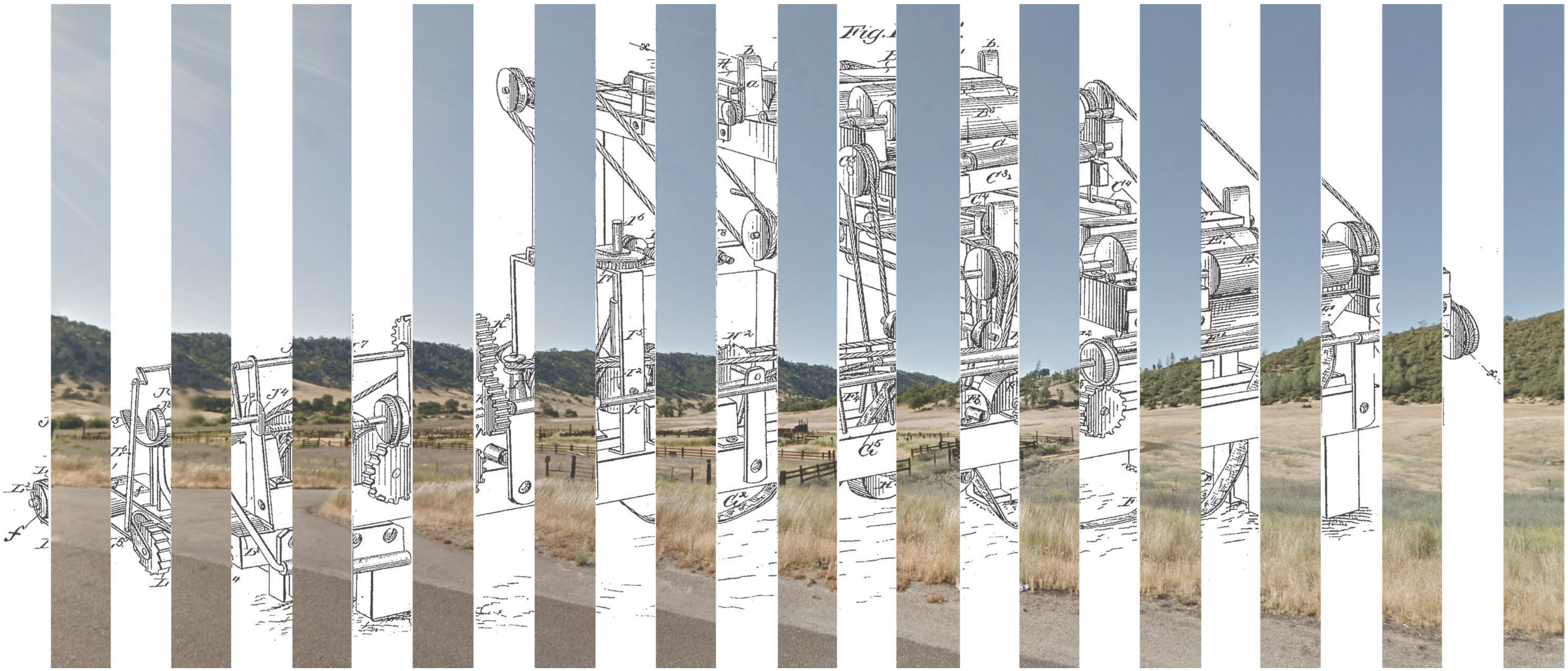
chapter 2: framework

"Sustainability means 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs. While originally envisioned as an expansion on concerns of pollution prevention, sustainability more directly addresses the issue of resources allocation… In the grandest sense, sustainability is a return to the ideals of our ancestors and their goal of protecting the world around them. But sustainability also recognizes the need for society to develop, for technology to flourish, and for humanity to expand. And this means the consumption of resources and the disposal of our wastes."

- Martin Abraham, Youngstown State University

Although the issue of water security is an extremely critical and current one in most places on the planet, it is not an issue that is inherently glamorous or interesting to the greater population. It is difficult for most people to understand or invest in an issue when there is no clear way to see how it directly affects them. Despite chronic, severe shortages, so long as clean water flows from the tap, the immediate and long-term repercussions of water management or lack thereof, are not at the forefront of discussion. However, food and food production is much more tangible and relatable to most. In general, people are interested in all aspects of food from the tradition of growing and harvesting to preparing and consuming; our human relationship with food is visceral and emotional. Food production, specifically agriculture, is dependent on water and ultimately on water management and reuse; underlining the important relationship between the two can help push issues of water security and water recycling to the forefront.

This thesis hypothesizes that integrating seemingly disparate elements of program in an architecturally compelling and functionally symbiotic manner can create a space for human experience and participation that will promote acceptance of water recycling for long term, widespread use. In order to establish and appropriately design for the physical program elements, it is necessary to understand and investigate case studies of successful closed loop water recycling initiatives, the public's sociological and psychological impediments from accepting wastewater reclamation for human consumption, agrotourism as a vehicle to facilitate public acceptance of water recycling, and the tradition of roadside capture.



5. Conceptual lenticular diagram depicting amalgamation of technology and nature.

2.1 Closed Loop Water Recycling Systems and Outreach Education

There have been groundbreaking innovations in water infrastructure over the past several decades, one of the most significant being water reclamation. In its inception, reuse was intended to increase available water supplies designated for limited urban uses, industrial uses, landscape irrigation and agriculture in some parts of the world. Today, usage of recycled water has expanded to indirect potable use and even goes so far as to serve as a viable potable supply in a handful of operations.

By 2030, the United Nations has estimated that approximately "half of the word's population could be facing a scarcity of water, with demand outstripping supply by 40 percent"[17] as water demands are projected to increase by 50 percent in the upcoming decade. Widespread approval and administration of water recycling infrastructure has the potential to augment the conventional drinking supply and decrease scarcity.

In her anthology of effective water reuse projects, *Milestones in Water Reuse: The Best Success Stories*[5], Valentina Lazarova states that the foundation of water reuse is built upon three principles:

1. Providing reliable treatment of wastewater to meet strict water quality requirements of the intended reuse application.
2. Protecting public health.
3. Gaining public acceptance.

There are a select number of water reclamation case studies that meet these principles. They are detailed in the following sections.

2.1.A NeWater, Singapore

Lacking land for rainwater collection and storage, and faced with urban water pollution and constant drought, Singapore has historically been dependent on imported water from neighboring countries, specifically Malaysia. Over the past fifty years, Singapore's national water management agency, PUB, has successfully implemented a diversified strategy named as "Four National Taps;" this strategy depends on the joint efforts of local water catchment, importing water, desalinated water, and the state-of-the-art highly purified water recycling program, NEWater.[18]

Through advancement in water treatment technologies, Singapore has harnessed its supply of wastewater effluent and reclaimed it as a supply of highly treated direct non-potable use. The treatment procedure is:

" *[a] multi barrier approach to ensure good water quality which includes: source control, high proportion of domestic water effluent, comprehensive secondary wastewater treatment, use of proven advanced technologies, comprehensive water quality monitoring, adhering to strict operating procedures*"[19]

Technically speaking, the process intakes secondary effluent (sewage that has been treated physically to separate solids and dissolved/suspended organic compounds) and then uses a "dual membrane filtration step consisting of microfiltration/ultrification, and reverse osmosis, followed by UV disinfection."[20] Essentially, once wastewater is filtered from solids and other suspended organic compounds it is then physically filtered further to remove molecule-sized solids. Reverse osmosis pushes the water through even finer filters that eliminate viruses and chemicals, and finally exposure to ultraviolet light eliminates any remaining microorganisms and bacteria. The resultant water is deemed "ultra-clean" and fully meets, and often exceeds, drinking standards.

Currently, the PUB only provides about 2.5 percent of Singapore's direct potable water usage in the form of recycled water directly into the public drinking water supply. Another small percentage is injected into fresh water sources for indirect potable consumption. Although the water produced by the NEWater surpasses the World Health Organization Drinking Water Guidelines[19], only a small portion of it is used for potable sources, while most of it is used for non-potable purposes so that natural fresh water may be reserved for drinking water. Additionally, since the treated water is deemed "ultraclean" and meets the highest standards, much of the it is allocated for industrial uses requiring highly purified water. The use of recycled water for direct potable consumption is anticipated to increase; the PUB anticipates that NEWater will meet 55 percent of Singapore's water demands by 2060.[18]

6. NeWater, Singapore Visitor Center (Exterior)

7. NeWater, Singapore Visitor Center (Storage Facility)

8. The Orange County Water District's Groundwater Replenishment System

2.1.B Orange County Water District, California

The Orange County Water District (OCWD) has recycled wastewater for non-potable reuse since the 1970s; however, in 2008 the OCWD began to contribute to the drinking supply. Similar to the PUB's practices in Singapore, the OWCD utilizes a multi-step treatment process including microfiltration, reverse osmosis, and ultraviolet disinfection. The resultant water "exceeds all state and federal drinking water standards."[14] The facility produces up to 70-100 million gallons of water a day, the equivalent required for 600,000 to 850,000 residents. [22]

Despite meeting and surpassing health standards, OWCD recycled water is injected into the main groundwater supply as non-direct recharge in partnership with the Groundwater Replenishment System (GWRS), currently the largest operation of this type in the world. The agency pumps reclaimed clean water back into underground reservoirs, pumps the mixed water back out of the ground and treats it once more prior to releasing it for public consumption.[21] Not only is this process costly and unnecessary, but it also reintroduces reclaimed purified water to natural contaminants in the aquifers. Admittedly, this step is unnecessary and is done mostly to "allay public fears" and build confidence in the product. The ultimate goal of the OWCD is to eliminate the recharge process and utilize direct potable procedures that would save energy and money.[14]

Despite a clear presence of successful technologies and processes that outperform national and international drinking water standards, the public still remains suspicious of and reluctant to accept recycled drinking water for direct potable use. “Standards [for recycled potable water] are stricter because of the novelty of the technology and process,” says Benedito Braga, President of the World Water Council, “the quality from sewage is very good, as good or better than the tap water in any city in the developed world.”[14] The public’s trust and involvement in water reclamation is vital to the success or failure of any project; this was evident in Toowoomba, Australia when in 2006 a local activist group, “Citizens Against Drinking Sewage,” prevented the use of reclaimed water in their municipality, primarily for “emotive factors.”[14]

As mentioned in the introduction of this thesis, the connection of water to human waste is a major inhibitor to acceptance and evokes feelings of revulsion; a large focus of acceptance research focuses on this response. In particular, there is a prevalent, albeit “irrational,” belief that once water is contaminated, it is always contaminated, despite treatment processes. A parallel insight reveals that equally discouraging is people’s view that the process is unnatural. For example, water from a lake is deemed as a more clean and trustworthy source than from a treatment plant because it came from a “natural” source, despite the fact that water from a reclamation plant is analytically cleaner.

Based on this, success may be dependent on “breaking the perceived nexus between the earlier state of the water (in the form of wastewater) and its subsequent posttreatment state.” This can be established by measures as simple as physical separation between treatment location and supply location. [24] Further surveys revealed that a small part of the public rejects recycled water because of “discomfort with advanced technology and attachment to traditional values.”[24]

9. “Citizens Against Drinking Sewage” signage in Toowoomba, Australia

In the study, *The Psychology of Water Reclamation and Reuse*, researchers Brent Haddad, Ph.D Et Al. conducted a five-year survey in the United States to investigate the:

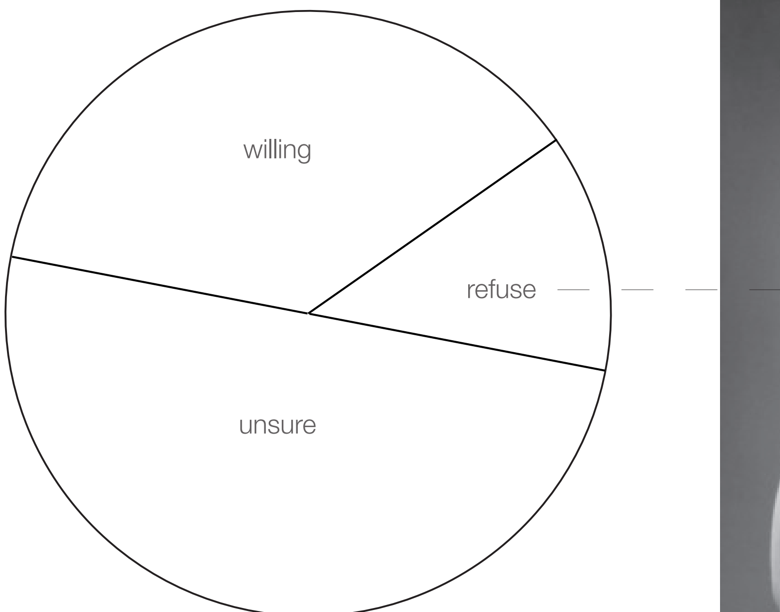
"human response to water reclamation and reuse [from] the perspective of social psychology and judgment and decision making, areas of psychology that focus on attitudes, beliefs, choices, and decisions and the multiple variables that influence them."[15]

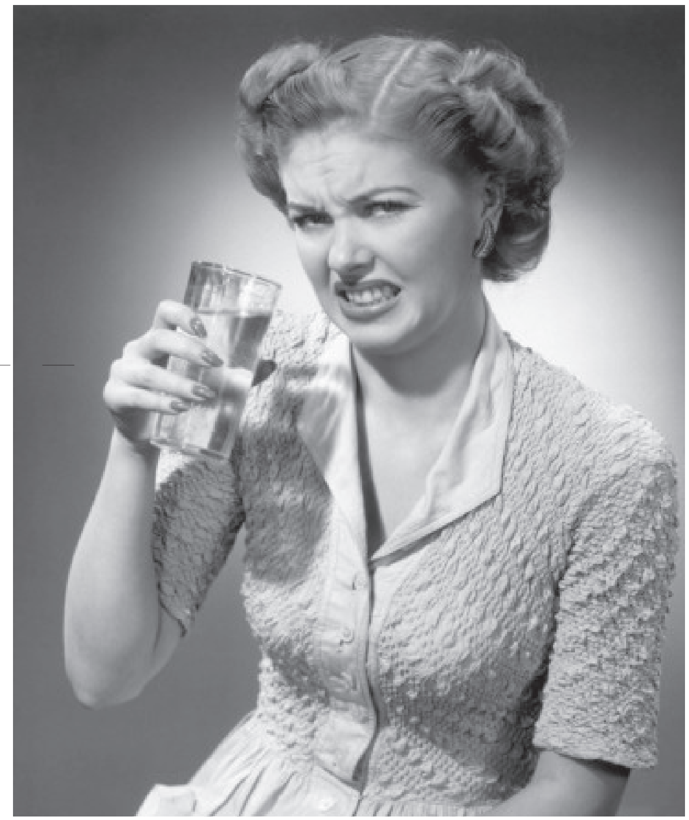
Researchers cite a few different approaches to promoting recycled water acceptance. First, is the idea of small-scale incremental exposure in "controlled" situations and settings; second, is a "flooding" tactic where positive, direct experiences with reclaimed water can "reduce or eliminate" the "discomfort or opposition." Lastly, the final approach evaluates individual's reactions to reclaimed water by touring facilities (such as those located in Orange County or Singapore).[24]

Surveys revealed that without any conscious exposure to or education in recycled water, less than 40 percent of those surveyed would be willing to drink recycled water. The other half remained uncertain, while a small hold out (13 percent) would outright refuse. Those who are uncertain are more comfortable with recycled water when delivered with "tried and true" methods[25]; essentially, the major factor that can increase one's willingness to accept water is whether or not it comes out of a tap or is served in a bottle. In addition, when learning about the process or touring a facility, those surveyed were more likely to accept recycled water when presented material by a "qualified scientist from a nearby university" rather than an engineer, staff from the facility, or medical doctors.[25]

In lieu of convincing the public to accept recycled water through education and outreach, Dr. Nemerhoff offers another approach; implement direct potable water reuse by directly providing the product to the public (via tap, directly into households) without notice. "When we do something enough, we stop seeing it as risky … when risks are unfamiliar, we tend to overreact to them." By exposing the public to reused water and only notifying them retroactively after a period of time, so long as there are no adverse effects, opposition will be minimal to nonexistent.[26]

Based on the survey findings, researchers concluded that there was in general a "broad" willingness for the public to use recycled wastewater. Ultimately, the major factors that inhibit the undecided majority is the concept of water being less "natural," i.e. being produced in a treatment facility or laboratory rather than being sourced from a natural source (such as a lake or aquifer), and perceived risk of contagion. These fears may be ameliorated with education and outreach through university researchers or professors, direct positive experiences with recycled water, and touring facilities where treatment occurs.

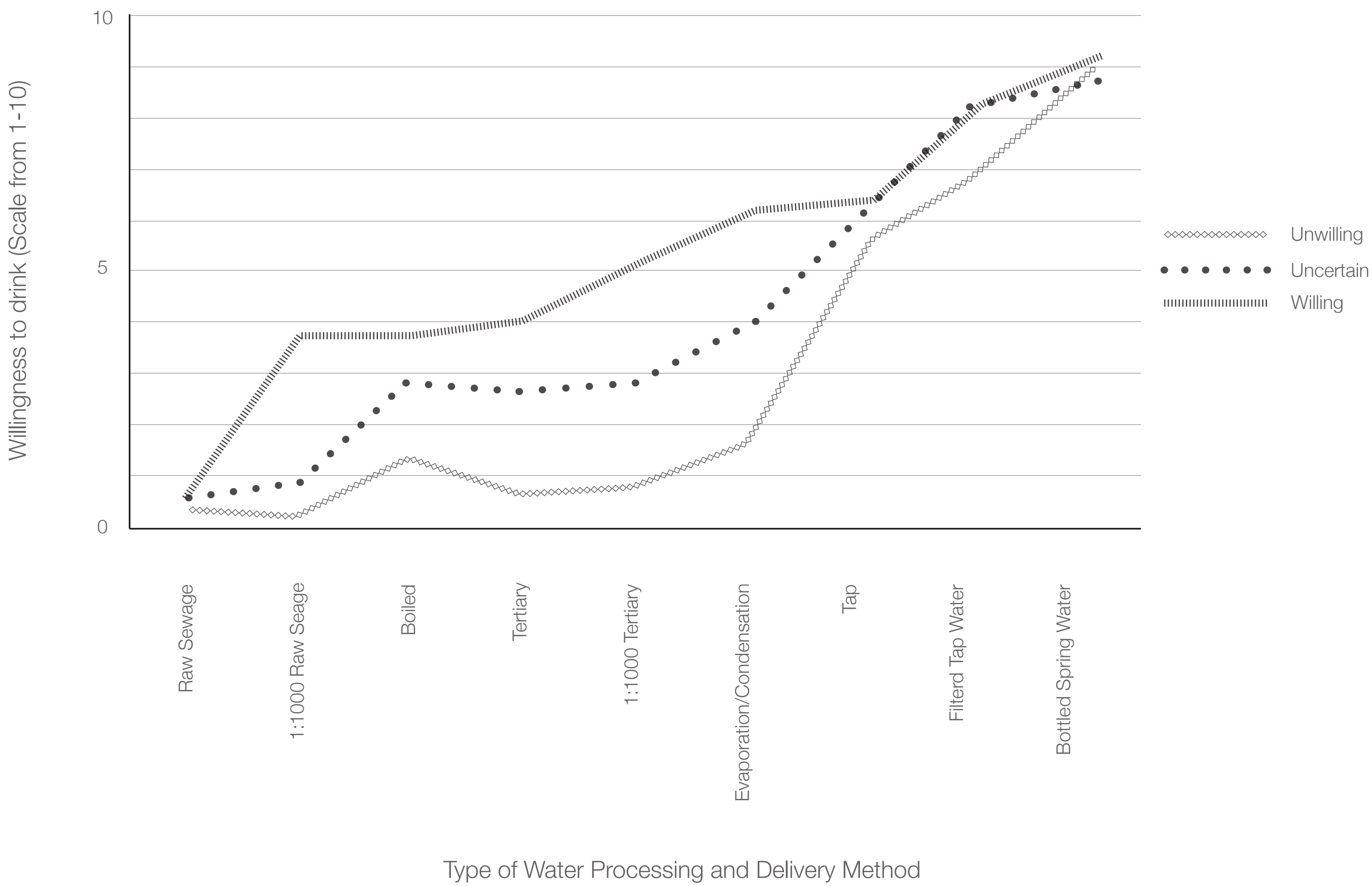




10. (leftt) Surveyed Participants indidcate willingness to drink reclaimed water.

11. (right) Emotive disgust and contagion as inhibitors to reclaimed water.

12. Willingness to Drink as a Function of Processing by Initial Willlingness (adapted from *The Psychology of Water Reuse*, Figure 4.5 [27])



In 2008, researchers in Australia conducted a similar study to Haddad, Et. Al. following the 2006 protest and thwarting of the construction of a water recycling treatment facility slated for Toowoomba. The purpose of the Marks, Et. Al. investigation was to determine the sociological attitudes of the public in response to assessing risks associated with recycled water. This subject matter is especially important because the "success of water recycling schemes" is directly founded on the public's acceptance; "The attitudes of the public are often seen as a significant impediment to the progress of recycled water…a more important issue than the actual health risks."[27]

Marks Et. Al base part of their research on anthropologist, Mary Douglas's, stance that risk perception is largely effected by the public's cultural belief that "sacred things and places are to be protected from defilement."[28] Thus, this cultural belief of purity and defilement are applied to the practice of recycling wastewater:

"A sociological approach to public perceptions of water recycling might focus on the ways different forms of recycling transgress cultural constructions of purity, danger and pollution. "[27]

The Australian survey included 2,504 participants and was conducted via telephone by the University of Queensland Social Research Centre from 2004 to 2005. The majority of the respondents had "little direct experience [or knowledge] of water recycling."[27] An important finding of the study found that with regards to willingness to use alternative water sources, the public was most willing to use "treated rainwater from roofs," followed by desalinated sources, with 96 percent and 91 percent positive responses respectively. In contrast, less than a quarter was willing to drink recycled wastewater even when described as "treated to a high, drinking water quality." [27]

Despite the fact that all the end products, treated water, would be indistinguishable, the original source of the water caused significant consternation. This reinforces Douglas's sociological theory; "the more water recycling transgresses cultural understandings of purity and pollution, the more it will be regarded as risky."[28] This is commonly referred to in the industry as the "yuck factor," also previously discussed by Dr. Carol Nemeroff under the issue of contagion. The public's cultural understanding of water, though contrary to fact and process, informs their refusal of water recycling proposals.

2.3 Agrotourism

An important element of this thesis is agrotourism, the practice of attracting visitors to an agriculturally based operation for leisure, recreation, participation, and/or education. While the public may be intimidated by or uninterested in the technological and process operations of water treatment facilities, incorporating elements of agrotourism may attract visitors to such a facility. Agrotourism has proven popular and successful among the public, particularly the urban subset. Connecting agriculture and water recycling processes could make the subject more approachable and appealing.

While an initial motivator behind agrotourism is to provide a diverse revenue stream for farmers, the multifaceted practice provides many other benefits, primarily encouraging education about food production and stewardship of the resources. Fitzsimmons, et. al state that "people are working to construct new initiatives and civic organizations that challenge the existing food system and seek to build alternatives." This may be especially true in the agribusiness in California that, as previously stated, consumes 80 percent of the state's water resources and is the cause of unsustainable water practices such as over drilling of underground sources and depletion of surface level lakes. Agrotourism is one type of "agrifood initiative" meant to "develop environmentally sustainable, socially just and economically viable food systems." There is an evident need on the behalf of producers and a desire on the behalf of consumers to develop links between the methods of food production and the end user.[29]

In his research on the education of consumers by farmers with respect to agrotourism, Abel Alonso maintains that the there is significant value in the grower-consumer relationship in agrotourism. Aside from the inherent "recreational value" in which visitors are able to feel connected with the land that bears their food, much of the benefit is educative in nature.

"Involvement in agr[o]tourism can … lead to educational opportunities [where] both children and adults can learn about a state's food production, agricultural heritage, or even resource stewardship."[30]

In Alonso's survey of Alabaman farmers engaged in some form of agrotourism, many of the farmers noted that the practice afforded them the opportunity "[connect with and educate] different consumer groups (schools, churches, individual visitors." This response demonstrated that growers are invested in "making genuine efforts beyond financial gains to bring new knowledge to consumers." The hope of spreading knowledge of farming is to instill in consumers a sense of relationship and care:

"A long term sustainable relationship may be established, whereby children and adults may become passionate advocates of consuming locally grown foods. In turn, these individuals may become much stronger supporters of local farmers, enjoy outdoor activities more often, and generally help strengthen the social fabric of their communities by means of their connection and relationship with their rural surroundings."

13. Agrotourists in a cornfield.

This sense of connection and relationship to rural surroundings and growing tradition can impart visitors with a sense of responsibility for the stewardship of the natural resources and environment that growing is inextricably dependent on, including the consumption and conservation of water.

The ability of agrotourism to facilitate connections between education, recreation, and the natural environment is also emphasized in Natthawut Shrikatanyoo's et al. research on the needs and motivations of the agrotourist in Chiang Mai. Shrikatanyoo defines agrotourism as a "nature-based tourism that has been promoted as an environmentally safe way for rural communities to generate income" and also promote the products and practices of a farm. Most notable is his acknowledgement that aside from generating income directly for the farmer, agrotourism can "provide economically feasible ways to care for natural habitats, natural scenic areas, national resources, and special places."[31] This is an important observation; agrotourism is not only a means of educating the public on sustainable practices but also on subsidizing them. Shrikatanyoo's survey of agritourist participants revealed that visitors were most interested in participation in agricultural life and the environment, as well as enjoying natural "beautiful scenery." He concludes that this combination of motivating factors indicates that agrotourism has the ability to harmonize recreation with environmental sustainability. [31]

Agrotourism is a successful endeavor among many farmers in California. The first statewide economic survey of agrotourism operators, conducted by the University of California (UC) Small Farm center, discovered that over 2.4 million visitors had taken part in some form of agrotourism in 2008. Participation in agrotourism came in many forms including visiting operational farms to work alongside farmers, picking fruit at "U-Pick" orchards, touring vineyards, or buying fresh produce from roadside stands and farmers markets.[32]

There is already a successful market for agrotourism in California. The United States Department of Agriculture's (U.S.D.A) census of agriculture found that California is a leader in agrotourism, "with nearly 700 farms." In general, it is most popular among "city dwellers who want to understand where their food comes from." The World Wide Opportunities on Organic Farms, a matchmaking online resource which pairs agrotourism operations with eager participants, cites strong growth; the service has 11,600 registered tourists and 1,300 registered farms in the United States.[33]

There is a desire among the public to learn about and participate in food production; this interest can be used to educate people about elements of farming, specifically resource management, and to focus attention and open minds on the use of reclaimed water. The "on-farm" recreation concept is used as a tool "to educate and provide enjoyment"[30] and can easily be utilized as a vehicle to promote the use of reclaimed wastewater and emphasize the importance it plays in sustainable agricultural practice.

In order to ensure success of any wastewater recycling project, it is necessary to deemphasize the idea of contagion, the "yuck factor" and the origin of recycled water as waste. Instead, positive associations should be established by underlining the fact that all water is recycled in some form or another through the natural water cycle. Positive associations may be established by linking the importance of the waste and water with growing. Highlighting the positive implications that water recycling can have on agriculture may help the public to understand the importance of the process; the relationship between food and water and providing a direct, firsthand experience of the two working in conjunction has the potential to improve the public's perception and willingness to accept water-recycling efforts.

Firsthand experiences can be facilitated via agrotourism. Studies and surveys of both farmers providing services and agrotourists partaking clearly denote a desire of people to connect with their food and the land from which it comes. There is also a demonstrated wish to protect the natural environment and farms. Based on these findings, this thesis postulates that there is a clear desire of the public to help foster sustainable practices, including water management as it pertains to the California growing culture. A significant part of water management practices includes water recycling; using agrotourism as a tactic to introduce water recycling to the public can promote the practice by providing positive, engaged, educative and recreational experiences. This framework serves as a basis for the development of the project's program, concept and design.

chapter 3: objectives and methodology

"More grass means less forest; more forest less grass. But either-or is a construction more deeply woven into our culture than into nature, where even antagonists depend on one another and the liveliest places are the edges, the in-betweens or both-ands … Relations are what matter most."

-Michael Pollan, *The Omnivore's Dilemma*

This thesis proposes a synthesis of sustainable agricultural water use and full cycle water treatment in order to promote black water reuse. It suggests a prototypical model that could be replicated at larger scales throughout the Central Valley, California and in other localities that are economically, socially, and traditionally dependent on agriculture. Agriculture practices as executed today are unmaintainable with respect to water scarcity and responsible resources use. On a larger scale, this proposal's intention is to induce discourse on rethinking our use of water, treatment of it and how we can create municipal and agricultural water use partnerships. On a smaller scale, this thesis aims to provide a space for direct positive experiences with water recycling for an individual.

The main objectives of this design proposal are to:

1. Promote wastewater recycling for direct potable use by providing a space for education and positive interaction with treatment technologies and process.
2. Create closed-loop relationships between agriculture, treatment, and the community at large that promote efficient and sustainable resource use.
3. Demonstrate sustainable agricultural practices with respect to water usage.
4. Create a connection between people with water, landscape, agriculture, and the machine of systems.

The objective in this joint endeavor between treatment and agriculture is to create a space where the public can visit where water recycling is always in the forefront of their minds, architecturally, programmatically and thematically. Agrotourism is currently used as a didactic vehicle to exemplify and encourage conservancy of the lands and growing resources; water is an invaluable resource that also merits conservancy, especially in relation to agriculture. The intention is to foster positive experiences with recycled water through outreach, recreation and education; these experiences can augment the acceptance of water recycling for drinking water. In addition, this proposal can act as vehicle for rethinking age-old treatment and farming practices and help to create and emphasize more efficient, integrated practices imperative to future water security.

To determine the appropriate program necessary to fulfill the design and theoretical goals set forth by this proposal existing projects with similar programmatic elements are investigated. These projects include water recycling educational or outreach facilities, and agrotourism ventures with an educational focus.

14. NeWater Visitor Center (Interior)

15. Grade school field trips and tours of the NeWater Visitor Center.

3.2.A The NEWater Visitor Centre, Singapore

In establishing the "Four National Taps" strategy, the PUB recognized that public perception and acceptance was critical for success, especially regarding the acceptance of recycled water for indirect potable use. In order to spread public awareness, educate, assure, and correct misconceptions, the PUB constructed the NEWater Vision Centre that "serve[s] as the focal point of the NEWater public education program."[19] The design of the center relies on the stimulation of sight and sound combined with emotionally appealing scientific research and information in order to create "confidence and acceptance of the process and product, [recycled water]." [19]

Architects, engineers, and interior designers were tasked with providing spaces that would enhance the visitors' experience by creating "comfortable, feel-good" spaces that incorporate aesthetically interesting elements and highlight technological information about the process while simultaneously making it approachable and easy to understand and accept. What is also particularly interesting about the mission of the outreach building is that the NEWater Visitor Centre does not only feature the science behind the process, but also teaches visitors about the inherent "preciousness" of freshwater, its limited presence as a resource, and the idea that water has always been used and reused in the some form or another. Not only is treatment and management a part of the education, but the idea of conservation is also at the forefront.[19]

The NEWater Visitor Centre's architectural and interactive design is successful in educating the public about water recycling and promoting acceptance. This is evident in following visitor's experience:

"I remember detesting NEWater just because of the fact that it is recycled water - I used to call it "bottled toilet water". Thinking it was dirty and unsanitary, I used to refuse to drink NEWater. That all changed after a school visit to the NEWater Visitor Centre. We were given a short tour inside the gallery and we were taught, in detail, about the various processes the water goes through before it is bottled for us to drink. Needless to say, I was very surprised about the advanced technology and I then realised that NEWater is actually clean and safe for us to drink. After the visit, I actually felt proud that Singapore managed to come up with such a beautiful and advanced piece of technology to counter our water shortage problem. I strongly recommend every Singaporean to visit this place at least once, especially those who have misconceptions about NEWater."[20]

This description is particularly important because details how an individual's reluctance to accept recycled waste water was changed by their physical and interactive visit to the NEWater Visitor Centre. Other visitor reviews clearly indicate the importance of an actual visit to the physical space and presentation of information influenced their opinions on water recycling:

"After walking through all the different stages and understanding more about the history of NEWater which was very thoroughly explained in the Visitor Centre, I have developed a newfound respect for NEWater."[20]

Also,

"Although I didn't see much value in NEWater then, the visit to the NEWater visitor centre then opened my eyes to a world of information that I didn't know then. Who knew that water would be so important to our nation? … The interactive and technologically-savy set up of the new visitor's centre makes it so much more interactive …"[20]

The spatial experience that the NEWater Visitor Centre provides is instrumental in disseminating information in an enjoyable, interactive and memorable way in order to promote acceptance.

3.2.B Groundwater Replenishment System, Orange County Water District, Fountain Valley, CA

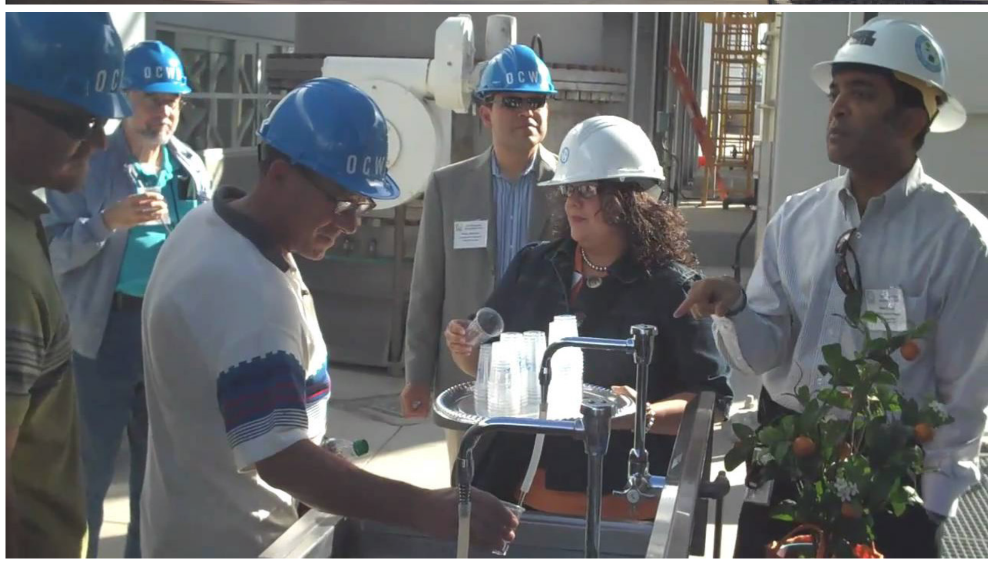
At the onset of their non-potable water reclamation efforts, the OWCD launched a comprehensive education and public relations campaign. In 2009, the Advanced Water Quality Assurance Laboratory was constructed as a celebrated reuse project that combines the engineering facilities as well as outreach functions.[21] The facility is open to the public for tours and educational sessions; the design of the building is intended to promote transparency and understanding.

The 39,000 square foot laboratory is LEED certified and used as a “showcase for advanced water quality treatment measures.” Hallways, testing facilities, and laboratories are glazed so that guests may openly observe daily operations; the circulation of the building was designed to accommodate public tours without having visitors double back through the space and keeping operations secure.[23] At the end of the tours, visitors sample the treated, recycled water. With outreach and educational efforts, the objective of the OWCE and GWRS is to provide a reliable and efficient direct potable supply.

The sleek, clean, and modern aesthetic of the facility is intentional. Water district staff required a design that was to be “admired, built to perform both a material and a social function” in order to prove to the public that water recycling was an “exciting and safe wave of the future.” Minimal material choices of concrete, glass and steel showcase innovative technology and leave visitors “confident and a little in awe” of the process. Interviews with area water managers reveal the true importance of the architecture; they state that the “value in building sewage-to-drinking water plants that look and feel shiny enough to evoke associations with interstellar travel and Space Age techno-optimism” is what helps to encourage acceptance and break down public fear over technologies that have been historically derided as “toilet-to-tap” by opponents.[34]

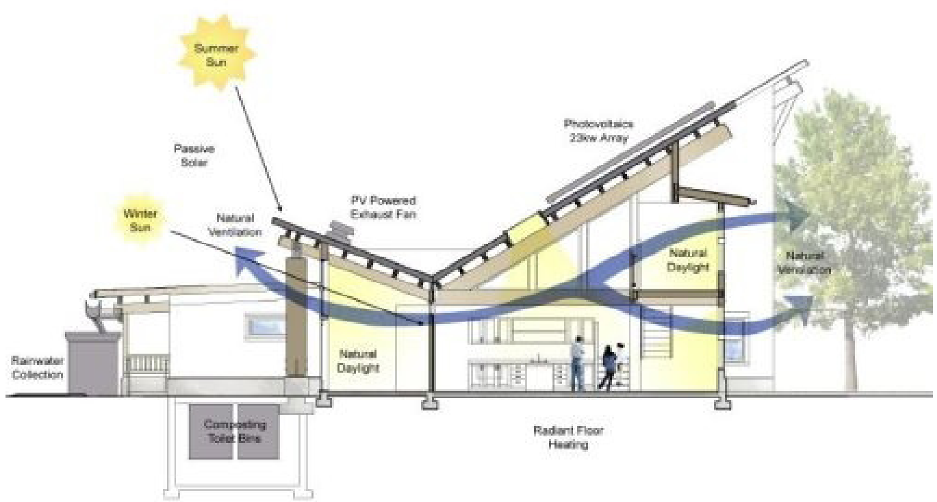
Each building is clearly titled with their function (i.e. microfiltration, reverse osmosis, ultra violet) in order to clearly demonstrate steps of the process. The architecture of the treatment plant focuses squarely on the technology, process and cleanliness and is meant to assuage associations with waste and contagion. The GWRS building design is so evocative of space-age modernism and technology that it has been used as the set in scientific fiction films such as Transcendence.[34]

16. The Reverse Osmosis processing building at the GWRS.



17. GWRS tours end in a sampling of the reclaimed water.

18. Gradeschool campers at Islandwood.



19. Integrated sustainable diagram for Islandwood's main lodge.

3.2.C IslandWood, Bainbridge Island, WA

Formerly the Puget Sound Environmental Learning Center, IslandWood is a 70,000 square foot "residential environmental education campus for children and adults" sited on 255 acres on Bainbridge Island, Washington.[35] The objective of the campus is to provide an escape from the city in the forest to facilitate "experiential-based learning" and to "serve as a model of environmentally sound design principles." Islandwood hosts 4,000 elementary school aged children annually for a three-day overnight experience where students are immersed in curriculum of science, technology and arts.[36] The project also provides day programs for day-campers, joint programs with area-schools and universities, and tours for adult visitors.[37] Mithun, the architect behind the immersive learning campus, describes the program of the project:

"The educational core of the center includes the main center (interpretive center, great hall, administration), learning studios, dining hall, art studio and maintenance building. Visitor accommodations include three lodges and a guesthouse. North of the educational core is a staff housing area. Shelters, bird blinds, walkways and lookouts are featured throughout the site. The shelters and walkways are connected by a system of primary and secondary trails."[35]

The mission of IslandWood is to act as an experiential catalyst to "discover a new way of seeing nature."[37] In order to do this, the architect developed a specific design intent that included protecting the natural environment of the site through "environmentally intelligent design," using the building itself as a teaching tool, connecting visitors back to nature, and rethinking standards for the building design and education in itself.[38]

One way in which IslandWood's architecture acts as a teaching tool is that water treatment is integrated into building design. Composting toilets and waterless urinals help reduce water demands, and blackwater generated on-site is treated to tertiary standards "using a Living Machine and Subsurface Flow Constructed Wetlands." Treated water is then re-piped through the buildings and recycled for flushing toilets; this lessens the demand of potable water from the municipal system.

The building itself exemplifies the same conservation and technology that IslandWood aims to teaches; the building is a tool in education. Students and visitors are even able to monitor and track water and energy usages with technology integrated into the building's mechanical systems. Other elements of sustainable water practices include rooftop and cistern rainwater collection, and storm-water mitigation through a natural watershed of wetlands, ponds and streams. [37]

3.2.D Fairview Gardens, Goleta, CA

The Center for Urban Agriculture at Fairview Gardens, located on twelve and a half acres in suburban Goleta, California is an organic non-profit educational farm. The mission of the organization is to build critical connections between education, land and community by providing a space for visitors to engage with the farm by cultivating the land and growing food.[39] The urban farm, located in a densely populated area, is highly visible within the community. The property is part of an agricultural conservation easement granted by the Land Trust for Santa Barbara County and permits Fairview Gardens to operate on the land so long as that they maintain a working farm in the urban area that will promote stewardship and conservation of natural resources.[40]

The land easement is also unique in that it stipulates an education component. Fairview Gardens offers summer camps and after school farming programs for children, tours, and volunteer opportunities for visitors, and provides a space for community events and gatherings.[40] Their educational aim is to:

"provide the local community with fresh, chemical-free fruits and vegetables; demonstrate the economic viability of sustainable agricultural methods for small farm operations; research and interpret the connections between food, land stewardship and community well-being…"[41]

The majority of the educational programs are for children aged four to ten years; there is an internship volunteer program available to teenagers.[42] The essential value of the educational outreach component at Fairview Gardens is its ability to change the minds of participants:

"Kids who previously would not eat their vegetables have watched in amazement as [farmers have] pulled carrots from the ground, washed them and provided them as a snack. Parents have reported back with enthusiasm that these same kids now not only eat vegetables, but they eat them with pride in their knowledge of where the food came from."[40]

This same kind of change can be extrapolated to attitudes towards water recycling so long as there are opportunities for positive, interactive learning experiences.

Other program elements of the Center include a retail store, produce stand, community sourced agriculture (CSA) component, and horticultural therapy. All of these programs are run with the aim to promote sustainable growing practices and to help people better understand the importance of appropriately scaled, local farming in connection with stewardship of our natural environment.[41]

20. Center for Urban Agriculture at Fairview Gardens in Goleta, CA

21. The Hidden Villa Visitor Centre and demonstration gardens.

22. Campers learn about the composting process.

3.2.E Hidden Villa, Los Altos, CA

Hidden Villa is a nonprofit educational organization sited on 1,600 acres in the foothills of the Santa Cruz Mountains in northern California. This mission of this organization is to “inspire a just and sustainable future through our programs, land and legacy.” Every year, 30,000 people visit Hidden Villa to take place in one of their many educational programs at their nature preserve and organic farm. [43]

Hidden Villa offers school programs for elementary school children and teens, summer camps, public programs for adults and children alike, internships, volunteer programs, farm tours, CSA delivery, and farmers markets. The Hidden Villa summer camp hosts 1,300 campers ages seven to seventeen and provides them with hands on educational opportunities to learn about organic farming practices, animal husbandry, and the wilderness. The farming component demonstrates “sustainable, organic practices that minimize outside inputs, promote biodiversity, honor labor, value animal welfare, and respect the capacity and wildness of the land.”[43] The goal is to emphasize environmental stewardship by using its farm and preserve as context for hands on experience.

The Hidden Villa campus is comprised of a hostel with lodging, dining, cooking and lounging space for guests, an educational center that hosts summer camps and large events, a ranch house for onsite management residence, and several rental facilities available for retreats and private gatherings.

Many of the buildings on site integrate sustainable design in order to demonstrate their mission of preservation and education. These features include passive solar design, harnessing solar energy, and ground source heating.[43] The buildings collect gray water for irrigation of landscaping on site; blackwater from toilets is not collected for treatment or reuse. Building roofs were designed to collect rainwater for toilet flushing, but the county has not granted permission for water storage or plumbing to connect these systems; despite the fact that the buildings have the capability for water catchment and reuse, they currently do not utilize them due to lack of permitting. [44]

chapter 4: design proposal

"… the closing of water use loops will become an increasingly central infrastructural tactic for municipalities and governments facing decreased water supplies and rainfall in the coming decade. Closed water loops may even become as integral and expected a part of architecture as air conditioning is today … buildings are the new aquifer."

- Stephen Becker and Rob Holmes

This thesis proposes a relationship between a selected municipality and a new treatment facility that will integrate demonstration, farming, outreach and education elements. The facility will source effluent from said municipality, treated to primary and secondary levels. Tertiary treatment, the final and most controversial step in water recycling bringing the cycle full circle in terms of waste to potable, will be done on site. Recycled water will then be returned as potable drinking water to the municipality or retained on site for direct human use, replenishment of groundwater aquifers, storage, or use for irrigation of agriculture.

As previously discussed, researchers cite a few different approaches to promoting recycled water acceptance. These include seeing clean water flow from a tap, direct hands on positive experiences with reclaimed water, conscious educational experiences and touring facilities. This thesis postulates that acceptance also hinges on showing the public that the technological water cycle is not that different from the natural water cycle. Lastly, demonstrating that water recycling is critical to sustained agricultural use and our own water security can be powerful in persuading water-recycling opponents.

The architectural proposal of this thesis is a prototypical and replicable tertiary treatment facility and farm that combines the experience of machine, water, landscape and agriculture into a spatial and physical experience in order to promote black water recycling acceptance. The specific program is for a demonstration treatment plant and integrated farm with an educational and extended stay (or camp) component. Refer to Figure 23 for a detailed list of program spaces.

23. Program Spaces

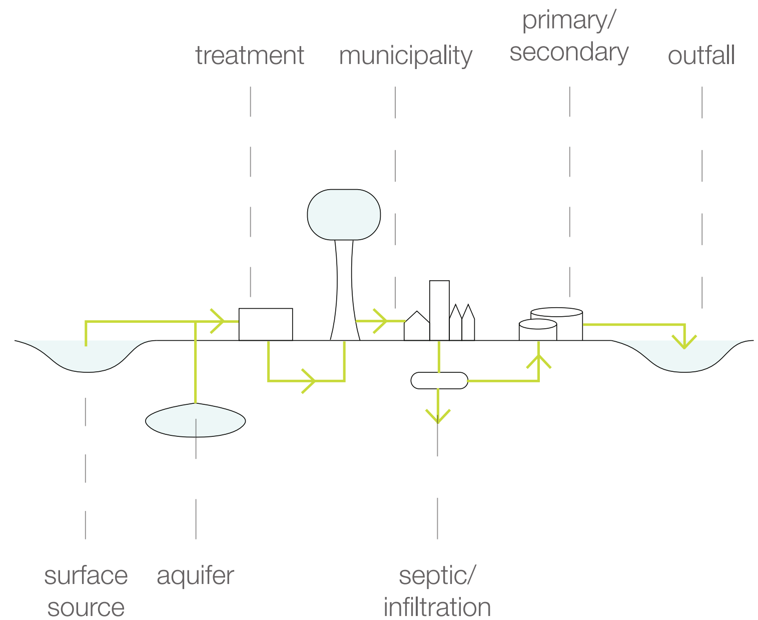
Treatment	
Tertiary Demonstration Area	1500 SF
Holding Basin	404,000 Gallons
Storage Tower	236,000 Gallons
Observation Platform	700 SF
Educational Outreach/Agrotourism	
Viticulture Farm	5 Acres
Barn	350 SF
Lodge	
Administrative Loft	490 SF
Kitchen	200 SF
Storage/Mechanical/Electrical	150 SF
Restrooms	140 SF
Cantina & Exhibition	1280 SF
Outdoor Classroom	550 SF
Dryhouse	
Sleeping quarters for 48	1710 SF
Rooftop Communal Deck	1710 SF
Wethouse	500 SF
8 toilets	
8 showers	
Communal Trench Sink	

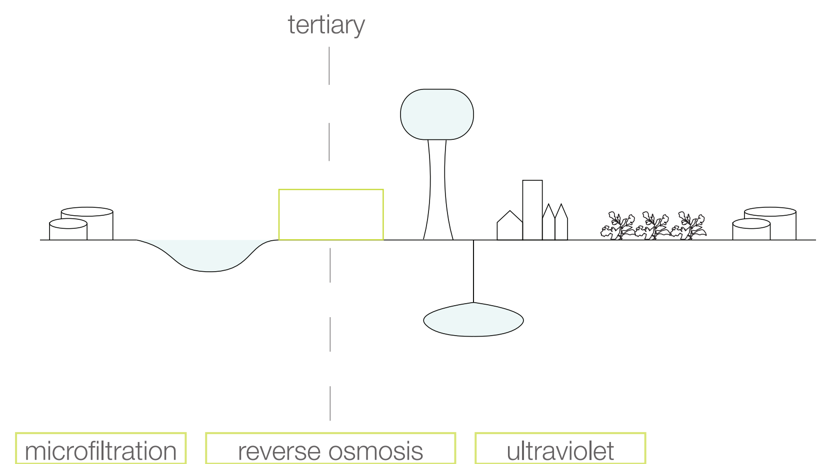
Tertiary treatment is a large component of this proposal.

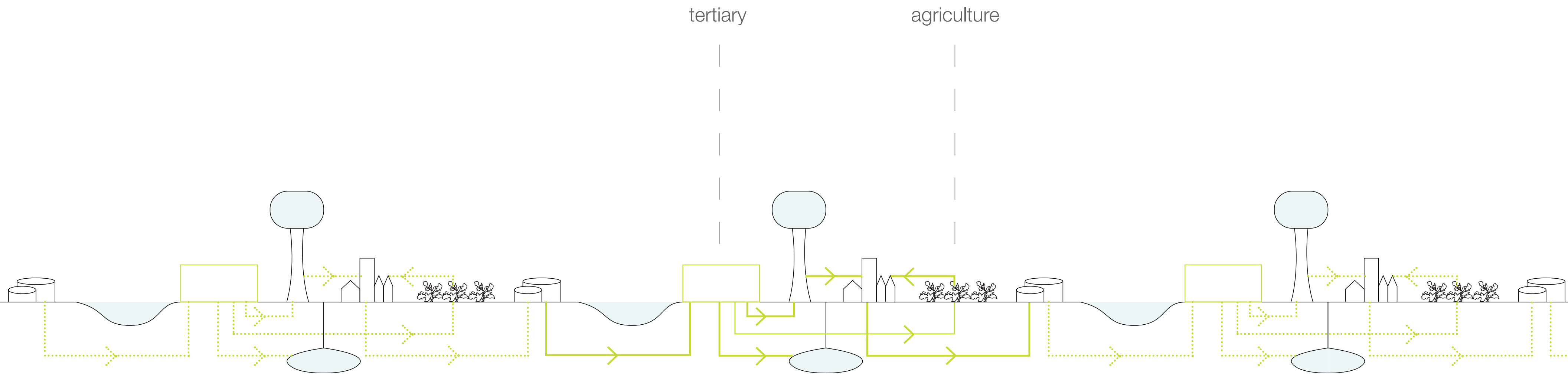
This first diagram depicts the typical cycle of our water use today. It begins by withdrawing water from sources such as lakes and aquifers, treating it to drinking standards and then distributing it to a municipality. Once used, the water is either sent to septic and ultimately infiltration, or it becomes sewage that is treated to primary and secondary treatment levels (essentially filtering for solids and some contaminants) before it is eventually sent to outfall, meaning discharge into a lake, ocean or creek.

Tertiary treatment, or the black water recycling component (the major programmatic element of this proposal), is an additional step that involves microfiltration, reverse osmosis, and ultraviolet light. This process restores wastewater treated to primary and secondary levels back to potable standards. Water treated to tertiary levels exceeds WHO requirements for drinking water.

The diagram on the far right depicts what the water cycle could be if we were to integrate tertiary treatment. Instead of sending water already in the system to outfall, we recapture it and treat it with the tertiary process, where it can then be sent back into the municipal system, used for groundwater recharge, or used for irrigation of agriculture. This system could essentially be repeated indefinitely, and theoretically close the water use loop. The addition of tertiary treatment is proposed in #poop2potable.







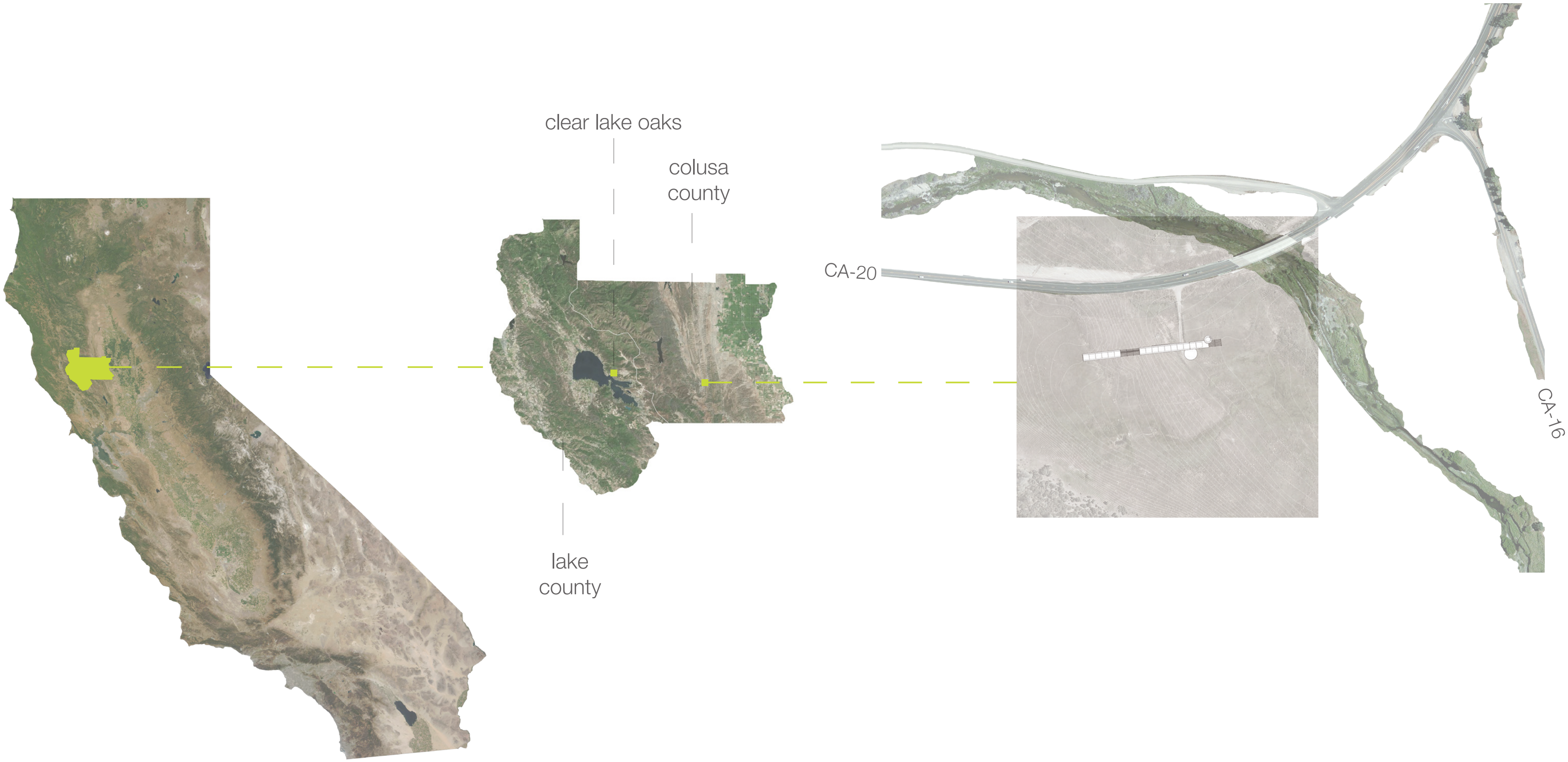
24. (top left) Current water loop
25. (bottom left) Tertiary treatment
26. (right) Proposed water loop
integrating tertiary treatment.

27. Views of the site from CA-20, westbound.
28. Views of the site from CA-20, eastbound.

4.2.A Selection and Analysis

The Sacramento Valley is located in the northern end of the Central Valley, bordered on the east by the Sierra Nevada Mountain Range and on the west by the Coastal Mountain Range. The counties within the Sacramento Valley include Butte, Colusa, Glenn, Placer, Sutter, Tehama, Yolo, and Yuba, for all of which agriculture has been a strong economic driver since the mid nineteenth century when levees were constructed for irrigation and flood control of the Sacramento River.[45] Though the Sacramento Valley's ubiquitous agriculture is most known for rice, cattle ranches, and citrus orchards, the fertile soils and a Mediterranean-like climate make this land prime growing real estate for many crops such as almonds, walnuts, plums, peaches, tomatoes, wheat, olives, corn, alfalfa, pears, sunflowers, grapes, kiwifruit, and hay.[46]

The project is located at the westernmost extents of Colusa County where California Route 16 (CA-16) terminates into California Route 20 (CA-20), a state highway connecting Interstate-5 (I-5) and U.S. Route 101 (101). The proposed design investigation is deliberately sited between Lake and Colusa County, two counties that share an interesting interdependence defined by water and agriculture; the site is equidistant between a natural water source, slowly drained by its surrounding municipalities and continued drought, and a vast valley of cultivated land that requires an endless supply of water for irrigation.



29. Site Maps

30. Clear Lake at record lows.

Clear Lake is the largest naturally occurring lake in California and serves as a municipal and irrigation source as well as recreation destination. It is located twenty miles west of the project site in the coastal mountain area of Lake County. The lake is considered full when it contains 1,200,000 acre-feet of water; today the water level is the lowest it has been in 37 years with approximately 842,000 acre-feet of water.[47] Along with groundwater, the lake provides potable drinking water to surrounding towns; some of the lake's raw water is sold to Sacramento Valley counties for irrigation. Clearlake Oaks, population 2,359[48], is located on the northeastern shore of the lake is one of the small towns with riparian rights on Clear Lake.[49]

Currently, the Clearlake Oaks County Water District's (COCWD) Wastewater Treatment Plant outputs treated waste water ranging in flows of half a million gallons to 2.1 million gallons per day. The treated effluent is either sent to outfall in Cache Creek or piped over fifty miles south to the Geysers, the largest complex of geothermal power plants in the United States.[49]

Less than twenty miles east of the site is Colusa County in the heart of the Sacramento Valley. Colusa County's primary industry is agriculture; the county produces over 900 million dollars in gross revenue by producing forty-five different commodity exports for sixty-nine countries, not including goods distributed domestically.[50]

4.2.B Site Strategy

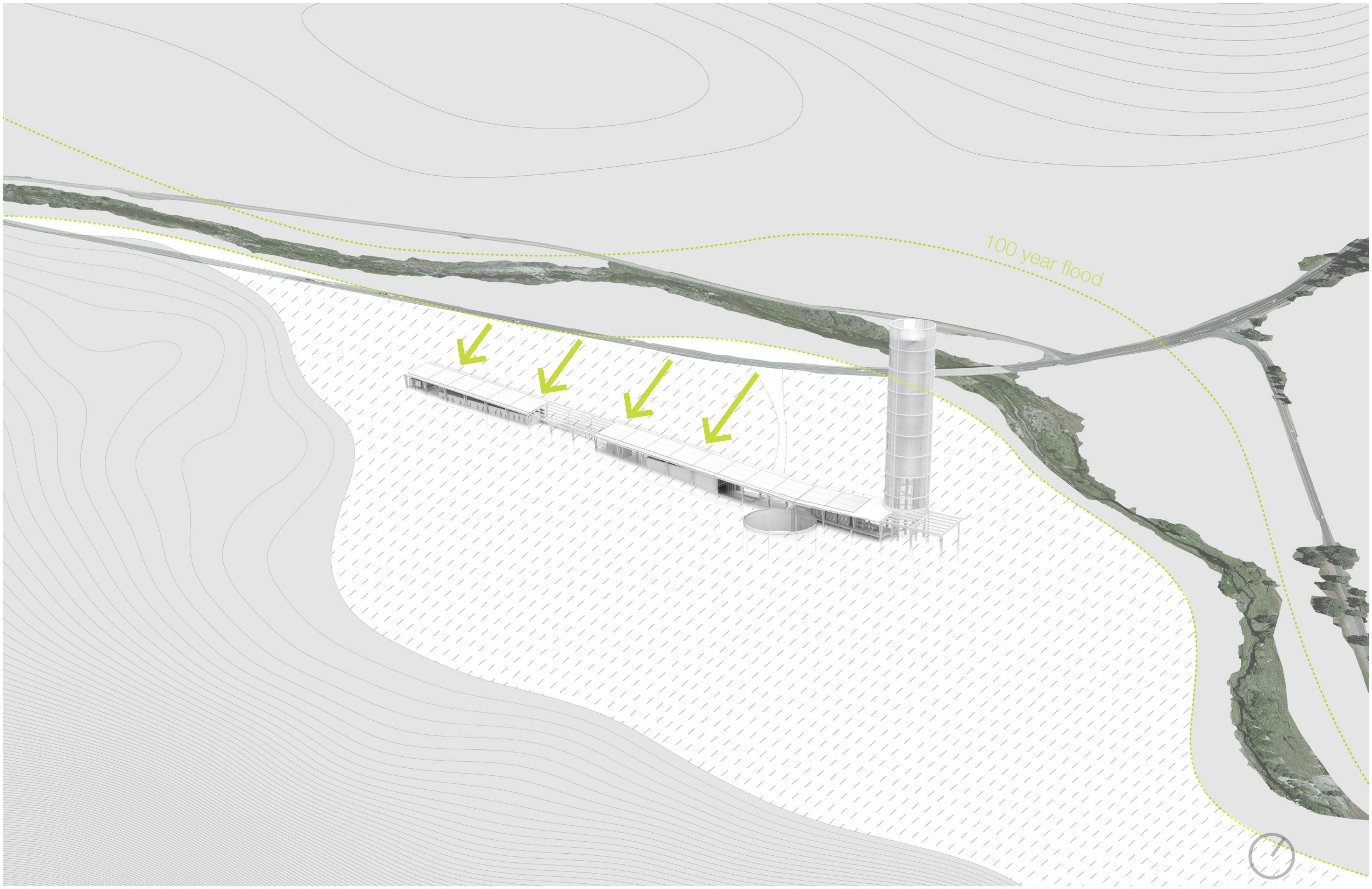
The chosen site, an abandoned cattle pen among the foothill transition from the valley to the mountains, is intentionally sited centrally between Clearlake Oaks near Clear Lake and Colusa county to underline the disconnect between the ways we currently use water and the potential that exists to close this gap. In order to demonstrate the connections and relationships that can be forged between water, cultivation, and people, the proposed design creates a symbiosis between tertiary water recycling endeavors and existing municipal wastewater treatment systems, between agriculture needs and water sources, and between people and resources.

Effluent from Clear Lake Oaks meant for outfall at Cache Creek will be diverted to #poop2potable where it will be treated via the tertiary process to drinking water standards. From there, the water may then be used for ground aquifer recharge, potable needs of users on site, irrigation, or returned to Clear Lake Oaks for municipal consumption.

31. Contextual Site Map

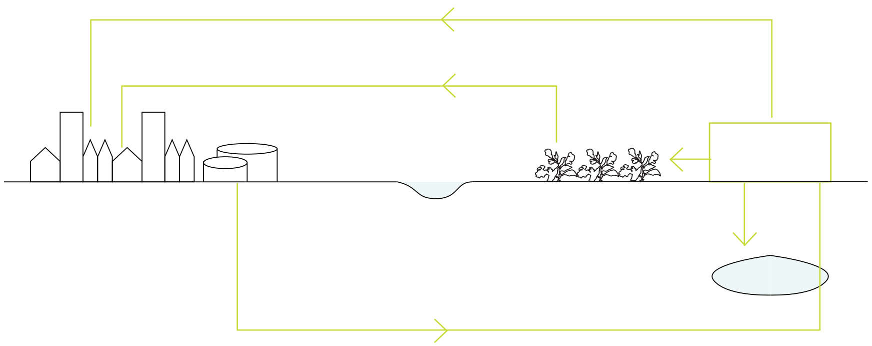
The project is sited to reveal itself to passersby on CA-20 in the tradition of roadside capture in California. The whole length of the building and all of its treatment components are visible from the road; the shed roof is lifted up towards the road to emphasize this connection. The existing cattle pen path is maintained as the main entry to the project to underline the agrarian component and past historical use of the site.

The siting of the building also creates a contained space for the vineyard between the terrain, the creek, and the building; the building shields the interior experience of being in the farm from the road. Grapes are selected as the primary crop for the project due to their successful cultivation in the area, as well as for their inherently structural nature. The project's five-acre vineyard is formed between the extents of the one-hundred year flood plain of Bear Creek and the steep rise of the terrain on the south and west sides of the site. The building reflects the existing topography to take advantage of the natural slope for water collection and drainage.

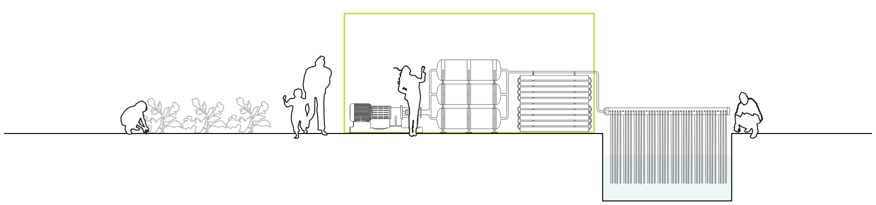


32. Siting Strategy Diagram

33. Perspective: CA-20 eastbound approach.



34. Municipal Scale



35. Human Scale

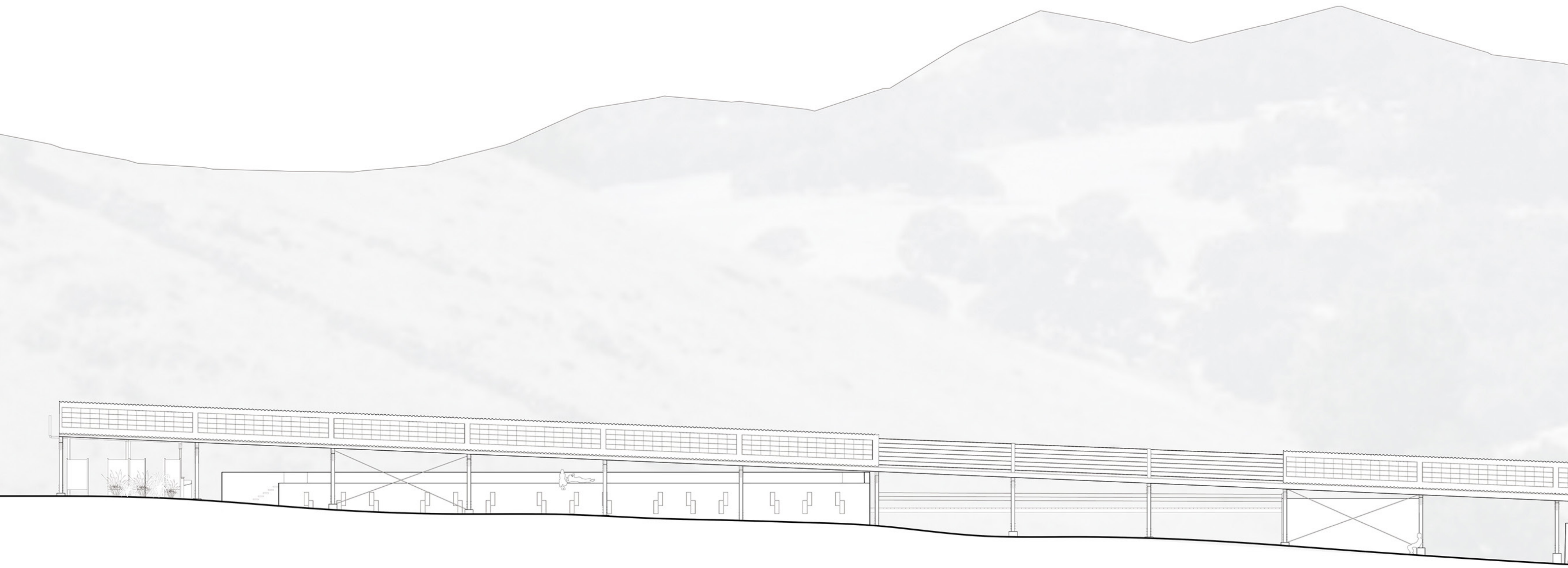
4.3.A Architectural Design

The project aims to create a resource network with an existing municipality to demonstrate how this system can interject into existing infrastructure. On the municipal scale, #poop2potable will capture the effluent from the primary and secondary treatment plants of Clear Lake Oaks, reclaim the water onsite through tertiary treatment, and return potable water to the town.

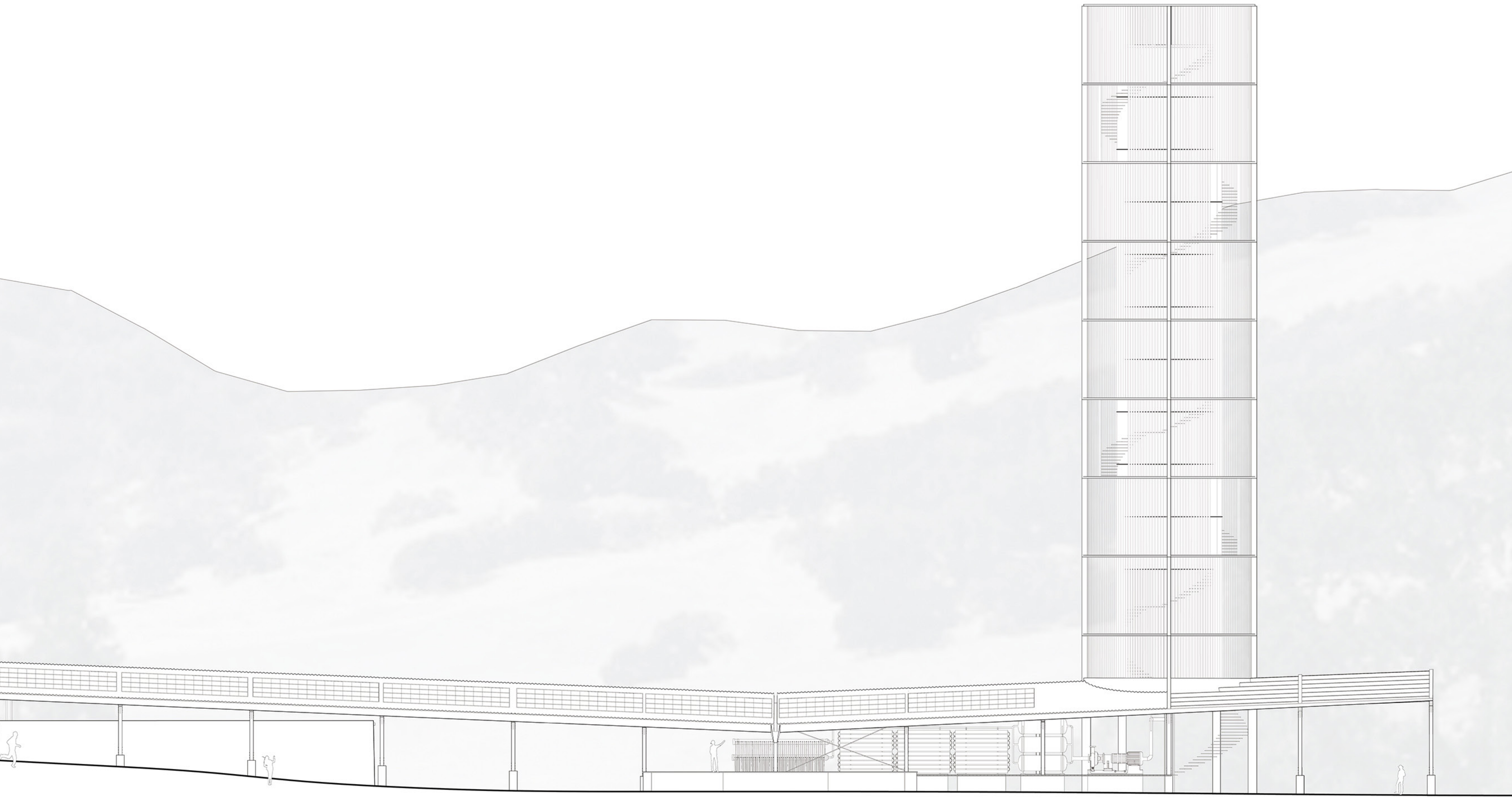
At the human scale, the project provides a place for people to witness and participate in the connection between farming, water, and the treatment machine in the landscape. Providing a place for positive spatial experience is important to make the technology more approachable, and to understand its importance to sustained farming practices in the region.

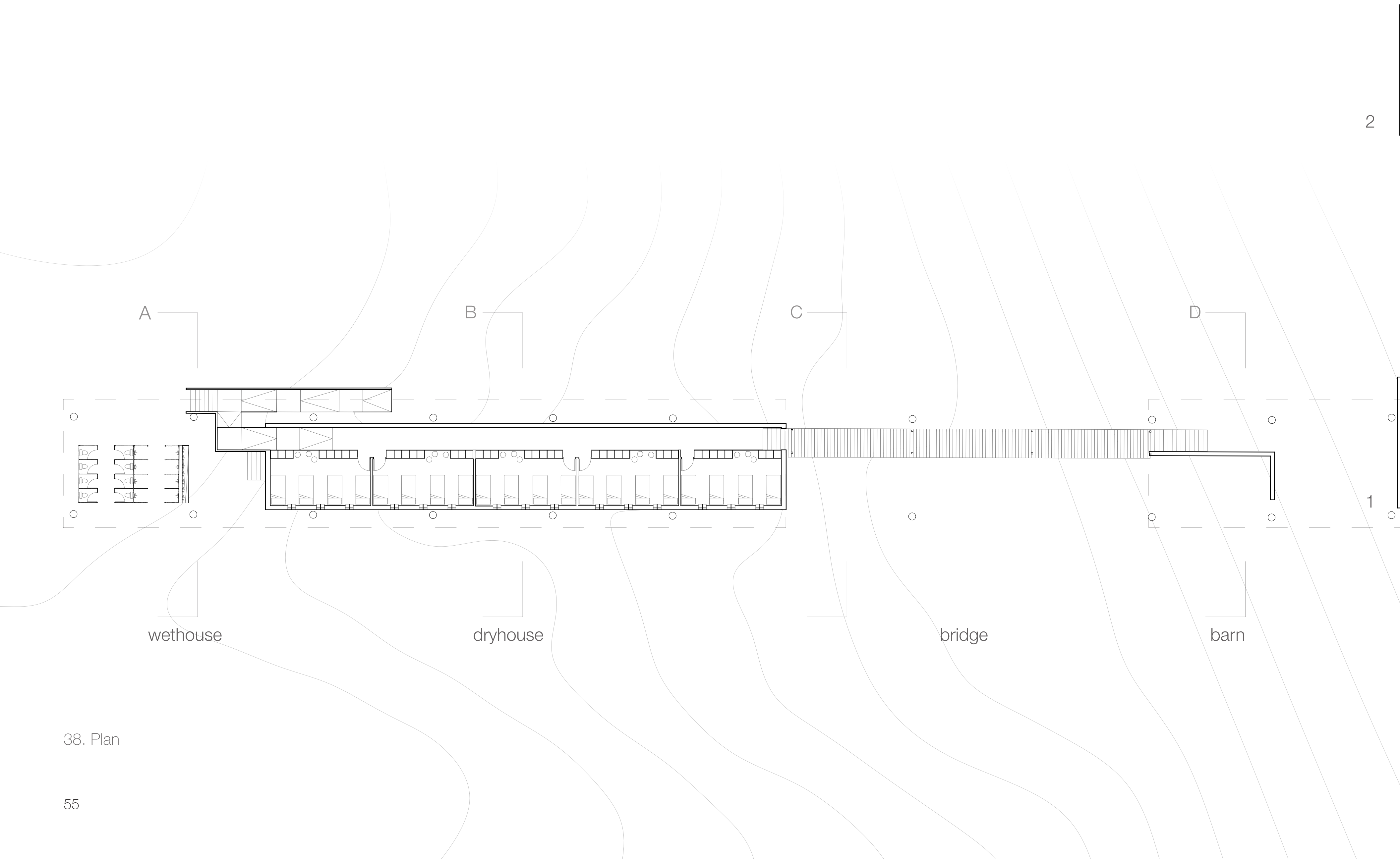
In order to curate each visitor's spatial and didactic experience, four main conceptual elements are emphasized. These include the concepts of machine, water, viticulture, and landscape. These elements together help to promote acceptance of water reclamation by emphasizing the need for each to ensure continued agricultural practice and water security in the Sacramento Valley. Combined with a desire to implement a standard of efficiency, these elements informed the architecture.

36. Conceptual Experience Collage

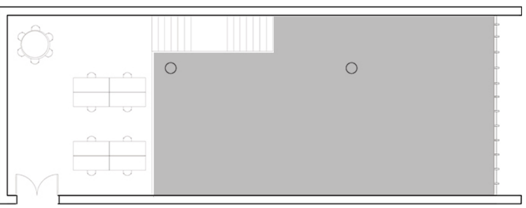


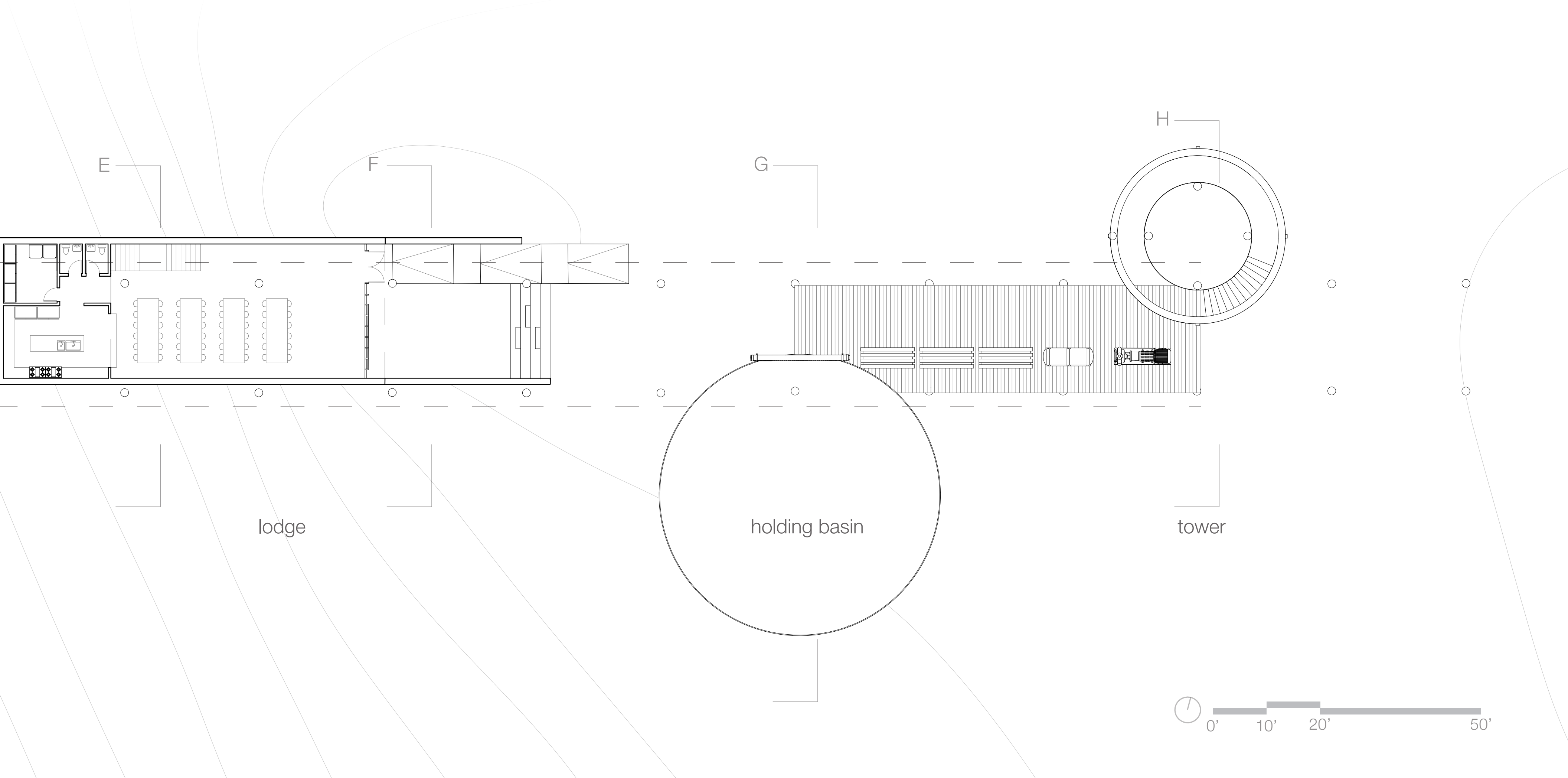
37. South Elevation

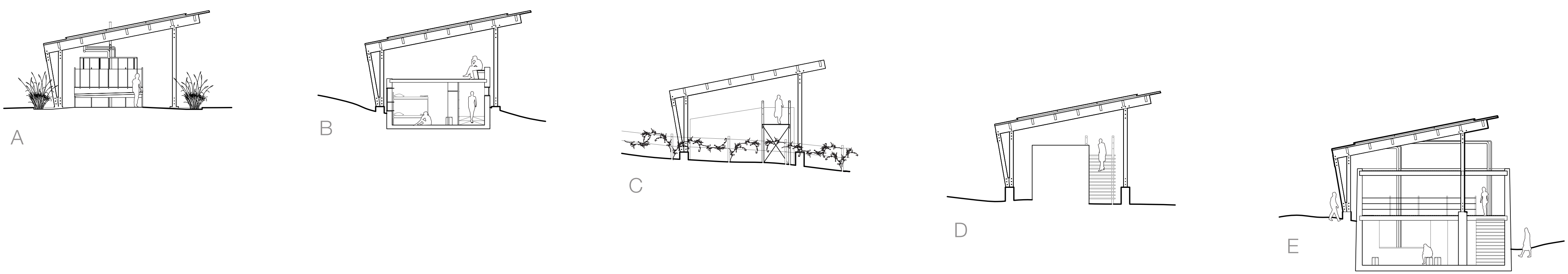




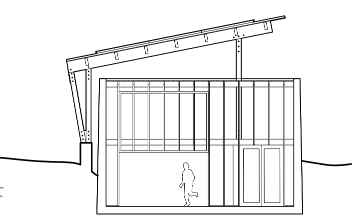
38. Plan




E
F
G
H
lodge
holding basin
tower
0'
10'
20'
50'



38. Transverse Sections



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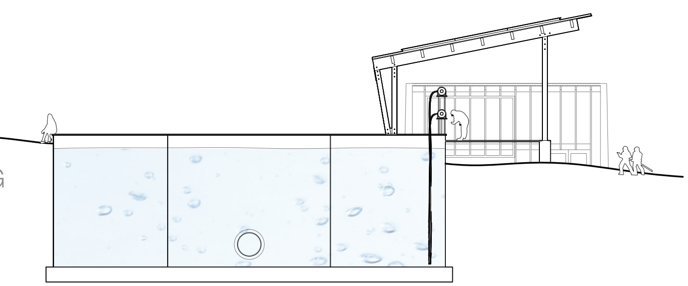

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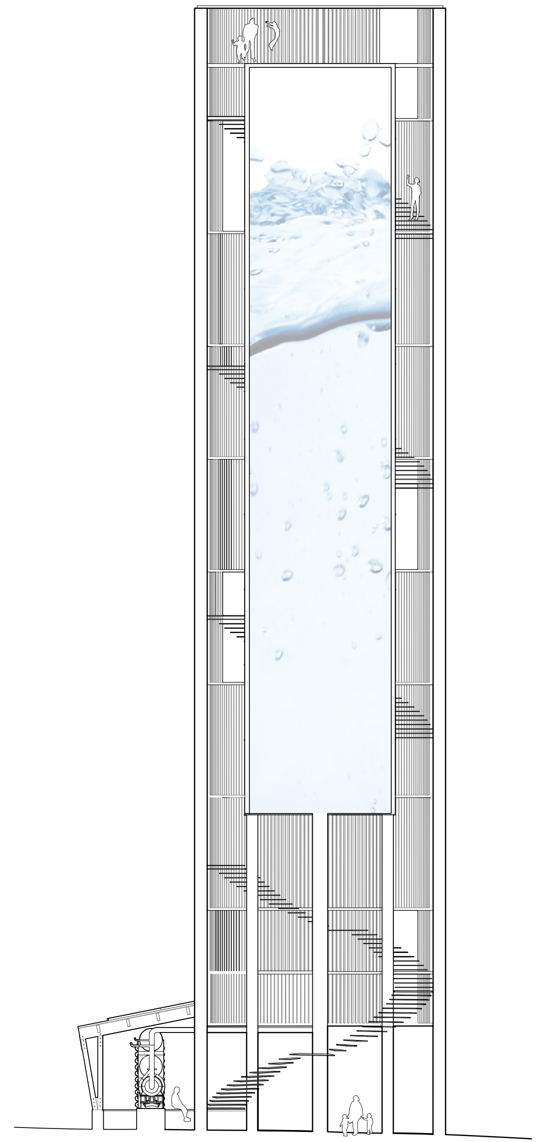

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4.3.B Machine

The program for #poop2potable formally manifests itself as a roof, a tower, a basin, embedded enclosed spaces, the vineyard and the treatment machine. The concept of architecture as armature for the machine was reinforced through formal design decisions. Showcasing the elements of treatment and water throughout the space and allowing the architecture to be formed by the functional and programmatic requirements of these is an integral part of the design process. The machine, suspended between the ground and the roof, includes the open-air treatment system, the delivery system (i.e.pipes), and the wethouse (restroom and washing facilities).

The physical character of this proposal is largely dependent on the volume of water to be treated and/or stored on site as well as the volume and type of crop production. Grapes grow well and are commonly grown Colusa County; however, in order to determine a baseline model for design and to provide for flexible future programming of the farm (i.e. the potential cultivation of more water intensive crops), agricultural water requirements are based on five acres of almonds. Almonds are the most water intensive crops that grow well in the project area and represent the worst-case scenario with respect to agricultural water demand.[3, 46] The volume of water necessary for daily treatment is the sum of domestic water demands of Clearlake Oaks, onsite project water demands, and crop demands. This volume is approximately one million gallons per day.

Because of the site's climate profile and remote location with regards to public utilities, an on-site, grid-independent solar power model is utilized. The roof supports a photovoltaic system sized to power the onsite needs including the program and treatment.

Generally industry-accepted numbers dictate that the average sized solar panel (39 inches by 65 inches) produces two hundred watts per hour.[51] It is estimated that the electrical demand of the project at full occupancy including domestic and treatment/program related items (such as the powering of water delivery pumps, microfiltration, reverse osmosis, and ultraviolet lights) is just over 672 kilowatts per day. Based on these estimates and with an additional contingency of ten percent, approximately 400 solar panels are required. The integration of the power generating system informs the elongated roof form.

Figures 40A and 40B detail the numerical determination of program sizes and operational requirements.

40A. Water

Municipal Use

	Population		2359 People
x	Average Daily Use/Person/Day		100 Gallons[A]
		=	235,900 Gallons/Day

Agricultural Use

	Acres		5 Acres
x	Irrigation (acre-ft/season)		36 (Acre-ft)/90 days
		=	651,703[B] Gallons/Day

Farm Stay Use

	36 Visitors + 12 fulltime staff		48 People
x	Average Daily Use/Person/Day		100 Gallons
		=	4,800 Gallons/Day

Total Treated Volume Required

	Municipal Use		235,900 Gallons/Day
+	Agricultural Use		651,703 Gallons/Day
+	Farm Stay Use		4,800 Gallons/Day
		=	892,403 Gallons/Day
x	10% Contingency	=	981,643 Gallons/Day[C]

40B. Solar

Treatment[D]

	Microfiltration		630 Watts/Day
+	Reverse Osmosis		157,700 Watts/Day
+	Ultra Violet		14,300 Watts/Day
+	Process Pumping[E]		19,100 Watts/Day
		=	191,730 Watts/Day

Farm Stay Use

	36 Visitors + 12 full time staff		48 people
x	Average energy use		10,000 Watts/Day[F]
		=	480,000 Watts/Day

Total Power Requred

	Treatment		191,730 Watts/Day
+	Farm Stay Use		480,000 Watts/Day
		=	671,730 Watts/Day
		=	672 Kilowatts/Day

Energy Produced Per Panel

	Power Generated[G]		200 Watts/Hour
x	Hours of daylight/day[H]		9.5 Hours/Day
		=	1.9 Kilowatts/Day

Panels Required

	Total Power Required		672 Kilowatts/Day
/	Energy Produced Per Panel		1.9 Kilowatts/Day
		=	354 Panels
x	10% Contingency	=	approx. 400 Panels

40. Program by the Numbers

[A] 100 Gallons/Day based on typical American consumption according to United States Geological Survey (USGS).[52]

[B] Includes conversion of (acre-ft)/(90 day growing season) into (gallons)/(day).

[C] Quantity of treated volume required is less than the typical 1,000,000 gallons of effluent outflow per day from Clear Lake Oaks.[49]

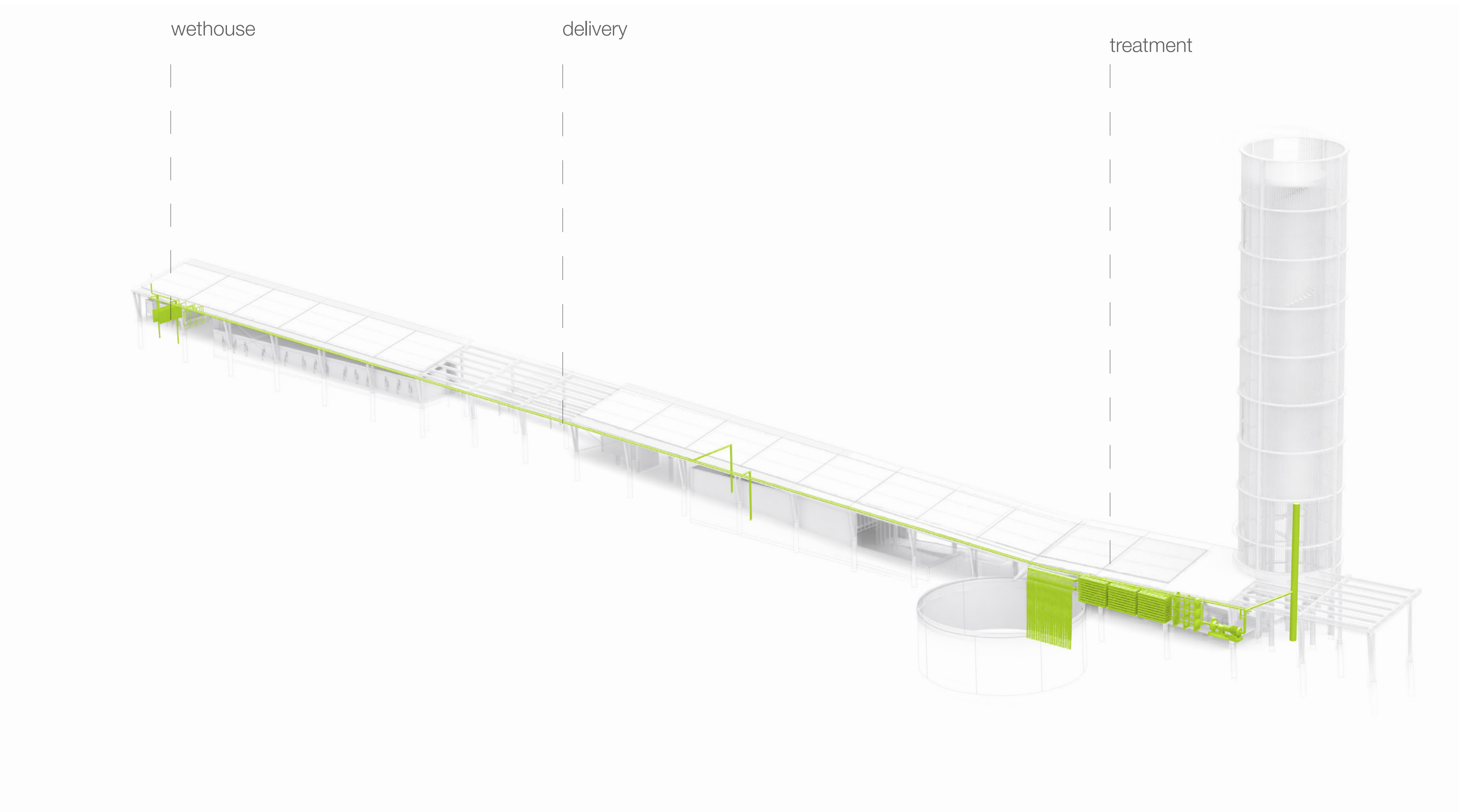
[D] Required Energy based off of GWRS power usage. The GWRS system is 70 times larger than that of the program proposed based on volume treated/day. Watts listed are scaled as such. Further information on the energy required may be found in the *GWRS Press Kit Facts and Figures 2009-2012*.

[E] Includes onsite piping and irrigation power needs.

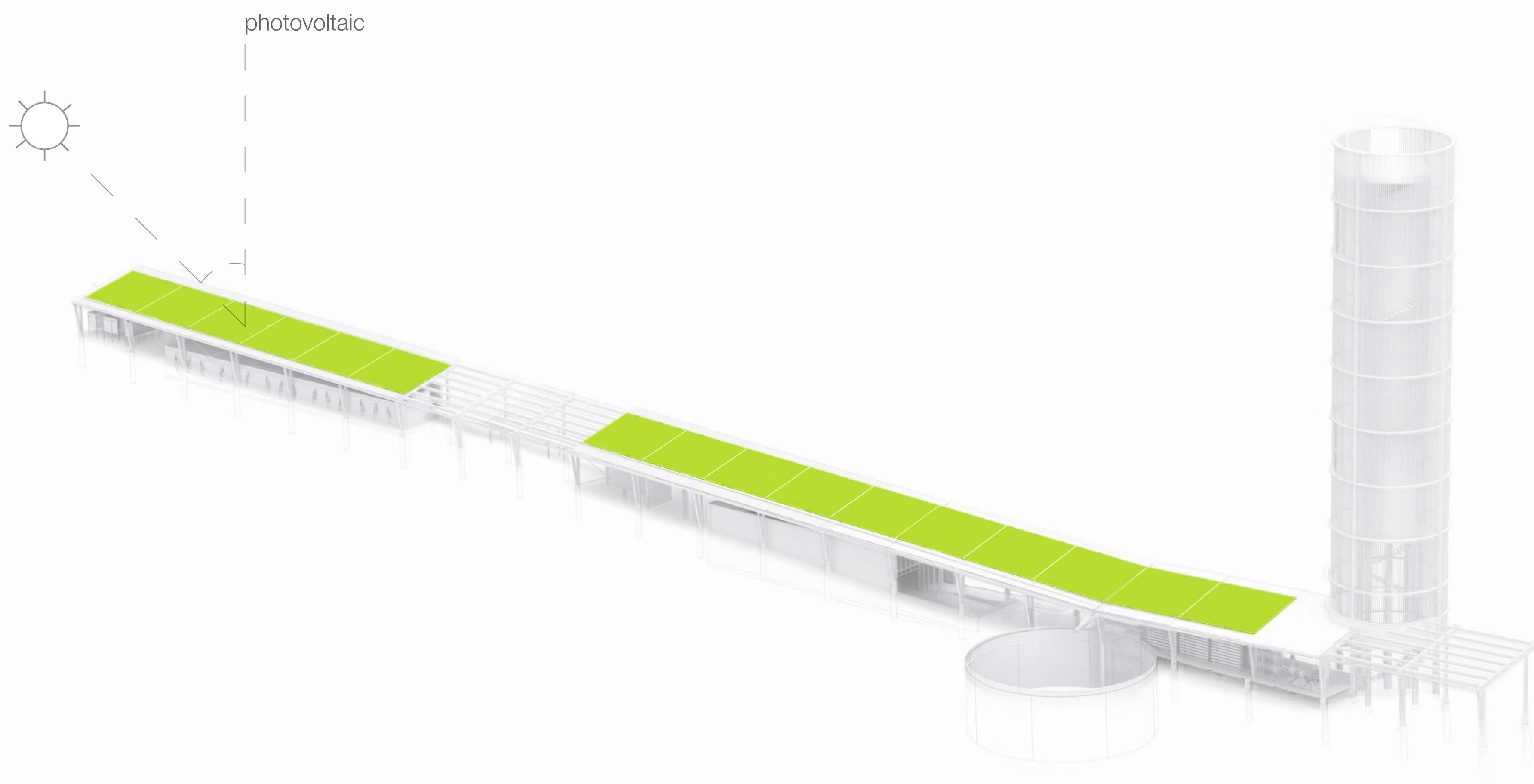
[F] Daily average usage in the United States according to the World Energy Council.

[G] Energy generated by one average sized solar panel (39"x65" in one hour)[51]

[H] Hours of daylight at winter solstice. Energy system designed to fully meet needs based on all times of year.



41. Machine Building Diagram



42. Photovoltaic Building Diagram

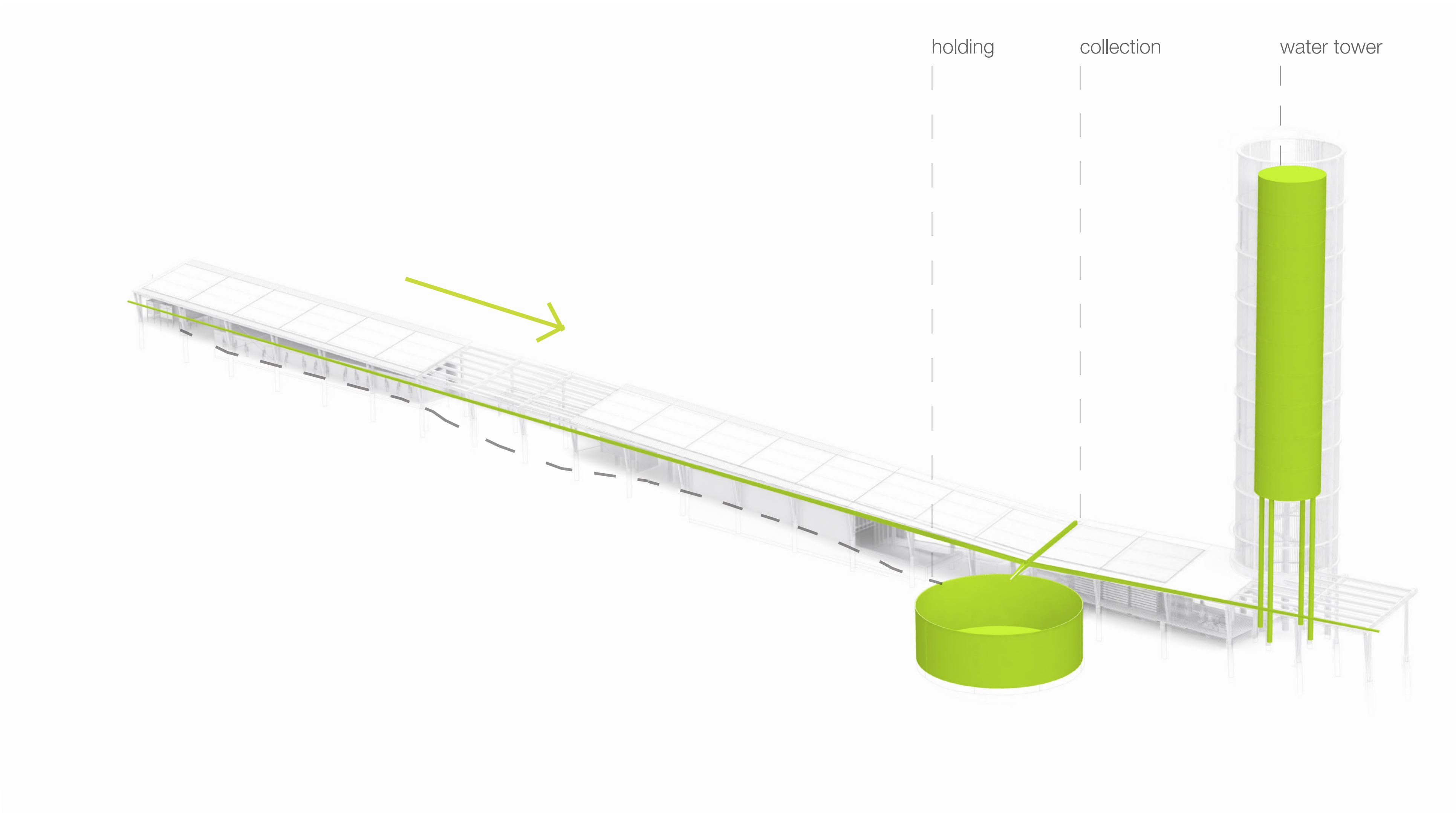
4.3.C Water

The tower is both experiential and functional. The tower is accessible for observation, yet also serves as water storage and holds a forty-eight hour emergency supply of drinking water for Clear Lake Oaks (based off an assumed average individual use of water, fifty gallons per person, under stress conditions)[52]. The basin is a holding area for effluent waiting for treatment and accommodates surges in the system; in addition the basin is also a collection vessel for water collected on the roof and directed to the basin via the gutter and scupper system.

The placement of the tower and the basin are deliberate. The basin is placed at the entry to the site allowing visitors' first experience with water to be with effluent in order to understand the wastewater as it first enters the machine. The effluent delivered onsite via pipeline has already been treated to primary and secondary levels by Clearlake Oak's existing waste water treatment system; hence the water is virtually odorless and relatively clean.

The tower's siting is in part motivated by solar orientation; the tower is placed so that it will not cast shadows on the vineyard. More importantly, the tower is located at the terminus of the open-air treatment components; visitors wishing to travel to the top of the tower must first walk past the effluent in the holding basin, through the treatment area, and then finally ascend up the tower where the clean, potable water is held above the ground. The tower elevates the water for pragmatic purposes in order to utilize gravity and height to create pressure head for the water's return to the system, but also makes a distinction between the treated, potable water from its current state as effluent in the ground basin in an effort to ease emotive uneasiness. Hence, the tertiary treatment is literally a physical mediator between the effluent and the potable water.

The wethouse is located at the westernmost point of the building, sheltered beneath the roof yet unenclosed and unconditioned. The wethouse is one specific point in the proposal where users can have a tangible, direct experience using water and understanding their relationship to the water use cycle. The facilities include showers and a trench sink which both drain to a grey water filtration garden that cleans the water and also provides privacy. Composting toilets are utilized and demonstrate our visceral contribution to the connection between water, land, and farming. Compost can then be used for the onsite vineyard.



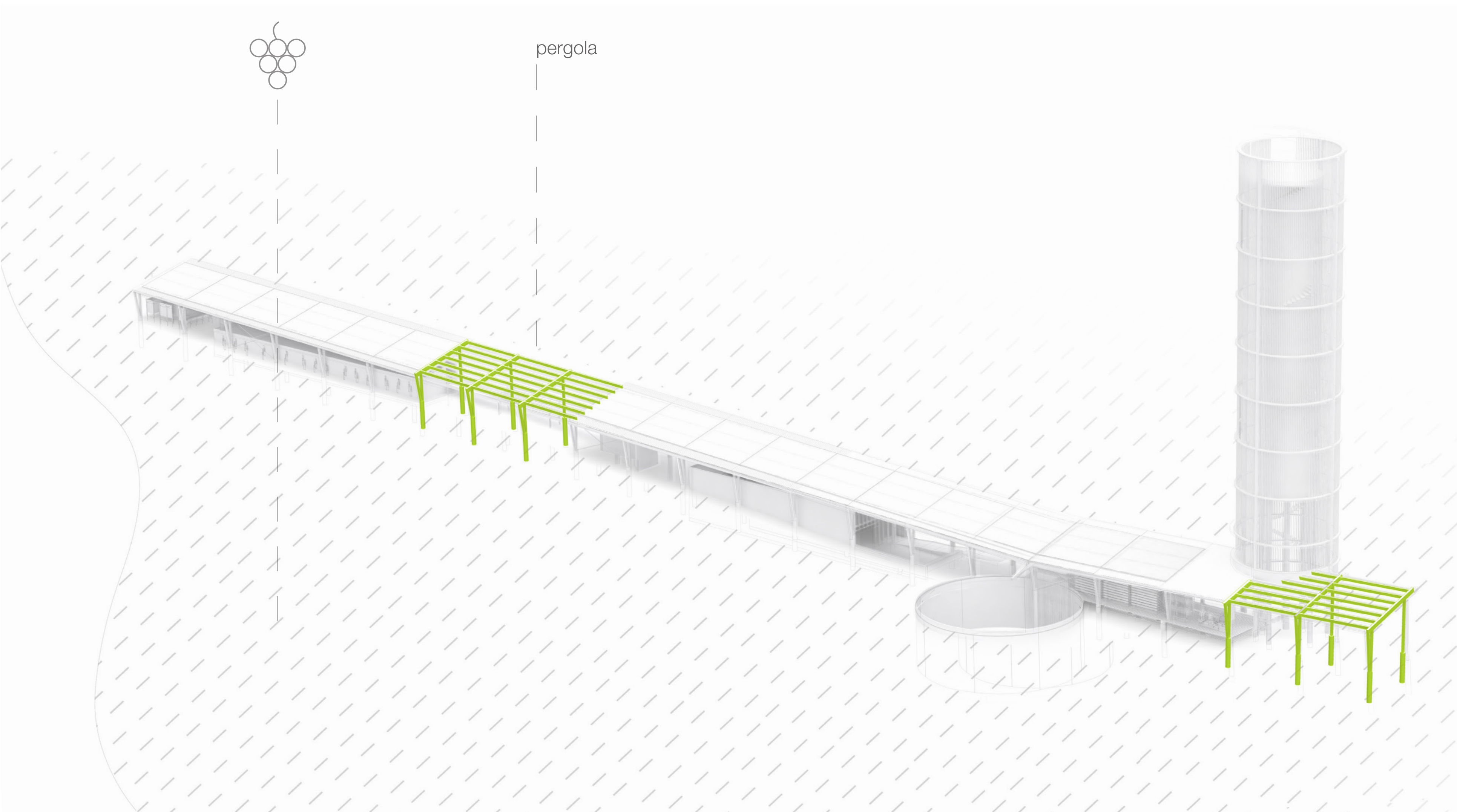
43. Water Diagram

44. Perspective: integrated farm and treatment.

4.3.D Viticulture

The roof's covering is broken down to allow for the viticulture to move through the project at specific points along the building. The vines are oriented north to south and spaced ten feet apart for efficiency of equal solar access to each plant.[53] The north-south orientation of the farm intersects the east-west building that was sited with water efficiency and road relationships in mind. The edge conditions between the machine and the agriculture become important points in the project for experiential learning.

It is important to note that viticulture was selected in part for its requirement of potable water for irrigation. Not all crops require water that is treated to such a standard; however, for crops that produce directly consumable fruit or vegetables (such as apples, lettuce, or grapes) that require no further processing before direct distribution (such as rice, oats, hay), the use of treated, clean water is necessary for health and sanitation concerns.



45. Viticulture Diagram

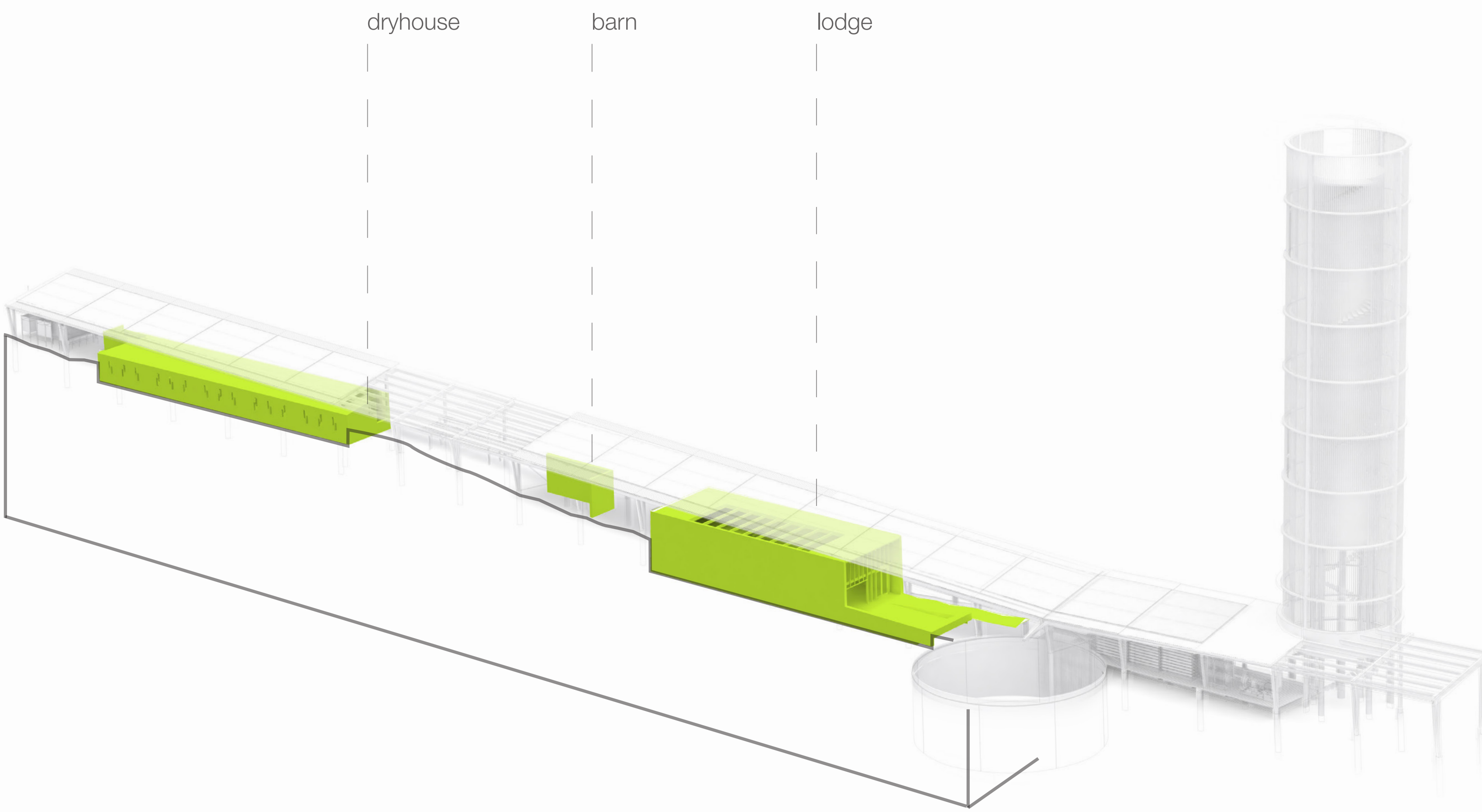
46. Perspective: at the nexus of viticulture and treatment.

4.3.E Place

Programmatic elements are held away from the roof and machine and embedded into the land, emphasizing the connection with place and landscape. These elements include the lodge, the main public gathering space of the project housing the café, exhibition space, administrative areas, kitchen and service areas. There is a barn and the dryhouse, the sleeping quarters for extended stay visitors. While the lodge and dryhouse are pushed into the ground to underline their experiential connection with the land, they are also held away from the roof to allow the machine to clearly and visible continue through. The void space suspended above these built areas and below the roof allows the machine to move through the entire length of the building uninterrupted.

The lodge and dryhouse both maintain an exterior and interior connection. The lodge, although protected, steretomic, and windowless on three sides, is clear and open on the east side. The east face of the building is composed of a window system with a large operable window wall that opens to reinforce the connection of interior and exterior. The space beyond the operable window wall extends to include an outdoor classroom area that is sited intentionally with the demonstration treatment areas as the background.

The dryhouse's main access point is from a bridge that travels over the vineyard. After crossing the bridge and having expansive views of the vineyard on the north and south sides of the building, users step down into the dry house. The dryhouse's long circulation hall is open air, allowing visitors to feel a connection to the outside while still being protected. The actual boarding rooms located off of the dryhouse's long hall are enclosed. The windows in the dryhouse provide views outwards that are focused on the ground and the viticulture, making the experience of the interior of the dryhouse more concentrated on the experience of land and place over water and machine.



47. Place Diagram

48. Perspective: entry and project approach.

49. Perspective: lodge interior with outdoor classroom and treatment beyond.

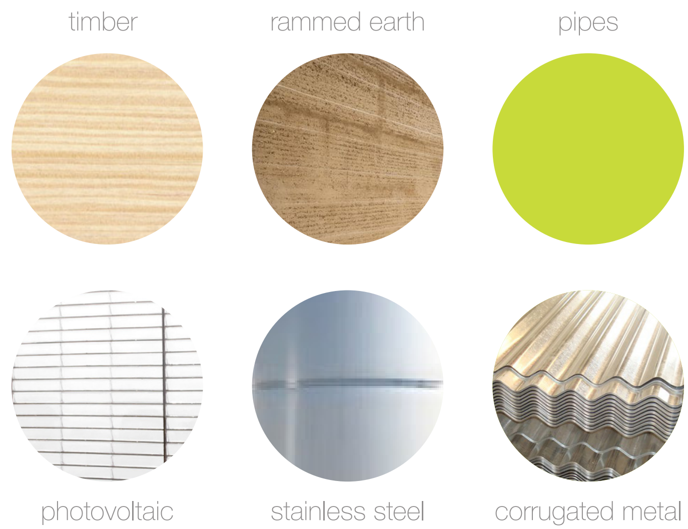
4.3.F Tectonics and Materiality

The roof is constructed of a kit of parts that is typical throughout the length of the building. The module of construction became important when thinking about construction in this relatively remote site and how to minimize the effects of staging and assembly in the landscape.

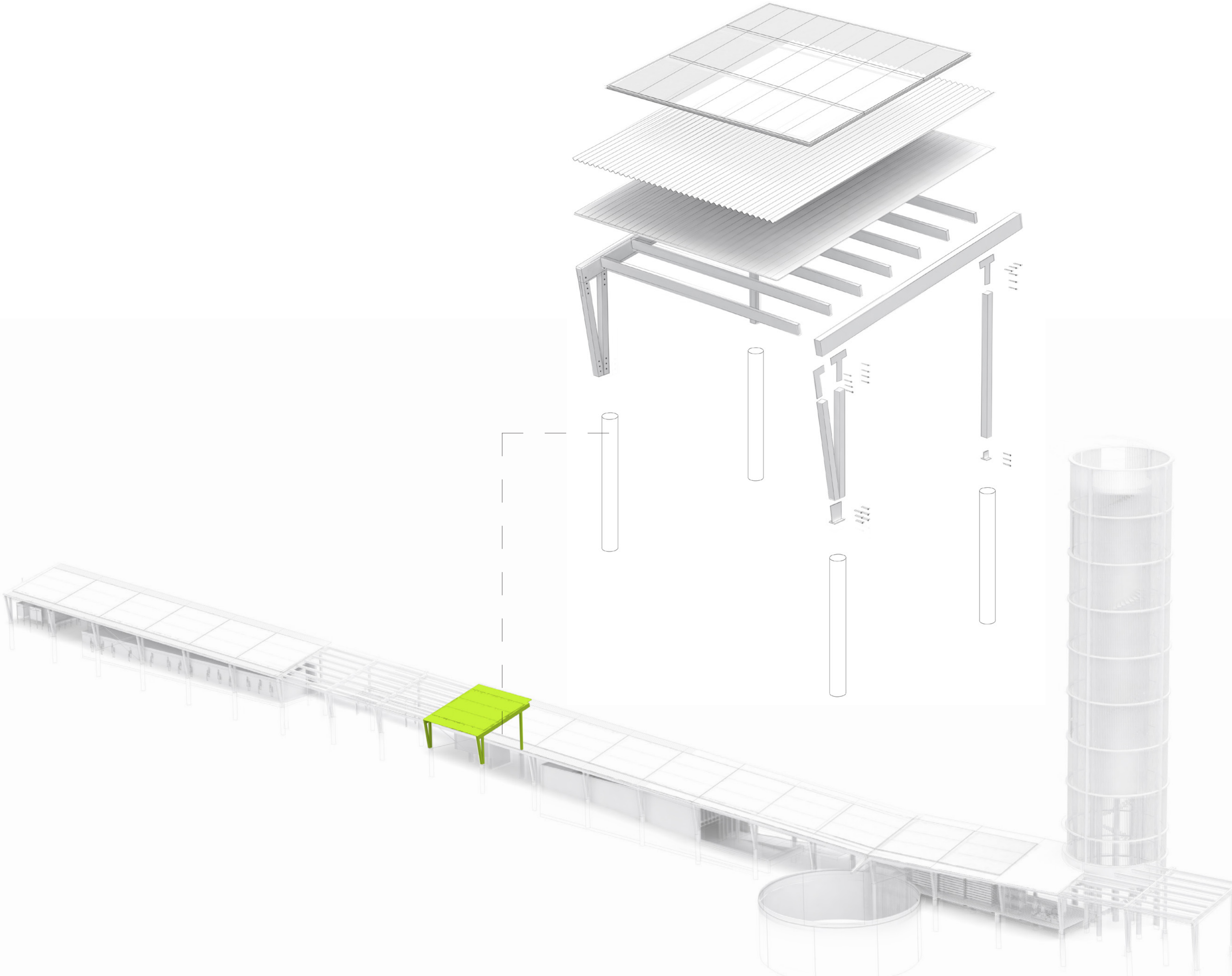
The roof is constructed of heavy timber. Timber was selected for its durability in the climate as well as for its carbon sequestration abilities, keeping in part with the desire to design for total system efficiency. For functional reasons and to differentiate itself from the rest of the project, any element carrying or containing water is steel. This includes the water tower and the holding basin, both constructed out of typical, industry sized steel water tank components.

The path of the machine is emphasized with an accent color thus allowing the location and movement of water to be easily identified throughout the project. Piping elements were colored for increased visibility. Visitors can easily see how water pipes travel through the machine; the use of pipes is a didactic strategy to show how water moves from holding, through treatment, and is dispersed through the machine and plugs into the building where it is required for program use (i.e. the wethouse, kitchen, and service facilities.)

The embedded, enclosed elements in the program are constructed with rammed earth. These spaces include the lodge and the dryhouse. This decision was made in part to take advantage of building material on site as well as to emphasize the connection of these program elements directly and literally with the land.

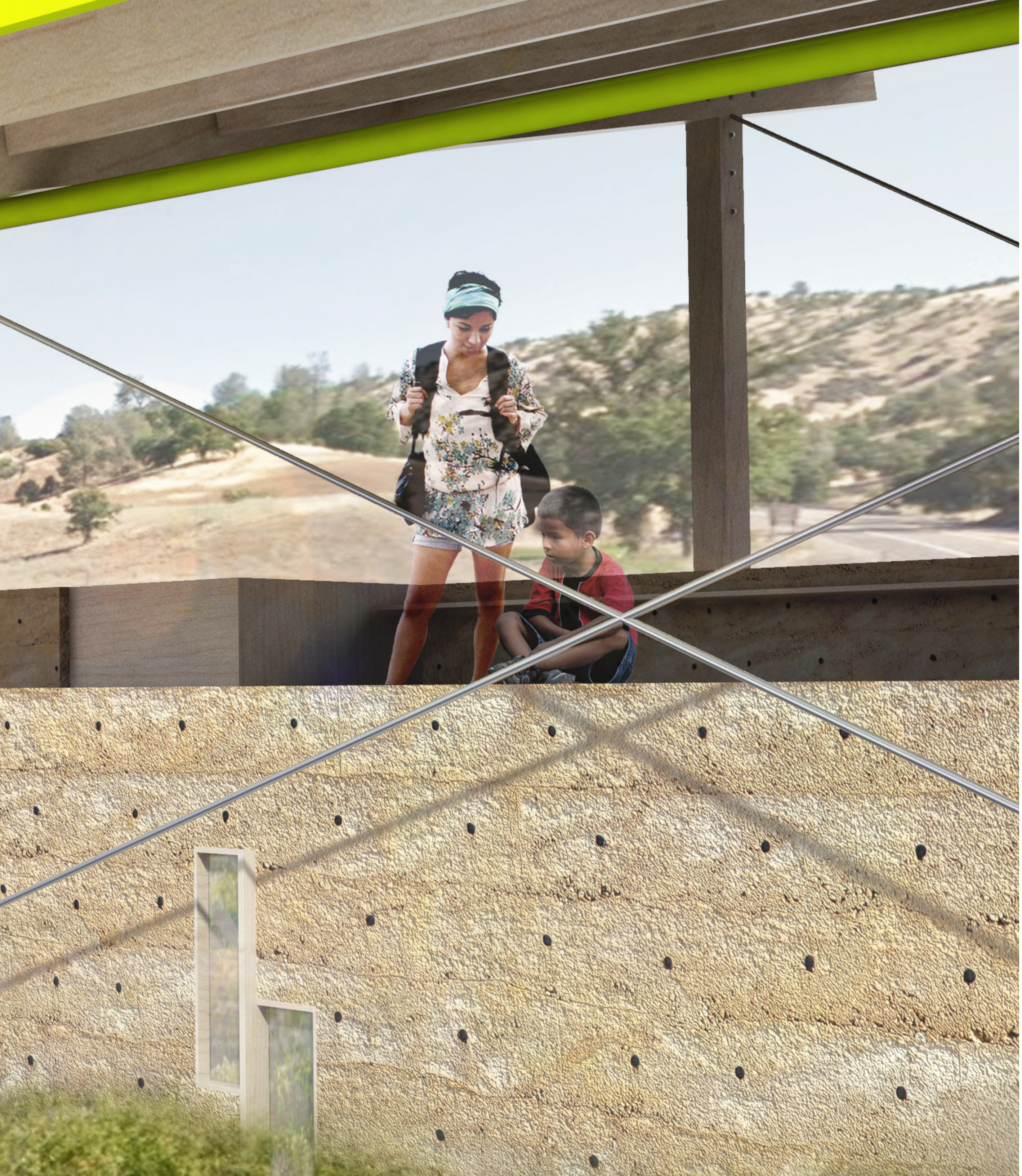


50. Material Palate



51. Module Diagram with kit of parts


Lee



52. Perspective: Wethouse and Dryhouse.

chapter 5: conclusion

"If we lived in a desert and our lives depended on a water supply that came out of a steel tube, we would inevitably watch that tube and talk about it understandingly. No citizen would need to be lectured about his duty toward its care and spurred to help if it were in danger. Teachers of civics in such a community might develop a sense of public responsibility, not only by describing the remote beginnings of the commonwealth, but also how that tube got built, how long it would last, how vital the intake might be if the rainfall on the forested mountains nearby ever changed in seasonal habit or amount. It would be a most unimaginative person, or a stupid one, who could not see the vital relation between the mountains, the forests, that tube and himself"

- Isaiah Bowman

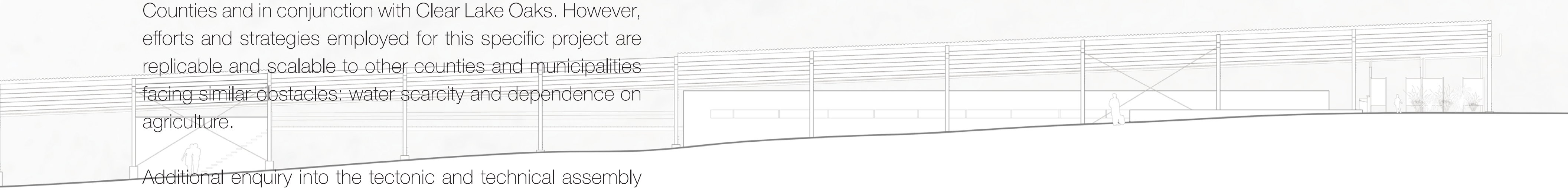
The initial impetus and constant objective of this thesis was to induce a social discourse challenging our attitudes and habits pertaining to water. This project re-envisions the disparate practices of water treatment, agriculture and municipal use as a symbiotic venture. Partially an exercise in education and demonstration, #poop2potable is ultimately an attempt to use spatial experiences informed by the amalgamation of water, landscape, machine and farming to change the way we think about water. This thesis contends that making specific and physical connections between human use, cultivation, and treatment while simultaneously providing a space for interactive and experiential education via agrotourism can increase our collective acceptance of black water recycling.

The architectural response became an expression of the machine. The form, though simple in its realization, is meticulously shaped contextually, programmatically, and pragmatically by a system of efficiency.

This investigation was completed with a specific site and municipal relationship in mind: between Lake and Colusa Counties and in conjunction with Clear Lake Oaks. However, efforts and strategies employed for this specific project are replicable and scalable to other counties and municipalities facing similar obstacles: water scarcity and dependence on agriculture.

Additional enquiry into the tectonic and technical assembly of the roof as an armature for the machine is needed; it is possible that a kit of parts including the construction module of the roof, the treatment, and water storage elements may be sized, distributed, and implemented across the Central Valley.

Network loop cycles between a small, local municipality and #poop2potable, as well as resource use-cycles within the project itself were explored. Still, further tests of this thesis should study how the implementation of this proposal can potentially affect use-loops that occur on larger scales. For example, how will diverting water outfall from Cache Creek affect the levels and withdraw of the larger rivers that Cache Creek feeds into, such as the Sacramento River? Supplementary investigation into the impacts of water reclamation on larger water estuaries, aquifers, and surface sources with respect to agricultural and urban needs is required. Additional continued studies of this thesis might also include further research into how food security, specifically linked to agricultural production, is both quantitatively and qualitatively related to the acceptance of water reclamation efforts.



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