

**Turning Water Into Wine: The Celebration of Water Through the
Aesthetic of the Sustainable Landscape**

by

Kelly Minto

Submitted in partial fulfilment of the requirements
for the degree of Master of Architecture

at

Dalhousie University
Halifax, Nova Scotia
July 2012

© Copyright by Kelly Minto, 2012

DALHOUSIE UNIVERSITY
SCHOOL OF ARCHITECTURE

The undersigned hereby certify that they have read and recommend to the Faculty of Graduate Studies for acceptance a thesis entitled "Turning Water Into Wine: The Celebration of Water Through the Aesthetic of the Sustainable Landscape" by Kelly Minto in partial fulfilment of the requirements for the degree of Master of Architecture.

Dated: July 10, 2012

Supervisor: _____

Reader: _____

Reader: _____

DALHOUSIE UNIVERSITY

Date: July 10, 2012

AUTHOR: Kelly Minto

TITLE: Turning Water Into Wine: The Celebration of Water Through the Aesthetic of the Sustainable Landscape

DEPARTMENT OR SCHOOL: School of Architecture

DEGREE: MArch

CONVOCATION: October

YEAR: 2012

Permission is herewith granted to Dalhousie University to circulate and to have copied for non-commercial purposes, at its discretion, the above title upon the request of individuals or institutions. I understand that my thesis will be electronically available to the public.

The author reserves other publication rights, and neither the thesis nor extensive extracts from it may be printed or otherwise reproduced without the author's written permission.

The author attests that permission has been obtained for the use of any copyrighted material appearing in the thesis (other than brief excerpts requiring only proper acknowledgment in scholarly writing), and that all such use is clearly acknowledged.

Signature of Author

CONTENTS

Abstract	vi
Acknowledgements	vii
Chapter 1: Introduction	1
Positioning	1
Context of the ‘Water Crisis’	2
Water, Wine and People in the Okanagan	6
Water and People	6
People and Wine	13
Water and Wine	21
Thesis Statement	24
Site Description and Strategy	24
Regional Geography and Climate	24
Selected Site Details and Strategy	25
Program Description	31
Precedents	34
Roman Aqueducts	34
India’s Water Buildings	35
Islamic Gardens	39
Tivoli and Granada: The Aesthetic Use of Water	42
Chapter 2: Design	45
Terracing	45
Vineyard Planning	47
Roadway and Retaining Wall	49
Landscape and Architecture	52
Massing and Nesting	53
Form Finding	54

Chapter 3: Conclusion	76
Appendix 1: Sizing Program Spaces.....	78
Appendix 2: Water Supply And Demand Calculations.....	88
References.....	92

ABSTRACT

This thesis examines the relationship between water and the wine-making industry through an integrated architectural approach to the landscape. The emphasis is on the refinement of water use for vineyard irrigation and wine processing, and the promotion of the value of water by celebrating a productive landscape. The proposition is explored through the design of a winery and its associated grapes to produce the wines.

ACKNOWLEDGEMENTS

A special thank you to my supervisor Sarah Bonne-maison for your encouragement, your gift with words and for continuing to push me to search for a better solution.

Thank you Catherine for your sincere interest and support. Your skill and passion as a mentor are unsurpassed.

To my West Coast Family, thank you for your love, support and networking. I greatly appreciate the efforts you have put into making this a success.

To Ellen my travel partner, thank you for pushing for the Okanagan road-trip which inspired this endeavour.

To my peers at Dalhousie, thank you for everything. You have been my best critics and the voices of most sincere encouragement when it mattered most. I am forever and most gratefully in your debt.

Lastly, thank you to my Mom, Dad and sister Alison for riding the roller-coaster with me throughout this process.

CHAPTER 1: INTRODUCTION

Positioning

A visit to British Columbia's Okanagan Valley is much like finding an oasis in a parched desert landscape, only from an inverse perspective. It is comparable to a dry island, which lies between the mild and rainy climate of coastal B.C. and the glacial, snow-capped mountains of the province's eastern border. The hot dry summers of the Okanagan, its sagebrush spotted landscape, and low annual precipitation create water challenges most British Columbians rarely face.

The initial focus for this thesis began with an interest in the relationship between water and architecture and to mutually emphasize the other through design. Charles Moore's *Water and Architecture* provided a starting point to build on my primarily aesthetic viewpoint.

Moore summarizes the history and meaning behind water display and draws attention to its animative, acoustic, and calming qualities as well as the magnetic pull it has on people in urban spaces. Moore acknowledges water's many practical uses and emphasizes the greater role water has played in settlement, and the shaping of cultures, infrastructure, transportation and agriculture. The metaphorical connections Moore presents – including fountains as a heart source and rivers as veins in the life-giving organism of water – contributed to forming my own views on the topic.

My interest in water issues of arid climates was sparked by a summer visit to the Okanagan. I envisioned applying Moore's metaphors to communicate the role and importance of water to the local landscape and culture. With the Okanagan providing the locus, the challenges presented by our modern global 'water crisis' offered a particularly acute angle to my research in water use and management.

Context of the 'Water Crisis'

Early in this process I struggled to understand the exact physical reality and cause of our global water crisis. The term 'water shortage' leads us to perceive that our water is disappearing and ultimately it will run out. Though this is a partial truth, the full explanation is more complex. The existence of water on earth is absolute and its quantity is finite. It cannot be produced and neither can it be destroyed and simply vanish. So where does this water go?

All of the water on earth is interconnected. Our understanding of the water cycle from high school science class is correct in telling us that water circulates naturally around the earth through evaporation from lakes and oceans. The water vapour held in the air eventually condenses into clouds which drift over landforms and oceans, releasing water as precipitation once they become saturated. This rain or snow is then absorbed into the soil to feed vegetation and groundwater supplies, or it flows as runoff into streams and lakes or rivers which return it to the ocean. Then the process begins again.

Taking this into consideration we can assume that a short-term water *shortage* in a particular area does not mean the water here has been consumed and is gone forever. It simply means that water which originated in a particular region has progressed through the water cycle and moved on to a different elemental state or geographical location.

What we often forget is that the movement of water through its natural cycle is also paralleled by water displacement as a result of human activity. The damming of rivers to generate electricity or create a reserve water supply for a settlement or city usually results in the deprivation of those downstream of water that once flowed through their land. Cultivation and irrigation of dry lands results in large amounts of water lost to the atmosphere as it evaporates from surface soil and plant leaves.

Increased water demand due to population growth and industry are perhaps the most influential. With our ability to move water over great distances we have developed many areas where the natural water supply is very limited and requires the import of water to satisfy local demand. The water source which supplies this demand is often put under greater strain since it now acts as a water source for water importing areas in addition to meeting the water demands of its originating region.

The greater demand for water is depleting the resources of many regions at a rate faster than the natural water cycle can replenish them. This plays

a role in the changing of landscapes and we see some regions, like Australia, which are experiencing prolonged draughts,¹ while others are dealing with increased precipitation, rising water levels and often flooding. As we have witnessed, altering the water balance of an area in this way, will eventually begin to effect ecosystems, climates and weather patterns. In Spain for example, the amount of precipitation has been noticeably decreasing since the 1970s, creating a water deficit in many areas of the country, and a major draught in the mid 1990s did severe damage to the agricultural community, affecting over six million people.²

Similar effects are often seen along major rivers, where high consumption and damming upstream reduce water flow to downstream areas. This leads to water shortages and draught-like conditions for those downstream who also rely on the river for their water supply. This territorial dispute over water is currently a major issue between the southern states of the U.S. who are heavy consumers of water and Mexico, whose livelihood is currently threatened by water shortage in their arid climate.

-
- 1 Brad Udall, “‘When will the Reservoirs Run Dry?’: The looming water crisis in the American Southwest” (lecture given at Department of Geosciences, University of Arizona, April 15, 2010).
 - 2 Ana Iglesias et al., “Challenges to Manage the Risk of Water Scarcity and Climate Change in the Mediterranean,” *Water Resources Management* 21, no. 5 (2007): 778.

There is also the more abstract notion of virtual water. This relates to agriculture and food production and emphasizes that all of the foods we produce and consume are composed of varying percentages of water. Import or export of these products means that we are technically gaining or losing the water contained by those products. The virtual water in wine for example, is related to the amount of water contained by the grapes used to produce it. A typical bottle of wine has approximately 86% of its volume composed of water.

In reality, the *water crisis* or *shortage* we are experiencing is the result of water management and allocation issues. Our human activities are altering the global displacement and distribution of water and if we want to ensure its availability to us in the future, we need to start thinking of closed-loop systems from the scale of cities to watersheds and even individual sites. In theory, if water is sourced and consumed locally, it is metabolized back into the local environment and becomes available for use again. Some water will of course be lost during this process but the net water balance should be restored by precipitation and other naturally incoming sources. Increasing self-reliance in this way will make us more aware of our water resources, how they are used, and the rate at which they are being consumed.

Although a truly closed-loop system is an ideal, we can strive to apply its basic principles to generate feedback between incoming and outgoing resources with the intent of maintaining a relative equilibrium.

Most simply put, if we know what we have, and use only what we have, we will have no debt.

Water, Wine and People in the Okanagan

Three main themes frame the area of study and form the focus of this thesis. Water, wine and people are the key elements and their connections will be revealed in a discussion of historical and current practice in the Okanagan.

Water and People

The interaction of water and people is the oldest and most persistent relationship in the Okanagan's history. Since the early 1800s the Okanagan Valley has been transformed from a desiccated ranching landscape to a green haven of orchards, vineyards and agricultural crops.

Early development was slow until the completion of the railroad line in the 1890s which connected the valley to the western coast and eastward to Alberta. This opened the valley up for settlement and drew the attention of developers, landholders and European upper-class investors. Among those drawn to the Okanagan was the Countess of Aberdeen, who noted in her book *Through Canada with a Kodak*:

Up to now, but little attention has been devoted to fruit growing, as this has been principally a stock raising country, but the possibilities shown by the few orchards already planted, point to its being found to possess exceptional advantages for the pursuit of this industry.³

3 Lady Aberdeen, *Through Canada with a Kodak* (Edinburgh: W.H. White & Co., 1893), 159.



"Irrigation." Photo by Jennifer E. Moore. (Anne Kerr, *Okanagan Fruitlands*). This 1958 Provincial plaque credits irrigation as the 'key' to development of the Okanagan.

Following the railroad, technology continued to play an important role in the settlement of the Okanagan. The need for a reliable water supply became the next focus and methods were developed and structures built to divert and carry water from mountain streams to settlements and individual lots.

Water has been called the lifeblood of the Okanagan and the irrigation of these semi-arid lands was in the beginning the basis for the existence of many of the communities. But the supply of water in this area has always been one of extremes – either there's the threat of a shortage or there's too much to handle.⁴

Developers began to invest heavily in the construction of a major network of irrigation trenches, flumes and dams with the hope that land with water access would attract more buyers. These networks were repaired as needed and expanded when the demand for water increased.

On the west bank near Okanagan Lake's southern tip is an agricultural town with a well-documented history of the role water has played in its development. Much of Summerland's past and present settlement depends on the working of orchards and vineyards, and as a result they have always been acutely conscious of their water use and supply.

Summerland's early settlers, ranchers and orchardists quickly learned of the need to harvest and store water from the spring melt. In the summer months, when the landscape was parched by the heat of the

⁴ Sherril Foster, *According to the Giant: A History of Summerland and the Okanagan Valley in British Columbia* (Summerland: Okanagan Annie Productions, 1998), 144.

sun, creeks ran dry, and little rain fell, the water that was stored became Summerland's primary water source.

Though Okanagan Lake holds a great volume of water it did not provide a practical source of water for irrigation at the time. Pumping systems did not yet have the power or capacity to move large volumes of water uphill.⁵ Instead, creeks were dammed using stones and logs as crude construction materials.⁶ This created uphill reservoirs which enabled water release to be controlled as needed:



Furrow irrigation. (Surtees, *Sunshine and Butterflies*)



Wooden Flume. (Surtees, *Sunshine and Butterflies*)

The early orchardists had dammed creeks and used a series of troughs and ditches to carry water to gardens and orchards. It required considerable planning and skill to bring water to the crops. The whole system depended largely on gravity feed, so that land had to be made to conform to the carrying of water.⁷

The early methods of furrow irrigation were typically "crude and wasteful,"⁸ since ditches and trenches were dug by hand into the earth seepage occurred regularly. In some cases, trenches were not used at all and irrigation would take place through controlled flooding, where entire plots of land would be saturated by the intentional opening of a dam. Eventually ditches were replaced by wooden flumes which proved slightly more effective.

5 Ibid., 34.

6 Sarah Riordan, "The History of Summerland's Water System," *Summerland Heritage Advisory Committee* (Aug. 1986), 1.

7 Ursula Surtees, *Sunshine and Butterflies: A Short History of Early Fruit Ranching in Kelowna* (Kelowna: Regatta City Press, 1979), 30.

8 Ibid.



Wooden flume carrying water above roadway. This proved particularly inefficient because these structures were often damaged by wagons and motorists and the water supply would be interrupted for days while repairs were made. (Foster, *According to the Giant*)



Concrete canal of Kelowna Irrigation Company with wood diversion channel to an individual lot (Rogers, *Report of Proceedings of the Sixth Annual Convention of the Western Canada Irrigation Association*)



Steel flume and elaborate wooden support structure. (Rogers, *Report of Proceedings of the Sixth Annual Convention of the Western Canada Irrigation Association*)

In 1903 the Summerland Development Company, formed by Sir Thomas Shaughnessy, established the first major irrigation network for the town. Speculative settlers and land buyers knew that irrigation was a necessity in the dry climate, so Shaughnessy had each of his lots fitted with irrigation systems to increase their appeal to buyers. His efforts had an influence on Summerland's existing irrigation systems and by 1910, irrigation ditches were being replaced by concrete lined channels and wooden flumes by steel ones. These concrete channels and steel flumes resisted seepage and were less likely to rot, leak, or require frequent repair.

As irrigation networks continued to grow in the area, new land was cultivated and the demand for water increased, the delivery of water developed into a local industry. During the irrigation season Ditchmen were hired to patrol the many flumes and ditches that crossed the landscape, and were responsible for maintaining and repairing them to ensure a consistent supply of water.

The 1920s brought a drought to Summerland which continued for nearly a decade and caused many fruit crops to perish. The drought "illustrated Summerland's lack of adequate water storage. It became very obvious that something drastic was going to have to be done. The Council set out to improve old dams and construct a new one."⁹

9 Ibid., 17.



Summerland residents arriving by train along the Kettle Valley Railway on May 24, 1941 to attend opening celebrations for the Thirsk Dam. (Riordan, *The History of Summerland's Water System*)

After a failed attempt to raise the Garnet Valley Dam in the 1940s, the Summerland Water Council decided to construct a new dam. One year after construction began, Summerland's first arch-type dam was revealed to a captivated public audience. With a storage capacity of 2,630 acre feet of water, the Thirsk Dam dramatically increased Summerland's water supply and made the project a great success.¹⁰

¹⁰ Ibid., 20.



Thirsk Lake Dam as it currently stands. (Kirby, *Thirsk Lake Dam*).



Sprinkler irrigation over a vineyard in Mission. (Kerr, *Okanagan Fruitlands*)

The introduction of sprinkler irrigation in the late 1940s enabled local growers to give up the practice of furrow irrigation. Pumps were installed to create the necessary water pressure to operate these systems,¹¹ and since water was no longer lost to seepage in furrows, sprinkler irrigation was considered to be a more efficient practice.

In the 1970s it was decided the whole system should be replaced. The irrigation and domestic water systems were joined together in one completely pressurized, completely chlorinated system. The water is now delivered in very durable plastic pipes.¹²

Despite the problems encountered throughout its development, Summerland's water system and its users have responded to the natural surroundings and adapted to changes over time. Today, through the careful management of water flowing into and out of the twelve dams located in Summerland's watersheds, their "water system is the envy of other water districts throughout the Okanagan and Similkameen Valleys."¹³

This look into Summerland's water system and its evolution is important in describing how water is viewed and handled in the region. Taken into the design context this knowledge of the local water culture helps to root the design to place, creating a winery which responds to its environment and contributes an unique perspective on it.

11 Ibid., 22.

12 Ibid., 25.

13 Ibid.

The simplicity of approach to water transport in Summerland's early development is of particular interest and is drawn into the current design. Although the historical approach to water transport was wasteful at times, it required no energy input after flumes and canals had been put in place because its flow was gravity-fed. The trade-off of modern technologies for more efficient water movement is the energy required to power pumps and pressurized systems. Through design, this thesis aims to find a balance between these two approaches and make the most effective use of water for the lowest required energy input.

People and Wine

Fruit growing and the tradition of winemaking are also deeply rooted in the Okanagan's history, stretching back over 140 years. Father Charles Pandosy was the first to plant grapes in the Okanagan and his vineyards near Mission were used to produce sacramental wines for his parish. Following settlers continued to have success with grape growing and this led to an increase in the popularity of wine which was mostly produced for personal consumption.

The planting of commercial vineyards and the opening of family estate wineries didn't occur until 1926,¹⁴ and by the late 1980s fourteen wineries were operating in the valley and the local landscape

14 Julianna Hayes, "BC Wine Country: Vine to Wine," *The Official Wine Tour Handbook to British Columbia* (Spring 2011 - Spring 2012): 37.



J.W. Hughes was the first to grow grapes at a commercial scale in the Okanagan. His first vineyards were planted in 1926 on 45 acres in Mission and he eventually put over 300 acres of grapes into production, selling them to local wineries. (Bell, "J.W. Hughes Harvesting Grapes")



Mission Hill Winery's Pinot Noir grapes ripening in the summer sun. Vineyard rows such as this typically run along a north-south axis to provide equal sun exposure from the east and west and ensure that grapes ripen evenly. August 2011.

had been planted with roughly 3,400 acres of vineyards.¹⁵

The signing of the Canada-US Free Trade Agreement in 1987 had a considerable effect on the Canadian wine market. Increased competition from Californian winemakers led Okanagan wineries to make substantial changes to remain in the market. The result was a major program to replace existing native grape varieties with high quality vines to enable the production of Chardonnay, Riesling, Sauvignon Blanc, Merlot and other premium wines.¹⁶

By the 1990s, BC's wine industry was flourishing and Okanagan wines were winning both domestic and international recognition. The success led to the unprecedented growth of the Okanagan wine industry. In just twenty years the number of wineries in the region has grown to over one-hundred and thirty.¹⁷

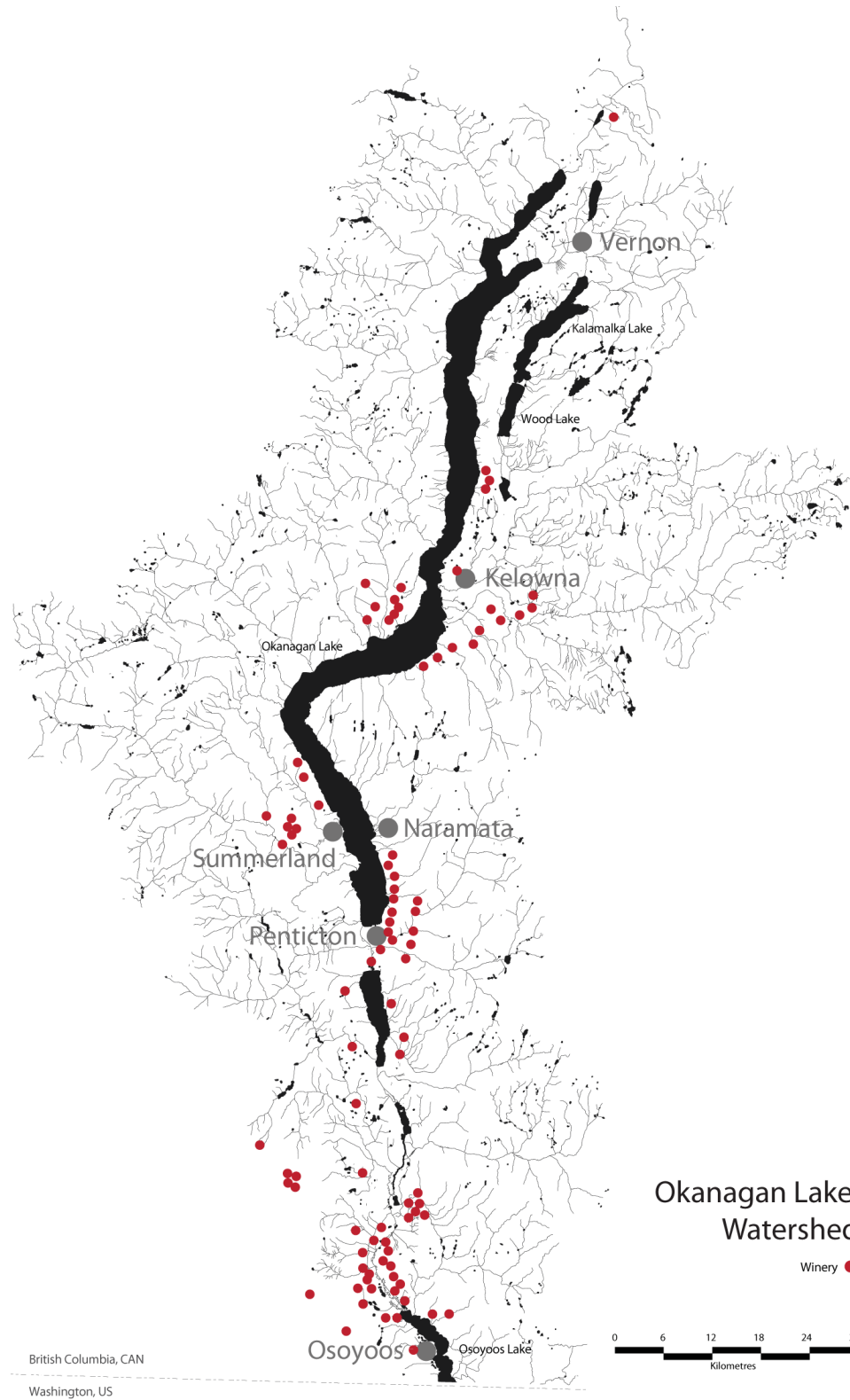
15 Ibid., 38.

16 Ibid., 37.

17 Ibid., 38.



The carefully tended vines at Quail's Gate Winery stretching towards the lake under the western sun. August 2011.



Map of current commercial wineries in the Okanagan overlaid on map of watershed. (Watershed base-map from: *Okanagan Lake Tributaries*. Vernon, BC: GEM Mapping and Design. Winery base-map from Hayes, "BC Wine Country," 34.)

The details of the winemaking process demonstrate that there has always been “a close relationship between humans and the environment.”¹⁸ An understanding of the landscape and natural processes are inherent to the management and use of land for vineyards, and human involvement in the process is discernible from the moment vines are planted in orderly rows.

Newly planted vines require several years to mature in the vineyard before they begin to bear harvestable fruit, after which, they can continue prime production for more than twenty years. Vines which have reached maturity begin their annual growth cycle each spring following winter dormancy. Wine-makers anticipate bud break which signals the start of growth and is followed shortly after by flowering. Within two months fruit set typically occurs and small green grapes begin to form visible clusters.

At this point, vineyard managers begin to monitor the canopy, trimming it to allow for sun exposure of the fruit and to ensure the vines put most of their energy into fruit production.

Veraison occurs when the grapes begin to change colour and produce sugars, signaling that the fruit has begun to ripen. The winemaker carefully monitors the fruit from this point and determines the exact time to harvest, which is typically between mid-September and late October in the Okanagan.

¹⁸ Sean Stanwick and Loraine Fowlow, *Wine by Design* (West-Sussex, England: Wiley, 2006), 14.

The grapes for white wines are often processed immediately and juice and skin are separated with the use of a press. The production of red wine involves de-stemming and crushing of the grapes until the juice is released, but the skins remain and are fermented with the juice to allow for the extraction of their colour and tannins.¹⁹

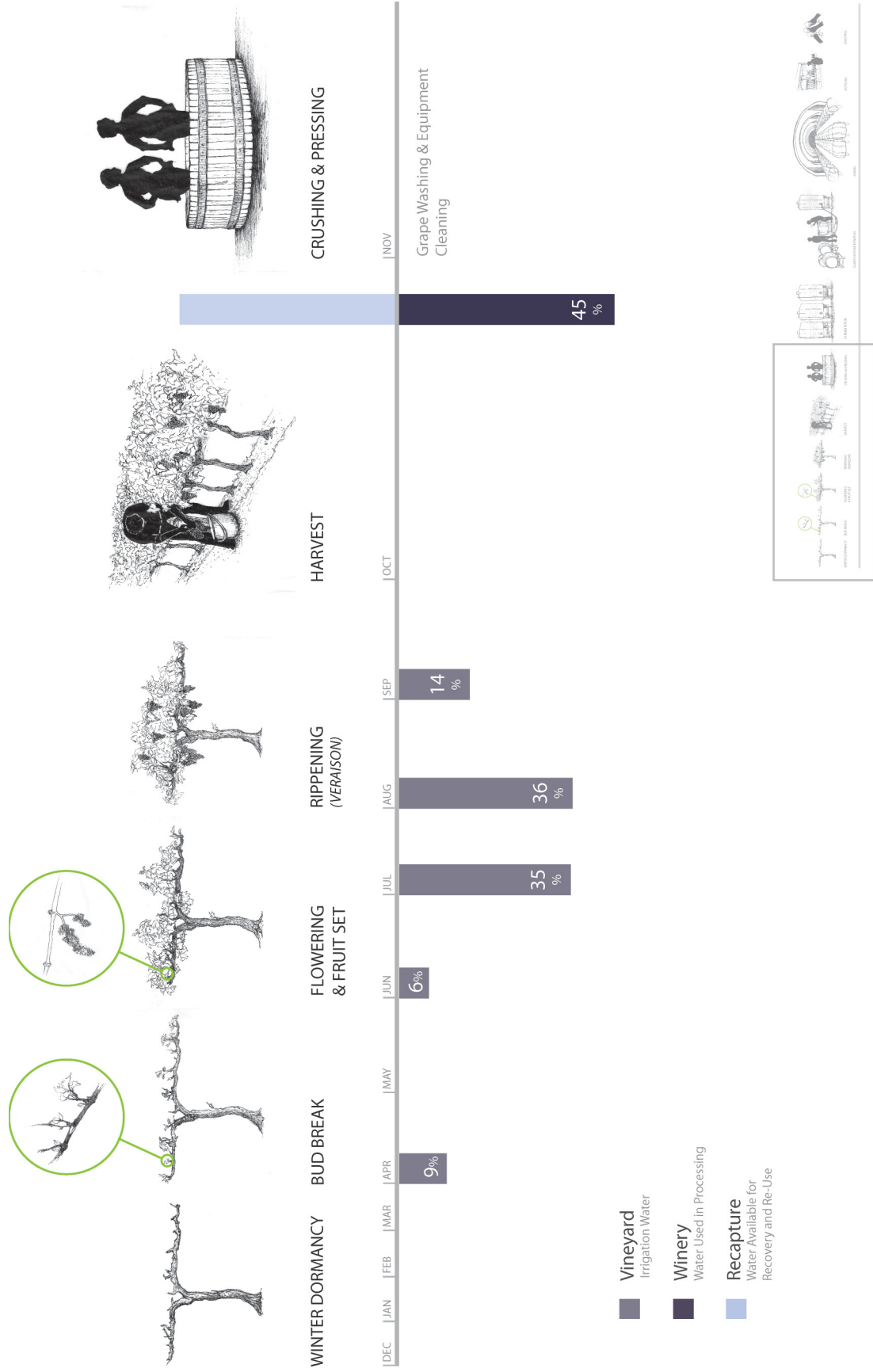
Fermentation is the next step, where yeast is added to consume sugar in the juice and convert it to alcohol. After two to four weeks fermentation is generally complete and whites are clarified and bottled. The skins and sediment are removed from reds, and the wine is often transferred to barrels for ageing before it is bottled and sent off to be enjoyed.

Though many people who enjoy wine have spent little time in a vineyard or harvesting and crushing grapes, they still share an interest in wine, its history, and the beauty of the landscapes it originates from. The wine industry is now the reason many people visit the Okanagan.

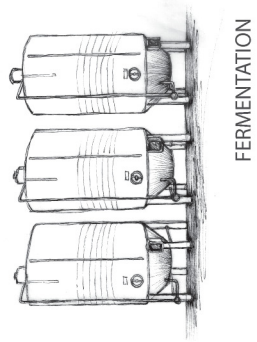
¹⁹ Hayes, "BC Wine Country," 6.



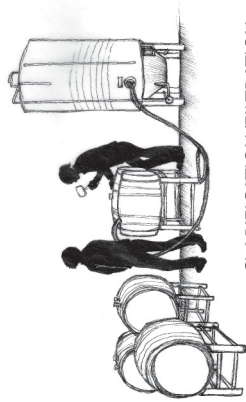
Pinot Blanc grapes just before harvest. August 2011.



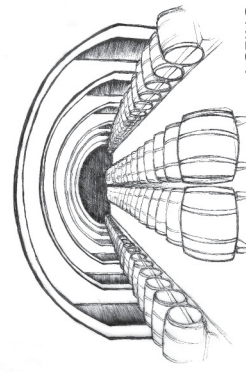
Summary of the winemaking process and it's required water input.



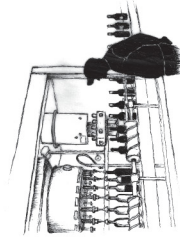
FERMENTATION



CLARIFICATION/FILTRATION



AGEING



BOTTLING

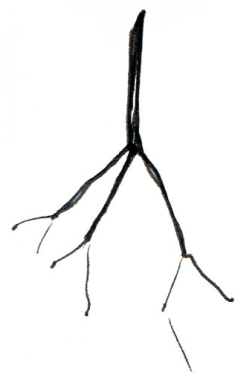


ENJOYING



The correct ordering of the wine-making tasks in and around the building is not only important for the good functioning of the production but also informs the design of the visitors experience.

Each of the rooms or spaces in a winery are linked through their facilitation in the winemaking process and this can be used to create a hierarchy of order among them. The layering of water into this equation sets up additional design parameters which place an overall emphasis on efficient flow and movement of water and wine.

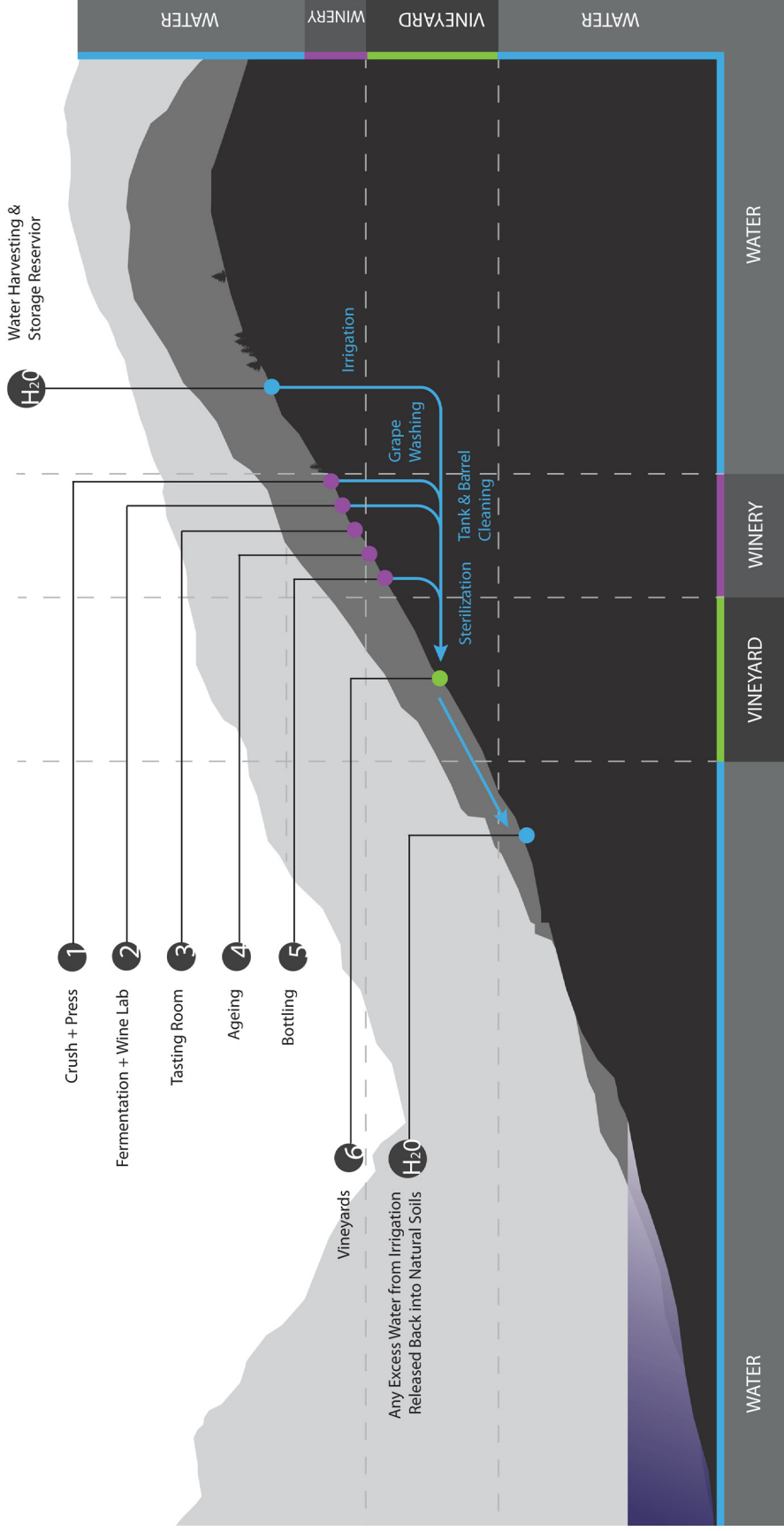


Schematic gradient of water availability vs. use.

My understanding of the involvement of water in the winemaking process enables decisions to be made about how water moves through the site and winery, often paralleling the route of wine but occasionally crossing through its path. Knowing how and where water is used helps to inform where the wastewater of one stage in the winemaking process may be re-used elsewhere to conserve water. Additionally it allows the designer to generate architectural experiences which emphasize the role water plays at each step in the process and create a visual connection between water and wine.

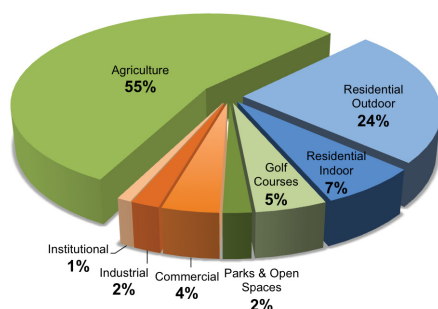
Water and Wine

Despite the fact that water security has always been a concern in the Okanagan, it is British Columbia's largest consumer of agricultural water. An estimated 120 billion liters of water are consumed annually

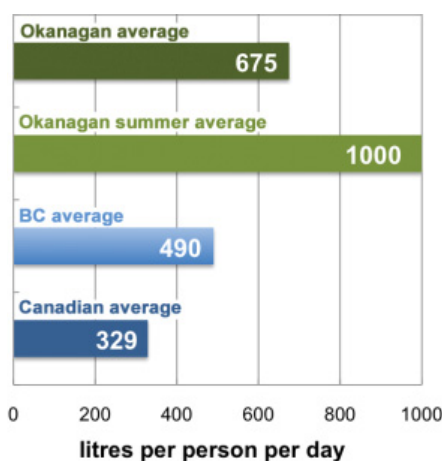


1	Grape Intake: Crush + Press	600 m ²
2	Fermentation + Winemaker's Lab	600 m ²
3	Tasting Room + Retail Shop	400 m ²
4	Cellar + Barrel Cleaning	1600 m ²
5	Bottling Room + Storage	800 m ²
6	Vine Terraces	Approx. 25 Hectares
		Water Reservoir Capacity to Meet Annual Water Demand: 105,000 m ³

Program zones and order of procession through site and building spaces to allow for gravity flow wine processing and water movement. Program space sizes are general guidelines determined from case studies of similar existing wineries of similar production scale. (See Appendix 1)



Distribution of water use by land use in the Okanagan (“Okanagan Water Supply and Demand Project”)



Domestic Water Use, Provincial and National Comparison (“Okanagan Water Supply and Demand Project”)

for irrigation.²⁰ Incidentally, they also have the highest per capita domestic water use in Canada. The average Okanagan resident consumes 675 liters of water per day, while the Canadian daily average is only 329 liters.²¹

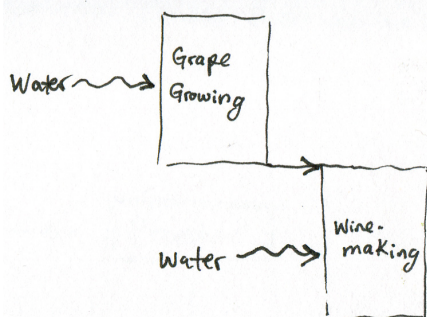
The extent of water use and the consequences of water shortage have led to the development of sustainable water management strategies in the Okanagan; many which focus on residential water use. Conservation is of course a part of the strategy, but there are also proposals to build new dams and expand water collection to surrounding watersheds.

Although irrigation practices are also becoming a major focus and the agricultural communities are particularly aware of the need for efficient water use, efforts often doesn’t extend beyond upgrades to water-saving systems and irrigating during cooler times of the day to reduce water loss through evaporation.

In comparison to other fruits such as peaches, apples and plums grown in the Okanagan, grapes require relatively little water for irrigation. However, unlike these orchard fruits the involvement of

20 Remy Scalza, “Tourism Threatens Water Security in Okanagan,” *BC Business Online*, August 4, 2010, <http://www.bcbusinessonline.ca/print/bcb/business-sense/2010/08/04/tourism-threatens-water-security-okanagan> (accessed 3 November 2011).

21 “Okanagan Water Supply & Demand Project,” Okanagan Basin Water Board, <http://www.obwb.ca/wsd/water-usage/residential-water-use> (accessed 23 November 2011).



Schematic of two separate water inputs required.

water does not end when grapes are picked from the vine. Additional water is used by the winery during the processing of grapes and production of wine. Concern is beginning to grow among winemakers, particularly those at the commercial scale, about the amount of water consumed by processing. Mark Wendenburg, the winemaker for Blasted Church Vineyards in Okanagan Falls says “I estimate that each bottle of wine produced requires an input of 1.5 litres of processing water.”²²

Thesis Statement

The celebration of water through landscape and architecture can influence the water use practices of the Okanagan’s wine industry and emphasize the scarcity of water to residents and visitors of the region.

Site Description and Strategy

Regional Geography and Climate

Located in the mountain valley of the Okanagan, the site is within the oldest of British Columbia’s three major wine regions. The irregular terrain and undulating water’s edges create varying microclimates and differing soil types which support the growth of many varieties of grapes and soft fruits in the vineyards and orchards that rim Okanagan Lake.

The climate is semi-arid due to the rain shadow effect of the coastal mountains. Average annual pre-

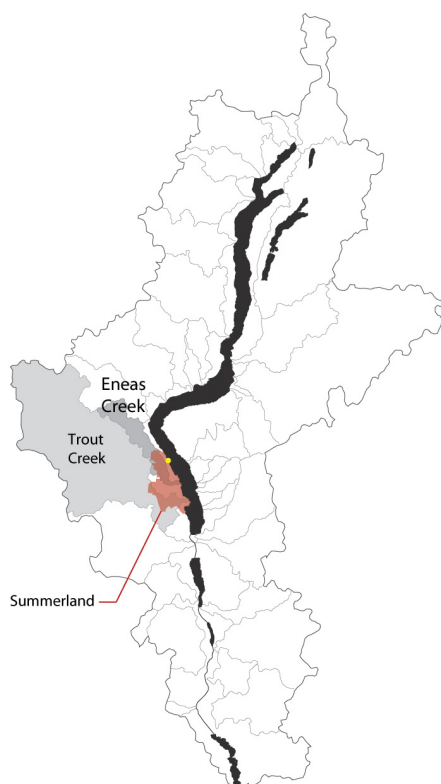


Often referred to as The Wine Route, Highway 97, is the main regional road. It runs closely along the lakefront and is seen here cutting into the hillside of the western slope. (BC Jobs and Economy, *Bentley Road to Okanagan Lake 4-Laning Project*).

²² Mark Wendenburg, winemaker for Blasted Church Vineyards, Okanagan Falls, BC. October 17, 2011.

precipitation in the Okanagan basin is a mere 300mm, with the majority falling as snow during the winter months. Limited rainfall, high summer temperatures and a high rate of evapotranspiration create desert-like conditions in this region. Resilient desert plants including bunchgrass, sagebrush and Ponderosa pine provide the native vegetation.

Summer heat and ample sun exposure create the ideal agricultural environment in the valley, giving it one of the longest growing seasons in Canada. The climate becomes increasingly dry towards the southern end of the valley where Osoyoos sits just above the Washington border. The lake and surface water from its surrounding watersheds provide the major water sources for irrigation, which is essential to the cultivation of all crops in this region.



Summerland Watersheds. Red shaded area shows township of Summerland. Yellow dot shows selected site. (Watershed base-map from: *Okanagan Lake Tributaries*. Vernon, BC: GEM Mapping and Design).

Water flow from melting snow packs and mountain rivers varies greatly between seasons in the Okanagan and locals often find themselves dealing with either an excess of water, causing flooding and erosion, or a water shortage which leads to wilting crops and summer draughts.

Selected Site Details and Strategy

The site lies at Summerland's most northern tip and consists of on an east-facing hillside just above the Wine Route highway and overlooking the vineyards of Naramata across the lake.

The three watersheds which provide Summerland's local water supply are Trout Creek, Eneas Creek and

Prairie Creek which are fed by snow pack melts in spring from the surrounding mountaintops. Water shortages are becoming a more frequent concern as global warming continues to reduce winter snow fall, and consequently leading to shrinking snow packs.

Although bordering the Eneas Creek watershed which feeds the Garnet Valley just behind it, the site is actually within its own micro-watershed and receives only water which flows towards the lake down the eastern face of the ridge. Since the highest elevation on site is around 300m below the elevation of snowpack formation, this offers a particular water challenge.

The site shows very seasonal water flow, as evidenced by clearly visible erosion paths, and it encompasses several small springs which will be used for water harvesting. Most water harvesting will occur in the spring when water is abundant and flowing, and will be stored in a reservoir on site for later use when water is scarce.

The advantage provided by the site's slope will be put to use and the movement of water will be entirely by gravity. The elimination of pumps and pressurized water systems is done with the intent of reducing water consumption by reducing waste. Pressurized water systems tend to use water at a faster rate to maintain pressure and consistent flow, and typically require electricity to run, which is provided locally by hydroelectric dams.

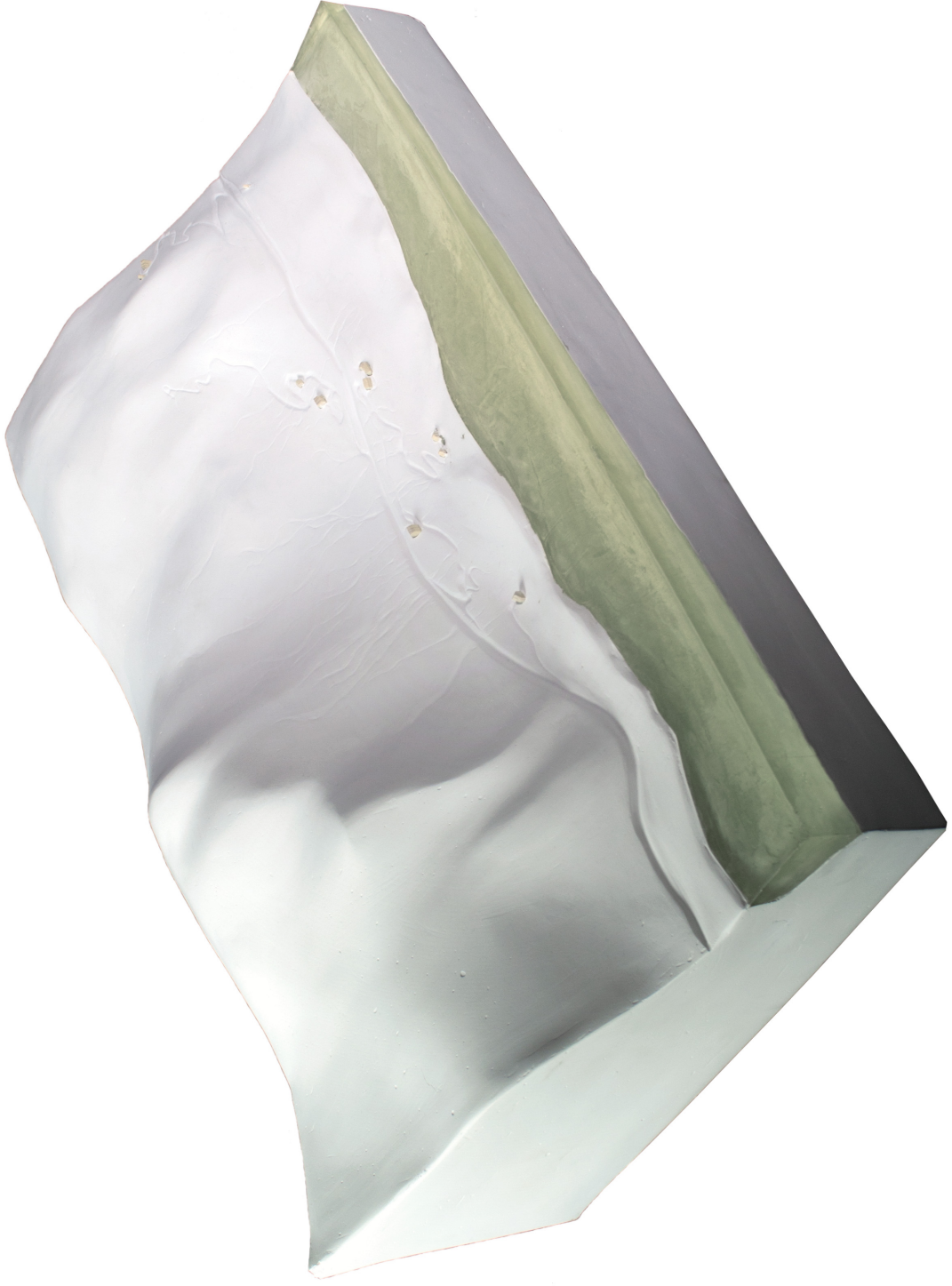
Accessibility from the major wine route was also a selection factor for the site and the ideal location to build the winery was chosen based on topography that would place it in a visible position on the hillside, provide a wide view over Okanagan Lake, and allow partial nesting of the building into the earth.

Terracing will be used in the vineyard to stabilize the earth against erosion and retain water in the hillside by slowing the flow of surface run-off and allowing for greater absorption into the soil. It will also enable the slope of the hillside to be manipulated and reduced in steeper areas so the vineyards are accessible by agricultural machinery.

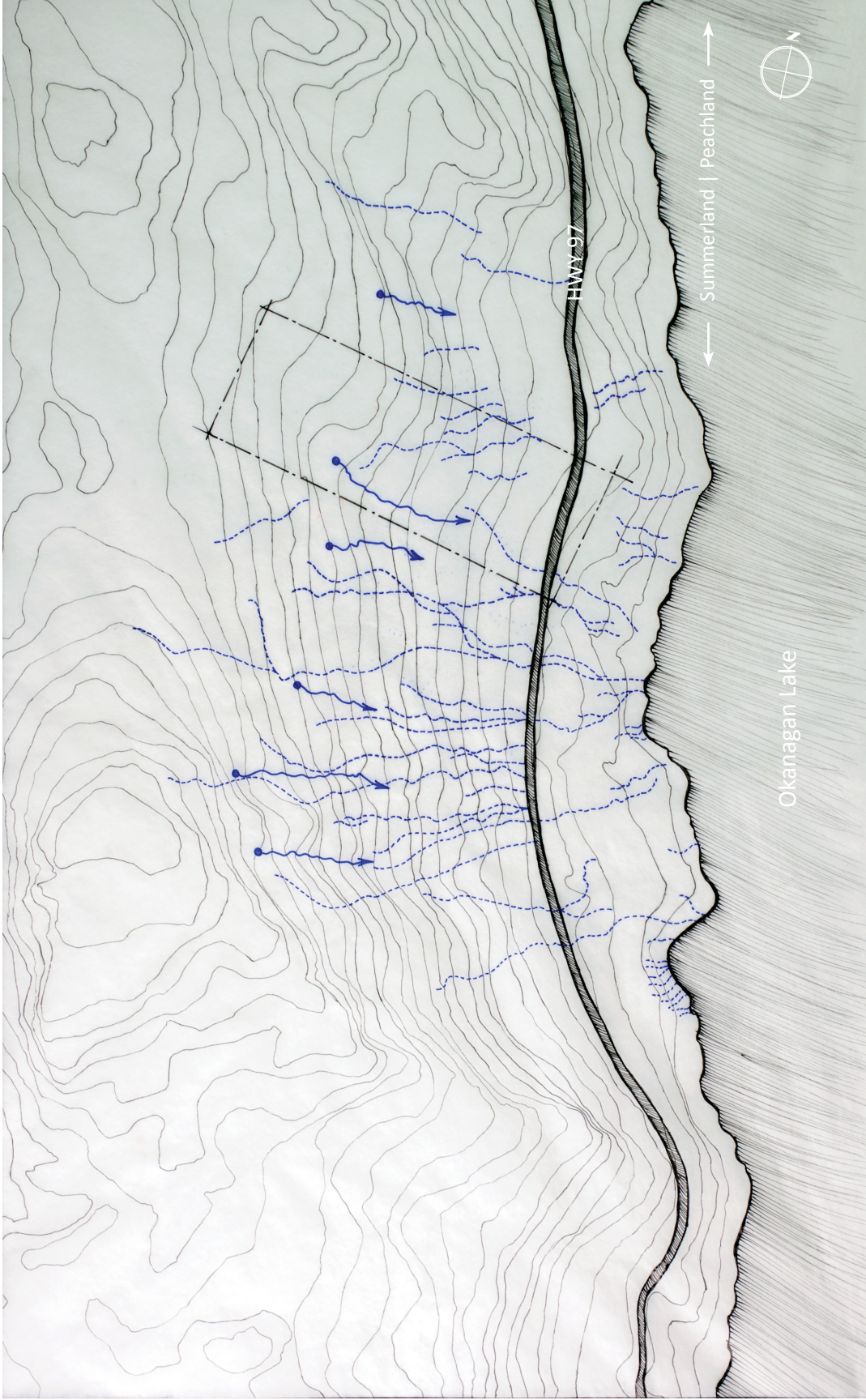


The cyan shaded region marks the site's micro-watershed. Magenta shaded region marks the project site. The agricultural land to the bottom left of the image shows part of Garnet Valley which is fed by the Eneas Creek Watershed and is blocked from direct view of the lake by the backside of the ridge selected as the project site. (Images stitched from Google Earth)





Model of site watershed showing topography, erosion paths and existing development.



Micro-watershed of site. Dotted lines mark erosion paths visible from satellite image. Arrow lines mark springs and seasonal stream paths. Dashed outline surrounds ideal building site and entry point from highway.



1: 1000 Contour model of area within dashed rectangular outline of previous drawing. Blue shaded region represents Okanagan Lake. Translucent grey areas mark the Wine Route Highway along lakeshore and the ideal building site for winery on uphill plateau.

Program Description

Centered on the popular local winemaking and touring industry, the program aims to merge vineyard and winery in a way which emphasizes water and celebrates the role it plays throughout the wine-making process.

The goal is to enable the operation of a self-contained system between landscape, winery and vineyard, in which all water needs on site are met by water collected on site, and gravity flow is used to move water whenever possible. Demonstration of this approach will allow the winery to remain independent of the municipal water supply, therefore reducing demand on city water, and also prove to the community and visitors that this approach can work at a localized scale.

In addition to harvesting and using gravity to cycle all water locally, the design of systems and architectural details will enable the use of all harvested water for more than one function on site. This will decrease the demand on the site's water source and make more efficient use of water that has been harvested and stored. For example, water used in the washing of harvested grapes before they are crushed and pressed will be re-captured and also used to irrigate the vineyard.

The design of the main building also takes advantage of the landscape for the use of gravity flow in wine processing. This approach is considered to be

a gentler approach and is favoured by many wine-makers for the lower stress it puts on the wines.

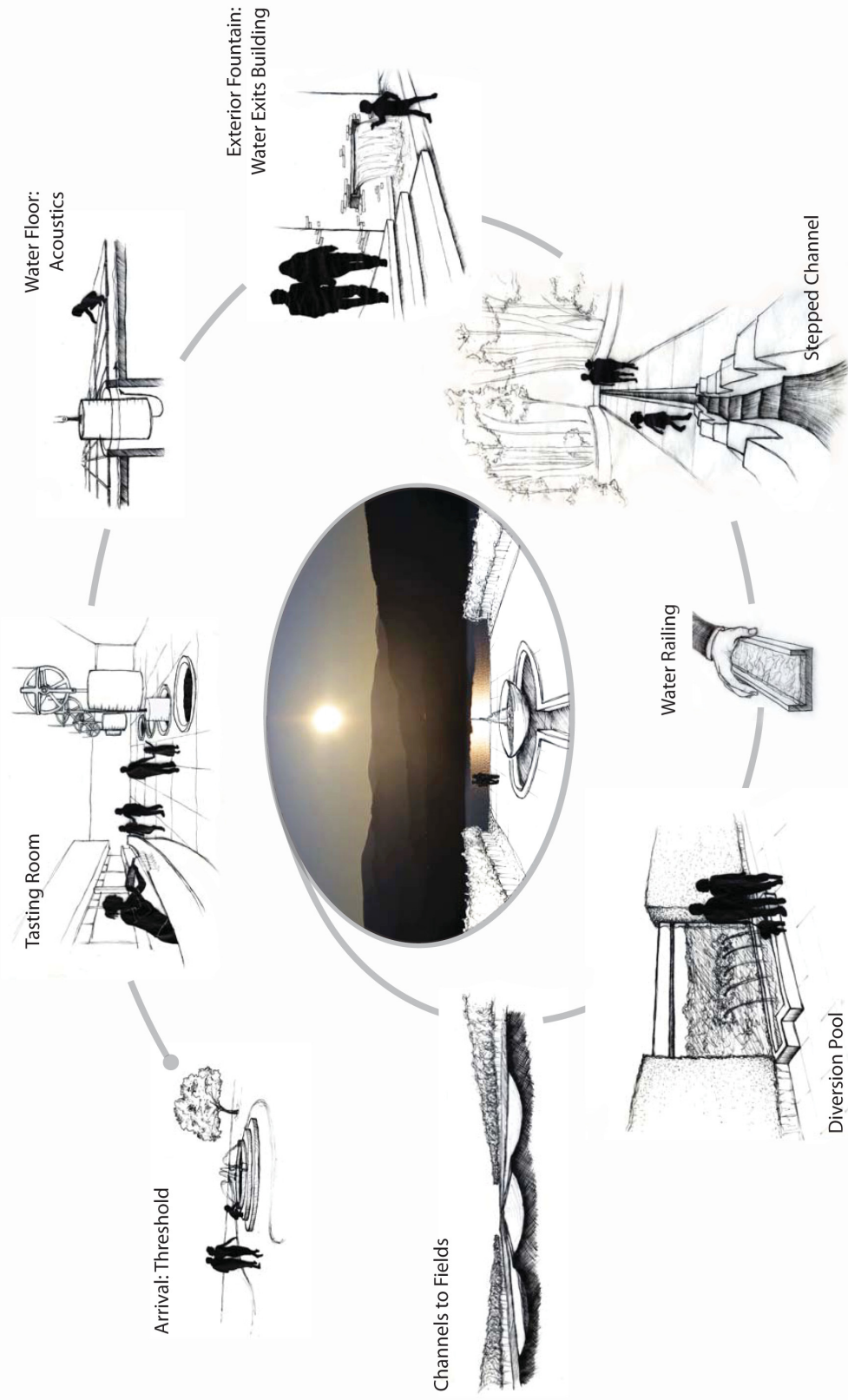
The celebration of water and winemaking is presented to the visitor through a series of 'water moments' which guide their procession through the winery and vineyard. These moments of pause are meant to engage the visitor and capture their interest in addition to teaching them something about the use of water at each stage of the winemaking process. The intent is to provide visitors with a form of visual quantification of water consumption and allow them to reflect on the value of water to the livelihood of the region and beauty of its landscape.

Lisa Heschong is of particular influence to this intention. She is a practicing architect, author, and an expert on the human factors involved in building design, and her book *Thermal Delight in Architecture* establishes a view of the human senses as the tools used in the exploration of the world around us. In addition to the main human senses, Heschong also emphasizes the importance of our thermal sense:

Thermal qualities enrich one's experience of a place and increase its value. Perhaps the simple bodily experience of thermal conditions is sensed as a metaphor for the more abstract meanings represented by a place: the comfort, the delight, the social affinity, each reinforcing the overall significance of the place in people's lives.²³

Taking this approach towards design I hope to encourage a similar sense of significance of place, and

²³ Lisa Heschong, *Thermal Delight in Architecture* (Cambridge: MIT Press, 1979), 65.



Representation of potential experiences and interactions with water framed by a procession sequence through winery and vineyards.

tie water to this experience through sensory engagement within the winery and surrounding landscape.

Precedents

Although the chosen site and program may be unique to this design project, seeking inspiration from historical and cultural examples is useful in the design process. By studying the treatment and value of water across various times and places I was presented with different perspectives and approaches to designing with water and offered examples of ways water is celebrated in the built environment.

I have chosen several of these architectural examples for further discussion due to their particular relevance to the design work of this thesis. Included are designs from Rome, India, Spain and Italy.

Roman Aqueducts

Most notably recognized for their efforts are the Romans who devised ingenious ways to collect, transport, retain and delight the public with water. In a description of the Giacomo della Porta and the Aqua Vergine fountains of Rome, Katherine Rinne demonstrates why Rome was a city so well known for its water engineering:

Whether the water shot in a lofty jet, fell in a rushing cascade, bubbled from a low nozzle or slipped slowly over a stone lip, it did so because the symbiosis between gravity and topography had been exploited by the design. Hence, each fountain told a topographic story that linked it simultaneously backward and forward to the other fountains in its network, to its aqueduct



Trevi Fountain, Rome. Photo by Ellen Kuschnik, 2002.



Ruins of a roman aqueduct which once carried water from the surrounding hills into the city. (Rinne, *The Waters of Rome*)

and to its source outside the city.²⁴

Every Roman understood that their water was brought to them through a meticulously constructed network of aqueducts. These aqueducts relied on careful design to maintain a constant slope over great distances. This ensured that water could be moved entirely by the force of gravity from the distant mountains to the fountains and people within the city of Rome. The investment of the physical, mental and material resources that went in to creating a vast and elaborate network of aqueducts is a clear demonstration of the necessity and value of water in Roman culture.

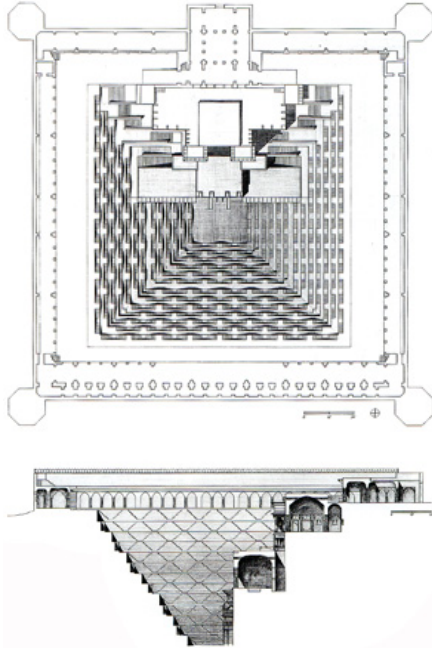
India's Water Buildings

India provides a particularly unique architectural precedent.

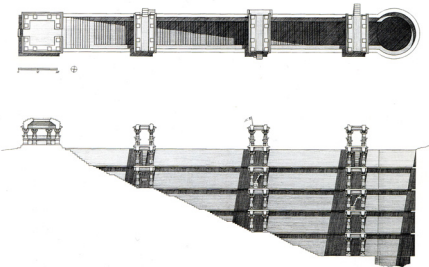
Author, academic and practicing architect Yatin Pandya, opens his book *Concepts of Space in Traditional Indian Architecture* by creating an image of India's hot dry climate and the annual cycle of sharp contrast generated when the monsoon season sweeps in. In just a few short months the monsoon dumps an entire year of rainfall onto the arid landscape and the collection and containment of this water is essential to sustainment of towns and villages through the remaining dry months of the year.²⁵

²⁴ Katherine Rinne, "Fluid Precision: Giacomo della Porta and the Acqua Vergine Fountains of Rome," in *Landscapes of Memory and Experience*, ed. Jan Birksted (New York: Spon Press, 2000), 183.

²⁵ Morna Livingston, *Steps to Water: The Ancient Stepwells of India* (New York: Princeton Architectural



Plan and Section of stepped pond in Abhaneri. The switchback stairs keep the design compact and enable the pond to reach deeper waters with a smaller footprint. (Livingston, *Steps to Water*. Drawing by Mike McCabe.)



Plan and section of Vikia stepwell. While the stepped pond allows descent into an open central pool, the linear plan of the stepwell requires its visitors to move through a series of rooms and semi-enclosed terraces. The suspense is allowed to build along the descent as often the water is only revealed once it comes within reach. (Livingston, *Steps to Water*. Drawing by Mike McCabe.)

Water and its seasonal presence are celebrated by the cultures of India and this phenomenon has led to the creation of many elaborate *water buildings*. The spaces and program of these buildings are entirely driven by the access to water and experience of it.

Taking two forms, and known either as step ponds or stepwells, these structures involve a descent into a subterranean journey. Stepped ponds have steep terraces of stairs which lead down to a central pool, while stepwells are slightly more elaborate. A stepwell leads one through a series of rooms, platforms, and stairways which play with opening and enclosure to reveal and conceal viewpoints to water during the descent.

For Indian women charged with the work of fetching water daily, these water buildings with their rituals of descent, transform a monotonous routine into an enjoyable event which offers the opportunity for social interaction, thermal relief from the heat, and a place to relieve stress.

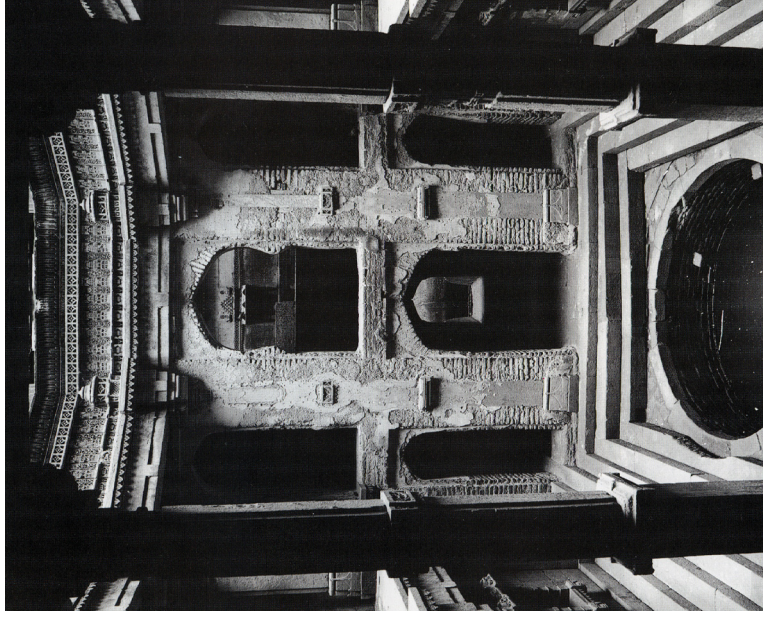
To visitors who have never experienced the descent into one of these buildings, “the clues for movement, inherent in the space, are revealed sequentially. This gradual unfolding of spaces creates a sense of curiosity within the perceivers and involves them in the process.”²⁶

Press, 2002), 7.

26 Yatin Pandya, *Concepts of Space in Traditional Indian Architecture* (Ahmedabad: Mapin Publishing, 2005), 46.



Boys swimming in the Ganga Stepped Pond in Gujarat. (Livingston, *Steps to Water*).



View down to water from platform of a stepwell in Adalaj. (Livingston, *Steps to Water*).



Time and use erode the ancient rock-cut walls of the Adi Kadi well. (Livingston, *Steps to Water*).



Chand Baori Stepped Pond (Livingston, *Steps to Water*).

Stepwells and step ponds function practically as reservoirs for the storage of water from the monsoon and provide a water source during the dry season. Contrary to their appearance however, these water buildings do not act simply as catch basins for the rain falling during the monsoon season. They mark aquifers where muddy monsoon water, caught in depressions or behind dams, has filtered down through the silt and recharged the water table with clear water. Thus stepwells and step ponds are filled mainly by water seepage²⁷ from surrounding soils and provide a visual indication of the quality and level of groundwater. As water is drawn from the well for use and groundwater becomes depleted, the water level in the stepwell gradually recedes, requiring further descent to reach water.

These Indian water buildings not only illustrate water use and its cultural values, but demonstrate an instinctive understanding of local water resources and cycles. These remarkable structures provide both temporal and physical quantification of the use and availability of water, and use architectural form to communicate the value of water to this culture in a poetic and elegant way.

²⁷ Ibid., 10.

Islamic Gardens

The Muslims and Moorish people are known throughout history for their “profound appreciation for the outdoors ... [and] real affection for the land,”²⁸ and their high regard for water is strongly evidenced by the forms of agriculture and irrigation they have developed.

The value of water in the arid climates of the Islamic people is demonstrated by their gardens, which use water in both practical and symbolic ways with great economy and effect. These gardens are typically enclosed spaces which feature a shaded central courtyard. This tranquil space uses the physiological and psychological cooling properties of water which circulates from a central fountain to the rooms and living spaces along the inner walls of the courtyard through narrow open channels in the paved floor. This disperses a relatively small amount of water across a large area, broadening its range of effect.

Plantings within the courtyard were often guided by an “ancient correlation between food and pleasure [which] was echoed by the presence of fish in the pool and canals, and fruit trees in the sides and corners. For vitally necessary shade there were larger trees, particularly planes and cypresses.”²⁹

The once Moorish city of Cordoba, Spain, offers a particularly interesting example of an Islamic garden

²⁸ Ibid., 31.

²⁹ Norman Newton, *Design on the Land: The Development of Landscape Architecture* (Cambridge: Belknap Press of Harvard University Press, 1971), 51.



An aerial view of the Court of Oranges. (Lisa Day, *Moorish Design in Southern Spain*)



Sunken tree wells along grid that branches off main distribution channel. (Spain - Cordoba - Patio de los Narajos, *Drip/Dry: Systems That Seep*)

and the inventive use water for both the cooling of the space and as a means of irrigation.

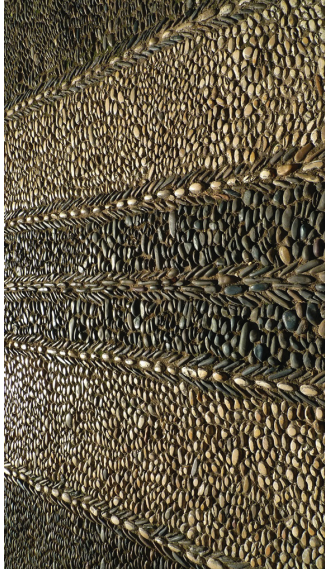
The Great Mosque of Cordoba is preceded by the famous Court of Oranges, in which over one hundred orange trees are planted neatly in rows. Each tree sits within a sunken circular well and is connected to others by a network of narrow channels in the brick paving.³⁰ These channels create a courtyard surface with beautiful geometric patterning as well as enable irrigation water to reach each tree when supplied from a single central pool. With minimal human effort, this efficient design combines landscape and architecture to create an irrigation system which distributes water evenly across the grid.

The shade offered by the orange trees keeps the brick of the courtyard cool and during irrigation, the flow of water through the channels also provides evaporative cooling to faithful Muslims performing their ablutions before entering the mosque.

The geometry of the court and rows of trees also establishes an ordered procession. A series of nineteen arched openings in the façade of the mosque provide an elegant transition between landscape and architecture by “allowing the multi-columned spaces of the interior to emerge into the grove of oranges [and maintain a] continuity of flow between indoor and outdoor space.”³¹

30 Ibid., 32.

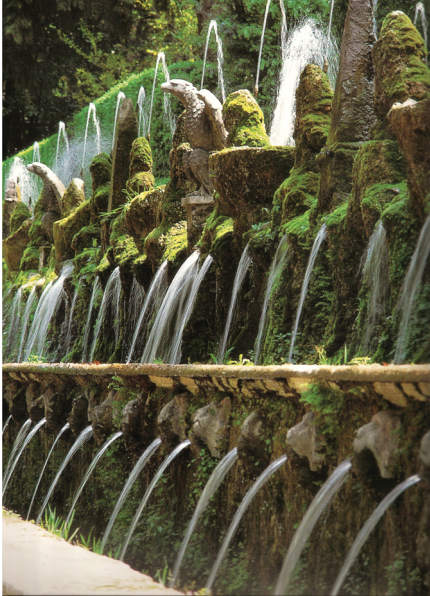
31 Ibid.



Rainwater from surrounding roofs drains into the plaza and is stored in an underground cistern. This water is then used to fill the fountain at the center of the patio and also to irrigate the orange trees. (All images from Spain - Cordoba - Patio de los Narajos, *Drip/Dry: Systems That Seep*).

Water streams from the fountain into a long distribution channel along the upper edge of the courtyard. From this channel water flows into the 14 chains of the sloped grid and flows downward across the patio. Excess water is returned to the cistern.

Tivoli and Granada: The Aesthetic Use of Water



Terrace of the Hundred Fountains. (Symmes, *Fountains: Splash and Spectacle*)

The Villa D'Este is a 16th century Italian villa in Tivoli that is well known and visited for its expansive gardens. Water is featured often in the garden and its diverse properties are demonstrated through a series of fountains and pools which make both aesthetic and playful use of water.

The Terrace of the Hundred Fountains is among the villa's most popular water features and makes use of repetition to grand effect, making a moderate amount of water appear infinite. Preceded by the slow quietly lapping waters of the Bicchierone, the sound of over one hundred jets cascading into the double terraced fountain provides a stimulating and pleasurable contrast. The spray of water that often splashes over the edge of the lower basin cools people as they pass and focuses them more intently on the effect of the fountain.



The Water Organ. (Symmes, *Fountains: Splash and Spectacle*)

A pattern of procession is established and following this active fountain, visitors are returned to an atmosphere of calm, where they encounter four pools of still water before arriving at the famous Water Organ. The Water Organ's meticulous combination of architecture, fountain pools, water jets and pressurized air were once known to play a melody of sounds for its visitors. Using only water, air and some ingenious engineering, the Organ generated sounds similar to the boom of a canon or the tunes of songbirds.



The Canal Garden at the Alhambra. (Hopwood, *Fountains and Water Features*)

Similar to the Villa D’Este, although occupying a different geographical region, the Alhambra of Granada, Spain, makes similar use of water to enliven and animate outdoor spaces. The Alhambra’s Moorish palace is characterized by “colour and calm, and the marvelous use of a little water.”³² Featuring a series of themed inner courts and fountains the Alhambra’s best known spaces include the Canal Garden and the Fountain of Lions.

In the Canal Garden a central canal establishes a central sight line running between the gate lodge and the house. Visitors to this feature are delighted not only by the colourful flowers and shrubs, the shaded arcade and the framed views, by also by the physiological cooling and auditory stimuli. “As though to make the wet pathway even more cooling – in sight and sound and actual temperature – thin streams of water spring into the air from both sides of the canal, arch toward each other and fall with an audible whisper upon the surface of the canal.”³³

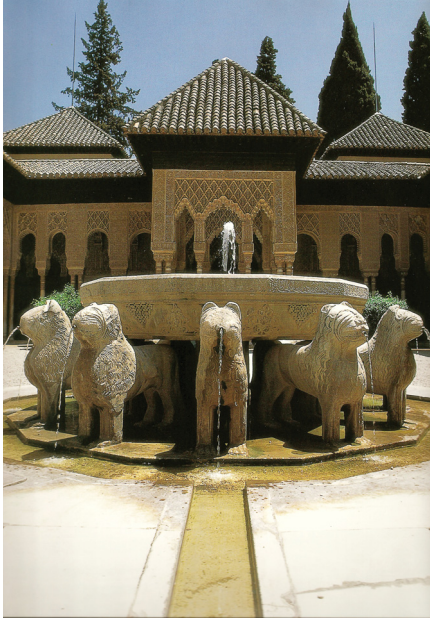


The Fountain of Lions at the Alhambra. (Hopwood, *Fountains and Water Features*)

Central to a nearby courtyard is The Fountain of Lions which is divided into four sections by two bisecting channels. Twelve stone-carved lions support the base of the fountain and a thin stream of water flows from each lion’s mouth to feed the channels that stretch across the court. Again we see repetition used to amplify the effect of minimal water.

³² Ibid.,47.

³³ Ibid., 49.



Close-up of The Alhambra's Fountain of Lions showing the fine streams of water flowing from each lion's mouth into the four channels which cross the courtyard. Photo by Jane Lidz. (Symmes, *Fountains: Splash and Spectacle*)

Offering stimuli to all of the senses and delighting people in more than just a physical sense, it is clear why gardens such as these are celebrated places in many cultures.

From each of these examples comes wisdom and insight which gives us a better understanding of the meaning of water within its context. The Romans offer methods for moving water, India offers the concept of the 'water building' with its depth of experience, Cordoba presents an elegant agricultural use of water and Granada and Tivoli demonstrate the use of aesthetics and sensual experience to engage people with water. Each of these concepts are tools to be brought to the design of this project.

CHAPTER 2: DESIGN

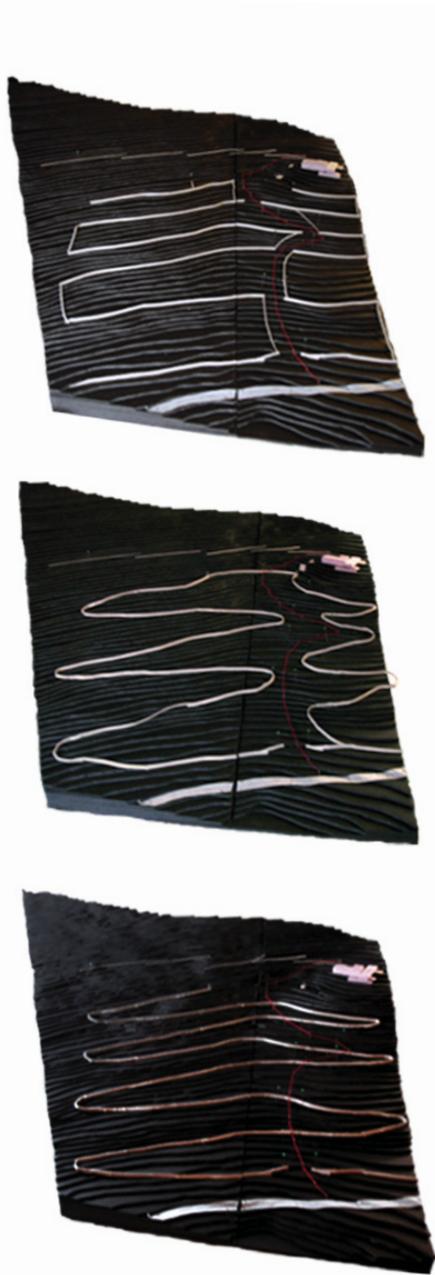
Terracing

The precedents discussed previously begin to inform the design process in the planning and design of the site. In order to allow for the planting and accessibility of vineyards the uneven slope of the site required alteration and levelling in certain areas.

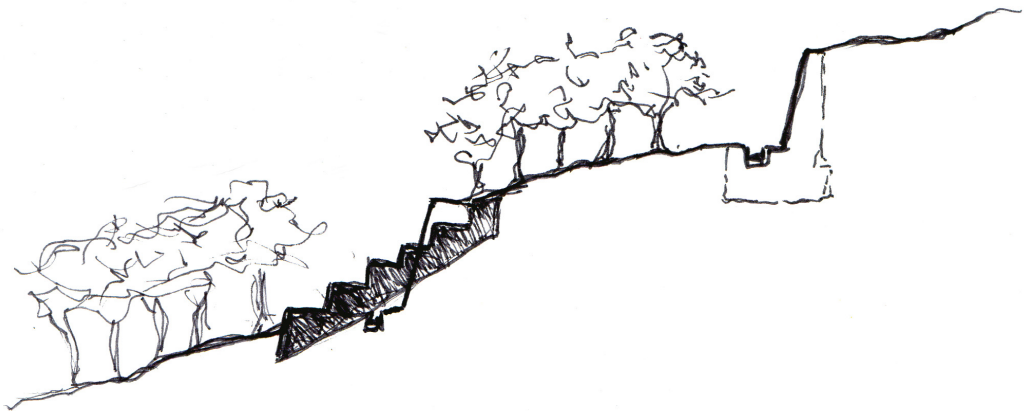
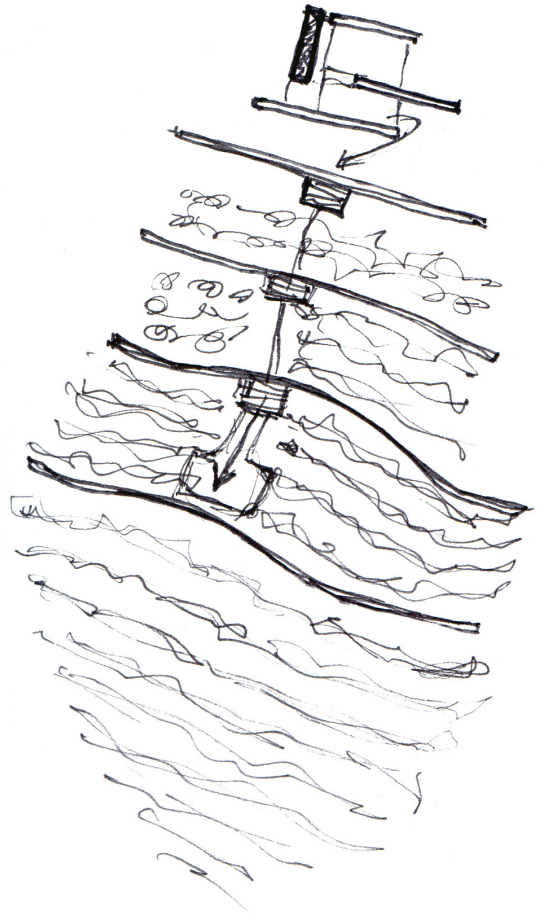
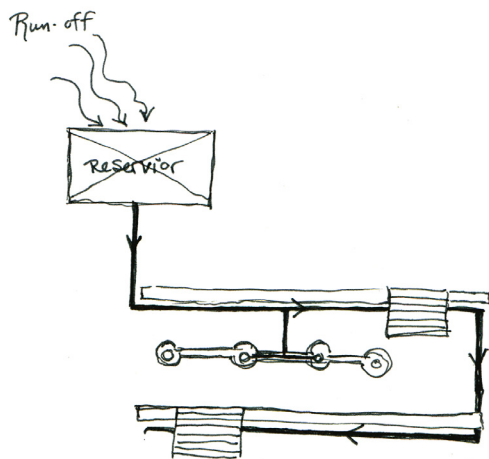
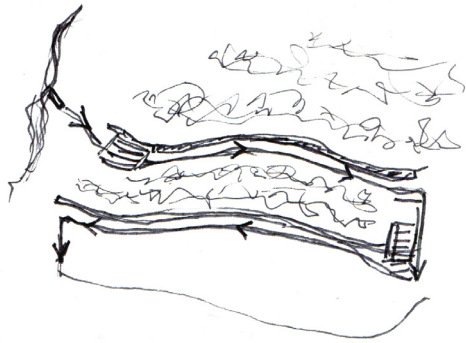
In consideration of Summerland's historical methods of water distribution and their notion of conforming the land to carry water, the idea of terracing provides a traditional solution with the potential for integration of other elements. This includes the use of gravity flow irrigation to the vineyards through a passive system which could easily take its form from examples of the Roman aqueducts.

With this in mind, landscape become the starting point for design and several site models were created to understand the proportion, slope, landforms, micro-climates and existing conditions of the site. Sketch model studies were used to survey potential methods for terracing.

Terrace placement was informed by the slope of the landscape and required terraces to be connected on a constant downhill slope. This allowed the retaining wall to be used as a means of gravity fed water transport in addition to retaining earth and defining the roadway.



Several terracing attempts prior to pairing terraces with the roadway. Stone retaining walls are marked in grey card. Massing of winery on hill-top to upper right. Red thread marks the initially proposed roadway path.



Sketch plans and sections used to study the linking of terraces, which would enable water to flow continuously and evenly downhill to irrigate the vineyards.

Vineyard Planning

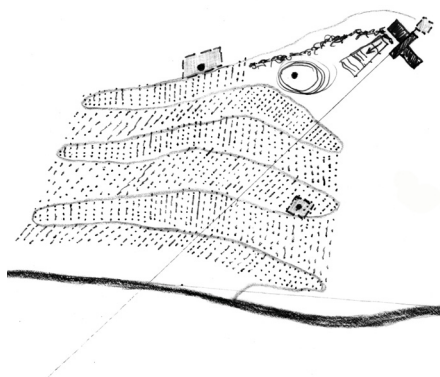
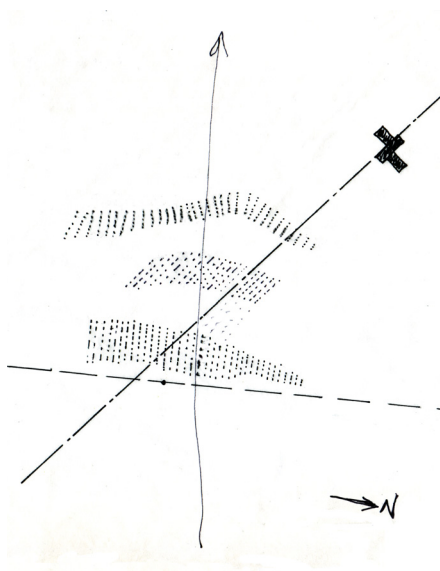
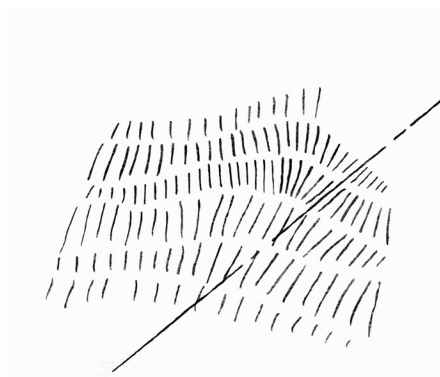
Early attempts to plan the layout of vineyards were the next step in site planning. Traditionally vines are planted in rows along a north-south axis to provide the grapes with the most even sun exposure to morning sun from the east and afternoon sun from the west. This takes advantage of the sun during the long summer days and helps to ensure that the grapes rippen evenly.

Several different options were also explored in an attempt to generate interesting visual effects for people passing by in cars and for visitors looking over the vineyards from the winery.

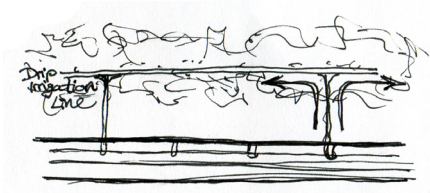
Rows which curved along in parallel to the natural contours of the terraced hillside were considered. Rows perpendicular to these natural contours were also considered because this orientation would be more easily irrigated by a gravity flow system.

Plans which extended the rows perpendicular to the main highway route were explored for the oscillating visual effect they would offer to those driving by. Additionally, vine rows were attempted in alignment with the tasting room patio and the lake to frame the view towards the water. The traditional approach of rows running along a north-south axis has been returned to as the final decision.

The delivery of water to these rows of vines became the next focus and led to the development of a roadway combined with retaining wall up the

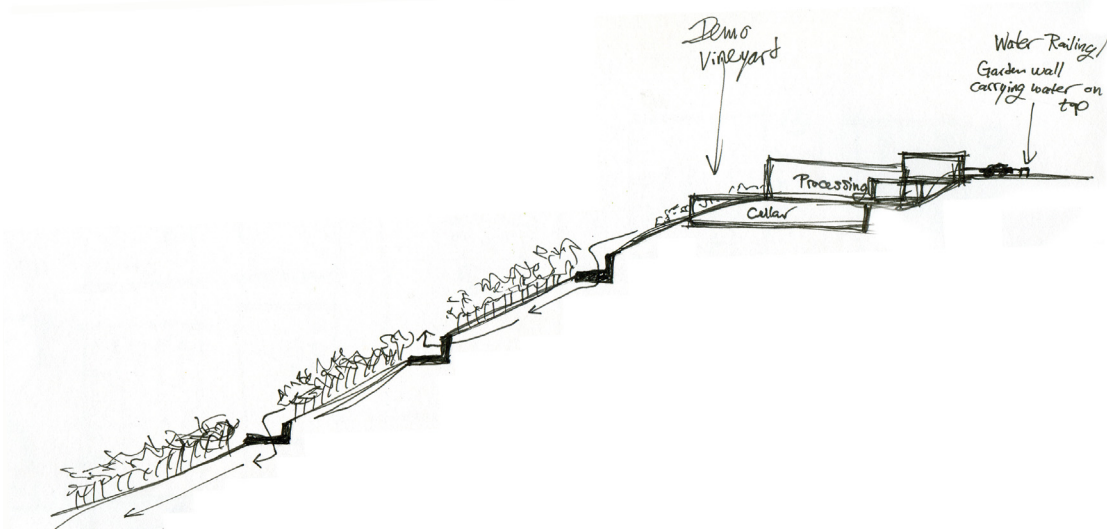
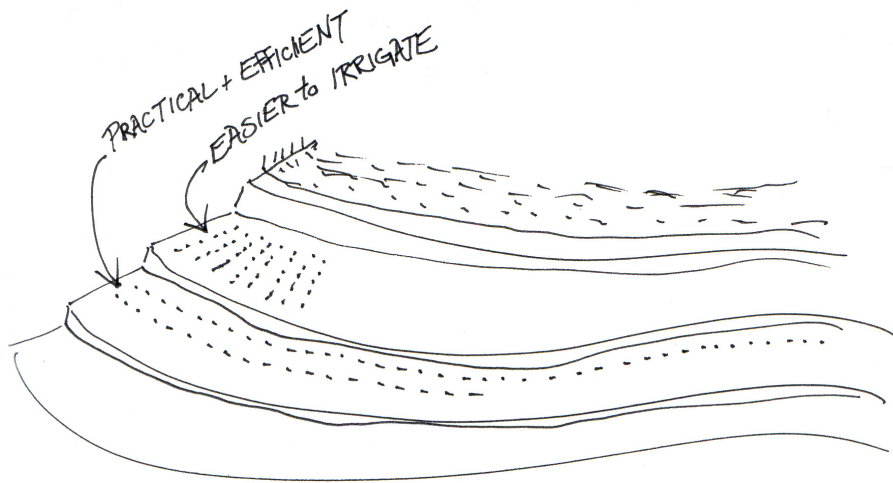


Vineyard Plans. Axes shown in dot-dash lines. Vineyard rows shown in solid strokes (top) or dotted lines.



hillside from the highway, running through the vineyards to the winery. Water was to be integrated into this wall system in some way.

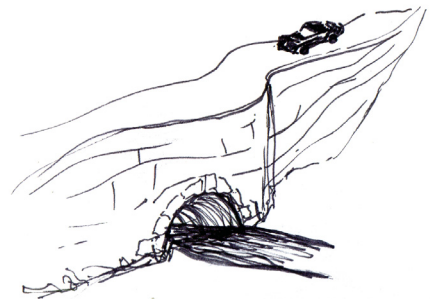
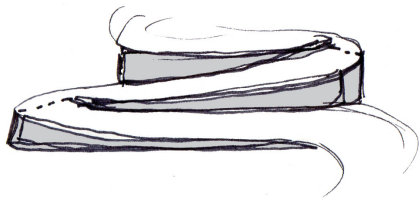
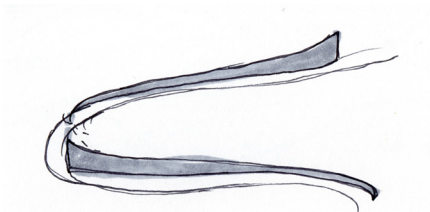
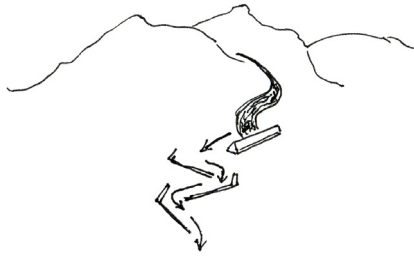
Proximity of the vineyards near the lake is ideal since the water moderates temperature changes and helps to reduce the risk of frost damage to grapes and vines.



Vineyard Planning. Upper image shows water delivery through drip irrigation tubes from the water channel associated with the retaining wall. Middle: Perspective of several row alignment options. Lower: Section through winery and vineyards suggesting how terraces might be created by retaining walls and showing arrows that mark the water flow between them.

Roadway and Retaining Wall

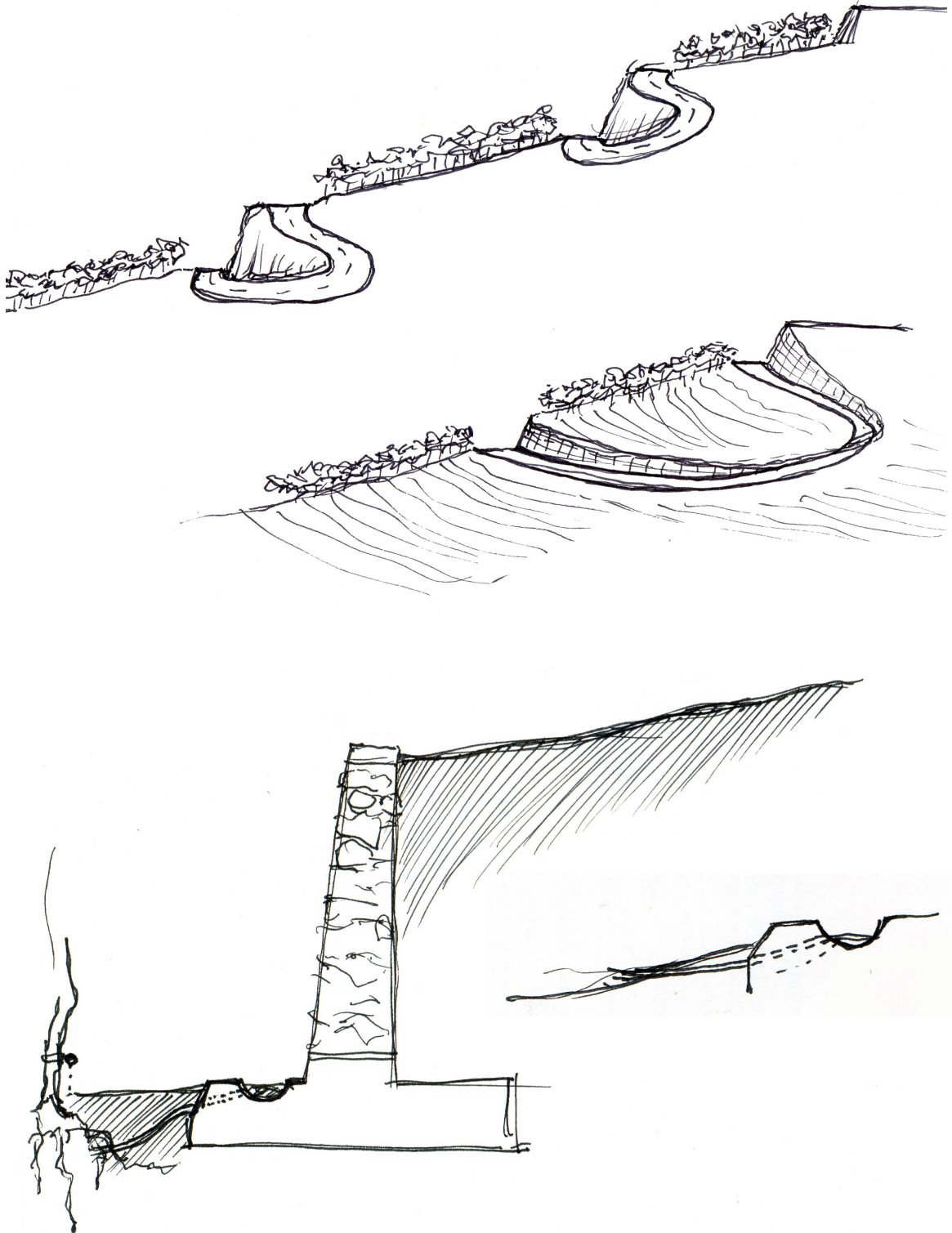
The switchback road is used in many mountainous regions and at times when steep slopes need to be ascended by vehicle. This strategy is used on the hillside leading up to the famous Incan city of Machu Picchu in Peru. Although the hillside on the selected thesis sight is significantly less steep and dramatic, this method is used to frame the design of the road on site.



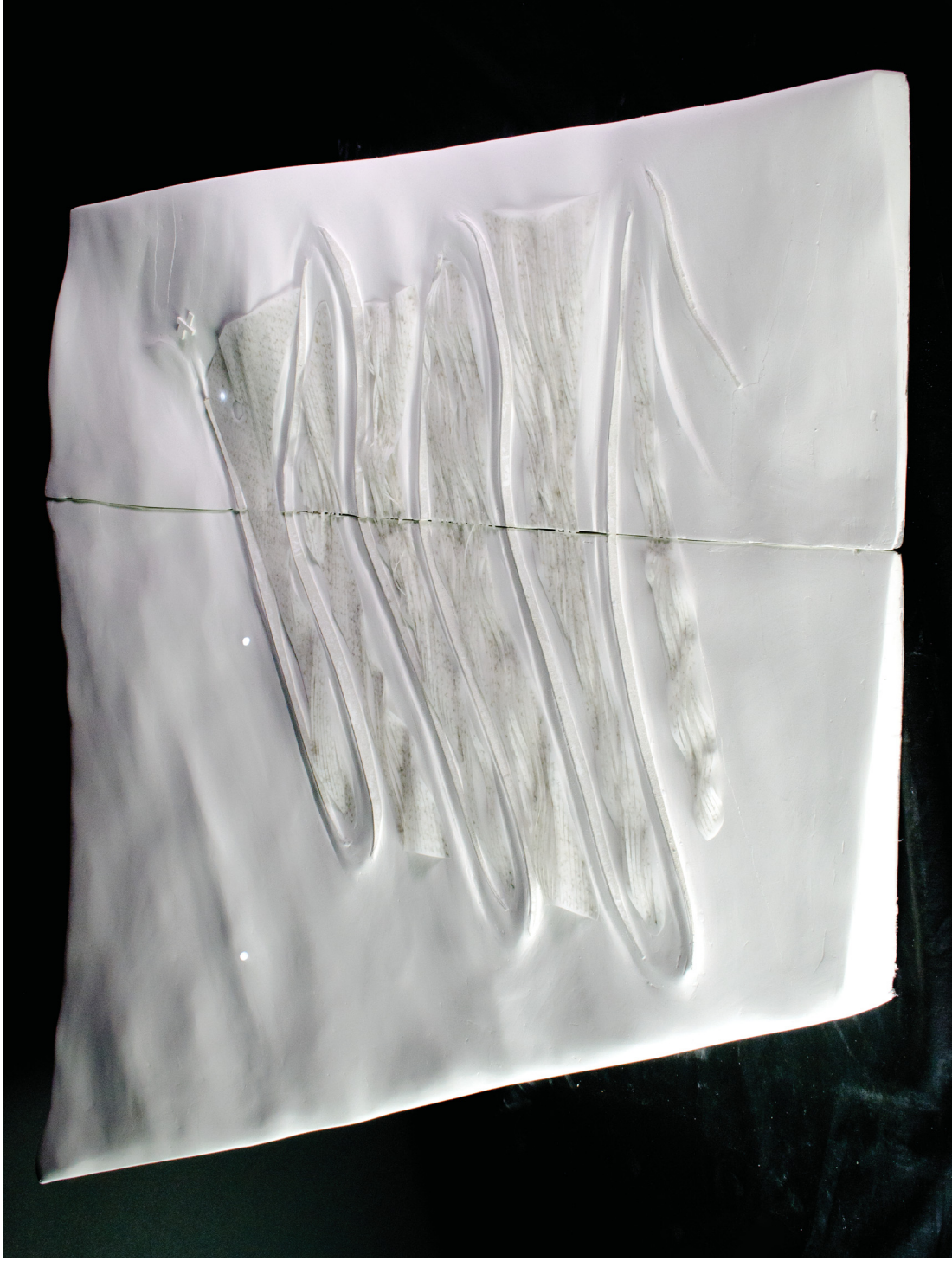
The roadway leads visitors uphill between terraces of the vineyard before arriving at the winery. Retaining walls extend from the winery and an irrigation reservoir following the lower edge of the road. At each switchback turn the water crosses under the road and re-emerges along the base of the retaining wall at the lower edge of the next turn in the road.

The bedrock revealed when the hillside is cut into to form terraces and the road will provide the upper retaining wall in areas where there is a steep change in elevation between turns. This will maintain the visual continuity of the retaining wall which moves irrigation water through the vineyard.

Terrace transitions. Schematic of mountain water source and examination of geometry of switchback roads and how water can pass underneath.



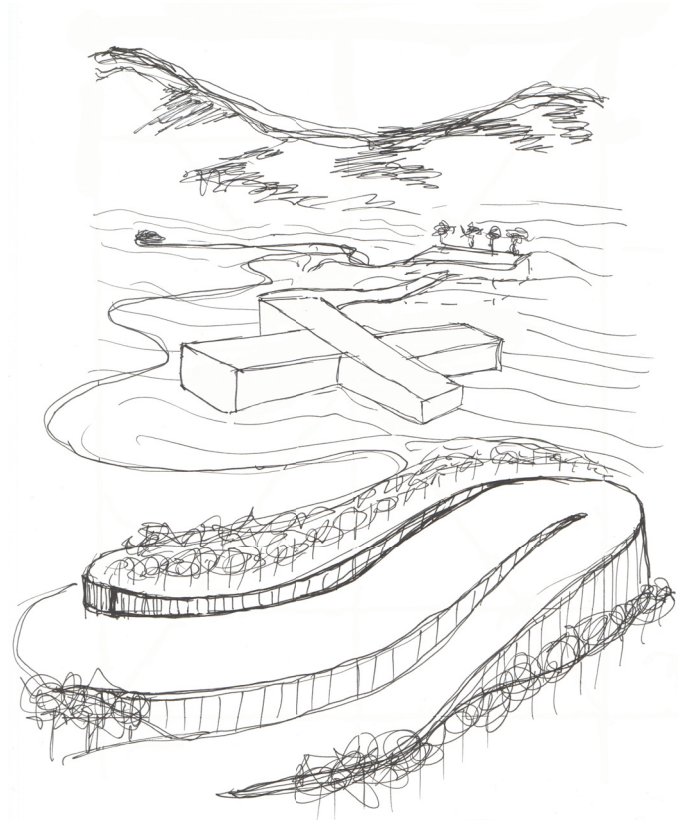
Sections through switchback roadway and retaining wall. Upper: roadway passes below vineyard sections along the edge of retaining wall and creates narrow switchbacks with vineyards between Middle: roadway passes above vineyard sections with vineyards between upper and lower turns of road, allowing for wider vineyards and more shallow turns in the road. Bottom: section through retaining wall showing how the water it carries in a channel is delivered to vines for irrigation.



Vineyard terracing between curves of switchback road. The three illuminated areas mark water sources on site.

Landscape and Architecture

The transition from landscape to architecture is intended to be linked and subtle. This sketch shows water flow from its source uphill to the winery and vineyards below. It illustrates how the site has been conformed to the movement of water and makes its use visible from water source to point of use.

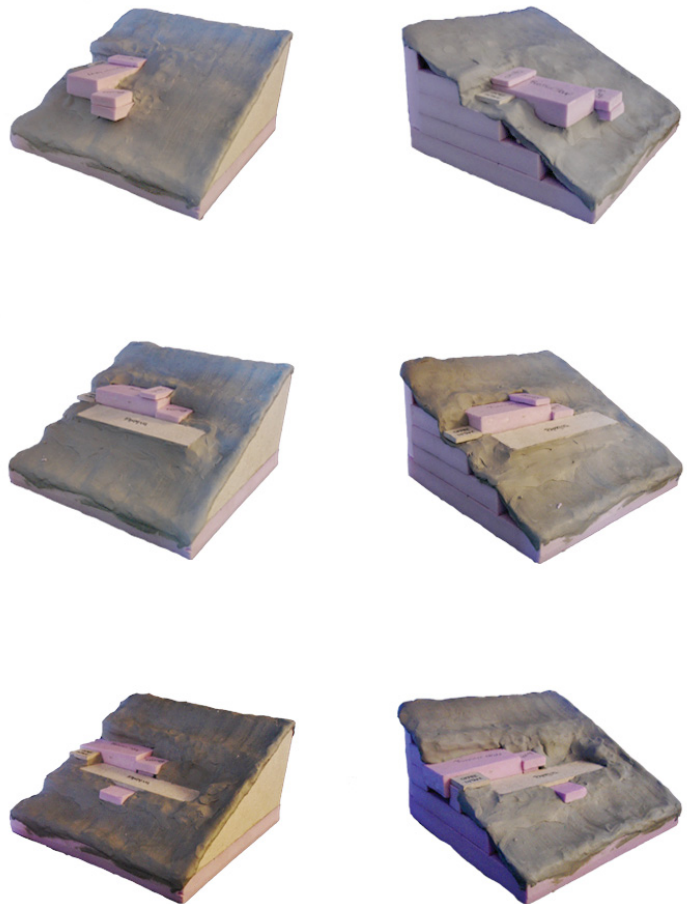


Schematic sketch of how winery is situated among landscape and the flows of water and people arriving on site.

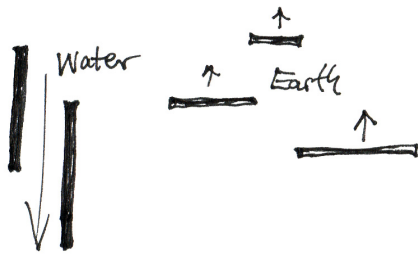
Massing and Nesting

Early massing model studies for the winery explored how the program could be inserted into the landscape. Massing blocks were made of each of the winery's program spaces, including a grape processing warehouse, tasting room, wine cellar, wine-maker's laboratory, bottling room, water reservoir and parking lot for visitors and staff.

The arrangement of spaces proved to be more effective when this method was abstracted slightly and spaces were considered in terms of framing walls and surfaces.



Massing models of program spaces nested into hillside.

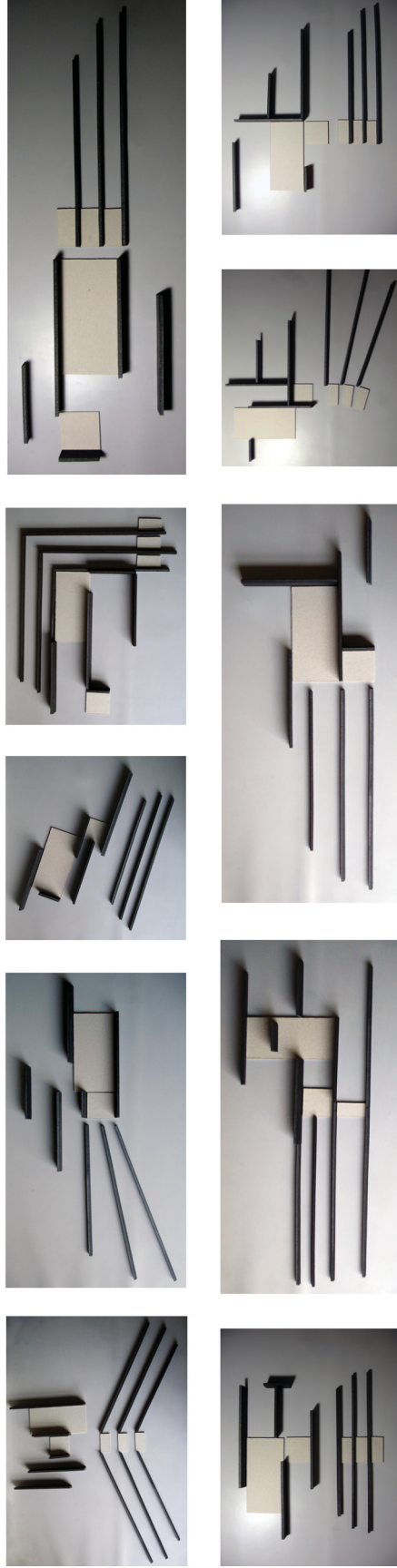


Schematic of flows and forces exerted by wall planes to control landscape elements.

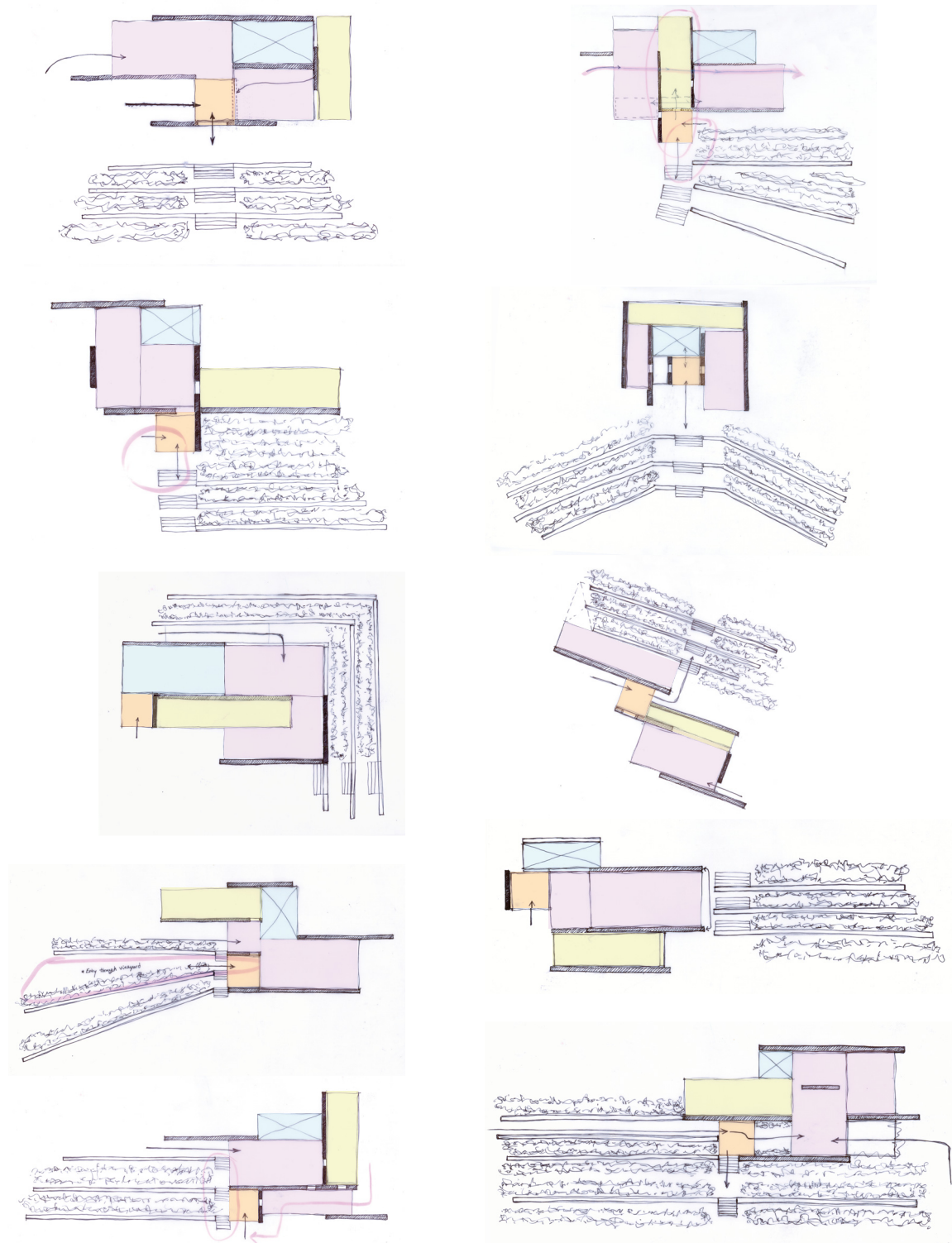
Form Finding

The concept of terracing was re-visited after massing studies and extended into the architecture of the winery itself. Rather than considering program spaces as masses, they were viewed as rooms framed by a simple set of walls and floor planes, where the walls acted as retaining walls for earth and the floor planes were seen as surfaces to hold water.

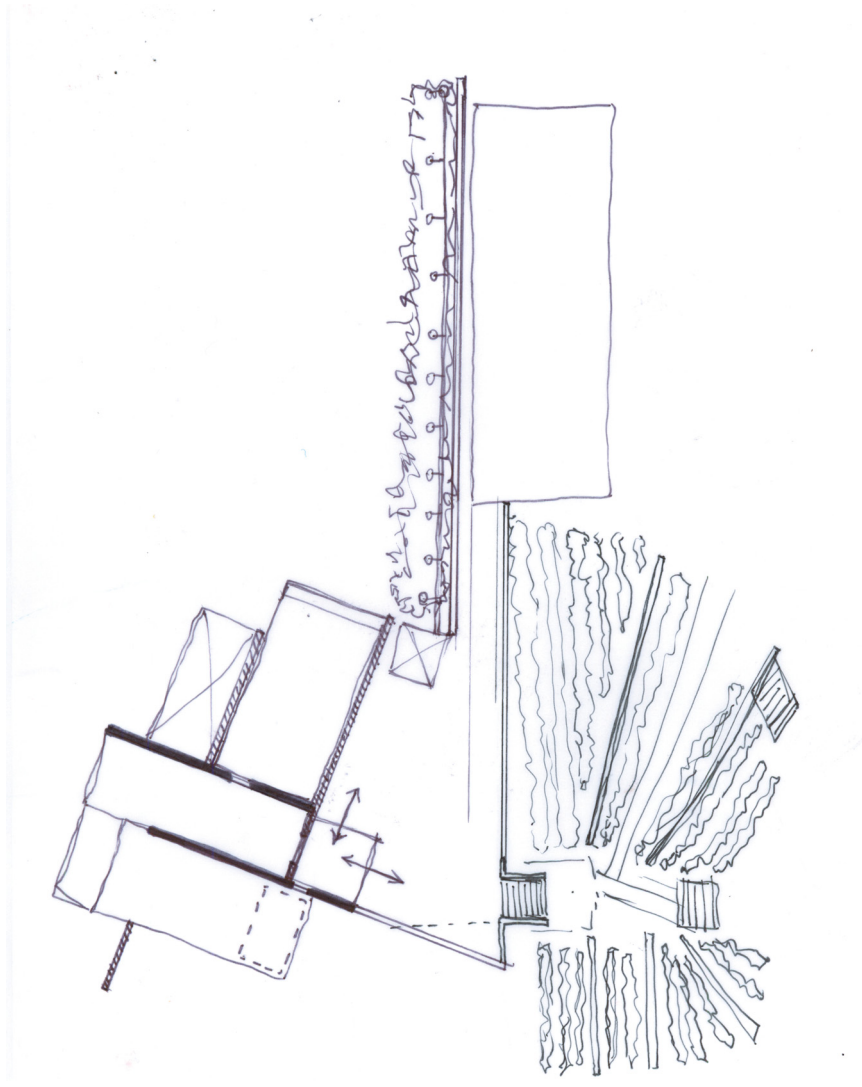
These sketch models are used as bases for the integration of program spaces into form. Sketches made of each model's basic form take the largest area (marked by grey card) to represent the grape intake and wine processing portion of the building. The smallest area represents the tasting room and main public space of the winery, while black card represents the winery walls. The taller of these walls are building elements which contain space and the shorter are landscape elements acting as garden walls which retain earth.



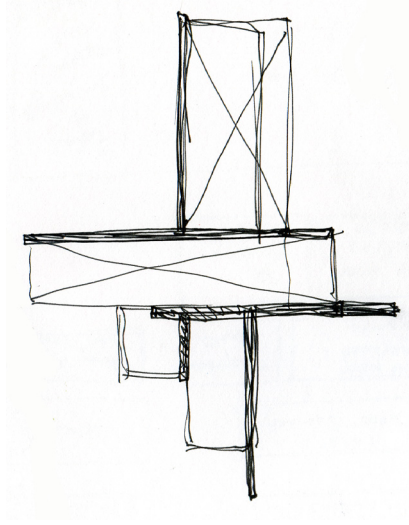
Sketch model explorations of building form. Walls (black) and floor plates (grey) used as elements to control water movement.



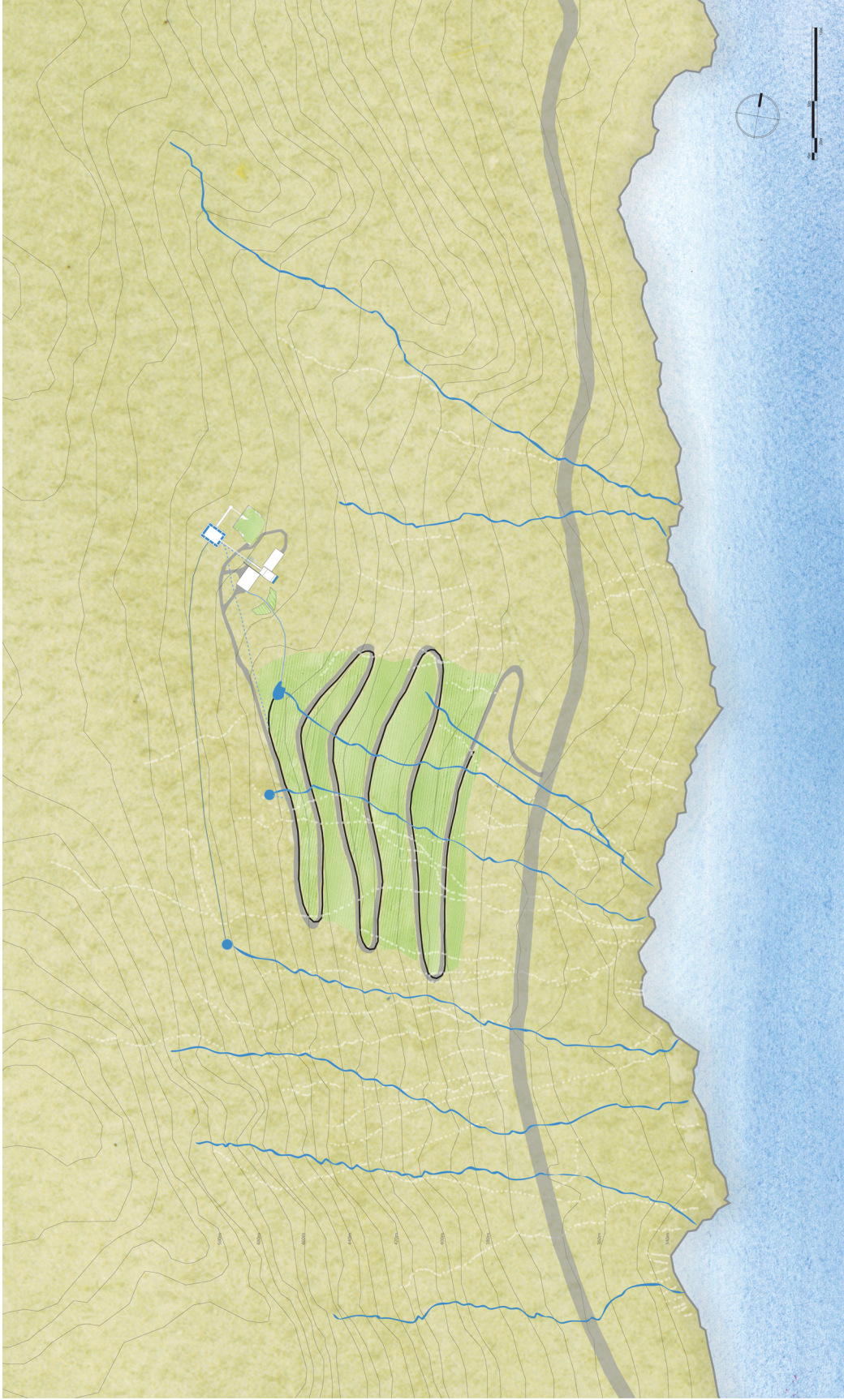
Sketches based on previous models. Pink represents grape/wine processing and bottling space in the winery and occupies the largest area. The longest and most narrow of the area represents the cellar which is considered as the heart or central element of this winery (yellow). Tasting room and public space (orange.) Areas marked by crossed lines represent water reservoirs for building use (blue). Arrows suggest entry points and areas of circulation.



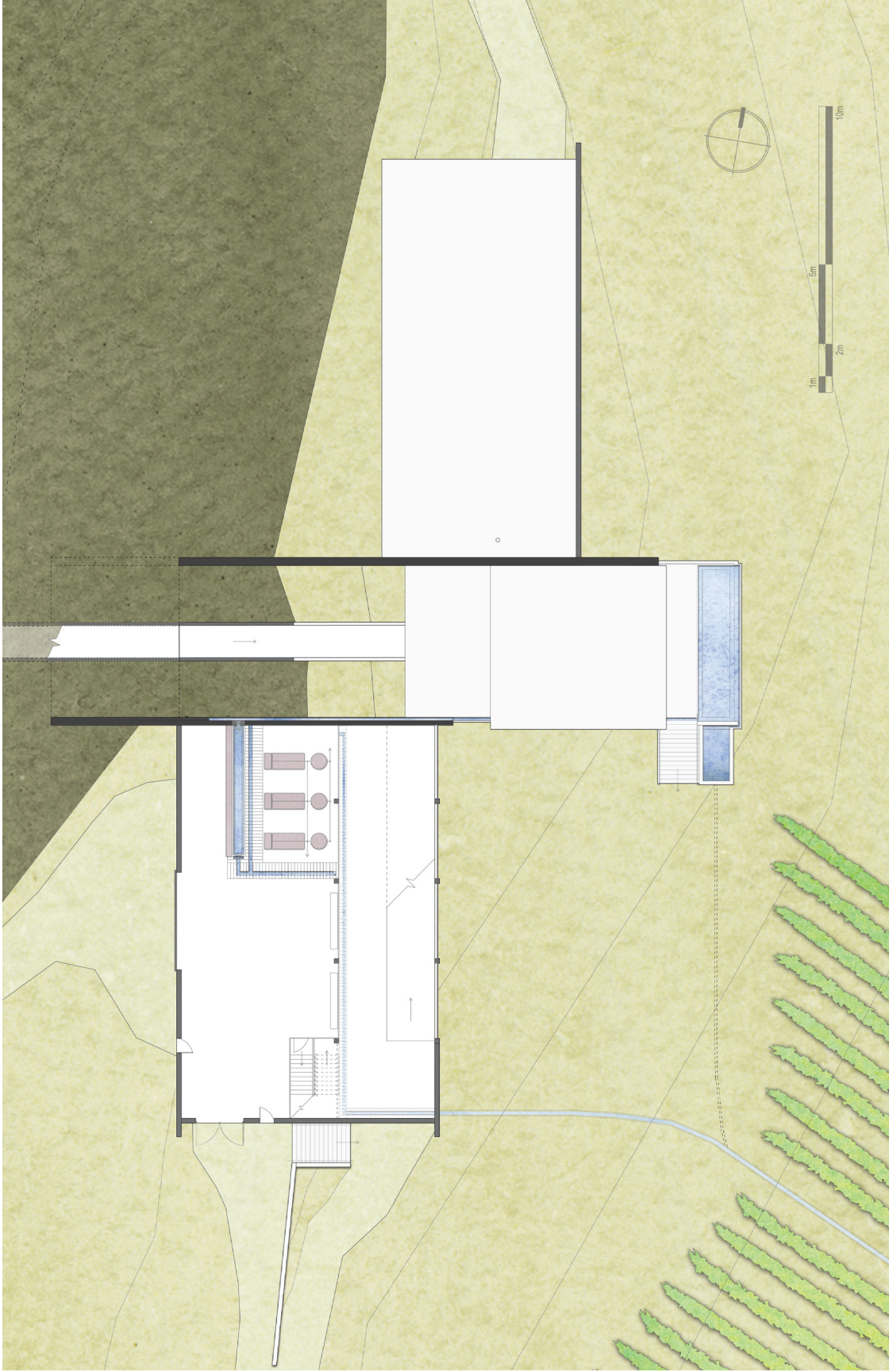
Site plan developed for the favourite and most functional of these sketch models.



Early parti of winery plan.



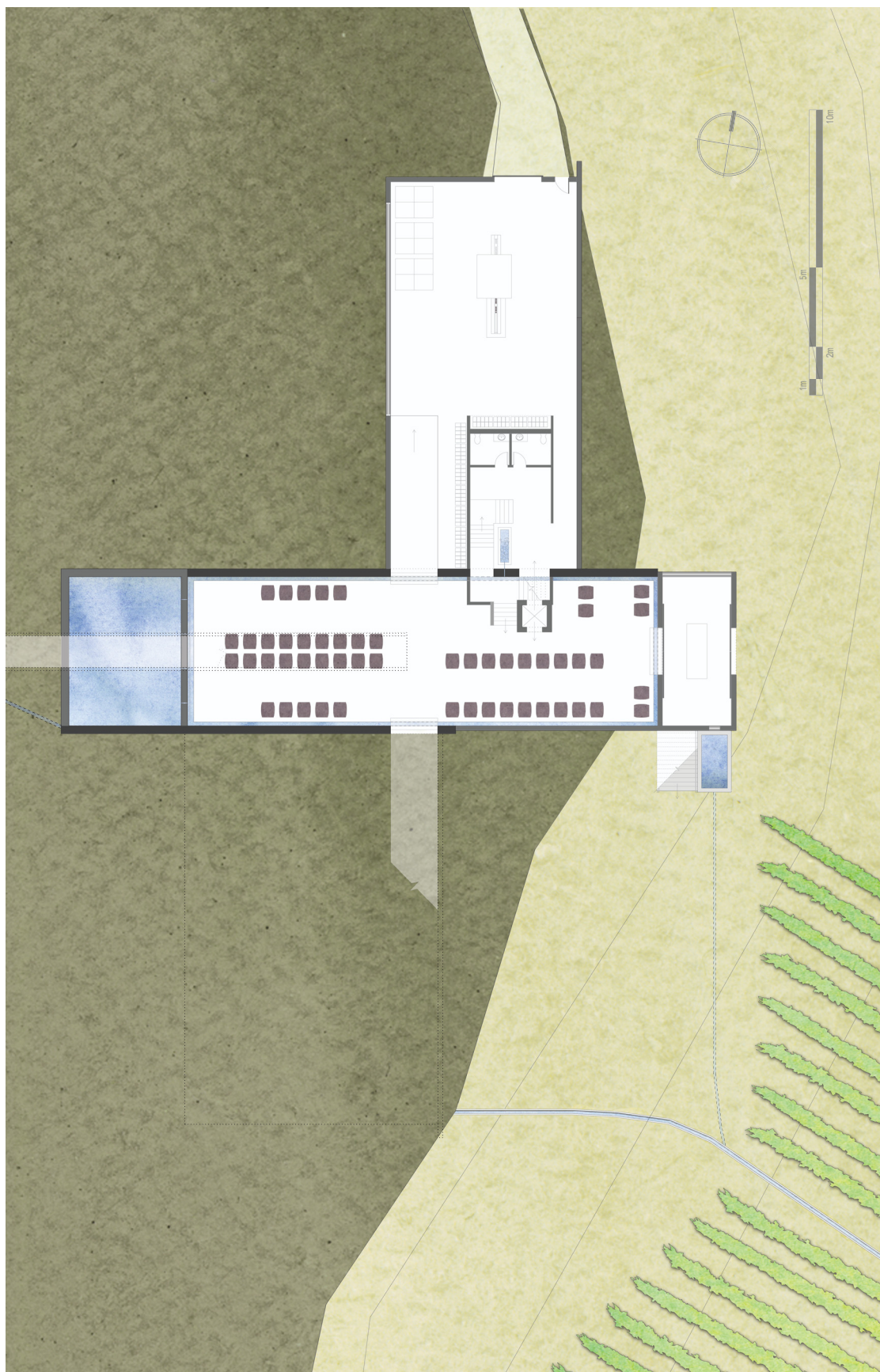
Site micro-watershed. Winery road and water wall shown in grey winding up from main highway along lakeshore. Vineyards between switch-backs of winery road and water-wall. Winery footprint shown in white with green grape arbor covering parking area and water reservoir uphill from winery.



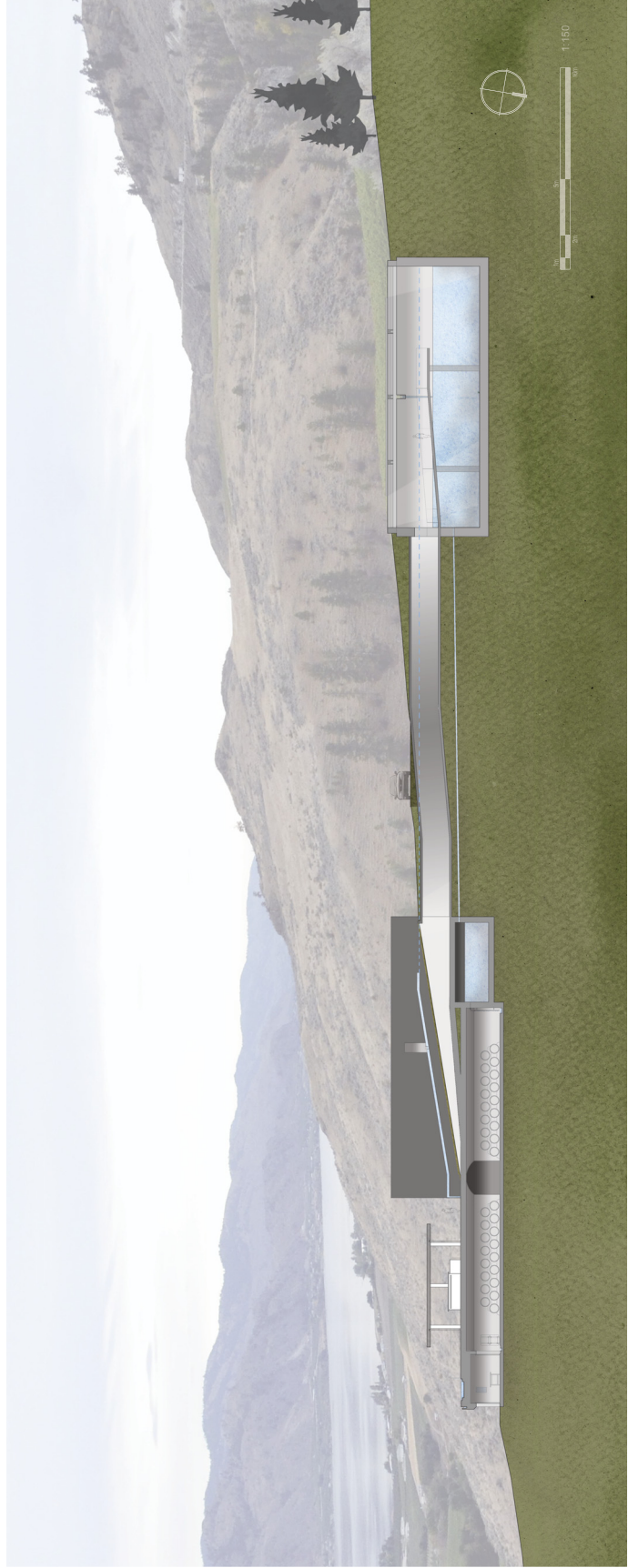
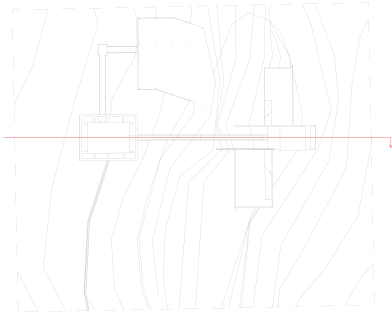
Level 1 Plan - Grape Processing. Purple shading marks areas where grapes are brought into the building and processed.



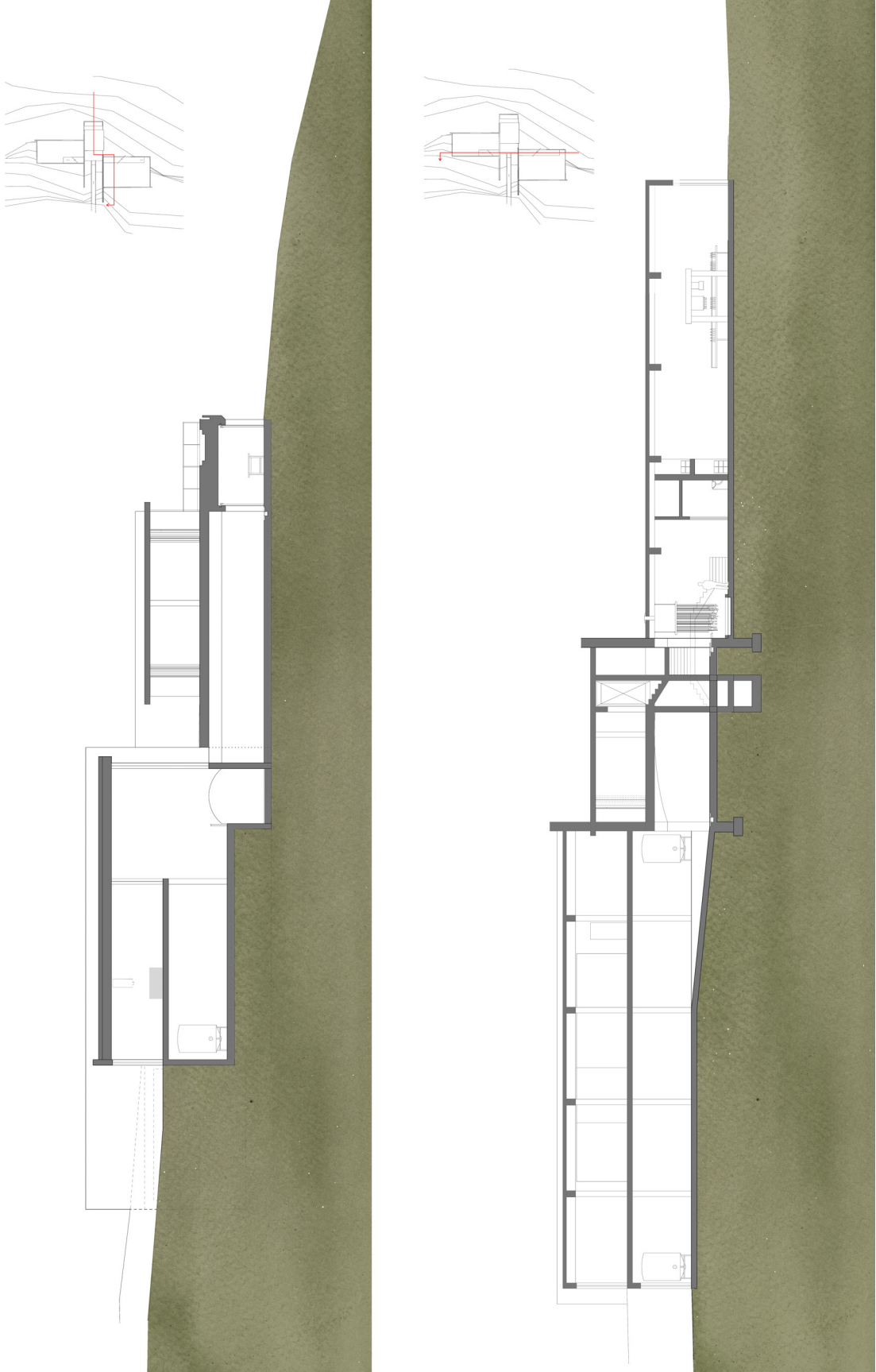
Level 2 Plan - Fermentation and Tasting Room. Purple shading marks fermentation tanks where grape juice transforms into wine.



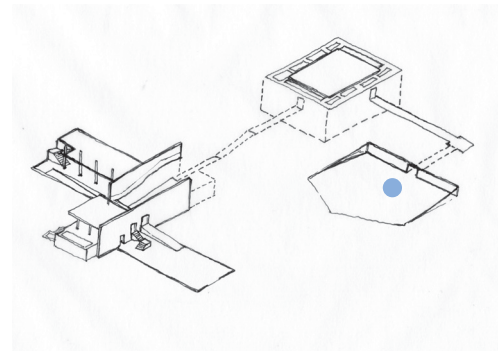
Level 3 Plan - Cellar and Bottling Room. Purple shading marks wine ageing in barrels before bottling.



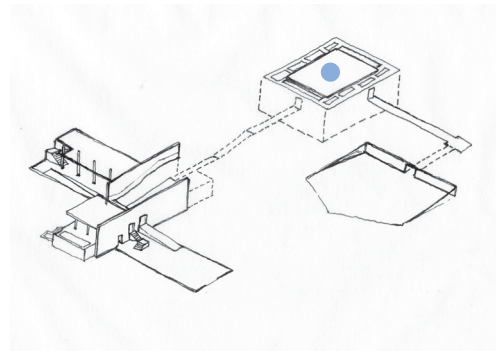
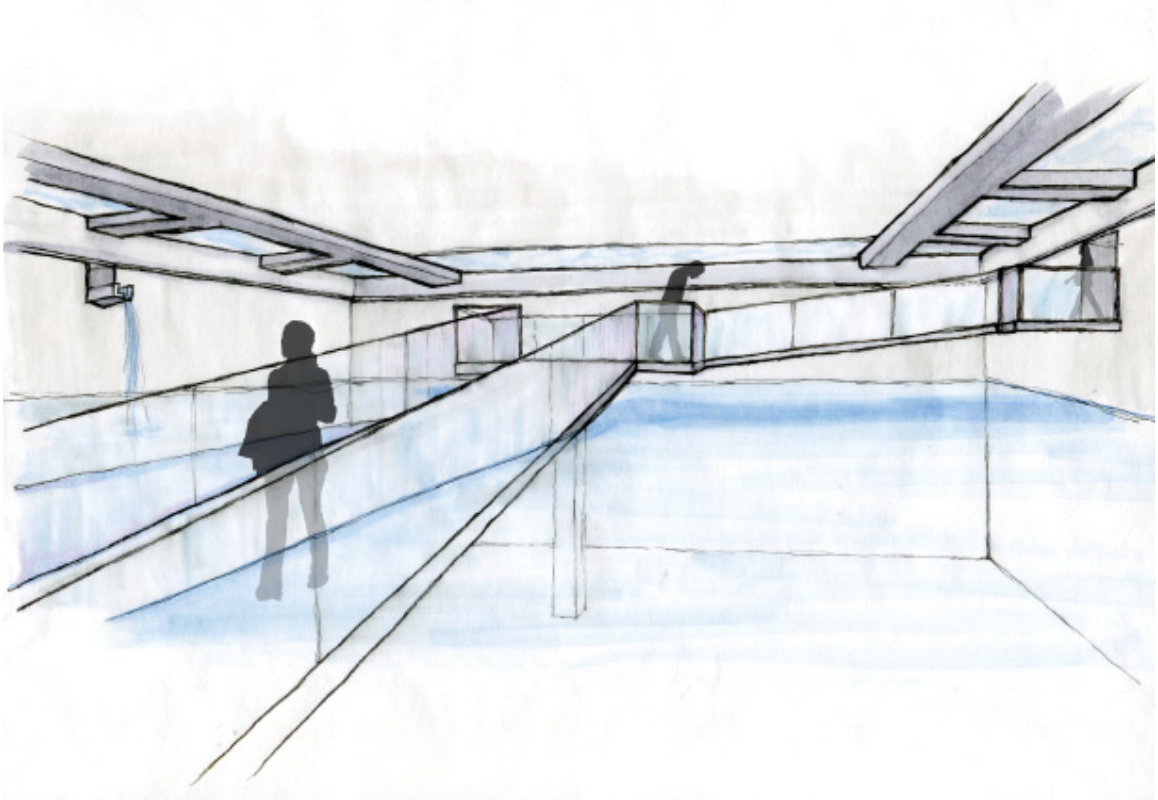
Section through winery and reservoir.



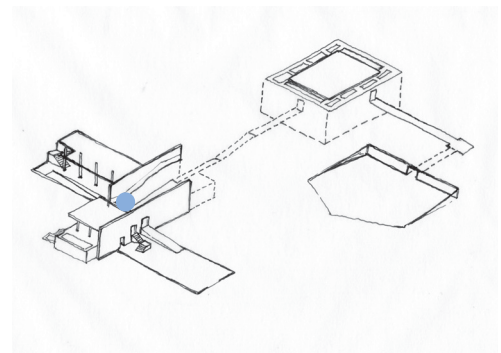
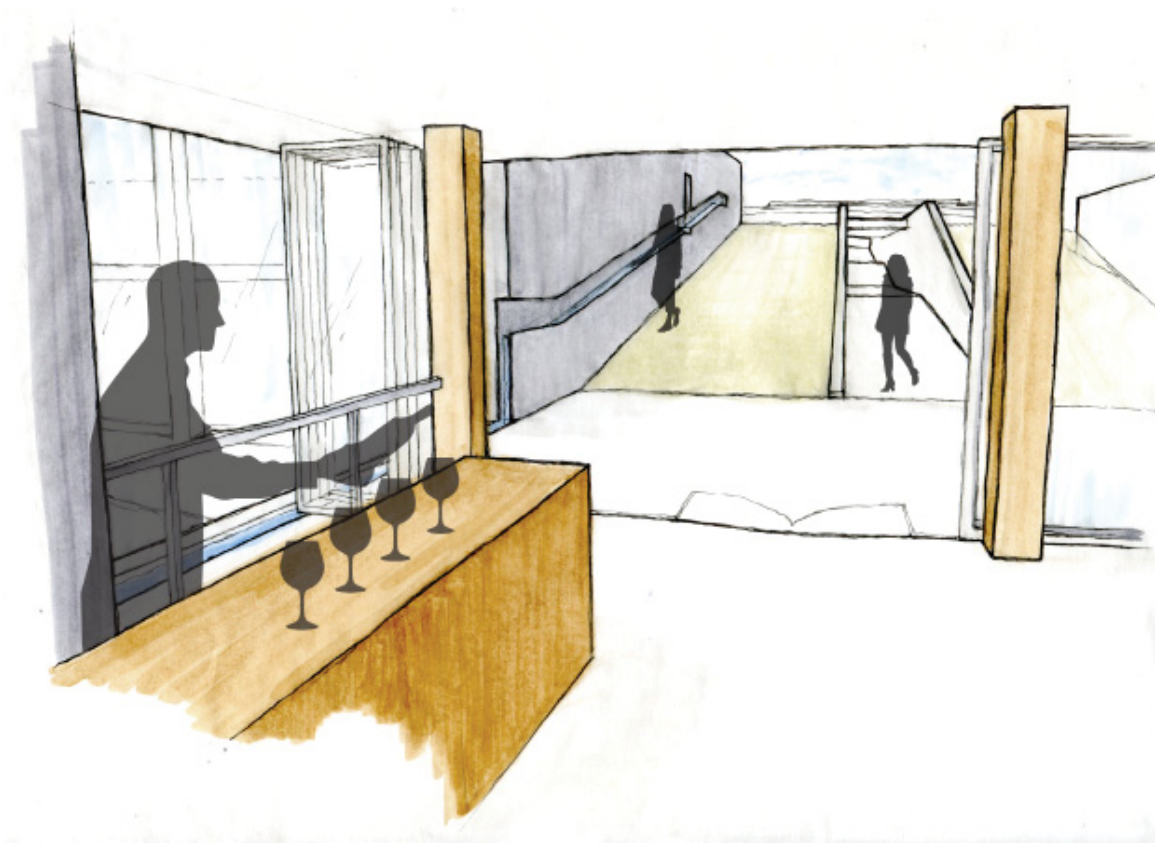
Winery Sections.



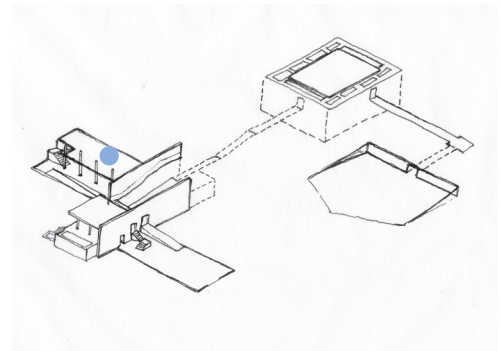
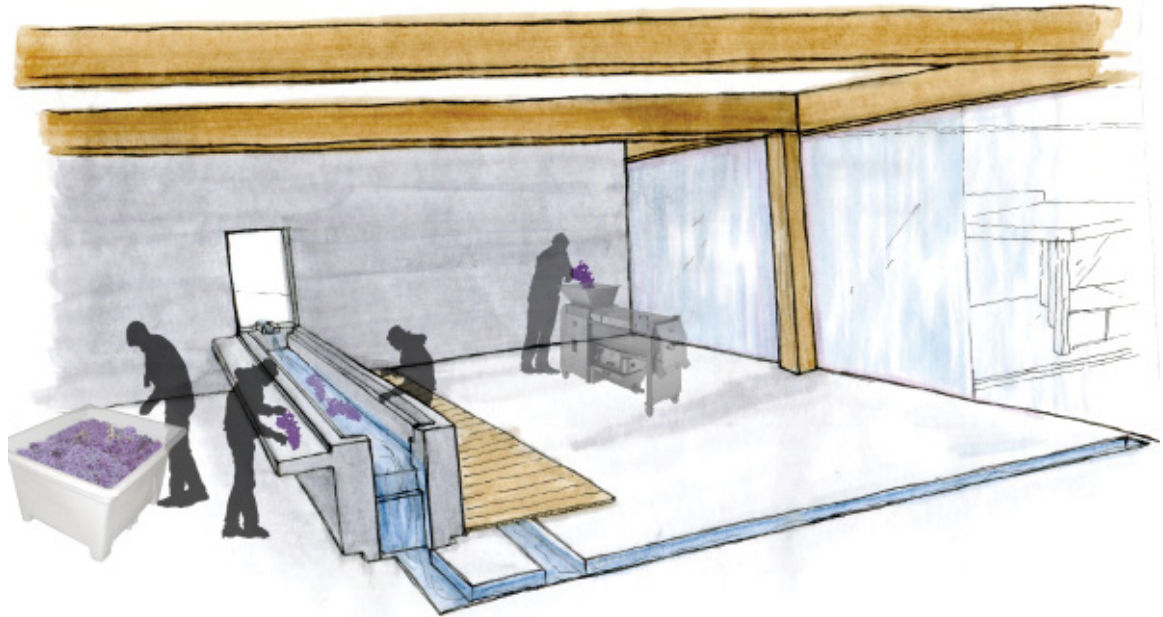
The Grape Arbor. Arriving visitors park their cars in the shade of a grape canopy and pass through the opening in a stone retaining wall drawn by the sound of water in a fountain in a sunlit courtyard.



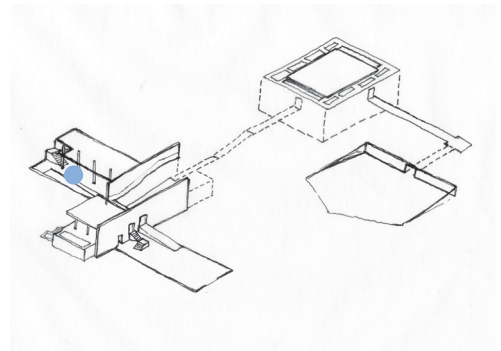
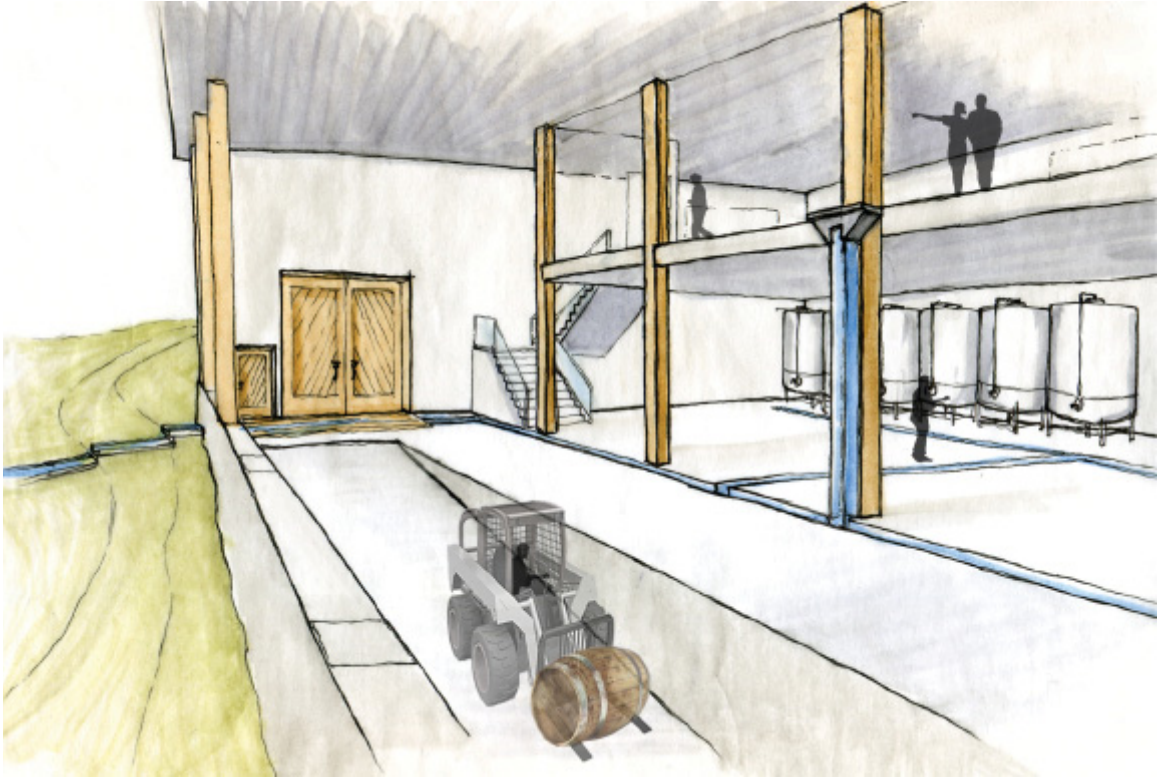
The Reservoir. Visitors enter the reservoir over the water, experiencing the mass of this large body of stored water. This provides a visual quantification of the amount of water required to run a winery.



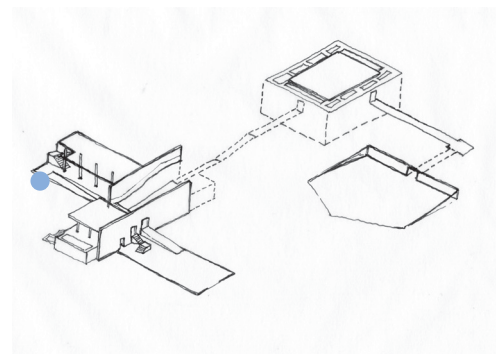
The Water Wall. Emerging from the tunnel that leads from the reservoir, visitors are able to hear the sound of water as it flows through a channel recessed in the wall. This channel runs at railing height encouraging visitors to touch and interact with the water. The channel feeds a reflecting pool which is overlooked by the Tasting Room.



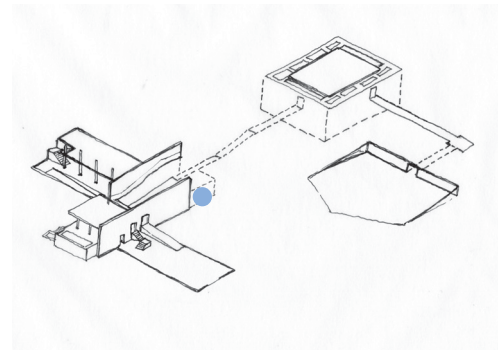
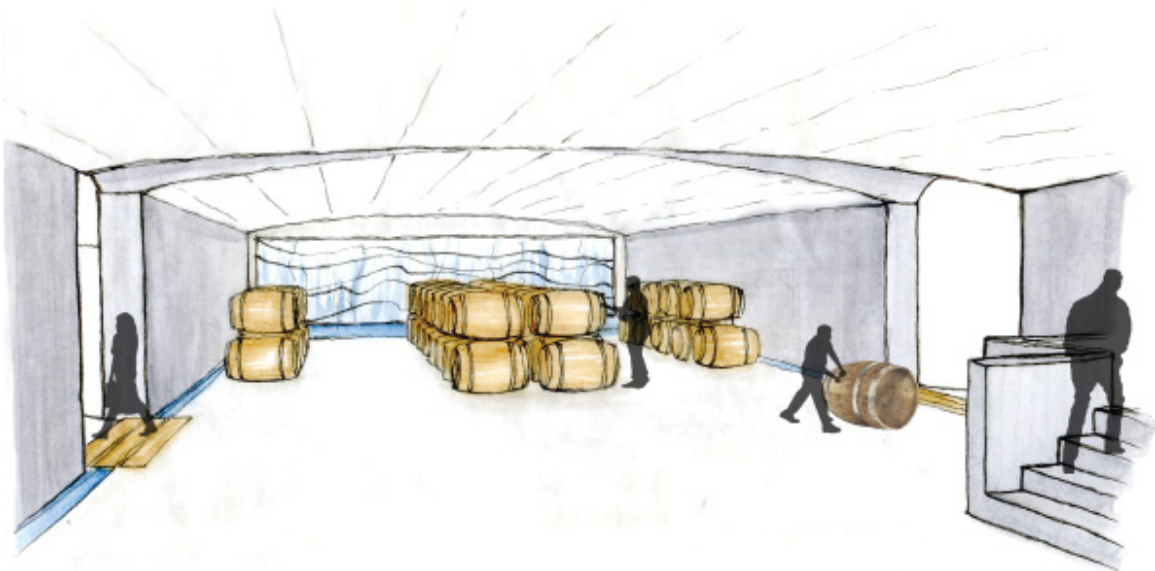
The Wash Basin. On a tour of the winery visitors are first brought to the Processing level of where they can observe grapes being brought into the winery and washed in a large trough-like basin before they are crushed and pressed to start the winemaking process. The wash basin is fed by the recessed channel in the Water Wall which the visitors passed on their way to enter the Tasting Room.



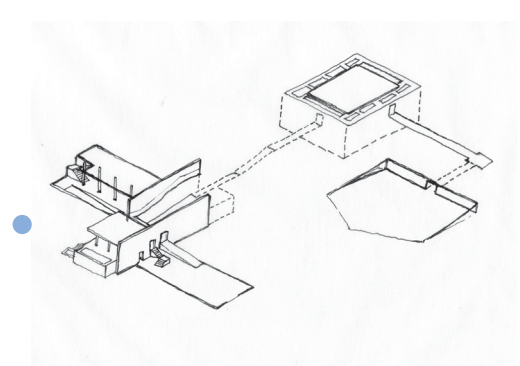
The Water Shaft. Descending to the next level visitors can watch as water from the wash basin on the Processing level is emptied and drops through a glass shaft into drainage trenches in the floor beneath their feet. These trenches collect wastewater used in the rinsing of fermentation tanks and transports it to an exterior channel which leads down to the vineyards for irrigation.



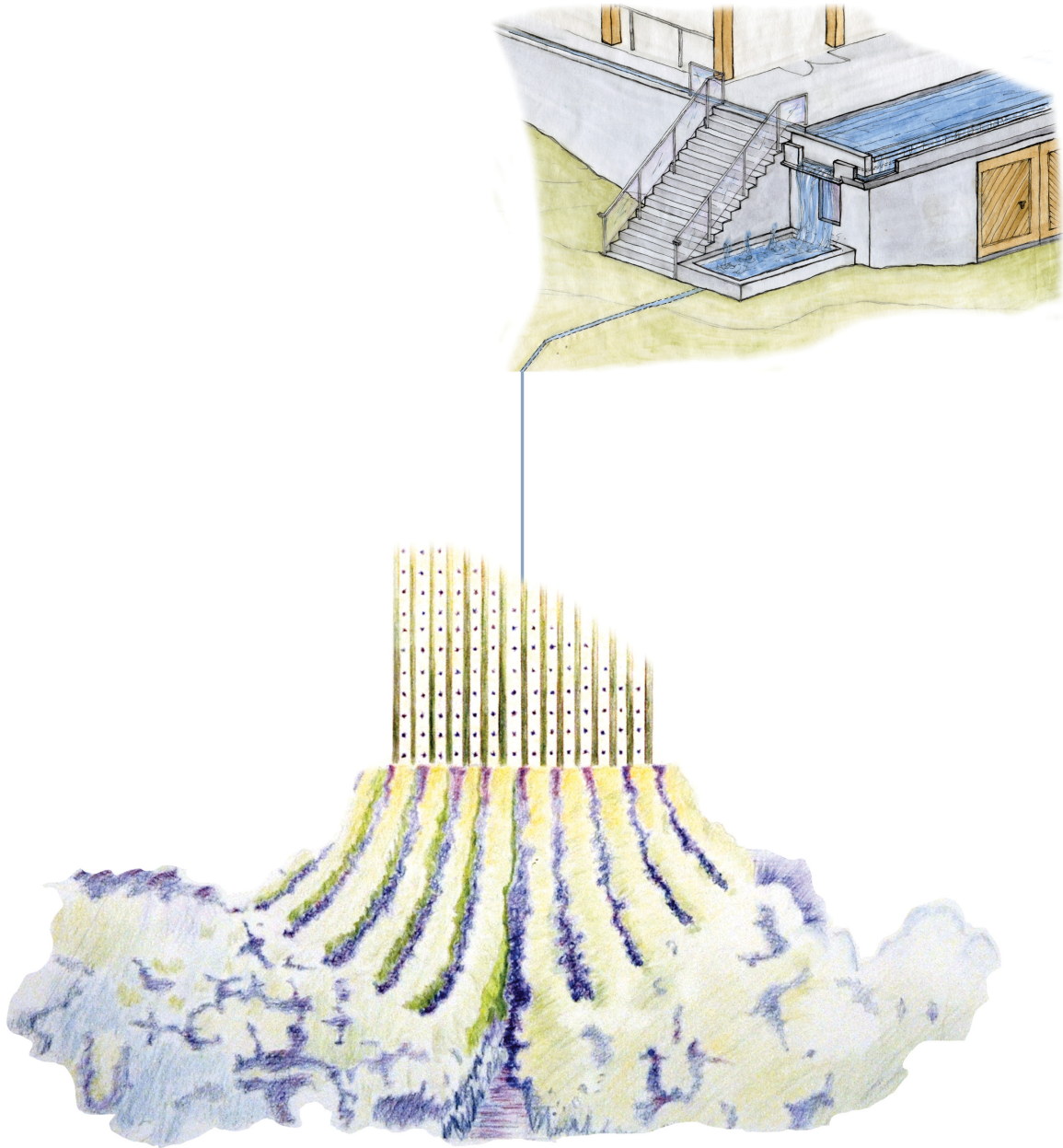
The Stepped Channel. Wastewater from the Processing and Fermentation levels of the winery is recaptured in recessed floor channels. These channels filter out any skins, stems or debris carried by the water before it passes through the wall and into a narrow exterior canal or channel which steps down the hillside leading toward the Demonstration Vineyard.



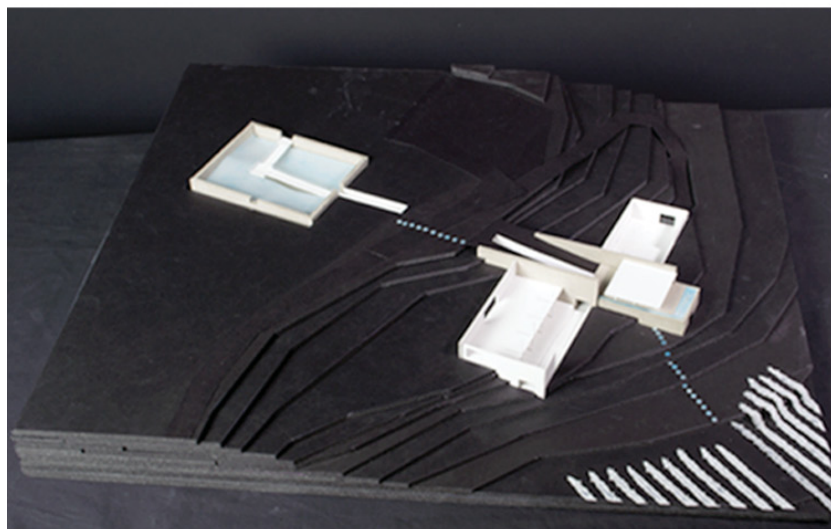
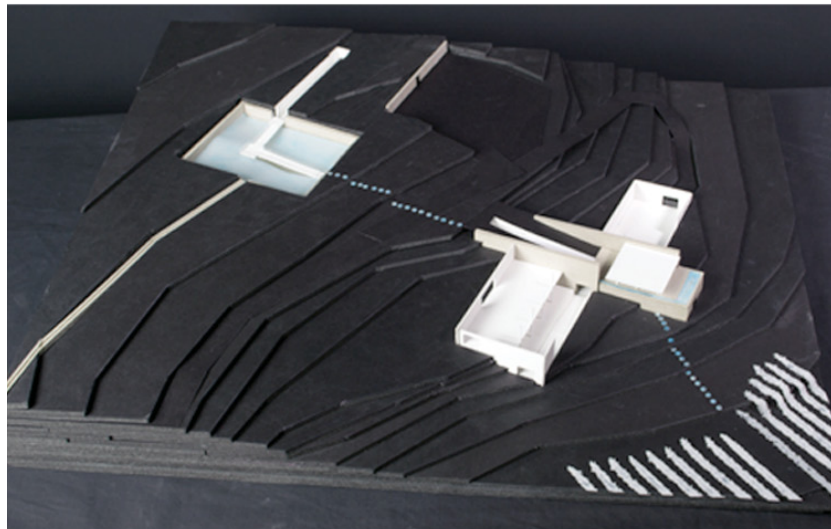
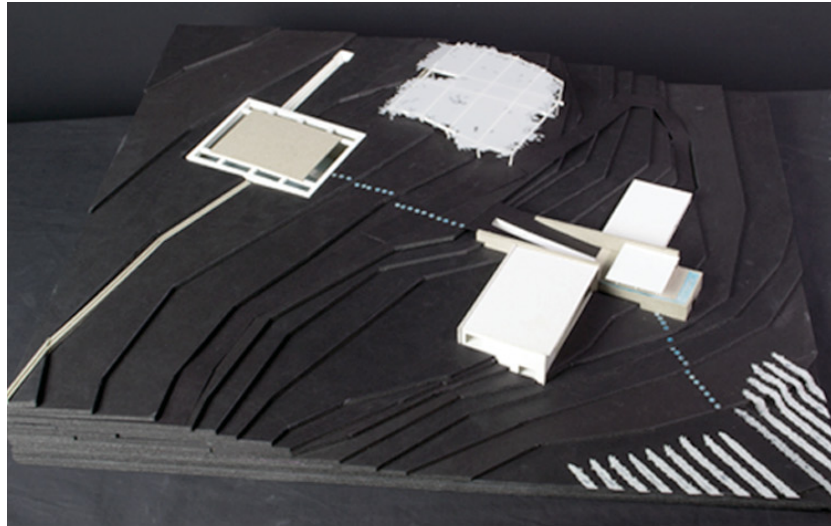
The Trickle Wall. To take advantage of passive cooling the Cellar shares a wall with a secondary reservoir that is attached to the upper end of the building. Here a feature wall is fed by a small amount of water that is piped through the wall from the reservoir. The winemaker is able to control humidity levels and temperature in the Cellar by adjusting the rate of flow at which water is drawn from the reservoir. Water trickles down the feature wall, its path altered by the textured wall surface and falls into an open channel in the floor which runs the perimeter of the room. Over time, the wall will gain a patina which reflects the path of water flow over its surface and offering a sense of process and change over time - elements which are linked to both winemaking and natural flow of water in the landscape.



The Demonstration Vineyard. Sitting close to the building the demonstration vineyard is a part of the wine tour and is planted with selected and feature grape varieties. It is accessible to visitors and overlooks Okanagan Lake and the vineyard terraces below. Divided by a central pathway, the vines lining the path are planted in sunken circular wells and irrigated in a manner similar to the Court of Oranges in Cordoba, by water channels which run along its edges. These channels are fed by filtered wastewater leaving the Processing and Fermentation levels of the winery.



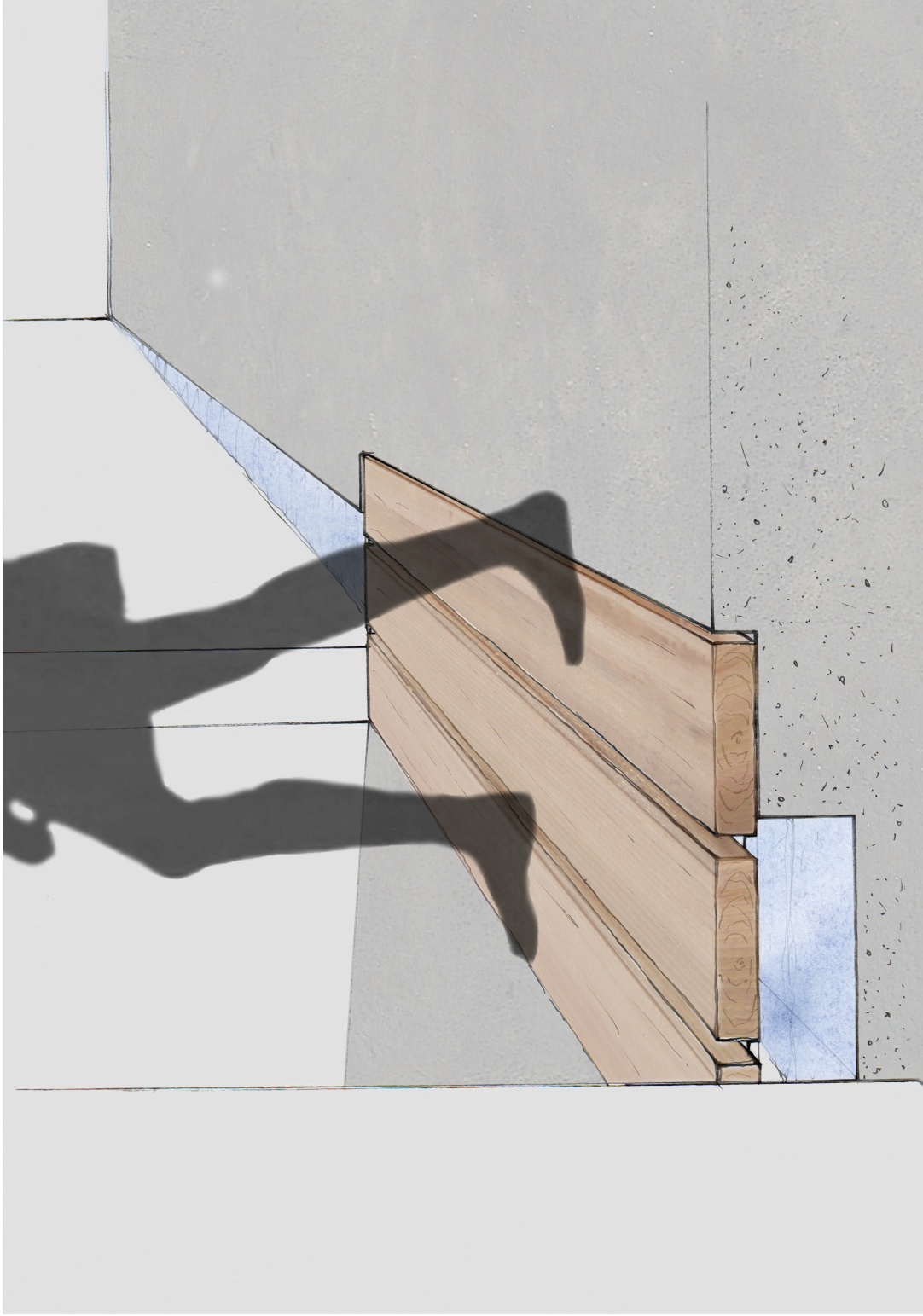
Axonometric section through building and water. After supplying the water features of the building the water is sent to the vineyards to be used for irrigation. Water from the reflecting pool outside of the Tasting Room slips over an infinity edge, is caught by a gutter and flows to feed a fountain pool adjacent to the stairs before flowing through an underground pipe into the vineyards.



Layers of landscape, building and water elements.



View of model looking uphill from vineyards to winery. At the upper level of the image is the roof line of the submerged reservoir which collects and stores water for the site. This view emphasizes the changes in elevation which enable gravity flow to move water from the reservoir down into the building and onward to the vineyards below. The floor levels in the building can also be seen stepping down the hillside and suggest how water flows through the building using the same approach.



Sketch of building and water relationship. A material association is established between cedar boardwalk and the movement of people over water.

CHAPTER 3: CONCLUSION

The popularity and success of Okanagan wineries is a strong indicator that the winemaking industry will continue to grow, as will concern over its intensive water consumption. Current issues of water availability in the Okanagan Valley will only be magnified if the value of water to local culture remains unchanged, and if new approaches to water management aren't implemented.

The flow of water through landscape and architecture is designed to chart the route of water through winery and vineyard, and mark points of celebration with different water experiences. A critique of the intensive use of water in the winemaking process and the cultivation of grapes led to design solutions which both address conservation practices and aim to encourage an appreciation of limited resources. Water conservation is addressed through the design of a re-capture and re-use water system which uses gravity feed and simplicity of design to emphasize the connection between water and the natural landscape.

The architecture of the winery frames particular moments in this water system which celebrates the role water plays at each step in the winemaking process. An appreciation of the magnitude of water consumed in the act of winemaking is communicated to visitors through a gradient of water visibility along the route of procession through the building. The journey begins as the visitor enters the reservoir,


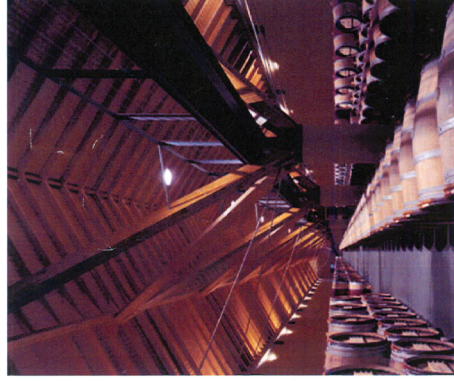
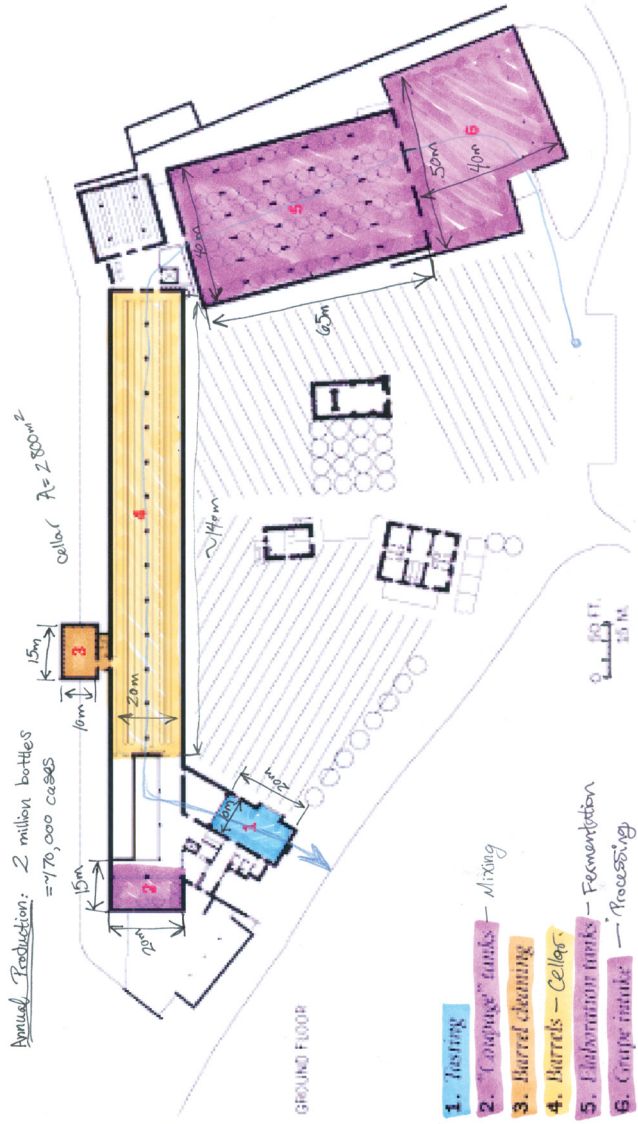
looking down into the depths of its stored water, and ends with a trickle into the vineyards.

Looking back on the historical photos of Summerland's development, it is clear how closely linked the people were to water when it flowed visibly across their landscape in canals and wooden flumes. The great effort that went into procuring water, and the care and appreciation of the landscape Summerland residents invested in the design of their water structures is evidence of the strong cultural value of water that once existed here.

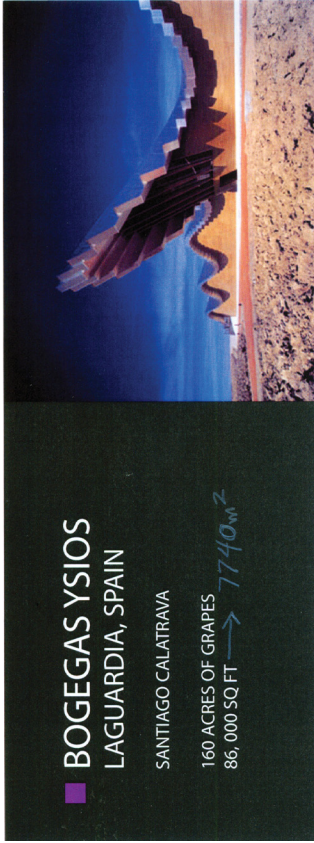
This appreciation has since been hidden by modern systems which lie buried underground and out of sight, taking away individual accountability for water. Revival of this past connection to the earth and thoughtful design which responds to it are necessary at both a local and regional scale in the Okanagan. This is particularly relevant among the many local orchards and wineries which take pride in the practice of cultivating and nurturing produce from the earth. An approach to water management which aims to manage needs and practices rather than supply and source is the underlying idea of this thesis, and one that will become increasingly relevant as clean water becomes a scarce resource.

APPENDIX 1: SIZING PROGRAM SPACES

■ **BODEGAS JULIAN CHIVITE**
 ARINZANO, SPAIN
 JOSE RAPHAEL MONEO ARCHITECTS
 110,000 sq ft → 9,900 m²

Brief case study of Bodegas Julian Chivite Winery in Arinzano, Spain and the sizes and proximities of its programmatic spaces.

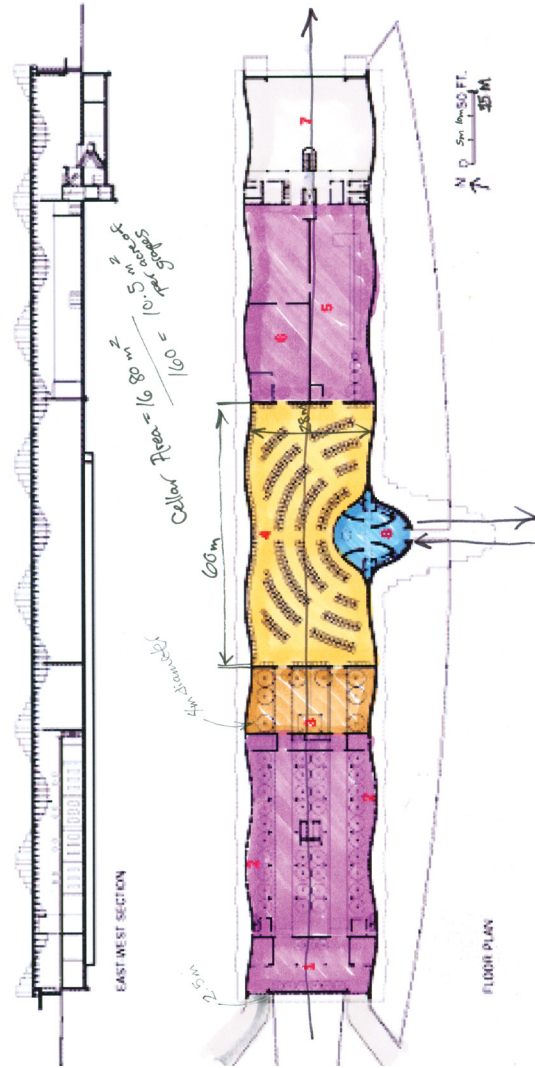


BOGEGAS YSIOS
LAGUARDIA, SPAIN

SANTIAGO CALATRAVA

160 ACRES OF GRAPES
86,000 SQ FT → 7740m²

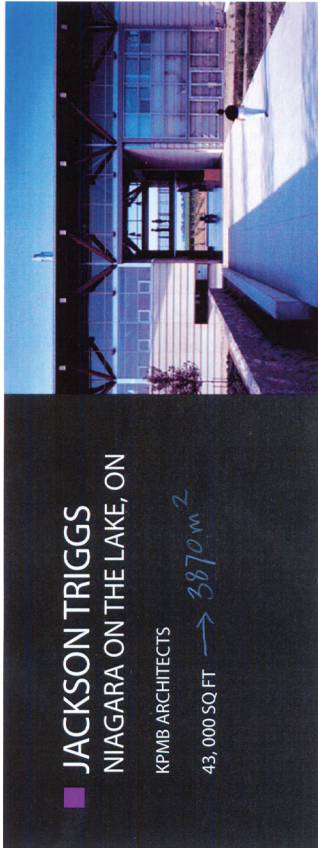
I have 52 acres of grapes
↳ 540m² of cellar area required (Minimum)



- 1. Grape intake
- 2. Production
- 3. Barrel cleaning
- 4. Storage
- 5. Bottling
- 6. Bottle storage
- 7. Shipping
- 8. Visitors' lobby

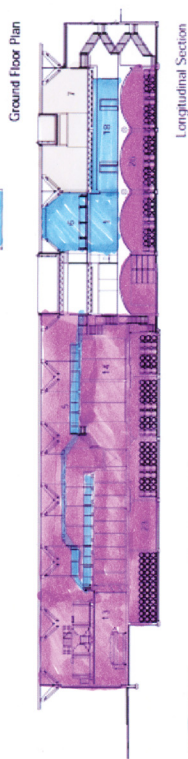
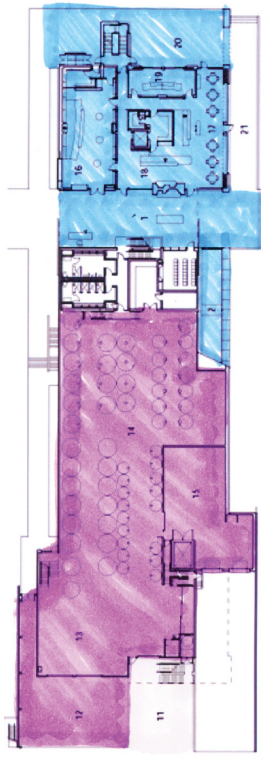
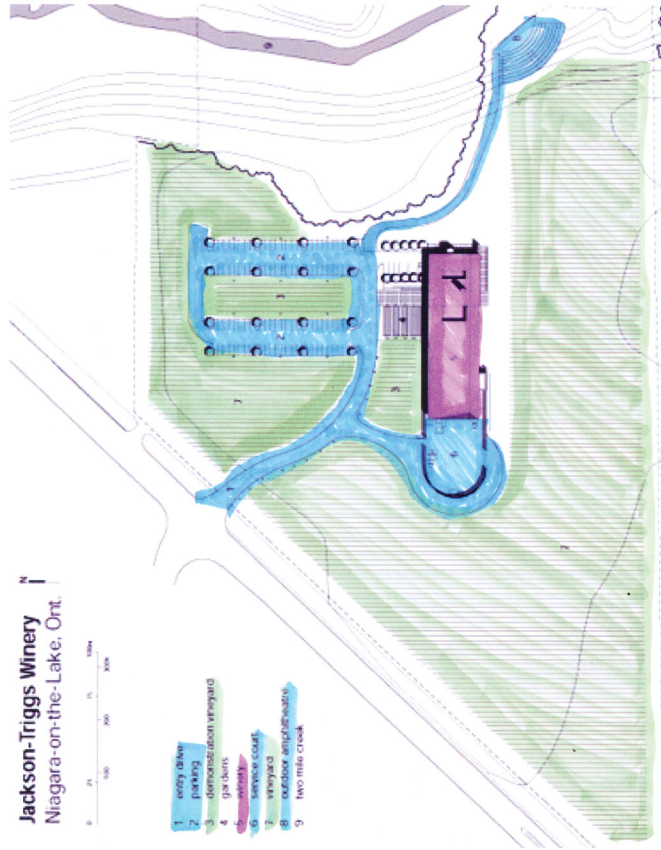


Brief case study of Bodegas Ysios Winery in Laguardia, Spain and the sizes and proximities of its programmatic spaces.

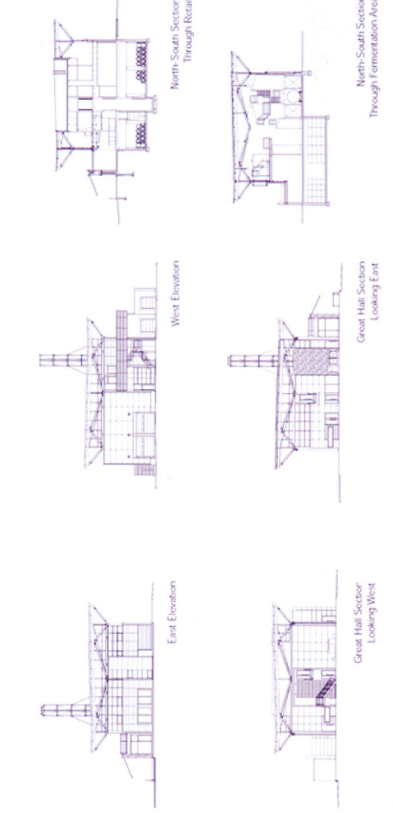


JACKSON TRIGGS
NIAGARA ON THE LAKE, ON

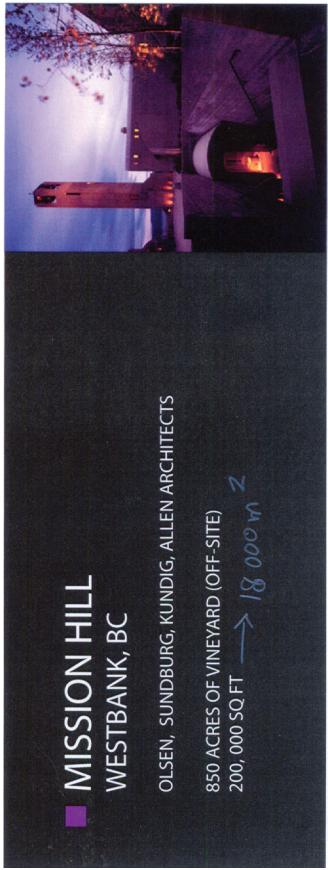
KPMB ARCHITECTS
 43,000 SQ FT → 3870 m²



- 11 service court
- 12 parking area
- 13 reception area
- 14 demonstration area
- 15 retail shop
- 16 cafe
- 17 office / administration
- 18 boardroom / dining
- 19 lounge
- 20 receive lounge & tasting
- 21 cafe terrace
- 22 winemaker's office & laboratory
- 23 winery office
- 24 barrel washing
- 25 winery
- 26 winery / storage
- 27 unexcavated
- 28 staff lounge



Brief case study of Jackson Triggs Winery in Niagara, Ontario and the sizes and proximities of its programmatic spaces.

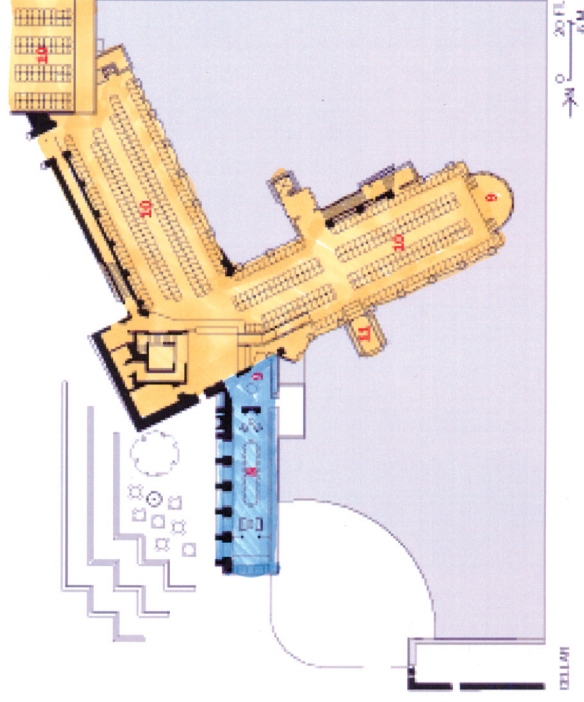
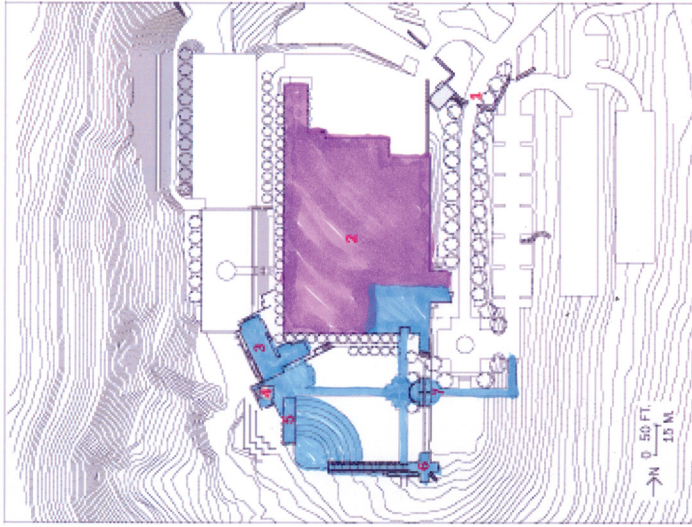


**MISSION HILL
WESTBANK, BC**

OLSEN, SUNDBURG, KUNDIG, ALLEN ARCHITECTS

850 ACRES OF VINEYARD (OFF-SITE)

200,000 SQ FT → 18,000 m²



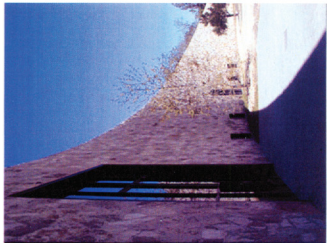
Brief case study of Mission Hill Winery in the Okanagan Valley, British Columbia and the sizes and proximities of its programmatic spaces.

QUINTESSA WINERY
RUTHERFORD, CALIFORNIA

WALKER WARNER ARCHITECTS

Winery = 27,000 sq ft → 2,420 m²
Winery caves = 15,000 sq ft → 1,350 m²
Office Building = 4,800 sq ft → 432 m²

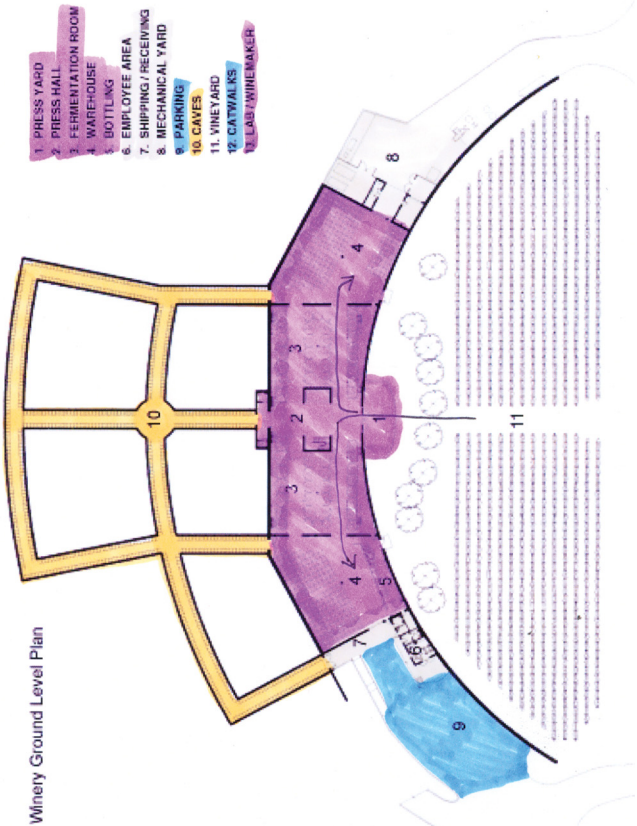
Total: 42,120 m²
16,800 sq ft



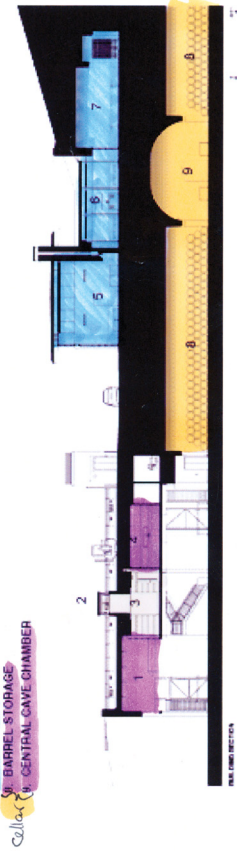
Annual Production:
180,000 gallons of red wine

Winery Ground Level Plan

- 1. PRESS YARD
- 2. PRESS HALL
- 3. FERMENTATION ROOM
- 4. WAREHOUSE
- 5. BOTTLING
- 6. EMPLOYEE AREA
- 7. SHIPPING/RECEIVING
- 8. MECHANICAL YARD
- 9. PARKING
- 10. CAVES
- 11. WINEYARD
- 12. CATWALKS
- 13. LAB/WINEMAKER



- 1. FERMENTATION ROOM
- 2. CRUSH TERRACE
- 3. MEETING ROOM
- 4. WINEMAKING LABORATORY
- 5. LOBBY
- 6. TASTING ROOM
- 7. TASTING CAVE
- 8. BARREL STORAGE
- 9. CENTRAL CAVE CHAMBER



Brief case study of Quintessa Winery in Rutherford, California and the sizes and proximities of its programmatic spaces.

PROGRAM CALCULATIONS:

Jan 23rd 2012.

- BODEGAS YSIOS, SPAIN
 - ↳ Santiago Calatrava
 - 7740m²

- Grape Intake → 250m²
- Production → 1000m²
- Barrel Cleaning → 375m²
- Cellar → 1680m²
- Bottling → 1000m²
- (+ Bottle Storage)
- Shipping → 625m²
- Visitor's Lobby → ~177m²

- JACKSON TRIGGS, NIAGARA
 - ↳ KPMB
 - 3870m²

- WINERY → ?
 - Pressing Area
 - Crushing Area
 - Fermentation Area
 - Storage
 - Wine maker's office / laboratory
 - Cellar
 - Wine Library
 - Barrel Washing
- PUBLIC → ?
 - Great Hall
 - Viewing Platform
 - Production Catwalks
 - Terrace
 - Lounge + Tasting Rm
 - Cafe
 - Retail Shop
 - Wine Bar
 - Tasting Terrace
- STAFF → ?
 - Offices + Administration
 - Boardroom / Dining
 - Staff Lounge

- MISSION HILL, OKANAGAN
 - ↳ Olson, Sundburg, Kundig + Allen
 - 18 000m²

- PUBLIC → ?
 - Entry Gate + Arch
 - Bell Tower
 - Loggia
 - Tasting Terrace
 - Amphitheatre
 - Reception
 - Media
 - Dining
 - Tasting
- WINERY → ?
 - Production
 - Offices
 - Cellar
 - Wine Vault
 - Kitchen

Approximate areas of program spaces and overall size of case study wineries were made to help inform the selection and sizing of necessary program spaces to be included in my design.

- BODEGAS JULIAN CHIVITE, SPAIN

↳ Jose Raphael Moneo
9900 m²

- Tasting → 200 m²
- "Coupage" Tanks → 300 m²
- Barrel Cleaning → 150 m²
- Cellar → 2800 m²
- Fermentation Tanks → 2600 m²
- Grape Intake + Processing → ~1800 m²

- QUINTESSA WINERY, CALIFORNIA

↳ Walker Warner
4212 m²

WINERY → 2420 m²
CELLAR → 1350 m²
OFFICES → 432 m²

- PROCESSING:

- Press Yard (Exterior Space/Terrace)
- Press Hall
- Fermentation Room
- Warehouse
- Bottling

- Cellar / Caves

- PUBLIC:

- Tasting Room
- Tasting Cave
- Lobby
- Catwalks
- Parking

- SUMAC RIDGE, SUMMERLAND

- PARKING → ~ 2600 m²
- PROCESSING → ~ 2275 m²
- TASTING + RETAIL → ~ 375 m²
- VINEYARDS → ~ 30 000 m²
(ON SITE)
- OTHER BUILDINGS → Offices, Admin,
Wine Lab, Residence,
Cellar?
① 300 m²
② 200 m²
③ 375 m²
- SHED → ④ 150 m²

WHITELINES

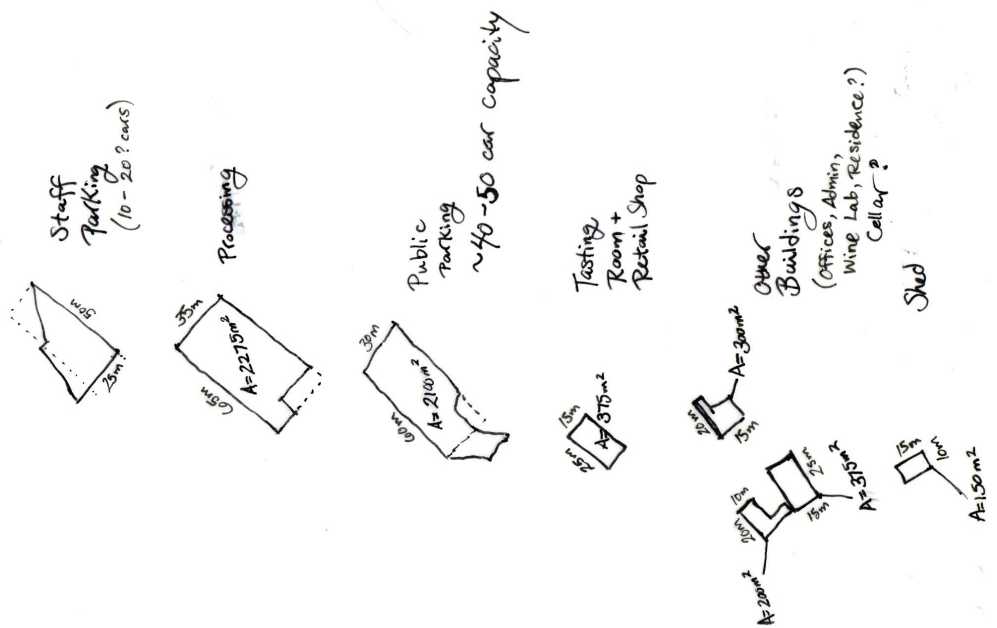
© 2015 Whitelines LLC. All rights reserved. www.whitelines.com

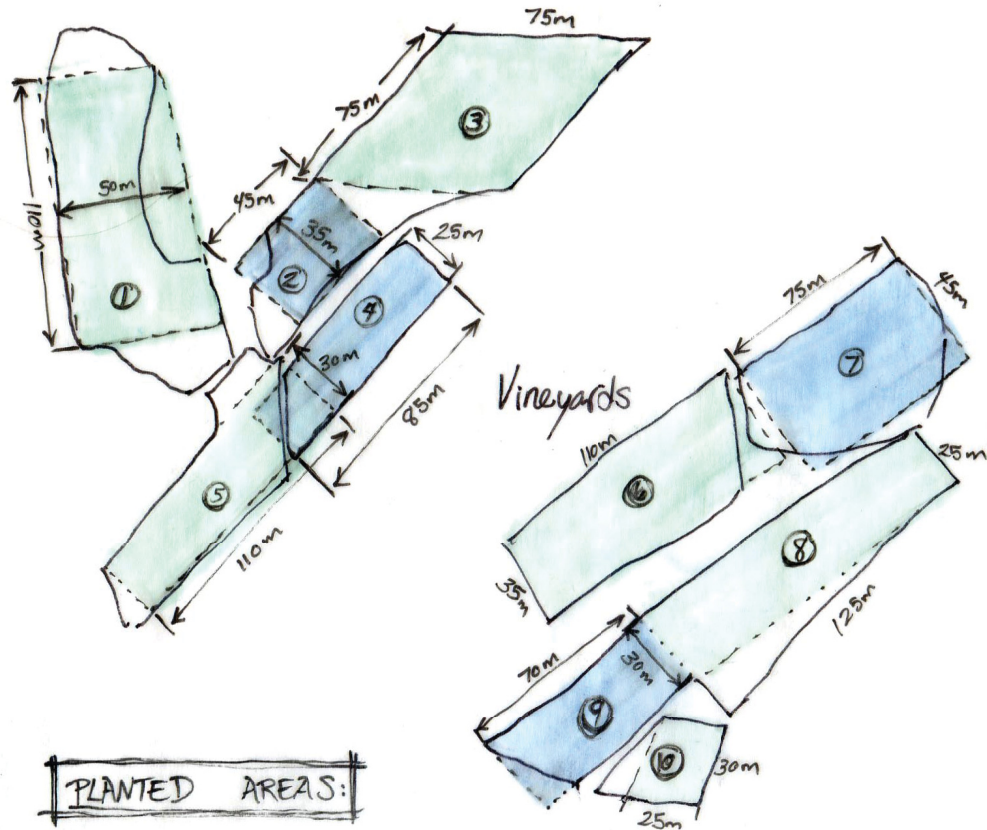
Approximate areas of case study program spaces (continued).



Sumac Ridge Winery is a very local case study which can be found in Summerland just south of the chosen project site. Its annual production level of wine was similar to what could be produced by the vineyards on my site. Approximate determination of program space sizes is based on calculations from this image and a visit to the winery in October 2012. Sumac Ridge purchases many of the grapes it uses to make wine from local growers so the calculated vineyard area from this image is not representative of the program space in the winery required to reach its production levels.

SUMAC RIDGE:





PLANTED AREAS:

① $A = 5500 \text{ m}^2$

② $A = 1575 \text{ m}^2$

③ $A = 5625 \text{ m}^2$

④ $A = 2125 \text{ m}^2$

⑤ $A = 3300 \text{ m}^2$

⑥ $A = 3850 \text{ m}^2$

⑦ $A = 3375 \text{ m}^2$

⑧ $A = 3125 \text{ m}^2$

⑨ $A = 2100 \text{ m}^2$

⑩ $A = 750 \text{ m}^2$

TOTAL: $29\,425 \text{ m}^2$

$\hookrightarrow \sim 30\,000 \text{ m}^2 = 3 \text{ hectares}$

* Production = Approx 50 000 cases annually
(not all grapes grown on site)

Approximate dimensions and total areas of vineyard and program spaces at Sumac Ridge Winery in the Okanagan. Green shading represent areas planted with vineyards while blue shading represents program spaces associated with the winery.

PROGRAM OUTLINE:

Jan 23rd, 2012.

• WINERY:

- Grape Intake (Pressing Area, Crushing Area, Fermentation)
+
Production 1250 to 1800m²
- Barrel Cleaning 150 to 375m²
- Cellar (~10.5m² required per acre of grapes) 540 to 1500m²
- Bottling + Bottle Storage 300 to 1000m²
- Visitors (Tasting Room/Lounge, Retail Shop) 180 to 375m²
- Staff (Offices/Admin, Lounge, Wine maker's Lab) 200 to 430m²
- Parking approx 2600m²
(50+ cars?)

• VINEYARDS:

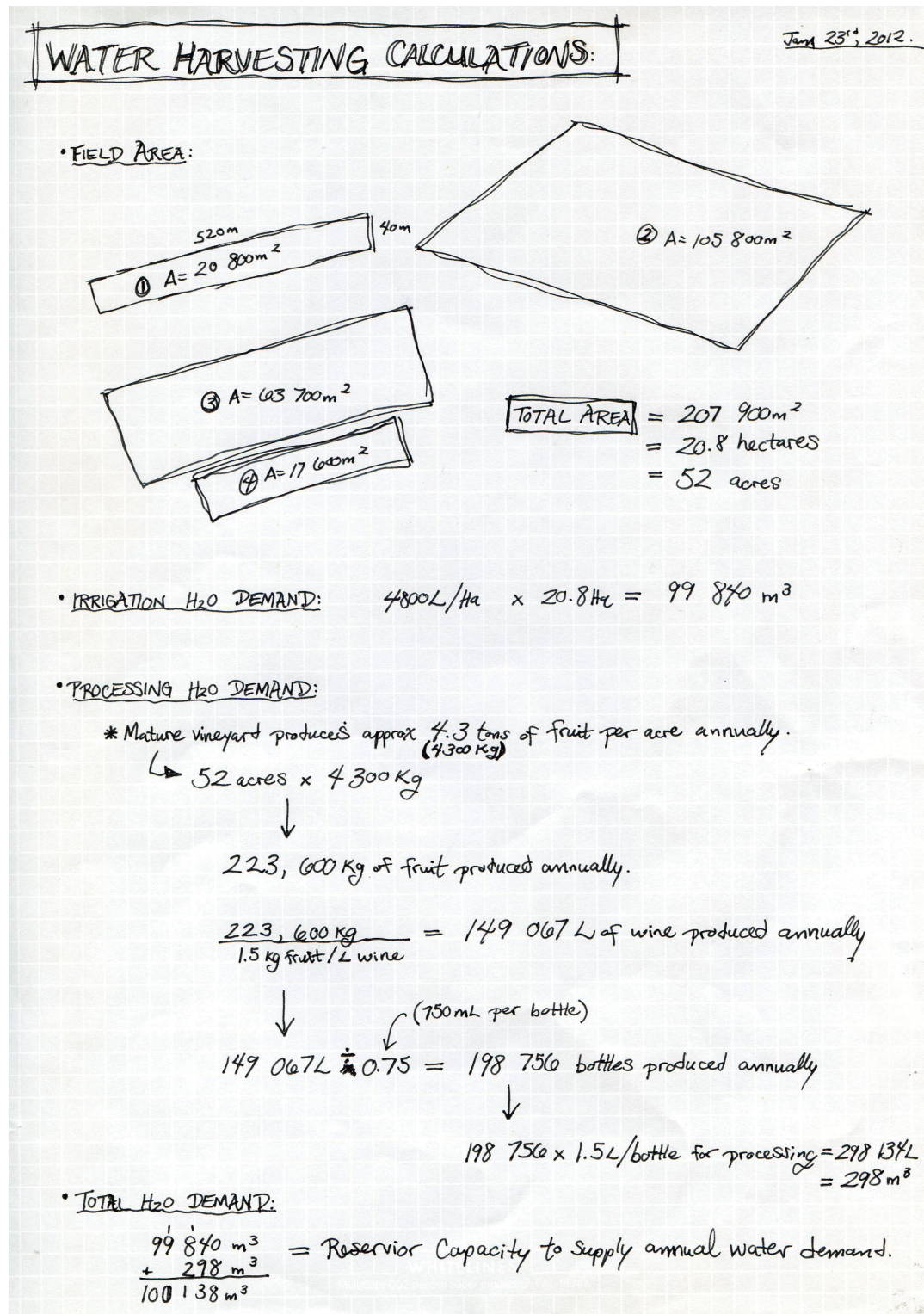
- Approx 8 fields down 4 to 8 terraces 52 acres
or 20.8 Hectares

• WATER RESERVIOR:

- Capacity of 105,000m³ if intention is to supply full annual water demand.
- Treatment Pond → to hold minimum of 300m³ (annual re-capture of processing water). To be aerated.

Outline of spaces essential to my design and the approximate areas required for each based on previous case studies.

APPENDIX 2: WATER SUPPLY AND DEMAND CALCULATIONS



Calculated estimates of the water demand required on site for both irrigation and processing of grapes into wine.

SPRINGWATER HARVESTING:

April 9th, 2012.

- * Flow rate of $+0.1 \text{ L/sec}$ from a spring will give approx 3000 L daily (over 15hrs)
 - ↳ Same output at lower flows achieved by adding storage tank!
- * Irrigation requires approx 4800 L/ha annually
- * GPM = gallons per minute

$$Q = -KiA$$

Q = Discharge (m^3/time)
 K = Hydraulic Conductivity (m/time)
 i = Hydraulic Gradient (m/m)
 A = Cross sectional Area (Length \times Width)

- * In Okanagan Valley, groundwater typically flows from South to North
 - ↳ Current rate of groundwater ~~capture~~ capture is approx 30% of natural recharge + groundwater flow through system. (30% is considered sustainable yield of system).

"Improving water management in the Twin Lakes basin will require the progressive adoption of an integrated land use and water management framework that may have voluntary as well as regulatory elements." (TWIN LAKE Aquifer Study, Pg 111)

INFO

NOTES:

- Peruvian Aqueducts (Canta. loc. Aqueduct)

250,000 L req. for 52ha annual irrigation

3.5 x 20 x 20m Tank Vol = 1,400m³ OR 1,400,000L

3000L over 15hrs (Rate of 0.1 L/sec)

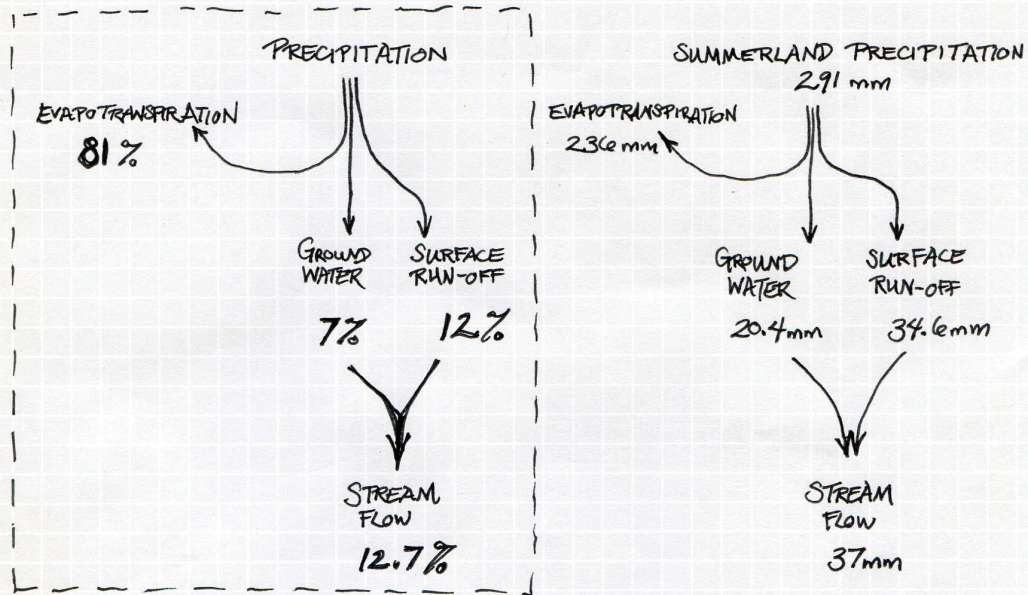
↓
250,000 L could be gathered in 84 days (1,200hrs)

~ 90 days = length of Spring (prime water harvest season).

↳ = 270,000 L From Spring H₂O Harvest

* Tank of 3 x 10 x 10m = 300,000 L storage capacity

• WATER DISTRIBUTION:



• FLOOD WATER HARVESTING:

- Run-off water captured + diverted to storage area
- Ratio catchment: cultivated area \rightarrow More than 10:1 (From Archana "Water Harvesting" p. 10)

Catchment : Cultivated Area

208 Ha : 20.8 Ha

\downarrow
Increase
to 220 Ha to capture
more water

• AVERAGE CEILING HEIGHT + SNOW PACK LEVEL:

<http://www.waterbucket.ca/okw/sites/wbcokw/documents/media/143.pdf>

- Average Elevation of Basin \rightarrow 3,900 ft (1170m)

\downarrow
Above this level, most of the run-off originates from
snow melt.

* Max Elevation on My Site = 9/2 m \therefore no snow pack melt water.

Examination of the viability of water harvesting from precipitation and run-off from spring-time snow-pack melt on site.

June 7th, 2012.

WATER USE ESTIMATE:

IRRIGATION: OUR SITE

- 15 - 20 hectares of vineyards on site (37-50 acres)
- Water NEED = 4,800 m³/Ha

$$15 \text{ Ha} \times 4,800 \text{ m}^3/\text{Ha} = 72,000 \text{ m}^3$$

↳ 72,000,000 L annually

* 1 Ha = 10,000 m² = 2.47 acres

* 1 m³ = 1,000 L

* If 1 km = 100 m then 1 km³ = 100,000 L

Our Winery:

$$72,000,000 \text{ L} + 135,235 \text{ L} = 72,135,235 \text{ L annually}$$

CURRENT PRACTICE: (2001)

- Water USE = ~ 6,389 m³/Ha

$$15 \text{ Ha} \times 6,389 \text{ m}^3/\text{Ha} = 95,848 \text{ m}^3$$

~~95,848,000 L annually~~
 ↳ 95,848,000 L annually

Industry Standard:

$$\begin{aligned} & \cancel{23,848,000 \text{ L}} \\ & 95,848,000 \text{ L} \\ & - 27,135,470 \text{ L} \\ & = \cancel{23,848,000 \text{ L}} \\ & 95,875,470 \text{ L annually} \end{aligned}$$

$$\begin{aligned} & 95,875,470 \text{ L} \\ & - 23,875,470 \text{ L} \\ & = 23,740,235 \text{ L} \\ & \text{Saved annually} \end{aligned}$$

$$95,848,000 \text{ L} - 72,000,000 \text{ L} = 23,848,000 \text{ L Saved.}$$

23,848 m³

* Okanagan Lake: Water Volume = 24.6 Km³

= 24,600,000 ML

= 24,600,000,000 L

* Olympic Swimming Pool Volume = 2.5 ML

= 2,500,000 L

↳ 9.5 Olympic Swimming Pools.

PROCESSING: CURRENT PRACTICE

- 1.5 L of water used to produce (750 mL) / bottle of wine.
- 4.3 tons (4,300 Kg of fruit produced per acre ~ average)

$$4,300 \text{ Kg} \times 37 \text{ acres} = 159,100 \text{ Kg of fruit produced annually}$$

* 1 Kg = 1 L (for Water)

Subtract ~5% for skins, seeds, pulp

$$= 135,235 \text{ Kg of liquid (wine) produced annually}$$

$$= 135,235 \text{ L of wine produced annually}$$

0.75 L per bottle

$$= 180,313 \text{ bottles produced annually}$$

$$\downarrow 1.5 \text{ L for processing} = 270,470 \text{ L}$$

OUR SITE:

* If all water has 2 uses then

$$\frac{270,470 \text{ L}}{2} = 135,235 \text{ L for processing}$$

Estimations of water demand and consumption by my design and conserved water savings based on current practice of Okanagan wineries.

REFERENCES

- Aberdeen, Lady. *Through Canada with a Kodak*. Edinburgh: W.H. White & Co., 1893.
- Bachelard, Gaston. *Water and Dreams: An Essay on the Imagination of Matter*. Translated by Edith R. Farrell. Dallas: Dallas Institute of Humanities and Culture, 1983.
- Bell, Robert A. "J.W. Hughes Harvesting Grapes." *The Names Behind Winemaking in Canada*. *Wines of Canada*, 2010. Accessed June 24, 2012. http://www.winesofcanada.com/history_names.html
- "Bentley Road to Okanagan Lake 4-Laning Project." *BC Jobs and Economy*. August 28, 2010. Accessed February 1, 2012. <http://www.bcjobsandecconomy.gov.bc.ca/tag/transportation/>
- Coffin, David. *Pirro Ligorio: The Renaissance Artist, Architect, and Antiquarian*. University Park, PA: Pennsylvania State University Press, 2004.
- Colby, Bonnie, and George Frisvold. *Adaptation and Resilience: The Economics of Climate, Water and Energy Challenges in the American Southwest*. Washington: Earthscan, 2011.
- Day, Lisa. "Moorish Design in Southern Spain. Designing Urban Agriculture." *Forage Berkely*, 2010. Accessed February 7, 2012. <http://forageberkeley.wordpress.com/2010/02/23/designing-urban-agriculture/>
- Forman, Richard T.T. *Land Mosaics: The Ecology of Landscapes and Regions*. New York: Cambridge University Press, 1995.
- Foster, Sherril. *According to the Giant: A History of Summerland and the Okanagan Valley in British Columbia*. Summerland: Okanagan Annie Productions, 1998.
- Geddes, Duane. "Snow Course Surveys – Key to Water Management." *Summerland Review* 6 (March 9, 1978).
- Google Earth. Summerland, British Columbia (map). Accessed February 16, 2012. <http://earth.google.com/>
- Hayes, Julianna. "BC Wine Country: Vine to Wine." *The Official Wine Tour Handbook to British Columbia*. Tammy Tomiye - eXpose Design Studio. Spring 2011 - Spring 2012.
- Heschong, Lisa. *Thermal Delight in Architecture*. Cambridge: The MIT Press, 1979.
- Hopwood, Rosalind. *Fountains and Water Features*. London: Francis Lincoln Ltd., 2009.

- Iglesias, Ana, Luis Garrote, Francisco Flores and Marta Moneo. "Challenges to Manage the Risk of Water Scarcity and Climate Change in the Mediterranean." *Water Resources Management* 21, no. 5 (2007): 775-788.
- Kerr, Anne M., Edward W. Manning, Jean Seguin, and L. Jane Pelton. "Okanagan Fruitlands: Land-Use Change Dynamics and the Impact of Federal Programs." *Land Use in Canada Series* 26 (March 1985).
- Kirby, Darren. "Thirsk Lake Dam." *Flickr*. May 23, 2010. Accessed June 5, 2012. <http://www.flickr.com/photos/badcomputer/4656653200/>
- Koroscil, Paul M. *The British Garden of Eden: Settlement History of the Okanagan Valley, British Columbia*. Burnaby, BC: Simon Fraser University, 2003.
- Kuschnik, Ellen. Photograph of Trevi Fountain, Rome. March 2002.
- Lazzaro-Bruno, Claudia. "The Villa Lante at Bagnaia: An Allegory of Art and Nature." *The Art Bulletin* 59, 4 (Dec., 1977): 553-560.
- Lippard, Lucy. *The Lure of the Local: Senses of Place in a Multicentered Society*. New York: New Press, 1997.
- Livingston, Morna. *Steps to Water: The Ancient Stepwells of India*. New York: Princeton Architectural Press, 2002.
- Macy, Christine, and Sarah Bonnemaïson. *Architecture and Nature: Creating the American Landscape*. New York: Routledge, 2003.
- McIver, Susan. "Thirsk Dam Spectacular for Grand Opening." *Penticton Herald* (May 23, 2008).
- Moore, Charles, and Jane Lidz. *Water and Architecture*. New York: H.N. Abrams, 1994.
- Newton, Norman. *Design on the Land: The Development of Landscape Architecture*. Cambridge, Mass.: Belknap Press of Harvard University Press, 1971.
- Okanagan Lake Tributaries*. Vernon, BC: GEM Mapping and Design.
- "Okanagan Water Supply & Demand Project." Okanagan Basin Water Board. Accessed November 23, 2011. <http://www.obwb.ca/wsd/data/water-management-use>.
- Pandya, Yatin. *Concepts of Space in Traditional Indian Architecture*. Ahmedabad: Mapin Publishing, 2005.
- "Report Card on our Water Treatment Plant." *District of Summerland Newsletter*, Summerland Archives. Dec. 2010.

- Rinne, Katherine. "Fluid Precision: Giacomo della Porta and the Acqua Vergine Fountains of Rome." In *Landscapes of Memory and Experience*, edited by Jan Birksted, 183-201. New York: Spon Press, 2000.
- _____. *Architecture for a Hybrid Landscape: Proposals for the California Delta*. San Francisco: California College of the Arts, 2009.
- _____. *The Waters of Rome*. New Haven: Yale University Press, 2010.
- Riordan, Sarah. "The History of Summerland's Water System." *Summerland Heritage Advisory Committee*, Aug., 1986.
- Rogers, Robert. *Report of Proceedings of the Sixth Annual Convention of the Western Canada Irrigation Association*. Ottawa: Government Printing Bureau, 1912.
- Ryan, Zoe. *Building with Water: Concepts, Typology, Design*. Basel: Birkhäuser, 2010.
- Scalza, Remy. "Tourism Threatens Water Security in Okanagan." *BC Business Online*. August 4, 2010. Accessed November 3, 2011. <http://www.bcbusinessonline.ca/print/bcb/business-sense/2010/08/04/tourism-threatens-water-security-okanagan>
- Schama, Simon. *Landscape and Memory*. New York: Alfred A. Knopf, 1995.
- Schreier, Hans, Les Lavkulich, and Sandra Brown. *Real and Virtual Water and Water Footprints: A Comparison between the Lower Fraser Valley and the Okanagan Basin*. Toronto, ON: Walter and Duncan Gordon Foundation, 2007.
- "Spain-Cordoba-Patio de los Naranjos." *Drip | Dry : Systems That Seep*. November 16, 2010. Accessed April 9, 2012. <http://systemsthatseep.wordpress.com/2010/11/16/spain-cordoba-the-patio-de-los-naranjos/>
- Spirn, Anne Whiston. *The Language of Landscape*. New Haven: Thomson-Shore Inc., 1998.
- Stanwick, Sean, and Loraine Fowlow. *Wine by Design*. West Sussex, England: Wiley, 2006.
- Stauffer Solomon, Barbara. *Green Architecture and the Agrarian Garden*. New York: Rizzoli International Publications, 1988.
- Surtees, Ursula. *Sunshine and Butterflies: A Short History of Early Fruit Ranching in Kelowna*. Kelowna: Regatta City Press, 1979.
- Symmes, Marilyn. *Fountains: Splash and Spectacle*. New York: Rizzoli International Publications Inc., 1998.
- Udall, Brad. "'When will the Reservoirs Run Dry?': The Looming Water Crisis in the American Southwest." Lecture given at Department of Geosciences at the University of Arizona, April 15, 2010.

Vidal de La Blache, Paul. *Principles of Human Geography*. New York: H. Holt and Company, 1926.

Wendenburg, Mark. Conversation with winemaker for Blasted Church Vineyards, Okanagan Falls, BC. October 17, 2011.