6-11-2014

Mission San Jose Well Initiative

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SANTA CLARA UNIVERSITY

Department of Civil Engineering

I hereby recommend that the
SENIOR DESIGN PROJECT REPORT
prepared under my supervision by

MARY FORAN
NONDA KOZAS
&
DANIEL LAFRANCHI

entitled

MISSION SAN JOSE WELL INITIATIVE

be accepted in partial fulfillment of the requirements for the degree of

BACHELOR OF SCIENCE IN CIVIL ENGINEERING

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SANTA CLARA UNIVERSITY
THE JESUIT UNIVERSITY IN SILICON VALLEY

MISSION SAN JOSE WELL INITIATIVE

by

Mary Foran
Nonda Kozas
Daniel Lafranchi

SENIOR DESIGN PROJECT REPORT

submitted to
the Department of Civil Engineering

of

SANTA CLARA UNIVERSITY

in partial fulfillment of the requirements for the degree of
Bachelor of Science in Civil Engineering

Santa Clara, California

Spring 2014

MISSION SAN JOSE WELL INITIATIVE

Mary Foran, Nonda Kozas, Daniel Lafranchi

Department of Civil Engineering
Santa Clara University, Spring 2014

Acknowledgements

We would like to demonstrate our gratitude to the many people who assisted and helped our team during the Senior Design process. Without the support of our family, friends, professionals and the Dominican Sisters, we would not have been able to achieve such a level of success.

A special thanks to:

Steven Chiesa…….Advisor

Ed Maurer…….Advisor

Michelle Meyer…….Industry Contact

Chris Tigh…….Industry Contact

Sister Barbara Hagel…….Project Coordinator

Sister Jeannette DeYoung…….Project Coordinator

ABSTRACT:

The objective of this community base project is to develop an irrigation system for a community garden that is sustainable and watered by one of the three wells on the Dominican Sisters' Convent property located in Fremont, California. The overall goal of this project is to have a submersible solar powered pump, which will pump water to a tank that will store water and function on a timer. This tank will then deliver water to the community garden as well as other areas on the property. This project focuses on both an environmental and water resources aspects of design work. The design aims to fulfill the customer needs based on budget, functionality and location.

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APPENDIX:

Introduction

Background

The site of the proposed project is in Fremont, CA at the Dominican Sisters of Mission San Jose Convent. The Convent's current irrigation system does not adequately irrigate their property. They have one small garden and approximately 300 fruit trees and would like to add an additional community garden in the future. The three on-site wells are currently sealed off and have been out of commission for almost 50 years. It has become increasingly difficult for the Sisters to pay for city water given their limited funds. The wells have the ability to not only sufficiently irrigate the nascent garden and orchard but also to diminish the Mission's environmental impact and reliance on city water. Two of the wells were artesian wells dug in 1918 and were in use until the 1950's. At which point the water table dropped due to an influx of population to the area. The third well was drilled in the 1950's and was in use until the late 1970's. The fact that the wells have not been in use in over 40 years is cause for some concern. The water may be contaminated and the well casings may be deteriorated or damaged.

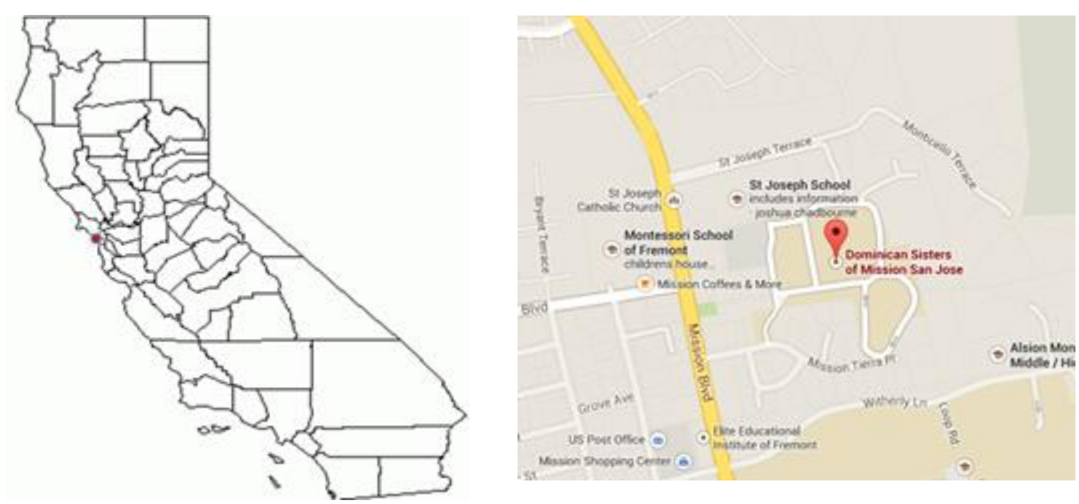


Figure 1 - Property Location And Vicinity Map

To adequately irrigate the property, one of the three wells will be refurbished and brought up to city standards. The goal of the project is to have a submersible solar-powered pump supplying water to a holding tank. With the determination of community needs, water will be delivered to the community garden and orchard with a piping network set on an automatic timer. Depending upon the well to be used, the piping network ranges from approximately 250 to 850 feet in length. The final part of the proposed solution deals with the design and implementation of the irrigation network. This design aims to fulfill the customer needs based on budget, functionality, and location.

Site Details

In Figure 2, an aerial view of the site is displayed. Currently, the dormitories on site in the southwest area are under construction. This was factored into our design due to conflicts with the implementation process. The construction company, Hillhouse Construction, has provided necessary site information and offered to help aid in the future implementation and construction. The hill sloping downwards from east to west has a 5% slope which is beneficial since it helped our gravity fed system in a downward direction to the proposed community garden. Figure 2 shows the areas that were previously served as an orchard (larger area) and community garden (smaller area). The proposed area for the new community garden is located on the same site as the old orchard shown in Figure 3, as well as the location of the three wells which we considered in our new design. By placing the proposed garden at the bottom of the hill, the water delivery system would be flowing at a downward slope making a gravity fed system possible. The three well options are uphill from the garden and each were analyzed as a potential sites for the pump and tank locations. Figure 4 shows the site from the top of the hill looking towards the east.

Figure 2- Aerial view with existing garden and orchard outlined in blue

Figure 3- Aerial view with proposed community garden and existing well locations

Figure 4 - View of well #1

DESIGN STRATEGY

The design strategy for this project was completed in four phases: Site Assessment, Determination of Current Demand Needs, Design, and finally Construction.

Site Assessment

The site assessment phase was completed through several site visits. During these site visits the design team was able to note the current landscaping including trees, roads, brush, and elevation changes. To limit the amount of site disturbance, in determining the completed design these site visits gave up to date information on the current topography. In addition to the landscaping, the viability of the three wells located on the property, were checked. In determining the viability the water depths were measured using a "Solinst Water Level Meter" model 102. The depth at well #2 was measured to be 42'. This measurement was taken in October of 2013. Using this water depth, the static water levels for both wells #1 and #3 were projected.

In addition to measuring the water depths the current casing conditions of the wells was analyzed by sending down a "Contour" camera with a LED light attached to it to get video footage of the insides of the wells. With the camera footage it was determined that wells #2 and #3 were 5' in diameter brick-lined wells. The site assessment visits gave a detailed analysis of the environment on constraints that will be placed upon the project's design.

Figure 5 - Screenshot of well #2 footage showing brick lining

Determination of Current Demand Needs

To determine the current demand needs several consultations were conducted with the project owner, the landscape architect, and several project experts. The project owner detailed their vision of having a community garden and orchard. They let the design team know of their current and future water needs and helped in making sure that the design would meet their specifications. The landscape architect, hired by the project owners, helped detail the landscape and plant locations inside the proposed community garden. As an expert in landscaping, he was able to help give information about water needs for specific plants and trees during different months of the year. This information was able to be put together to determine a daily water need for the community garden. The daily water demand needs are shown in Table 1 below given by the hired landscape architect Chris Tigh.

Table 1- Monthly water needs as calculated by the landscape architect

MissionGarden.xlsx

	A	C	D	E	F	G	H	I	J	K	L
1	**WATER USE ESTIMATE**										
2	**Mission Community Garden**										
3								Gallons	Gallons	Gallons	
4					Water Use			Hottest	Hottest	Hottest	
5			Sq. Ft.	Acres	Factor			Month	Week	Day	YEAR
6	Raised Planters		1,344	0.03	0.8			4,323	998	333	22,259
7	Ground Row Crops		1,800	0.04	0.7			5,066	1,170	390	26,085
8		Orchard	9,900	0.23	0.5			19,903	4,596	1,532	102,475
9	Ornamental Shrubs		3,200	0.07	0.5			6,433	1,486	495	33,123
10			-	-	0.3			-	-	-	-
11			16,244	0.37				35,725	8,251	2,750	183,942
12											
13											
14			GALLONS	GALLONS	GALLONS	GALLONS	GALLONS	GALLONS	GALLONS	GALLONS	GALLONS
15		ETo	TOTAL	Raised Planters	Ground Row Crops	Orchard	Ornamental Shrubs	0	PER WEEK	PER DAY	PER MINUTE
16	JANUARY	-2.68	-	0	0	0	0	0	-	-	-
17	FEBRUARY	-1.99	-	0	0	0	0	0	-	-	-
18	MARCH	0.21	1,163	141	165	648	209	0	269	90	0
19	APRIL	2.62	14,512	1,756	2,058	8,084	2,613	0	3,383	1,128	5
20	MAY	4.9	27,140	3,284	3,849	15,120	4,887	0	6,268	2,089	9
21	JUNE	5.66	31,349	3,794	4,446	17,465	5,645	0	7,308	2,436	10
22	JULY	6.45	35,725	**4,323**	**5,066**	**19,903**	**6,433**	**0**	8,251	2,750	11
23	AUGUST	5.83	32,291	3,908	4,579	17,990	5,815	0	7,458	2,486	10
24	SEPTEMBER	5.02	27,805	3,365	3,943	15,490	5,007	0	6,481	2,160	9
25	OCTOBER	2.48	13,736	1,662	1,948	7,652	2,474	0	3,172	1,057	4
26	NOVEMBER	0.04	222	27	31	123	40	0	52	17	0
27	DECEMBER	-3.04	-	0	0	0	0	0	-	-	-
28			183,942								
29											
30	WATER WINDOW		4								
31	DAYS PER WEEK		3								

If we water only 4 hours per day, and only 3 days a week, we will have to generate this gallonage per minute.

Gallons per day, 3 times per week, hottest week of the year

This is how many hours we will allow the watering to happen

This is how many times per week we will water.

Page 1

Lastly, industry experts helped throughout the design phase. The design strategy involved using the industry experts to help with well-permitting and construction. Michelle Myers, a Santa Clara University graduate, works at the Alameda County Water District and was a vital contact to help coordinate the plans for well permitting and receiving information about aquifers and other wells located in the area.

Design and Construction

The last phase of this project was to be the final design and construction. Through site visits and assessment and consultations with the owner and industry experts the final design was concluded. It consisted of a solar powered pump delivering water up to a storage tank, sitting on a concrete pad that will feed water through a water delivery pipeline to an irrigation system completely driven by gravity flow. A conceptual rendering of the design can be seen below in Figure 6.

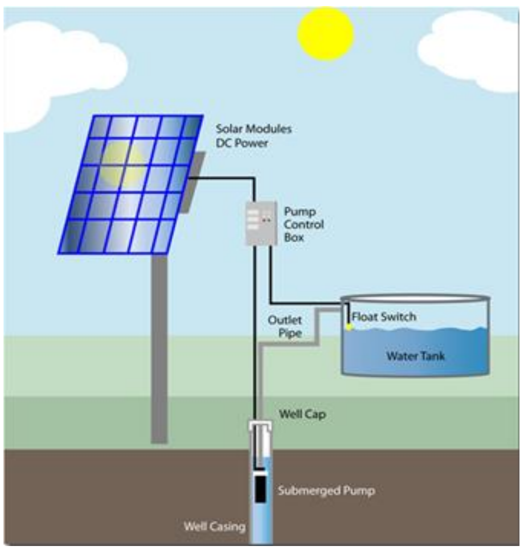


Figure 6 - Conceptual rendering

ALTERNATIVE ANALYSIS

There were four questions that were asked in the decision making process for the alternative analysis. First, which of the 3 wells would the design feature? Second, where would the tank be placed and what size tank would be used? Third, how would the pipeline system be routed in order to minimize the amount of equipment used and to limit the amount of site disturbances? Lastly, what type of irrigation system would be implemented? All of these questions would be answered keeping the 3 E's in mind; a system that is efficient, environmentally friendly, and economically viable.

Pump Location

When analyzing the possibilities for different pump locations three factors were used as criteria; if one of the three existing well locations were viable, the elevation of the pumping surface, and the well casing conditions.

Starting with well number 3 as shown in Figure 7 below, it was disregarded early in the design process. This was decided upon after preliminary calculations showed that its elevation would not provide adequate hydraulic head pressure for the drip irrigation system at the proposed garden. Also, there was a 10'x10'x1' concrete pad on top of the existing well as a way of sealing the old well. This removal would add to the cost of the project.

The inspection of well number 2, also shown in Figure 7, began with a site walk to examine site conditions and measure water level. Although this well also had a 10'x10'x1' concrete pad on top of the well casings there was a 3" hole drilled through the pad allowing for measurements to be taken. The first series of measurements taken in October 2013 revealed a static water level of 42’ and an overall well depth of 100’. A secondary inspection was done to examine the well casing conditions. This was done by lowering a contour camera and small LED flashlight into the well. This inspection showed that the well was hand dug, brick-lined, and 5’ in diameter. This posed concerns regarding contamination and cave-ins in the event of seismic activity.

For well number 1 research began at the Alameda County water District where the original drillers log was obtained. It showed that the well was a 12” diameter well drilled in 1955 with cast iron casing. Its physical location on the property was the most advantageous of the existing wells because it sits at the highest point on the property. Well number 1 was found to be the most viable despite having the original turbine pump rusted on top, and needing to be removed, which would add to the costs.

Figure 7 - Existing well locations

Storage Tank

For the storage tank that would need to be placed on site, the pressure requirements of the gravity fed irrigation system was examined along with the property slope, proximity to the pump, and the need for an integrated control system. Ultimately, a gravity feed system would be implemented so the further up the hill the greater the pressure head and the greater the possibility for future expansion.

For Option number 3, shown in Figure 8 below, there was already an existing tank on a concrete pad, so the only need would be to supply the tank with water from the pump, but it was discovered that the tanks were unavailable for use. This specific site also was difficult to access because of surrounding trees and shrubs. Originally, when looking at option number 2 shown in Figure 8, the plan was to have a concrete pad poured at this location because at this specific site there was a plateau and would not need to be leveled, prior to any concrete pouring. The drawback to this site was its limiting options in terms of hydraulic pressure head. This elevation would not allow for expansion of the system in any way and would only meet the immediate minimum needs. Option number 1 offered the greatest hydraulic head pressure, at that specific site, although there was approximately a 2% slope so any tank that would be placed there would need a concrete slab as well as seismic restraints. This would add significant cost to the project but offered the most for future expansion on the current system.

Figure 8 - Possible tank locations

Piping Network

When considering different options for the piping delivery system from the tank to the garden, several criteria were taken into consideration. The overall length of the pipe in relation to head loss and cost, obstructions to avoid to reduce cost, and varying the size of the pipe to alter cost and head loss.

All four options were considered when looking at piping networks shown in Figure 9. With Option 4 the concern was the fact that the water delivery pipe would have to traverse an area riddled with shrubs and tree roots. With Option 3 although it is the second longest in length it provided the most options in terms of future expansion and did not intersect tree roots. Option 2 was the longest in length but it would be the simplest in terms of constructability. Option 1 was the shortest in length and only intersected one road.

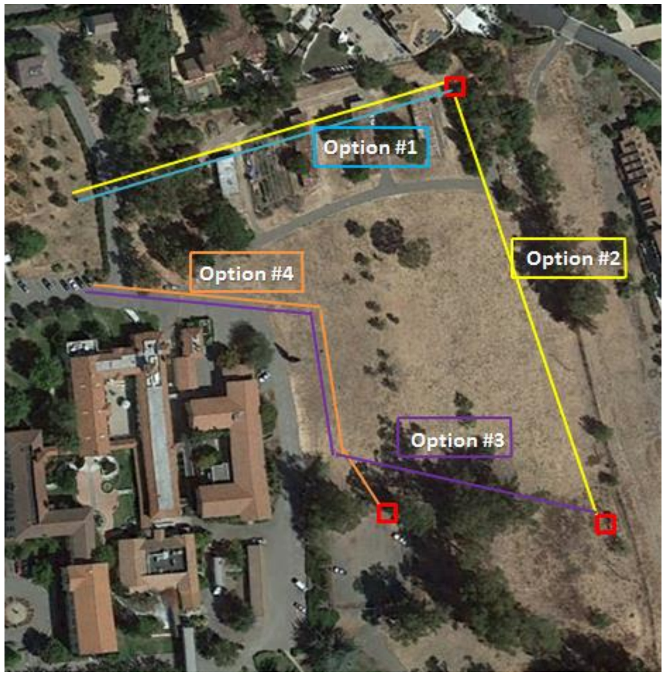


Figure 9 - Piping network options

Irrigation System

For the proposed garden there were three options for a possible irrigation system. The first was a ditch irrigation system which has been used for centuries, is extremely frugal, but highly inefficient. The second was a spray irrigation system which is more efficient than a ditch system but requires high pressures to operate properly. The last is a drip irrigation system that is highly efficient operates under low pressures but has a high initial cost.

Site Specific Constraints

For this specific project location there were existing site specific constraints that shaped the final design. When determining well viability the Alameda County Water District was consulted to ensure compliance with current standards and regulations. Wells were also examined on site for how recently they were drilled as well as which one had the highest elevation.

The required operating pressure for drip irrigation is 20psi and for a spray irrigation system the minimum requirement is 30 psi. These pressure requirements were crucial in determining the final design.

With any construction that will take place on site minimal disruption to the existing landscape was crucial for design. The convent values a lifestyle of peace and tranquility, ensuring that lifestyle was a key design component. For any water that would be pumped out the maximum efficiency of that water was planned for in the design. The garden itself would need to be watered with 2,750 gpd once in a three day period.

FINISHED DESIGN

Solar Well Pump

Location

The fact that the northeastern well is brick-lined poses a significant problem with using this specific well. Through research it was discovered that a brick-lined wells, or dug wells, have a variety of distinct issues. Normally, they are not deep enough to sustain water through a dry period, there is no stability from keeping the well from collapsing in on it and there is little protection from contaminants affecting the water supply. This leads to the conclusion the well located to the southeast is the best option, as the northeastern well is no longer viable.

The southeast well poses its own problem by the fact that before tests can be run and a pump installed, the surrounding shed and rusted on turbine-pump must be removed. A demolition crew will most likely be necessary for the shed while a well contractor will be needed to remove the turbine pump off of the entrance to the well. In the end it was decided that the southeast well be used for its viability.

Figure 10 - Southeast Well; Left: pre-demolition, Right: post-demolition

Figure 11 - Aerial view of well #1

Necessary Power

The water depth measured at the northeast well was 42’ on October 31st 2013. The elevation difference between the northeast well and the southeast well is 20’ thus providing the information that the depth to water at the southeast well is approximately 62’. The figure below shows the basic pump kit flowchart from Advanced Power.

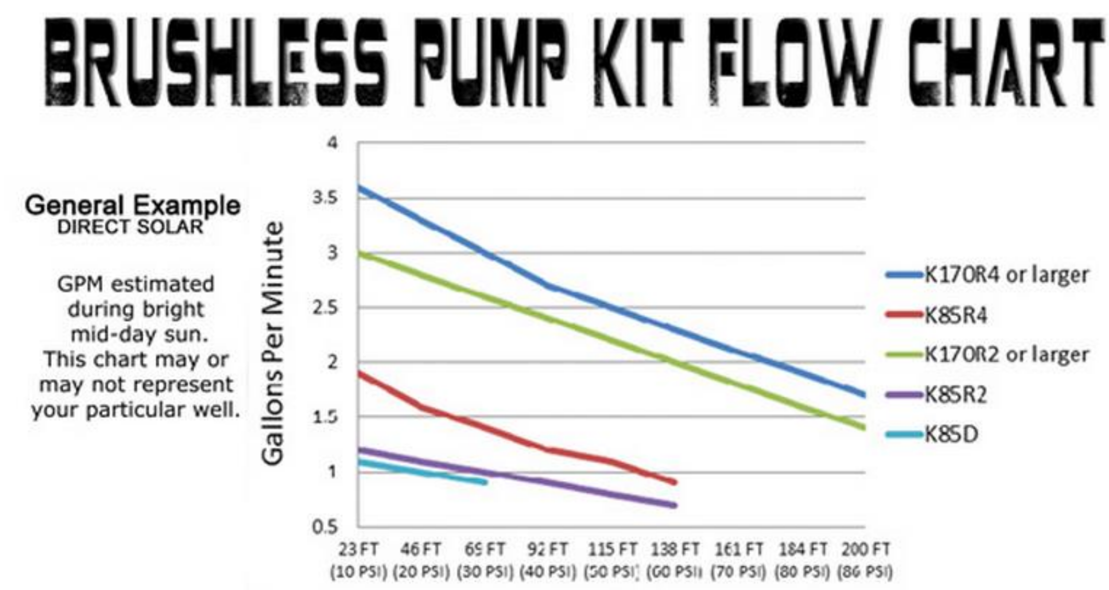


Figure 12 - Flow chart from Advanced Power

Using the Pump Kit Flow Chart from Advanced Power it was decided that the model K170 OR4 was the most economical and efficient for our pumping needs. With this model pump a yield of approximately 2.5-3.5 gpm and an overall yield of 1,500-2,000 gpd with 10 hours of sunlight would be reached. The solar panels used to be able to achieve this yield are 2-85 Watt solar panels. The company gives a 25 year power outage warranty by stating that the solar panels will still be producing at least 80% power after 25 years of usage.

Supplier and Cost Analysis

In choosing from suppliers, it was decided that the most beneficial purchase would be to buy the solar panels, pump, and advanced level cut off from the same company. This would lead to fewer suppliers to connect with and would ensure that the multiple piece system would be able to fit and work well together. Upon culmination through research, Advance Power had the ideal supplies that would help us accomplish the design goals. The company has supplied and worked on similar projects in the past and their expertise would also prove to be beneficial.

Tank

Location

In determining the location of the tank there were a few specifics that needed to be considered. First, the tank's location was analyzed with regards to the pump placement. The tank will have an electrical sensor that will signal the pump to stop pumping once the water has reached a certain height in the tank. This will provide a safety measure so that the tank does not start to overflow. In order to have this sensor on the tank, electrical wires will have to be sent from the tank to the pump and if the distance between these two locations are too long then there will be added unnecessary work.

In addition, the tank needs a stable location to be placed on. The terrain at the Mission is hilly with high elevation changes and slopes making the placement of the tank a particular problem. The first location that was looked at was at the northeast corner of the property shown in the image below.

Figure 13 - Aerial view of well 1

This location was chosen for its low slope and the fact that a construction company would already be in the area filling in concrete and they would be able to pour a concrete slab to provide as a deck for the tank.

Upon completing an analysis of the pressure head that would be achieved at that location through the use of both WaterCAD and FlowMaster would not be enough to provide enough pressure for a drip-irrigation system. With this information pressurized tank would be needed and would not be able to use a gravity fed system.

With the pressure constraint in mind, the only location available that would allow us to use solely a gravity fed system would be directly next to the southeast well as shown in Figure 13.

Sizing Needs

The size of the tank had several effects on the overall scope of the project. First, the tank needed to be of a size that would be able to provide the required daily water needs. The pump would be able to provide a certain amount of flow but the tank provides for an extra water storage to help meet those water demands. Second the size of the tank affects the ground on which it stands. With a large tank, a more stable foundation and possibly a soils report would have to be conducted to ensure that the project is stable and viable.

Supplier and Cost Analysis

There were a few options with regards to holding tanks on site. As stated above, the two options were with the smaller tank and a more powerful pump, or a larger tank and thus need a less powerful pump. Upon researching several irrigational water holding tanks online, it was determined that the average cost around $11,225. In addition to looking upon outside suppliers of the tank, we found that the Convent had an old irrigation tank on the property. The tank on the property was circular in shape with a 12' diameter and a 6' height thus giving us a 3,000 gal tank water volume.

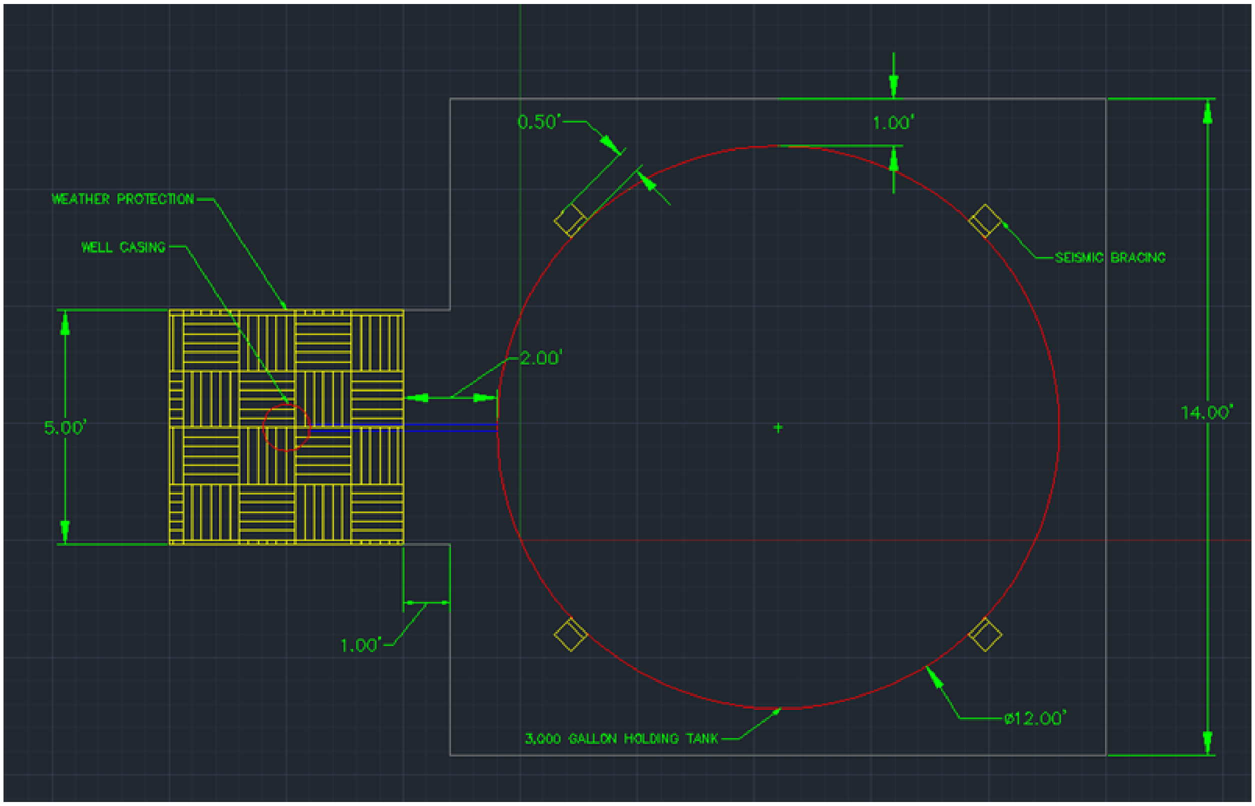


Figure 14 - Tank detail with concrete pad and well shed

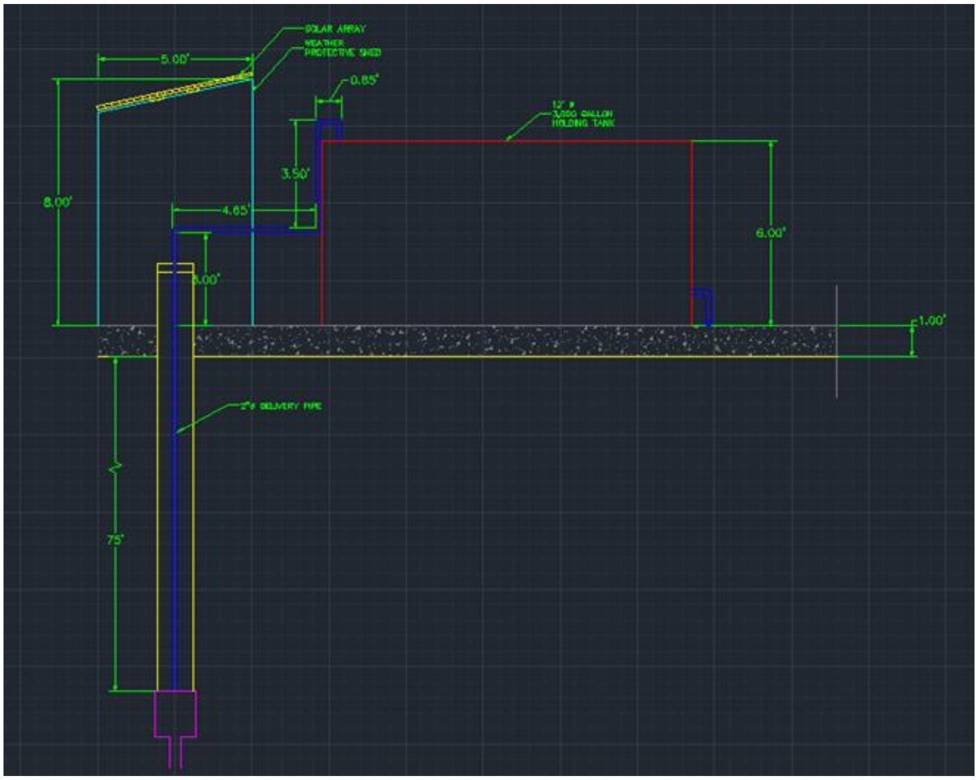


Figure 15 - Well and tank section view

Delivery Pipeline Transfer Network

Route

There were several design routes that could fulfill the design needs of the owner. These design routes are labeled #1,#2,#3, and #4 in Figure 9 of appendix C. There were several design considerations with deciding the piping route. One such consideration was to minimize the distance the piping covered. A longer piping network entails more material and in turn entails a larger cost. In addition, minimizing the need to lay pipe near any pre-existing landscaping was looked at. Laying piper near trees involves having to deal with the hindrance of tree roots. These tree roots would impede the ability to lay down an effective pipeline network.

The owners also made in clear that in the future they were planning on terracing the hill. With this in mind, future landscaping plans were examined so that the proposed pipeline would not be dug up or encounter any other problems with the new terracing plan.

In addition to the terracing, there are several roads that stand in between the tank and pump location and the the proposed community garden. The roads serve as another barrier as it costs more money to dig up the road and emplace pipe underneath it.

With all these thoughts in mind it was determined that route #3 was to be chosen. Route #3 gave the smallest length as shown in the the chart below:

Table 2 - Delivery pipeline lengths

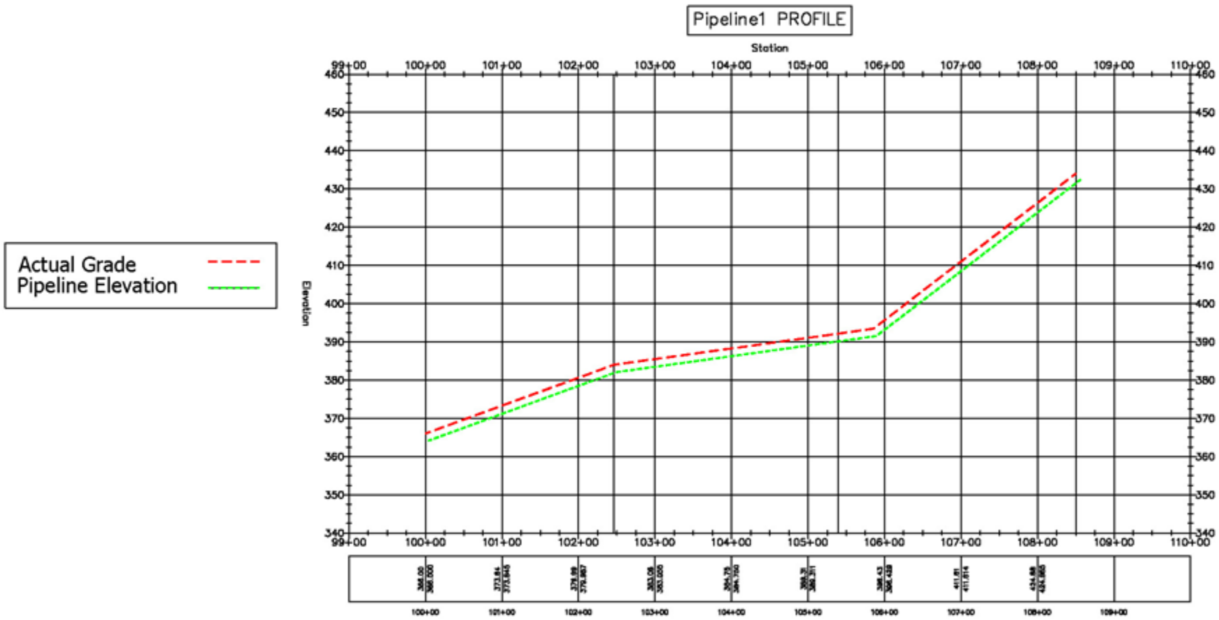
Route	Length
#2	1070 ft
#3	801 ft

Route #3 also avoided much of the habitat already existing on the property including trees, shrubs, and the future terracing. Route #3 also had the smallest amount of roads to be crossed with a value of only two roads. The proposed route for our finished design can be seen below in Figure 16.

Figure 16 - Final delivery pipeline route

A pipeline profile was created through AutoCAD in order to show the existing ground after grade and the proposed pipeline. The profile shown below in Table 3 shows the elevation on the y-axis and the length on the x-axis. This pipeline profile shows the 2' of cover for the underground piping network. This pipeline profile describes the piping slope of an 8.5% grade.

Table 3 Delivery pipeline profile, elev. vs. length



Material

In deciding upon the material of which to use for the detailed pipeline network several considerations were taken: cost and the mechanical stresses that would be placed along the pipe. If the pipe would be subject to any extreme temperatures or to any chemical contacts that could hinder the effectiveness of the pipe. The pipe will not be subject to more than 40 psi and the pipe will not be in contact with any major chemicals, mechanical stresses, or temperature extremes so it made sense to go with the economical choice of Polyvinyl Chloride (PVC) schedule 40 pipe. There are times that the pipe goes above ground (when going into and out of the tank) and with this change it was decided to also change the pipe material to a galvanized steel pipe design. This is due to the suns ability to make PVC brittle through oxidation.

Size (Fit Pressure and Velocity Needs)

The size of the pipe has a direct correlation to both the pressure and velocity. Using 1 in., 2 in., 3 in., and 4 in. pipes were considered. The pipe was chosen to maximize the output pressure and minimize the diameter. By maximizing the output pressure enough pressure could be provided through a gravity fed system and there would be no need to have a pressurized device to meet the demand needs. In minimizing the diameter the amount of material is also minimized and is thus decreasing the overall cost of the water delivery pipeline. Table 4 charts the pressure at the outlet vs. the diameter of the pipe. It is clearly seen that the output pressure levels off at approximately .17' which is equal to 2".

Table 4 - Outlet pressure vs. diameter of pipe

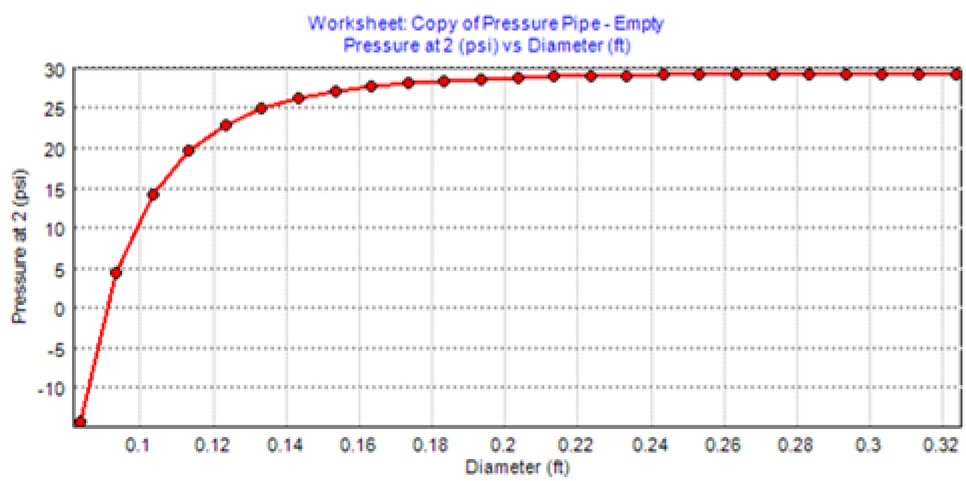
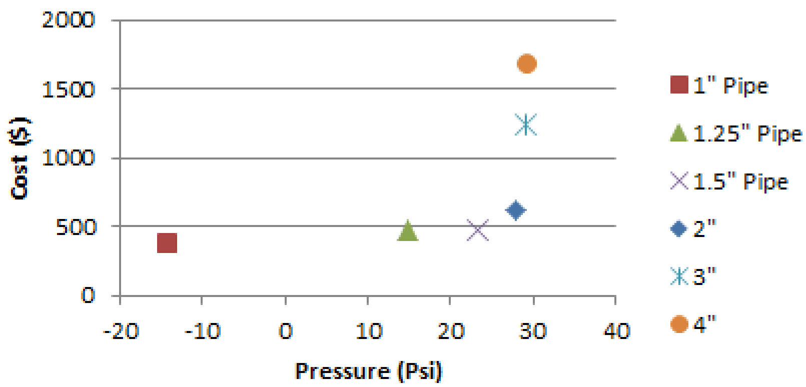


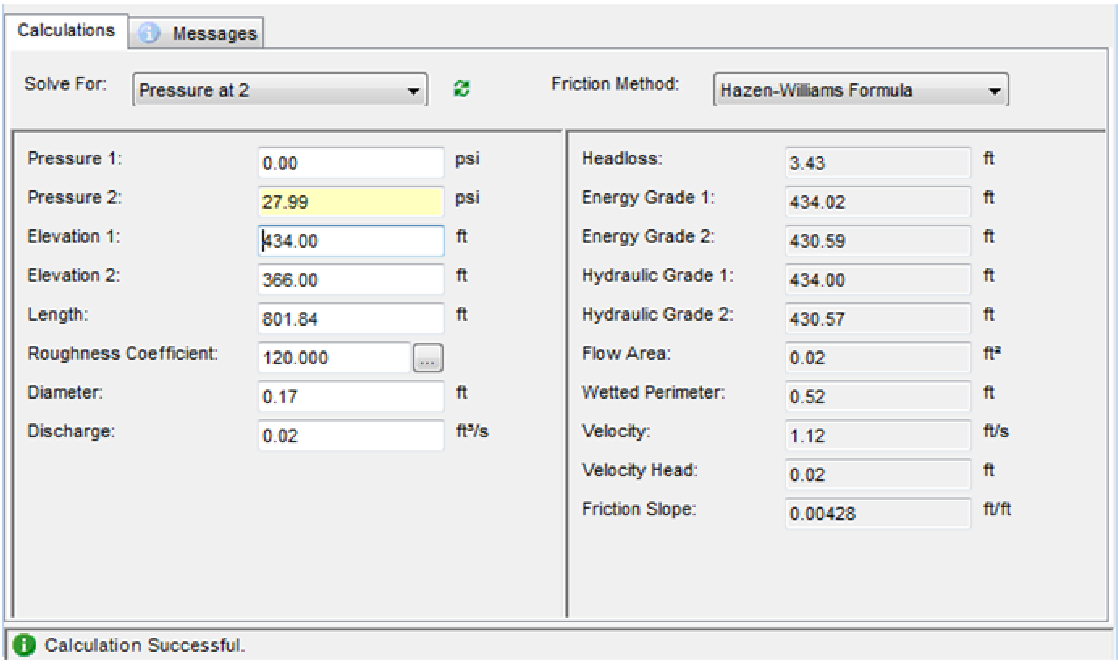
Table 5 charts the overall pipeline cost vs. the pressure at the outlet. Just above 2" the price increases exponentially due to the more equipment that will be used in the greater sized pipes. This chart was used in order to minimize the cost at the greatest pressure and the 2" pipe best fit in with that demand criteria.

Table 5 - Cost vs. pressure



The civil-engineering water program entitled "Flowmaster" was used throughout the project in determining the output pressures at various spots throughout the proposed alternative design. Table 6 shows an outlet pressure of approximately 27.99 psi which fits into the required need for a drip irrigation system. The normal Hazen Williams roughness coefficient for PVC pipe is 150 but that is for a brand new smooth PVC pipe. In order to detail this system for its last day of service the design assumed a roughness coefficient of 120 because friction losses will increase with time. Table 30 shows the calculated values at a high water level. With a full tank there would be approximately 30.16 psi which is 2.15 psi greater than an empty tank. All calculations were based on the low water level for those were the values that governed the design.

Table 6 - System Performance at Low Water Level using Flowmaster



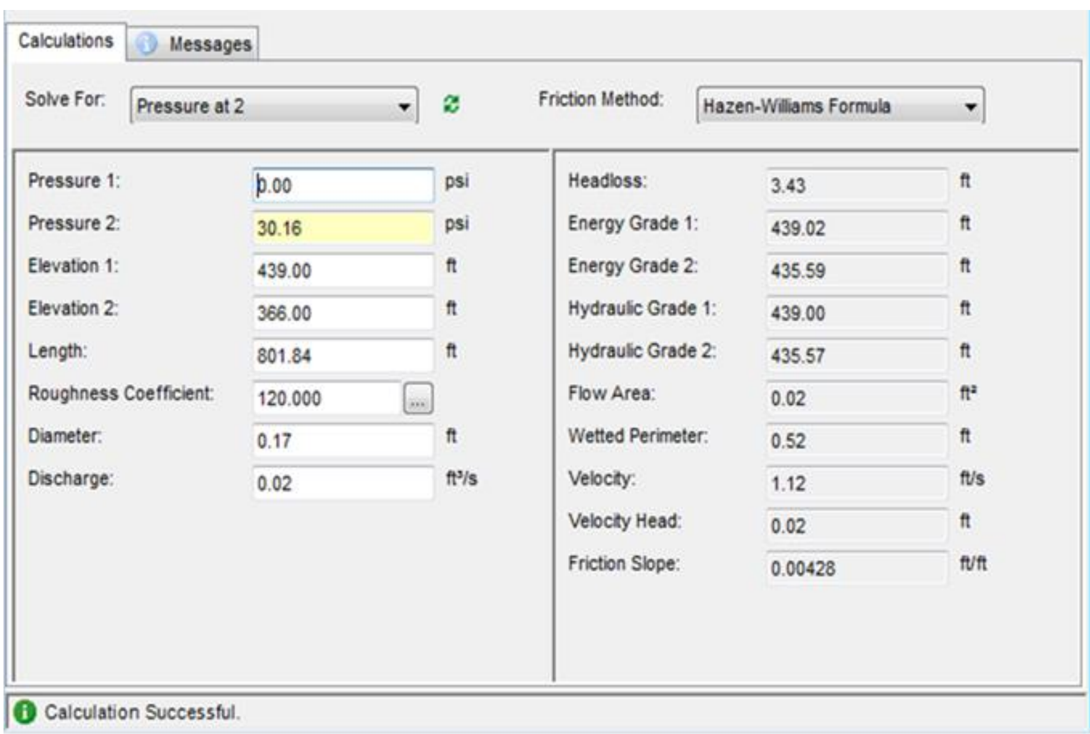
Calculations | Messages

Solve For: Pressure at 2 | Friction Method: Hazen-Williams Formula

Pressure 1:	0.00	psi	Headloss:	3.43	ft
Pressure 2:	27.99	psi	Energy Grade 1:	434.02	ft
Elevation 1:	434.00	ft	Energy Grade 2:	430.59	ft
Elevation 2:	366.00	ft	Hydraulic Grade 1:	434.00	ft
Length:	801.84	ft	Hydraulic Grade 2:	430.57	ft
Roughness Coefficient:	120.000		Flow Area:	0.02	ft²
Diameter:	0.17	ft	Wetted Perimeter:	0.52	ft
Discharge:	0.02	ft³/s	Velocity:	1.12	ft/s
			Velocity Head:	0.02	ft
			Friction Slope:	0.00428	ft/ft

Calculation Successful.

Table 7 - System Performance at High Water Level using Flowmaster



Calculations | Messages

Solve For: Pressure at 2 | Friction Method: Hazen-Williams Formula

Pressure 1:	0.00	psi	Headloss:	3.43	ft
Pressure 2:	30.16	psi	Energy Grade 1:	439.02	ft
Elevation 1:	439.00	ft	Energy Grade 2:	435.59	ft
Elevation 2:	366.00	ft	Hydraulic Grade 1:	439.00	ft
Length:	801.84	ft	Hydraulic Grade 2:	435.57	ft
Roughness Coefficient:	120.000		Flow Area:	0.02	ft²
Diameter:	0.17	ft	Wetted Perimeter:	0.52	ft
Discharge:	0.02	ft³/s	Velocity:	1.12	ft/s
			Velocity Head:	0.02	ft
			Friction Slope:	0.00428	ft/ft

Calculation Successful.

In order to double check the Flowmaster calculations the team designed the same system in the Civil Engineering Hydraulic program WaterCAD. Figure 17 and Table 8 show the water delivery pipeline and calculations calculated from WaterCAD respectively. As with the design in Flowmaster the Hazen Williams Coefficient was changed to 120 instead of 140. Table 8 also notes the lengths, velocities, and pressures of each individual pipe to be used. The ultimate water delivery pipeline system involves 1 tank, 4 pipes, and 4 junctions.

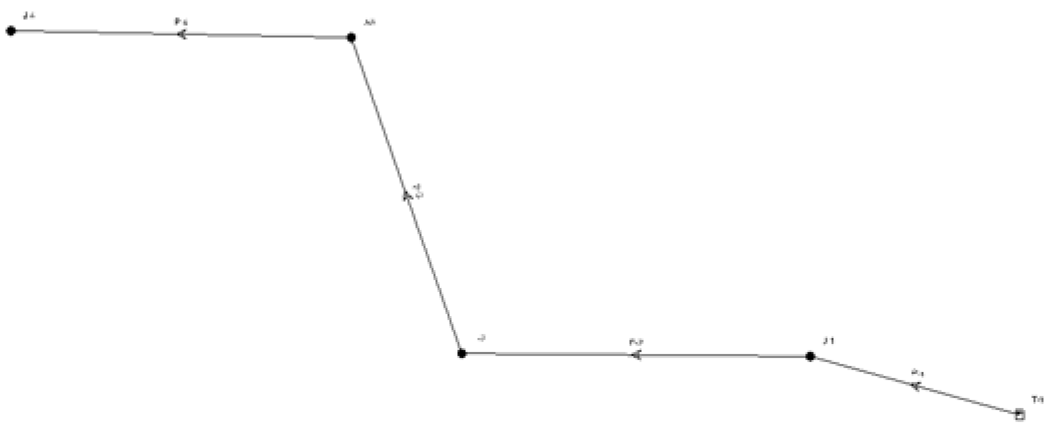


Figure 17 - Water Delivery Pipeline as shown in WaterCAD

Table 8 - Calculations received from WaterCAD profile

	ID	Label	Length (Scaled) (ft)	Start Node	Stop Node	Diameter (in)	Material	Hazen-Williams C	Has Check Valve?	Minor Loss Coefficient (Local)	Flow (gpm)	Velocity (ft/s)	Headloss Gradient (ft/ft)	Has User Defined Length?	Length (User Defined) (ft)
33: P-1	33	P-1	140	T-1	J-1	2.0	PVC	120.0	☐	0.000	11	1.12	0.004	☐	0
34: P-2	34	P-2	224	J-1	J-2	2.0	PVC	120.0	☐	0.000	11	1.12	0.004	☐	0
35: P-3	35	P-3	215	J-2	J-3	2.0	PVC	120.0	☐	0.000	11	1.12	0.004	☐	0
36: P-4	36	P-4	219	J-3	J-4	2.0	PVC	120.0	☐	0.000	11	1.12	0.004	☐	0

Irrigation System

There were two main irrigation system types that were considered: drip-irrigation and spray irrigation. The minimum required operating pressure for drip irrigation is 20 psi while the minimum required operating pressure for spray irrigation is approximately 30 psi. While the implementation of a spray irrigation is much more accessible it is much more inefficient as compared to drip irrigation. The nuns, the owners of the project, made it clear that they wanted this project to be environmentally friendly which favored the drip irrigation system. According to a Colorado State University study, “Drip irrigation exceeds 90 percent efficiency whereas sprinkler systems are 50 to 70 percent efficient.” The increase in efficiency is due to the evaporation and transpiration of the water on top of the soil. With regards to irrigation times we would irrigate in the early morning in order to avoid those losses due to evaporation.

NON-TECHNICAL ISSUES

There were four main focuses on the non-technical issues. First, the environmental impact of refurbishing a well and adding in a water delivery system was analyzed. Anything implemented, was examined to ensure it did not have a negative effect on the environment and surrounding habitat. Since the project is on site of a convent, there were certain environmental and aesthetic reasons to specific choices. Not interrupting the peacefulness of the Mission was crucial, so a solar pump and an underground water delivery system was chosen as the more environmentally friendly options. For any system implemented, one requirement was to have a long, sustainable life. On the subject of Social Justice, ethical concerns about the project and its design were raised. This included a variety of questions and concerns regarding the system. Who would be benefiting from the garden? Who would be allowed access to the garden? Would growing crops take away from local producers? Would pumping water draw any resources away from neighboring well and pumping systems? These questions were all analyzed and answered so that the project could be the most beneficial to the Sisters as well as the surrounding community. Lastly, economic concerns for the project were raised as an affordable option to sustain water flow into the garden. All choices were considered while balancing the economic considerations for the highest quality at the lowest price.

PROJECT COST ANALYSIS

In total, the project will cost an estimated $11,225. This is broken down into four main categories. First, a total of $7000 dollars was calculated for the cost of the existing turbine removal. This price also includes the cost of the labor and the PVC piping that will be inserted to line the well casings. Currently, there are two different contractors that are in contact about their availability to remove the turbine. The pump, panel and control system, when purchased as a whole package, will be $2,725 from Advanced Power. This system includes two 85 Watt solar panels, all necessary equipment to put the system into effect, a 5-year overall warranty and a 25 year output warranty on the solar panels. While the price for concrete seems to be on the low side at $1000, this only includes the cost of concrete and rebar without the labor factored into the total. There is an additional construction project on site already and the contractor has offered to pour and lay the concrete slab once the design has been approved. Lastly, 2” Schedule 40 PVC piping will be used in for the water delivery system pipeline. This will be installed by workers already employed by the Mission during an allotted time once the pumping system has been placed. A $500 allocation has been made for approximately 800 feet of this piping. This brings the grand total for the project to $11,225. A table outlined with the project cost is shown in Table 9 of Appendix B.

Table 9 - Cost breakdown

Cost Item	Cost ($)	Source of Funds
Turbine Removal	7000	TBD
Pump, Panel & Control System	2725	TBD
Concrete Slab & Rebar	1000	Santa Clara University School of Engineering Grant
PVC Piping	500	Santa Clara University School of Engineering Grant
TOTAL COST	$11,225	

LEGAL PERMITS

Through research and having met with a contact at the Alameda County Water District, Michelle Meyers, it was found that a one-time permit fee of $430 would be needed to re-establish the well. Once established, the cost of pumping one's own water is charged at $300 per acre-foot. This will be measured by a meter on top of the well.

CONSTRUCTION WORK TO BE COMPLETED

The shed covering well #1 has been demolished with the help of Hillhouse Construction. The turbine cap is now in full view and can be ultimately removed when the required funds have been obtained. After the turbine cab is removed the ground can be leveled and a concrete pad emplaced. After the emplacement of the concrete pad the project design can be finished. As of May 2014 $4,000 dollars has been raised and when the final $7,000 is raised the project may be continued and finally come to fruition.

Figure 18 –Photo after demolition of shed encompassing turbine pump

CONCLUSIONS

The proposed project is appropriate for its applicable civil engineering design criteria and standards in which it will fulfill a community based need. The mission of the Santa Clara University Department of Civil Engineering is outlined with three bullets:

- capably design, build, maintain, or improve civil engineering-based systems in the context of environmental, economic, and societal requirements.
- serve the community as ethical and responsible professionals.
- engage in lifelong learning for professional growth.

The proposed project fits in well in accordance with the departments mission. We are improving a civil engineering based system directly based on utilizing environmental assets to increase economic value, and provide a community based need that reflects ethical professionalism.

The project focuses primarily on water resource engineering, hydraulics, construction engineering, and environmental engineering and through our combined knowledge in upper division civil engineering classes we can show that we have the necessary qualifications to complete the proposed design.

The final design solved the problem at hand by creating a well irrigation to provide water for a community garden located at a convent in Fremont, CA. With the location, irrigation demands, delivery pipeline, tank size, and financial constraints the design team was able to propose a solar powered pump that will pump water up to a 3000 gallon tank and then provide water to a drip-irrigation system through a 800 foot piping network.

Appendix A - Design Drawings

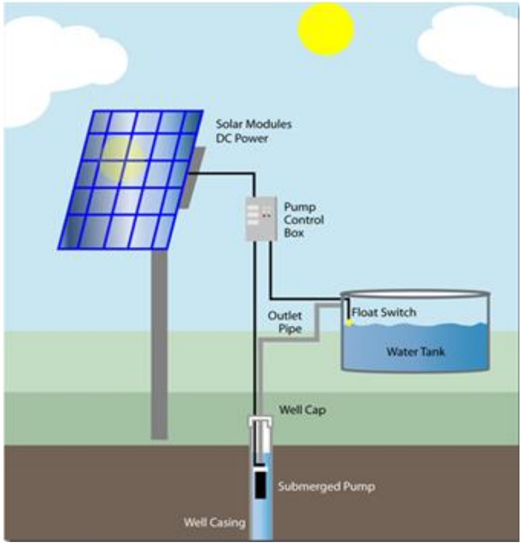


Figure 18 - Conceptual rendering

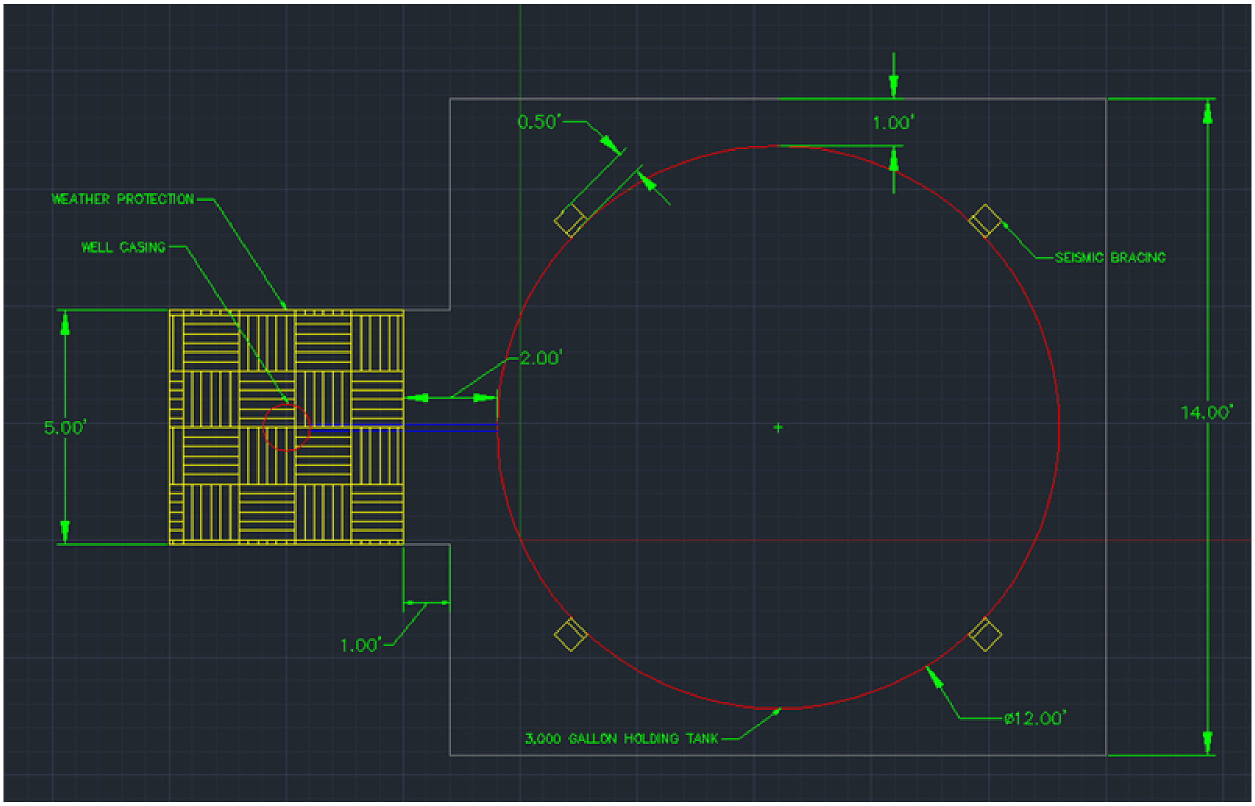


Figure 19 - Tank detail with concrete pad and well shed

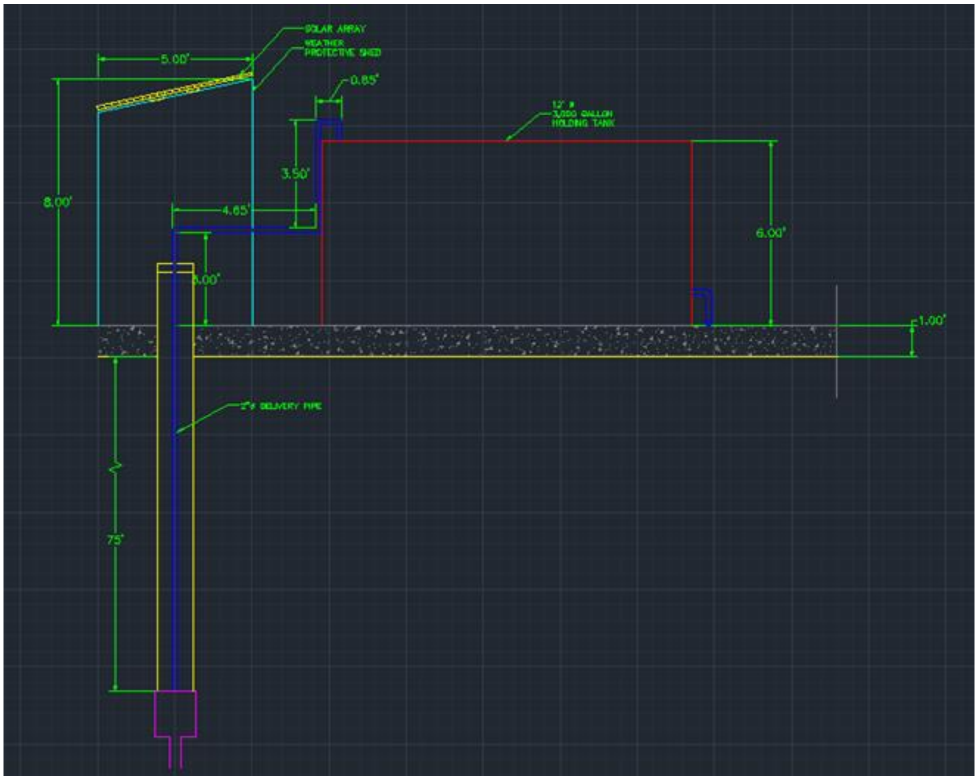


Figure 20 - Well and tank section view

Appendix B - Design Calculations

MissionGarden.xlsx

	A	C	D	E	F	G	H	I	J	K	L	M
1	**WATER USE ESTIMATE**											
2	**Mission Community Garden**											
3								Gallons	Gallons	Gallons		
4					Water Use			Hottest	Hottest	Hottest		
5			Sq. Ft.	Acres	Factor			Month	Week	Day	YEAR	
6	Raised Planters		1,344	0.03	0.8			4,323	998	333	22,259	
7	Ground Row Crops		1,800	0.04	0.7			5,066	1,170	390	26,085	
8	Orchard		9,900	0.23	0.5			19,903	4,596	1,532	102,475	
9	Ornamental Shrubs		3,200	0.07	0.5			6,433	1,486	495	33,123	
10			-	-	0.3			-	-	-	-	
11			16,244	0.37				35,725	8,251	2,750	183,942	
12												
13												
14			GALLONS	GALLONS	GALLONS	GALLONS	GALLONS	GALLONS	GALLONS	GALLONS	GALLONS	
15		ETo	TOTAL	Raised Planters	Ground Row Crops	Orchard	Ornamental Shrubs	0	PER WEEK	PER DAY	PER MINUTE	
16	JANUARY	-2.68	-	0	0	0	0	0	-	-	-	
17	FEBRUARY	-1.99	-	0	0	0	0	0	-	-	-	
18	MARCH	0.21	1,163	141	165	648	209	0	269	90	0	
19	APRIL	2.62	14,512	1,756	2,058	8,084	2,613	0	3,383	1,128	5	
20	MAY	4.9	27,140	3,284	3,849	15,120	4,887	0	6,268	2,089	9	
21	JUNE	5.66	31,349	3,794	4,446	17,465	5,645	0	7,308	2,436	10	
22	JULY	6.45	35,725	**4,323**	**5,066**	**19,903**	**6,433**	**0**	8,251	2,750	11	
23	AUGUST	5.83	32,291	3,908	4,579	17,990	5,815	0	7,458	2,486	10	
24	SEPTEMBER	5.02	27,805	3,365	3,943	15,490	5,007	0	6,481	2,160	9	
25	OCTOBER	2.48	13,736	1,662	1,948	7,652	2,474	0	3,172	1,057	4	
26	NOVEMBER	0.04	222	27	31	123	40	0	52	17	0	
27	DECEMBER	-3.04	-	0	0	0	0	0	-	-	-	
28			183,942									
29												
30	WATER WINDOW		4									
31	DAYS PER WEEK		3									

If we water only 4 hours per day, and only 3 days a week, we will have to generate this gallonage per minute.

Gallons per day, 3 times per week, hottest week of the year

This is how many hours we will allow the watering to happen

This is how many times per week we will water.

Page 1

Table 10- Monthly water needs as calculated by the landscape architect

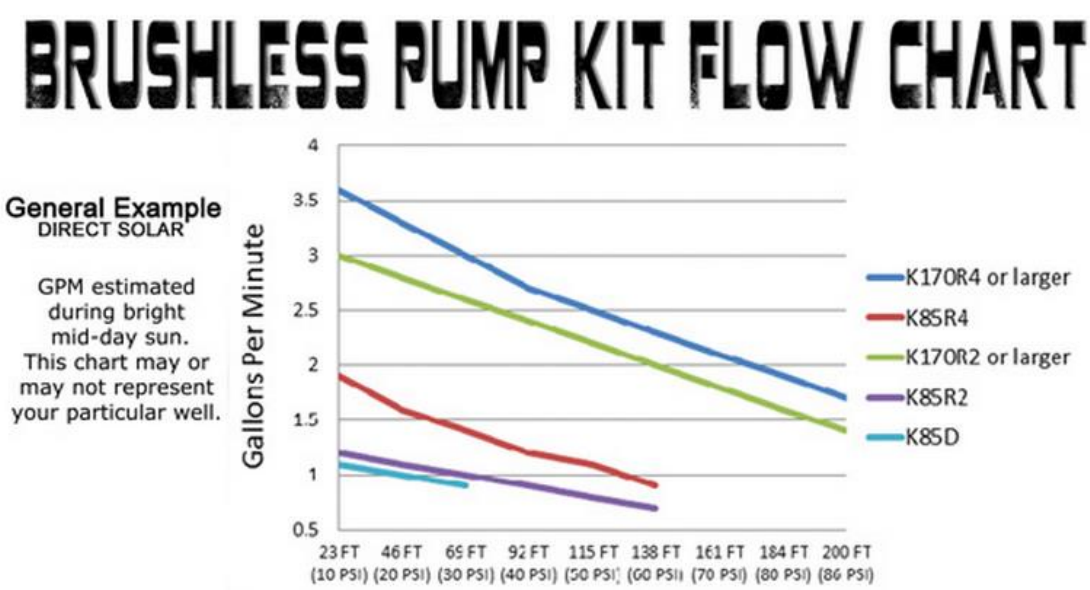


Figure 21 - Flow chart from Advanced Power

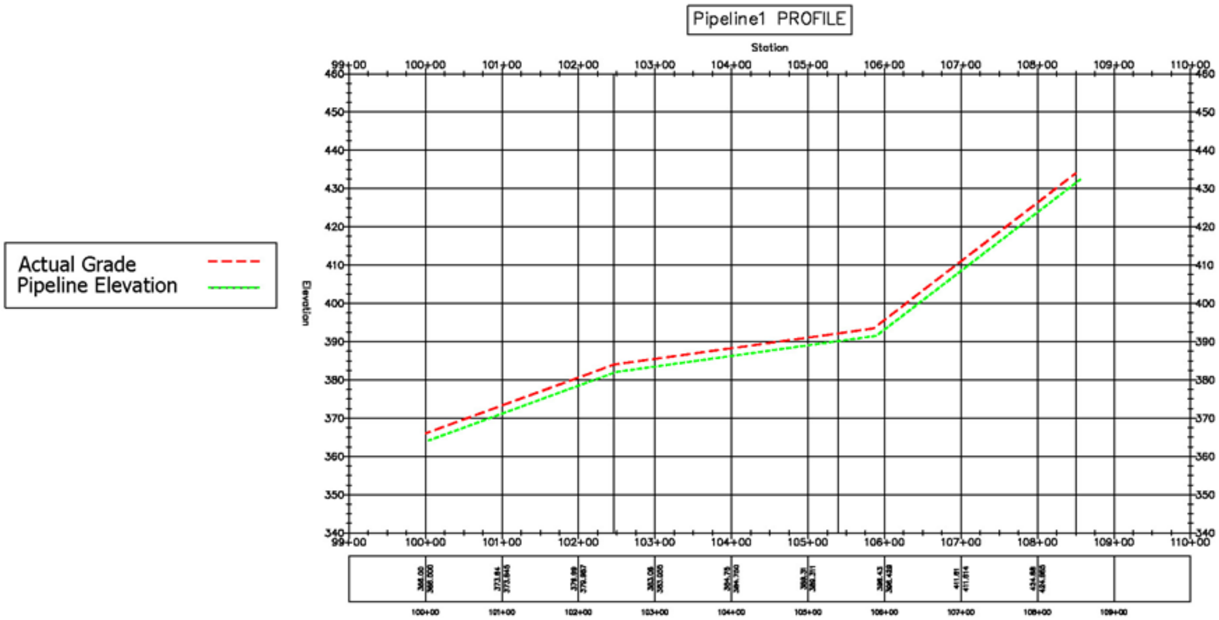


Table 11 Delivery pipeline profile, elev. vs. length

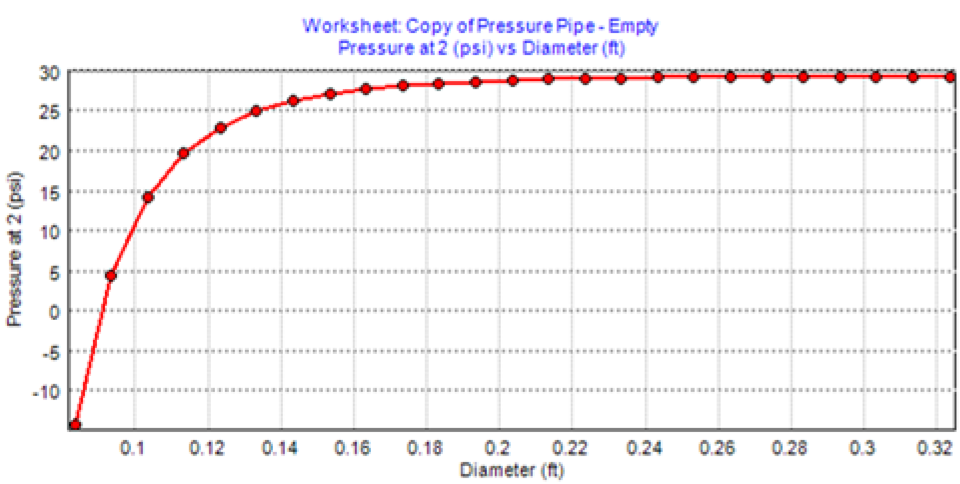


Table 12 - Outlet pressure vs. diameter of pipe

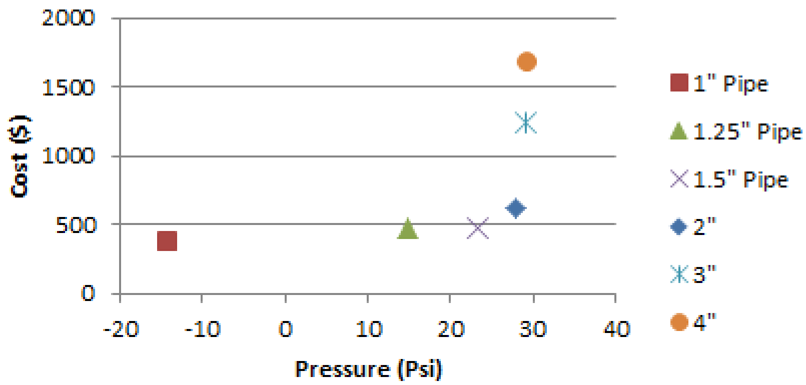


Table 13 - Cost vs. pressure

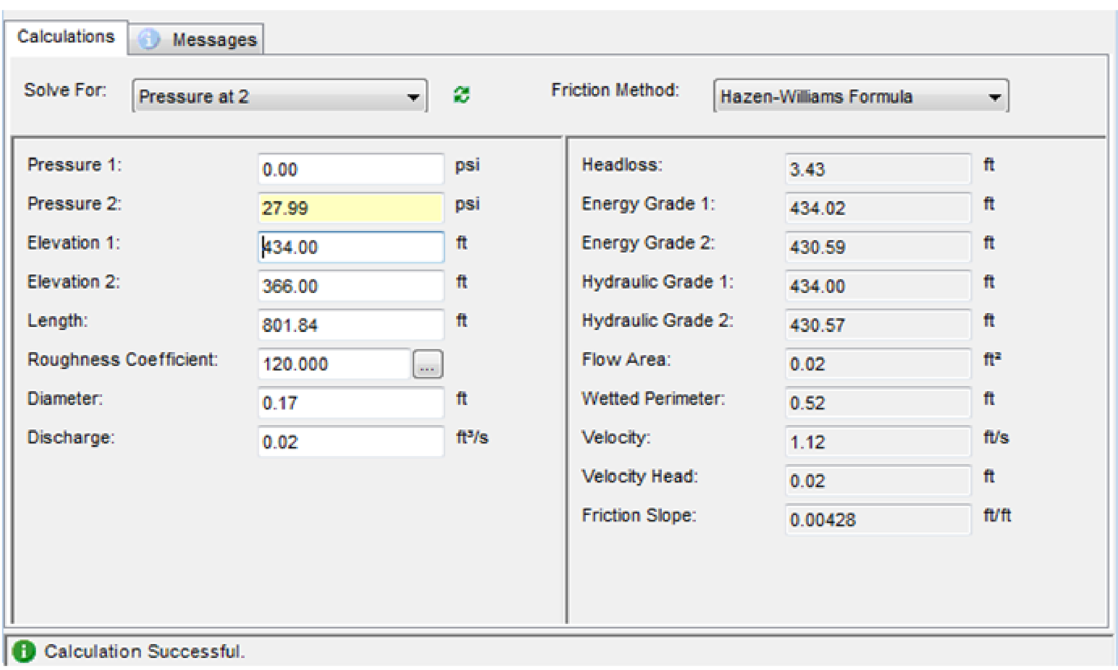


Table 14 - System Performance at Low Water Level using Flowmaster

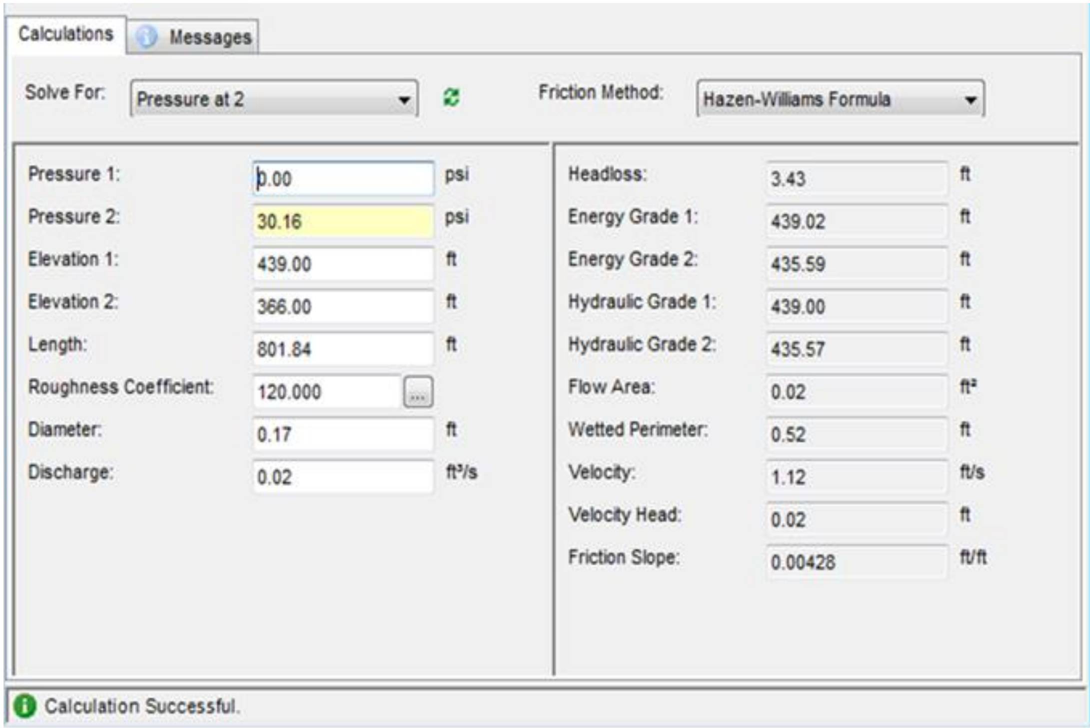


Table 15 - System Performance at High Water Level using Flowmaster

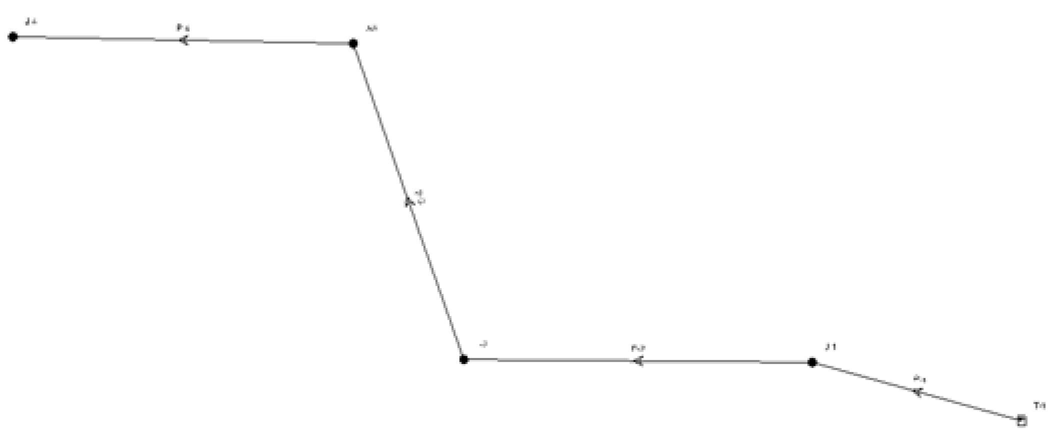


Figure 22 - Water Delivery Pipeline as shown in WaterCAD

	ID	Label	Length (Scaled) (ft)	Start Node	Stop Node	Diameter (in)	Material	Hazen-Williams C	Has Check Valve?	Minor Loss Coefficient (Local)	Flow (gpm)	Velocity (ft/s)	Headloss Gradient (ft/ft)	Has User Defined Length?	Length (User Defined) (ft)
33: P-1	33	P-1	140	T-1	J-1	2.0	PVC	120.0	☐	0.000	11	1.12	0.004	☐	0
34: P-2	34	P-2	224	J-1	J-2	2.0	PVC	120.0	☐	0.000	11	1.12	0.004	☐	0
35: P-3	35	P-3	215	J-2	J-3	2.0	PVC	120.0	☐	0.000	11	1.12	0.004	☐	0
36: P-4	36	P-4	219	J-3	J-4	2.0	PVC	120.0	☐	0.000	11	1.12	0.004	☐	0

Table 16 - Calculations received from WaterCAD profile

Cost Item	Cost ($)	Source of Funds
Turbine Removal	7000	TBD
Pump, Panel & Control System	2725	TBD
Concrete Slab & Rebar	1000	Santa Clara University School of Engineering Grant
PVC Piping	500	Santa Clara University School of Engineering Grant
TOTAL COST	**$11,225**	

Table 17 - Cost breakdown

Appendix C - Site Conditions

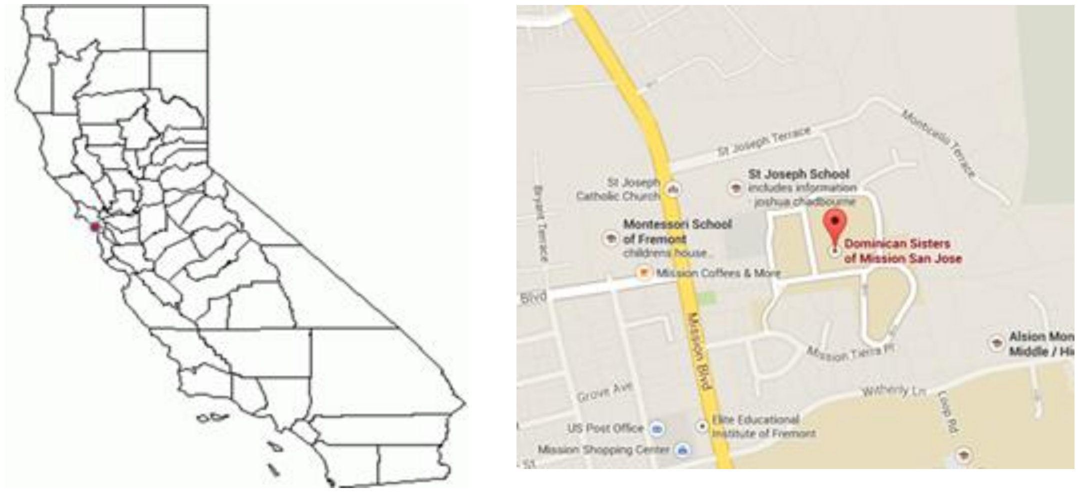


Figure 23 - Property Location And Vicinity Map

Figure 24- Aerial view with existing garden and orchard outlined in blue

Figure 25- Aerial view with proposed community garden and existing well locations

Figure 26 - View of well #1

Figure 27 - Screenshot of well #2 footage showing brick lining

Figure 28 - Existing well locations

Figure 29 - Possible tank locations

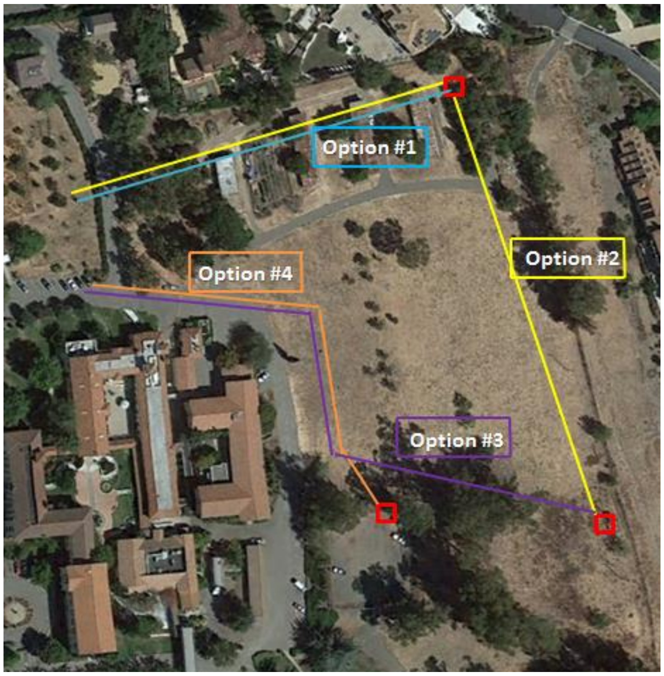


Figure 30 - Piping network options

Figure 31 - Southeast Well; Left: pre-demolition, Right: post-demolition

Figure 32 - Aerial view of well #1

Figure 33 - Aerial view of well 1

Figure 34 - Final delivery pipeline route

Figure 18 –Photo after demolition of shed encompassing turbine pump