ALTERNATIVE SEPTIC & IRRIGATION SYSTEM

Alternative Septic Team

ABSTRACT

A proposal for an alternative septic system and irrigation system design at the request of Adam Bringhurst.

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CENE-486

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Acknowledgement

Alt. Septic would like to thank Adam Bringhurst who is the client and the supporter for the project. Adam provided feedback when we had any concerns. Also, special thanks to Dr. Terry Baxter for preparing for us with lab equipment. We would like to acknowledge Dr. Paul Gremillion for providing us with some feedback and experience regarding our project. Finally, thanks to our grader and technical advisor, Alarick Reiboldt, for guiding us on the right path. We appreciate all the professionals who were grateful for our concerns and contribution.

Project Introduction

The property location address is 2955 N. Echo Canyon Road, Cornville, AZ. It is a 4.5 acre size, mostly flat land with a hill on the West side of the mobile house and the river on the East side. Our client is Adam Bringhurst, his father-in-law owns the property. The client requested a number of objectives to be completed. The objectives are as follows: design an alternative septic tank system that is in compliance with Yavapai County, design an irrigation system for a future vineyard to be installed, conduct a water quality analysis, and create a 1ft topographic map to measure the contour elevations. Figure 1 displays the location and aerial view of the property.

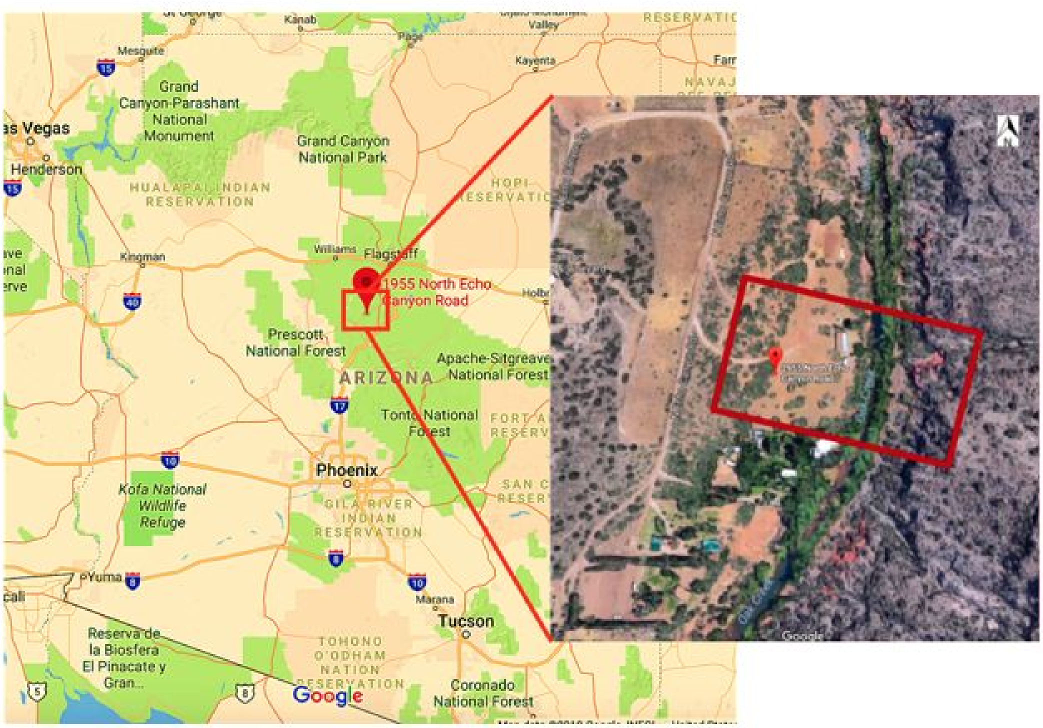

Figure 1: Aerial view of property in Oak creek [1]

Technical Sections

Field Work

The field work consisted of the team completing an on-site survey, water analysis, and soil analysis. The survey was done in order to gather point to later generate a 1-ft topographic map of the site, where changes in elevation will be considered during the irrigation system design. The water quality analysis included pH, temperature, and conductivity testing through the use of a Hanna Meter. This testing was done for the water out of the tap, directly from the well, and also the adjacent creek. This information gathered through the Hanna Meter will be used to ensure the current pH and conductivity values in the well water system are normal. Values from creek will be used as a reference to the drinking water data and to see if there is a direct influence from the creek water to the aquifer that the well is drawing from. Water samples from the well, tap, and creek were also taken to be tested in the lab. Also, completed on-site were three percolation tests to determine the water absorption rate of the soil. This data will be analyzed and used for determination of the possibility and location of a leach field for an alternative septic system.

Testing

Water quality testing was conducted by the team on the collected samples. Water collected from the tap, well, and creek were tested for total nitrogen, nitrates, and fecal coliform. On site, a percolation test was conducted in order to determine the hydraulic conductivity of the soil.

HACH Method 10071 was used to determine the total nitrogen levels in the water. Seven tests were conducted; there were two samples tested from both the well and tap, two samples were blanks, and one sample was tested from the creek. The results may be viewed in the Appendix. The results from the testing are inaccurate, as some of the tests yielded negative values. Egro, the water samples will be tested again. For the next set of tests, three samples will be taken from both the well and the tap. The average value of each location will be used in order to produce more representative results. As the total nitrogen components may be converted to nitrates, the total nitrogen levels should be low in order to ensure safe consumption.

HACH Method 8192 was used to test for nitrates in the water. One sample was taken from the well and tap, one sample was blank. The results from this test may be viewed in the Appendix. These results appear to be legitimate, as the values are relatively low.

HACH Method 8074 was used to test for fecal coliform in the water samples. Two samples from the well were tested; one undiluted and one diluted 1:5. Three samples were tested from the creek; one undiluted, one diluted 1:10, and one diluted 1:100. One sample from the tap was tested, and was undiluted. The results from this testing may be viewed in the Appendix. These results appear to be legitimate, as there were no fecal colonies found in the water sources. The creek would be the most likely to have fecal colonies, but as the water was sampled during a cold time of year, and the water was undisturbed due to the lack of rainfall, it is possible the sample taken contained zero fecal colonies.

An EPA method was used in order to conduct the percolation testing. As recommended by the procedure, three holes were dug, 6 inches in diameter and 12 inches deep. The holes were filled with water twice before being timed, during the third filling. One test was conducted directly in front of the house, on the side of the hill on the west side of the property, and one on the south side of the road that runs through the property. The results from the percolation testing may be viewed in the Appendix.

Alternatives Pursued

Alternative Septic System

The primary consideration when designing an alternative septic system is the regulatory requirements, design requirements, and the maintenance required for each system. Such regulatory requirements can be found in 18 A.A.C. 9, Article 3, which describe requirements for design and site investigations for all septic system designs permitted in Arizona. When considering the possible septic systems, the possible alternative septic system designs are listed in 18 A.A.C. 9, as R-18-9-E303 to R-18-9-E322 [2]. Although not all of these systems will be feasible for the site conditions, this is the list of systems that may be approved by the county.

The team researched three alternative septic systems that met the requirements provided by the A.A.C. An aerobic septic system, wisconsin mound septic system, and a sequencing batch reactor septic system were pursued.

Aerobic Septic System

Aerobic septic systems allow for treatment of wastewater in many areas where conventional septic tanks are not allowed. These systems work similarly to a wastewater treatment plant where influent water is run through a series of tanks that each have a different purpose for treatment. The first is a primary treatment tank, where larger solids are removed to prevent clogging for the later portions of the system. The second stage consists of aeration and agitation of the wastewater. This addition of air is to promote the growth of aerobic bacteria which help to breakdown much of the solids and waste within the water. The water is then sent to the clarification tank where any remaining solids that were not consumed by the bacteria can settle out. Finally, the water goes to the last tank where chlorination of the water is applied to kill any pathogens, microorganisms, or bacteria that are still present. When this tank fills to a certain point, the water is pumped out to a drain or leach field. These systems differ from traditional septic systems because traditional systems utilize anaerobic bacteria for treatment, which do not treat the effluent water to as high of a standard as aerobic bacteria can. This makes aerobic septic systems more viable in areas where high water tables, sensitive soil or ecosystems, and flooding is present or common.

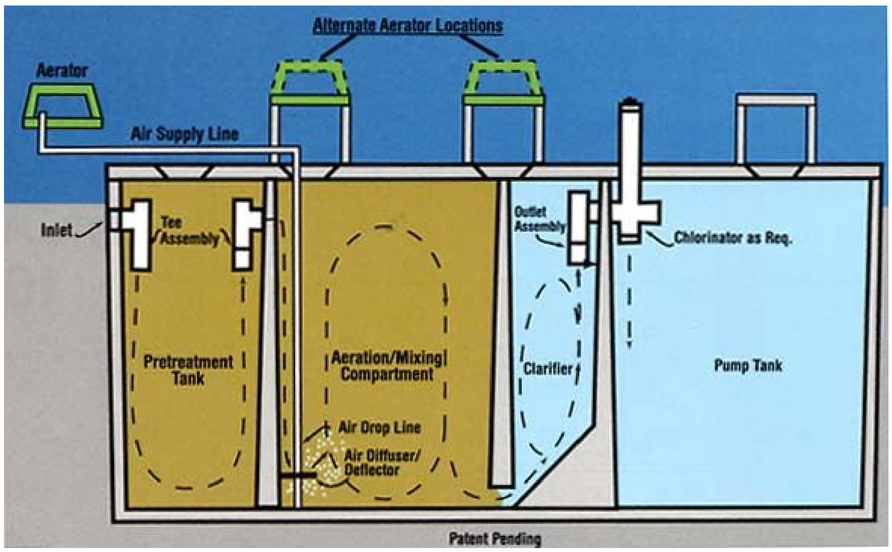

Figure 2: Aerobic Septic System Components [3]

Wisconsin Mound Septic System

The Wisconsin Mound system can work in rain and protects the water table. However, it requires outside materials to be brought for construction of the mound, and it cannot be within the 100-year flood plain. Also, it requires a lot of pipelines, design, testing, inspections, and space to obtain [4]. Figure 3 illustrates a schematic view of a Wisconsin Mound System. It consists of a septic tank, dosing chamber, and the mound [4]. The septic tank allows heavier solids to settle to the bottom while oils, grease, and smaller solids float to the surface. The clarified water from the middle will then go through the dosing chamber which contains a siphon and a pump. The effluent will be pumped to a higher elevation in order to percolate through the mound, which will remove the accumulated pathogens and organic matter.

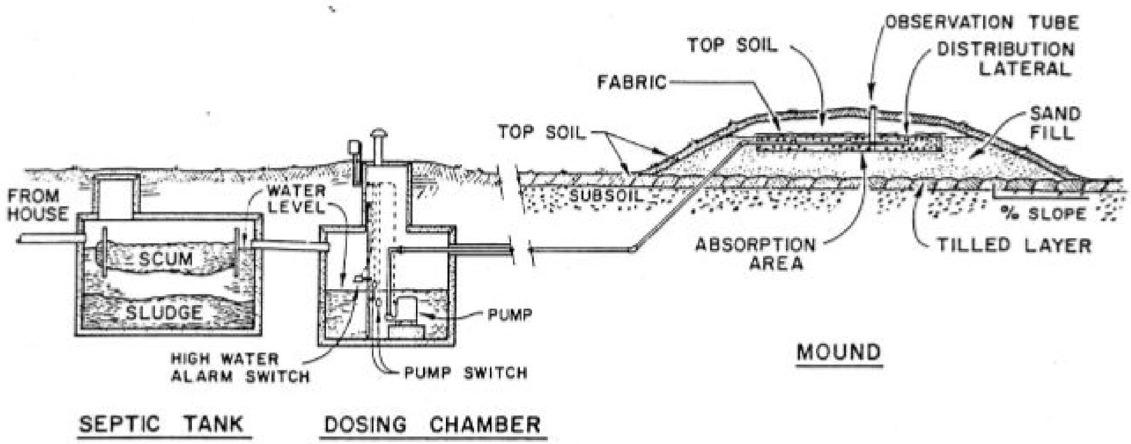

Figure 3: Schematic View of Wisconsin Mound Septic System [4].

Sequencing Batch Reactor Septic System

The Sequencing Batch Reactor (SBR) Septic System shown in Figure 4 depicts the steps that are generally followed for these systems. These steps all occur in one tank.

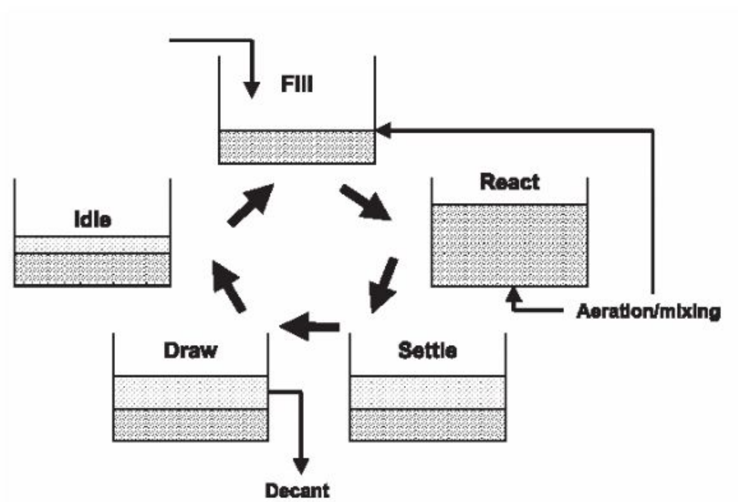

Figure 4: Sequencing Batch Reactor (SBR) [5]

SBRs treat the wastewater with a process similar to the aerobic septic systems, but are confined to one single tank. SBRs use activated sludge to remove nitrogen, phosphorus, ammonia, TSS, and BOD from wastewater. SBRs are designed to treat intermittent flow conditions, and typically treat wastewater to a higher degree than a conventional septic system due to the use of aeration.

Once the tank is filled with wastewater, the aeration and mixing processes occur. The addition of oxygen to the wastewater promotes the growth of the bacteria that consume the nutrients. Once finished, the aeration ceases and the heavy solids settle to the bottom of the tank. The treated water is pumped to a drainfield and the excess sludge is removed from the tank.

Irrigation

The main considerations with designing the irrigation systems is determining the type of irrigation system and calculating the required dynamic head to pump water through the system. The various irrigation systems that have been deemed feasible for this project include drip irrigation, subsurface drip irrigation, and spray irrigation.

Drip Irrigation

In drip irrigation, water flows through pipes slightly above the ground and drips almost directly on the crops. This method reduces evaporation and transpiration that would occur with other irrigation methods. This method reduces the wetted area and requires less pressure within the system. This can increase the yield of crops and the efficiency of the system. As well, this system is not labor intensive and can irrigate on a slope or irregularly-shaped land [6]. Alternative to having the pipes above the ground, a study was conducted on the efficiency of placing the drip irrigation system underground and found it to be just as efficient as the traditional above-ground system. As well, the study found that the lifetime of a subsurface drip irrigation is long, assuming the system is designed correctly and maintained [7].

Subsurface Drip Irrigation

Subsurface drip irrigation precisely delivers water to the roots of the crops through buried tubes. As the pipes are placed under the soil’s surface, the water lost to evaporation, evapotranspiration, and runoff are minimized. Like drip irrigation systems, this precise application of water can increase crop yields and decrease the growth of weeds. These systems are ideal in arid, semi-arid, hot, and windy areas with limited water supplies [8].

Spray Irrigation

Spray irrigation is widely used, though slightly less efficient than drip irrigation. The most common use of spray irrigation is the “center-pivot” system that utilizes electric motors to pivot a large frame to spray water over crops. Spray irrigation requires a high-pressure system and loses roughly 35% of water to evaporation [9]. Low energy precision application (LEPA) spray irrigation does not shoot water through the air, but the pipes hang low to the ground and spray water directly onto the crops. This type of application allows for only a 10% loss of water as it closer resembles the efficiency of drip irrigation than traditional spray irrigation [10].

Final Design Recommendations

Alternative Septic System

The alternative septic system that was selected was the Sequencing Batch Reactor. This system was selected due to the intermittent flow conditions produced by the property owners. Since the project site is not occupied on a consistent basis, the wastewater production is inconsistent. This eliminates the aerobic septic system as a viable option, as they are ideal for continuous flow conditions.

Sequencing Batch Reactors are designed for intermittent flow conditions and are confined to one tank. The elimination of an additional clarifier reduces the cost of the overall system, as well as the cost for installation.

Irrigation System & Design

The irrigation system that was selected for the final design is drip irrigation. The reason for this selection is due to a variety of reasons. These reasons include the low cost of the system, the high efficiency of the system, and the ease of access to the system. For these reasons, drip irrigation is a common method of irrigation for vineyards of our size. As well, the implementation of this system is easy and at a low installation and maintenance cost as compared to similar irrigation systems. In determining the design and layout of the system, some parameters must be defined. These parameters include the size and spacing of the vines and the water demand.

As instructed by our client, the irrigation system is designed to meet the the water demand for 1500 vines per acre with a spacing of 6ft by 8ft and a total acreage of 1 to 2 acres. This information is used to determine the water demand per acre and the system pressure required to adequately meet these requirements.

Estimating Water Requirements

When estimating the water demand, certain assumptions needed to be made for various reasons. The primary reason for assumptions in the lack of data for the area and surrounding areas with similar climates. Therefore, data was generally taken from areas with similar climate or harsher climates to overestimate the water demand. By overestimating the water demand, we ensure that even during peak water usage the system will operate correctly and allow the vineyard to accommodate growth if needed. The true water demand will be determined by the as the vineyard is operated during the wine growing season. The assumed variables include the evapotranspiration rate and crop coefficient. These variables were taken from three areas, Safford, Tucson, and Phoenix Arizona.

Methods

First, we must determine the area that will be used for reference; a pseudo-area to represent the Cottonwood/Cornville area. The area that was selected was Jerome, AZ, and the data used for reference can be found below:

- Avg. Temperature = 60.2 °F [11]
- Avg. Precipitation = 18.79 in [11]

The two areas that were selected to have the most similar climate data from the evapotranspiration data available were Safford and Tucson, AZ. The climate data for the two areas can be found below:

Safford:

- Avg. Temperature = 63.85 °F [11]
- Avg. Precipitation = 9.67 in [11]

Tucson:

- Avg. Temperature =70.9 °F [11]
- Avg. Precipitation = 11.62 in [11]

To better determine a reference evapotranspiration rate. The data collected for these two areas were averaged between the two for each month of the year. This maximum value from this data was then selected to be used to determine the maximum water requirement for the vineyard. The maximum evapotranspiration for taller plants is observed in July with a value of 10.48 in/mo [12]. Finally, the crop coefficient for grapevines in Arizona was found, dependent on the growing degree day (GDD) and time period during the wine season. As well, the maximum value for the crop coefficient was determined to be 0.52 [13]. In addition to the above coefficients, the minimum efficiency of the drip irrigation system was assumed. Although drip irrigation efficiency ranges from 0.8 to 0.95 and is generally assumed to be 0.9, a system efficiency of 0.8 was used [14]. The equations used in these calculations can be found in the appendix.

Results

Using the above assumptions, as well as the equations listed above the water demand per vine can be determined per month and per day, assuming maximum evapotranspiration and crop coefficients. The water demand results that were determined to be the most impactful to the design of the system are as follows:

- Water Req.= 6.812 in/mo
- Gal/vine/day = 6.8 GPD/vine
- 1500 vines/acre = 10200 GPD/acre

Cost of Implementation

This section is not complete and a final design has not yet been chosen. Further analysis and testing still needs to be done.

Summary of Engineering Work

The engineering work that has been completed includes a site investigation, site characterization, septic design type selection, irrigation design type selection, and site topographic map. The work includes the collection of survey data, soil evaluation, water testing, alternative septic system evaluation, and irrigation system evaluation. The design for the septic system was chosen to be a sequencing batch reactor however, an actual final specification of the design has not yet been decided upon. This will be done through comparison of designs from manufacturers. Also, the irrigation design was chosen to be drip irrigation. The final design of the drip irrigation is still being completed, and is not yet finished.

The Gantt Chart from the project proposal is shown below in Figure 5.

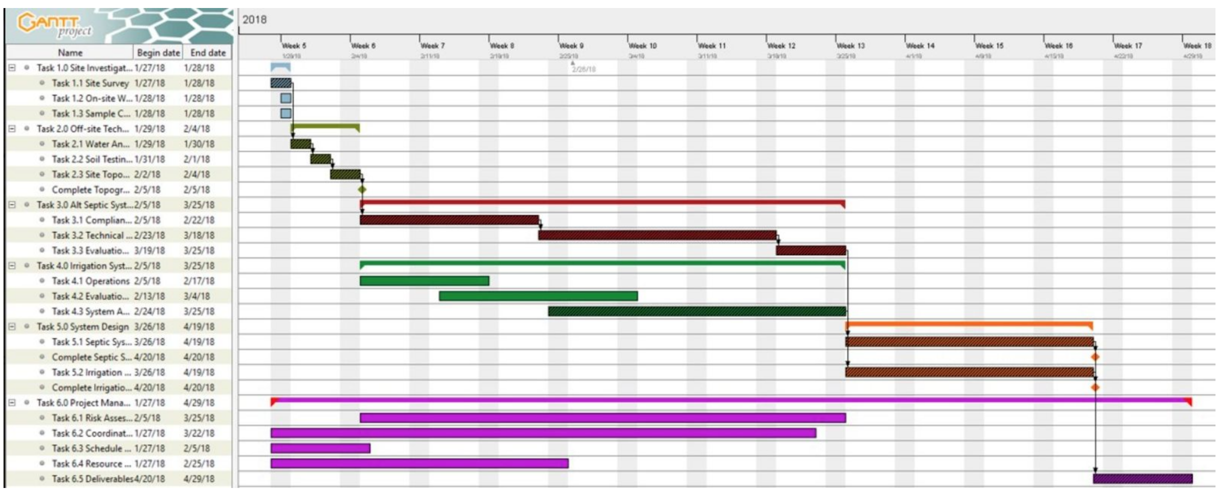

Figure 5: Project Gantt Chart

Summary of Engineering Costs

Below is the summary of engineering costs at the point in the project and the summary of engineering costs for the proposed cost for the project.

Table 1: 30% Engineering Costs

	Classification	Hours	Rate ($/hr)	Cost
Personnel	PE	1	$ 194.00	$ 194.00
	MGR	21	$ 95.00	$ 1,995.00
	EIT	24	$ 67.00	$ 1,608.00
	AA	49.5	$ 56.00	$ 2,772.00
	TECH	10	$ 48.00	$ 480.00
	Total Personnel Cost			$ 7,049.00
Travel	1 Site Visit @ 110 miles		$0.40 per mile	$ 44.00
Subcontract	Site Survey			$ 1,000.00
Total				$ 15,142.00
*Includes bas pay and overhead				

Table 2: Overall Project Proposed Costs

	Classification	Hours	Rate ($/hr) [16,17]*	Cost
Personnel	PE	20	$194.00	$3,880.00
	MGR	70	$95.00	$6,650.00
	EIT	250	$67.00	$16,750.00
	AA	150	$56.00	$8,400.00
	TECH	10	$48.00	$480.00
	Total Personnel Cost			**$36,160.00**
Travel	3 Site Visits @ 110 miles		$0.40 per mile	$132.00
Subcontract	Site Survey [18]			$1,000
Total		500		**$37,300.00**
*Includes base pay and overhead				

Conclusion

The project deliverables are designing an alternative septic system, designing an irrigation system, and creating a 1ft topographic map. An alternative system for the septic tank has been decided, which was chosen to be a sequencing batch reactor (SBR). The actual design itself of the SBR still needs to be chosen through a manufacturer. Also, a percolation test was accomplished to determine how fast actually a leach field drain in the area. This will help to determine the final location of the leach field, along with Arizona Administrative code for placement and setbacks of the leach field as well as the systems performance standards provided by the manufacturer needed for design specifics of the field. Tank and pump selection still needs to be completed for the irrigation design, and the final components of a water quality analysis have not been completed yet. Finally, the 1ft topographic map is complete and was done by a site survey.

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Appendices

Table 1, On-site Percolation Test Times

Test Number	Time for Percolation test (min)
1	10:31
2	17:52
3	18:57

Table 2, Tap Water and Creek Hanna Meter Readings

	Tap	Creek
pH	7.14	8.78
Temperature (Celcius)	18.47	7.62
Conductivity (µS/cm)	462	309

Table 3, Total Nitrogen Sample Testing Data

Test Source (mg/L)	Test 1	Test 2
Blank	0	0
Well	-0.6	-0.2
Tap	1	0.1
Creek	-0.2	N/A

Table 4, Nitrate Sample Testing Data

Source	Results (mg/L)
Blank	0
Tap	0.1
Well	0.3

Table 5, Fecal Coliform Testing Data

Water Source	Number of colonies
Well (No Dilution)	0
Well (1:5 Dilution)	0
Tap (No Dilution)	0
Creek (No Dilution)	0
Creek (1:10 Dilution)	0
Creek (1:100 Dilution)	0

Table 6, Decision Matrix for Irrigation Design Selection

Criteria	Drip Irrigation	Sub-Surface Drip	Low-Elevation Spray
Crop Yield	8	8	6
Water Usage	9	9	7
Water Loss	8	9	7
Installation	8	6	8
Maintenance	9	7	7
Total score	**42**	**39**	**35**

Water Demand Equations [w4]

$$H_2O\ Req. = \frac{(ET \cdot K_c)}{eff} \quad (1)$$

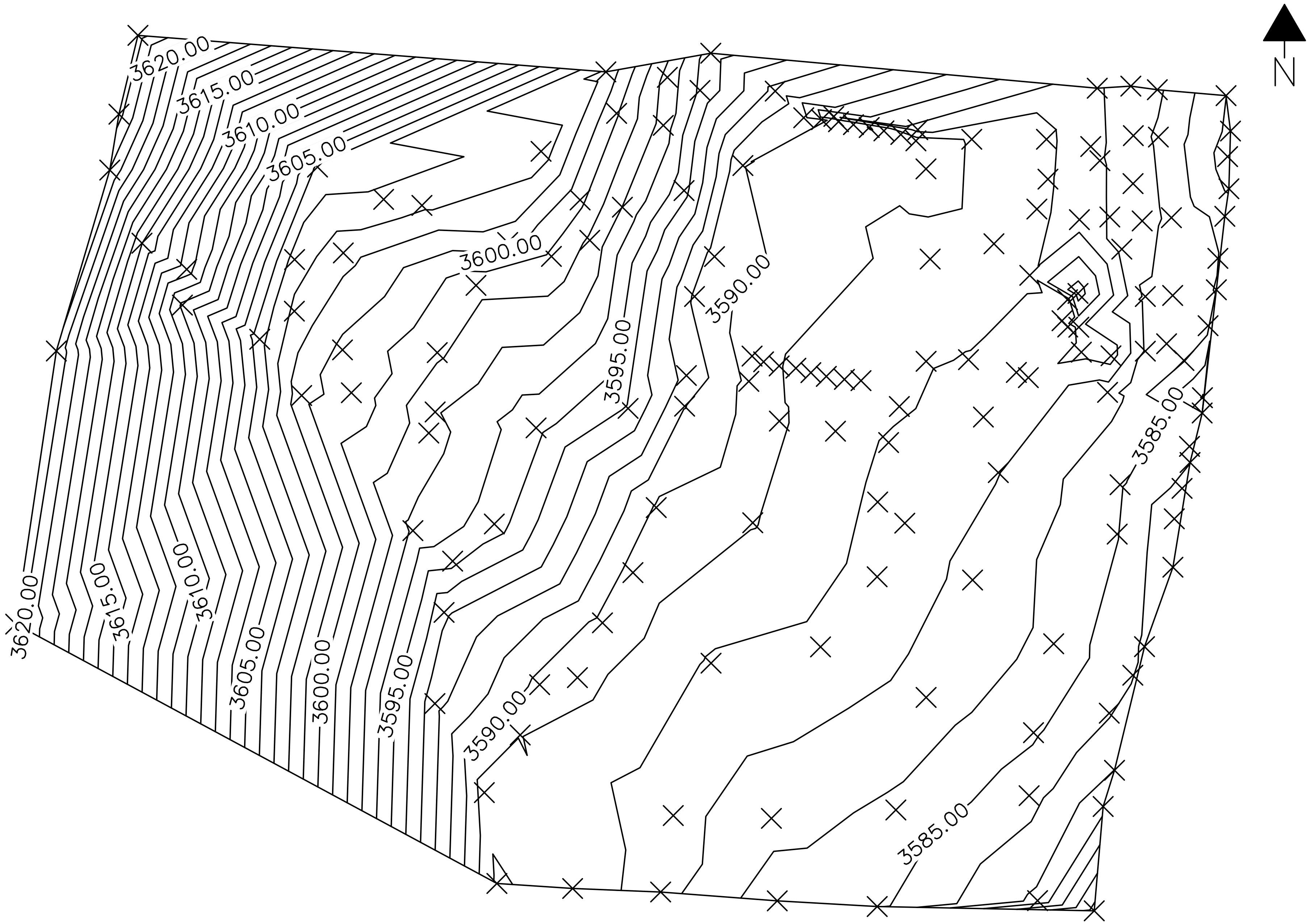
Where:

ET = evapotranspiration rate (in/mo)

K_C = Crop coefficient

eff = Drip irrigation efficiency

$$Gal/vine/time = (0.623)(H_2O\ Req. - in.)(row\ spacing - ft)(vine\ spacing - ft) \quad (2)$$



PROJECT NAME CENE–486C ALT–SEPTIC TEAM	DATE 25 FEB 17	BY WILL RICHARDSON	DRAWING NO. 01	NOTES
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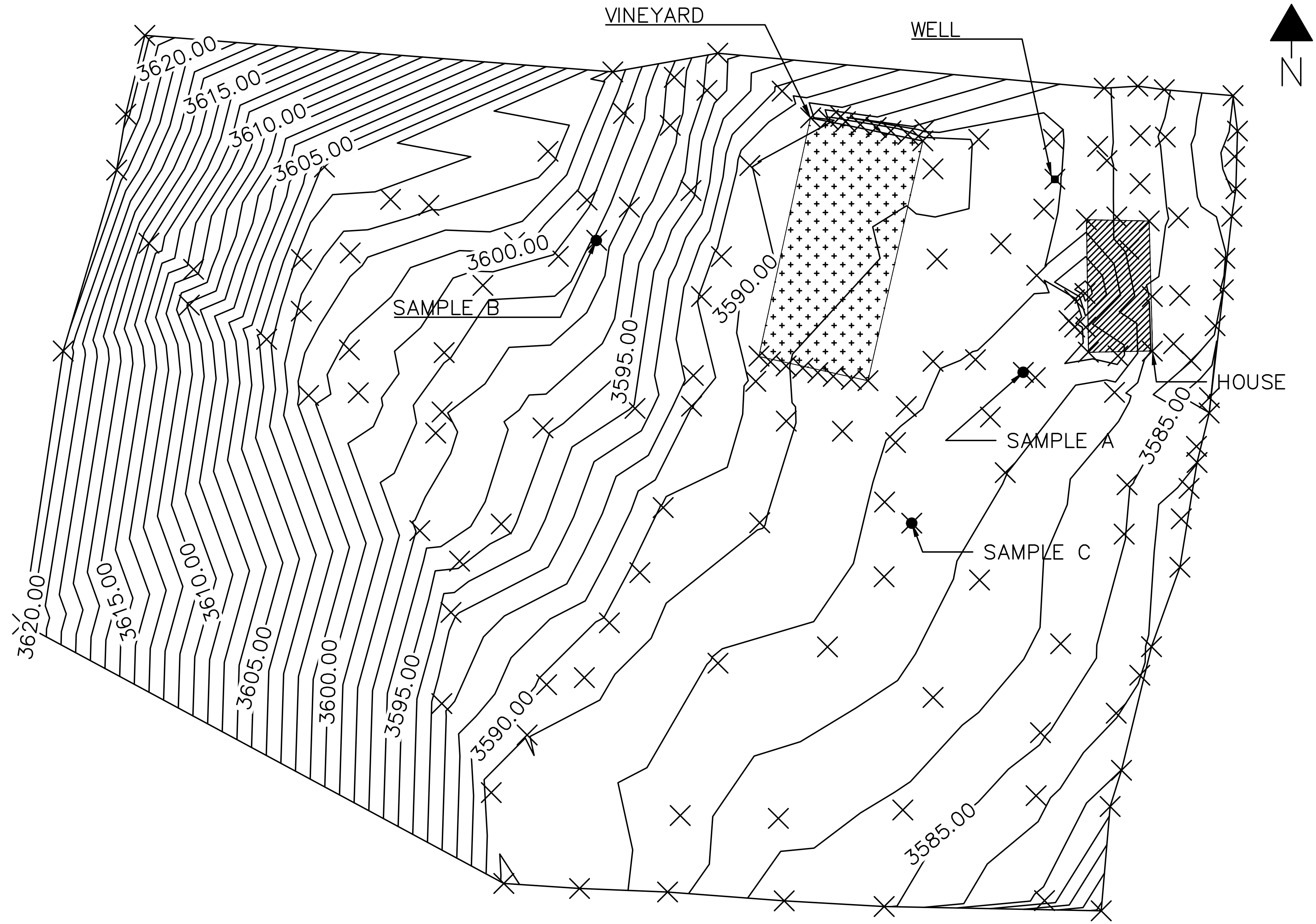
	2 N/A	SCALE 1in = 60ft	REV N/A	



PROJECT NAME CENE-486C ALT-SEPTIC TEAM

SITE TOPO & FEATURES

DATE 25 FEB 17

1 N/A

2 N/A

BY WILL RICHARDSON

0 15' 30' 60'

SCALE 1in = 60ft

DRAWING NO. 02

OF 02

REV N/A

NOTES

- PERC SAMPLE LOCATION
- GROUNDWATER WELL
- HOUSE
- CURRENT VINEYARD