RICE UNIVERISTY ENGINEERS WITHOUT BORDERS

Appendix D: Calculations

Hydraulic, Structural, and Electrical

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Given Values

	Value	Origins
General		
Total Population (people)	1,200	Census from community
Growth Rate	7%	UN Nicaraguan growth rate with safety factor of 5
Location Of Tank (Elevation, M)	825	Given by ENACAL, determined using GPS
Location Of Pump (Elevation, M)	724	Given by ENACAL, determined using GPS
Hydraulics		
Gallons Per Person (Gallons/Day)	24	Provided by handbook from engineer at ENACAL
Needed Tank Capacity (Days)	1	Community request
Pump Functioning Hours	5.5 - 9.5	From pressure test completed on assessment trip, only accounting for time that PSI at this elevation is >10 (min pressure for pump is < 4 psi)
Number of tanks (22,000L each)	Max 8	This number is capped at 8 because it was determined to be
Structural		
Psi Strength of Concrete	3000	Determined by mix ratios
Mass of Tank (lbs)	201	From pump spec sheet

* More values given in structural section

Electrical

Power Supply	Single Phase	This is determined from the phase of the Nicaraguan electrical grid

Hydraulic Calculations

The following is the calculations completed for the hydraulics team. Final calculations are numbered and related to each section of the hydraulic design in their respective section following the calculations (i.e. Upstream Design Conclusions).

Population and Need Analysis

Tanks needed for current system:

For the current population of 1200 people, the storage facility needs to hold a minimum of 109,020 liters of water to provide for one day of storage. To accommodate this minimum storage criteria, five tanks will be required.

$$1200\ people * \frac{24 gallons}{day} * 1\ day * 3.78541 \frac{liters}{gallon} = 109{,}020\ liters$$

$$109{,}020\ liters * \frac{1 tank}{22{,}000\ liters} = 4.96\ tanks$$

The lower bound for population growth, with a safety factor of 5, is 7% over one year. The upper bound for population growth is 50% over two years. Five tanks will provide water for 1211 people, which the population will grow to within two months. Therefore, we recommend including six tanks in the original construction.

$$\frac{5\ tanks * \frac{22{,}000 liters}{tank}}{\frac{3.78541 liters}{gallon} * \frac{\frac{24 gallons}{person}}{day} * 1 day} = 1211\ people$$

$$\frac{1}{log_{1.07}\left(\frac{1211 people}{1200 people}\right)} = 0.13\ years$$

$$\frac{1}{log_{1.5}\left(\frac{1211 people}{1200 people}\right) * 2} = 0.02\ years$$

The storage facility includes a total of eight concrete foundation pads to allow for community expansion. Eight tanks will accommodate community expansion for about two to seven years.

$$\frac{8\ tanks * \frac{22000 liters}{tank}}{\frac{3.78541 liters}{gallon} * \frac{\frac{24 gallons}{person}}{day} * 1 day} = 1937\ people$$

$$\frac{1}{log_{1.07}\left(\frac{1937people}{1200people}\right)} = 7.1\ years$$

$$\frac{1}{log_{1.5}\left(\frac{1937people}{1200people}\right) * 2} = 2.4\ years$$

Max water capacity of current system:

$$8\ tanks * 22{,}000\ L = 176{,}000\ L$$

Max population:

$$176{,}000L\ \div \left(\frac{24\ gallons}{day} * \frac{3.78541L}{gallons}\right) = 1{,}937\ people$$

Life span of currently designed system:

$$1{,}200\ people * 1.7^{\#\ years} = 1{,}937\ people$$
$$total\ years = 0.90$$

Flow rate needed:

Current desired flow rate: 5 tanks in 5.5 hours:

$$5tanks \times 22{,}000L * \frac{1gallon}{3.78541L} * \frac{1}{5.5hrs} * \frac{1hr}{60min} = 88.1gpm$$

Minimum flow rate: 8 tanks in 9 hours:

$$176{,}000L * \frac{1gallon}{3.78541L} * \frac{1}{9hrs} * \frac{1hr}{60min} = 86.1gpm$$

Note that the maximum pumping time is 9.5 hours. We use 9 hours to create a 30min buffer zone in case the pressure fluctuates at the beginning and end of the 9.5 hours.

To leave a buffer zone for the current desired flow rate, we set the objective flow rate to be $\mathbf{90}\boldsymbol{gpm}$*, which also allows for the easy read of pump curve.*

Velocity in pipe: Under the pipe size of 3 in, water in the pipeline is going to move at a velocity of 3.906 ft/s. Such a speed ensures that the system runs in a safe and low noise condition.

Pipe size: The 3 inch size schedule 40 PVC pipeline is used for the upstream pipeline. It has an inner diameter of 3.068 in and an outer diameter of 3.5 in. This size of pipeline allows a low fluid velocity and therefore a low Total Dynamic Head.
The link for the pipe size:
http://www.all-about-pipe.com/pvc-pipe-dimensions.html

IPS PVC Pressure Pipe

Schedule 40 PVC Pipe				
Size	O.D. (Inches)	I.D. (Inches)	Wall Thickness	Working P.S.I.
1/2"	0.840	0.622	0.109	600
3/4"	1.050	0.824	0.113	480
1"	1.315	1.049	0.133	450
1-1/4"	1.660	1.380	0.140	370
1-1/2"	1.900	1.610	0.145	330
2"	2.375	2.067	0.154	280
2-1/2"	2.875	2.469	0.203	300
3"	3.500	3.068	0.216	260
4"	4.500	4.026	0.237	220
5"	5.563	5.047	0.258	190
6"	6.625	6.065	0.280	180
8"	8.625	7.961	0.332	160
10"	10.750	9.976	0.365	140
12"	12.750	11.890	0.406	130

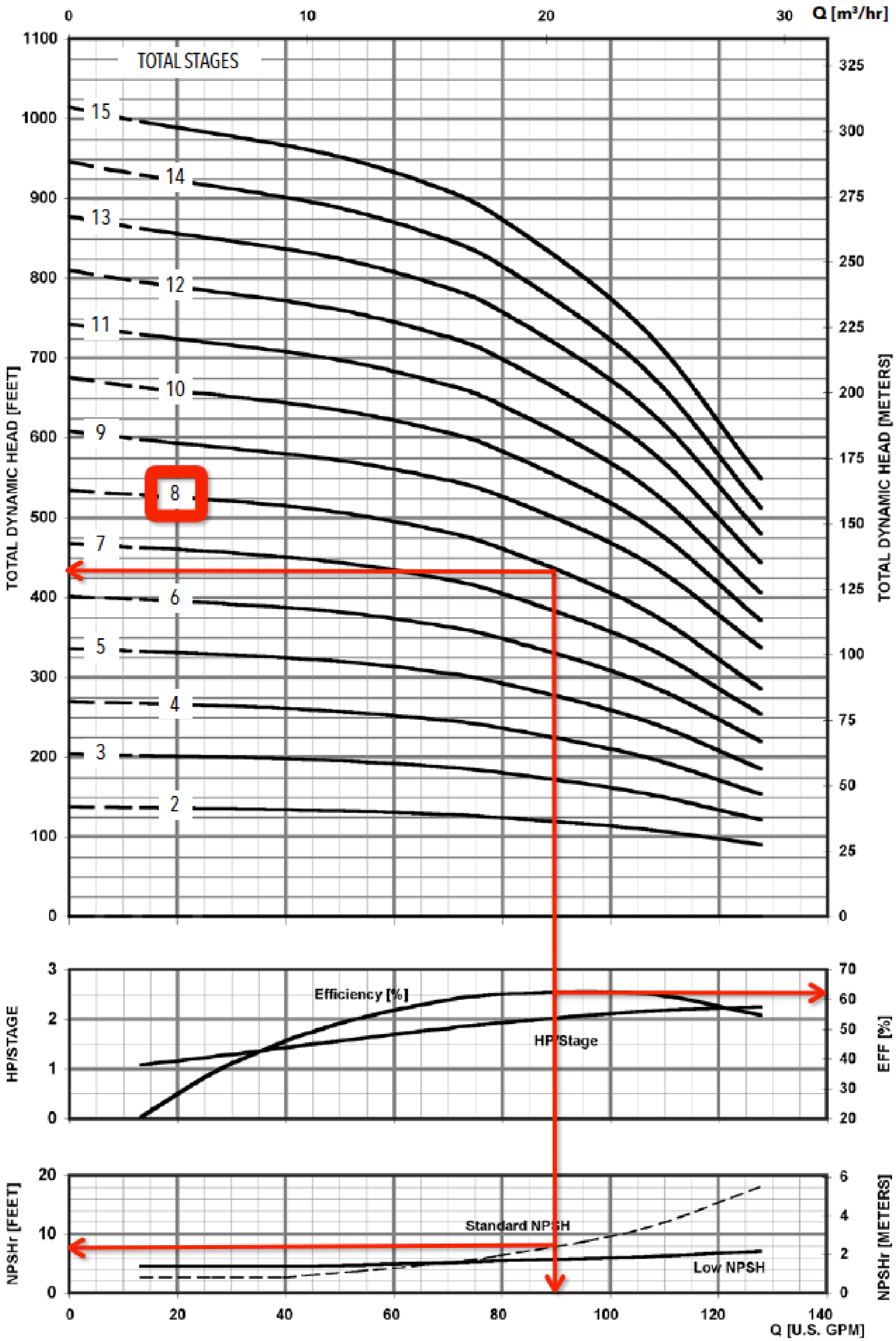
Frictional head loss:
The head loss generated in upstream pipeline is 54.719 ft.

Resulting total dynamic head (TDH):
The Total Dynamic Head is 386.583 ft.

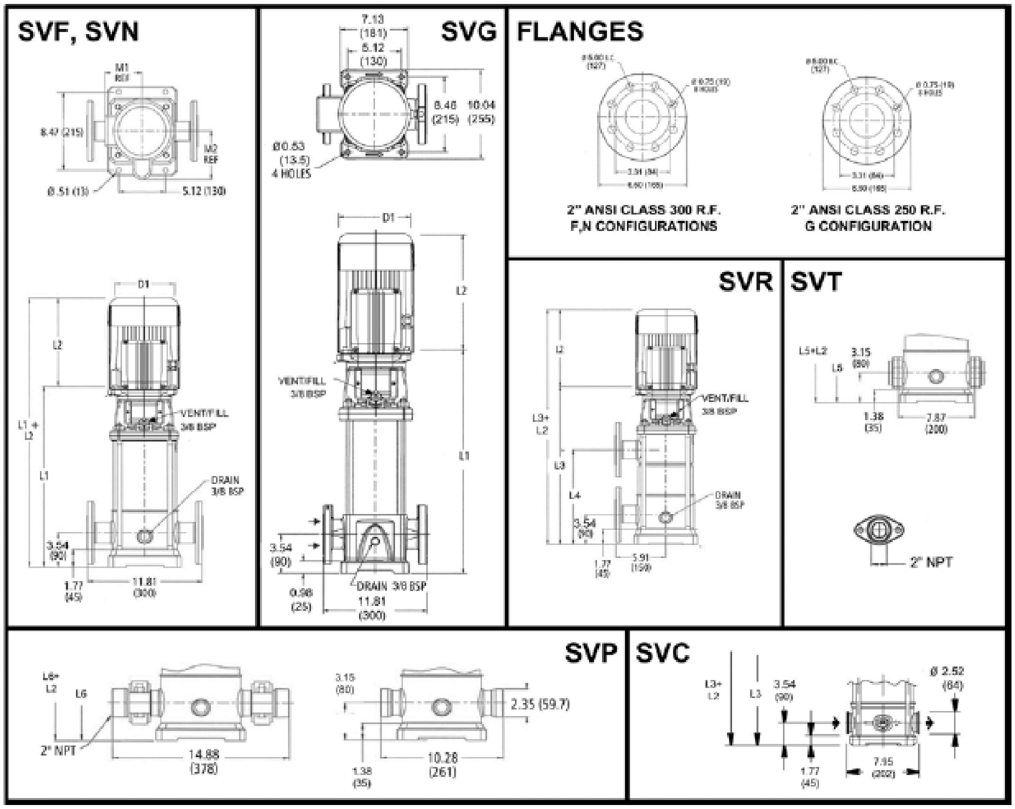
Pump Sizing:
Based on the flow rate of 90gpm, we choose the 15SV Series pumps by the Goulds Pumps. The series has an efficiency of 63% at 90gpm, which is at the highest point (Figure 1: Pump Curves). Besides, the net positive suction head required (NPSHr) for the 15SV Series at 90gpm is only 8ft, or 3.47psi, which is much lower than 10psi.

To select the number of stages for the pump, we look at the pump curve in Figure 1.
With a total dynamic head (TDH) of 386.583 ft, the 7-stage pump and the 8-stage pump are within our consideration. However, the 7-stage pump is just enough to provide 90gpm at the provided TDH, which does not allow for any error. We decide to use the 8-stage pump to allow for safety if TDH is greater due to poor quality GPS or data.

Based on the pump selected (15SV-08), we look at Figure 2: Pump Dimensions to decide the motor. The motor indicated is a 15HP motor, and because the pump will be protected by the pump station, we decide to use the ODP 15HP motor for the pump.



MINIMUM FLOW RATE: 18 GPM [4.1 m³/hr]



All dimensions are in inches (mm).

PUMP DIMENSIONS AND WEIGHTS - 15SV SERIES – 60Hz, 3500 RPM ODP/TEFC Enclosures

Pump Type Stages	Motor					Dimensions (in)															Weight (lbs.)								
	HP	NEMA Frame				L1	L2				L3	L4	L5	L6	M (Ref.)	D1 (max.)				D2	Pump	Motor				Pump/Motor			
		ODP 1Ø	TEFC 1Ø	ODP 3Ø	TEFC 3Ø		ODP 1Ø	TEFC 1Ø	ODP 3Ø	TEFC 3Ø						ODP 1Ø	TEFC 1Ø	ODP 3Ø	TEFC 3Ø			ODP 1Ø	TEFC 1Ø	ODP 3Ø	TEFC 3Ø	ODP 1Ø	TEFC 1Ø	ODP 3Ø	TEFC 3Ø
15SV-02	5	184TC		182TC	184TC	18.71	13.93	15.43	12.55	13.93	-	-	18.32	18.32	6.87	8.88	8.86	9.02	8.86	5.51	44	81	92	62	69	125	136	106	113
15SV-03	7.5	213TC		184TC		20.60	13.88	15.53	13.93	15.43	-	-	20.21	20.21	8.05	8.89	10.62	8.88	8.86	5.51	47	100	120	75	85	147	167	122	132
15SV-04	10	215TC		213TC	215TC	23.06	16.63	16.68	15.55	15.51	23.06	11.85	22.67	22.67	8.77	10.62	10.18	10.18	10.28	5.51	57	132	145	107	122	189	202	164	179
15SV-05						24.95	16.63	16.68	15.55	15.51	24.95	13.74	24.56	24.56	8.77	10.62	10.18	10.18	10.28	5.51	59	132	145	107	122	191	204	166	181
15SV-06	15	-		215TC	254TC	27.49	-	-	15.55	16.57	27.49	15.63	27.10	27.10	9.22	-	-	10.18	10.28	5.51	71	-	-	125	195	-	-	196	266
15SV-07						29.38	-	-	15.55	16.57	29.38	17.52	28.99	28.99	9.22	-	-	10.18	10.28	5.51	74	-	-	125	195	-	-	199	269
15SV-08						31.27	-	-	15.55	16.57	31.27	19.41	-	30.88	9.22	-	-	10.18	10.28	5.51	76	-	-	125	195	-	-	201	271
15SV-09	20			254TC	256TC	33.16	-	-	16.66	20.08	33.16	21.30	-	32.77	9.5	-	-	10.18	13.13	5.51	79	-	-	144	285	-	-	223	364
15SV-10						35.05	-	-	16.66	20.08	35.05	23.19	-	34.66	9.5	-	-	10.18	13.13	5.51	83	-	-	144	285	-	-	227	368
15SV-11						36.94	-	-	16.66	20.08	36.94	25.08	-	36.55	9.5	-	-	10.18	13.13	5.51	86	-	-	144	285	-	-	230	371
15SV-12	25			254TC	284TC	39.46	-	-	21.44	19.54	-	-	-	39.07	12.94	-	-	11.63	12.94	5.51	97	-	-	185	283	-	-	282	380
15SV-13						41.35	-	-	21.44	19.54	-	-	-	40.96	12.94	-	-	11.63	12.94	5.51	100	-	-	185	283	-	-	285	383
15SV-14						43.24	-	-	21.44	19.54	-	-	-	42.85	12.94	-	-	11.63	12.94	5.51	103	-	-	185	283	-	-	288	386
15SV-15	30			284TC	286TC	45.13	-	-	21.75	19.54	-	-	-	44.74	12.21	-	-	13.25	12.94	5.51	106	-	-	296	382	-	-	402	488

Structural Calculations

Soil Bearing Capacity Calculations

To calculate the ultimate bearing capacity of the soil, we used the following equation, the Terzaghi Bearing Capacity equation.

$$q\_ult \ = (c)(Nc)(sc) \ + (\gamma)(D)(Nq)(sq) \ + (0.5)(B)(\gamma)(Ng)(s\gamma)$$

Important pieces of information for the calculation of the ultimate bearing capacity were:

Cohesive Strength of Soil (c)	245	kPa
Internal Angle of Friction (φ)	18	degrees
Unit Weight of Soil (ɤ)	9.27	kN/m^3
Depth of Foundation (D)	0	m
Width of Foundation (B)	4	m
Safety Factor	3	
Angle Of Internal Friction	18	degrees
Bearing Capacity Factor (cohesion) Nc	13.1	
Bearing Capacity Factor (surcharge and friction) Nq	5.3	
Bearing Capacity Factor (self weight and friction) Nɤ	2.1	
Shape Factor (Sc)	1.3	
Shape Factor (Sq)	1	
Shape Factor (Sɤ)	0.8	

The angle of internal friction was determined by identifying the soil type as clay.
Bearing capacity factors were derived from the internal angle of friction.
Shape factors were derived by using a square foundation.

$$Q\_ult = \ (245)(13.1)(1.3) + (9.27)(0)(5.3)(1) + 0.5(4)(9.27)(2.1)(0.8) = \ 4203kPa$$

$$Safe\ Bearing\ Capacity = Qs = \frac{Qult}{Safety\ Factor} = \frac{4203}{3} = 1401\ kPa$$

$$Theoretical\ Load\ supported\ by\ Slab = \frac{1000(Qs)(B^2)}{g} = \frac{1000(1401)(4^2)}{9.81} = 2285285\ kg$$

The mass of the 22000 liter tank is 22000 kg. And the slab is approximately 8000 kg. Therefore, the soil is more than strong enough to support the tank.

Pump Station Cross-Section Calculations

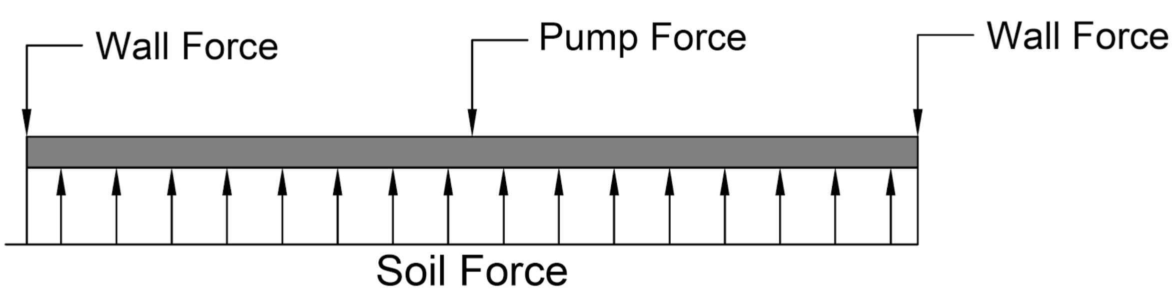
a. Design moment calculation:

To calculate the design moment, we need to determine what part of the slab will experience the most moment. We will assume the slab dimensions of 5.80 x 2.60 x 0.20 meters as given, due to the amount of spacing needed for the pump and valves. The max moment will occur along the center of the long dimension of the slab. The deadweight of the pump will sit in the middle and the deadweight of the CMU walls will sit on the ends of the slab. The slab will be assumed to be uniformly supported by the underlying soil.

Table of Constraints		
Dimensions of Slab	5.80 x 2.60 x 0.20	meters
Mass of pump	91.17	kg
Dimensions of pump platform	1.00 x 0.40 x 0.50	meters
Density of concrete and CMU blocks	2400	kg/m^3
Height of CMU wall	2.40	meters
Width of CMU wall	0.15	meters
Acceleration due to gravity (g)	9.81	m/s^2

The moment will be calculated for the critical portion of the slab, the 0.40 meter wide strip that lies along the long axis of the slab that crosses the pump pad.

Force diagram:



$$Moment\ along\ outside\ edge\ to\ center\ =\ (force\ of\ cmu\ wall)(distance)\ +\ (force\ from\ soil)(distance)$$

$$force\ from\ soil\ =\ force\ from\ both\ CMU\ walls\ +\ force\ from\ pump\ and\ platform$$

$$force\ from\ CMU\ wall\ =\ (volume)(density\ of\ CMU)(g)$$

$$Force\ from\ pump\ and\ platform\ =\ (volume\ of\ platform)(density\ of\ concrete)(g)\ +\ (mass\ of\ pump)(g)$$

$$force\ from\ soil\ =\ 2*(0.15)(0.4)(2.40)(2400)(9.81)\ +\ (1.00)(0.4)(0.5)(2400)(9.81)+(91.17)(9.81)$$

$$force\ from\ soil\ =\ 12383\ newtons$$

$$distributed\ force\ from\ soil\ =\frac{force}{length}=\frac{12383}{5.8}=\ 2135\ N/m$$

$$Moment\ along\ left\ outside\ edge\ to\ center$$
$$=\ (0.15)(0.4)(2.40)(2400)(9.81)*x\ -\ 2135*x*\frac{x}{2}$$

$Maximum\ moment\ is\ when\ x\ =\ 1.59\ meters.$
$Maximum\ moment\ =\ 2691\ N*m$
$Design\ moment\ =\ Maximum\ moment\ *\ safety\ factor$

$Design\ moment\ =\ 2691\ *\ 1.2\ =\ 3230\ N*m$

b. Rebar design calculations

For rebar design, Whitney Stress Block theory will be used. We need to solve for the area of steel to be used. We will assume the bars are placed 7 cm from the bottom of the slab.

Design Inputs		
Concrete Design Compressive Stress (f'c)	21	MPa
Yield Stress of steel (fy)	420	MPa
Base (b)	0.2	meter
Design Moment (M_u)	4100	N-m
Safety Factor (phi)	0.9	
Depth (d)	0.13	meter

$$Maximum\ force\ in\ steel\ *\ distance\ =\ moment$$

$$(fy)(Area\ of\ steel)(d-\frac{a}{2})\ =\frac{moment}{safety\ factor}$$

$$a\ =\frac{(fy)(Area\ of\ steel)}{(0.85)(f'c)(width)}$$

$$(fy)(As)(d-\frac{(fy)(Area\ of\ steel)}{(1.7)(f'c)(width)})\ =\frac{moment}{safety\ factor}$$

$$(420000000)(As)(.13-\frac{(420000000)(As)}{(1.7)(21000000)(.5)})\ =\ \frac{3230}{0.9}$$

$$As\ =\ .00006653\ m^2\ =\ .6653\ cm^2$$
$$=\ area\ needed\ for\ a\ .4\ meter\ wide\ segment\ of\ the\ slab.$$

$$As\ total\ short\ side\ =\ As\ *\ width/unit\ area\ =\ .8473 * 2.6/0.4\ =\ 4.32\ cm^2$$
$$As\ total\ long\ side\ =\ As\ *\ width/unit\ area\ =\ .8473 * 5.8/0.4\ =\ 9.64\ cm^2$$
$$Area\ of\ \#2\ rebar\ =\ .31669\ cm^2\ =\ 14\ bars\ needed\ (short\ side)\ =\ 32\ bars\ (long)$$
$$Area\ of\ \#3\ rebar\ =\ .71256\ cm^2\ =\ 7\ bars\ needed\ (short\ side)\ =\ 14\ bars\ (long)$$
$$Area\ of\ \#4\ rebar\ =\ 1.2668\ cm^2\ =\ 4\ bars\ needed\ (short\ side)\ =\ 8\ bars\ (long)$$

To minimize cracking, we will use the #2 rebar for the pump station slab. Rebar will be equally spaced, with 10 cm or greater clearance from the edges.

Final rebar specifications for the slab		
Size of Rebar	#2	
Depth(d)	13.0	cm
Total No. of Rebar for short side	14	
Total No. of Rebar for long side	32	

Pump Station Construction Notes

a. Concrete skirt

The purpose of the concrete skirt is to prevent the slab from being undermined by erosion. The subterranean concrete skirt will be poured before the slab is poured and the slab rebar is placed. Ensure that the rebar that is inside the CMU walls is vertically placed in the concrete skirt and sticking out of the ground and to the proper measurements. This rebar will help secure the skirt and the CMU walls.

b. Pump platform

Ensure that rebar is sticking up in the middle of the slab before pouring. Also ensure that this rebar sticks out at least 0.45 meters from the surface of the slab. The pump will be placed on a raised concrete platform, a 1.00x0.50x0.50 meter block of concrete. This platform will be poured separately from the underlying slab, so it needs to be secured to the slab through the rebar. This rebar will secure the platform, and therefore the pump, to the slab, and the rebar will minimize cracking so that the pump remains level.

c. Thrust block

The thrust block is a block of concrete placed around the pipes in front of the discharge end of the pump so that the pipes are protected from hydraulic forces. The thrust block adds mass to the pipes, so for a given force they are deflected a shorter distance. This reduction in deflections reduces the stress on the pipes and reduces the risk of the pipes breaking. It is poured after the slab is poured and after the pipes are set.

d. Top of wall slope

After the wall is complete, ensure that the top of the wall has a slope. This can be achieved by mixing concrete and placing it on the top of the CMU wall. Make sure the 0.2 meter high section is on the side of the facility facing uphill and that the top of the wall slope is in the same direction as the surrounding terrain. This ensures that rain runs off of the roof and away from the building and not back towards the foundation.

e. CMU wall and roof interface

Ensure that the rebar that is placed in the CMU walls penetrates through the top of the wall and the sloped concrete layer. This allows the welders to weld metal beams directly onto the structure. These beams go across the roof, which provides an anchor point for the sheet metal roof.

Storage Facility Concrete Cross Sections

The slabs for the water tanks will experience distributed forces while being uniformly supported by the underlying soil. Therefore these slabs will experience very low bending moments, so no structural steel is needed for these slabs.

However, these slabs have a chance to crack due to shrinkage and temperature stresses. These slabs are exposed to the outdoor environment, so if these cracks are not controlled the slab can disintegrate into pieces or become too uneven to be used as a storage tank foundation. Proper construction practices during the pouring of concrete will reduce the risk of cracking, but steel will be designed into the slab so it will remain as one whole piece even if severe cracking occurs. According to ACI committee 360, a steel ratio of 0.1% is enough to halt the expansion of cracks without causing additional cracks.

a. Steel area calculation

We will assume the slab dimensions of 3.15 x 3.15 x 0.20 meters as given, due to the dimensions of the storage tank and space needed to anchor the tank.

$$Area\ of\ steel\ =\ cross\ sectional\ area\ of\ slab * (0.001)$$
$$Area\ of\ steel\ =\ (3.15)(0.2)(0.001)\ =\ .00063\ m^2\ =\ 6.3\ cm^2$$
$$Area\ of\ \#2\ rebar\ =\ .31669\ cm^2 =\ 20\ bars\ needed$$
$$Area\ of\ \#3\ rebar\ =\ .71256\ cm^2 =\ 9\ bars\ needed$$
$$Area\ of\ \#4\ rebar\ =\ 1.2668\ cm^2 =\ 5\ bars\ needed$$

Depending on available materials in country, this area of steel will be placed 5 cm from the top of the slab.

b. Landslide Risk Analysis

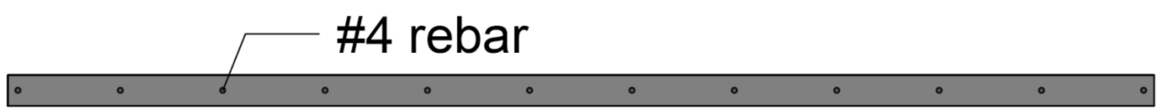
This storage facility will be placed on a sloped hill. The construction area will be flattened prior to construction, but a mass of soil will sit uphill of the facility. In heavy rains some of the hillside may flow downhill and impact the walls of the storage facility.

These calculations determine the resistance of the walls to a mass of fluid soil pushing against it. Specifically these calculations will determine the maximum height of flowing soil that the wall can resist. If soil is determined to be flowing near this height, then the wall must be reinforced and braced at the expected centroid of the fluid force.

Calculation Inputs		
Density of Soil	9270	N/m^3
Yield Stress of Steel (fy)	420	MPa
Width of Wall	5.6	meter
Height of Wall	2.4	meter
Thickness of Wall	0.15	meter
Depth of rebar in wall	0.075	meter

i. Moment Strength of the CMU wall

Cross section of wall:



Number of rebar = 12 #4 rebar

$Area\ of\ steel\ =\ 2.36\ in^2\ =\ .00152\ m^2$

Using Whitney Stress Block theory

$$Maximum\ force\ in\ steel\ *\ distance\ =\ moment$$

$$(fy)(Area\ of\ steel)(d - \frac{a}{2})\ = moment$$

$$a\ =\ \frac{(fy)(Area\ of\ steel)}{(0.85)(f'c)(width)}$$

$$(fy)(As)(d - \frac{(fy)(Area\ of\ steel)}{(1.7)(f'c)(width)})\ = moment$$

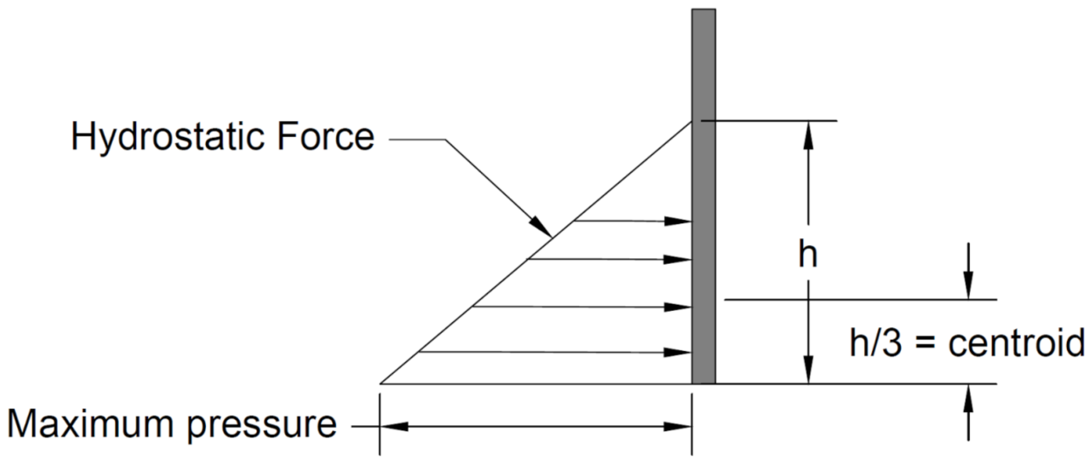
$$(420000000)(.00152)(.075 - \frac{(420000000)(.00152)}{(1.7)(21000000)(5.6)})\ =\ Moment$$

$$Moment\ =\ 45844\ N * m$$

ii. Height of fluid soil needed to break the wall

Assuming the soil is perfectly fluid, then as it accumulates up against a wall segment it will exert a hydrostatic pressure against the wall. This pressure then exerts a moment on the fixed end of the wall in the ground.

Force diagram:



$$Force = (Average\ pressure) * (area)$$

$$Force = \frac{(unit\ weight)(height)}{2} * (height)(Width)$$

$$Moment = Force * distance$$

$$Moment = \frac{(unit\ weight)(height)}{2} * (height)(Width) * (\frac{height}{3})$$

$$45844 = \frac{(9270)(h)}{2} * (h)(5.6) * \frac{h}{3}$$

$$h = 1.74\ meters\ of\ fluid\ soil$$
$$centroid\ of\ force = 1.74/3 = 0.58\ meters$$

Storage Facility Construction Notes

a. CMU wall vertical rebar

Unlike the pump station rebar, there will be 2 pieces of rebar in each indicated cell. These walls are longer and taller than the pump station so the extra rebar is to provide greater strength.

b. CMU wall horizontal rebar

At specific heights horizontal rebar will be placed in the wall. This horizontal rebar prevents the wall from bending around a vertical axis. The CMU blocks must have notches cut into them so that the rebar can fit. Also, concrete must be poured around the rebar to secure it to the CMU wall.

c. CMU wall gaps

The wall is designed to have periodic vertical gaps where CMU blocks are not mortared together. A long continuous wall will randomly crack due to shrinkage, moisture, and thermal effects. Random cracks could compromise the structural strength of the wall and should be avoided. The designed gaps break the wall up into shorter segments that are less likely to randomly crack. Also, these gaps act like controlled cracks so we know where the weaknesses are located and we know where to place reinforcement.

d. Landslide risk

The walls as designed can withstand a landslide of perfectly fluid soil that is 1.74 meters tall. If soil accumulates past this height then additional reinforcement of the walls will be needed. This can be accomplished by adding steel reinforcement or steel bracing on the inside of the structure. It must be attached to a point on the wall that is 0.6 meters or higher off the ground to be effective because this is the height where the centroid of the landslide force will occur.

Electrical Calculations

In order to find out what wiring we needed to install, as well as the size of breaker box we needed, the team calculated the VA load, or the watts necessary to run the pump and the light.

VA calculations:

Pump Horsepower=15
Pump Efficiency=0.63
Volts=240

$$Amperes = \frac{Hp * 746}{Volts * Efficiency} = \frac{15 * 747}{240 * .63} = 74\ amps$$

$$Total\ Watts = 240Volts * 74Amps = 17{,}760W = 17.76kW$$

Wire Size Based on NEC: Copper-AWG #3

In order for the pump and the light to work, the total VA load that the breaker box would need to handle is 17.76kW.

The VFD was selected based on the fact that we are using a 1phase input and controlling a 3phase, 15hp pump. For this reason, the VFD chosen is rated for 30hp.