Final Design Report

Team 06

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Engineering 339/340

Calvin College

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Executive Summary

The community of Chañac San Miguel, Ecuador currently operates a water system, known as Chañac Puelaso, that was intended to be temporary when it was installed 30 years ago. This existing system is inadequate, deteriorating, and needs serious renovations as the community is continuing to grow and relocate homes. Team 06 partnered with the organizations Life Giving Water International and Codiense and analyzed the existing water distribution system to produce design recommendations for retrofitting and replacing the current water distribution system.

Two members of Team 06 traveled to Ecuador in January 2017 to meet the community and take a geographic survey of the locations of existing and future home sites as well as salvageable parts of the existing water system. Team 06 then designed a system that integrated the existing feedline and splitting tank, two of the existing storage tanks, one new storage tank, and one new pressure breaking tank in order to feed all new and existing homes via a network of new, buried PVC pipes.

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1. Introduction

1.1 Calvin Engineering and Senior Design

Calvin College offers a unique liberal arts approach to its engineering program, which is accredited by the Accreditation Board of Engineering and Technology (ABET). The program offers four concentrations including mechanical, civil and environmental, electrical and computer, and chemical engineering. Students who complete the four-year professional program are required to take classes outside their major to fulfill the liberal arts aspect of the program, as well as complete a senior design capstone course. This capstone course is a two-semester commitment to choosing, proposing, designing, and presenting a completed design project. The intent is to bring together the knowledge acquired throughout each student’s previous three years at Calvin College, incorporating both engineering knowledge and a Christian perspective throughout the entire design process. To complete the capstone, students are required to work in teams of 3-5 peers to choose and complete a design project from initial proposition to final design.

1.2 Senior Design Team 06

Team 06, which also goes by "Volcán Altar", is comprised of three senior civil/environmental engineering students. These team members are pictured below in Figure 1. Pictured from left to right are Ariana Strydhorst, Jennah Maier, and Emily Lawson.

Figure 1. Members of Team 06

1.2.1 Emily Lawson

Emily Lawson is a senior level student majoring in civil/environmental engineering and minoring in international development studies. She grew up in Denver, Colorado with a diverse culture of immigrants, environmental activists, and passionate Christians. This upbringing has inspired her to act out her faith in love through holistic evangelism. She has traveled to Ecuador, Peru, Ethiopia, and Kenya to work on water projects varying from physical access to, cultural appropriations of, and the cleaning of water. She is passionate about human rights, justice, water, and the intersection of all three. After graduating in July 2017, she hopes to pursue a career in which engineering can be used to provide humans access to water through engineering or law.

1.2.2 Jennah Maier

Jennah Maier is a senior level student majoring in civil/environmental engineering and minoring in environmental studies. She grew up in Grand Rapids, Michigan and spent the past summer working under the Clean Water Institute of Calvin College. For this job, she did research on the various water disinfection approaches used in developing countries. She is passionate about the intersection of environmental and humanitarian work and plans to pursue a career in water engineering after graduation in May 2017.

1.2.3 Ariana Strydhorst

Ariana Strydhorst is a senior level student majoring in civil/environmental engineering and international development studies at Calvin College. Ariana came to Calvin from Calgary Alberta, Canada. Growing up in the foothills of the Rocky Mountains influenced Ariana to become passionate about environmental consciousness. She spent the past summer, and still holds an intern position, at an agricultural engineering consulting firm in Grand Rapids, Michigan. Ariana is spending her summer in the same intern position before returning to Calvin for a final semester of international development studies a semester abroad in the spring. Upon graduation in May 2018, she plans to follow her passion for travel and international development by utilizing her engineering degree overseas.

1.3 Project Description

1.3.1 Project Description

Team 06's project was to design a new water distribution system for the community Chañac San Miguel in Chimborazo, Ecuador. The Chañac San Miguel community currently operates a 30-year-old water distribution system, which was intended to be temporary when installed. This system supplies the five communities that comprise Chañac, approximately 1800 people, with water from a nearby spring. Although the water quality of the spring is very high, the feedline and distribution system were poorly designed and are degrading with time. Additionally, unstable soil conditions have caused the school, community center, and approximately 20 homes to begin soil creeping down the mountain. In general, the water needs of the community are unsatisfied and the system needs serious renovations. The organization Life Giving Water International and Team 06 have analyzed the current system of Chañac San Miguel and produced recommendations for improvements to the water distribution system.

1.3.2 Project Location and Local Culture

Chañac is a rural area made up of 5 communities of indigenous Kichwa people. It is located in Chimborazo, Ecuador, just East of Riobamba and approximately 90 kilometers West of Volcán Altar. Chañac lies between the White River and Lake San Martin, with elevations ranging between 3800 and 2700 meters above sea level. The locations of Ecuador and its Chimborazo province are shown below in Figures 2 and 3, respectively. The approximate location of Chañac relative to the city of Riobamba in Chimborazo, Ecuador is given following in Figure 4, as seen from a satellite. One of these five communities is Chañac San Miguel, whom this project was designed for; the other four communities that comprise Chañac include San Francisco Palace, San Pedro de Iguazo, Santa Ana Saguer and Puelazo.

Figure 2. Location of Ecuador in South America

(image from http://wrm.org.uy/browse-by-country/america/ecuador/)

Figure 3. Location of the Chimborazo Province in Ecuador

(image from http://ecuador.teach-english-volunteer.com/about-ecuador/)

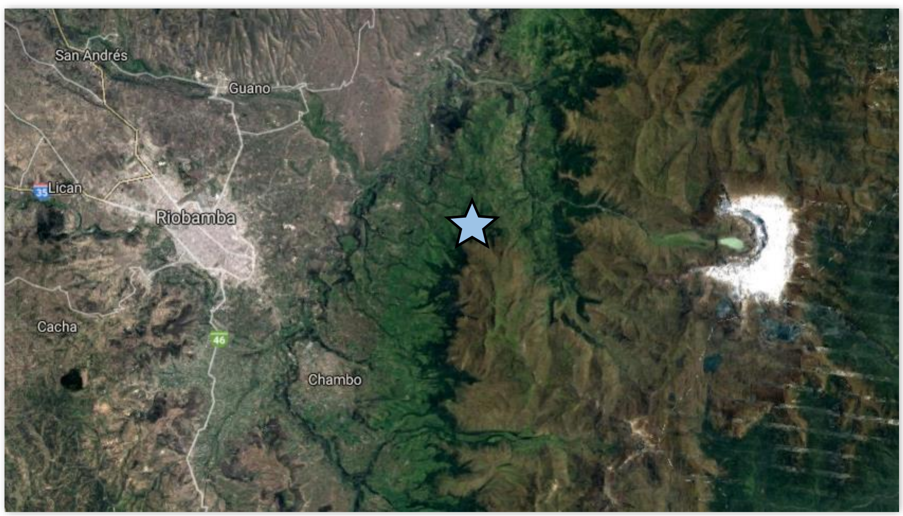

Figure 4. Location of Chañac San Miguel, Ecuador

(image from https://www.google.com/maps/@-1.6743318,-78.5530222,30466m/data=!3m1!1e3)

These communities are almost exclusively indigenous people, speaking Kichwa as a primary language. Due to the increase in education efforts towards the indigenous groups of Ecuador, some of the population speaks Spanish in addition to Kichwa. Much of the population are farmers, working along the slopes of the Andes. They produce crops such as quinoa, potatoes, barley, cattle, sheep, and pigs. These crops comprise most of their diet, with the occasional chicken, or ceremonial guinea pig. Given Chañac's elevation and proximity to the equator, the climate remains cool and dry with a rainy season from mid-September to mid-January. The harsh conditions were both a protector of the Kichwa people during colonial times and a major obstacle, leaving much of the region very poor.

The five communities of Chañac have a combined population of 1,855 people as of 2015, with a population growth of approximately 1% per year. 371 families are recorded, with an estimated 'floating' population of 157 people comprised of students and teachers who do not reside in the community permanently. The average annual income is $1,225 per person, and the average household includes five inhabitants.

All five of these communities share a water system, known as Chañac Puelaso, which carries water from a nearby spring to a splitting tank that distributes water to all five communities. The people use an average of only 60 liters of water per person per day, due in part to a lack of sanitary systems within the communities. Assuming 5 people per home, the households in this community use an average of 300 liters of water per day. As a comparison, the average household in the United States uses 300 gallons (1100 liters) of water per day ("How We Use Water," 2017).

1.3.3 Project Partnership

Life Giving Water International is an organization with a base in the province of Chimborazo, Ecuador that does work with many local communities to design new or improved water distribution and disinfection systems. Life Giving Water International has been working in Ecuador with the Kichwa people for over 25 years. This organization practices holistic evangelism with a strengths-based community development model. Communities invite Life Giving Water to enter as the engineering expertise for water distribution systems, spring protection, and disinfection systems. In these situations, the community agrees to provide labor and any necessary materials to construct the water system. Head engineering consultants of Life Giving Water International include Bruce Rydbeck and Martin Henrich.

Life Giving Water also has an existing relationship with the local, Ecuadorian Non-Governmental Organization (NGO) Codeinse. Efrain Morocho is the Ecuadorian project manager and construction overseer. Like Life Giving Water, Codeinse provides technical assistance to indigenous communities throughout the Ecuadorian Andes. Team 06 worked closely with Life Giving Water International and Codeinse throughout the duration of the project both for technical advice and to keep in contact with the Chañac community.

Life Giving Water International and Codeinse got connected with this project for Chañac San Miguel because the priest of the local parish witnessed how a neighboring community's water system implementation (clients of Life Giving Water approximately 10 years previous) functioned seamlessly. He initiated contact with Codeinse, who subsequently contacted Life Giving Water. Team 06 became involved in the project through an existing connection with Bruce Rydbeck from Life Giving Water International.

When Life Giving Water works with communities, the communities are expected to contribute the labor for implementation as well as some agreed upon amount of financial resources. Alterations to the splitting tank and distribution system would be jointly financed by both the community and contacts of Life Giving Water International, given recommendations provided by Team 06.

1.3.4 Existing Distribution System

This community has a significant need for a new water distribution system for several reasons. Chañac San Miguel currently uses a 30-year-old system that was intended to be temporary when it was installed. It has a piping network that mostly hangs in trees, which is not as sustainable as a system protected by burying. The community is growing and expects to be building many new homes. Furthermore, because of unstable soil, many of the existing homes need to relocate to stable ground. These new and relocated homes will need the proposed water system to service them as well. For these reasons, it is a good time for Chañac San Miguel to invest in a new water system that will serve them well for years to come.

1.4 Design Norms

Throughout the project, Team 06 focused on designing a water distribution network for the community while upholding all eight design norms. While all eight of the design norms (caring, justice, stewardship, open communication, trust, delightful harmony and cultural appropriateness) are equally important in engineering design and Christian witness, upon completion of the project, Team 06 has highlighted three that were particularly important in this project's context.

1.4.1 Cultural Appropriateness

Because this project was designed by North Americans to be implemented in an Ecuadorian context, the design norm of cultural appropriateness was vital to the success of the design. After traveling to the project location, making observations, and being immersed in the culture for a short time, Team 06 has taken careful measures to design a distribution system appropriate for the culture in which it could be implemented and utilized.

1.4.2 Justice

Because human rights and justice are intimately linked, Team 06 recognized the importance of justice as a design norm in this context. The Kichwa people of Ecuador were a sub-servient class up until the mid-1900s; it was only then that they were granted citizenship and given minimal land ownership. Due to the hundreds of years of oppression the Kichwa faced, much this people group still live in extreme poverty throughout the Andes Mountains. By bringing clean and accessible water to oppressed groups, just practices are achieved.

1.4.3 Stewardship

This design norm came into play in many aspects of Team 06's design. First and foremost, members of Team 06 acted as stewards of the community's resources, both financial and physical. Knowing that cost was the most significant barrier to implementation, Team 06 worked to design a system within the means of the community's financial resources. As well, with regard to God's creation, Team 06 sought to design a system that nurtures the natural environment and utilizes the community's water resources appropriately.

2. Project Management

2.1 Team Organization

Organization that played to the strengths of each of Team 06's members was essential to the success of the project. Jennah Maier and Ariana Strydhorst acted as the primary data collection personnel, and completed the topographic survey and important design notes in Ecuador in January 2017. Upon return to Grand Rapids, Jennah specialized in sizing and placement of pipes in the proposed network as well as sizing of the tanks. Ariana used her AutoCAD experience to draft and design the final recommended pipe network and tank specifications. Emily Lawson also contributed to the EPANET model, researched tank specifications, and completed a GIS model to display the final proposal. While some general tasks were completed individually, the project as a whole was largely team based. Significant portions of the design decisions, the drafting process, and final presentations were worked on collaboratively.

2.2 Schedule

2.2.1 Fall Semester

The nature of Calvin College's year-long senior design project creates a natural break between the fall and spring semesters. The fall semester is focused on a project proposal and feasibility study (PPFS), followed by design in the spring. Team 06's schedule followed this pattern, making the fall semester a project selection, research, and data collection semester. At the end of 2016, team 06 had completed a proposal and feasibility study, and was prepared to travel to Ecuador and conclude the data collection phase of the project.

2.2.2 January Trip to Ecuador

During the month of January 2017, team members Jennah Maier and Ariana Strydhorst traveled to the community of Chañac San Miguel in Ecuador to complete the data collection necessary for the final design. The ten-day trip consisted of intensive immersion in the community and resulted in a complete topographic survey of the community as well as acquiring design considerations and cultural norms to be accounted for. This trip was an integral part of the project and design process, and it was also required by the partnership agreed upon between Team 06 and Life Giving Water International.

2.2.3 Spring Semester

After the data collection was complete, Team 06 reassembled in Grand Rapids, Michigan to complete the design phase of the project. From February to May 2017 the team met three times a week at minimum as well as worked individually to successfully complete the project. Throughout this design semester the team manipulated the data collected in January to create an EPANET model as validation of design, complete cost calculations, and create a final AutoCAD deliverable draft of the design recommendations for Life Giving Water and the community of Chañac San Miguel.

2.3 Budget

Per the Calvin College engineering department's policies, each senior design team is allotted $500 from the department for the completion of the project. In addition to this, Team 06 was generously provided $2,000 from the Eric DeGroot Scholarship Fund to make the successful completion of this project possible.

Due to the international component of this project, Team 06 incurred a total expense of approximately $1,625. The total project budget breakdown can be found following, in Table 1.

Table 1. Budget Overview

Expense	Estimated Cost	Total (for 2 people)
In-Country Meals & Housing	$110/person	$220
In-Country Transportation	$160/person	$320
Bus to airport & Flight Cost	$542.28/person	$1,084.56
	Total:	$1,624.56

This budget refers to the cost of design work done by Team 06. The implementation of the proposed project will incur additional expenses, which are outlined in Section 4.5.

3. Design Process

3.1 Design Process Introduction

After the collection of data in Ecuador, analysis and design began based upon the surveyed community elevations and layout. Team 06 split the community into five zones based on which tank sets the pressure of the homes in that area. These zone titles, given in Figure 5, were used throughout the design process and throughout this report for the sake of clear communication.

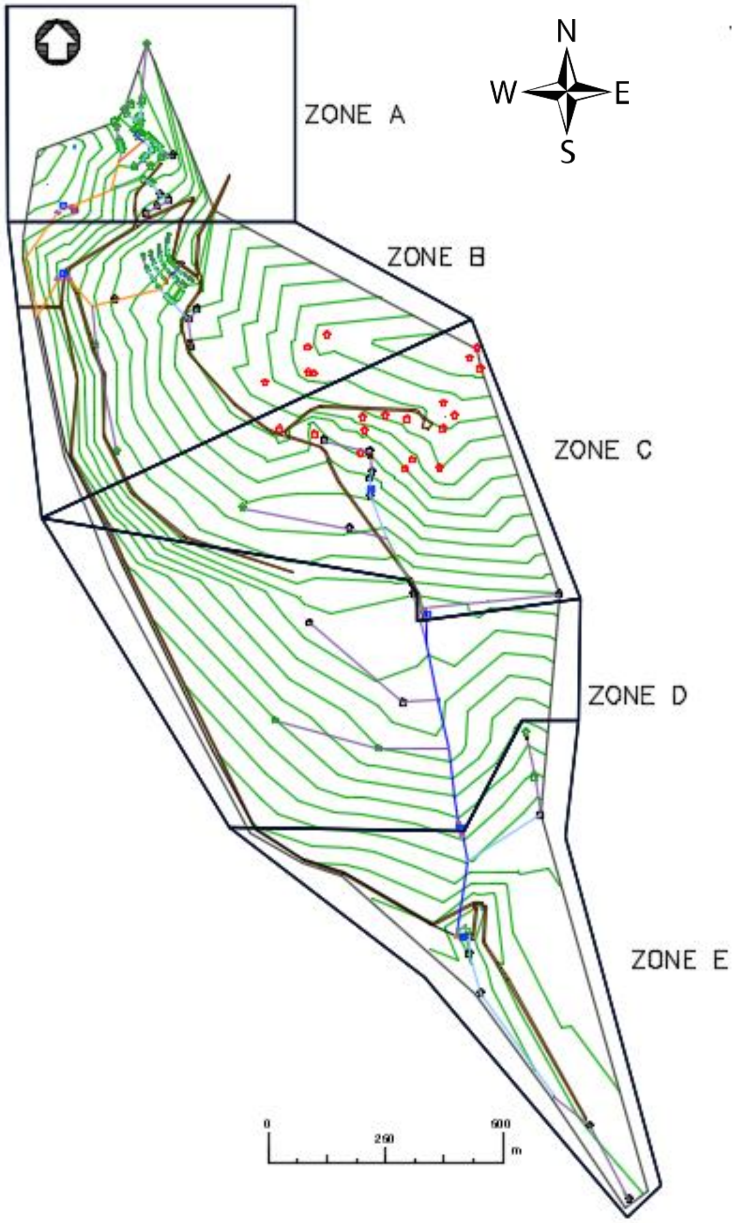

Figure 5. Pressure Zone Map

The overall design process was approached from an attitude of humility, seeking guidance from the community's wants, strengths, and needs. Additionally, Bruce Rydbeck, Efrain Morocho and Martin Henrich were consulted as experts in Ecuadorian water systems throughout the design process.

3.2 Design Constraints and Preliminary Calculations

3.2.1 Cost Constraint & Introduction

The main constraint of the system design was cost. The team reduced the costs of materials to a minimum while still maintaining a high quality system. Cost estimations and community requirements of the system were compared to a government generated assessment for the system that was produced in 2015. Before design, the team aimed to reduce the cost of the system to at least half of what the government assessment projected, giving an overall maximum price of approximately $200,000.

Although the cost of the system was a priority, other constraints were taken into account. Factors such as future population growth, water demand, integration with the existing system, pressure zones, strategic pipe placement and design, and tank placement all constrained the possible system design. These constraints aided the team in eliminating possible designs, until they arrived at the final design that satisfied all the needs and constraints.

3.2.2 Projected Population Growth

The final system proposal was designed for a 20-year lifetime. That being said, since the current system has been in place for 30 years, it is likely that the proposed system will have greater longevity than this. The community has a growth rate estimated at 1% per year according to Table 2 from Ecuador's "Secretaría del Agua." Although the exact population of the community was unknown, it was assumed that on average, each home had five members. Current houses on stable ground, and the new location for houses to be relocated were counted for the current population estimate. Houses on unstable soil that will be abandoned were not included in the current population. This method of population estimation allows for growth beyond the 20-year design life. The 20-year future population was calculated using the equation below:

$$P = P_0 * e^{r*t}$$

In this equation, P is the future population, P_0 is current population, and r is growth rate, and t is the time period considered. This equation is from James Mihelcic and Julie Zimmerman's Environmental Engineering: Fundamentals, Sustainability, Design.

Table 2. Growth Rate Data from Ecuadorian Regulations

Geographical Region	Rate, r [%]
Mountain range	1
East coast	1.5

The 20-year population resulting from this calculation was 629 people. Full population growth calculations can be found in Appendix A.1. This future growth population was accounted for in all tank calculations, and pipe sizing was done using present population data from a table that accounts for population growth.

3.2.3 Water Demand Regulations and Calculations

The average daily demand used in design was determined based upon the Ecuadorian governmental requirement as outlined by Ecuador's "Secretaría del Agua." Chañac San Miguel is located in a cold climate within the Andes Mountains, with approximately one connection to the system per house. This places the community within service level IIa Cold, as seen in Table 3.

Table 3. Demand Values from Ecuadorian Regulations

Service Levels		Water Allocations (L/person/day)		Leakage Safety Factor
Level	Description	Cold Weather	Hot Weather	
Ia	Public water taps	25	30	10%
Ib	Public water taps, plus public laundry and bathroom	50	65	10%
IIa	home connections, one water tap per house	60	85	20%
IIb	home connections, more than one water tap per house	75	100	20%

60 L/person/day was used as average daily demand, and 75 L/person/day was used for the peak water demand, based upon a 25% contingency factor of the average day. By accounting for the leakage factor and multiplying by the 20-year population estimate, the total average demand for the entire community of Chañac San Miguel was determined to be 0.52 L/s and the total peak demand was determined to be 0.66 L/s. These calculations can be found in Appendix A.2.

Due to the limited time for the trip in January, Team 06 could not take data to determine a daily demand pattern. Instead, research was done assuming Chañac San Miguel's usage to be similar to typical rural towns with limited infrastructure. Two similar studies were used to determine the percentage of daily demand used each hour. These percentages were compared to the average demand to determine a pattern for the EPANET models. The resulting average and peak day pattern demand coefficients are shown in Figures 6 and 7 below.

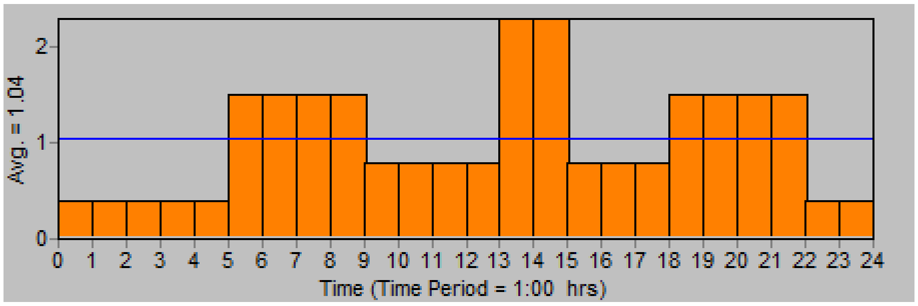

Figure 6. Average Day Demand Pattern

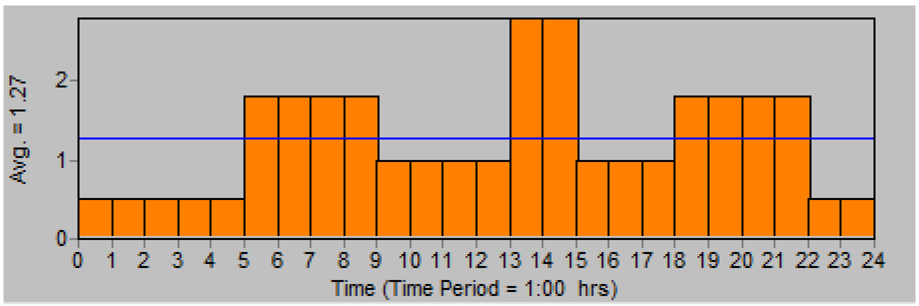

Figure 7. Peak Day Demand Pattern

3.2.4 Integration with Existing System

In order to minimize costs, Team 06 aimed to integrate the proposed system with the current system where possible. Originally, this included using the current pipes, valves, and tanks in the design of the new system. However, upon inspection of the system, it was determined that the old piping network was too degraded from exposure to last another 20 years. Because of this, the team designed an entirely new piping network. For ease of installation, the proposed network was designed to follow roads where possible.

Although the pipes of the distribution network were no longer usable, the current water storage tanks of the community were determined to be in good condition, which was a cost saving advantage. The original feedline, splitting tank, and water storage tanks in zones A and C were used as key features in the design process. This also ensured that the community would use the same high quality water source they have been using up until this point, so a new spring catchment was not necessary.

3.2.5 Pressure Zones

According to Ecuadorian specifications, pressure heads in the water distribution system must stay between 10 and 70 meters (approximately 14 to 100 psi). To fulfill this requirement, the community was split into five pressure zones (see Figure 5), each ranging approximately 60 meters of elevation and each fed by a different storage or pressure breaking tank. The EPANET model was used to verify that each housing connection in the network was in this pressure head zone and the location of the proposed tanks and pipes were adjusted iteratively where necessary until most housing connections fit this range.

Three housing connections in pressure zones B, C, and D reach pressure heads slightly higher than 70 meters. Pressure reducing valves on each of these three homes have been proposed. The locations of these three homes are shown below in Figure 8 as indicated by the red stars, with coordinates 775665 m East 9818488 m North, 775285 m East 9818712 m North and 775999 m East 9817888 m North (UTM Zone 17M).

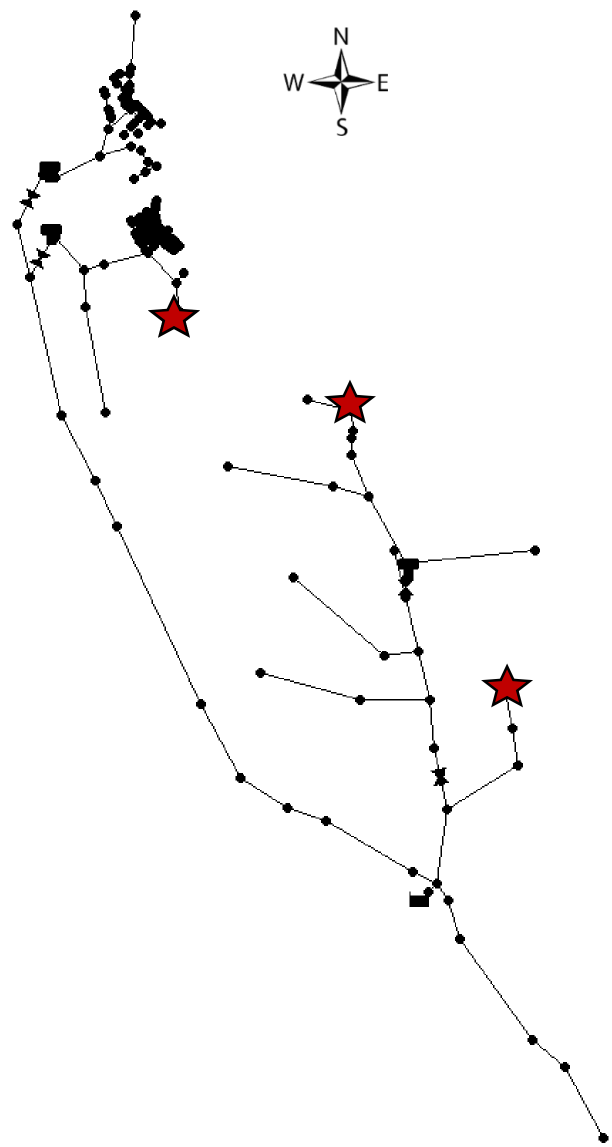

Figure 8. Location of Homes with Pressure Heads Greater than 70 Meters

Additionally, Zone E has several house connections with pressure heads less than 10 meters. Because these homes are fed from the splitting tank, which already exists, there are no simple or inexpensive design alterations that can be made to increase the pressure head at these locations. It is suggested that Section E be supplied from the feed line before it enters the splitting tank, to ensure all houses within the community receive at least 10 meters of pressure head. However, this becomes more of a social and political problem than a technical one because Chañac San Miguel does not have rights to water before it is split in the splitting tank. For this reason, Team 06 has made Life Giving Water International aware of the technical issue of feeding these homes after the splitting tank, and it will be up to the community to work out relations with the other four communities of Chañac and ultimately decide what to do with these housing connections.

3.3 Pipe Design

3.3.1 Pipe Placement

Using EPANET software, the surveyed homes were connected with a network of pipes. This piping network is branched, not looped, as this is common practice in Ecuador. Due to the lack of infrastructure throughout the community, the proposed branching network ensures outages and leaks can be easily detected, and cause little disturbance to the rest of the network. Where convenient, the pipes were proposed along existing roads for ease of installation. Otherwise, pipes were placed strategically to minimize pipe length while serving each home.

3.3.2 Pipe Sizing

The pipes were sized based on the number of homes each pipe would service downstream. Table 4 below shows the maximum number of house connections allowable for each pipe diameter. Although this is not how pipes are sized in the U.S., this is common practice for Ecuadorian systems and is the method that Life Giving Water traditionally uses. The value for the number of house connections allowable with 110 mm pipe was extrapolated from the rest of the table. 110 mm is a valid and accessible pipe size in this context.

Table 4. Pipe Diameter Selection Criteria

Pipe Diameter (mm)	Number of House Connections
20	2
25	5
32	10
40	20
50	30
63	50
90	70
110	84.8

3.3.3 Pipe Pressure Rating Analysis

After pipes were sized based upon the Ecuadorian standard above, an updated EPANET model of the system was created. This model indicated four nodes along the West boundary of the community with very high-pressure heads, as shown in Figure 9. Although the high-pressure heads were not a concern for households, as there were no household connections there, they raised the concern of a possible pipe burst. Because of this concern, a pressure rating analysis was performed on this main feedline.

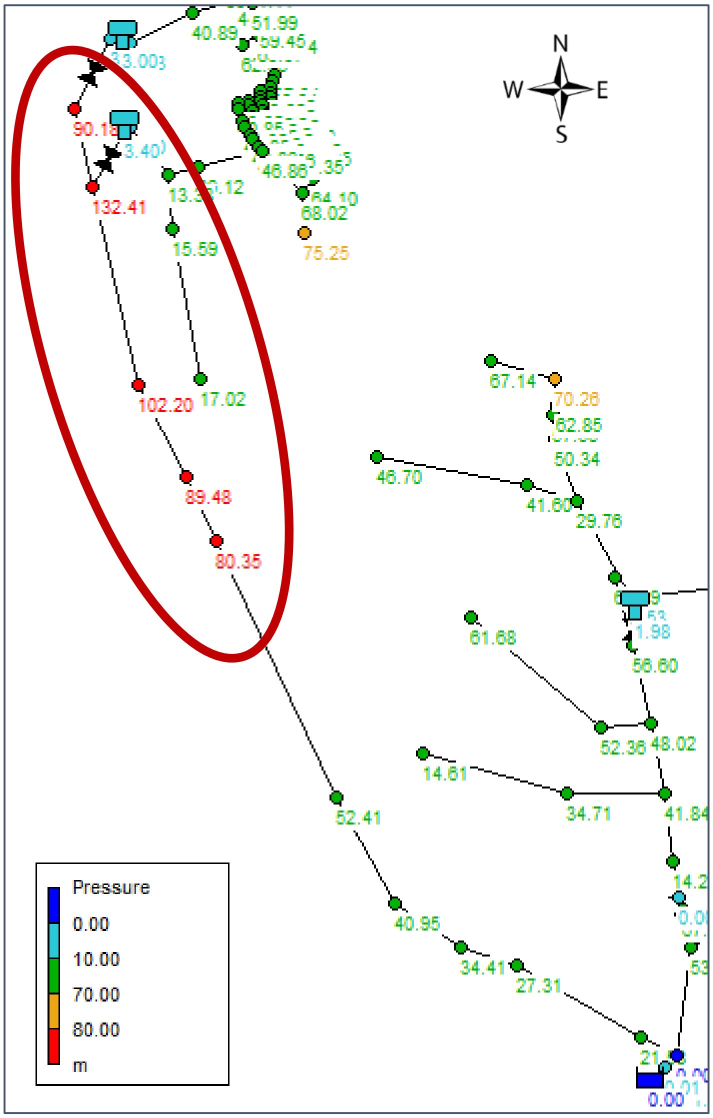

Figure 9. Pressure Head of Feedline Analysis

The feedline was split into sections of pipe between the model nodes, which have zero demand or no housing connection. For each section of pipe the elevation change and slope were calculated. The average slope of a pipe was a 10% grade. However, excluding the initial pipe from the reservoir, which is highly variable, the average slope was 6.8%. With this data, the head loss due to friction was calculated using the Hazen-Williams formula below.

$$h_f = \frac{10.67 * L * Q^{1.852}}{C^{1.852} * D^{4.87}}$$

In this equation L is representative of the length of the pipe. Q is the volumetric flow rate, D is the outside diameter and C is the Hazen Williams coefficient. A Hazen-Williams coefficient of 150 was used for new, PVC pipe. The equation was sourced from Fundamentals of Thermal Fluid Sciences, and data for PVC pipe was sourced from ASTM.

This friction head loss was an input in the energy equation below to determine the total head loss.

$$Head\ Loss = \Delta z + \frac{\Delta P}{S} + \frac{\Delta V^2}{2g} + h_f$$

This equation was sourced from Water Resources Engineering.

To determine the minimum burst pressure of the pipe, Barlow’s formula (below, from Cenegal) was used for a 110 millimeter, schedule 80 PVC pipe with a 1.25 MPa pressure rating. For this type of pipe, wall thickness (t) was approximated at 4.8 mm, and the minimum bursting pressure (S) was 1.2945 MPa. (engineering toolbox). D represents the outside diameter.

$$P = \frac{2 * S * t}{D}$$

Through these calculations, a maximum allowable internal pressure (P) of 1.13 MPa was determined. Table 5 summarizes the calculated head in each section of pipe at peak demand. This proves that the feedline to Zones A and B will not burst because all pressure heads are below 1.13 MPa.

Table 5. Feedline Analysis Results

Pipe ID	Elevation change [m]	Pressure Change [m]	Length [m]	Head [MPa]
12	21.585	21.58	59.8	0.4231
92	5.726	5.73	219.07	0.1123
93	7.102	7.1	90.77	0.1392
94	6.54	6.54	122.13	0.1282
103	11.46	11.46	185.75	0.2247
104	27.933	27.94	431.58	0.5477
102	9.136	9.13	109.79	0.1791
124	12.719	12.72	160.46	0.2494
125	30.212	30.21	311.36	0.5923

3.4 Tank Design

3.4.1 Introduction

The tanks in this system are either storage tanks or pressure breaking tanks. The purpose of a storage tank is for equalization of water flow. This is important because water is entering the system at a fairly consistent rate, but water exiting the system fluctuates throughout the day based on variations in demand. In this system the storage tanks were designed such that they can hold one average day's worth of water demand. Storage tanks also provide a break in pressure, so that water leaving the tank is at atmospheric pressure. Pressure breaking tanks are small and do not provide any equalization storage, but they do reset the system to atmospheric pressure.

3.4.2 Tank Placement

Tanks were placed based on maintaining house connection pressure heads between 10 and 70 meters. Chañac San Miguel currently has two storage tanks in use, as well as one splitting tank. The splitting tank and both of the existing storage tanks were utilized in Team 06's proposed design to minimize costs. The location of these tanks can be seen in Figure 10, indicated by the gold circles. An additional pressure breaking tank serves the section of the community that is being relocated, and will not be necessary for the proposed system. Team 06 proposed the addition of another storage tank and a pressure breaking tank in the final design. In Figure 10, the green star to the North indicates the placement of the proposed storage tank and the green star to the South indicates the placement of the proposed pressure breaking tank. These locations were chosen based upon both land elevations and open space in the community, while also considering the number of homes the existing tanks could serve.

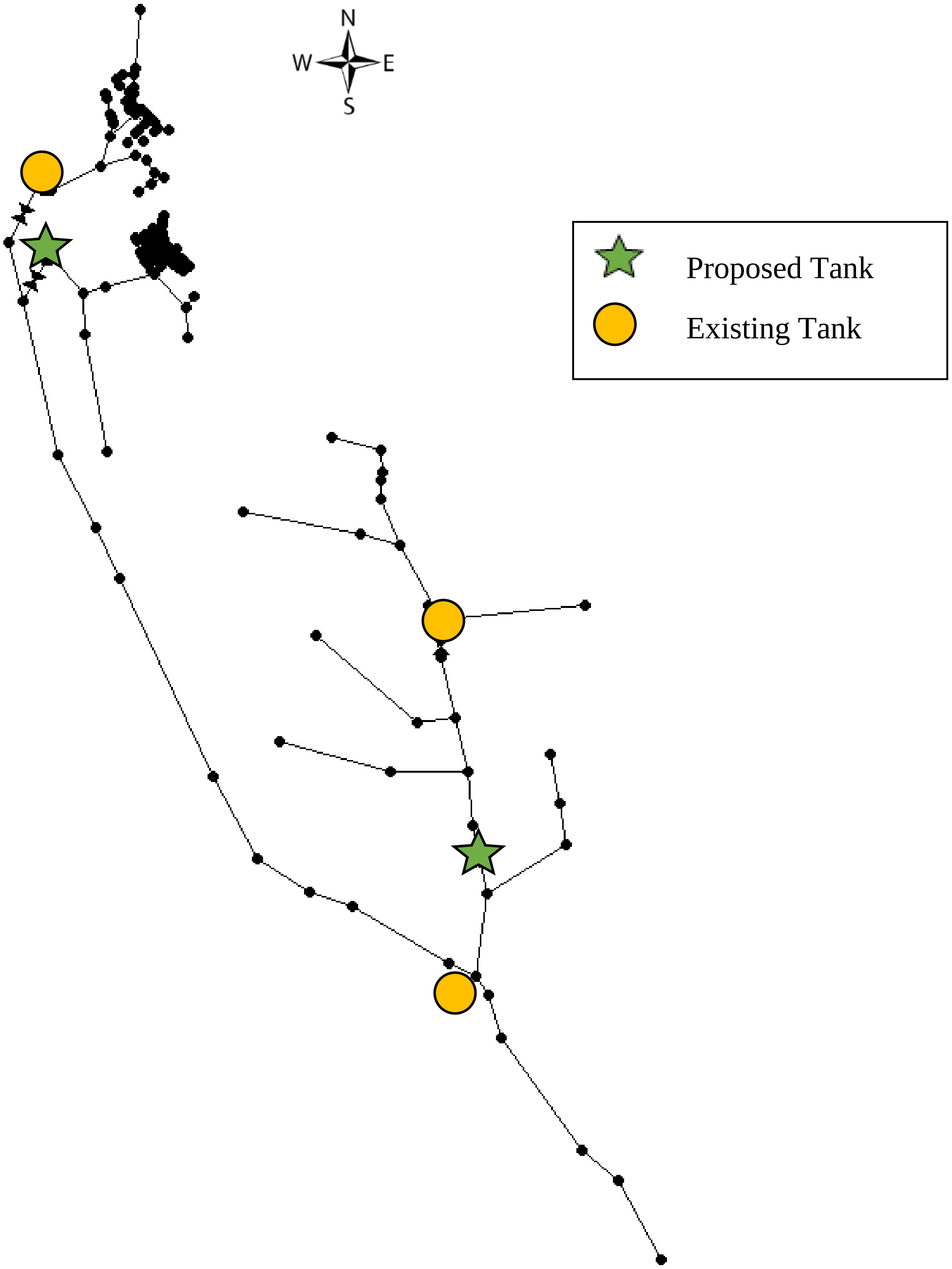

Figure 10. Tank Placement

3.4.3 Tank Sizing

The team designed each storage tank to provide an enough storage for average day demand for each zone of the community, in which the tanks feeds. Each tank will provide equalization storage so that the system can adapt to changes in demand throughout the day with consistent inflow from the splitting tank.

Before calculations on the proposed tank could be done, the existing tanks were analyzed. Each tank was sized based upon the previous standards. This result was then compared to the current size of the tank. Each tank provided enough volume for their housing zones.

Table 6. Existing water tank size comparison

Water Storage Tank Zone	Required Volume [m^3]	Actual Volume [m^3]	Difference [m^3]
A	11.1	20.32	+9.22
C	4.05	10.00	+5.95

To determine the ideal tank size for the proposed new tank, the houses it would serve were counted, and a demand per section was calculated. The complete tank sizing calculations can be found in Appendix A.4.

3.5 Flow Meters

Another facet included in Team 06's proposal was flow meters at every home in the community. The proposed flow meters are intended to track water usage per household, then charge a small fee for water used. The fees collected for water usage aid the community in paying for the implementation of the system as well as general maintenance. Additionally, flow meters are intended to keep members of the community accountable for sustainable water usage and negate social issues that often form over water in the developing world.

4. Design Proposal

4.1 EPANET Model Proof of Concept

EPANET was used primarily as a tool for design, but the results of Team 06’s EPANET model is also validation and proof of concept of the proposed design. A steady-state analysis provided a general overview of the system with assurance that each house connection had a pressure head between 10 and 70 meters. The transient model produced by the team provided reassurance that storage tanks were sized properly and would maintain steady water levels throughout average daily and peak day demands.

Team 06 was careful when using data from the topographic survey to replicate the exact surveyed location of all aspects of the community in the EPANET model. While the survey and therefore EPANET model are highly accurate, but in reality when the system is implemented, pipes and proposed tanks will be placed as close to the proposed design as possible while still convenient to construct. The EPANET model was constructed conservatively and will function under minor unpredicted changes.

4.2 Proposed Pipe Network

4.2.1 Pipe Specifications

The designed piping network is described below in Figures 11, 12 and 13 as well as in more detail in Appendix A.5.

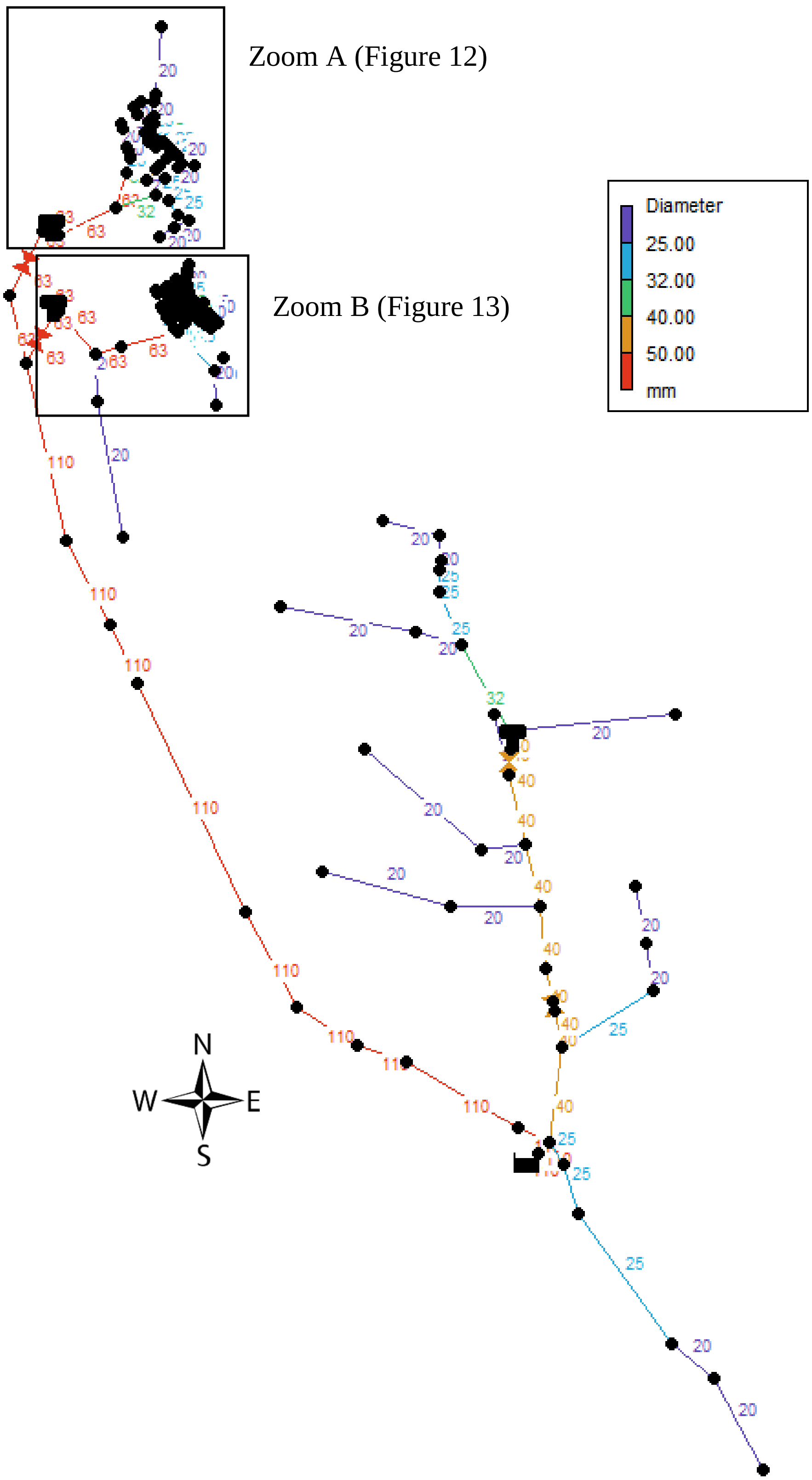

Figure 11. Proposed Pipe Network - Entire System

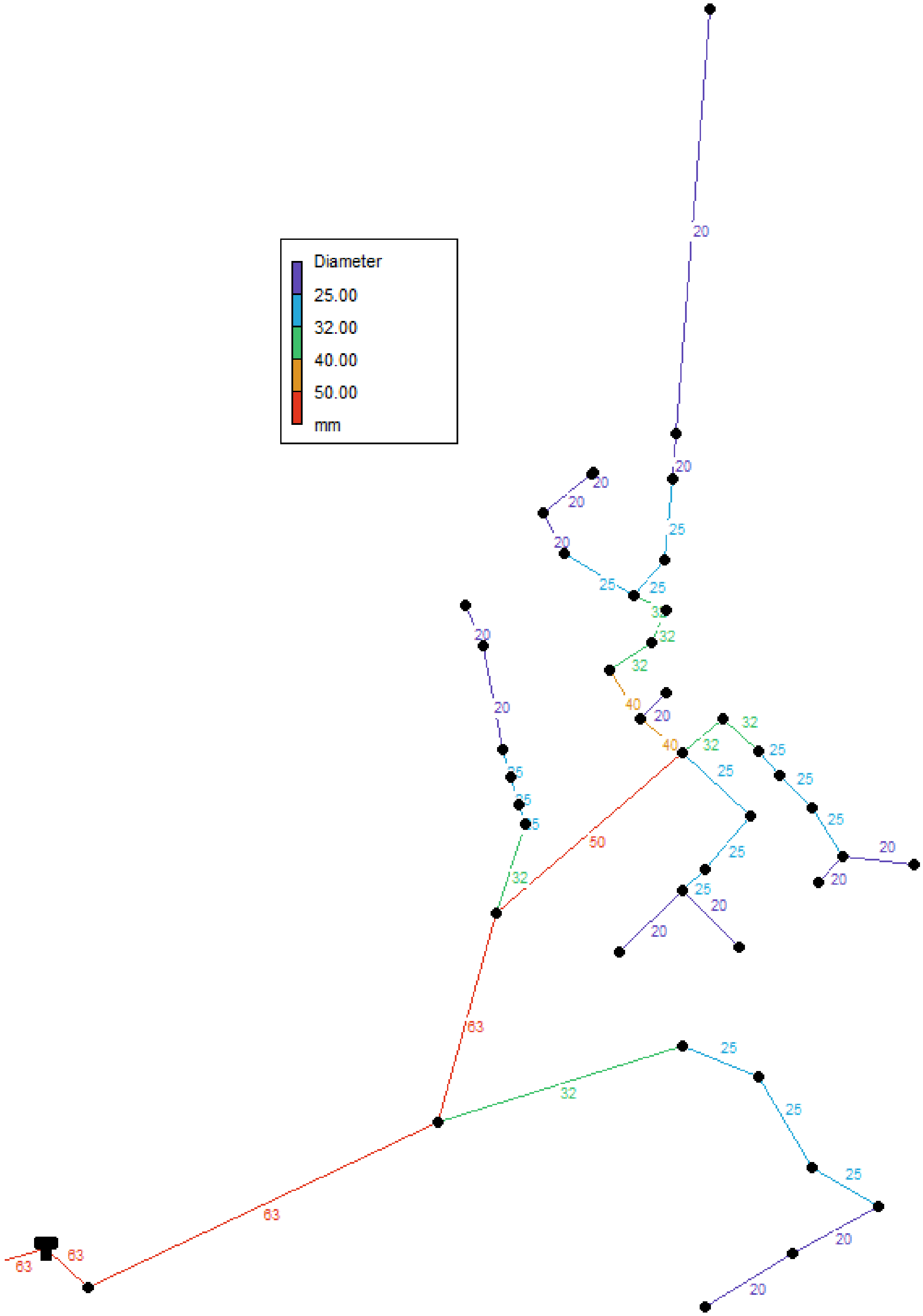

Figure 12. Proposed Pipe Network - Zoom A

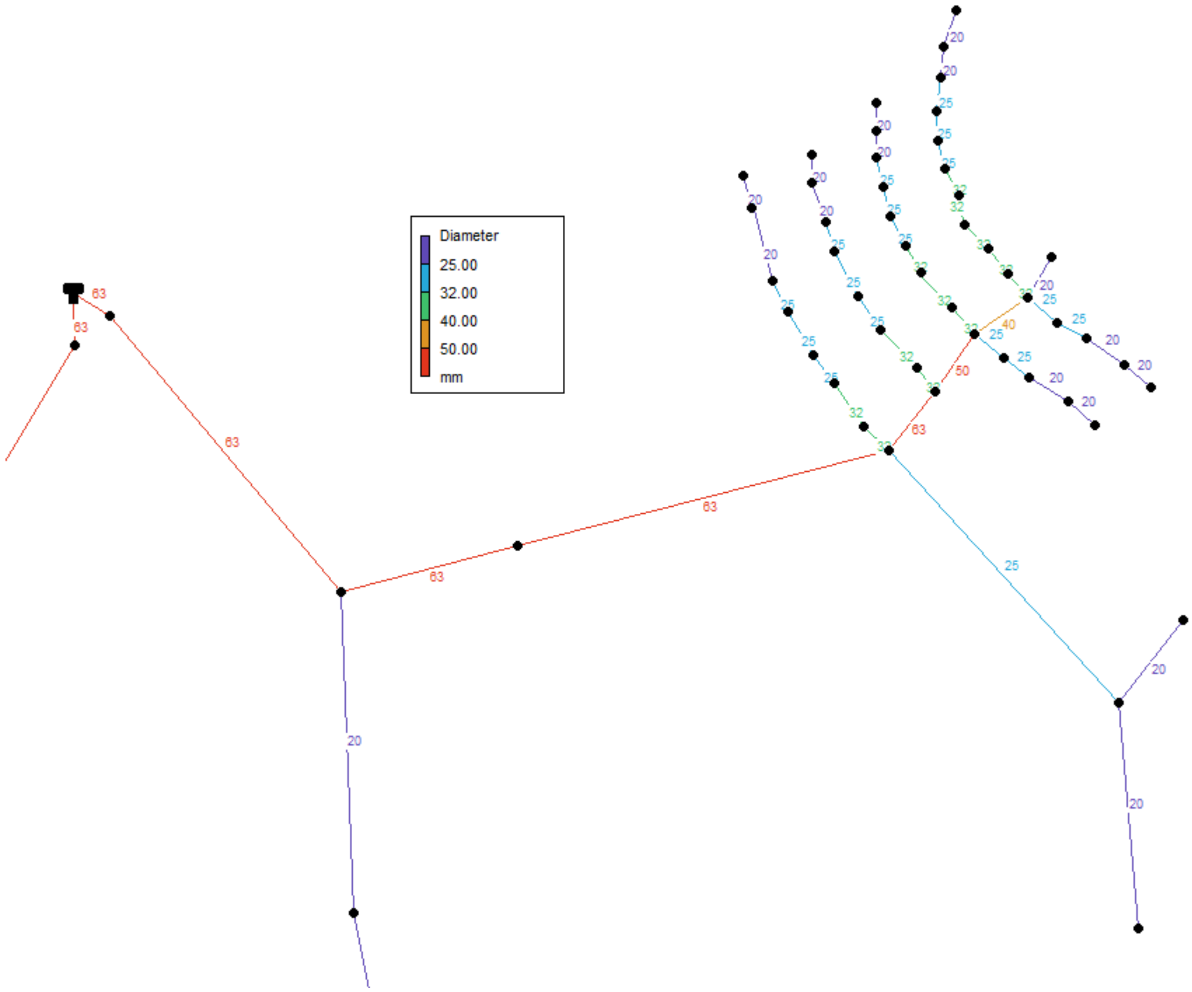

Figure 13. Proposed Pipe Network - Zoom B

This design results in the piping requirements below in Table 7, for a total pipe length of 7,334.4 meters. All piping should be PVC with a pressure rating of 1.25 MPa.

Table 7. Required Pipe Quantities

Pipe Diameter [mm]	Total Length [m]
110	1,744.8
90	0
63	549.9
50	86.8
40	667.2
32	396.9
25	1,196.9
20	2,691.9

4.2.2 Valve Placement and Specifications

Team 06 has specified three different types of valves and their placement required for the functioning of the proposed distribution system. Pressure reducing valves (PRVs) have been specified at three homes within the system where the delivery pressure is slightly above the allowable 70 meters. Gate valves were placed before and after every tank in the system, both existing and proposed to allow isolation of tanks for maintenance. Lastly, one butterfly valve was positioned immediately following the splitting tank. The butterfly valve was required both to control the flow out of the splitting tank, and to meet the fitting required for the main 110 mm pipe leaving the splitting tank. Following, in Figure 14 the location and type of each valve can be observed. Manufacturer specification sheets of proposed valve models can be found in Appendix A.6.

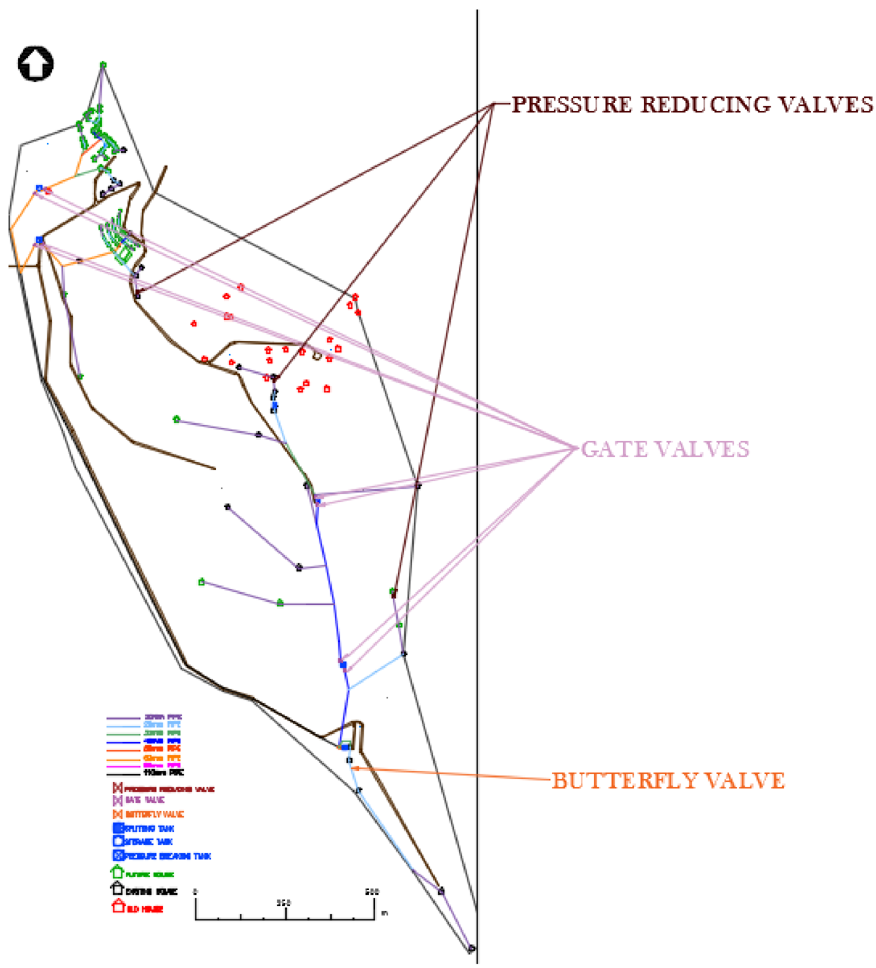

Figure 14. Location and Type of Specified Valves

4.3 Proposed Tanks

4.3.1 Placement

As discussed above in section 3.4.1, the proposed system includes usage of the existing splitting tank and two of Chañac San Miguel's existing storage tanks. The system also requires installation of a new storage tank and pressure breaking tank. Approximate locations of these tanks are shown previously in Figure 10. The storage tank is to be placed at 775006 m East and 9818876 m North (UTM coordinates, Zone 17M), where the elevation is approximately 3424 meters above sea level. This tank will serve as equalization storage for the homes in Zone B (see Figure 5). The proposed pressure breaking tank is to be placed at 775860 m East and 9817684 m North (UTM coordinates, Zone 17M), where the elevation is approximately 3465 meters above sea level. This pressure breaking tank will set the pressure heads for Zone D.

4.3.2 Tank Size and Specifications

The required volume for the water storage tank of zone B is 21.6 m^3 in volume. However, due to material constraints, a tank of this size is not possible for construction. Instead, the team proposes a volume of 30 m^3 for this new pressure tank, with 2.6 m height and 3.8 m diameter. The tank will be a circular, reinforced masonry brick structure, as is Life Giving Water's common practice. Additionally, materials for this type of structure are easily accessible within the region.

The proposed pressure-breaking tank will be approximately 1 m^3 in volume. It will use a simple float valve on the inlet pipe to control the volume of water in the tank. This tank will be open to the atmosphere with only a cover for sanitary protection. Specifications and drawings for both the proposed water storage and pressure breaking tanks are located in Appendix A.7.

4.4 Proposed Flow Meters and House Connections

The proposed system includes the use of flow meters and faucets at every house connection. The flow meters recommended are ManuFlo, model MES-M in the 20mm size. These flow meters are mechanical, so that their operation does not required access to electricity, and they read in liters. An image of the flow meter is shown below in Figure 15. The specifications can be found in Appendix A.8.

Figure 15. Recommended Flow Meter

Each house connection will also require a faucet to control outflow. The faucet recommended can be seen in Figure 16 below. It is brass and has a 20mm inlet connection and 25mm outlet. The faucet is from Irrigation Express and is their “Brass Angle Hose Tap Fitting.”

Figure 16. Recommended Faucet for House Connections

The flow meter and the faucet connection are representative of the types that should be used in the implementation of this project, but because of availability in Ecuador it is likely that these exact models will not be used. According to an estimate from Life Giving Water, house connections (including both the flow meter and faucet) cost approximately $75 each.

4.5 Cost

4.5.1 Distribution Network Cost

The material cost of all PVC pipes was estimated based on data from Martin Henrich for the cost per meter of various pipe diameters. It is important to note that Team 06 was not given a cost estimate for 20 mm diameter PVC. As a conservative estimate, the team used the same cost as what was given for 25 mm diameter pipe, with the assumption that 20 mm pipe will cost at most the same amount as 25mm pipes. The estimated total cost for pipe material is $18,050. In addition to the pipe network, Team 06 specified the installation of individual house meters, which cost $75 each. For all 103 homes, the additional cost was $7,725. Lastly, several valves, tees, and adaptors were necessary to complete the design. With the addition of gate, float, and butterfly valves, two sizes of tees, and three sizes of adaptors, the final cost for the distribution network materials alone was $27,540. A complete cost breakdown for the materials required can be seen following in Table 8.

Table 8. Distribution Network Cost Breakdown

Description	Unit	Quantity	Cost/unit	Total Cost
110 mm PVC, 1.25 Mpa	6 Meter	291	$ 44.13	$ 12,841.83
63	6 Meter	92	$ 14.77	$ 1,358.84
50	6 Meter	15	$ 9.43	$ 141.45
40	6 Meter	112	$ 7.66	$ 857.92
32	6 Meter	67	$ 4.78	$ 320.26
25	6 Meter	200	$ 3.95	$ 790.00
20	6 Meter	449	$ 3.95	$ 1,773.55
20mm Water Meters & Housing Connection	each	103	$ 75.00	$ 7,725.00
Butterfly valve-cast iron (110mm)	each	1	$ 192.66	$ 192.66
Bronze Gate Valve (2")	each	4	$ 39.00	$ 156.00
Bronze Gate Valve (3")	each	4	$ 103.91	$ 415.64
Float valve	each	2	$ 22.96	$ 45.92
Tee (2")	each	16	$ 3.41	$ 54.56
Tee (1 1/4")	each	5	$ 1.75	$ 8.75
Female adapter (63mm)	each	92	$ 2.56	$ 235.52
Female adapter (50mm)	each	127	$ 1.07	$ 135.89
Female adapter (20/25mm)	each	649	$ 0.75	$ 486.75
			Network Cost:	$ 27,540.54

4.5.2 Tank Cost

As previously stated, Team 06 recommended the addition of one pressure breaking tank, and one new storage tank. The total cost of materials required for the new storage tank has been estimated at $3,993 using data sourced from Bruce Rydbeck from Life Giving Water International. The proposed pressure breaking tank was estimated at $677. The total tank material estimated expense equaled $4,670. The cost breakdown for both proposed tanks can be seen following, in Tables 9 and 10.

Table 9. Proposed Storage Tank Cost Breakdown

Accessory	Unit	Quantity	Unit Price	Total Cost
Cement	gg	95	$ 8.00	$ 760.00
Boards	meters	80	$ 2.50	$ 200.00
Rails	meters	40	$ 2.00	$ 80.00
Iron	each	16	$ 52.00	$ 832.00
Nails	lbs	50	$ 1.25	$ 62.50
Wire	lbs	25	$ 1.25	$ 31.25
Rags (3m)	c/u	50	$ 2.50	$ 125.00
Sanitary Lid	c/u	1	$ 120.00	$ 120.00
Stairs	c/u	1	$ 100.00	$ 100.00
Concrete block	c/u	400	$ 2.25	$ 900.00
Control	kg	30	$ 2.00	$ 60.00
DM Impersan	kg	30	$ 2.00	$ 60.00
Betoncryl	kg	30	$ 10.00	$ 300.00
Plumbing 10%				$ 363.08
			Total:	$ 3,993.83

Table 10. Proposed Pressure Breaking Tank Cost Breakdown

Accessory	Unity	Quantity	Unit Price	Total Cost
Cement	qq	7	$8.00	$56.00
Boards	m	10	$2.50	$25.00
Rails	m	5	$2.50	$12.50
Iron	qq	2	$52.00	$104.00
Nails	lbs	10	$1.25	$12.50
Wire	lbs	10	$1.25	$12.50
Rags (3m)	c / u	5	$3.00	$15.00
Sanitary Lid	c / u	1	$125.00	$125.00
Concrete blocks (15x40x20)	c / u	100	$2.25	$225.00
Aditec 1	kg	2	$2.00	$4.00
Impersam DM	kg	2	$2.00	$4.00
Betoncryl	kg	2	$10.00	$20.00
Plumbing 10%	-	-	-	$61.55
			Total:	$677.05

4.5.3 Labor

Labor costs made up the most significant cost allocation. Based on approximate numbers shared by Bruce Rydbeck, the community would provide 52 members at minimum for 50 days to install the proposed distribution network. Each community member’s daily labor was valued at $15 per day as per Ecuadorian standard. In addition to this, a tank mason, and general supervisor were also required for the project. Following, in Table 11, the labor cost breakdown can be seen. Although the total labor cost displayed is significantly more than the total for materials, this price tag is deceiving. When communities ask to work with Life Giving Water International, part of the contract consists of the community agreeing to provide labor for instillation. Due to this, the community labor is paid not out of pocket in dollars, rather with what is referred to as “sweat equity”. This simply means that the community would install the system, instead of hiring out the labor. This allows for more ownership of the system, as well as providing the community with knowledge on the functioning of the system, should it become damaged in the future they will likely be able to mend it on their own. Subtracting out the community labor from the total labor cost resulted in a labor cost of $3,500.

Table 11. Labor Cost Breakdown

Description	Unit	Quantity	Unit Cost	Total Cost
Community Day Labor	per day*(0.5*house)	50	$15	$ 38,625
Tank Mason	per day	20	$25	$ 500
Supervisor Day Labor	per day	50	$50	$ 2,500
Supervisor mileage	each	1	$500	$ 500
			Labor Cost:	$ 42,125

4.5.4 Total Cost

In addition to the previously noted distribution network, tank, and labor cost, Team 06 included a 15% addition to the total cost to account for material transportation and contingency. The total cost of the project amounted to $79,170, including paid community labor. Without accounting for the community labor in dollars, the total cost of the project amounted to $41,068.

4.6 Future work

4.6.1 Implementation

The future of Team 06's proposed design is at the discretion of Chañac San Miguel, Life Giving Water International and Codeinse. Earlier in the semester, the team was informed that the community will be moving forward with implementation of a new water distribution system beginning in the summer of 2017. To aid in this process, a copy of this report, AutoCAD specifications, proposed tank designs and the EPANET model have been sent to Bruce Rydbeck of Life Giving Water International as the team's final deliverable.

4.6.2 Funding

This project will be funded in part by the members of Chañac San Miguel. In accordance with their agreement with Life Giving Water, they are both committed to contributing labor and some of the material cost. All of the physical work of implementation, such as trench digging, pipe laying, and tank building, will be done by members of Chañac San Miguel. This is known as 'sweat equity' and it was discussed previously in section 4.5.3. It brings down the financial cost of the project, allows the community to contribute in a significant way even though they have minimal funds, and in that way it is empowering to the community and cultivates ownership of the system. It also allows the project to be more sustainable. Bruce Rydbeck and other members of Life Giving Water will be checking in from time to time after implementation to aid in maintenance of the system, but the fact that members of Chañac San Miguel will be involved in construction means that they will understand the system better and be able to maintain it themselves for the most part. Much of the remaining financial cost of the project is being fund-raised by a gymnastics gym called R-Athletics, which is based in Grand Rapids, Michigan.

Other projects done by Life Giving Water that do not have specific sponsors are often funded directly by Life Giving Water. Life Giving Water is a non-profit and people who wish to help fund similar projects can donate to Life Giving Water online at http://www.lifegivingwaterinternational.org/donate.html.

5. Conclusion

Team 06 has designed a water distribution system for Chañac San Miguel, which will serve that community for a minimum of 20 years. The designed system integrated the existing feedline and splitting tank, both of the existing storage tanks, one new storage tank, and one new pressure breaking tank in order to feed all new and existing homes via a network of new, buried PVC pipes. The construction details were put together in AutoCAD and can be found in Appendix A.9.

6. Acknowledgements

Team 06 has many people for whom they are very grateful, and without who they would not be able to complete this project with success. Specifically, Team 06 would like to thank Bruce Rydbeck and his wife Cherith Rydbeck for not only facilitating this project partnership, but for being such gracious and generous hosts for Jennah and Ariana in Ecuador. As well, Efrain Morocho, Martin Henrich, and Christoph for all the help we received from them in the Codeinse office, as well as upon return to Grand Rapids. Special thanks to Professor De Rooy for being such a great advisor throughout the entire project, Professor Hoeksema without whom our EPANET model would likely still be faulty, Professor Wunder for facilitating out schedules and making our trip possible, and of course, the Calvin College Engineering Department. Team 06 is indebted and eternally grateful for the Eric DeGroot scholarship, without which this international project would not have been feasible. Lastly, Team 06 extends special thanks to all three of their significant others for putting up with their busy schedules and minds throughout the year. Also, Ariana and

Jennah would like to thank their parents for continually asking about and listening to project updates, and making this education possible.

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A.1 Population Calculations

Population Calculations			
Number of Houses	103	houses	P=Po*e^(rt)
People per House	5	people	P = future population
			Po = estimated
Estimated Population 2017	515	people	population
Growth Rate	1%		r = growth rate
Design Period	20	years	t = period
20yr Population Est.	629	people	

A.2 Water Demand Calculations

Demand Calculations for Entire Population		
Recommended demand	60	L/(hab*day)
Peak day use	25%	
Peak day demand	75	L/(hab*day)
Leakage Factor	1.2	
Total Daily Storage-Average	45,290	L/day
Total Demand-Average	0.52	L/s
Total Daily Storage-Peak	56612	L/(hab*day)
Total Demand-Peak	0.66	L/s

The resulting total peak demand is 0.66 L/s. This implies that there is more than enough water for the community's needs, because the community is guaranteed at least 1 L/s.

A.3 Pipe Pressure Rating Analysis Calculations

General Constants							
Houses	80						
Flow (Pea	20.83336	L/min	0.000347	m^3/s	Wall thickness	4.8	mm
D, out	110	mm			specific gravity	9.81	KN/m^3
D, in	105.2	mm			Coefficient	150	

Energy Conservation Calculations											
Pipe ID	Start Node ID	Start Node Elevation	Start Node Pressure	End Node ID	End Node Elevation	End Node Pressure	Elevation change	Pressure Change	Length	Slope	velocity
		meters	meters		meters	meters	meters	meters	meters		m/s
12	170	3532.413	0	L56	3510.828	21.58	21.585	21.58	59.8	0.360953	0.040
92	L56	3510.828	21.58	L58	3505.102	27.31	5.726	5.73	219.07	0.026138	0.040
93	L58	3505.102	27.31	L59	3498	34.41	7.102	7.1	90.77	0.078242	0.040
94	L59	3498	34.41	L60	3491.46	40.95	6.54	6.54	122.13	0.053549	0.040
103	L60	3491.46	40.95	LA10	3480	52.41	11.46	11.46	185.75	0.061696	0.040
104	LA10	3480	52.41	L61	3452.067	80.35	27.933	27.94	431.58	0.064723	0.040
102	L61	3452.067	80.35	L62	3442.931	89.48	9.136	9.13	109.79	0.083213	0.040
124	L62	3442.931	89.48	L63	3430.212	102.2	12.719	12.72	160.46	0.079266	0.040
125	L63	3430.212	102.2	LA5	3400	132.41	30.212	30.21	311.36	0.097032	0.040

At node 125, elevations increase and consiquently, internal pressure will decrease

Pipe ID	Velocity head (v^2/2g)	Friction Lost	Pressure Head	Headloss	Head	
		meters	meters	meters	Mpa	
12	0.0001	0.00139	21.567	43.154	0.4231	
92	0.0001	0.00508	5.727	11.458	0.1123	
93	0.0001	0.00210	7.096	14.200	0.1392	
94	0.0001	0.00283	6.536	13.079	0.1282	
103	0.0001	0.00431	11.453	22.918	0.2247	
104	0.0001	0.01001	27.923	55.866	0.5477	
102	0.0001	0.00255	9.125	18.263	0.1791	
124	0.0001	0.00372	12.712	25.435	0.2494	
125	0.0001	0.00722	30.192	60.411	0.5923	
				Maximum	0.5923	<1.12MPa

Calculations for Minimum Burst Pressure		
barlow's formula		P=2St/do
operating pressure	1.25	Mpa
minimum bust press	1294.5	Kpa
Internal pressure at	112.9745	Kpa
min. yield (P)	1.129745	Mpa
Schedule 80, 1.25MPa pressure rating		

A.4 Tank Sizing Calculations

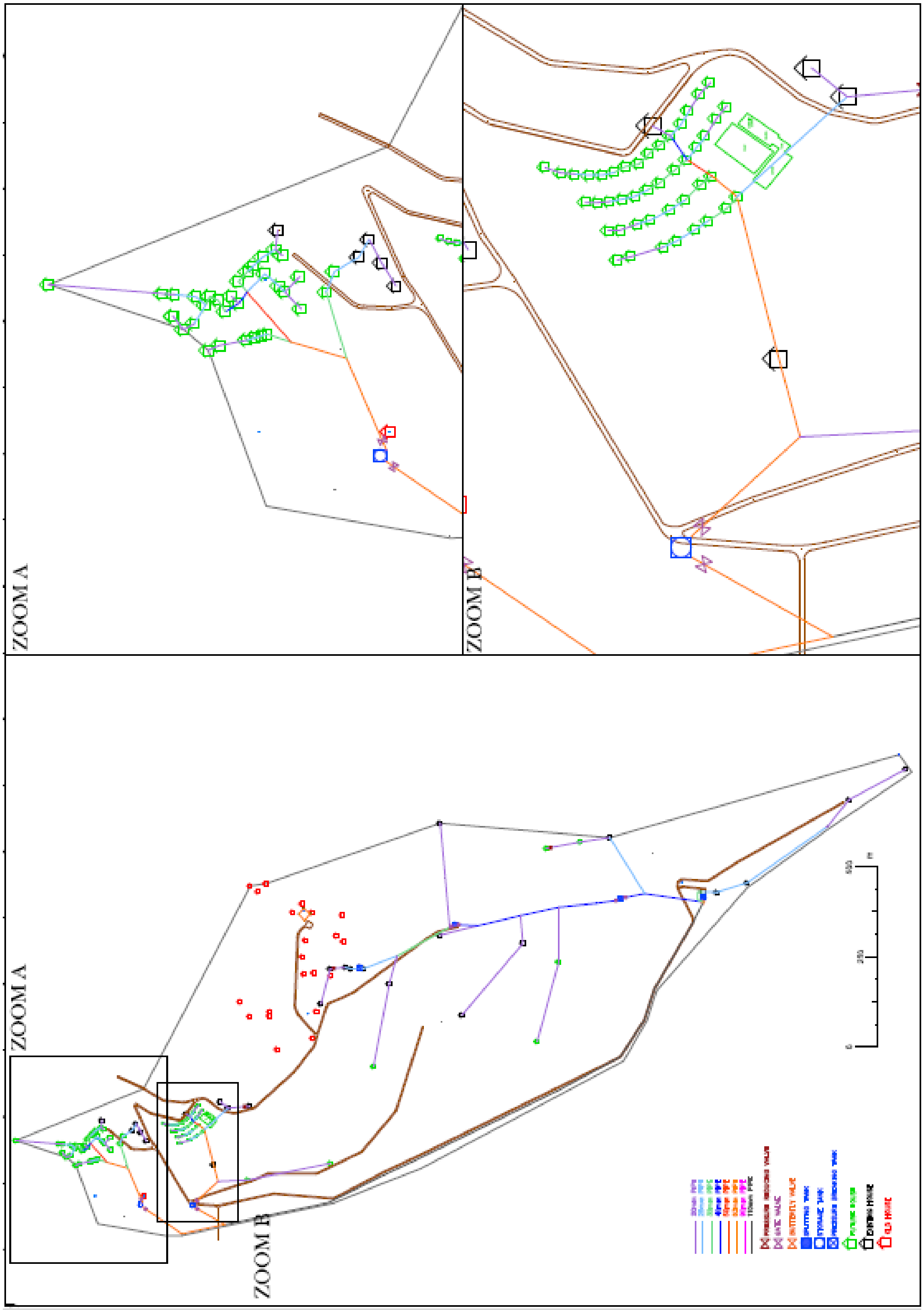
Section A Tank Verification			
dimensions (from notes)			
inside width	3.72	m	
inside length	2.375	m	
inside height	2.3	m	*tank depth not water depth
total volume	20.32	m^3	*note: contingency = leakage factor
volume without contingency	16.93	m^3	= equalization storage
	16933.75	L	= 375L/house/day * 1day * N houses
number of houses served	45.2	homes	*round to 45
*note: 37 homes in the area that this tank services, the existing tank is large enough			

Section B Tank Design			
number of homes served	48		*43 homes + community center
volume without contingency	18000	L	= 375L/house/day * 1day * N houses
	18	m^3	
total volume (with contingency)	21.6	m^3	

The dimensions and specifications of this proposed storage tank as well as for the proposed pressure breaking tank for Section D are outlined further in Appendix #.

Section C Tank Verification			
total volume	10.00	m^3	volume is an estimate given by Bruce Rydbeck
			*note: contingency = leakage factor
volume without contingency	8.33	m^3	= equalization storage
	8333	L	= 375L/house/day * 1day * N houses
number of houses served	22.2	homes	*round to 23
*note: 9 homes in the area that this tank services, the existing tank is large enough			

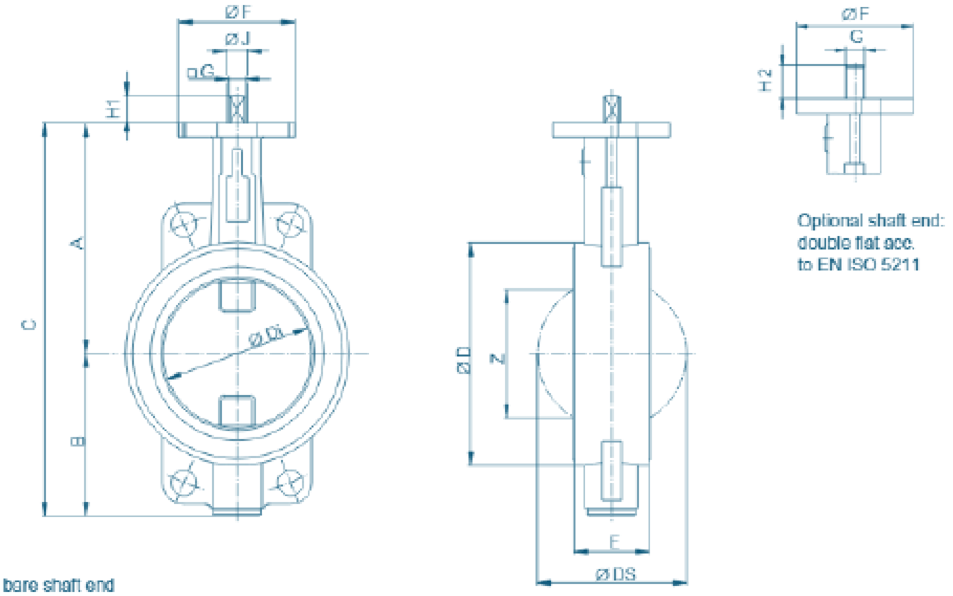
A.5 Piping Network Details



A.6 Valve Specifications

Butterfly Valves

WAFER TYPE BUTTERFLY VALVE Z 411-A SDR 11



Z 411-A with bare shaft end

DN [mm]	Ø = da [mm]	A	B	C	D	Di	DS	E	F	Flange	G	H1	H2	J	Z	Weight [kg] GGG40 Splitted Shaft	TS-Shaft	Al Splitted Shaft
		Dimensions [mm]																
40	**50**	113	66	179	80	37	38	33	54	F04	11	12	19	14	22	1,8	–	–
50	**63**	126	84	210	95	48,5	49,6	43	54	F04	11	12	19	14	25	2,2	–	1,5
65	**75**	134	93	227	115	63,5	64,6	46	54	F04	11	12	19	14	45	2,9	–	1,8
80	**90**	157	104	261	138	78,5	79,6	46	65	F05	14	16	25	18	65	4,0	–	2,1
100	**110**	167	115	282	158	98,5	99,2	52	65	F05	14	16	25	18	85	5,2	–	2,5
100	**125**	167	115	282	158	98,5	99,2	52	65	F05	14	16	25	18	85	7,5	–	2,5
125	**140**	180	127	307	166	111,2	112,2	56	65	F05	14	16	25	18	98	8,5	–	3,1
150	**160**	203	150	353	186	123,2	124,2	56	90	F07	17	19	30	22	111	10,0	–	4,9
150	**180**	203	150	353	212	148	149,2	56	90	F07	17	19	30	22	139	10,8	–	6,0
200	**200**	228	176	404	226	161,5	162,5	60	90	F07	17	19	30	22	151	11,2	–	6,6
200	**225**	228	176	404	250	182	183	60	90	F07	17	19	30	22	173	12,5	–	7,2
250	**250**	266	212	478	268	198,2	199,2	68	90	F07	17	19	30	22	188	19,0	–	7,6
250	**280**	266	212	478	315	224,3	225,3	68	125	F10	22	24	39	30	215	20,5	–	12,0
300	**315**	293	237	528	358	255	256	78	125	F10	22	24	39	30	244	28,0	–	18,0
350	**355**	332	269	601	365	285,7	286,7	92	125	F10	22	24	39	30	272	36,0	–	18,6
400	**400**	363	314	677	428	327	328	102	150	F12	*	*	–	40	312	–	68,0	–
500	**450**	437	405	842	454	365,8	366,8	127	150	F12	*	*	–	40	345	–	97,0	–
500	**500**	437	405	842	508	409	410	127	150	F12	*	*	–	40	390	–	105,0	–
600	**560**	475	418	893	530	426	427	114	210	F16	*	*	–	50	412	–	120,0	–
600	**630**	475	418	893	574	488	490	127	211	F17	*	*	–	50	473	–	135,0	–

* according to the mounted actuator

Subject to change without notice.

SOURCE: http://pdf.directindustry.com/pdf/ebro-armaturen-gebr-broeer-gmbh/wafer-type-butterfly-valve-z-611-a/7410-474147.html

Model NR3XL

Water Pressure Reducing Valve with Integral By-Pass Check Valve and Strainer

Application

Ideal for use where Lead-Free* valves are required. Designed for installation on potable water lines to reduce high inlet pressure to a lower outlet pressure. The integral strainer makes this device most suitable for residential and commercial water systems that require frequent cleaning of sediment and debris. The direct acting integral by-pass design prevents buildup of excessive system pressure caused by thermal expansion. The balance piston design enables the regulator to react in a smooth and responsive manner to changes in system flow demand, while at the same time, providing protection from inlet pressure changes.

Standards Compliance

- ASSE® Listed 1003
- IAPMO® Listed
- CSA® Certified
- Meets the requirements of NSF/ANSI 61*

*(0.25% MAX. WEIGHTED AVERAGE LEAD CONTENT)

Materials

Main valve body	Low Lead Cast bronze ASTM B 584
Bell housing	UV resistant polymer composite
Internals	Stainless steel, 300 Series
Stem	Low Lead Brass
Elastomers	EPDM (FDA approved)
	Buna nitrile (FDA approved)
Cartridge	Delrin™
Springs	302 Stainless Steel
Strainer screen	300 Series Stainless Steel

Features

Sizes: 1/2", 3/4", 1", 1-1/4", 1-1/2", 2"

Max. working water pressure (1/2" - 1-1/4")	400 psi
Max. working water pressure (1-1/2" - 2")	300 psi
Max. working water temperature	140°F
Reduced pressure range (1/2" - 1-1/4")	15 to 75 psi
Reduced pressure range (1-1/2" - 2")	25 to 75 psi
Factory preset	50 psi
Threaded connections (FNPT)	ANSI B1.20.1
Copper connections (FC)	ANSI B16.22
CPVC tailpiece: Max. hot water temp.	140°F @ 100 psi
Cold water rated temp.	73.4°F @ 400 psi

Options (Suffixes can be combined)

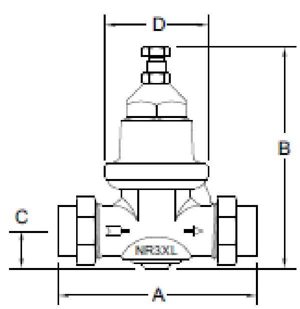
- ☐ - standard with single union FNPT connection and 20 mesh strainer screen
- ☐ C - with FC (copper sweat) union connection
- ☐ DM - with double male 3/4" & 1" meter threads connection with SS spring & sealed cage
- ☐ G - tapped and plugged with gauge
- ☐ DU - with double union connection (FNPT)
- ☐ DULU - with 2 integral FNPT connection (no union)
- ☐ PEX - with male barbed connection tailpiece for crossed-linked polyethylene tubing
- ☐ PEXF1960- with male barbed connection PEX tailpiece conforming to ASTM F1960
- ☐ SC - with ss adjustment bolt and lock nut with ss spring for below-ground installations
- ☐ P - tapped and plugged for gauge
- ☐ CPVC - CPVC tailpiece connection (3/4" - 1")
- ☐ HRSC - High Range 15-150 psi (1/2"-1-1/4" only) with sealed cage
- ☐ DUPF - with 2 Z-Bite™ push fit tailpiece connection 250 psi max pressure (1/2" - 1" only)
- ☐ DUPR - with 2 Z-Press™ press fit tailpiece connection 250 psi max pressure (3/4" - 2" only)
- ☐ DULUPF- with 2 integral Z-Bite™ push fit connections 250 psi max pressure
- ☐ DULUPR- with 2 integral Z-Press™ press fit connections 250 psi max pressure

Accessories

☐	Repair kit	
☐	1" BR4DUSPC	Special plastic spacer nipple
☐	1-1/4" BR4DUSPC	Steel pipe
☐	1-1/2" NR3DUSPC	Steel pipe
☐	2" NR3DUSPC	Steel pipe
☐	TPKXL	Lead-Free Tailpiece kit
☐	TPKXLPF	Z-Bite™ push fit Tailpiece kit 250 psi max pressure (1/2"-1" only)
☐	TPKXLPR	Z-Press™ press fit Tailpiece kit 250 psi max pressure (3/4"-2" only)
☐	RFK-114NR3XL	Extends body length of 1-1/4" NR3XL to match 1-1/4" 70DU for easy retrofit.

Dimensions & Weights (do not include pkg.)

SIZE		CONNECTIONS	DIMENSIONS (approximate)								WEIGHT	
			A		B		C		D			
in.	mm		in.	mm	in.	mm	in.	mm	in.	mm	lbs.	kg
1/2	15	SINGLE UNION	4 3/8	111	6 1/4	159	1 1/8	29	2 1/2	64	3	1.5
1/2	15	LESS UNION	3 1/2	89	6 1/4	159	1 1/8	29	2 1/2	64	3	1.5
1/2	15	DOUBLE UNION	5 1/4	133	6 1/4	159	1 1/8	29	2 1/2	64	3	1.5
3/4	20	SINGLE UNION	4 7/16	113	6 1/4	159	1 1/8	29	2 1/2	64	3	1.5
3/4	20	LESS UNION	3 1/2	89	6 1/4	159	1 1/8	29	2 1/2	64	3	1.5
3/4	20	DOUBLE UNION	5 3/8	137	6 1/4	159	1 1/8	29	2 1/2	64	3	1.5
3/4	20	DOUBLE MALE METER	3 5/8	92	6 1/4	159	1 1/8	29	2 1/2	64	3	1.5
1	25	SINGLE UNION	4 15/16	125	6 1/4	159	1 1/8	29	2 1/2	64	4	2
1	25	LESS UNION	4	102	6 1/4	159	1 1/8	29	2 1/2	64	3.5	1.6
1	25	DOUBLE UNION	5 15/16	151	6 1/4	159	1 1/8	29	2 1/2	64	4.5	2.1
1	25	DOUBLE MALE METER	4	102	7 3/4	197	1 3/16	30	3	76	4	2.0
1 1/4	32	SINGLE UNION	6 3/16	157	7 3/4	197	1 3/16	30	3	76	5.5	2.5
1 1/4	32	LESS UNION	5	127	7 3/4	197	1 3/16	30	3	76	5	2.3
1 1/4	32	DOUBLE UNION	7 3/8	187	7 3/4	197	1 3/16	30	3	76	6	2.7
1 1/2	40	SINGLE UNION	6 5/16	160	8 1/2	216	1 3/4	45	3 3/4	95	6.6	3
1 1/2	40	LESS UNION	5	127	8 1/2	216	1 3/4	45	3 3/4	95	5.5	2.5
1 1/2	40	DOUBLE UNION	7 1/2	191	8 1/2	216	1 3/4	45	3 3/4	95	7.7	3.5
2	50	SINGLE UNION	6 1/4	159	8 1/2	216	2	51	3 3/4	95	8.1	3.7
2	50	LESS UNION	5	127	8 1/2	216	2	51	3 3/4	95	6.7	3
2	50	DOUBLE UNION	7 1/2	191	8 1/2	216	2	51	3 3/4	95	9.5	4.3



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In Canada | **Zurn Industries Limited**
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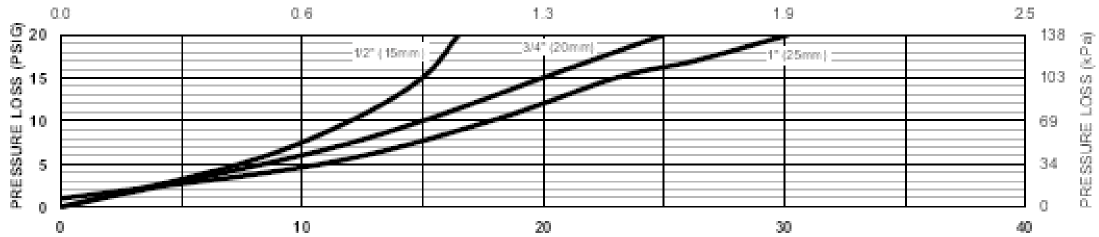
www.zurn.com

Rev. L
Date: 11/16
Document No. REG-NR3XL
Product No. Model NR3XL

Flow Characteristics

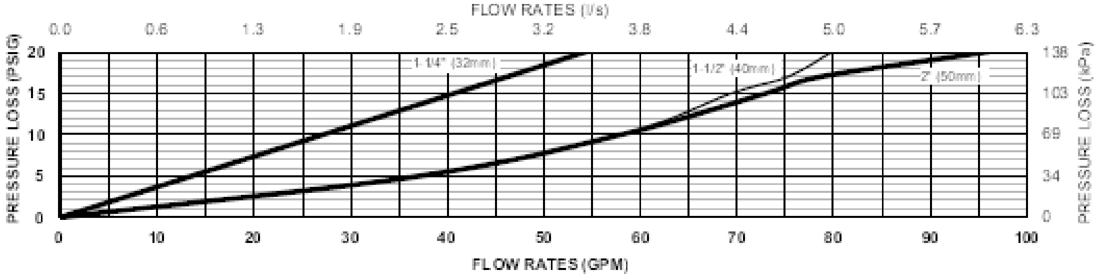
◇ Rated Flow (established by approval agencies)

MODEL NR3XL 1/2", 3/4" & 1" (STANDARD & METRIC)



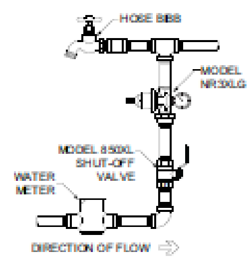
"Flow curves are based on a 50 psi pressure differential"

MODEL NR3XL 1-1/4", 1-1/2" & 2" (STANDARD & METRIC)

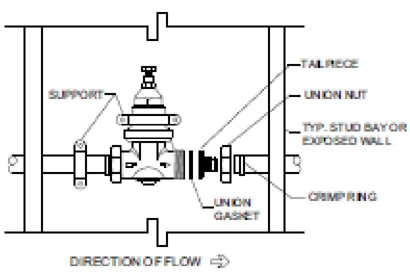


Typical Installation

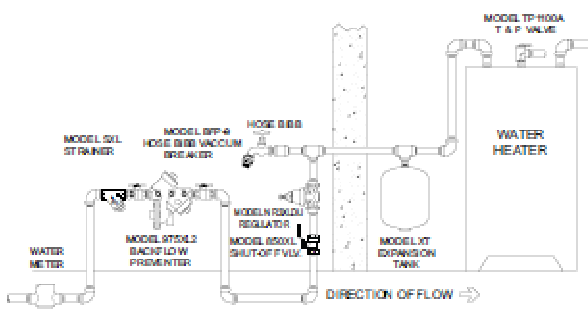
Local codes shall govern installation requirements. Unless otherwise specified, the assembly shall be mounted in accordance with the latest edition of the Uniform Plumbing Code. The Model NR3XL may be installed in any position. If installed in a pit, vault, or inside application, specify the "SC" sealed cage option. The assembly shall be installed with sufficient side clearance for testing and maintenance. Multiple installations are recommended for wide demand variations or where the desired pressure reduction is more than 4 to 1 (ie: 200 psi inlet reduced to 50 psi outlet). CAUTION: Anytime a reducing valve is adjusted, a pressure gauge must be used downstream to verify correct pressure setting. Do not bottom adjustment bolt on bell housing.



OUTDOOR INSTALLATION



NR3XLDUPEX INSTALLATION



TYPICAL INSTALLATION

Specifications

The Water Pressure Reducing Valve shall be certified to NSF/ANSI 61 and ASSE® Listed 1003, available with single union, double union and less union end connections. The main body shall be low lead cast bronze (ASTM B 584) alloy. The bell shall be composite plastic. The cartridge shall be acetal and incorporate an integral seat. The seat disc elastomer shall be EPDM. The assembly shall be accessible for maintenance without removing the device from the line. The Water Pressure Reducing Valve shall be a ZURN WILKINS Model NR3XL.

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SOURCE: http://www.zurn.com/Zurn/files/e5/e51f2685-9b3d-4ecf-a12c-c6acee6dd807.pdf

Gate Valve

NIBCO
AHEAD OF THE FLOW®

www.nibco.com
Revised 4/29/2015

Brass Gate Valve

Brass Body • Non-Rising Stem • Full Port

200 PSI/14 Bar Non-Shock Cold Working Pressure

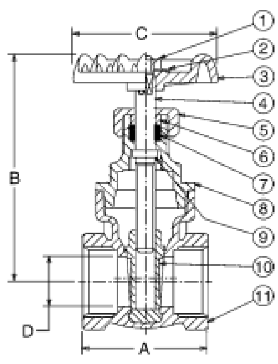
TI-8
Threaded

SI-8
Solder

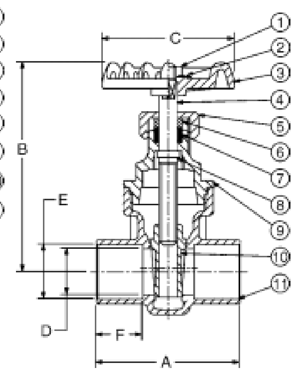
MATERIAL LIST

PART	SPECIFICATION
1. Nut	Steel plated ASTM A 108 Alloy G10100
2. Name Plate	Aluminum ASTM B 209 Alloy 1100
3. Handwheel	Cast Iron ASTM A 48 Class No. 35
4. Stem	Brass ASTM B 16 Alloy C36000
5. Packing Nut	Brass ASTM B 16 Alloy C36000 or B 584 Alloy C85700
*6. Gland	Brass ASTM B 16 Alloy C36000
7. Packing	Graphite/Rubber Non-Asbestos
8. Bonnet	Brass ASTM B 584 Alloy C85700
9. Lock Nut	Brass ASTM B 16 Alloy C 36000
10. Wedge	Brass ASTM B 584 Alloy C85700
11. Body	Brass ASTM B 584 Alloy C85700

*** Packing gland only for valves 1½" and larger.**
† Available with Drain in sizes ½" and ¾" for TI-8. Specify TI-8D on order.



TI-8
NPT x NPT



SI-8
Cup x Cup

DIMENSIONS—WEIGHTS

Size		TI-8 A		SI-8 A		TI-8 B		SI-8 B		TI-8 C		SI-8 C		TI-8 D		SI-8 D		SI-8 E		SI-8 F		WEIGHT TI-8		WEIGHT SI-8	
In.	mm.	In.	mm.	In.	mm.	In.	mm.	In.	mm.	In.	mm.	In.	mm.	In.	mm.	In.	mm.	In.	mm.	In.	mm.	Lbs.	Kg.	Lbs.	Kg.
¼	8	1.61	41	—	—	2.76	70	—	—	2.13	54	—	—	0.39	10	—	—	—	—	—	—	0.55	0.25	—	—
⅜	10	1.61	41	1.57	40	2.76	70	2.76	70	2.13	54	2.13	54	0.39	10	0.39	10	.50	13	0.38	10	0.55	0.25	0.55	0.25
½	15	1.69	43	1.77	45	2.83	72	2.83	72	2.13	54	2.13	54	0.50	12	0.50	13	.63	16	0.50	13	0.59	0.27	0.59	0.27
¾	20	1.85	47	2.32	59	3.31	84	3.31	84	2.13	54	2.13	54	0.75	19	0.75	19	.88	22	0.75	19	0.77	0.35	0.77	.035
1	25	2.13	54	2.76	70	3.86	98	3.86	98	2.40	61	2.40	61	0.94	24	0.94	24	1.13	29	0.91	23	1.06	0.48	1.06	0.48
1¼	32	2.40	61	2.87	73	4.57	116	4.57	116	3.03	77	3.03	77	1.25	32	1.25	32	1.38	35	0.97	25	1.54	0.70	1.54	0.70
1½	40	2.56	65	3.19	81	4.92	125	4.92	125	3.03	77	3.03	77	1.48	38	1.48	38	1.63	41	1.09	28	2.11	0.96	2.11	0.96
2	50	2.83	72	3.90	99	6.02	153	6.02	153	3.27	83	3.27	83	1.94	49	1.94	49	2.13	54	1.34	34	3.17	1.44	3.17	1.44
*2½	65	3.50	89	4.61	117	7.32	186	7.32	186	4.13	105	4.13	105	2.48	63	2.48	63	2.63	67	1.47	37	3.79	2.63	5.79	2.63
*3	80	3.98	101	5.20	132	8.70	221	8.70	221	4.41	112	4.41	112	2.95	75	2.95	75	3.13	80	1.66	42	8.10	3.68	8.10	3.68
*4	100	4.57	116	—	—	10.16	258	—	—	6.67	172	—	—	3.62	92	—	—	—	—	—	—	20.94	9.52	—	—

***Conventional Port only**

NOT FOR USE WITH POTABLE DRINKING WATER APPLICATIONS AFTER JANUARY 3, 2014.

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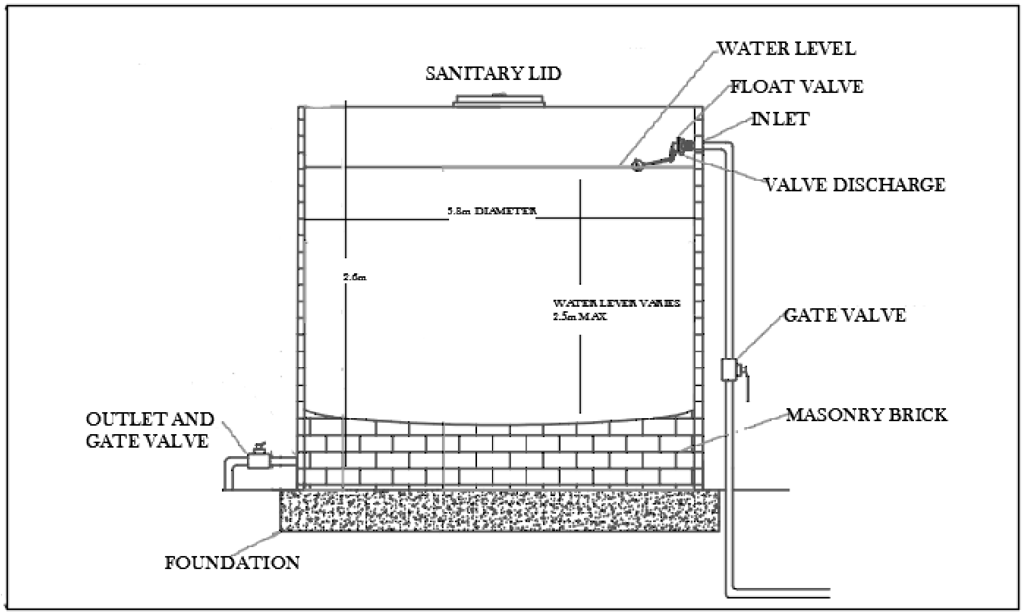
SOURCE:http://www.nibco.com/resources/ProductSubmittalDocs/TSI8PV.pdf

A.7 Tank Specifications

PROPOSED STORAGE TANK

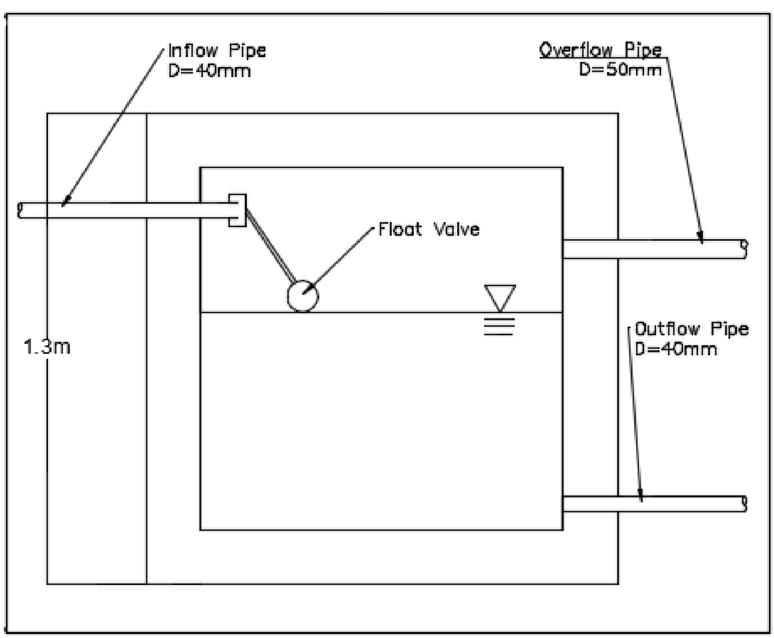
TANK VOLUME = $30m^3$



ADAPTED FROM: http://www.calvin.edu/academic/engineering/2015-16-team04/Team04_Final_Report.pdf

PROPOSED PRESSURE BREAKING TANK

TANK VOLUME = $1m^3$



A.8 Flow Meter Specifications

MES-M / MES-MR Mechanical register totaliser flowmeter

with optional contact closure high rate pulse output

Sizes 20, 25, 32, 40 & 50 mm

- **Nutating disc measurement.**
- **High rate of pulses for precision data logging.**
- **Mechanical totaliser register.**
- **Low head pressure loss.**
- **Passes impurities without jamming.**
- **Accuracy +/-1.5%, with 0.1% repeatability.**

25mm size shown
with optional pulse output

25mm size shown
Mechanical total only

The MESM series nutating disc positive displacement flowmeters are fitted with a non-resetable mechanical totaliser sealed counter and with a Contact Closure output (the flowmeters are also available with the mechanical counter only and no pulse output). The pulse output delivers a high rate of pulses per volume, making these meters ideal for precision data logging and batching applications. The volt-free contact allows use in remote areas where no power source is available.

The nutating disc design allows the meter to be used in applications where the water is not pure, and the meter can pass small impurities without blockage. These meters are ideal for economical totalising applications e.g. for measurement of water consumption. A range of water-based chemical liquids can be measured.

The body and measurement chambers of the 20, 25, 32, 40mm and 50mm size meters are common to the entire MES range of flowmeters (MES, MESLCD5, MESM and MESR series). Therefore, the MES20M mechanical totaliser meter for example can be upgraded to a digital LCD resetable unit (MES20LCD) or to a transistor pulse output unit (MES20) by simply changing the capsule head.

SPECIFICATIONS

Size mm	20	25	32	40	50
Start flow @ ±5% accuracy	0.6	1.1	1.5	3.0	4.0
Minimum flow Litres/min @ ±1.5%	1.5	2.7	3.8	7.5	9.5
Nominal flow Litres/min	45	65	125	200	360
Maximum flow Litres/min	75	112	185	375	600
Minimum register reading	1 Litre	1 Litre	1 Litre	1 Litre	1 Litre
Maximum register reading	99999 M^3	99999 M^3	99999 M^3	99999 M^3	99999 M^3
Contact Closure Pulse Output (pulses / Litre)	60.6	34.2	16	7.2	3.9
Connection Type	¾" BSP(m)	1" BSP(m)	1 ¼" BSP(m)	1 ½" oval flange kit BSP(f)	2 " oval flange kit BSP(f)
Weight (kg) (# including connectors)	1.5	2.3	6.0	17 #	21 #

ManuFlo®™
Flow Measurement & Control Products

Page 1

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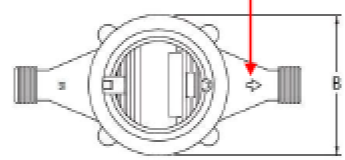
Other Data

Accuracy minimum to maximum flowrange curve	± 1.5 %
Repeatability of set flowrate	± 0.1 %
Headloss at maximum continuous flow	25 kPa (3 metres)
Maximum continuous working pressure	<= 32mm 1160 kPa; 40 & 50mm: 1034 kPa
Maximum temperature	50 °C

Pulse Output Data

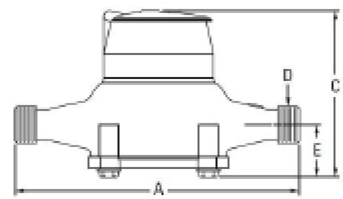
2-wire connection (shielded) with 270 Ω internal current limiting resistor. 0 - 24 VDC.
Max. current switching: 5VDC = 18mA, 12VDC = 44mA, 24VDC = 88mA (100mA max)

Dimensions in mm	size mm	20	25	32	40	50
Length of threaded end	A	191	229	273	330	432
Overall height	C	158	178	200	252	283
Height to centreline	E	41	48	54	65	79
Overall width	B	092	111	165	205	240



MATERIAL SPECIFICATIONS (MESM / MESMR)

Register window	Tempered Glass.
Register body & lid	Synthetic polymer.
Register internals	Hermetically sealed (mechanical only).
Dry gearing	Plastic.
Magnet	Polymer Barium Ferrite.
Meter body	Gunmetal AS 1565 C83810.
Filter	Polyolefin.
Measuring chamber & disc	Nepton (synthetic polymer)
Nutating disc peg	Stainless steel AS1444-316.
Roller pin & drive shaft	Nylon 11, glass fibre, graphite.
Chamber O ring & Base seal	Ethylene propylene & Neoprene.
Base plate	20mm: ABS Plastic.
	25, 32mm: Cast Iron with Nylon cup.
Upper casing	40, 50mm: Gunmetal.
Base bolts	Stainless Steel 304.



ORDERING CODES

Order Code	Size	Display/Output
MES20-MR	20mm (¾")	Mechanical + Pulse
MES20-M	20mm (¾")	Mechanical
MES25-MR	25mm (1")	Mechanical + Pulse
MES25-M	25mm (1")	Mechanical
MES32-MR	32mm (1¼")	Mechanical + Pulse
MES32-M	32mm (1¼")	Mechanical
MES40-MR	40mm (1½")	Mechanical + Pulse
MES40-M	40mm (1½")	Mechanical
MES50-MR	50mm (2")	Mechanical + Pulse
MES50-M	50mm (2")	Mechanical

Reading shown above is 109 L

Note: 1 M³ = 1,000Litres

Options for 20mm size:

-S Ryton chamber for petroleum based products.
-S-T Ryton chamber and teflon coated body for corrosive chemicals.
-**CSM** Ceramic magnet for higher resistance to chemicals

INSTALLATION

1. **Arrow on meter body indicates direction of flow.**
2. The MES-M version's display is hermetically sealed. With the MES-MR pulse version, loop the pulse cable downwards to prevent water ingress.
3. Consider an accessable area for any future service. Flowmeters may generally be installed in any plane without affecting accuracy (but not upside down if particles are present, as mag-drive assembly in the measuring chamber may become obstructed).
4. Flush out pipes thoroughly before connecting flowmeter. Ensure arrow on meter body coincides with forward direction of flow.
5. Although meter passes small impurities, a filter box or strainer (800 micron cartridge filter recommended) may be fitted prior to flowmeter if fluid contains granules or many impurities.
6. Any flow restriction or regulation valve should be fitted preferably before (upstream of) the flowmeter. Quick-closing valves should be fitted before the meter if used for higher-end flowrates (thus avoiding sudden pressures on the flowmeter chamber) provided that the plumbing configuration allows the pipe to remain full where the flowmeter is located.
7. Once installed, flowmeter must be full of liquid at all times.
8. Display capsule can be repositioned in 90° angles to the preferred viewing position.
9. **IMPORTANT: AS LAST STEP OF INSTALLATION, A CALIBRATION CHECK OF FLOWMETER MUST BE PERFORMED.**

MAINTENANCE

1. If flow becomes excessively restricted, or meter is out of calibration, or flowmeter stops counting/pulsing, then the measuring chamber may be blocked/broken.
2. To access the measuring chamber, first rotate meter body in the pipe, or remove meter body from the pipe, to access the flowmeter's base screws. Unscrew the 4 x hex bolts in the base, remove base plate and base seal ring. Using long nose pliers, pry and pull out the white strainer screen thus unlocking the measuring chamber assembly. Remove chamber and inspect.
3. If required, clean chamber parts in warm soapy water. Make sure internal chamber wobble disc roller pin is in place and shutter plate is refitted. Re-assemble meter by reinserting measuring chamber; secure in position with strainer. Refit other components and test meter.

   Alternatively, a new measuring chamber can be ordered from ManuFlo:

   For the standard measuring chamber, the Order Code format is "*size-5*"
   e.g. "20-5" is the measuring chamber for 20mm MES20-M / MES20-MR flowmeter.

   For the measuring chamber with ceramic magnet for higher resistance to chemicals, the Order Code format is "*size-5-CSM*"
   e.g. "20-5-CSM" is the chamber for 20mm MES20-M / MES20-MR flowmeter.
4. After use with chemicals, if the flowmeter is removed from the pipeline, be sure to flush out the flowmeter measuring chamber with water.

IMPORTANT: AFTER ANY SERVICE, A CALIBRATION CHECK OF THE FLOWMETER MUST BE PERFORMED.

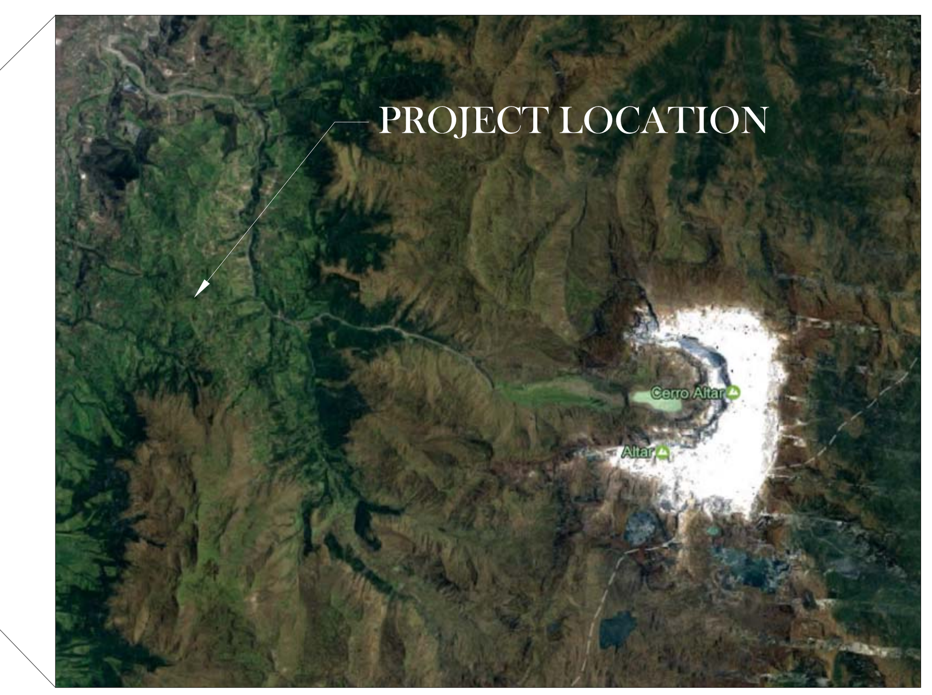
Due to continuous product improvement, specifications may change without notice.

41 Carter Road, Brookvale
Sydney NSW 2100 Australia
Ph: + 61 2 9905 4324, 9938 1425
Fax: + 61 2 9938 5852
Web: www.manuelectronics.com.au
Email: sales@manuelectronics.com.au

Source: http://www.manuelectronics.com.au/flowmeters.html & http://www.manuelectronics.com.au/pdfs/MESMR.pdf

A.9 AutoCAD

CHAÑAC SAN MIGUEL, ECUADOR POTABLE WATER DISTRIBUTION NETWORK PROPOSED DESIGN



INDEX OF SHEETS:

1 - COVER PAGE
2 - TOPOGRAPHIC SURVEY
3 - PRESSURE ZONES
4 - PROPOSED DISTRIBUTION NETWORK
5 - TANK DESIGN
6 - HOUSE CONNECTION AND METERS
7 - VALVES
8 - TRENCH
9 - MATERIAL ORDER AND COST BREAKDOWN

CALVIN COLLEGE ENGINEERING SENIOR DESIGN

FINAL DESIGN PROPOSAL

TEAM 06 *VOLCÁN ALTAR*

MAY 6th, 2017

Emily Lawson   Jennah Maier   Ariana Strydhorst

Life Giving Water International

VOLCÁN ALTAR

CALVIN Engineering

CLIENT: CHAÑAC SAN MIGUEL

PROJECT: Potable Water System for Chanac San Miguel

PAGE: COVER PAGE

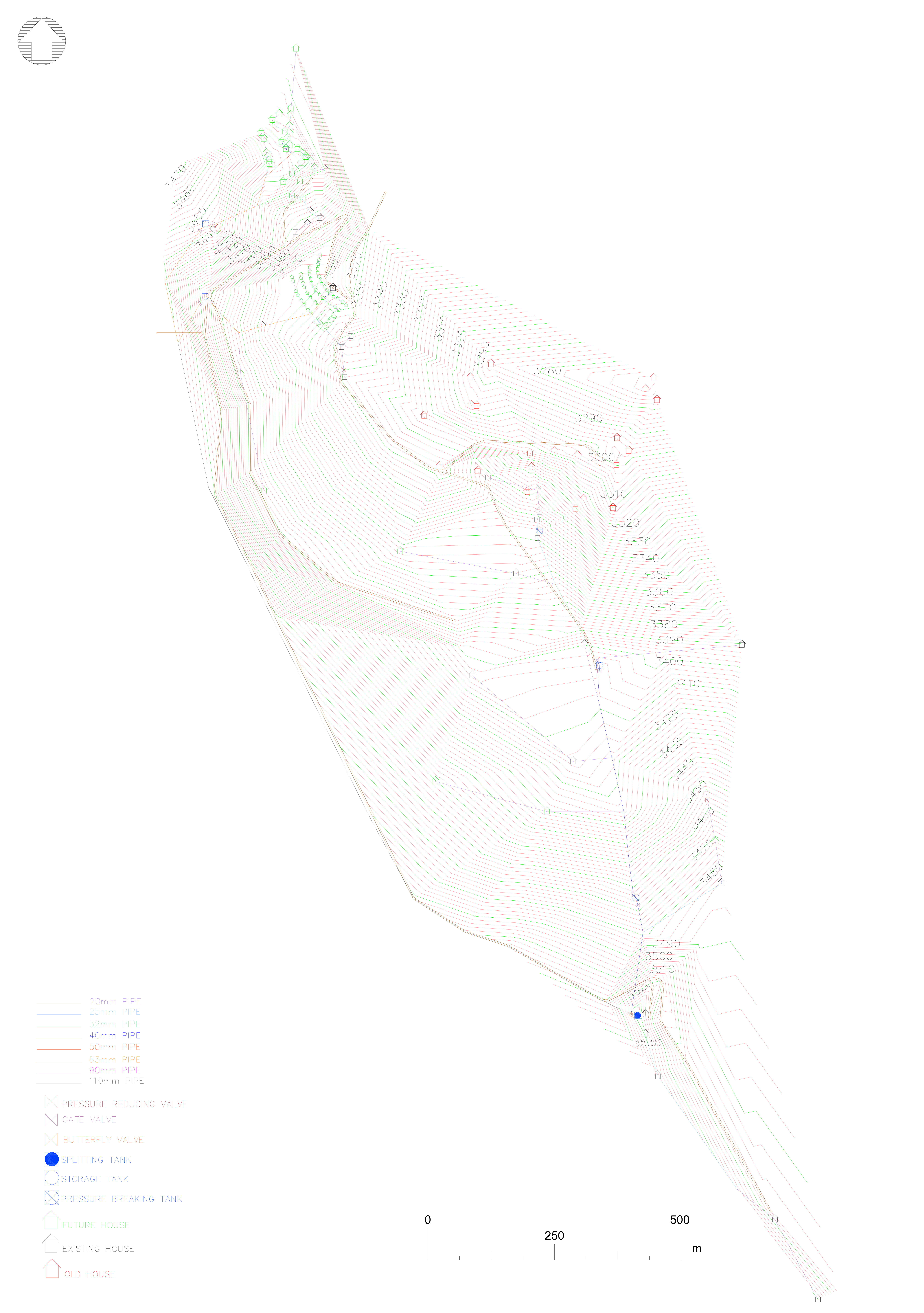
LOCATION: QUIMIAG CHIMBORAZO PROVINCE

TECHNICAL SUPPORT: ENG. Bruce Rydbeck
CODEINSE
Corporación de Desarrollo Integral Socio Economico Riobamba

DATE: MAY 2017

Calvin College Sr. Design Team 06

PAGE NO. 1



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CALVIN Engineering

CLIENT:
CHAÑAC SAN MIGUEL

PROJECT:
Potable Water System for Chanac San Miguel

PAGE:
TOPOGRAPHIC SURVEY

LOCATION:
QUIMIAG
CHIMBORAZO PROVINCE

TECHNICAL SUPPORT:
ENG. Bruce Rydbeck
CODEINSE
Corporación de Desarrollo Integral Socio Economico
Riobamba

DATE:
MAY 2017

Calvin College
Sr. Design
Team 06

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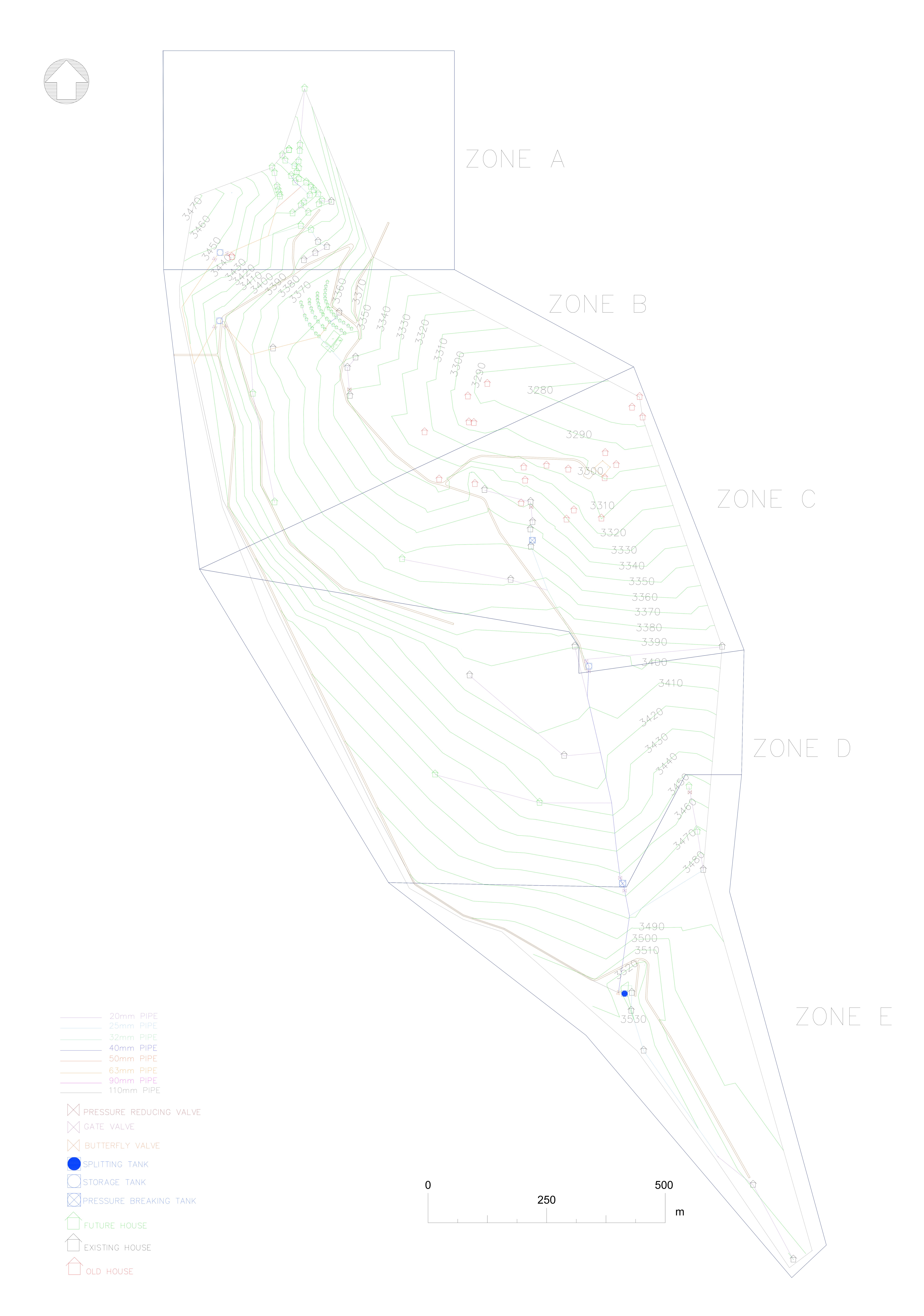
2



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CLIENT: CHAÑAC SAN MIGUEL

PROJECT: Potable Water System for Chanac San Miguel

PAGE: PRESSURE ZONES

LOCATION: QUIMIAG CHIMBORAZO PROVINCE

TECHNICAL SUPPORT: ENG. Bruce Rydbeck CODEINSE Corporación de Desarrollo Integral Socio Económico Riobamba

DATE: MAY 2017

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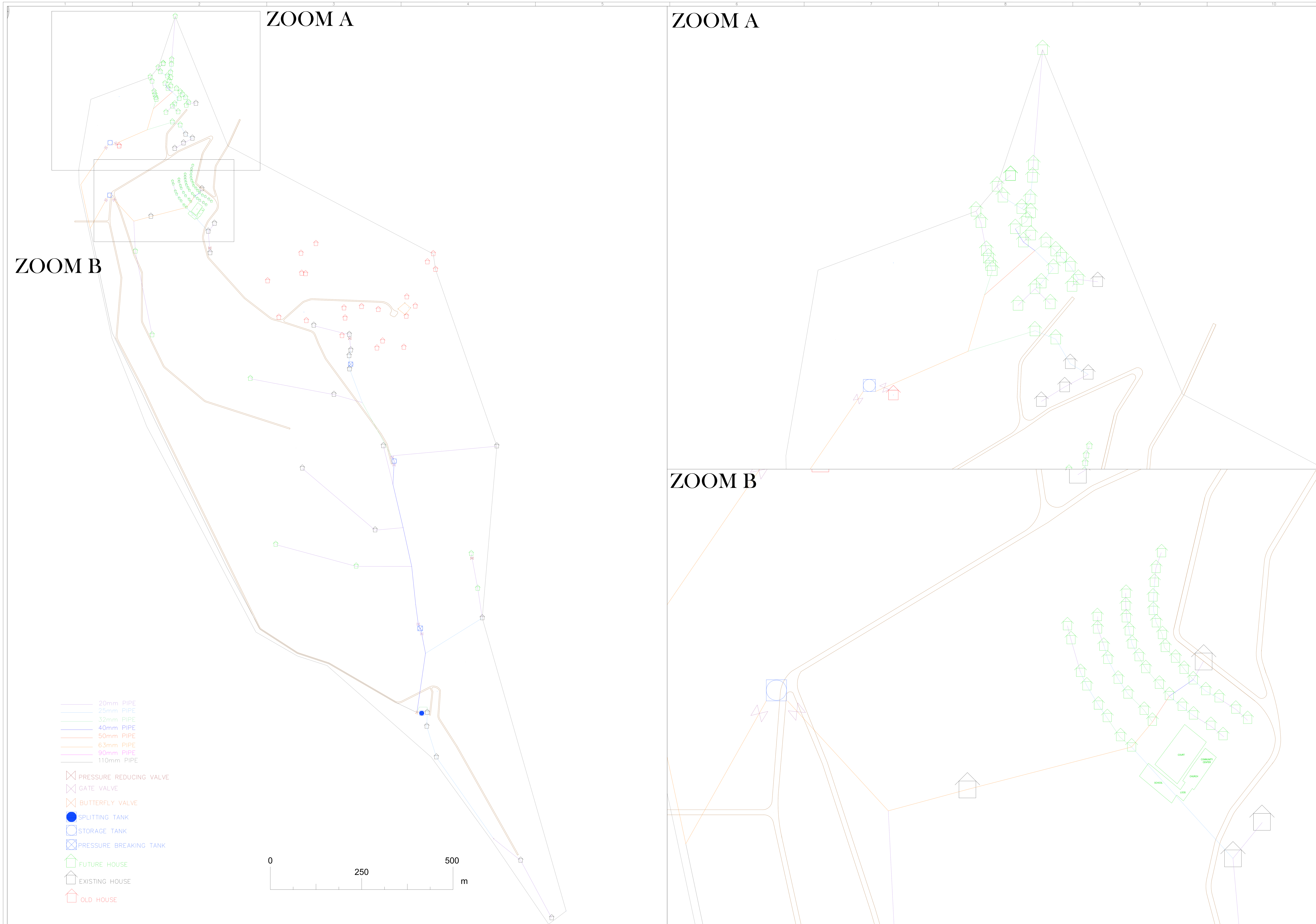

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VOLCÁN ALTAR

CALVIN Engineering

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PROJECT: Potable Water System for Chanac San Miguel

PAGE: PROPOSED DISTRIBUTION NETWORK

LOCATION: QUIMIAG CHIMBORAZO PROVINCE

TECHNICAL SUPPORT:
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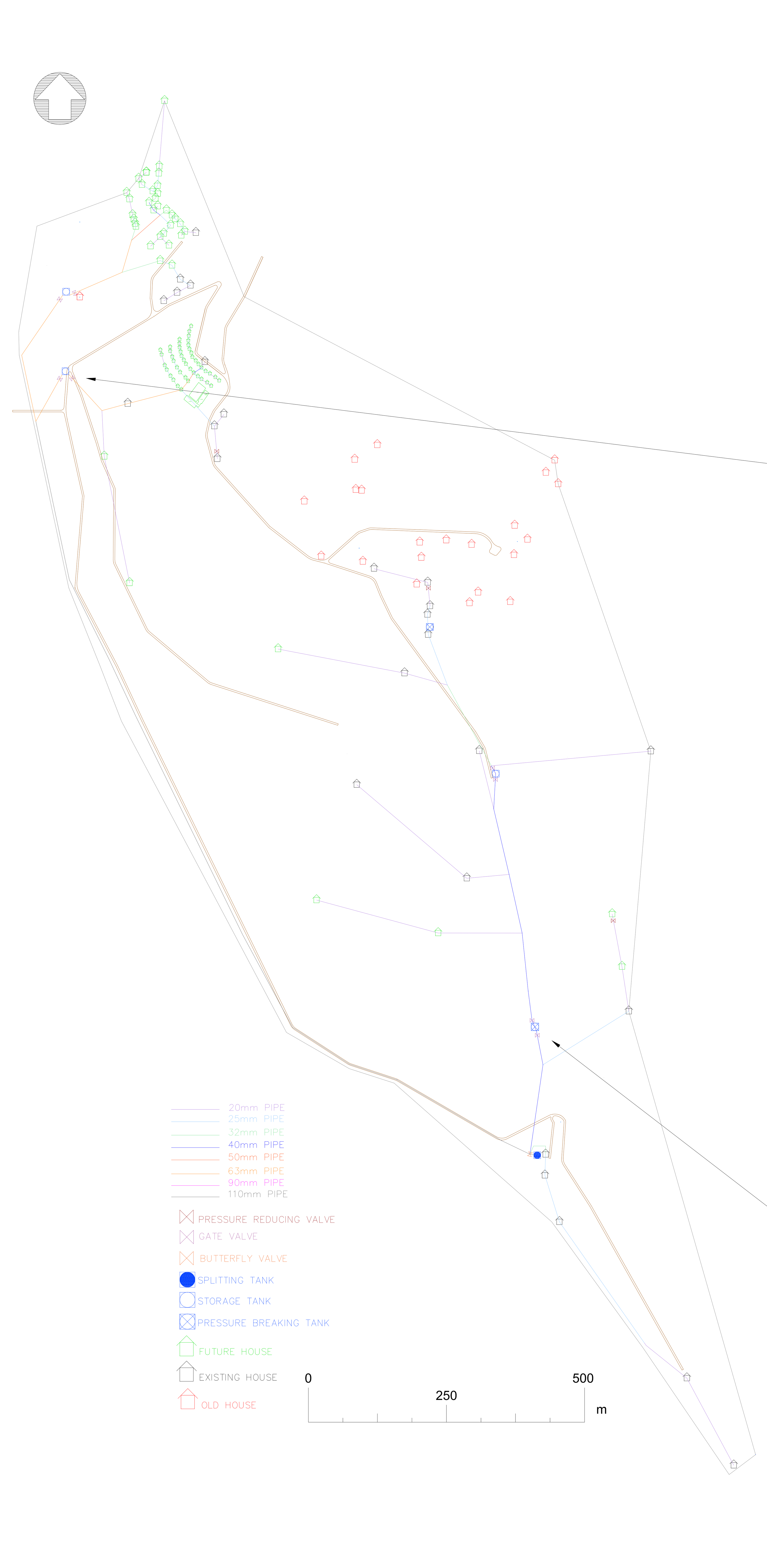
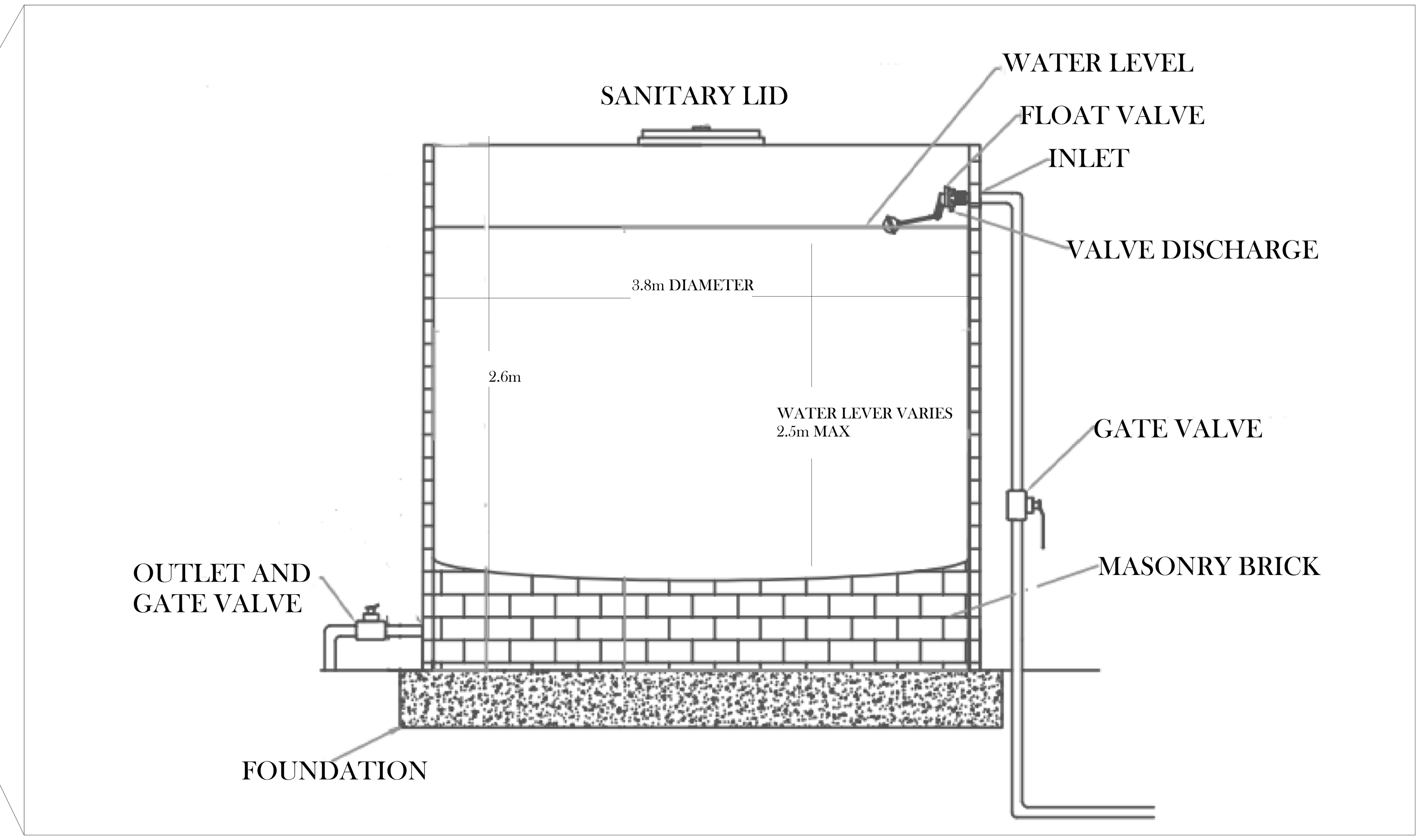


PROPOSED STORAGE TANK

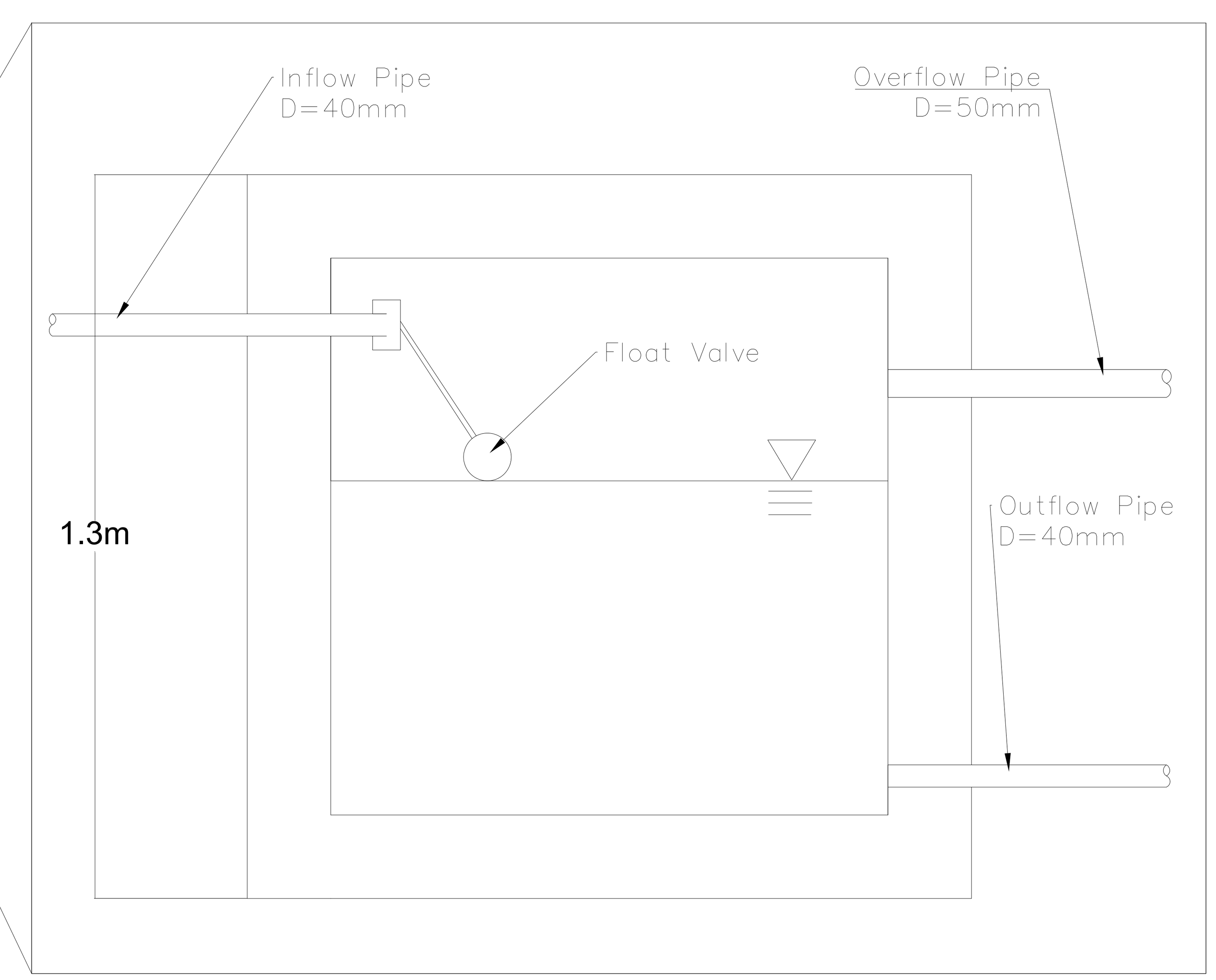
TANK VOLUME = $30m^3$



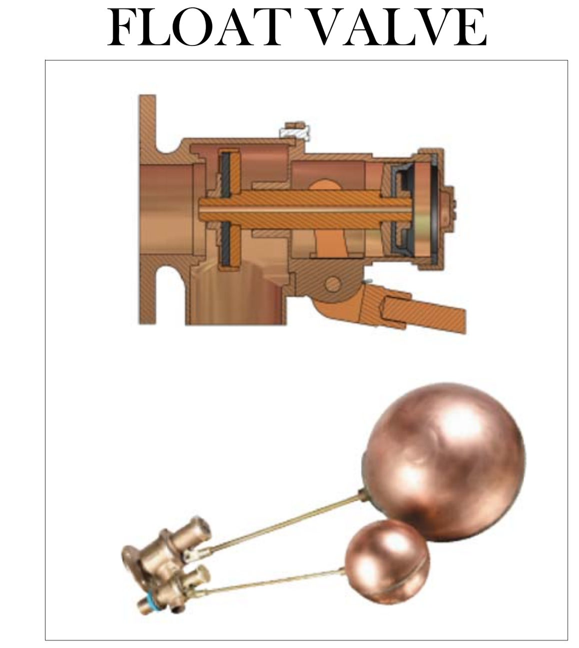
ADAPTED FROM: http://www.calvin.edu/academic/engineering/2015-16-team04/Team04_Final_Report.pdf

PROPOSED PRESSURE BREAKING TANK

TANK VOLUME = $1m^3$



FLOAT VALVE



SOURCE:http://talis-uk.com/wp-content/uploads/2013/10/Equilibrium-Float-Valves-Info-Sheet-02.12.pdf

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VOLCÁN ALTAR

CALVIN Engineering

CLIENT:
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PROJECT: Potable Water System for Chanac San Miguel

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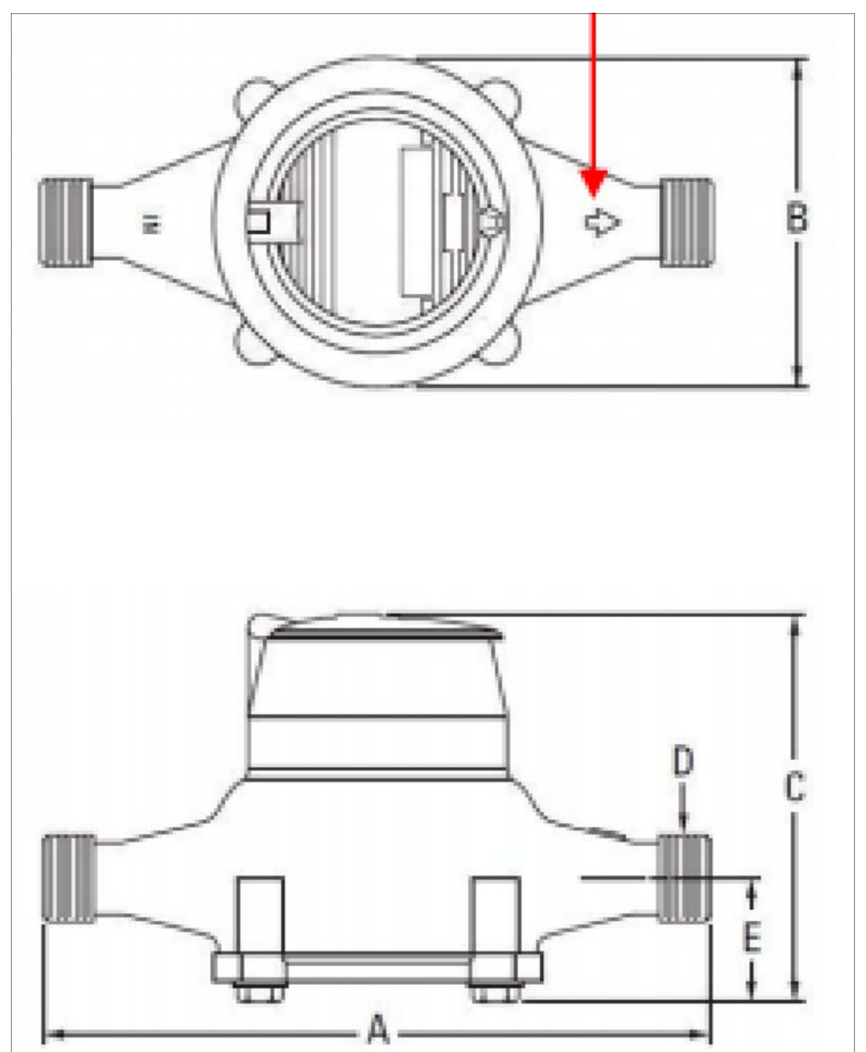
HOUSE CONNECTION WATER METER

25mm size shown

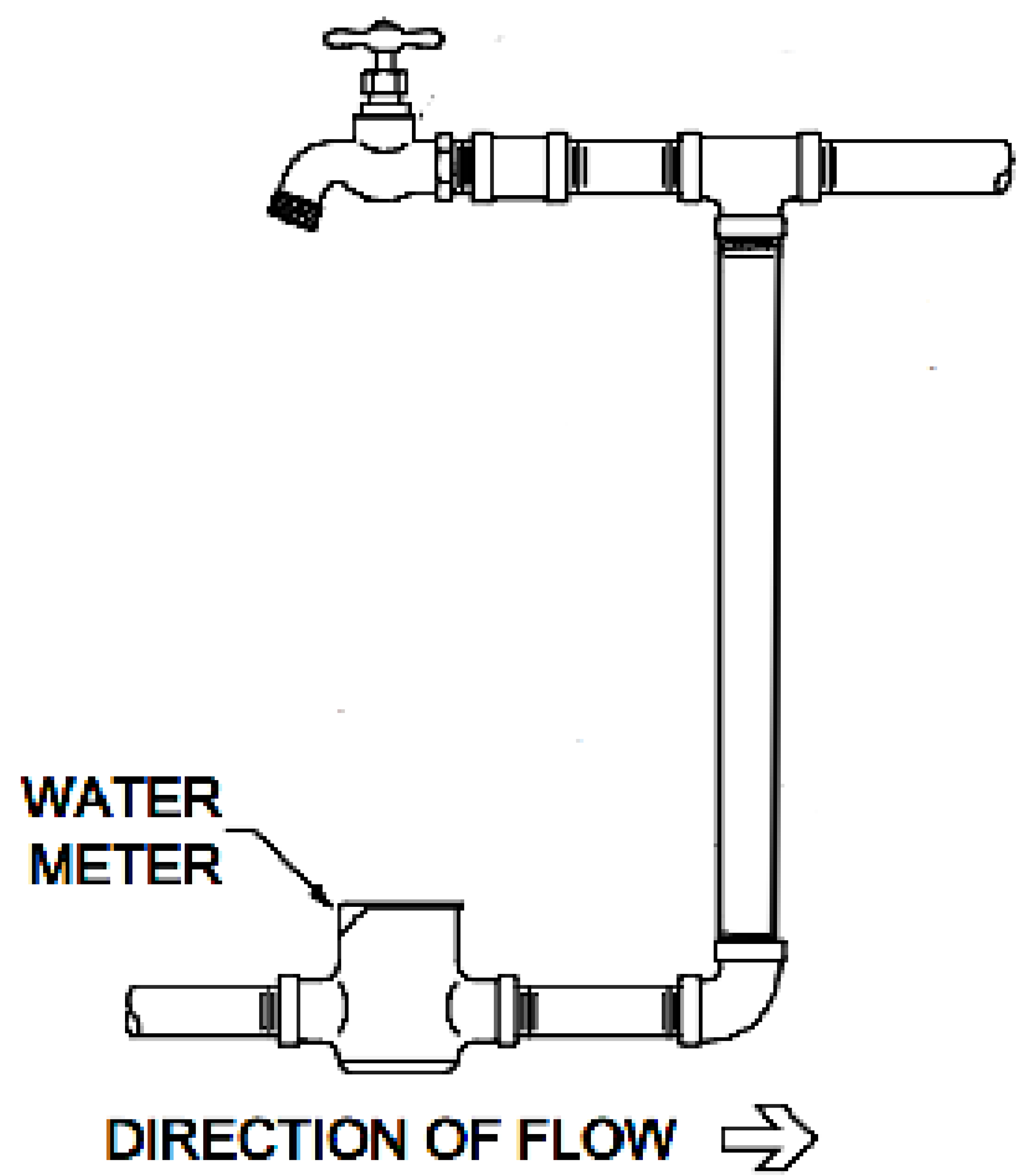


SPECIFICATIONS

	Size mm
Start flow @ ±5% accuracy	
Minimum flow Litres/min @ ±1.5%	
Nominal flow Litres/min	
Maximum flow Litres/min	
Minimum register reading	
Maximum register reading	
Contact Closure Pulse Output (pulses / Litre)	
Connection Type	
Weight (kg) (# including connectors)	

SOURCE: http://www.manuelectronics.com.au/pdfs/MESMR.pdf

OUTDOOR CONNECTION



ADAPTED FROM: http://www.zurn.com/Zurn/files/e5/e51f2685-9b3d-4ecf-a12c-c6acee6dd807.pdf

20mm INLET, 25mm OUTLET HOUSE CONNECTION SPIGOT

SOURCE:http://irrigationexpress.co.nz/brass-angle-hose-tap.html

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CALVIN Engineering

CLIENT:	CHAÑAC SAN MIGUEL
PROJECT:	Potable Water System for Chanac San Miguel
PAGE:	HOUSE CONNECTIONS AND METERS
LOCATION:	QUIMIAG CHIMBORAZO PROVINCE
TECHNICAL SUPPORT:	ENG. Bruce Rydbeck; CODEINSE Corporación de Desarrollo Integral Socio Economico Riobamba
DATE: MAY 2017	Calvin College Sr. Design Team 06

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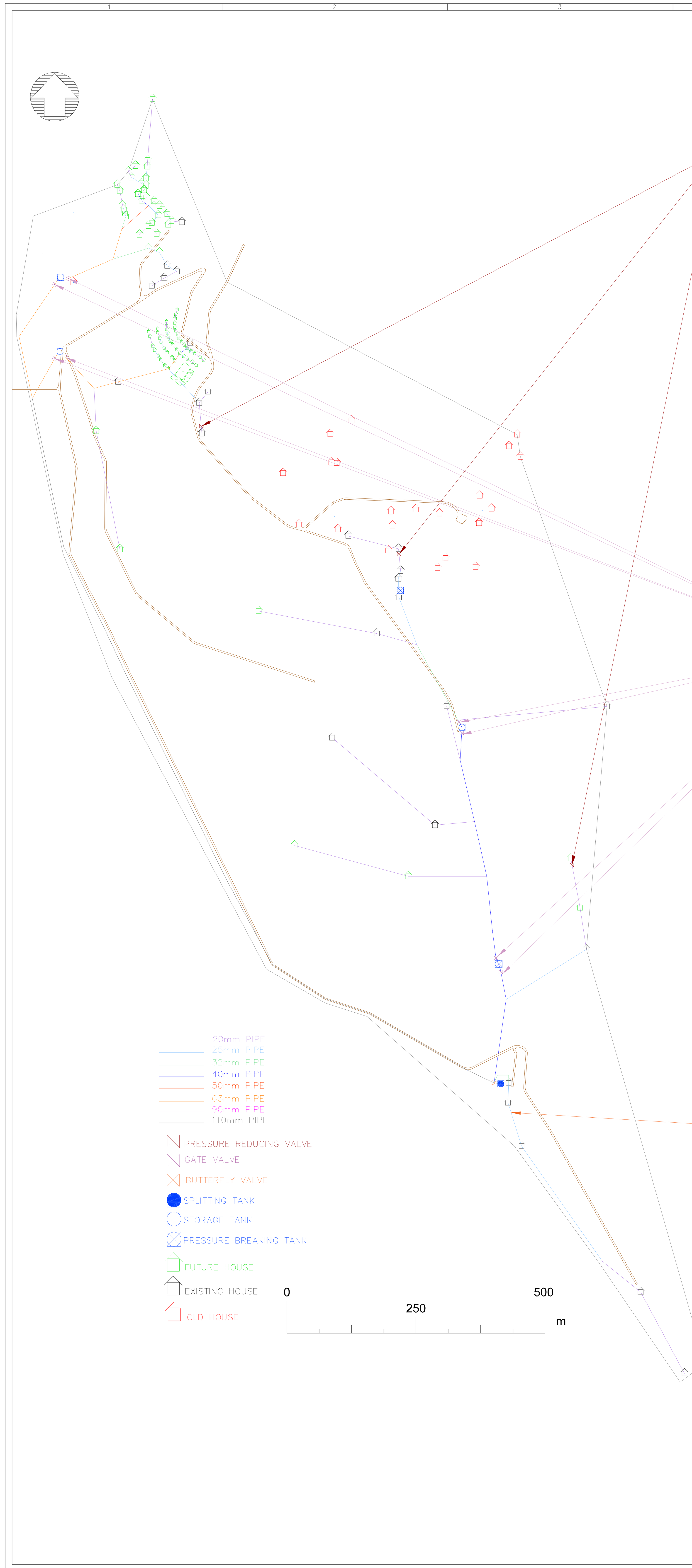
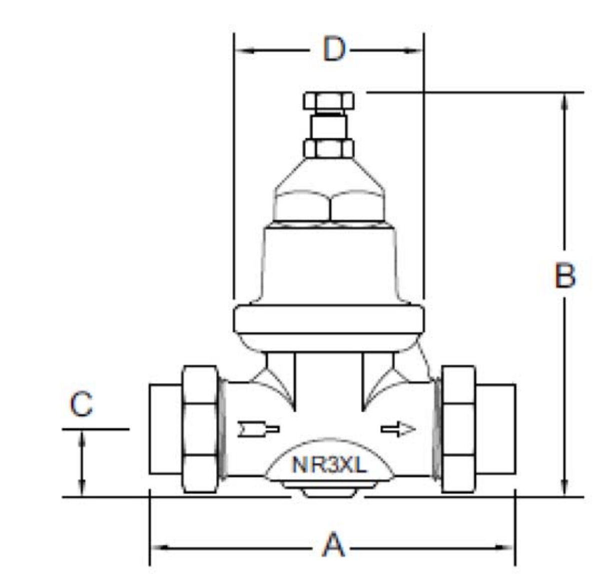


PRESSURE REDUCING VALVES

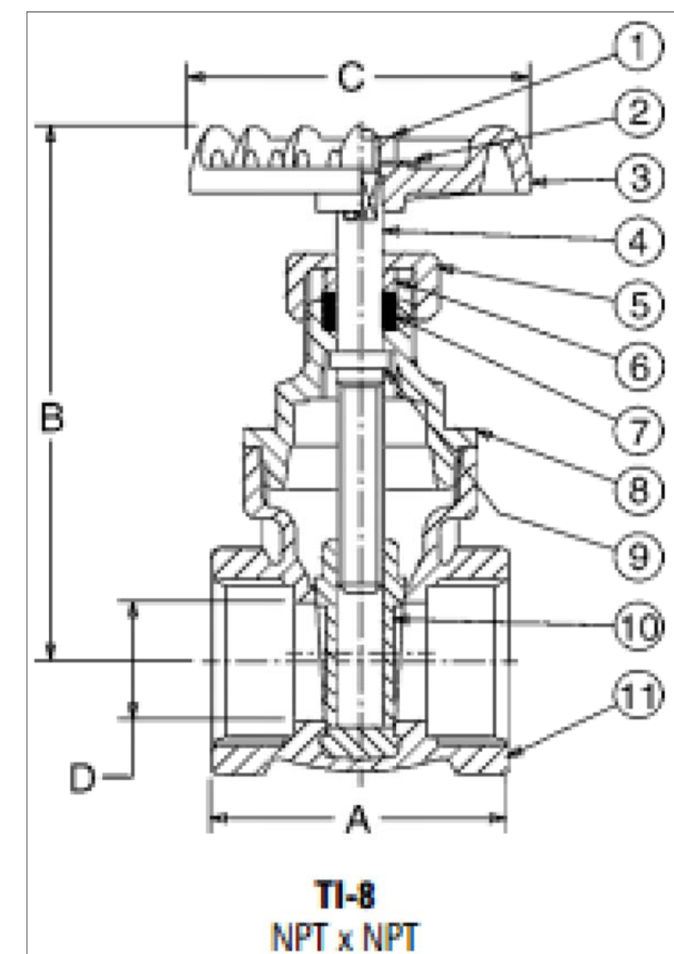
Dimensions & Weights (do not include pkg.) ☐ RFK-114NR3XL Extends body length of 1-1/4" NR3XL to match 1-1/4" 70DU for easy retrofit.

SIZE		CONNECTIONS	DIMENSIONS (approximate)								WEIGHT	
			A		B		C		D			
in.	mm		in.	mm	in.	mm	in.	mm	in.	mm	lbs.	kg
1/2	15	SINGLE UNION	4 3/8	111	6 1/4	159	1 1/8	29	2 1/2	64	3	1.5
1/2	15	LESS UNION	3 1/2	89	6 1/4	159	1 1/8	29	2 1/2	64	3	1.5
1/2	15	DOUBLE UNION	5 1/4	133	6 1/4	159	1 1/8	29	2 1/2	64	3	1.5
3/4	20	SINGLE UNION	4 7/16	113	6 1/4	159	1 1/8	29	2 1/2	64	3	1.5
3/4	20	LESS UNION	3 1/2	89	6 1/4	159	1 1/8	29	2 1/2	64	3	1.5
3/4	20	DOUBLE UNION	5 3/8	137	6 1/4	159	1 1/8	29	2 1/2	64	3	1.5
3/4	20	DOUBLE MALE METER	3 5/8	92	6 1/4	159	1 1/8	29	2 1/2	64	3	1.5
1	25	SINGLE UNION	4 15/16	125	6 1/4	159	1 1/8	29	2 1/2	64	4	2
1	25	LESS UNION	4	102	6 1/4	159	1 1/8	29	2 1/2	64	3.5	1.6
1	25	DOUBLE UNION	5 15/16	151	6 1/4	159	1 1/8	29	2 1/2	64	4.5	2.1
1	25	DOUBLE MALE METER	4	102	7 3/4	197	1 3/16	30	3	76	4	2.0
1 1/4	32	SINGLE UNION	6 3/16	157	7 3/4	197	1 3/16	30	3	76	5.5	2.5
1 1/4	32	LESS UNION	5	127	7 3/4	197	1 3/16	30	3	76	5	2.3
1 1/4	32	DOUBLE UNION	7 3/8	187	7 3/4	197	1 3/16	30	3	76	6	2.7
1 1/2	40	SINGLE UNION	6 5/16	160	8 1/2	216	1 3/4	45	3 3/4	95	6.6	3
1 1/2	40	LESS UNION	5	127	8 1/2	216	1 3/4	45	3 3/4	95	5.5	2.5
1 1/2	40	DOUBLE UNION	7 1/2	191	8 1/2	216	1 3/4	45	3 3/4	95	7.7	3.5
2	50	SINGLE UNION	6 1/4	159	8 1/2	216	2	51	3 3/4	95	8.1	3.7
2	50	LESS UNION	5	127	8 1/2	216	2	51	3 3/4	95	6.7	3
2	50	DOUBLE UNION	7 1/2	191	8 1/2	216	2	51	3 3/4	95	9.5	4.3



SOURCE: http://www.zurn.com/Zurn/files/e5/e51f2685-9b3d-4ecf-a12c-c6acee6dd807.pdf

GATE VALVES



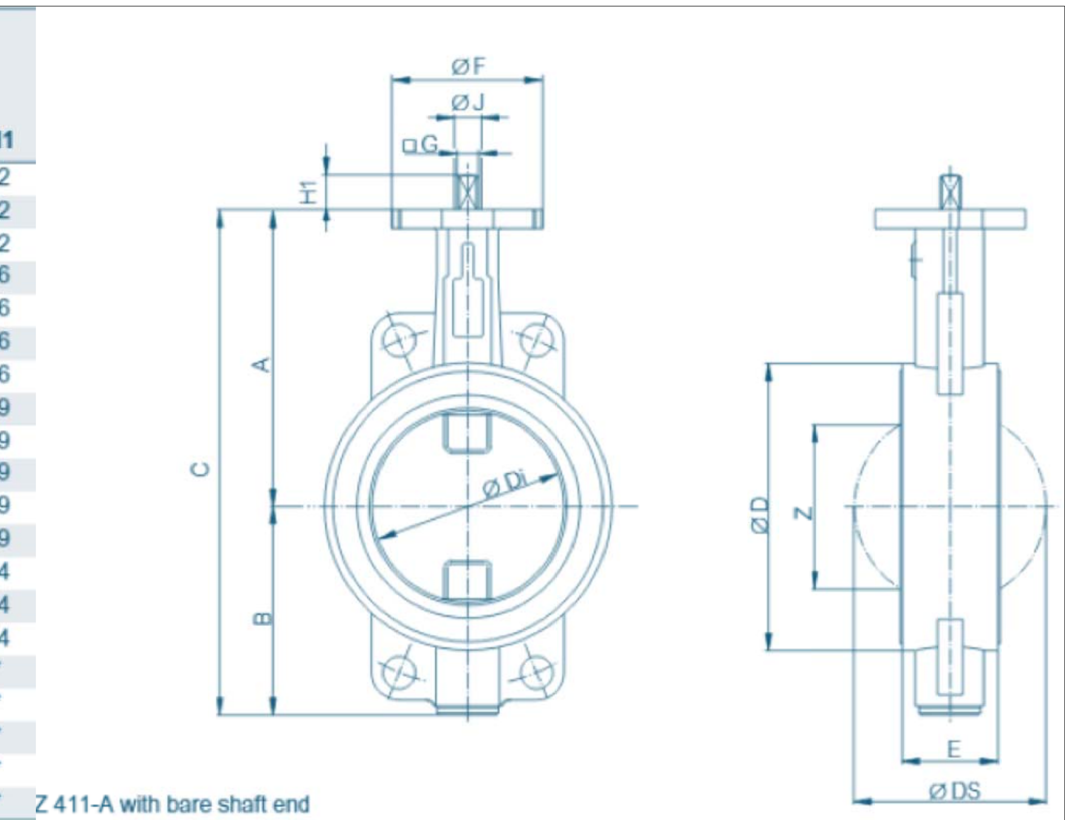
MATERIAL LIST

PART	SPECIFICATION
1. Nut	Steel plated ASTM A 108 Alloy G10100
2. Name Plate	Aluminum ASTM B 209 Alloy 1100
3. Handwheel	Cast Iron ASTM A 48 Class No. 35
4. Stem	Brass ASTM B 16 Alloy C36000
5. Packing Nut	Brass ASTM B 16 Alloy C36000 or B 584 Alloy C85700
*6. Gland	Brass ASTM B 16 Alloy C36000
7. Packing	Graphite/Rubber Non-Asbestos
8. Bonnet	Brass ASTM B 584 Alloy C85700
9. Lock Nut	Brass ASTM B 16 Alloy C 36000
10. Wedge	Brass ASTM B 584 Alloy C85700
11. Body	Brass ASTM B 584 Alloy C85700

SOURCE:http://www.nibco.com/resources/ProductSubmittalDocs/TSI8PV.pdf

BUTTERFLY VALVES

DN [mm]	Ø = da [mm]	Dimensions [mm]										
		A	B	C	D	Di	DS	E	F	Flange	G	H1
40	50	113	66	179	80	37	38	33	54	F04	11	12
50	63	126	84	210	95	48,5	49,6	43	54	F04	11	12
65	75	134	93	227	115	63,5	64,6	46	54	F04	11	12
80	90	157	104	261	138	78,5	79,6	46	65	F05	14	16
100	110	167	115	282	158	98,5	99,2	52	65	F05	14	16
100	125	167	115	282	158	98,5	99,2	52	65	F05	14	16
125	140	180	127	307	166	111,2	112,2	56	65	F05	14	16
150	160	203	150	353	186	123,2	124,2	56	90	F07	17	19
150	180	203	150	353	212	148	149,2	56	90	F07	17	19
200	200	228	176	404	226	161,5	162,5	60	90	F07	17	19
200	225	228	176	404	250	182	183	60	90	F07	17	19
250	250	266	212	478	268	198,2	199,2	68	90	F07	17	19
250	280	266	212	478	315	224,3	225,3	68	125	F10	22	24
300	315	293	237	528	358	255	256	78	125	F10	22	24
350	355	332	269	601	365	285,7	286,7	92	125	F10	22	24
400	400	363	314	677	428	327	328	102	150	F12	*	*
500	450	437	405	842	454	365,8	366,8	127	150	F12	*	*
500	500	437	405	842	508	409	410	127	150	F12	*	*
600	560	475	418	893	530	426	427	114	210	F16	*	*
600	630	475	418	893	574	488	490	127	211	F17	*	*



SOURCE: http://pdf.directindustry.com/pdf/ebro-armaturen-gebr-broeer-gmbh/wafer-type-butterfly-valve-z-611-a/7410-474147.html

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VOLCÁN ALTAR

CALVIN Engineering

CLIENT: CHAÑAC SAN MIGUEL

PROJECT: Potable Water System for Chanac San Miguel

PAGE: VALVE DETAILS

LOCATION: QUIMIAG CHIMBORAZO PROVINCE

TECHNICAL SUPPORT: ENG. Bruce Rydbeck
CODEINSE
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Riobamba

DATE: MAY 2017

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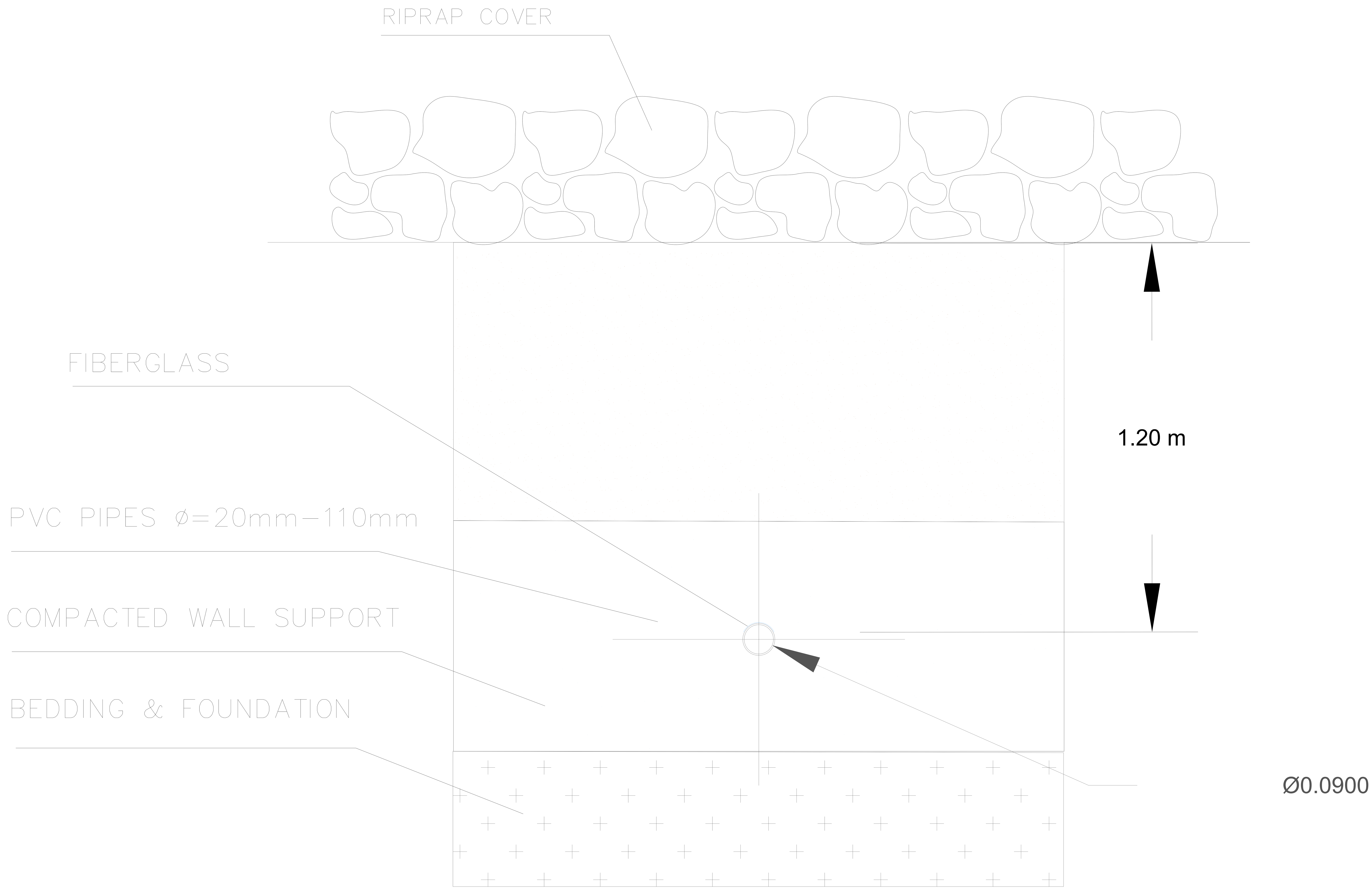

DESIGN ADAPTED FROM LIFE GIVING WATER INTERNATIONAL AND http://www.gfps.com/country_US/en_US/harvel.html

Life Giving Water International

VOLCÁN ALTAR

CALVIN Engineering

CLIENT: CHAÑAC SAN MIGUEL

PROJECT: Potable Water System for Chanac San Miguel

PAGE: TRENCH DETAILS

LOCATION: QUIMIAG CHIMBORAZO PROVINCE

TECHNICAL SUPPORT: ENG. Bruce Rydbeck

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MATERIAL ORDER AND COST BREAK DOWN

30m^3 Reservior

Accessory	Unit	Quantity	Unit Price	Total Cost
Cement	gg	95	$ 8.00	$ 760.00
Boards	meters	80	$ 2.50	$ 200.00
Rails	meters	40	$ 2.00	$ 80.00
Iron	each	16	$ 52.00	$ 832.00
Nails	lbs	50	$ 1.25	$ 62.50
Wire	lbs	25	$ 1.25	$ 31.25
Rags (3m)	c/u	50	$ 2.50	$ 125.00
Sanitary Lid	c/u	1	$ 120.00	$ 120.00
Stairs	c/u	1	$ 100.00	$ 100.00
Concrete block	c/u	400	$ 2.25	$ 900.00
Control	kg	30	$ 2.00	$ 60.00
DM Impersan	kg	30	$ 2.00	$ 60.00
Betoncryl	kg	30	$ 10.00	$ 300.00
Plumbing 10%				$ 363.08
			Total Cost:	**$ 3,993.83**

Distribution Network

Description	Unit	Quantity	Cost/unit	Total Cost
110 mm PVC, 1.25 Mpa	6 Meter	291	$ 44.13	$12,841.83
63	6 Meter	92	$ 14.77	$ 1,358.84
50	6 Meter	15	$ 9.43	$ 141.45
40	6 Meter	112	$ 7.66	$ 857.92
32	6 Meter	67	$ 4.78	$ 320.26
25	6 Meter	200	$ 3.95	$ 790.00
20	6 Meter	449	$ 3.95	$ 1,773.55
20mm Water Meters and housing connection	each	103	$ 75.00	$ 7,725.00
Butterfly valve-cast iron (110mm)	each	1	$ 192.66	$ 192.66
Bronze Gate Valve (2")	each	4	$ 39.00	$ 156.00
Bronze Gate Valve (3")	each	4	$ 103.91	$ 415.64
Float valve	each	2	$ 22.96	$ 45.92
Tee (2")	each	16	$ 3.41	$ 54.56
Tee (1 1/4")	each	5	$ 1.75	$ 8.75
Female adapter (63mm)	each	92	$ 2.56	$ 235.52
Female adapter (50mm)	each	127	$ 1.07	$ 135.89
Female adapter (20/25mm)	each	649	$ 0.75	$ 486.75
			Subtotal:	**$ 27,540.54**

Pressure Breaking Tank

Materials for 1 m^3

Accessory	Unity	Quantity	Unit price	cost
Cement	qq	7	$8.00	$56.00
Boards	m	10	$2.50	$25.00
Rails	m	5	$2.50	$12.50
Iron	qq	2	$52.00	$104.00
Nails	lbs	10	$1.25	$12.50
Wire	lbs	10	$1.25	$12.50
Rags (3m)	c / u	5	$3.00	$15.00
Sanitary Lid	c / u	1	$125.00	$125.00
Concrete blocks (15x40x20)	c / u	100	$2.25	$225.00
Aditec 1	kg	2	$2.00	$4.00
Impersam DM	kg	2	$2.00	$4.00
Betoncryl	kg	2	$10.00	$20.00
Plumbing 10%	-	-	-	$61.55
*1qq=50kg			Total	$677.05

Labor

Description	Unit	Quantity	Unit Cost	Total Cost
Community Day Labor	/day*(0.5*house)	50	$15	$38,625.00
Tank Mason	/day	20	25	$ 500.00
Supervisor Day Labor	/day	50	50	$ 2,500.00
Supervisor mileage	each	1	500	$ 500.00
			Subtotal:	**$ 42,125.00**

LABOR COST: $42, 125.00

MATERIAL COST: $32,211.42

TOTAL: $79,168.13

Life Giving Water International

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CALVIN Engineering

CLIENT: CHAÑAC SAN MIGUEL

PROJECT: Potable Water System for Chanac San Miguel

PAGE: BILL OF MATERIALS

LOCATION: QUIMIAG CHIMBORAZO PROVINCE

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