

Automated Intake Valve Control Systems for Rural Community Water System Prototype Community: Wala, Panama



University of Tennessee- Knoxville

Tickle College of Engineering

Department of Civil and Environmental Engineering

Senior Design Course Experience

CE399S & CE400

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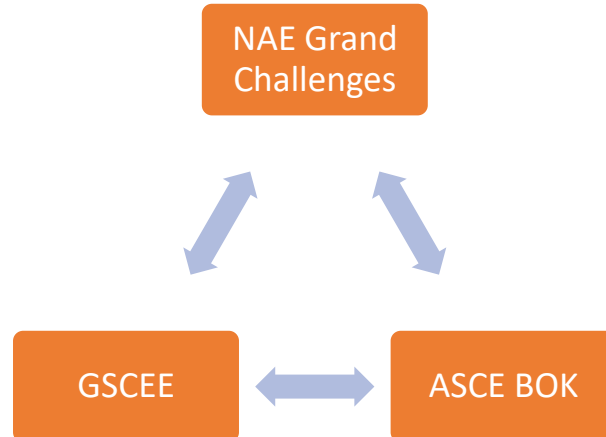
Mission Statement

Tickle Tech places health, safety, and sustainability at the forefront of engineering design work. Our goals align with Solea Water in the dedication to bring water solutions to communities facing water poverty. The implementation of our engineering work directly correlates to the National Academy of Engineers



Grand Challenge (NAE): Provide Access to Clean Water. NAE seeks technological solutions to address the problem of inequitable distribution of water resources, which Tickle Tech tackles through designs to improve access to water sources and help communities implement and operate water utilities. Through our mission, Tickle Tech follows the regulations of the American Society of Engineers (ASCE). Our commitment to help provide access to clean water and improve the lives of others is reflected in our engineering design work for each community. The team aims to prioritize global, social, cultural, environmental, and economic (GSCEE) factors in our design through intentional design considerations and a deliberate focus on the impact our design will have on surrounding areas. Tickle Tech plans to emphasize ASCE's Body of Knowledge (BOK) in all engineering applications. ASCE's BOK outlines the necessary values and mindset to become a successful professional engineer. Tickle Tech strives to provide sustainable and ethically responsible solutions as outlined in the BOK. The application of the BOK allows us to become more knowledgeable

regarding the implementation of GSCEE factors in our solution and helps us fulfill the NAE clean water grand challenge.



Disclaimer

The work for the project was performed by students at the University of Tennessee-Knoxville. While all work was done to the best of the student's ability, they are not licensed Professional Engineers. If the design in the project is used, a Professional Engineer should check calculations and stamp the project prior to utilization.

Acknowledgement

The members of Tickle Tech want to express gratitude for the technical guidance and support on our intake valve design. Our mentors, Mark McKinney with Barge Designs and Alan Foster with Solea Water, have guided us through the design process and have offered beneficial feedback. Our faculty advisor, Dr. Jennifer Retherford, helped us organize our design process by making sure we met pivotal deadlines and connected with the community in Panama. We would also like to acknowledge Dr. John Schwartz for assisting in the prototype process and contributing his time and resources to Tickle Tech's development. Thomas Peplow was critical in helping the team write and edit the technical report.

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Introduction

Solea Water aims to assist communities with resilient water infrastructure solutions to enhance the quality of life of indigenous people in rural Panama. Remote villages across Panama lack reliable infrastructure to consistently deliver clean water without being damaged. Many water systems use gravity to transport water from rivers in nearby mountains to the villages; however, the systems get overwhelmed or broken during times of high precipitation and sedimentation. To avoid damage to the existing pipelines and water tanks, a protected system is needed to automatically close off a water intake based on high turbidity levels or water level increases while remaining open at acceptable operating conditions. Solea Water requests consideration of appropriate technology, local economics, and social adoption, to develop a “high-tech” and “low-tech” solution able to satisfy the needs of Wala, Panama, and any community with similar conditions.

Site Conditions

The 10,000 square foot project site is located within the Darién region of Panama and can be described through the surrounding environment, the existing system components, and the adjacent services. Thick vegetation and forest grow on both sides of the 30-foot-wide riverbed and sloped riverbanks contain large rocks and forest debris. The bank alongside the river is exposed during periods of lower rainfall and the decreased river width is 10 feet. Water elevation within the river increases up to 3 feet during the wet season which occurs from May to January. A concrete dam, approximately 6 feet high, stretches 10 feet across the river and contains several 4-6-inch diameter PVC pipes offering supply, clean-out maintenance, opportunity for future tie-in, as well as downstream continuity of the river (see Figure 1). One 4-inch PVC pipe is connected to the supply at the dam and continues for approximately 1-mile filling water storage tanks to provide water to approximately 3,000 people of the Wala community.



Figure 1: Proposed water system

Project Team

Tickle Tech is comprised of four undergraduate civil engineering students from the University of Tennessee, Knoxville (UTK). Ashlyn Celichowski possesses prior knowledge in water resource engineering design given internships at Kimley-Horn and LJA Engineering. Isabelle Hamby has a research background in stormwater and urban tree canopy through undergraduate research at UTK as well as consulting experience in environmental engineering through a summer internship at Goodwyn Mills Cawood. Jackson Reeves gained engineering experience through an internship with The Tennessee Department of Transportation. Elizabeth Morgan worked as an electrician in the United States Navy and gained proficiency with technical writing as a Teaching Assistant at UTK. The team (pictured in Figure 2) conducted work with the help of community partner Alan Foster, technical advisor Mark McKinney, graduate teaching assistant Thomas Peplow, and the course professor Dr. Jennifer Retherford. Each team member assumed responsibility of specific project tasks (Table 1) and worked closely together through a deliberately designed team organizational structure (Figure 3).



Figure 2: Tickle Tech Team (From Left to Right- Isabelle Hamby, Jackson Reeves, Ashlyn Celichowski, Elizabeth Morgan)

Team Member	Association	Role	Email
Alan Foster	Solea Water	Client	alan@soleawater.org
Mark McKinney	Barge Design Solutions	Technical Mentor	Mark.McKinney@bargedesign.com
Ashlyn Celichowski	UTK	Student Designer	acelicho@vols.utk.edu
Elizabeth Morgan	UTK	Student Designer	emorga29@vols.utk.edu
Isabelle Hamby	UTK	Student Designer	klz321@vols.utk.edu
Jackson Reeves	UTK	Student Designer	jreeve28@vols.utk.edu
Thomas Peplow	UTK	Graduate Teaching Assistant	tpeplow@vols.utk.edu
Jenny Retherford	UTK	Faculty Advisor	jretherf@utk.edu

Table 1: Project Roles

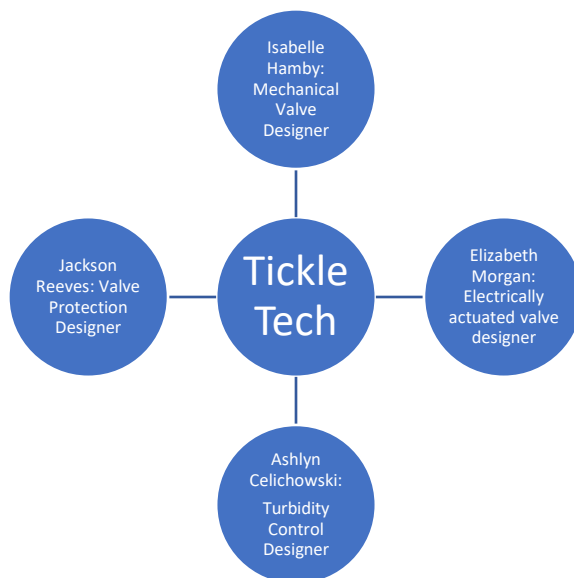


Figure 3: Team Organization Chart

Technical Scope of Work

Two water intake control systems were designed and prototyped in order to develop an operational guide and life-cycle cost estimate for the rural application. Two control systems and custom protection schemes were developed contingent on high-water elevations and turbidity design criteria defined to preserve the distribution system's integrity. Prototypes of both intake systems were developed to test accuracy of each actuation method and provide proof of concept for system designs. An operational guide was created, and life-cycle cost was estimated for both control system solutions, influenced by the results of the prototyping.

Water Intake Control Systems

Two water- intake control systems were developed to regulate flow based on hydraulic conditions of specified high-water levels and water quality standards influenced by elevated turbidity levels. A mechanically actuated system was designed with a float valve to control high-water levels in accordance with hydraulic principles of reservoir pressure. An electrically actuated system was designed with consideration of power system demands calculated following the National Electrical Code. Turbidity control for the electrically actuated system was designed following drinking water health standards referenced from the Illinois Department of Public Health for adaptation to site specific needs. The method for valve actuation was chosen by addressing hydraulic principles and feasibility. Valve protection schemes incorporating screens and boxes were designed based on NEMA ratings, KUB standards, and ACI strength requirements of materials.

A mechanical actuated system was designed based on the stage of the intake river. The elevation variation of the water was determined to be a maximum of 24 in based on past storm events. A mechanically actuated valve was selected using a decision matrix considering cost, technical suitability, and implementation practicality with a score of 1 meeting minimum requirements and a score of 5 providing excellent satisfaction (Table 2). A float valve was chosen over an altitude valve due to the higher total score and better fit for the community. A control box was chosen to house the valve and was chosen to be placed on the downstream side of the dam so that the existing dam and intake pipe could be used. The control box was designed according to Pascal's principle of transmission of pressure in open reservoirs (seen in appendix A) so the water elevation would be open to the atmosphere and match the water elevation of the river. The valve box was placed to the side of the dam to avoid the turbulent waters in the middle of the stream during a storm surge. Valve and pipe material were chosen to be PVC in accordance with the NSF International Standard 61, General Requirements section for water system components. A two-inch Merrill Manufacturing Float Valve was selected to be most suitable for the project due to its material, dimensions, and cost.

Criteria	Weight	Altitude Valve		Float Valve	
		Rating	Weighted Score	Rating	Weighted Score
Cost	1	2	2	4	4
Technical Suitability	3	4	12	5	15
Implementation Practicality	3	3	9	5	15
Total			23		34

Table 2: Decision Matrix for Valve Selection

Solar power was assessed as a power supply for the electrically actuated water intake system based upon site photovoltaic potential, safety for the community, and voltage drop limitations. Photovoltaic potential for Panama was evaluated based on Sun Radiance charts from solargis.com and determined to be sufficient for solar panel use. Minimum solar duration, 11-hours, was determined based on values from World Data's website representing the most limiting solar power generation in Wala, Panama. A solar panel was selected from Victron Energy's catalog based on client preferences, durability, and safety for future maintenance technicians. A sealed and waterproof 115-Watt solar panel was assessed based on

availability in Panama and ability to withstand the variable environmental conditions experienced by the project site (Appendix A). A DC voltage system was chosen based on a comparison of AC and DC adverse health effects of electrical shock. DC was identified as safer than AC to personnel for similar voltage and amperage systems and selected as the voltage type of the system. As the increased distance between the solar panel and valve will reduce power output, the voltage drop was calculated for the system based on electrical principles. The maximum distance from electrical source to load was determined to maintain the standard voltage drop of 3-5% found within National Electrical Codes Section 210.19(A) (Table 3).

Parameter	Value	Note:
Photovoltaic Potential	3.0-3.2 KWhr/m ²	Site assessment for solar power generation
Total Solar Power Capability of a 115-Watt solar panel	1,334 Watts-hours	Based on 11-hour sun exposure.
Maximum Distance between Solar panel and loads	45 ft	Within 3-5% drop recommendations

Table 3: Solar Power Potential for Wala, Panama

A turbidity sensor for the electrically actuated system was selected based on cost, compatibility with an Arduino board, ease of use, and measurement range (see Appendix A). The acceptable cost was determined by considering the product availability in Panama and the replacement price. The compatibility with Arduino was assessed based on product specifications. The measurement range of the sensors was analyzed with the safe drinking level ranges of turbidity and unit conversions. The Walfront Store turbidity sensor was chosen to send signals to an electrically actuated valve based on a safe drinking number of particles, which is above or below 1,500 mg/L of total dissolved solids, as outlined by the Illinois Department of Public Health (Table 4). The turbidity sensor components must be enclosed in a watertight conduit and box (see Appendix A).

Total Dissolved Solids Ranges (mg/L)	Deciding Factors	Valve Function
Less than 500	Satisfactory	Open
500-1,000	Less than desirable	Open
1,000-1,500	Undesirable	Open
Over 1,500	Unsatisfactory	Close

Table 4: Valve Functions for Turbidity ranges

The valve for the electrically actuated system was selected based actuation and site conditions and the power supply selection was finalized based on electrical calculations. Valve actuation for the electrically actuated system was determined based on a scored decision matrix including feasibility of actuation, complexity of installation and operation, and programmability. Solenoid actuation was evaluated with the highest score and selected for the water intake control system. Valve options were assessed based on existing site conditions and required operational parameters. Pressure felt on the valve

was calculated based on hydraulic principles and compared to valve data sheets. A 4-inch normally open solenoid valve was selected from Sizo Tech Corporation's catalogue. Power demand was calculated for the turbidity sensor, valve cycling, and Arduino board, assuming 24-hour continuous energization, based on engineering fundamentals and basic electrical power equations (**Error! Reference source not found.**). The Victron Energy LFP Smart 12.8/160 Lithium Battery was selected based on battery capacity assessment assuming 3-day maximum electrical loading. One 115Watt Blue Solar Monocrystalline solar panel from Victron Energy's catalogue was determined to provide sufficient power capacity for system electrical loads and was selected with consideration towards sustainability and maintaining the natural environment (Table 5).

Equipment:	Totals	Manufacturer:	Quantity	Notes:
Power Requirements	517.2 Watt-hours	Various	1 of each component	Power includes turbidity sensor, Arduino board, valve
115-Watt Solar Panel	1, 334 Watt-hours	Victron Energy	1	One solar panel with 11.6 hours of sun provides more power than required.
Lithium Battery	160 Ah	Victron Energy	1	Storage for 3-days at maximum loading
Solenoid Valve	4"	Sizo Tech Corporation	1	Rated for 100% continuous duty cycle.

Table 5: Equipment selections for electrical solution

Protection schemes were developed to ensure effective performance of both water intake control systems. A protective component that was designed to be implemented for both the mechanical and electrical water intake control systems is a protective screen. The protective scheme is designed with the screen being placed at the inlet of both control system designs. A No. 200 screen was selected based on its filtration properties. It was determined that the screen would not restrict flow through the pipe using the head loss of fluid through a screen equation. Protection for the electrical components of the electrically actuated water intake control system was developed based on NEMA ratings. The electrical systems will be subject to submersion for prolonged periods. The protective system involves the electrical components being placed in NEMA 6P enclosures with a water-tight conduit running necessary wiring to each enclosure. A protective component for the mechanically actuated water intake control system was designed to protect the float valve from debris. The control box that houses the float valve was designed to be constructed out of concrete with anchoring rebar rods and have a compressive strength of 4,000 psi in accordance with KUB standards. The control box was designed to be installed on the site's existing igneous rock by drilling holes and using epoxy to anchor the rebar. The box was designed to have a square base with a width of 4 ft. and height of 5 ft. The structural aspects of the control box were modelled after Tennessee Department of Transportation standard drawings and designed to have 8 in. thick walls in accordance with ACI 318-19 exterior wall requirements and 8 in. thick footing. The spacing of the reinforcement is to be 18 in. maximum with a 3 in. cover in accordance with ACI 318-19 11.7.2.1 and 20.5.1.3.1. The box was designed with dowels with a 90-degree bend and development length of 12 in. to connect the walls to the footing (see drawings). The shearing force the control box is subject to was determined to be caused by the hydrostatic pressure of the water within the box and the concrete's weight. The hydrostatic pressure was calculated as 1,331 lbs. and the concrete's weight was 8,550 lbs. The

total shearing force was calculated to be 10,000 lbs (see appendix A). The anchoring rods were designed to withstand the shearing force. The anchor rods selected were four # 5 rebar rods. The shear strength of the rebar anchor rods was calculated for four grade 60 #5 rebar rods to be 135,000 lbs. The necessary rod diameter based on pull-out from shear forces was calculated to be 0.56 in². #5 rebar was selected because it has a diameter of 0.625 in². The necessary pull-out depth of embedment based on #5 rebar anchor rods was calculated to be 10in (see appendix A). There is no information regarding anchoring into rock using epoxy so the team selected Hilti RE 500 V4 as the anchoring epoxy due to it having the highest available bond strength.

Prototypes

Two scaled prototypes were developed to assess the effectiveness of the mechanical and electrically actuated water intake control systems. Tickle Tech devised a prototyping plan for both the mechanical solution and electrical solution. A scale prototype of the team's mechanical solution was constructed at UTK's East Tennessee Research and Education Center and tested to evaluate performance based on water elevation change. Proof of concept of the mechanical solution was analyzed based on intended operational functions to verify the designs' hydraulic feasibility. The electrical solution was also assembled, and valve cycling was tested for specified turbidity conditions in a tabletop experiment. Proof of concept of the electrical solution was analyzed based on the tabletop experiment's effectiveness in its intended purpose.

Tickle Tech devised prototype plans for both the mechanical and electrical solutions. A materials list was compiled to prototype the systems based on the components' availability in Panama and manufacturers Solea Water preferred. The materials list was compiled based on mentor input and client needs. The materials list was examined to determine where Tickle Tech could acquire the materials needed to construct the prototypes. Once the materials list and sources were outlined, Tickle Tech ordered the materials. It was determined that the mechanical prototype would be constructed on a quarter scale based on material availability and construction feasibility. Tickle Tech developed prototype testing parameters for both the mechanical and electrical water intake control designs. The prototype materials were acquired, and the prototypes were constructed following the CEE Field Safety Manual. The mechanical design was tested as a scaled prototype and the electrical design was tested as a tabletop experiment. The hydraulic feasibility for the mechanical prototype was defined as the float valve closing the inlet pipe at a water elevation change within the box of 6in. The effectiveness of the electrical solution was defined as the valve closing in a turbid sample and opening in a clear sample. The prototypes were used to refine both designs. The prototype process is outlined in (Figure 4).Figure 4



Figure 4: Prototype Process

A scaled model of the mechanical water intake system was built to show proof of the design's concept. The prototype was constructed in the flume at the University of Tennessee Knoxville's Agriculture Research Center (Figure 5) to determine functionality. The model dam structure was created out of particle board acquired through left over materials from flume construction. Wooden plank supports were installed on the downstream side of the dam and secured to the side of the flume with waterproof caulking. The pipe heights were determined to be 4 inches and 12 inches from the ground to simulate the pipes in the existing dam structure. A hole was added to allow water to flow through the dam, similar to the open outflow pipe in the site dam. The control box with the float valve was created to be 22.5 inches by 20 inches by 48 inches (Figure 6) in order to hold up to 2 feet of water with 2 feet of extra freeboard (see Appendix B). The control box was lined with waterproof material, and all connections were sealed with waterproof caulking (Figure 7). Two PVC pipes were added to the dam and connected to the box. A one inch Robert Manufacturing float valve was installed within the box and connected to the discharge pipe representing the pipe that would lead to the community water system.



Figure 5: Agriculture Research Center Flume

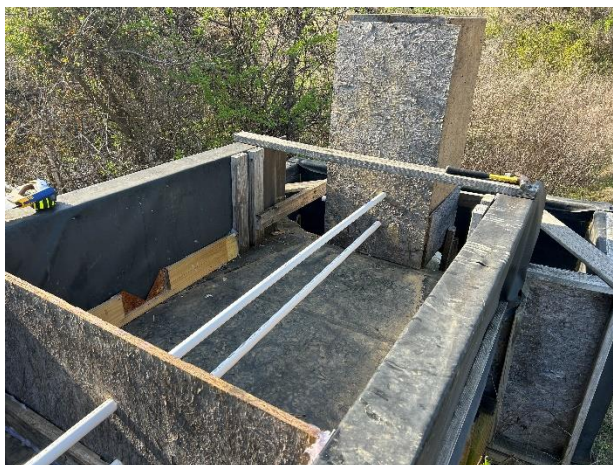


Figure 6: Prototype Configuration



Figure 7: Valve Connection and Waterproof Lining

Proof of concept of the mechanical prototype was analyzed based on the scaled mechanical prototype's functionality. The testing metrics that Tickle Tech devised to prove proof of concept were that the float valve closes when water in the control box passes and set elevation and opens when the stage lowers. To test proof of concept Tickle Tech used a 1 hp pump to fill the flume and allow water to flow into the control box. During the testing, the water in the control box rose to an elevation change of 6 in and the valve closed and did not allow more water to flow. The float valve shut, the team stopped the flow into the control box and let the excess water drain. When the water elevation in the box lowered, the float valve opened and let flow pass. Based on the prototype test, Tickle Tech determined that proof of concept was proved.

The electrical water intake system was prototyped to verify accuracy of component connections and compatibility with Arduino code. The electrical valve was scaled to 1-inch based on cost and compatibility

with existing laboratory and campus equipment. A 12-V charged car battery was selected as the power source to power the valve simulating the solar battery bank for the proposed system. A 5-volt battery was used to power the Arduino system components simulating the intended disposable batteries for the system. Kaolinite slurries were prepared in accordance with standard methods at 500 mg/L, 1500 mg/L, and 2,000 mg/L with deionized water to clean the turbidity sensor between tests (Appendix B). Testing was performed on a simplified version outside of an operational system to verify turbidity sensor accuracy, compatibility with the valve, and to verify the Arduino code controlled valve actuation in stable conditions. The turbidity sensor was submerged 1-inch into solutions to simulate proposed conditions when within the pipes of the water intake system. The electrical prototype is shown in Figure 8. Electrical connections were verified and finalized drawings were drawn based on prototype electrical connections.

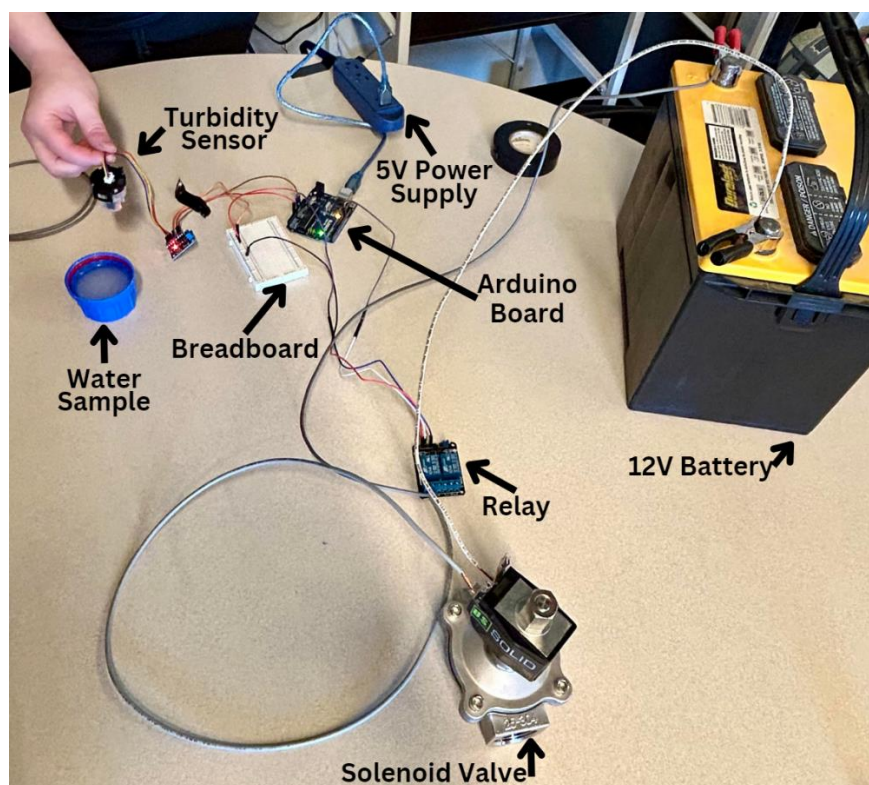


Figure 8: Electrical Prototype

Proof of concept of the electrical prototype was analyzed based on the functionality of the tabletop experiment. The testing metrics devised to prove proof of concept were that the solenoid valve closes when there is high turbidity in water and opens when there is low turbidity. Tickle Tech followed the health standards of total dissolved solids in drinking water from the Illinois Department of Public Health to create two water solutions. The unsatisfactory amount of total dissolved solids was used for the high turbidity condition, and the satisfactory range was used for the low turbidity condition. Tickle Tech created the high turbidity condition with a solution of 1,500 mg/L of Kaolinite particles in water and the low turbidity condition with pure distilled water. We needed the valve to close when the turbidity sensor

was placed in high turbidity and close when in low turbidity. Tickle Tech determined proof of concept based on the valve's correct functionality from the reading of the turbidity sensor.

Operations Guide and Lifecycle Cost

An operational guide was created for the community to utilize, and the lifecycle cost was estimated for the design solutions, influenced by the prototyping outcome. The operational guide was created by outlining the installation, operation, and maintenance steps considering community skills and experience. The lifecycle cost was estimated for the mechanical and electrical valve systems inclusive of initial investment alongside forecasted cost of consumable and reusable materials.

A detailed guide was created explaining the installation, operation, and maintenance of the proposed water systems to allow long-term sustainability of the system and provide the local community with field operation steps. The materials needed to install the mechanically automated and electrically automated water systems were determined through the prototype process. Materials for each system were selected considering the remote location of the project site and the need to physically carry the materials to reach the site. A materials list was specified in the operations guide in preparation for installation steps. Installation steps were written following the EPA's Guidance for preparing standard operating procedures for each section of the project (Table 6). Steps for the mechanical installation were determined to outline the box construction, the piping connections, and the valve connection. Electrical solution installation steps were chosen to detail the power supply and electrical valve. A total of 40-man hours was calculated to be needed based on prototype construction hours and assuming a team of 4 members (see appendix C). The system operation was established according to the community's needs and strengths. The mechanical operation section was chosen to explain the water elevation valve control including how to check for proper function. The electrical operation was detailed through the Arduino programming and valve actuation steps. Maintenance checks and frequencies were listed based on aspects that might malfunction including pipe fittings, structural integrity, debris build up, and water damage.

Operations Guide			
System	Installation	Operation	Maintenance
Mechanical	Concrete Box, Pipe Connections, Valve Connections	Water Elevation, Valve Automation, Valve Reopening	Cleanout, Pipe Fittings, Float Angle, Storm Event Function
Electrical	Power Supply and Electrical Valve	Arduino Programming, Valve actuation	Structural Integrity, Connections, Water Damage

Table 6: Operations Guide Outline

The construction cost estimation was calculated for the mechanical solution and electrical solution. Material lists were compiled for both water intake system solutions based on previously selected materials and manufacturers. Unit prices and number of units for initial construction were identified for each system based upon design decisions for the water intake systems. Initial construction costs were calculated to be \$1,974.12 for the mechanical solution and \$4,318.29 for the electrical solution. 25-year costs were estimated based upon lifespan of individual materials and number of units required for each

material over the 25-year duration (Appendix C). The 25-year costs of the electrical solution were calculated to be \$6, 630.63 for the electrical solution and \$2,535.08 for the mechanical solution (Table 7).

	INITIAL COST	25-YEAR COST
MECHANICAL SOLUTION	\$2,098.10	\$2,535.08
ELECTRICAL SOLUTION	\$4,318.29	\$6, 630.63

Table 7: Initial and Lifecycle Cost Estimate

Conclusion

Two water intake control systems were developed with an operational guide and cost estimate for use in a rural drinking water system piloted in Wala, Panama. The Merrill Manufacturing float valve and the Sizo Tech Corporation solenoid valve were chosen for the corresponding designs. A scaled design of the mechanical system and a tabletop experiment of the electrical system proved proof of concept of the two water intake systems. The operational guide can be utilized for construction, and the initial project cost for the mechanical and electrical systems are roughly \$2,098.10 and \$4,318.29.

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Operation Guide and Lifestyle Cost

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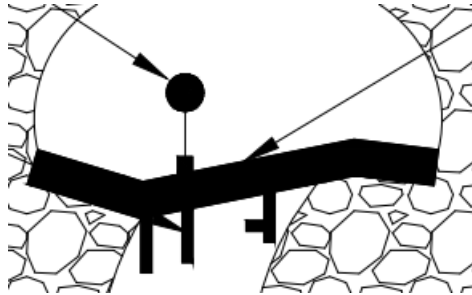
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Appendix A: Water Intake Control Systems

Conceptual Brainstorming

Solution 1:

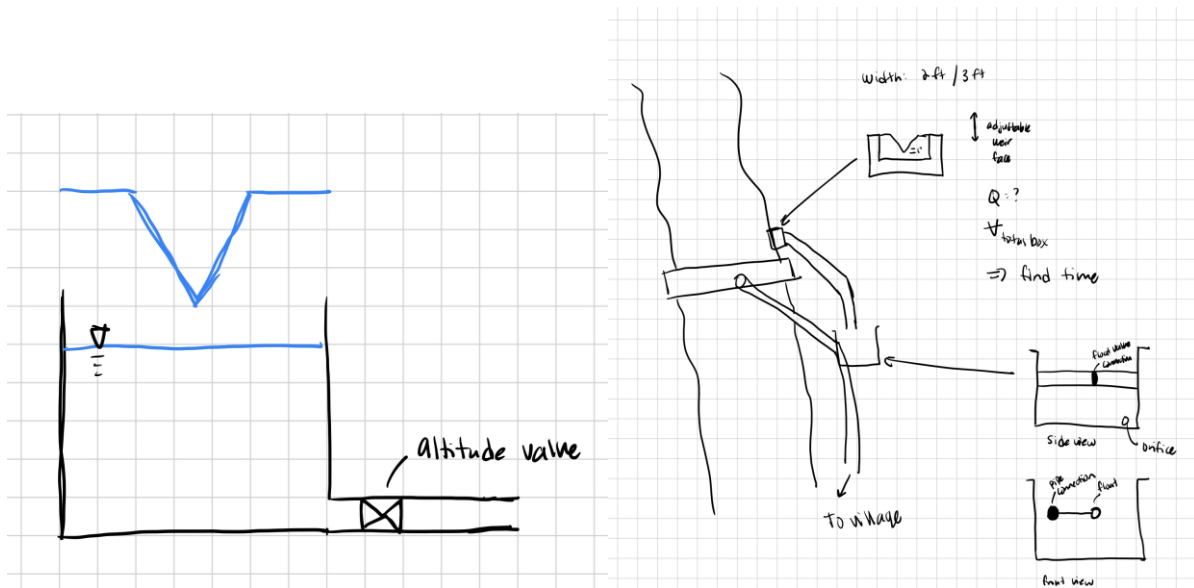


- Float valve could break off when water gets high.
- The valve would only close after the flow gets too high and would probably start to overwhelm the system before closing.
- Mechanics of a float valve do not allow the valve to directly connect to the inlet pipe.

Solution 2:

- Box with float valve on downstream side of dam.
- Float valve inserted into pipe, based on level that flows through the pipe.
- Client input: nothing can be put on the downstream side of dam, the water would be too violent during high precipitation.

Solution 3:



- Water will flow through weir to the box.
- The elevation in the box will depend on the water elevation in the pool upstream of the dam.
- The box will have a designed orifice to discharge water to the river.
- The village intake pipe will go through the box and will be connected to a valve.
- The box will have an overflow design as well.

Criteria	Weight	Altitude Valve		Float Valve	
		Rating	Weighted Score	Rating	Weighted Score
Cost	1	2	2	4	4
Technical Suitability	3	4	12	5	15
Implementation Practicality	3	3	9	5	15
Total			23		34

1: minimui 2: acceptable 3: fair 4: good 5: excellent

rating importance out of 5
weights chosen based on level of understanding from mentor and client

Brand	Float Material	Body Material	Cost	Max Pressure	Inlet Connection	Outlet Connection	Rod Length	Float Size	Size Range	Photo
Keckley Globe	Stainless steel	Iron	\$5,340.88	200psi	Flanged	Flanged	18in	8in	4in	
Keckley Angle	Stainless steel	Iron	\$4,976.42	200psi	Flanged	Flanged	18in	8in	4in	
Grainger Globe Float Valve	Stainless steel	Stainless Steel	\$3,115.80	60psi	NPT	NPT	20in	8in	2in	
Merrill Manufacturing	N/A	PVC	\$124.00	Not listed	NPT	NPT	N/A	N/A	2in	
Keckley	Stainless steel	Iron	\$1,975.62	75psi	NPT	NPT	16in	7in	2in	
Robert Manufacturing	N/A	Brass	\$60.33	85psi	MNPT		NA	NA	1in	



Chosen in accordance with NSF 61

SOLAR RESOURCE MAP

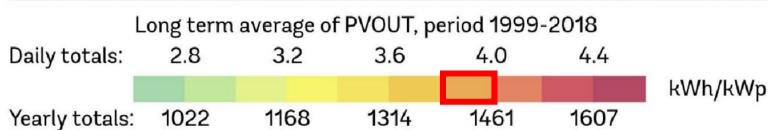
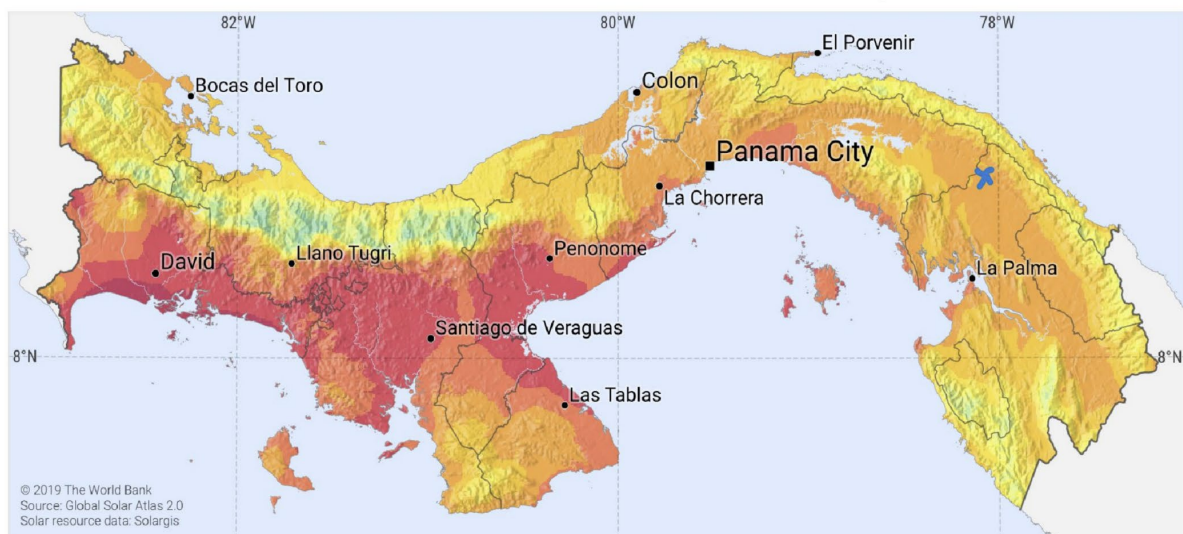
PHOTOVOLTAIC POWER POTENTIAL

PANAMA



ESMAP

SOLARGIS



SOLAR RESOURCE MAP

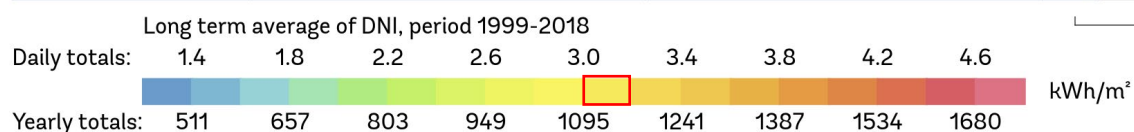
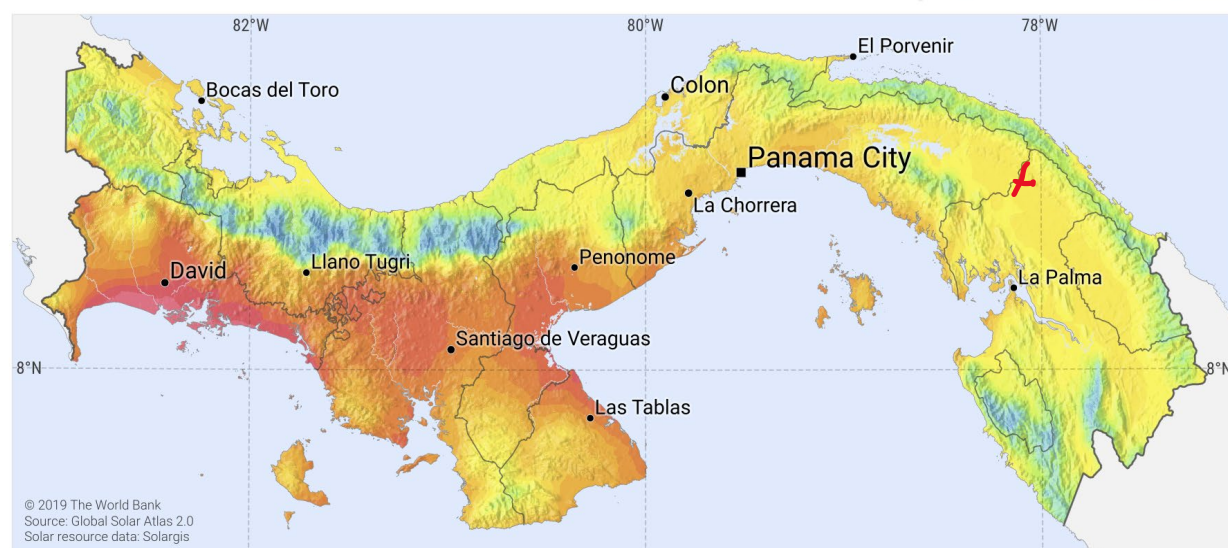
DIRECT NORMAL IRRADIATION

PANAMA



ESMAP

SOLARGIS



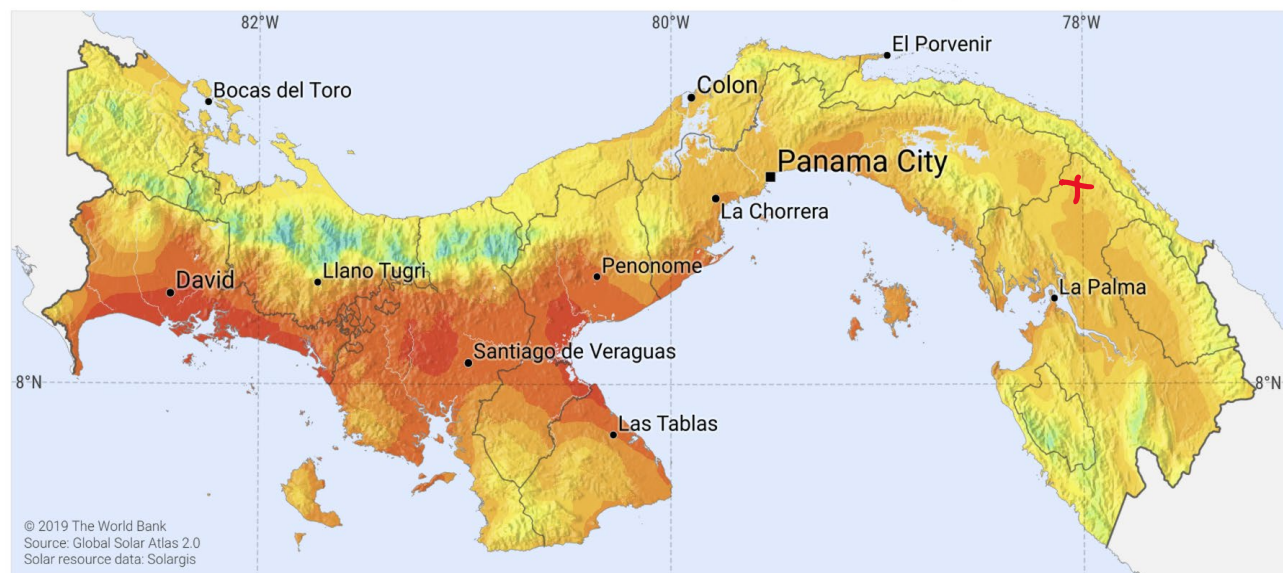
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GLOBAL HORIZONTAL IRRADIATION

PANAMA

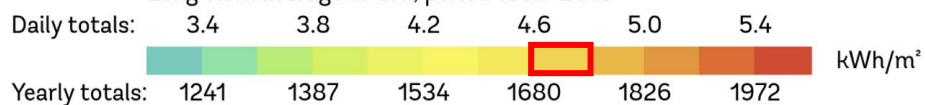
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Long term average of GHI, period 1999-2018

50 km



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BlueSolar Monocrystalline Panels

www.victronenergy.com



BlueSolar Monocrystalline 305W

- Low voltage-temperature coefficient enhances high-temperature operation.
- Exceptional low-light performance and high sensitivity to light across the entire solar spectrum.
- 25-Year limited warranty on power output and performance.
- 5-Year limited warranty on materials and workmanship.
- Sealed, waterproof, multi-functional junction box gives high level of safety.
- High performance bypass diodes minimize the power drop caused by shade.
- Advanced EVA (Ethylene Vinyl Acetate) encapsulation system with triple-layer back sheet meets the most stringent safety requirements for high-voltage operation.
- A sturdy, anodized aluminium frame allows modules to be easily roof-mounted with a variety of standard mounting systems.
- Highest quality, high-transmission tempered glass provides enhanced stiffness and impact resistance.
- High power models with pre-wired quick-connect system with MC4 (PV-ST01) connectors.

Article Number	Description	Net Weight	Electrical data under STC ⁽¹⁾										
			Nominal Power	Max-Power Voltage	Max-Power Current	Open-Circuit Voltage	Short-Circuit Current						
			P _{MPP}	V _{MPP}	I _{MPP}	V _{oc}	I _{sc}						
		Kg	W	V	A	V	A						
SPM040201200	20W-12V Mono 440 x 350 x 25mm series 4a	1.9	20	18.5	1.09	22.6	1.19						
SPM040301200	30W-12V Mono 560 x 350 x 25mm series 4a	2.2	30	18.7	1.61	22.87	1.76						
SPM040401200	40W-12V Mono 425 x 668 x 25mm series 4a	3.1	40	18.3	2.19	22.45	2.40						
SPM040551200	55W-12V Mono 545 x 668 x 25mm series 4a	4	55	18.8	2.94	22.9	3.22						
SPM040901200	90W-12V Mono 780 x 668 x 30mm series 4a	6.1	90	19.6	4.59	24.06	5.03						
SPM041151200	115W-12V Mono 1015 x 668 x 30mm series 4a	8	115	19.0	6.04	23.32	6.61						
SPM041151202*	115W-12V Mono 1030 x 668 x 30mm series 4b	8	115	19.0	6.04	23.32	6.61						
SPM041401200	140W-12V Mono 1250 x 668 x 30mm series 4a	9	140	19.4	7.22	23.6	8.05						
SPM041751200	175W-12V Mono 1485 x 668 x 30mm series 4a	11	175	19.4	9.03	23.7	9.89						
SPM042152400	215W-24V Mono 1580 x 808 x 35mm series 4a	15	215	37.4	5.75	45.82	6.30						
SPM043052000	305W-20V Mono 1640 x 992 x 35mm series 4a	18	305	32.5	9.38	39.7	10.27						
SPM043052002*	305W-20V Mono 1658 x 1002 x 35mm series 4b	19	305	32.5	9.38	39.7	10.27						
SPM043602400	360W-24V Mono 1956 x 992 x 40mm series 4a	22	360	38.4	9.38	47.4	10.24						
SPM043602402*	360W-24V Mono 1980 x 1002 x 40mm series 4b	23	360	38.4	9.38	47.4	10.24						

Module	SPM 040201200	SPM 040301200	SPM 04040120	SPM 040551200	SPM 040901200	SPM 041151200	SPM 041151202	SPM 041401200	SPM 041751200	SPM 042152400	SPM 043052000	SPM 043052002	SPM 043602400	SPM 043602402	
Nominal Power (±3% tolerance)	20W	30W	40W	55W	90W	115W	115W	140W	175W	215W	305W	305W	360W	360W	
Cell type	Monocrystalline														
Number of cells in series	36										72	60	60	72	72
Maximum system voltage	1000V														
Temperature coefficient of MPP (%)	-0.45/°C	-0.45/°C	-0.45/°C	-0.45/°C	-0.45/°C	-0.45/°C	-0.45/°C	-0.45/°C	-0.45/°C	-0.45/°C	-0.45/°C	-0.45/°C	-0.45/°C	-0.45/°C	
Temperature coefficient of Voc (%)	-0.35/°C	-0.35/°C	-0.35/°C	-0.35/°C	-0.35/°C	-0.35/°C	-0.35/°C	-0.35/°C	-0.35/°C	-0.35/°C	-0.35/°C	-0.35/°C	-0.35/°C	-0.35/°C	
Temperature coefficient of Isc (%)	+0.04/°C	+0.04/°C	+0.04/°C	+0.04/°C	+0.04/°C	+0.04/°C	+0.04/°C	+0.04/°C	+0.04/°C	+0.04/°C	+0.04/°C	+0.04/°C	+0.04/°C	+0.04/°C	
Temperature Range	-40°C to +85°C														
Surface Maximum Load Capacity	200 kg/m²														
Allowable Hail Load	23 m/s, 7.53 g														
Junction Box Type	PV-LH0805		PV-LH0806		PV-LH0801		PV-LH0808			PV-LH0701			PV-JB002		
Length of Cables / Connector Type	No cable					900 mm MC4									
Output tolerance	+/-3%														
Frame	Aluminium														
Product warranty	5 years														
Warranty on electrical performance	10 years 90% + 25 years 80% of power output														
Smallest packaging unit	1 panel														
Quantity per pallet	380	260	200	140	72	72	36	48	42	42	42	42	37	37	

*New dimensions: will replace 4a model

(1) STC (Standard Test Conditions): 1000 W/m², 25°C, AM (Air Mass) 1.5

*New dimensions: will replace 4a model

¹⁾ STC (Standard Test Conditions): 1000 W/m², 25°C, AM (Air Mass) 1.5

Max Voltage	19
Max Current	6.04
Power	114.76
Dimensions opt 1 (mm)	1015*668
Dimensions opt 2 (mm)	1030*668
Area of 115 Watt solar panel opt 1	0.67802
Area of 115 Watt solar panel opt 2	0.68804

Hours of Daylight	
January	11.7
February	11.8
March	12.1
April	12.3
May	12.5
June	12.6
July	12.6
August	12.4
September	12.2
October	11.9
Novemer	11.7
December	11.6
Average	12.11667
Max	12.6
Min	11.6

Hours of peak sunlight	
Jan	5.11
Feb	5.38
Mar	5.45
Apr	5.64
May	4.79
Jun	4.8
July	4.66
August	4.87
September	4.81
October	4.46
November	4.17
December	4.45
Average	4.8825
Max	5.64
Min	4.17

Based on Area of the solar panels and photovoltaic potential maps:

Available solar power per Sun Radiance (Kw/Day) 2.71208

Based on rating of solar panel and minimum available hours of sunlight:

Power Generation 115 Watt solar Panel (Watts-hours) 1334

From A02F 517.2 Watt-hr required, 1334 watt-hours>517.2 --> One 115-Watt Solar panel sufficient

**Power generation based on poor light conditions/poor exposure

Based on Peak Sunlight hours (Watts/day) 478.5492

Based on A02F, if poor sunlight conditions, 2 Solar panels required to meet 517.2 Watt-hours

Design based on full sunlight exposure (11.6hrs). One solar panel sufficient

Victron energy has warranty for 10 years at 90% power output(Watt-hours) 1200.6

Victron energy has warranty for 25 years at 80% power output(Watt-hours) 1067.2

Both remain above the 517.2 Watt-hours required for loading

Optimum solar panel angle changes based on time of year

****For best performance angle of solar panel should be adjusted as follows:**

Jan	Feb	Mar	Apr	May	Jun
65°	73°	81°	89°	97°	104°
Jul	Aug	Sep	Oct	Nov	Dec
97°	89°	81°	73°	65°	58°

Winter	Spring/Autumn	Summer
		
58° angle	81° angle	104° angle

<http://www.solarelectricityhandbook.com/solar-angle-calculator.html>

Electrical Power Supply Selection

Type of Power	Solar
Power Rating	115 Watts
Requirements to produce power	
Voltage Rating	18.9 V
Current Rating	6.08
Cost	< \$200
Manufacturer	Victron
Weight (Portability)	8 Kg
Type of Current	**DC
website	https://www.victronenergy.com

Euro	US Dollar
109	117.72
121	130.68
127	137.16
172	185.76



Monocrystalline panel



Polycrystalline panel

SOLAR PANELS				hxwx	€	cells	kg	Ex VAT
20W-12V Mono 440×350×25mm series 4a* (min 5pcs)	SPM040201200	✓	36	1.9	€ 32,00			
30W-12V Mono 560×350×25mm series 4a* (min 5pcs)	SPM040301200	✓	36	2.2	€ 37,00			
40W-12V Mono 425×668×25mm series 4a* (min 5pcs)	SPM040401200	✓	36	3.1	€ 48,00			
55W-12V Mono 545×668×25mm series 4a* (min 5pcs)	SPM040551200	✓	36	4.0	€ 63,00			
90W-12V Mono 780×668×30mm series 4a (min 4pcs)	SPM040901200	✓	36	6.1	€ 95,00			
115W-12V Mono 1015×668×30mm series 4a (min 4pcs)	SPM041151202	✓	36	8.0	€ 109,00			
140W-12V Mono 1250×668×30mm series 4a (min 4pcs)	SPM041401200	✓	36	9.0	€ 121,00			
175W-12V Mono 1485×668×30mm series 4a (min 4pcs)	SPM041751200	✓	36	11.0	€ 127,00			
215W-24V Mono 1580×808×35mm series 4a (min 4pcs)	SPM042152400	✓	72	15.0	€ 172,00			
305W-20V Mono 1658×1002×35mm series 4b (min 4pcs)	SPM043052002	✓	60	18.4	€ 221,00			
360W-24V Mono 1980×1002×40mm series 4b (min 4pcs)	SPM043602402	✓	72	22.5	€ 248,00			
20W-12V Poly 440×350×25mm series 4a* (min 5pcs)	SPP040201200	✓	36	1.9	€ 32,00			
30W-12V Poly 665×350×25mm series 4a* (min 5pcs)	SPP040301200	✓	36	2.8	€ 36,00			
45W-12V Poly 425×668×25mm series 4a* (min 5pcs)	SPP040451200	✓	36	3.1	€ 50,00			
60W-12V Poly 545×668×25mm series 4a* (min 5pcs)	SPP040601200	✓	36	4.0	€ 59,00			
90W-12V Poly 780×668×30mm series 4a (min 4pcs)	SPP040901200	✓	36	6.1	€ 88,00			
115W-12V Poly 1030×668×30mm series 4b (min 4pcs)	SPP041151202	✓	36	8.0	€ 98,00			
175W-12V Poly 1485×668×30mm series 4a (min 4pcs)	SPP041751200	✓	36	12.0	€ 132,00			
270W-20V Poly 1640×992×35mm series 4a (min 4pcs)	SPP042702000	✓	60	18.4	€ 179,00			
330W-24V Poly 1980×1002×40mm series 4b (min 4pcs)	SPP043302402	✓	72	22.5	€ 207,00			

* without connection cable and MC4 connector

* without connection cable and MC4 connector

Voltage Drop Calculation

ENTER INFORMATION:

Project: Intake Valve for Solea Water
Site #:
Location: Wala, Panama
Power Service:
Circuit:
Sheet #:
Supply Voltage: 12 Volts
Calculations by:

Wire Size (AWG)	Resistance (Ohms/Kft)
12	2.05
10	1.29
8	0.809
6	0.51
4	0.321
3	0.254
2	0.201
1	0.16
1/0	0.127
2/0	0.101
3/0	0.0797
4/0	0.0626

High likelihood Power would i
Best distance for environment
acceptable distance due to en

Section					Current (Amperes)		Voltage Drop			
		Length (ft)	AWG	Resistance (Ohms/Kft)	At Point	Accum	In Section	Accum	% Drop	Power Loss (W/ft)
		46	10	1.29	5	5	0.5934	0.5934	4.9450	0.0645
		40	12	2.05	5	10	0.82	1.4134	6.8333	0.167
		25	10	1.29	5	15	0.3225	1.7359	2.6875	0.2315
		25	12	2.05	5	20	0.5125	2.2484	4.2708	0.334
		100	10	1.29	5	25	1.29	3.5384	10.7500	0.3985
		100	12	2.05	5	30	2.05	5.5884	17.0833	0.501
						30	..	..	..	..
						30	..	..	..	..
						30	..	..	..	..
						30	..	..	..	..
						30	..	..	..	..

ANSI C84.1

Range A: Range A provides the normally expected voltage tolerance on the utility supply for a given voltage class. Variations outside the range should be infrequent. The utilization equipment (loads) are expected to function and provide full satisfactory performance for range A voltage tolerance.

1. Service Voltage: It is expected that most service voltage variation occurs within this range. The occurrence of service voltage variation outside this range should be infrequent. For range A this variation of allowable service voltage is +5% to -5% for system operating 600V and below. For systems operating above 600V this range is +5% to -2.5%.
2. Utilization Voltage: End user equipment should be designed to operate effectively and to provide full performance within the limits of range A service voltage. The tolerance for range A utilization voltage is +5% to -10%.

Voltage Drop Equations:

$$\text{Voltage drop in circuit section} = \frac{2 * I * l * R}{1000} \text{ (V)}$$

I = Accumulated Current in Section (A)

l = Length of section (ft)

- length includes the length of section with 5-10 ft added to each end, then round up to the closest increment of 5 ft.

R = Resistance of wire (Ω/1000ft)

$$\& \text{ Drop} = \frac{\text{Accumulated Voltage Drop}}{\text{Supply Voltage}} * 100 \text{ (\%)}$$

$$\text{Power Loss} = \frac{\text{voltage drop in section} * \text{current at point}}{\text{length}} \left(\frac{\text{watts}}{\text{ft}} \right)$$

Wire Data from 2011 Edition of National Electrical Code, Chapter 9 Table 8

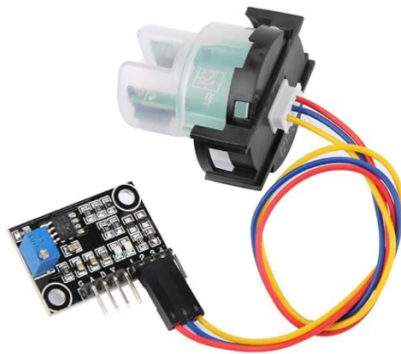
Range 1-5 (Worst-Best)

Criteria	CQRobot Ocean	Walfront Store
Cost	5	4
Compatability to Arduino	4	5
Ease of Use	3	4
Measurment Range	3	4

Total Points

15

17



Turbidity Sensor Module, Turbidity Sensor Water Quality Monitoring Sewage Turbidity Value Detection Module TSW-20M for Turbidity Measurement and Control of Washing Machines

[Visit the Walfront Store](#)

3.9 ★★★★★ 5 ratings | [Search this page](#)

\$23⁴⁶

[FREE Returns](#)

✓ Save 3% at checkout [Terms](#)

- **ACCURATE MEASUREMENT:** The module adopt high quality electronic components, ensuring the accuracy of turbidity measurement.
- **CURRENT CONVERT:** This module converts the current of the sensor to module output voltage. The lower the output voltage is, the higher the turbidity value.
- **TURBIDITY SENSOR:** This turbidity sensor adopts optical principle to detect the turbidity of liquid solution.
- **SIMPLE STRUCTURE:** Come with simple structure, the turbidity sensor module is easy to wire and operate.
- **SUITABLE FOR:** Suitable for turbidity measurement and control of washing machines, dishwashers, industrial controls and environmental wastewater collection.



CQRobot Ocean: TDS (Total Dissolved Solids) Meter Sensor Compatible with Raspberry Pi/Arduino Board. for Liquid Quality Analysis Teaching, Scientific Research, Laboratory, Online Analysis, etc.

Brand: CQRobot

4.3 ★★★★★ 133 ratings | [Search this page](#)

Amazon's Choice

\$11⁹⁹

[FREE Returns](#)

- **Wide Voltage Input:** 3.3V to 5.5V. Good Compatibility Output: 0 to 2.3V analog signal output, compatible with 5V or 3.3V controller.
- **AC Excitation Source:** effectively prevent probe from polarization, Waterproof Probe.
- **Easy to Use:** Arduino compatible, simple connection, plug and play without soldering.
- **Used with ADS1115 16-Bit ADC Module** (ASIN: B08KFZ3PVT, Model: CQRADS1115), Compatible with Raspberry Pi Motherboard.
- **Note:** When using the TDS instrument sensor, the sensor probe is immersed in liquid, and the purchaser needs to Separate the sensor Probe Protective Cover to avoid incorrect data reading and malfunction.

```

// This program will read the turbidity through the Turbidity sensor
// and will send a signal to an electrically actuated valve to open or close
// when the total dissolved solids is above or below 1,500 mg/L

const int valve_relay_pin = 12; //Defined pin for the valve relay

void setup() {
  Serial.begin(9600); // initializes water
  pinMode(valve_relay_pin, OUTPUT); // Define the pin mode for valve relay output
}

void loop() {

  int turbidity_raw = analogRead(A0);
  float turbidity = turbidity_raw*(5.0/1024.0)*3;
  Serial.println(turbidity);
  delay(500);

  if(turbidity <= 2){ //open valve, this corresponds to just under 1,500 mg/L
    Serial.println("Open Valve");
    digitalWrite(valve_relay_pin, HIGH);
  }
  else{ //close valve, this corresponds to 1,500 mg/L
    Serial.println("Close Valve");
    digitalWrite(valve_relay_pin, LOW);
  }
}

```

Selecting Watertight Conduit

Criteria

Waterproof ✓

Fits electrical wiring ✓

Allows connection to watertight box	✓
-------------------------------------	---

DWALE® DWALE Electrical Conduit and Connector Kit, Liquid-Tight, Flexible, Non Metallic...

★★★★★ 204 \$43.99 prime

Tools & Home Improvement • Electrical • Electrical Boxes, Conduits & Fittings • Conduits

SAFETY AND STURDINESS

The Flexible Non Metallic Liquid Tight Electrical Conduit kit is constructed with Resists corrosion PVC to ensure quality and service life

Resists corrosion, abrasion

Resists abuse, pull and crushing

Oil resistant

Oil resistant

Resistant to harsh environments
Resists corrosion, abrasion, oil, water, acid, metal shavings, and rough environments, outdoor, sunlight resistant, direct burial

Click image to open expanded view

DWALE Liquid-Tight Conduit and Connector Kit, Flexible Non Metallic Liquid Tight Electrical Conduit, 3/4 inch 50ft Electrical Conduit Kit, with 5 Straight and 3 Angle Fittings Included, 3/4 in. Dia

Visit the DWALE Store

4.6 ★★★★★ \$99 ratings

\$0+ bought in past month

\$42.99

FREE Returns

Get a \$50 Gift Card: Pay \$0.00 \$42.99 upon approval for Amazon Visa. No annual fee.

Size: 50FT

25FT	25FT 1/2"	50FT	50FT 1/2"	100FT
\$28.99	\$24.99	\$42.99	\$36.99	\$66.99
100FT 1/2"				
\$65.99				

Brand

DWALE

Material

metal, pvc, iron

Color

Gray

Product Dimensions

600L x 1" W

Nominal Wall

0.65 inch

Thickness

About this item

- [PREMIUM Liquid-Tight Conduit] - Length: 50', ID: 3/4inch, OD: 1inch, Thickness: 2.5 mm The Flexible Non Metallic Liquid Tight Electrical Conduit kit is constructed

☐ Add your free 30-day trial of Prime and get fast, free delivery

\$42.99

FREE Returns

FREE delivery **Saturday**. Order before 8 hrs 30 mins

Deliver to Ashlyn - Chattanooga 37415

In Stock

Quantity: 1

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<https://www.arr>

The following levels of chlorides are expressed in mg/l:

0 - 250	Acceptable
250 - 500	Less than desirable
500 - 1,000	Undesirable
Over 1,000	Unsatisfactory

pH

A measure of the acid or alkaline content of water, pH values range from 0 to 14. The lower the pH value the more acidic the water, and the higher the pH value the more alkaline the water. The pH of drinking water normally ranges from 5.5 to 9.0. At pH levels of less than 7.0, corrosion of water pipes may occur, releasing metals into the drinking water. This is undesirable and can cause other concerns if concentrations of such metals exceed recommended limits.

Total Dissolved Solids

The total dissolved solids test measures the total amount of dissolved minerals in water. The solids can be iron, chlorides, sulfates, calcium or other minerals found on the earth's surface. The **dissolved minerals can produce an unpleasant taste or appearance** and can contribute to scale deposits on pipe walls.

The following levels of total dissolved solids are expressed in mg/l:

Less than 500	Satisfactory
500 - 1,000	Less than desirable
1,000 - 1,500	Undesirable
Over 1,500	Unsatisfactory

} try to stay
below 1,000 ppm
but probably closer
to 1500 ppm

The only effective means of reducing total dissolved solids is by using reverse osmosis; however, removal is not economical.

Type of system AC or DC

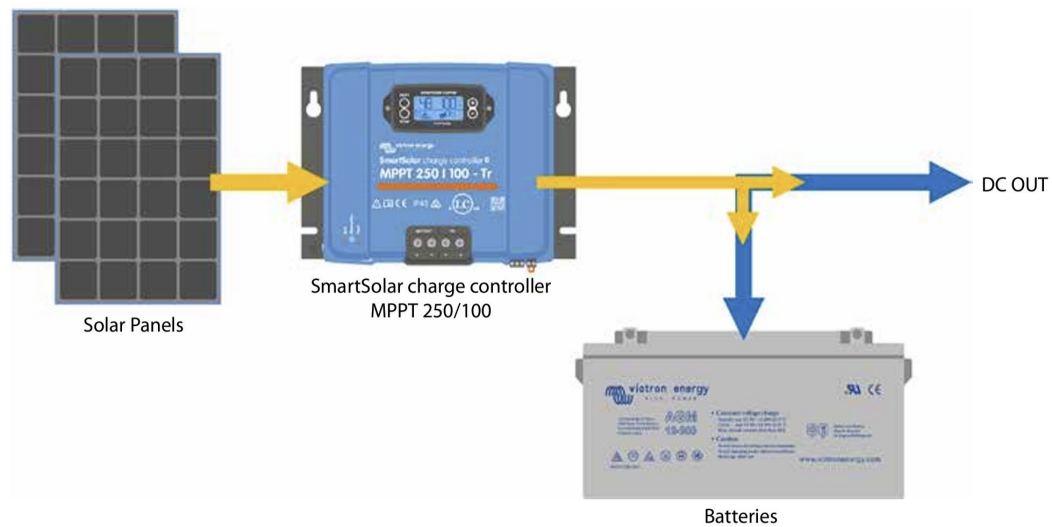
***DC was selected based on comparison between the adverse health effects of DC and AC exposure.

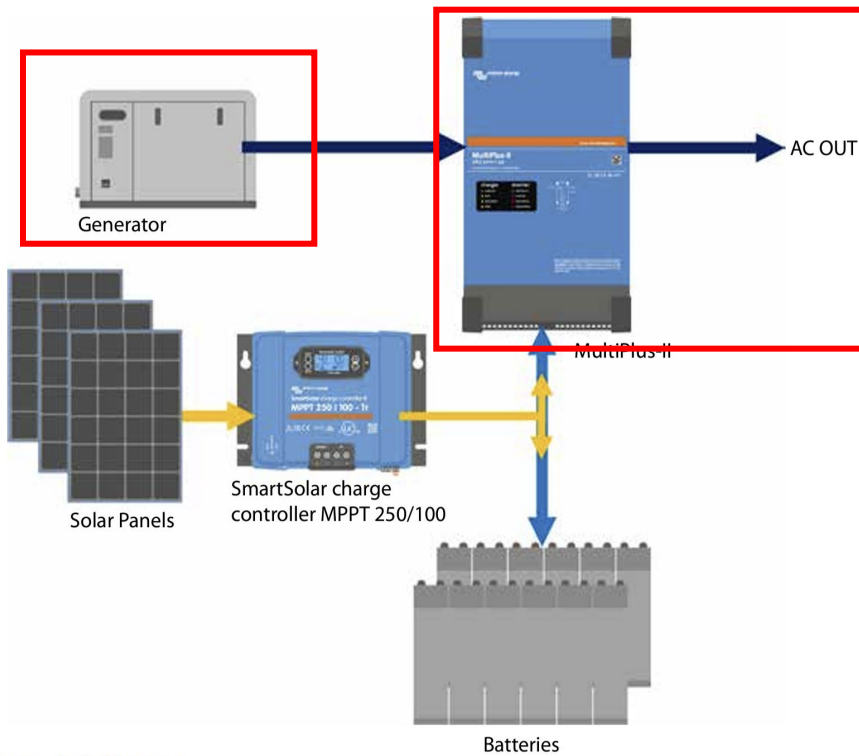
***DC systems are less complex and require less equipment.

AC in mA (50Hz)	DC in mA	Effects
0.5 – 1.5	0.4	Perception
1.3	4 – 15	Surprise
3 – 22	15 – 88	Let's Go (Reflex Action)
22 – 40	80 – 160	Muscular Inhibition
40 – 100	160 – 300	Respiratory Block
More than 100	More than 300	Usually Fatal

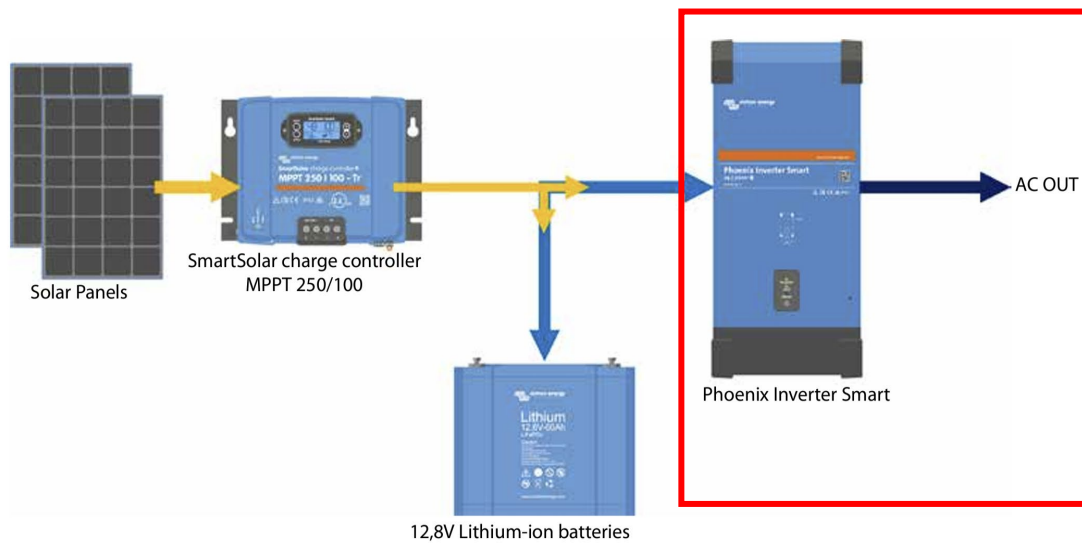
DC Systems

In DC systems solar energy is converted into regulated DC. Consequently the regulated DC is fed to the batteries and consumers. An inverter powers any AC consumers that are connected to the DC system. Unlike in DC systems, solar power is directly converted into AC in AC systems.





3. Not enough sun – hybrid power



Valve Selection Guide

Conveyed Fluid	Nature of Fluid	Valve Function	Type of Disc
Liquid	Neutral (Water, Oil, etc.)	On/Off	Gate
			Rotary ball
			Plug
			Diaphragm
			Butterfly
		Control valve, modulating	Plug gate
			Globe
			Butterfly
			Plug gate
			Diaphragm
			Needle
	Corrosive (Acid, alkaline etc.)	On/Off	Gate
			Plug gate
			Rotary ball
			Plug
			Diaphragm
		Control valve, modulating	Butterfly
			Globe
			Diaphragm
			Butterfly
			Plug gate
	Hygienic (Food, beverages, drugs etc)	On/Off	Butterfly
		Control valve, modulating	Diaphragm
			Butterfly
			Diaphragm
			Squeeze
			Pinch
	Slurry	On/Off	Rotary ball
			Butterfly
			Diaphragm
			Plug
			Pinch
		Control valve, modulating	Squeeze
			Butterfly
			Diaphragm
			Squeeze
			Pinch
Gas	Fibrous Suspensions	On/Off, Control valve, modulating	Gate
			Diaphragm
	Neutral (Air, Steam etc)	On/Off	Squeeze
			Pinch
			Gate
			Globe
			Rotary ball
		Control valve, modulating	Plug
			Diaphragm
			Globe
			Needle
			Butterfly
	Corrosive (Acid vapors, chlorine etc.)	On/Off	Diaphragm
			Gate
			Butterfly
		Control valve, modulating	Rotary ball
			Diaphragm
			Plug
Solids	Vacuum	On/Off	Butterfly
			Rotary ball
	Abrasive Powder (Silica, etc)	On/Off, Control valve, modulating	Diaphragm
			Plug
			Butterfly
			Globe
		On/Off, Control valve, modulating	Needle
			Diaphragm
			Gate
			Globe
	Lubricating powder (graphite, talcum, etc)	On/Off, Control valve, modulating	Rotary ball
			Butterfly
			Spiral sock
			Squeeze

Valve Actuation					
	Complexity(installation)	Actuation (feasibility w/site)	Programmable	Automatic	Totals
Score Weight	15%	20%	40%	25%	
Electrical	3	4	4	3	3.6
Pneumatic	2	2	3	3	2.65
Manual	4	4	1	1	2.05
Solenoid	3	4	4	4	3.85
altitude	1	1	2	2	1.65
Scale	1: Minimum	2: Acceptable	3: Good	4: Excellent	

***First Choice Solenoid

**Second Choice Electrical operator

Project Valve Suggestion					
Valve Type	Solenoid	Solenoid	Solenoid	Solenoid	Solenoid
Valve Size	4"	2"	3"	4"	4"
Normal Position	Normally open	Normally open	Normally Open	Normally Open	Either
LOP Position					
Power Requirement	13-20 Watts	13-20 Watts	35-40 Watts		
Valve Material	Stainless Steel	Stainless Steel	Brass	SS(optional)	SS
Valve Cost	\$2,931.17	\$846.32		\$3,483-\$4,700	Undisclosed
Manufacturer	STC	STC	Magnatrol Valve Corps	Flomatic	Rotex
website	https://www.stcvalve.com	https://www.stcvalve.com	https://www.magnatrol.com	https://www.flomatic.com	https://www.rotexvalve.com
Product	2DSO400-2000 Series	2DSO400-2000 Series	1" AR" Full Port	Moel: C/CF802	Model 2410

STC 2DSO400-2000 Series Anti-Hammering Slow Closing Pilot Solenoid Valves

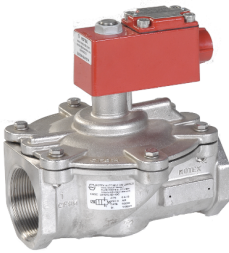


2DSO400-2000 Series Solenoid Valve Specifications

Valve Model	2DSO400F	2DSO500F	2DSO650F	2DSO800F	2DSO1000F	2DSO1250F	2DSO1500F	2DSO2000F
Port Size	1 1/2" NPT	2" NPT	2 1/2" NPT	3" NPT	4" NPT	5" NPT	6" NPT	8" NPT
Orifice	40mm	50mm	65mm	80mm	100mm	125mm	150mm	200mm
Flow Coefficient (Cv)	21	30	52.5	81.7	128.4	221.7	291.7	513.5
Valve Type	2 Way, Normally Open (NO)							
Action	Pilot Diaphragm, Uni-Directional							
Wetted Surfaces	Valve Body: 304 Stainless Steel Seal: NBR (Buna N), Viton (FKM)							
Seal Material	Standard Option: NBR (Buna N) Upgrade Option: Viton (FKM)							
Operating Temperature	Media with NBR Seal: 23°F to 176°F (-5°C to 80°C) Media with Viton Seal: 23°F to 248°F (-5°C to 120°C) Ambient: 23°F to 113°F (-5°C to 45°C)							
Operating Pressure	AC Coil: 6 PSI to 120 PSI DC Coil: 6 PSI to 87 PSI							
Electrical Connections	DIN 43650, Form A							
Coil Power	AC Coil: 28VA DC Coil: 13-20W							
Coil Duty	100% ED (Continuous Duty)							
Voltage Options	12VDC, 24VDC, 24VAC, 110/120VAC (50/60Hz), 220/240VAC (50/60Hz)							
Voltage Tolerance	±10% of Specified Voltage							
Ingress Protection	IP65							
Insulation Class	H Class							
Installation	No Orientation Requirement Optimum Position: Flow Horizontal and Solenoid Vertical							
Service	Liquid, Water, Air, Inert Gas							



24101



Model: 24101

Pressure Range(Bar): 0.5-10

Orifice Size (mm): 12 | 20 | 40 | 50 | 65 | 80 | 100

Port Connection: 1/2" | 3/4" | 1 1/4" | 1 1/2" | 2" | 2 1/2" | 3" | 4"

MOC: Aluminium Cast (1/2" | 3/4" | 1") | CF8 (SS304 Cast) | CF8M (SS316 Cast)

Solenoid: Weather Proof | Explosion Proof | Intrinsically Safe

Media: Air | Fuel | Inert gas | Liquid | LPG | Oil | Water

Application: Deluge Valve operation | Dispensing Drain | DM Plant | Dust suppression | ETP Water | Fire Fighting

Certificate: ATEX | CCOE/PESO | CUTR-EAC | IEC Ex | INMETRO | UKRAINE | CE | UL

Documents / Downloads

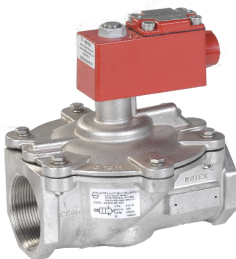
Catalogue: EN

Installation Manual: EN

Send Enquiry



24201



Model: 24201

Pressure Range(Bar): 0.5-10

Orifice Size (mm): 12 | 20 | 25 | 40 | 50 | 65 | 80 | 100

Port Connection: 1/2" | 3/4" | 1" | 1 1/4" | 1 1/2" | 2" | 2 1/2" | 3" | 4"

MOC: Aluminium Cast (Only in 1/2" | 3/4" | 1") | CF8 (SS304 Cast) | CF8M (SS316 Cast)

Solenoid: Weather Proof | Explosion Proof | Intrinsically Safe

Media: Air | Fuel | Inert gas | Liquid | LPG | Oil | Water

Application: Deluge Valve operation | Dispensing Drain | DM Plant | Dust suppression | ETP Water | Fire Fighting

Certificate: ATEX | CCOE/PESO | CUTR-EAC | IEC Ex | INMETRO | UKRAINE | CE | UL

Documents / Downloads

Catalogue: EN

Installation Manual: EN

Send Enquiry



Valve Selection					
	Cost	Size	Power Req'd	Material	Totals
Score Weight	15%	20%	40%	25%	
STC 4"	3	4	4	4	3.85
STC 2"	4	1	4	4	3.4
MVC 3"	1	2	2	2	1.85
Rotex 4"	1	4	1	4	2.35
Scale	1: Minimum	2: Acceptable	3: Good	4: Excellent	

Load 1: Arduino Board	
Voltage (volts)	7
Current (200 ma)	200
Power Draw	1.4
Type of Current	DC
Continuous/Cycling	continuous

Load 2: Solenoid Valve	
Voltage (volts)	12
Current	1.66666667
Power Draw (Watts)	20
Type of Current	DC
Continuous/Cycling	Cycling

Load 3: Turbidity Monitor	
Voltage	5
Current	30
Power Draw	0.15
Type of Current	DC
Continuous/Cycling	continuous

$$P = I * E$$

DC Loads		
Watts	Hours Per Day	Watt-Hours
Arduino Board	24	33.6
Turbidity Monitor	24	3.6
Valve (Max)	24	480
Total	N/A	517.2

Solenoid Valve		
Watts	Hours per Day	Watt-Hours
20	0	0
20	1	20
20	2	40
20	3	60
20	4	80
20	5	100
20	6	120
20	7	140
20	8	160
20	9	180
20	10	200
20	11	220
20	12	240
20	13	260
20	14	280
20	15	300
20	16	320
20	17	340
20	18	360
20	19	380
20	20	400
20	21	420
20	22	440
20	23	460
20	24	480

Watt-Hours		
Min (No turbidity)	Mid (12 Hour)	Max (24 hour)
37.2	277.2	517.2

Capacity in milliamp-hours (Q) = (I) Current in amperes $\times 1000 \times (T)$ Time in hours
Capacity in amp-hours (Q) = (I) Current in amperes $\times (T)$ Time in hours

Watt-hours = Nominal Battery voltage x Amp-hour capacity

¹⁾ When fully charged
²⁾ The lithium battery can be mounted upright and on its side, but not with the battery terminals facing down
³⁾ The 12,8V/330Ah lithium battery may only be mounted in an upright position

<https://weatherspark.com>

Hours of Daylight	
January	11.7
February	11.8
March	12.1
April	12.3
May	12.5
Jun	12.6
July	12.6
August	12.4
September	12.2
October	11.9
November	11.7
December	11.6
Average	12.11667
High	12.6
Low	11.6
Standard Dev.	0.368864

Temperature in Panama			
	High	Average	Low
Jan	88	81	76
Feb	89	81	76
Mar	90	82	76
Apr	89	83	77
May	87	81	77
Jun	86	81	77
Jul	87	81	77
Aug	86	80	76
Sep	86	80	76
Oct	85	80	76
Nov	85	80	76
Dec	87	80	76

	°F	°C
Average High Temp	87.1	30.6
Average Low Temp	76.3	24.6
Average Temp	80.8	27.1
Temperature Max	90.0	32.2
Temperature Min	76.0	24.4

Required Ah for battery	
Max DC Load (Watt-hour)	517.12
Battery Voltage	12
Battery Capacity	43.09333
Assume Lithium Batter (80%)	53.86667
3-Day storage capacity	161.6

3-day storage capacity was selected to provide margin to battery depletion under 24-hour turbid conditions

*** Average temperature is >25°C which will reduce lifespan of the battery

*** LFP-Smart 12.8/160 provides sufficient Ah for the calculated 3-day storage capacity

***Selected battery enclosed in red box

Starting elevation (ft)	702
ending elevation (ft)	200
pipe length total (ft)	5280
pipe length to valve (ft)	15
Diameter of pipe (inches)	4
area of pipe (ft ²)	0.087266
max flow of water (gpm)	150
min flow of water (gpm)	30
elevation 15 feet from dam (assumed)	697
gravity constant (ft/sec)	32.2
Diameter of pipe (ft)	0.333333
friction factor (assumed)	0.04
Conversion to gpm	
conversion factor	448.8
max flow (ft ³ /min)	0.334225
min flow (ft ³ /min)	0.066845

Head loss values	
45 degree bend	0.24
90 degree bend	0.45
Valve	0.15

Specific Weight of Water (lb/ft ³)	62.4
Max Velocity	3.829932
Min Velocity	0.765986

hL (major) using max V	0.409986
hL (minor) using max v	0.191327
hL (Total) using max	0.601312
hL (major) using min V	0.016399
hL (minor) using min V	0.007653
hL total using min	0.024052

$$\frac{P1}{\gamma} + z1 + \frac{v1}{2 * g} = \frac{P2}{\gamma} + z + \frac{v2}{2 * g} + hL$$

$$\frac{P1}{\gamma} + z1 + \frac{v1}{2 * g} = \frac{P2}{\gamma} + z + \frac{v2}{2 * g} + hL$$

$$hL (major) = \frac{L * v^2}{2 * g * D}$$

$$hL (minor) = Kl * \frac{v^2}{2 * g}$$

$$700 ft = \frac{P2}{\gamma} + 0.6 ft + 697 ft$$

max: 1.906098 psi

$$700 ft = \frac{P2}{\gamma} + 0.024 ft + 697 ft.$$

min: 0.034669

**** Valves must operate under a minimum of 5 psig

MESH and MICRON SIZES

What is a micron? Micron is the measure of length most frequently used to describe tiny particle sizes. The term micron is actually a commonly used shorthand for micrometer (American spelling) or micrometre (international spelling). The official symbol for the micron or micrometer is μm , sometimes simplified as um . A micron is defined as one-millionth of a meter, a little more than one twenty-five thousandth of an inch.

Note: ISM offers fluid, gas and air flow management components some of which contain filter mesh as a component part. ISM does offer mesh itself and is unable to source or provide it.

What does mesh size mean? Mesh size usually is referring to the mesh number (a US measurement standard) and its relationship to the size of the openings in the mesh and thus the size of particles that can pass through these openings. Figuring out the mesh number is simple. All you do is count the number of openings in one linear inch of screen. This count is the mesh number. A 4-mesh screen means there are four little square openings across one inch of screen. A 100-mesh screen has 100 openings per inch, and so on.

As the number indicating the mesh size increases, the size of the openings and thus the size of particles captured by the screen decreases. Higher mesh numbers = smaller particle sizes. It is very important to remember that mesh size is not a precise measurement of the mesh opening size. This is because screens can be made with different materials with different thicknesses of strands or wire. The thicker the strands, the smaller the openings that a particle can pass through, and vice versa.

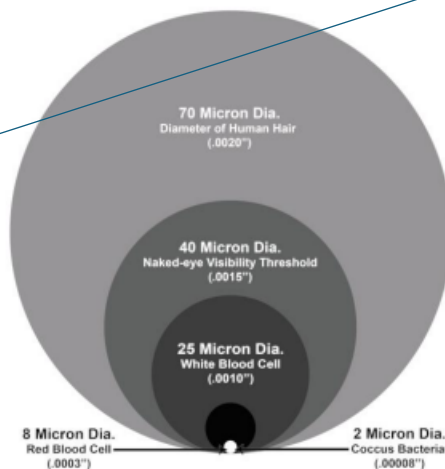
Also keep in mind that mesh is a two-dimensional sheet and the actual 3D shapes of particles vary dramatically. A good example of this is the diameter of a hair versus its length. Particles can also be elastic amalgams or clumps of mixed materials that can deform and squeeze through mesh openings.

How fine do screens get? This depends on the thickness of the wire or strand used to make the mesh. Most ISM flow control components do not contain filter screens any finer than 500 mesh. The primary reason for this is that as the mesh number rises, the space between the wires or strands becomes smaller. At some point the mesh number becomes so high that the percentage of open area is too low to be useful. This point is usually somewhere between 450 and 700 mesh depending on the diameter of the wire or filament used. *Note: Beyond 325 to 400 mesh, particle size is normally described only in microns.*

US Mesh*	Microns	Inches	Millimeters
35	500	0.0197	0.5000
40	400	0.0165	0.4000
45	354	0.0138	0.3540
50	297	0.0117	0.2970
60	250	0.0098	0.2500
70	210	0.0083	0.2100
80	177	0.0070	0.1770
100	149	0.0059	0.1490
120	125	0.0049	0.1250
140	105	0.0041	0.1050
170	88	0.0035	0.0880
200	74	0.0029	0.0740
230	63	0.0025	0.0630
270	53	0.0021	0.0530
325	44	0.0017	0.0440
400	37	0.0015	0.0370
450	32	0.0013	0.0320
500	25	0.0010	0.0250
635	20	0.0008	0.0200

*Values are based on the American National Standard for Industrial Wire Cloth (American Standard ASTM - E 11).

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Some micron size comparisons

4091 S. Elliot St., Englewood, CO 80110-4396
Phone 303-781-8486 | Fax 303-761-7939
industrialspec.com | ismedspec.com
© Copyright 2020 Industrial Specialties Mfg.

No 200 Screen was selected and these parameters were used to calculate head loss caused by the screen. This screen was selected because it will not allow coarse-grained sediment to pass

head loss of Fluid through screen
in pipe

$$h_L = K_{loss} \times (u_m^2 / (2 \times g))$$

u_m = mean flow velocity

$$K_{loss} = 1.3 (1 - FAR) + (1 / FAR - 1)^2$$

FAR = open Area / Total Area

g = gravitational acceleration

Open Area

$$.9929^2 (200) = .00168 \text{ in}^2 = 1.2 \times 10^{-5} \text{ ft}^2$$

Total Area

$$(\frac{.33}{2})^2 \pi = .0873 \text{ ft}^2$$

$$Q_{flow} = 30 \text{ gpm} = .0803 \text{ cfs}$$

$$Q = VA \quad V = \frac{Q}{A} = \frac{.0803}{.0873 \text{ ft}^2}$$

$$V_{flow} = .92 \text{ ft/s}$$

$$FAR = \frac{1.2 \times 10^{-5}}{.0873} = 1.34 \times 10^{-4}$$

$$K_{loss} = 1.3 (1 - (1.34 \times 10^{-4})) + (1 / (1.34 \times 10^{-4}) - 1)^2 = 2.3$$

$$h_L = 2.3 \times (.92^2 / (2 \times 32.2)) = .03 \text{ ft}$$

Conclusion: No. 200 screen does not
cause too much head loss to be
functional



SECTION 03303 CONCRETE FOR UTILITY LINES

PART 1. GENERAL

This item shall include furnishing and installing concrete blocking, cradles, anchors, caps, pipe protection, and/or encasement at the locations shown on the drawings and/or as directed by the owner.

PART 2. PRODUCTS

Not Used

Tickle Tech based its concrete specifications recommendations on the KUB standard value of a minimum 28-day compressive strength of 3000psi.

PART 3. EXECUTION

3.1 Concrete work shall conform to ACI 301-72 (as revised).

3.2 Supplemental requirements are listed below:

- A. Strength – The minimum 28-day strength of concrete shall be 3,000 psi or greater unless otherwise shown on the drawings, or as directed by the owner.
- B. Durability – All concrete exposed to weather shall be air entrained.
- C. Slump – Concrete shall be proportional and produced to have a slump of 3 inches with a 1-inch tolerance.
- D. Admixtures – Air entrainment, mandatory for concrete exposed to weather, may be used. A water-reducing admixture (retarding, normal, or accelerating, depending on placing temperature), may be used if approved by the owner.
- E. Reinforcing Steel – Yield strength of reinforcing steel shall be 60,000 psi.

END OF SECTION

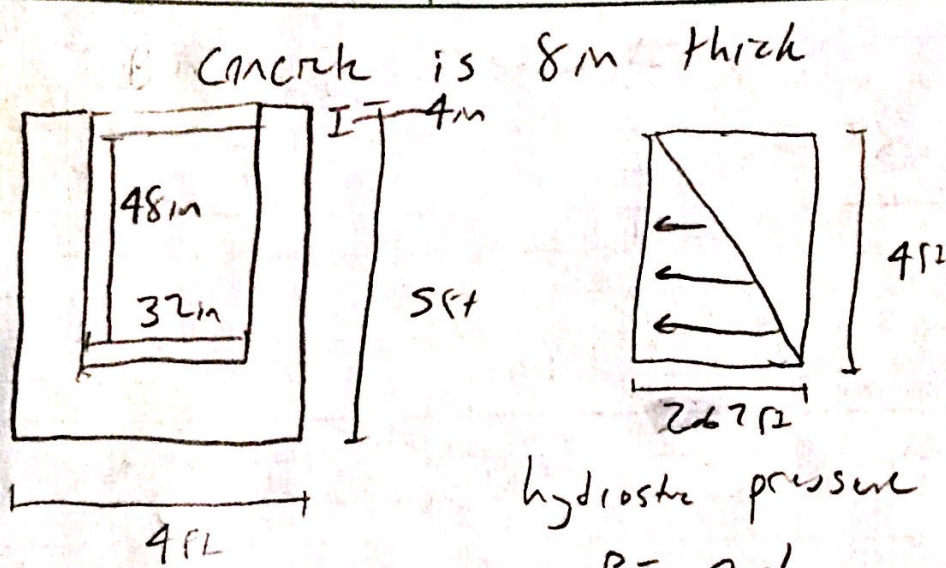
Type 4X Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (windblown dust); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, snow, splashing water, and hose directed water); that provides an additional level of protection against corrosion; and that will be undamaged by the external formation of ice on the enclosure.

Type 5 Enclosures constructed for indoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (falling dirt and settling airborne dust, lint, fibers, and flyings); and to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (dripping and light splashing).

Type 6 Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (falling dirt); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (hose directed water and the entry of water during occasional temporary submersion at a limited depth); and that will be undamaged by the external formation of ice on the enclosure.

Type 6P Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (falling dirt); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (hose directed water and the entry of water during prolonged submersion at a limited depth); that provides an additional level of protection against corrosion and that will be undamaged by the external formation of ice on the enclosure.

Tickle Tech recommends the use of NEMA 6P enclosures for all electrical components due to the relation of the electric components to the water.



hydrostatic pressure $\rightarrow$ shearing force

$$P = \rho g h$$

$$= 62.4 \frac{\text{lb}}{\text{ft}^3} \times 4 \text{ ft} = 249.6 \frac{\text{lb}}{\text{ft}^2}$$

$$V_w = PA = 249.6 \frac{\text{lb}}{\text{ft}^2} \left(\frac{1}{2} (2.67 \times 4) \right) = 1331 \text{ lb}$$

Weight of concrete shearing force

base

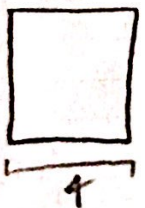


4

side

4 sides

$$\text{Vol} = 4 \times 4 \times \frac{2}{3} = 10.67 \text{ ft}^3$$



$5 - \frac{2}{3}$

$$\text{Vol} = 4 \frac{1}{3} \times 4 \times \frac{2}{3} = 11.56 \text{ ft}^3 (4)$$

$$\text{Vol}_c = 10.67 + 11.54(4) = 57.74 \text{ ft}^3$$

$$V_c = W_c = 150 \frac{\text{lb}}{\text{ft}^3} \times 57.74 \text{ ft}^3 = 8661 \text{ lb}$$

Total shearing force

$$V_T = V_w + V_c = 1331 + 8550 = 9881 \rightarrow \boxed{11000 \text{ lb}}$$

Rebar shear strength

$$V_{ult} = .6 F_y A_s \quad \# 5 \text{ rebar}$$
$$.6 \times 60000 \text{ psi} \times 4(.625)$$
$$= 135000 > 10000$$

Pull-Out

Bar diameter

$$N_u = N_s$$

$$10,000 \text{ lb} = \phi_s A_e F_y = .9 \times .75 \left(\frac{\pi d^2}{4} \right) \times 60000 \text{ lb}$$
$$= .56 \text{ in} \sim \# 5 \text{ bar } d_b = .625 \text{ in}$$

embedment depth

$$N_c = \phi_c \psi_e \psi_{sn} N_o \quad (\text{no spacing concern})$$
$$= .85 \times 1 \times \pi d h_e$$

$$N_{cr} = 1.25 A_c F_y \leq A_c F_{un}$$
$$\left(A_c = .75 \left(\frac{\pi (.625)^2}{4} \right) = .23 \text{ in}^2 \right)$$
$$\rightarrow = 1.25 (.23) (60000) \leq (.23) (60000 \times 1.25)$$
$$N_{cr} = 17250 \text{ lbs} = 17.25 \text{ k}$$
$$17.250 = .85 (1) (1) (1.08 \pi \times .625 \times h_e)$$

$$h_e = 9.57 \text{ in} \rightarrow 10 \text{ in}$$

Selecting a Watertight Box

- Criteria
- ✓

Waterproof
- ✓

Fits all equipment
- ✓

Allows Connections for Wiring

[Amazon Link](#)



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5.9"x5.9"x3.5" \$18.99	8.7"x6.7"x4.3" \$24.98	11.4"x7.5"x5.5" \$31.98	13.8"x9.8"x5.9" \$53.98
---------------------------	---------------------------	----------------------------	---------------------------------------

Material	Stainless Steel, Plastic, Acrylonitrile Butadiene Styrene
Brand	Joinfworld
Color	grey
Style	Outdoor

Appendix B: Prototype

Scale Considerations for prototype

size of float valves
size of pvc needed
calculation ratios

Original Site Specifications	
Pipe Diameter (inch)	4
High flow rate (gpm)	150
Low flow rate (gpm)	30

Scaled model Option 1	
Pipe Diameter (inch)	1
High flow (gpm)	37.5
Low flow (gpm)	7.5
Scale factor= 1:4	

Scale model option 2	
Pipe Diameter (inch)	3/4
High Flow (gpm)	28.12676
Low Flow (gpm)	5.625352
Scale factor= 1:5.333	

Scale model option 3	
Pipe Diameter (inch)	1/2
High flow (gpm)	18.75
Low flow (gpm)	3.75
Scale factor = 1:8	

*scale needed to be chosen to select prototype materials and initiate build plan

1" scale chosen for prototyping due to ease of construction and calculation scale factor

Electrical Prototype Valve Selection

Prototype Vavle Suggestions						
Valve Type	Solenoid	Solenoid	Solenoid	Solenoid	Solenoid	Solenoid
Valve Size	1"	1"	1 1/2"	3/4"		
Actuator	Direct lift diaphragm		Semi-Direct lift			
Normal Position	Open	Open	Open	Open		
LOP Position	Open					
Power Requirements	30 Watts	18 Watts	18 Watts	20 Watts		
Valve Material	Plastic	Steel	Steel	Brass		
Valve Cost	\$85.16	\$66.99	\$49.99	\$46.88		
Manufacturer	WIC	U.S. Solid	U.S solid	U.S solid		
website	https://wicvalve.com/?gclid=CjwKCAiAq4KuBhA	https://www.amazon	https://www.amazon	https://www.a		
Picture						

Project Valve Suggestion						
Valve Type	Solenoid	Solenoid				
Valve Size	4"	2"				
Actuator						
Normal Position	Normally open	Normally open				
LOP Position						
Power Requirements	13-20 Watts	13-20 Watts				
Valve Material	Stainless Steel	Stainless Steel				
Valve Cost	\$2,931.17	\$846.32				
Manufacturer	Sizto Tech Corporation	Sizto Tech Corporation				
website	https://www.stcvalve.com/Process_Valves.htm	https://www.stcvalve				
Product	2DSO400-2000 Series Solenoid Valve	2DSO400-2000 Series				
Picture						

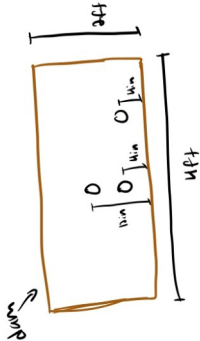
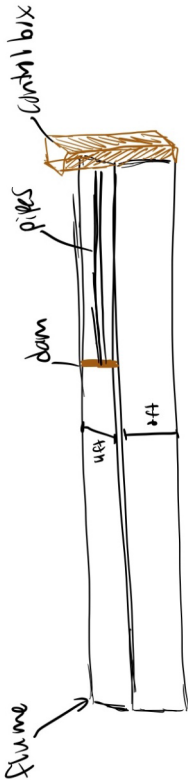
Brand	Float Material	Cost	Max Pressure	Temperature	Inlet Connection	Outlet Connection	Size Range	Photo
Uenede	Brass	\$20.99			National Pipe Tapered	G Connector	3/4" - 1"	
GOVALVE	Stainless Steel	\$31.99	116 PSI	<248 F	National Pipe Tapered	G Connector	3/4" - 1"	
Robert Manufacturing	Brass	\$92.88	100 PSI		National Pipe Tapered	MNPT	1"	
IMXMI	Nylon pa66	\$56.99			threaded			
absfloat	Acrylonitrile Butadiene Styrene	\$40.00			National Pipe Tapered	FNPT	0.5" - 1"	
GOVALVE	Stainless Steel	\$49.99	116 PSI	34 - 248 F	National Pipe Tapered	MNPT	3/4" - 1"	
MACGOAL	Plastic, Rubber, Acrylonitrile Butadiene Styrene	\$17.98						

This rod and float were used due to shipping errors with chosen valve

Prototype Build Plan

Build List	Build Tools
Dam	Saw
Drill holes	Hammer
Secure to flume	Nails
Control Box	Work Gloves
Measure out side	Eye protection
Cut particle board	Electric drill
Cover bottom outlet	
Connect sides with epoxy and nails	

Dimensions	Requirement	Created
Pipe for intake		4in
Pipe for village	Higher than pipe for intake	12in
Hole for discharge through dam		4in
Control Box Height	24in	48in
Control Box Width		20in
Control Box Length		22.5in



Electrical Solution Prototype materials List	Provided By
Solenoid valve	
Turbidity Monitor	
Tee Connection	
No. 200 Protective Screen	
PVC Pipeing (diameter TBD)	
Solar Panel	UTK
Arduino Board	Mark McKinney
Wiring	
Conduit	
Relay switches	

Mechanical Solution Prototype materials List

- Float Valve
- Water Receptacle (Volume TBD)
- PVC Pipeing (diameter TBD)



THE UNIVERSITY OF
TENNESSEE
KNOXVILLE

Prototype Plan: Tickle Tech Electrical Solution

Introduction

Solea Water has requested an intake system for their gravity fed water systems. During the wet season of Panama, rivers flood and debris flow down river causing high turbidity conditions in the drinking water. An automatically actuating intake system was designed and requires testing to verify accuracy and proof of concept. The electrical water intake system utilizes a turbidity monitor to continuously monitor the water quality and send data through an Arduino board which then sends an electrical signal to a valve through a pre-uploaded code. During low turbidity conditions, or normal conditions the valve remains open, but when the turbidity conditions surpass a programmed setpoint, the valve closes.

Methods

Three samples: 500mg/L, 1500mg/L, and 2000mg/L of Kaolinite slurry were prepared for tabletop testing, proof of concept testing. They were prepared in accordance with standard methods.

Equipment

1. 12Volt Charged Car battery.
2. 5-Volt power source (USB connection)
3. Arduino Board
4. Bread Board
5. Solenoid Valve
6. Various Concentrations of Kaolinite slurry
7. Compatible relay with valve and Arduino
8. Turbidity sensor
9. Suitable wires to connect components.

Measuring and Sample Procedures

1. Place measuring container on scale and zero scale.
2. Measure the appropriate amount of Kaolinite needed for each solution.
3. Mix Kaolinite solution with Deionized water until the proper concentration is reached.
4. Place each sample in a labeled container.

Testing Procedures

1. Electrically connect components with wire.
2. Connect system to power source provided.
 - a. If the system does not work, verify electrical connections.
 - b. Verify charge on the battery.
 - c. Verify power to both sides of the relay.
3. Test accuracy of the turbidity sensor.

- a. Verify readings with deionized water.
 - b. Verify readings with various kaolinite concentrations.
4. Verify valve actuates at correct setpoint:
 - a. Submerge the turbidity sensor 1-inch into the solutions at or greater than 1500 mg/L.
 - b. Observe and record response (Valve Actuation is heard)
 - c. Rinse the turbidity sensor with deionized water between Kaolinite solutions.
5. Verify valve does not actuate at concentrations below the setpoint.
 - a. Submerge the turbidity sensor 1-inch into solutions lower than 1500 mg/L.
 - b. Observe and record response.
 - c. Rinse the turbidity sensor with Deionized water between uses.

Table 1: Electrical tabletop test

	Deionized Water	500 mg/L	1500 mg/L	2000 mg/L
Valve Position (Expected)	Open	Open	Closed	Closed
Valve Response (Actual)	No actuation	No Actuation	Actuation	Actuation

Lessons Learned and Future work

The 5-Volt power supply and the 12-Volt power supply for the Arduino and valve should be different power supplies. The relay electrically isolates both sides, the Arduino side and the valve side, of the electrical system. The valve actuates in concentrations as intended. Proof of concept was a success. Future work should include the turbidity monitor installation in existing equipment as a test for feasibility of setup.

Appendix:**References:**

EPA. 1993. Method 180.1: Determination of Turbidity by Nephelometry.
Cincinnati, Ohio.

NEMI. 1995. Standard Methods: 2130 B: Turbidity by Nephelometry.

Raw Data/Pictures:

```
// This program will read the turbidity through the Turbidity sensor
// and will send a signal to an electrically actuated valve to open or close
// when the total dissolved solids is above or below 1,500 mg/L

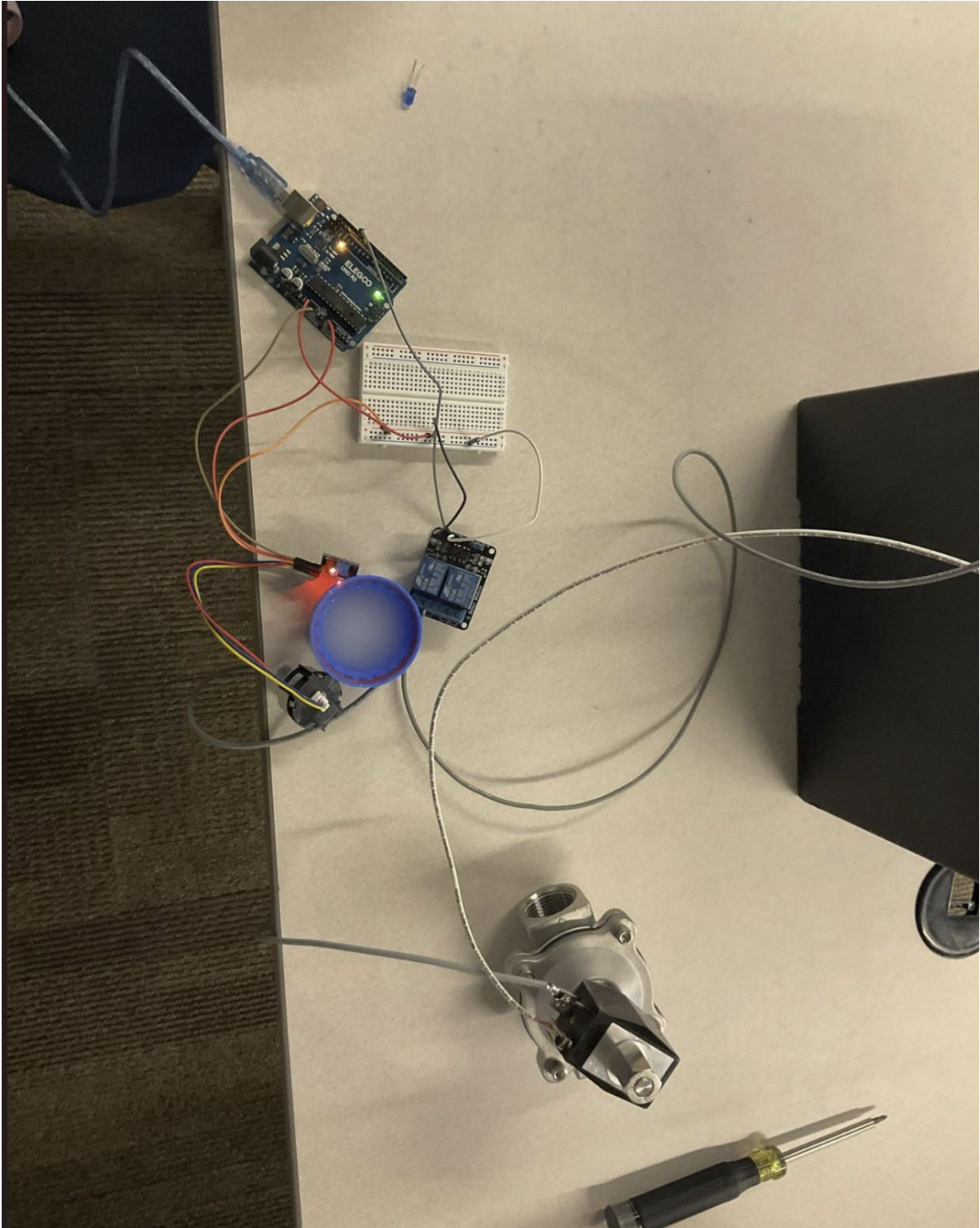
const int valve_relay_pin = 12; //Defined pin for the valve relay

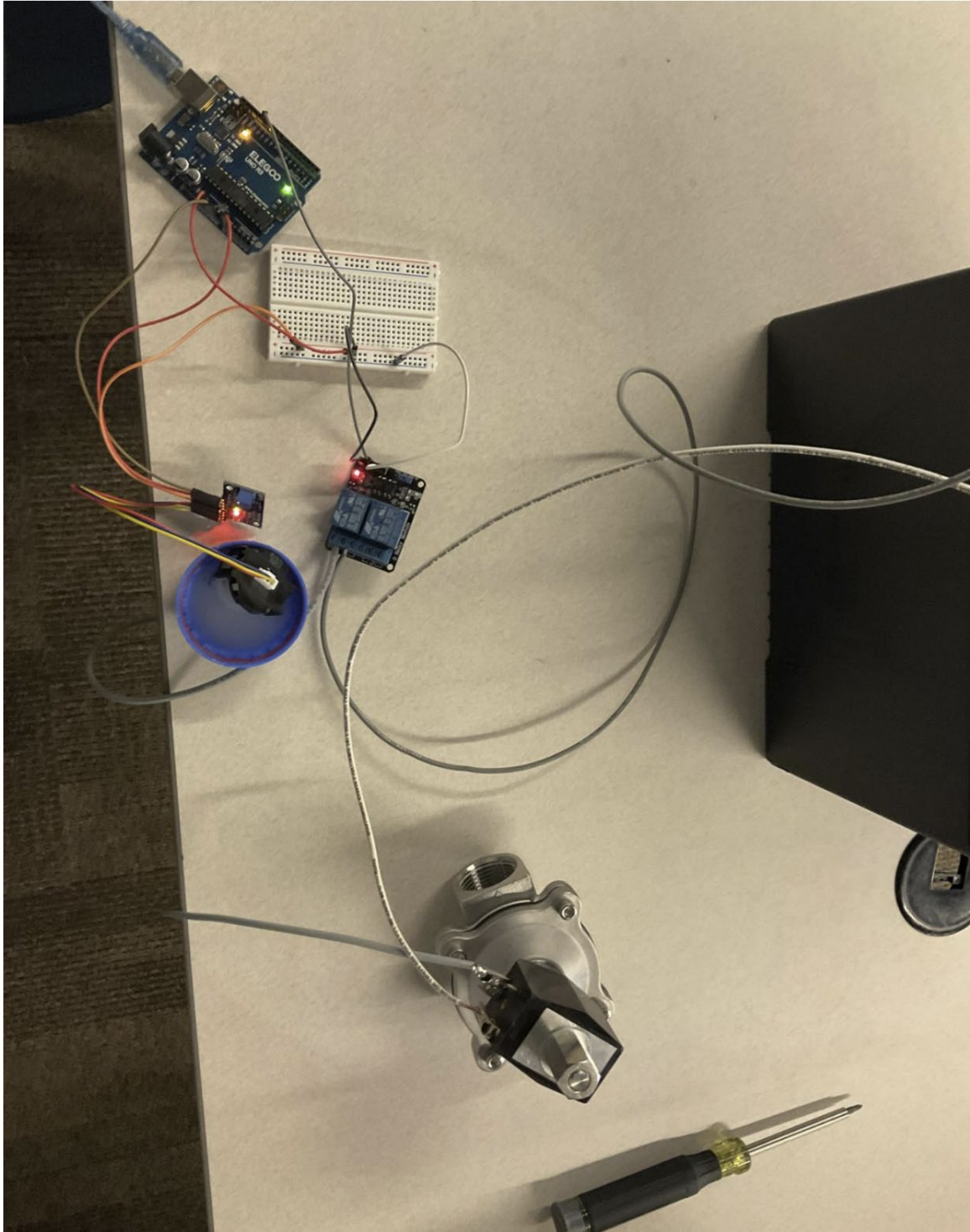
void setup() {
  Serial.begin(9600); // initializes water
  pinMode(valve_relay_pin, OUTPUT); // Define the pin mode for valve relay output
}

void loop() {

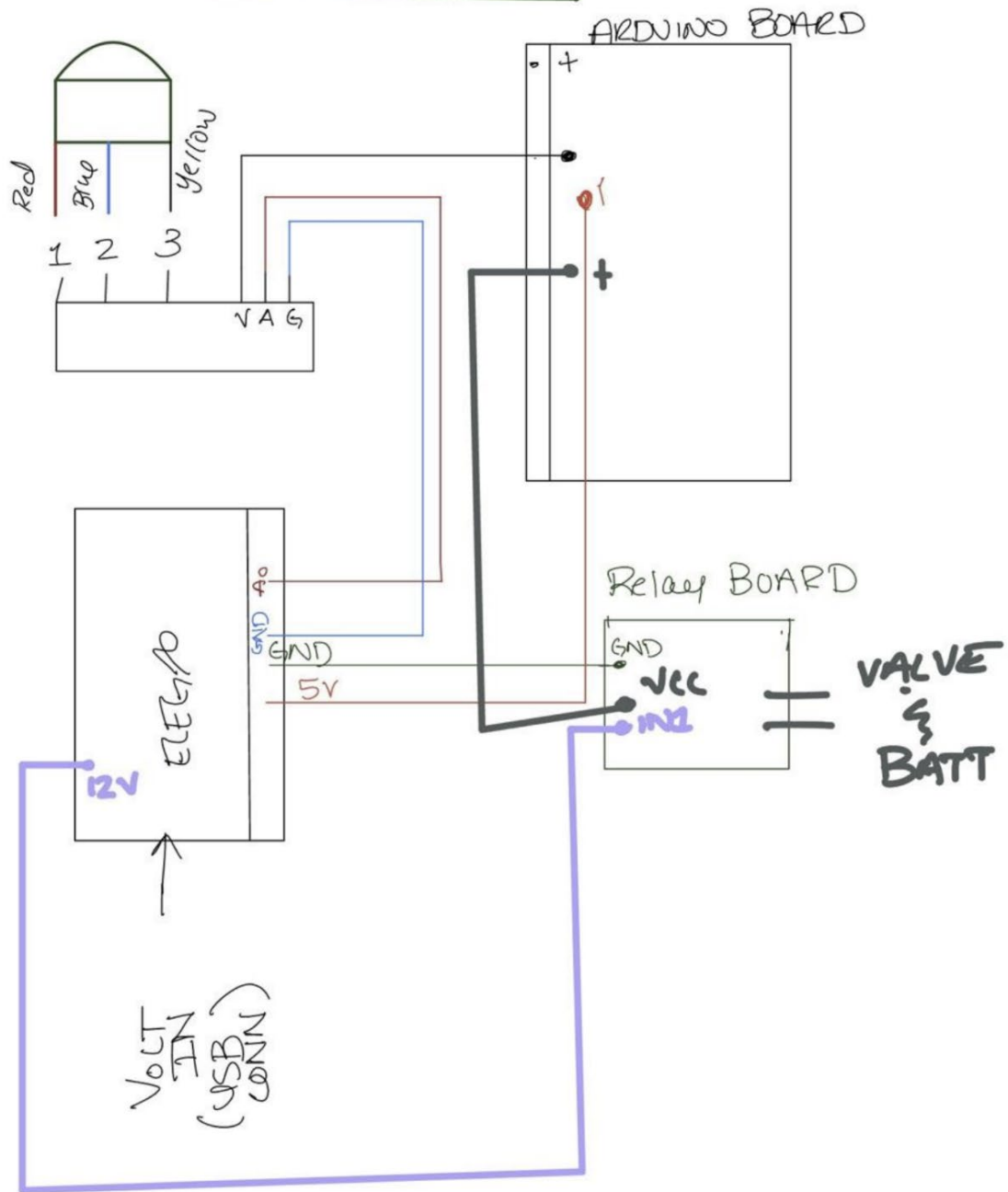
  int turbidity_raw = analogRead(A0);
  float turbidity = turbidity_raw*(5.0/1024.0)*3;
  Serial.println(turbidity);
  delay(500);

  if(turbidity <= 2){ //open valve, this corresponds to just under 1,500 mg/L
    Serial.println("Open Valve");
    digitalWrite(valve_relay_pin, HIGH);
  }
  else{ //close valve, this corresponds to 1,500 mg/L
    Serial.println("Close Valve");
    digitalWrite(valve_relay_pin, LOW);
  }
}
```





WIRING DIAGRAM



```
// This program will read the turbidity through the Turbidity sensor
// and will send a signal to an electrically actuated valve to open or close
// when the total dissolved solids is above or below 1,500 mg/L

const int valve_relay_pin = 12; //Defined pin for the valve relay

void setup() {
  Serial.begin(9600); // initializes water
  pinMode(valve_relay_pin, OUTPUT); // Define the pin mode for valve relay output
}

void loop() {

  int turbidity_raw = analogRead(A0);
  float turbidity = turbidity_raw*(5.0/1024.0)*3;
  Serial.println(turbidity);
  delay(500);

  if(turbidity <= 2){ //open valve, this corresponds to just under 1,500 mg/L
    Serial.println("Open Valve");
    digitalWrite(valve_relay_pin, HIGH);
  }
  else{ //close valve, this corresponds to 1,500 mg/L
    Serial.println("Close Valve");
    digitalWrite(valve_relay_pin, LOW);
  }
}
```

Mechanical Solution Prototype Testing and Results

Test Run: valve closes when water elevation in box increases and reopens when water elevation in box decreases.



Pump set up next to flume discharge pipes:



Images below show the water flow when the pipe is partially open (top) and when it is almost fully closed (bottom). Testing did not result in water flow completely stopping because water elevation in the box was not able to keep constant due to leakage.



Appendix C: Operation Guide and Cost



United States
Environmental Protection
Agency

Office of Environmental
Information
Washington, DC 20460

EPA/600/B-07/001
April 2007

Guidance for Preparing Standard Operating Procedures (SOPs)

EPA QA/G-6

Quality

GUIDANCE FOR PREPARING STANDARD OPERATING PROCEDURES

1.0 INTRODUCTION

1.1 Overview

A Standard Operating Procedure (SOP) is a set of written instructions that document a routine or repetitive activity followed by an organization. The development and use of SOPs are an integral part of a successful quality system as it provides individuals with the information to perform a job properly, and facilitates consistency in the quality and integrity of a product or end-result. The term “SOP” may not always be appropriate and terms such as protocols, instructions, worksheets, and laboratory operating procedures may also be used. For this document “SOP” will be used.

SOPs describe both technical and fundamental programmatic operational elements of an organization that would be managed under a work plan or a Quality Assurance (QA) Project Plan [EPA Requirements for QA Project Plans (QA/R-5) (EPA 2001a)], or Chapter 5 of the EPA Quality Manual for Environmental Programs, (EPA Manual 5360 A) and under an organization’s Quality Management Plan [EPA Requirements for Quality Management Plans (QA/R-2) (EPA 2001b)], or Chapter 3 of the EPA Quality Manual. This document is designed to provide guidance in the preparation and use of an SOP within a quality system.

1.2 Purpose

SOPs detail the regularly recurring work processes that are to be conducted or followed within an organization. They document the way activities are to be performed to facilitate consistent conformance to technical and quality system requirements and to support data quality. They may describe, for example, fundamental programmatic actions and technical actions such as analytical processes, and processes for maintaining, calibrating, and using equipment. SOPs are intended to be specific to the organization or facility whose activities are described and assist that organization to maintain their quality control and quality assurance processes and ensure compliance with governmental regulations.

If not written correctly, SOPs are of limited value. In addition, the best written SOPs will fail if they are not followed. Therefore, the use of SOPs needs to be reviewed and re-enforced by management, preferably the direct supervisor. Current copies of the SOPs also need to be readily accessible for reference in the work areas of those individuals actually performing the activity, either in hard copy or electronic format, otherwise SOPs serve little purpose.

1.3 Benefits

Aiming to do this for Solea

The development and use of SOPs minimizes variation and promotes quality through consistent implementation of a process or procedure within the organization, even if there are temporary or permanent personnel changes. SOPs can indicate compliance with organizational

and governmental requirements and can be used as a part of a personnel training program, since they should provide detailed work instructions. It minimizes opportunities for miscommunication and can address safety concerns. When historical data are being evaluated for current use, SOPs can also be valuable for reconstructing project activities when no other references are available. In addition, SOPs are frequently used as checklists by inspectors when auditing procedures. Ultimately, the benefits of a valid SOP are reduced work effort, along with improved comparability, credibility, and legal defensibility.

SOPs are needed even when published methods are being utilized. For example, if an SOP is written for a standard analytical method, the SOP should specify the procedures to be followed in greater detail than appear in the published method. It also should detail how, if at all, the SOP differs from the standard method and any options that this organization follows. As noted in ASTM D5172-91 (2004), *Standard Guide for Documenting the Standard Operating Procedures Used for the Analysis of Water*, "a significant part of the variability of results generated by different laboratories analyzing the same samples and citing the same general reference is due to differences in the way the analytical test methods and procedures are actually performed in each laboratory. These differences are often caused by the slight changes or adjustments allowed by the general reference, but that can affect the final results." Using a correct well-written SOP can minimize such differences.

1.4 Writing Styles

Guidance followed when
writing operations guide

SOPs should be written in a concise, step-by-step, easy-to-read format. The information presented should be unambiguous and not overly complicated. The active voice and present verb tense should be used. The term "you" should not be used, but implied. The document should not be wordy, redundant, or overly lengthy. Keep it simple and short. Information should be conveyed clearly and explicitly to remove any doubt as to what is required. Also, use a flow chart to illustrate the process being described. In addition, follow the style guide used by your organization, e.g., font size and margins.

- present tense
- no "you"
- short
- flow chart utilized

Operations Guide Outline Plan:

- What would the Panama community need to create a self-sustaining process?
 - Instructions for the entire project
 - How the system should function so that they are educated on how it works and should work/what could go wrong
- What level of writing should the guide be at? Does it need to be easily translated to Spanish?
 - The report should be written simply but it can be translated to Spanish and does not need to consider the wording used because a translator will be able to change it for the community
- What have previous teams done in terms of operations guide sections or formatting?
 - They used clear steps for what should be done, and prefaced sections with what the purpose was
 - Included product manuals and manufacturer sheets in appendix
- What does the drafted technical scope of work say should be present?
 - Produce a user-friendly manual in English for the construction, operation, and maintenance of the designed solution(s)
- What does the EPA writing guide say about formatting and language?
 - Straightforward steps and simplified language

Determined Purpose: Help the community create a self-sustaining water intake system. This echoes the Solea Water mission of supporting communities to become self-sufficient for “community led, long term, sustainable, and collaborative solutions.”

Rough Outline:

- I. Installation
 - a. Simplifies the project for a less technical audience and provides direct steps they can take to implement the solution.
- II. Operation
 - a. Give community basic understanding of how the system works so they can be educated when something goes wrong.
- III. Preventative and corrective maintenance
 - a. Regular checks
 - b. Troubleshooting malfunctions

3.2 Preliminary Cost Estimates

We will define costs based on previous projects

Preliminary estimates of future construction expenditures, made during the project planning and design phases, are necessarily approximate because they are compiled before the project is completely defined. Making such conceptual estimates is an art quite different from determining the final detailed estimate of construction costs.

Fundamentally, all conceptual price estimates are based on some system of gross unit costs obtained from previous construction work. These unit costs are extrapolated forward in time to reflect current market conditions, project location, and the particular character of the job presently under consideration. Some of the methods commonly used to prepare preliminary estimates include:

Cost per Function Estimate

This analysis is based on the estimated expenditure per unit of use, such as cost per patient, student, seat, or car space. Construction expense may also be approximated as the average outlay per unit of a plant's manufacturing or production capacity. These parameters are generally used as a method of quickly defining facilities costs at the inception of a project when only raw marketing information is known, such as the number of patients that a planned hospital will hold. This broad method of developing costs can also provide a powerful check on more detailed estimates once they have been generated.

Index Number Estimate

This method involves estimating the price of a proposed structure through updating the construction cost of a similar existing facility. It is done by multiplying the original construction cost of the existing structure by a national price index that has been adjusted to local conditions, such as weather, labor expense, materials costs, transportation, and site location. A price index is the ratio of present construction cost to the original construction outlay for the type of structure involved. Many forms of price indexes are available in various trade publications.

Unit Area Cost Estimate

Method could be used for weir, pvc, and channel prices

This method of estimating facilities costs is an approximate cost obtained by using an estimated price for each unit of gross floor area. The method is used frequently in building and residential home construction. It provides an accurate approximation of costs for structures that are standardized or have a large sampling of historical cost information from similar structures. This type of estimate is used often in the industry to compare the relative worth of various facilities.

Unit Volume Cost Estimate

This estimate is based on an approximated expenditure for each unit of the total volume enclosed. This estimating method works well in defining the costs of warehouses and industrial facilities.

Panel Unit Cost Estimate

This analysis is based on unit costs per square unit area of floors, unit length of perimeter walls, partition walls, and unit roof area. Generally this form of estimating is used to improve the preceding estimates once additional detailed information about the facility is known.

Parameter Cost Estimate

This estimate involves unit costs, called parameter costs, for each of several different building components or systems. The prices of site work, foundations, floors, exterior walls, interior walls, structure, roof, doors, glazed openings, plumbing, heating and ventilating, electrical, and other items are determined separately by the use of estimated parameter costs. These unit expenses can be based on dimensions or quantities of the components themselves or on the common measure of building square footage.

Partial Takeoff Estimate

This analysis uses quantities of major work items taken from partially completed design documents. These are priced using estimated unit prices for each work item taken off. During the design stage, this type of estimate is considered to provide the most accurate preliminary costs. Yet the feasibility of this method is highly dependent on the availability of completed design documents. Generally this estimate cannot be made until well into the design process. Hence it is often used to refine the previously discussed estimating methods.

Example for appendix
table

Unit Price Schedule					
Item No. [1]	Description [2]	Unit [3]	Estimated Quantity [4]	Unit Price [5]	Estimated Amount [6]
1	Excavation, unclassified	cy	1,667		
2	Excavation, structural	cy	120		
3	Backfill, compacted	cy	340		
4	Piling, steel	lf	2,240		
5	Concrete, footings	cy	120		
6	Concrete, abutments	cy	280		
7	Concrete, deck slab, 10 in.	sy	200		
8	Steel, reinforcing	lb	90,000		
9	Steel, structural	lb	65,500		
10	Bearing plates	lb	3,200		
11	Guardrail	lf	120		
12	Paint	ls	job		
Total Estimated Amount =					

Figure 3.3
Highway bridge, bid form

Final Project Cost

Item	Description	Units	Unit Cost	Total
Mechanical Valve Solution				
2in Float Valve	Merrill Manufacturing	1	\$ 124.00	\$ 124.00
Float Rod	Merrill Manufacturing	1	\$ 5.50	\$ 5.50
Float Ball	Merrill Manufacturing	1	\$ 27.00	\$ 27.00
4" PVC Piping	10 ft sections of piping for connections from dam to gravity feed piping to village	3	\$ 23.94	\$ 71.82
Ball Valve	4in PVC Ball Valve	2	\$ 61.99	\$ 123.98
Waterproof caulking	caulking to create watertight seals	10	\$ 9.84	\$ 98.40
15'x15' waterproof pond lining	Lining for box interior	1	\$ 335.00	\$ 335.00
PVC Pipe bends	Bends for float valve assembly	4	\$ 13.63	\$ 54.52
PVC Pipe reducing couplings (if needed)	To match float valve size	2	\$ 13.94	\$ 27.88
Concrete	Control box concrete	57 ft^3	\$ 10.00	\$ 570.00
Hilti Re 500 V4	Epoxy for anchoring rods	4	\$ 165.00	\$ 660.00
			Total	\$2,098.10
Electrical Valve Soltuion Cost Estimate (Initial)				
Sloenoid Valve	reoccurring cost - will have to be replaced. Lifespan 20 years	1	\$ 2,931.17	\$2,931.00
Solar Panel	reoccurring cost- replacement every 25 years	1	\$ 117.00	\$ 117.00
Lithium Battery	reoccurring cost-will have to be replaced. Lifespan is approx. 10 years	1	\$ 1,109.25	\$1,109.25
Turbidity Sensor	reoccurring cost - will have to be replaced every 5 yrs	1	\$ 23.46	\$ 23.46
Arduino Board	programmed to work with turbidity sensor	1	\$ 27.60	\$ 27.60
Watertight Conduit	Use Conduit to connect to Watertight box	1	\$ 49.99	\$ 49.99
Watertight Box	Where Electrical components are placed	1	\$ 59.99	\$ 59.99
			Total	\$4,318.29

25 Year Cost Estimation

25-Year Cost Estimate				
Item	Description	Units	Unit Cost	Total
Electrical Valve Soltuion Cost Estimate				
Sloenoid Valve	reoccurring cost - will have to be replaced. Lifespan 15 years	2	\$2,931.17	\$ 2,931.00
Solar Panel	reoccurring cost- replacement every 25 years	1	\$ 117.00	\$ 117.00
Lithium Battery	reoccurring cost-will have to be replaced. Lifespan is approx. 10 years	3	\$1,109.25	\$ 3,327.75
Turbidity Sensor	reoccurring cost - will have to be replaced every 5 yrs	5	\$ 23.46	\$ 117.30
Arduino Board	programmed to work with turbidity sensor	1	\$ 27.60	\$ 27.60
Watertight Conduit	Place Sensor at one end and use conduit to connect to Watertight box	1	\$ 49.99	\$ 49.99
Watertight Box	Where Electrical components are placed	1	\$ 59.99	\$ 59.99
			Total	\$ 6,630.63

25-Year Cost Estimate				
Item	Description	Units	Unit Cost	Total
Mechanical Valve Solution				
2in Float Valve	Merrill Manufacturing; Replaced every 10 years	3	\$ 124.00	\$ 372.00
Float Rod	Merrill Manufacturing	3	\$ 5.50	\$ 16.50
Float Ball	Merrill Manufacturing	3	\$ 27.00	\$ 81.00
Ball Valve	4in Ball Valve need replacing every 15 years	4	\$ 61.99	\$ 247.96
4" PVC Piping	10 ft sections of piping for connections from dam to gravity feed piping to village	3	\$ 23.94	\$ 71.82
Waterproof caulking	caulking to create watertight seals	10	\$ 9.84	\$ 98.40
5'x15' waterproof pond liner	Lining for box interior	1	\$ 335.00	\$ 335.00
PVC Pipe bends	Bends for float valve assembly	4	\$ 13.63	\$ 54.52
PVC Pipe reducing couplings	To match float valve size	2	\$ 13.94	\$ 27.88
Concrete	Control box concrete	57 ft^3	\$ 10.00	\$ 570.00
Hilti Re 500 V4	Epoxy for anchoring rods	4	\$ 165.00	\$ 660.00
			Total	\$ 2,535.08