Automated rainwater collection and storage: design and maintenance manual

ARMENIA TREE PROJECT

WPI

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Overview of the manual

Rainwater collection systems are an effective way to combat the effects of inconsistent rainfall and dry conditions, as well as reducing the amount of water consumed from Lake Sevan and other sources. Rain water can supplement, or even replace, water needs for households, gardens, or even tree nurseries. The collection of rainwater can come in many forms, however, the prototype outlined in this manual is automatic and facilitates the storage of larger quantities of rainwater by storing the water in a separate tank from the tank that it was collected in. It also has the benefit of being automatic, not requiring any human interference other than maintenance to work.

This prototype reacts to the water level in the collection and storage tanks, and once there is enough water to move to the storage tanks, and there is enough room in the tanks to receive the water, a pump will activate and move the water from one tank to another. A combination of float switches allows this to happen. How to install these component will be shown later in the manual.

Safety & Disclaimer

⚠ Safety Information ⚠

It is never safe to work with live wires. Make sure that all wiring work is done while the main power is off!

Disclaimer

The design outlined in the manual is a prototype designed by WPI and AUA engineering students. This manual details only how to construct this prototype, any installation or use of this prototype comes at the risk of the installer and user.

Components

Necessary

Items per system

Item	Quantity
Float Switch	2
2 Pole Miniature Circuit Breaker - Type C25	1
AC Magnetic Contactor	1
Electrical box	1

Custom

All items here should be purchased depending on the infrastructure of the installation site.

Item	Quantity	Customization*
Single Phase Pump	1	0.5 HP, 0.22371 KW
Submersible Pump	1	1 HP, 0.7457 KW
12 Gauge (2.05 mm) wire	X m	
Return valve	4	
Pipes	X m	

*Customization made for the Karin Nursery

Optional

Item	Quantity
Wire nuts	Approx. 10
Automatic Pump Controller	1
Pin crimps	Approx. 20

Tools

Required tools:

- Wire Stripper
- Phillips Head Screwdrivers
- Drill
- Voltmeter
- Electrical Tape
- Tape Measurer
- Wire cutters

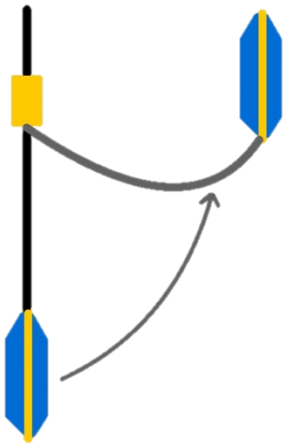
Optional but recommended:

- Crimper *necessary if using pin crimps
- Clamp

Float Switch

A float switch detects the level of a liquid in a container. It floats on the liquid surface and acts a mechanical switch as the level goes up or down.

Installation



1) Fix the counterweight on the electrical cable to control the height of the water level.

2) Adjust the length of the cable inside your container.

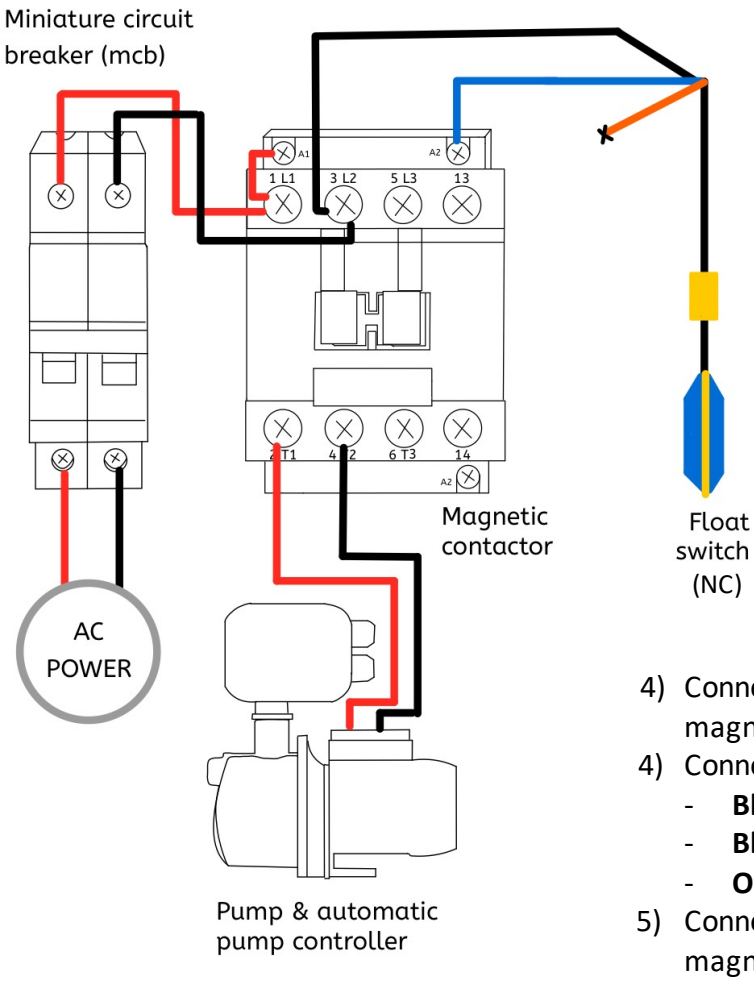
3) Move the counterweight to the desired height. When the container is full at the desired height, the counterweight will downforce the float switch to the up position.

Usage

Depending on the mode selected, a float switch can either turn the circuit on or off at its up position. This is called normally open and normally closed, respectively.

Construction guide

Instructions for auto-filling a tank



This would activate the pump when the tank where the switch is placed is empty.

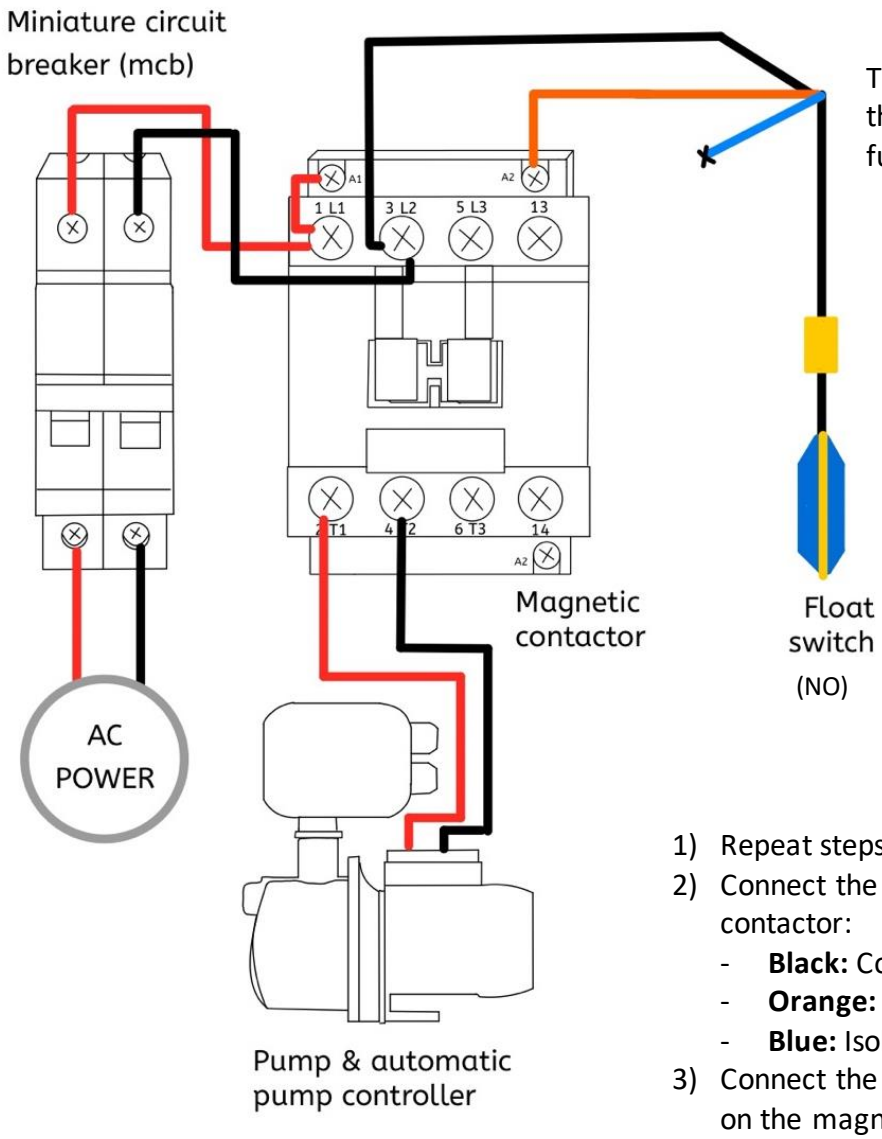
1) Install the float switch as desired in the container that is getting filled.
2) Connect one pole of the MCB to terminal 1 L1 on the magnetic contactor.
3) Connect 1 L1 to A1 on the magnetic contactor.
4) Connect the other pole of the MCB to 3 L2 on the magnetic contactor.
4) Connect the float switch to the magnetic contactor:
   - **Black:** Common ground to 3 L2.
   - **Blue:** NC to A2.
   - **Orange:** Isolate NO.
5) Connect the pump to terminals 2 T1 and 4 T2 on the magnetic contactor.
6) Finally connect your MCB to power.

⚠ WARNING ⚠

Do not work on the system if connected to power.

The wires should not be in contact with water.

Instructions for auto-emptying a tank



This would activate the pump when the tank where the switch is placed is full.

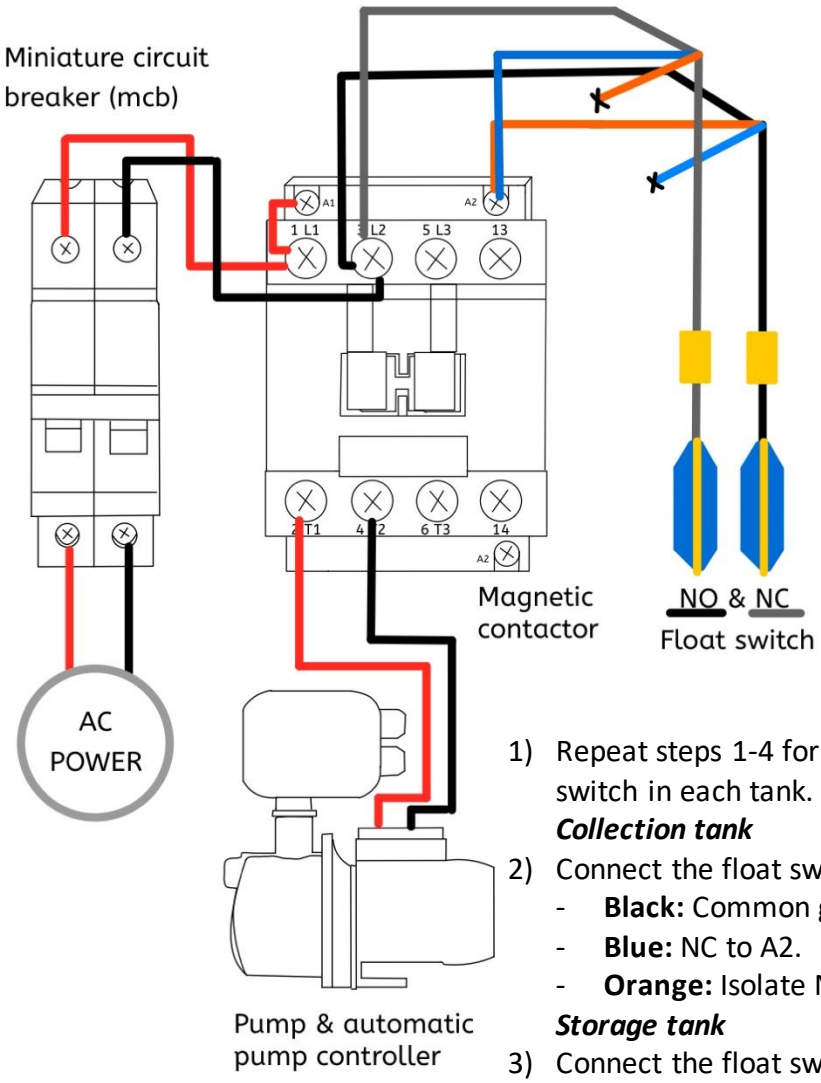
1) Repeat steps 1-4 for auto-filling a tank.
2) Connect the float switch to the magnetic contactor:
   - **Black:** Common ground to 3 L2.
   - **Orange:** NO to A2.
   - **Blue:** Isolate NC.
3) Connect the pump to terminals 2 T1 and 4 T2 on the magnetic contactor.
4) Finally connect your MCB to power.

⚠ WARNING ⚠

Do not work on the system if connected to power.

The wires should not be in contact with water.

Instructions for auto-emptying and auto-filling tanks



This would activate the pump when the collection tank is full AND the storage tank is empty.

1) Repeat steps 1-4 for auto filling a tank, placing one float switch in each tank.

Collection tank

2) Connect the float switch to the magnetic contactor:
   - **Black:** Common ground to 3 L2.
   - **Blue:** NC to A2.
   - **Orange:** Isolate NO.

Storage tank

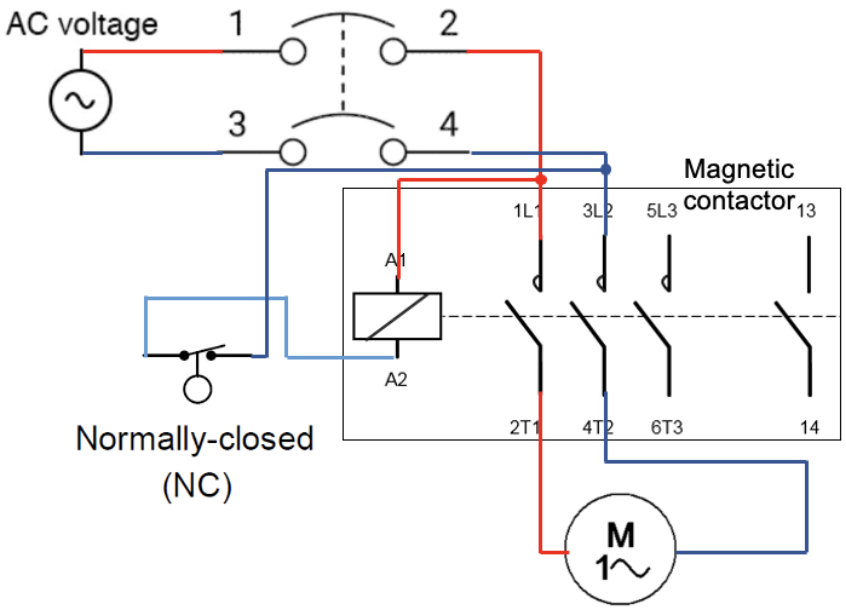
3) Connect the float switch to the magnetic contactor:
   - **Black:** Common ground to 3 L2.
   - **Orange:** NO to A2.
   - **Blue:** Isolate NC.
4) Connect the pump to terminals 2 T1 and 4 T2 on the magnetic contactor.
5) Finally connect your MCB to power.

⚠ WARNING ⚠

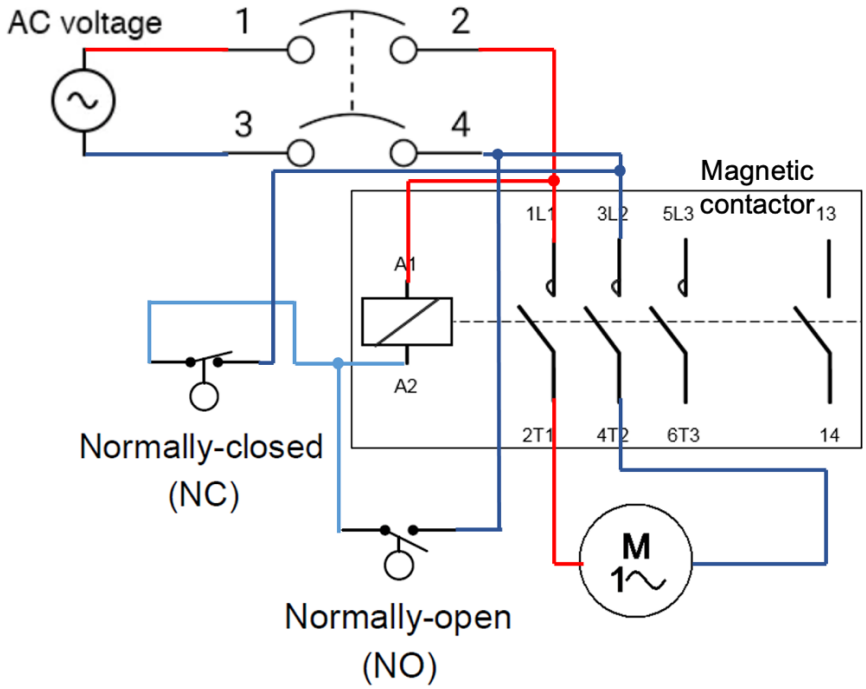
Do not work on the system if connected to power.

The wires should not be in contact with water.

Electrical diagram for auto-filling a tank



Electrical diagram for auto-emptying and auto-filling a tank



Troubleshooting & Maintenance

This section of the manual goes over troubleshooting methods that would be most useful for the prototype. As well as the maintenance and expected regular care that is anticipated for this prototype.

Troubleshooting

The pump is not turning on or off even when I move the float switches.

This is likely caused by the one of two issues:

- The wires are not properly connected to components (MCB, contactor, etc). Check all connections and make sure there is full contact.
- The system may not be wired correctly, most likely the float switch is not wired properly. Check all connections and make sure they line up with the diagram.

The MCB keeps tripping and not letting the prototype turn on

This can be most commonly caused by one of two issues:

- A short circuit: if two live wires were to touch, it would short the circuit and trip the breaker. This should be noticeable, as this will likely cause insulation on a wire to melt, which has a distinct smell. It can also cause visible damage to wires. If this were to happen, find the two wires that are touching and ensure that they no longer touch at all.
- An excess of voltage or current. This can be caused by a variety of things, most notably lighting strikes or drawing more power from the circuit than it can handle.

Maintenance

While this prototype is designed to work autonomously, there is still some regular maintenance and checks that should be done to ensure everything still works as intended

- *Wire condition should be checked regularly*
    - While all outside wires should be wrapped in a weatherproof tubing, it is still possible for this tubing to fail. Periodically check the condition of this tubing.
    - Poor tubing conditions can lead to the wires being damaged, either their insulation being worn away, making them unsafe or allowing animals to have access and chew through the wires.
    - While none of these are guaranteed if the tubing is broken, they are possible. A malfunction can be prevented by keeping an eye on the condition of the tubing.

- *During long periods where rain is not expected, the power should be turned off*
    - While the prototype is designed not to let an electricity past the MCB if it is not activated, taking this extra step removes the chances of any accidents happening with the prototype itself.

- *Be mindful of pipe seals*
    - Overtime, the pipes can develop leaks, oftentimes at the places where two pipes or hoses are joined. These leaks can be noticeable, but it is still recommended that these connections are inspected every so often to try to prevent these leaks from starting.

Operation checklist

Steps to follow for a monitoring or maintenance session of the prototype:

☐ Turn off the MCB.

☐ Disconnect the prototype from power.

☐ Make sure all wired connections are in place.

☐ Inspect the state of each wire.

☐ Examine the condition of the pump.

☐ Ensure all pipe connections are in good condition.

☐ Inspect float switch condition.

☐ Connect the prototype back to power.

☐ Turn on the MCB.

☐ Test each component is functioning.

Karin Nursery

General Information

Two prototypes were installed at the nursery by Mr. Hovhannes Sahakyan, and any questions about the details of the installation should be directed to him. Each prototype operates on 220 V to 240 V, and approximately 4-5 amps. This is a lethal amount of electricity, and while the electrical conditions are approved and/or installed by Mr. Hovhannes Sahakyan, caution should be taken whenever interacting with the prototype in any way. If there are any doubts or concerns about the safety or operation of the system, unplug it immediately and seek aid.

No amount of water is worth risking your life for.

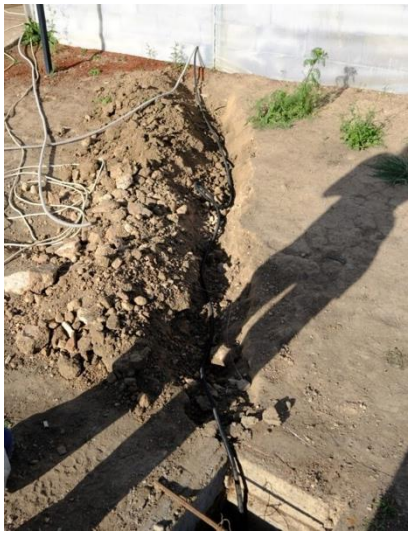
Education Building

As previously stated, the installation was approved and/or done by Mr. Hovhannes Sahakyan, so things should be up to standards and working safely, however there are things to note that are not related to electricity:

- When walking behind the education building, be mindful of the cables between the electrical box and the tanks, as they are at head height
- Likewise, be aware of the plumbing connections between the tanks and pumps.
- The electrical box is locked with a key to make sure it doesn't accidentally open, the key is located in the lock.

Greenhouse

- The cables that connect the pump and the float switch run under the ground, and while they are several inches deep and the soil is hard and dry, caution should still be exercise after extremely heavy rain in case any of the cables are now exposed.
    - Immediately disconnect the electrical box from the main power, which is located in the outlet on top of the box.
    - Be aware of any puddles surrounding the greenhouse that are near the buried cables. If any wires were torn or exposed, then you will be electrocuted if you were to have contact with the water.
    - In order for the puddles to be charged, several things would have to go very wrong, but it is always worth exercising extreme caution when dealing with the voltages present in the prototype.



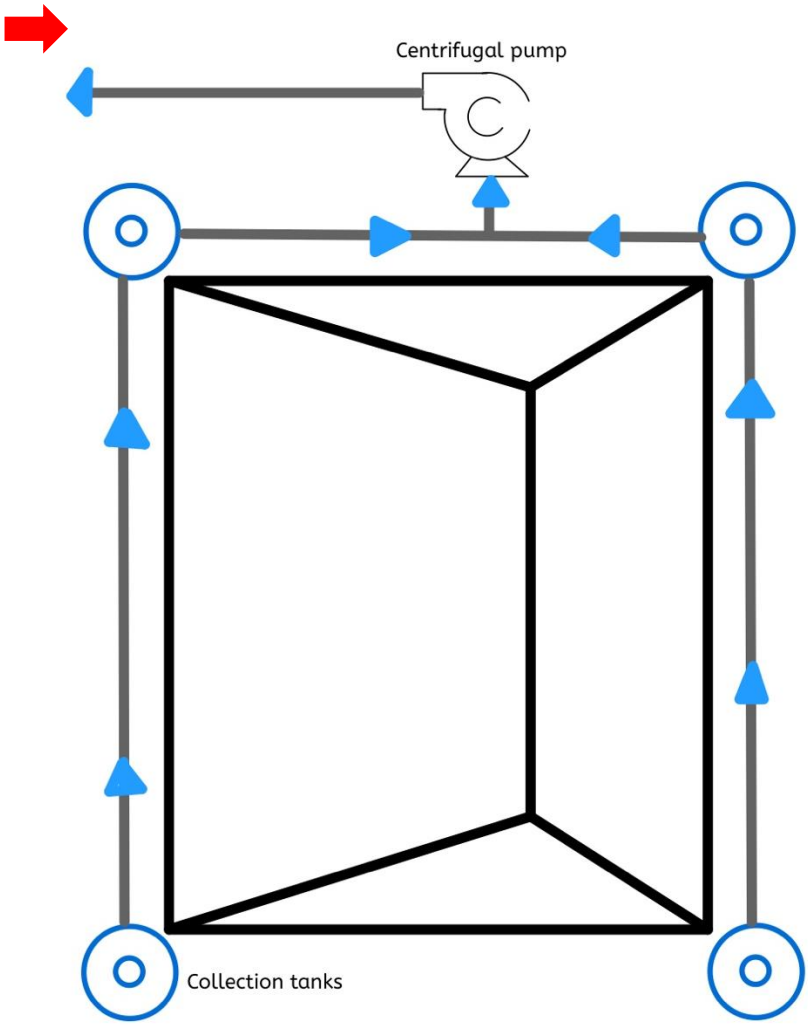
- The electrical box is located on the second post on the right once you enter the building. It is locked with a key to prevent the box from accidentally opening

- During normal operation of the greenhouse, refrain from spraying the electrical box directly with water, as water directly sprayed on it can cause issues with the wiring and lifespan of the box

Grafting Building Expansion

Here is the proposed design for the water collection at the grafting building and buildings like it.

Glossary



The connecting pipes in each tank should be placed at the bottom of the tanks with return valves to avoid the water from flowing back.

This system would consist of 4 tanks, one under each rain gutter. Since the building is on an incline, the tanks on the top will gravity-feed the ones on the bottom (closer to the pump). Using the instructions for auto-emptying and auto-filling tanks (See page 9), place a float switch in the tank marked with a red arrow (this one will fill up faster) and one in the desired storage tank. This system will fill up the storage when it is empty, and there is sufficient water in the collection area.

Rainwater Collection System: system designed to collect and store rainwater.
Prototype: preliminary model or version of a product or system used for testing and evaluation.
Float Switch: device that detects the level of a liquid in a container and acts as a mechanical switch as the level changes.
Counterweight: weight used to balance or offset another weight; it adjusts the height of a float switch.
Electrical Wiring: system of wires and components used to transmit electrical power within a structure.
Miniature Circuit Breaker (MCB): safety device that automatically interrupts electrical flow in a circuit in the event of an overload or short circuit.
Magnetic Contactor: electrical device used to remotely switch power circuits to control electromechanical devices.
Automatic Pump Controller: device that automatically controls the operation of a pump.
Single Phase Pump: type of pump that operates using a single-phase electrical supply.
Submersible Pump: pump designed to be fully submerged in liquid.
Gauge: unit of measurement for the diameter of wire, with lower gauge numbers indicating thicker wire.
Return Valve: valve used to control the flow of fluid in a pipe, allowing it to flow in only one direction.
Pipes: tubes used to convey fluids from one location to another.
Wire Nuts: connectors used to join or splice electrical wires together.

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