



# Rainwater Harvester System

# Table of Contents

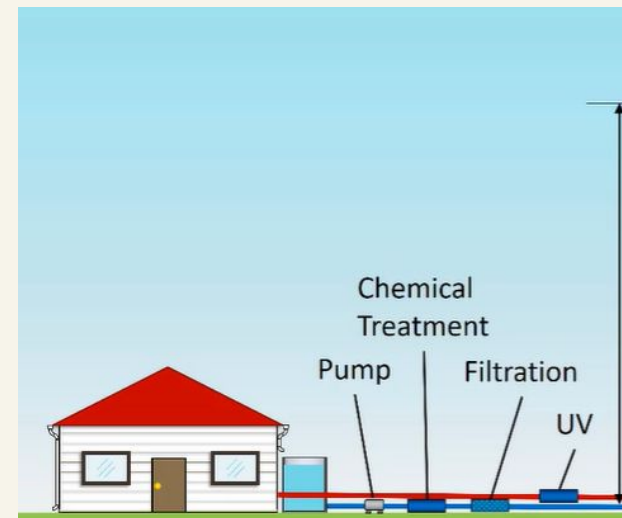
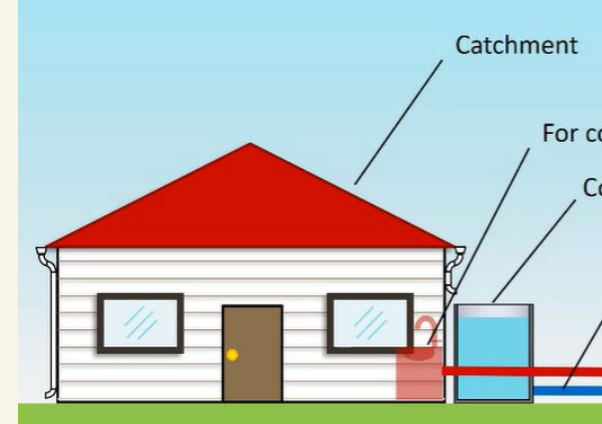
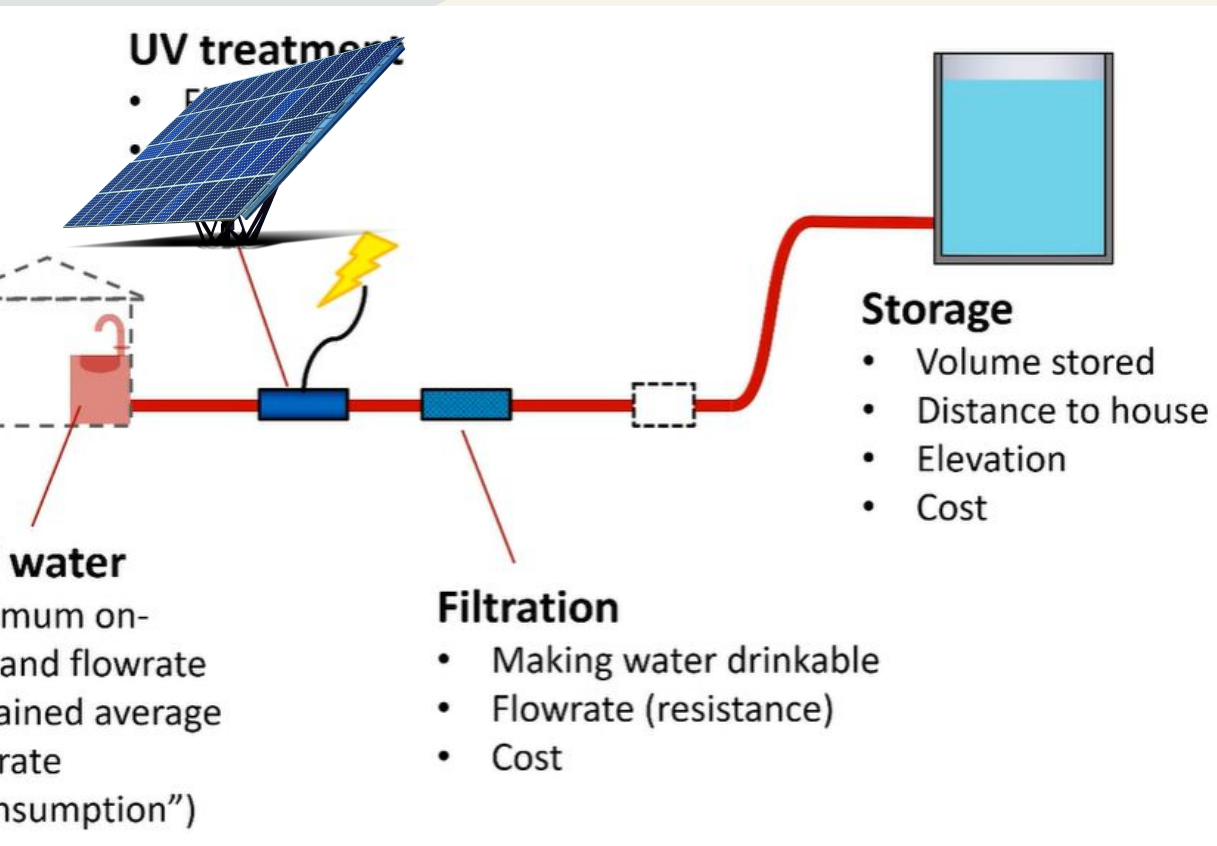
Introduction: Context & Recommendation

Alternative Configurations

Decision – making process

Justification & Suitability

Conclusion



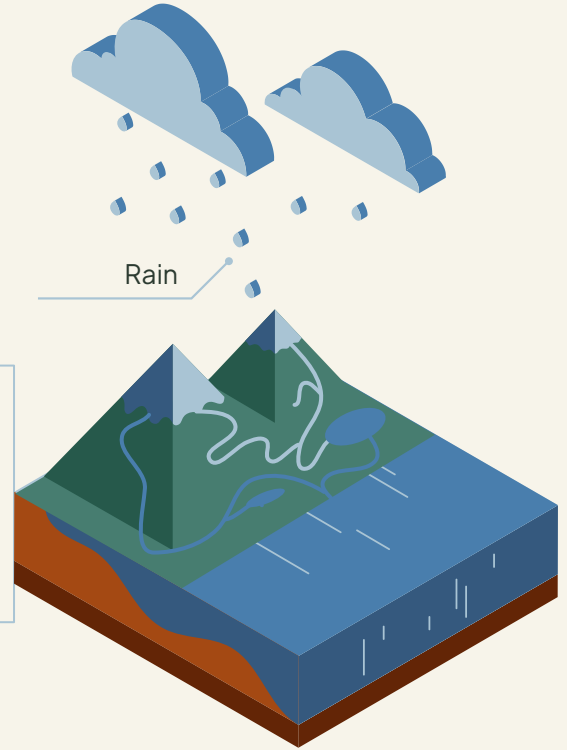
# Context

01

Alleviate water stress in remote communities like Van Anda

02

Recommend a feasible decentralized Rainwater Harvester System for consumption and storage



# Decision Making Process



# Stakeholder Satisfaction Attributes

Attribute	Weighting	System Req.
Consumption	10 %	Min. 155 L/day
Relative Cost	23 %	Max. 100% relative
Health and Environmental Risk Exposure	12 %	Max. 32
Power system Greenhouse Gas Emissions	5 %	Max. 100% relative to shipping water
Maintenance Occurrence	15%	Max. 72 / year
On-demand Flow Rate	10%	Min. 40 L/min
Reliability	15 %	Min. 250 days/ year of reliability
Land Use	10 %	% impact relative to worst case

# Recommendation Outline

Rainwater collection	100 m <sup>2</sup> rain catchment
	2.5 m <sup>3</sup> collection tank
Storage	26 m <sup>3</sup> storage tank on 6.2 m tower
Pumping	Pump B
Filtration	3-step: 1 µm + 5 µm + 200 µm filters
Disinfection	Ozone + UV
Power System	9 HES - 260 Solar panels
	4 12V Deep Cycle Wet Lead Acid Batteries
	2.8kW DC - AC Power Inverter

# Recommendation Outline



**9 HES - 260 Solar panels**  
**4 12V Deep Cycle Wet Lead Acid Batteries**  
**2.8kW DC - AC Power Inverter**

**7) Storage**

**6) Power**

**1) Catchment**

**2) Collection**

**5) Ozone treatment**

**26 m<sup>3</sup> storage tank on 6.2 m tower**

**100 m<sup>2</sup> rain catchment**  
**2.5 m<sup>3</sup> collection tank**

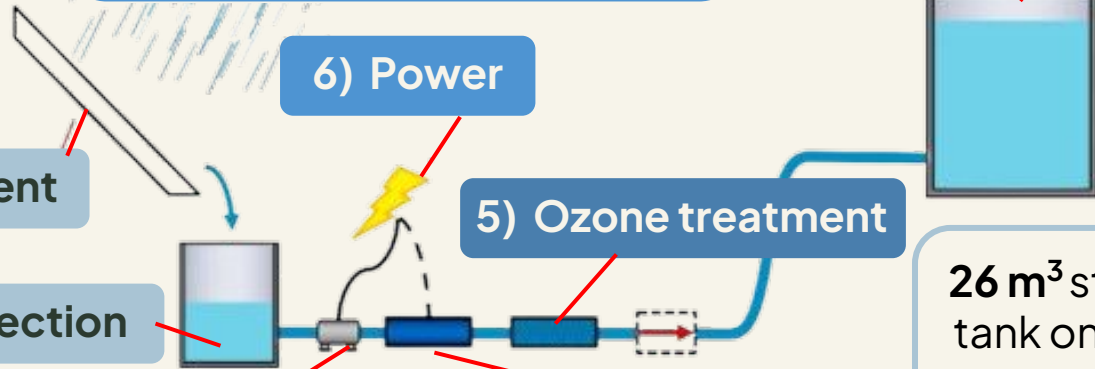
**3) Pumping**

**4) Filtration**

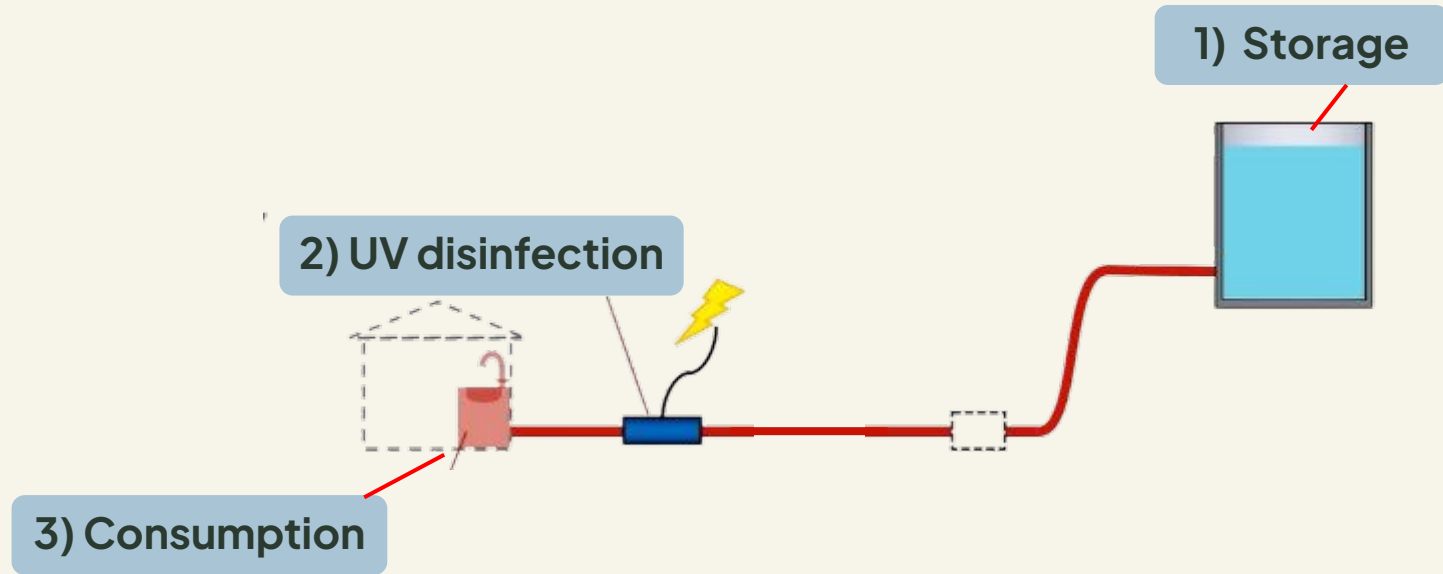
**Pump B**

**3-step:**  
**1 μm + 5 μm + 200 μm filters**

# Catchment to storage



# Storage to consumption



# Alternative Configurations

Energy system, chemical disinfection, land use, consumption

# Prototyping & Simulations

We executed meticulous testing and simulation with Microsoft Excel Spreadsheets.

- Each recommended parameter was rigorously assessed to optimize stakeholder satisfaction.
- Utilized charts and graphs to visualize trends and interpret data.

Pump ID	Pump Name	Pump Type	Pump Size (mm)	Pump Material	Pump Status	Pump Location	Pump Age (Years)	Pump Manufacturer	Pump Model	Pump Serial Number	Pump Capacity (m³/hr)	Pump Power (kW)	Pump Efficiency (%)	Pump Voltage (V)	Pump Frequency (Hz)	Pump Speed (RPM)	Pump Flow Rate (m³/min)	Pump Head (m)	Pump Suction Diameter (mm)	Pump Discharge Diameter (mm)	Pump Inlet Pressure (bar)	Pump Outlet Pressure (bar)	Pump Inlet Temperature (°C)	Pump Outlet Temperature (°C)	Pump Inlet Flow Rate (m³/min)	Pump Outlet Flow Rate (m³/min)	Pump Inlet Velocity (m/s)	Pump Outlet Velocity (m/s)	Pump Inlet Pipe Size (mm)	Pump Outlet Pipe Size (mm)	Pump Inlet Pipe Material	Pump Outlet Pipe Material	Pump Inlet Pipe Length (m)	Pump Outlet Pipe Length (m)	Pump Inlet Pipe Fitting	Pump Outlet Pipe Fitting	Pump Inlet Pipe Flange	Pump Outlet Pipe Flange	Pump Inlet Pipe Gasket	Pump Outlet Pipe Gasket	Pump Inlet Pipe Seal	Pump Outlet Pipe Seal	Pump Inlet Pipe Joint	Pump Outlet Pipe Joint	Pump Inlet Pipe Weld	Pump Outlet Pipe Weld	Pump Inlet Pipe Corrosion	Pump Outlet Pipe Corrosion	Pump Inlet Pipe Damage	Pump Outlet Pipe Damage	Pump Inlet Pipe Repair	Pump Outlet Pipe Repair	Pump Inlet Pipe Replacement	Pump Outlet Pipe Replacement	Pump Inlet Pipe Installation	Pump Outlet Pipe Installation	Pump Inlet Pipe Commissioning	Pump Outlet Pipe Commissioning	Pump Inlet Pipe Decommissioning	Pump Outlet Pipe Decommissioning	Pump Inlet Pipe Dismantling	Pump Outlet Pipe Dismantling	Pump Inlet Pipe Storage	Pump Outlet Pipe Storage	Pump Inlet Pipe Disposal	Pump Outlet Pipe Disposal	Pump Inlet Pipe Recycling	Pump Outlet Pipe Recycling	Pump Inlet Pipe Reuse	Pump Outlet Pipe Reuse	Pump Inlet Pipe Repairs	Pump Outlet Pipe Repairs	Pump Inlet Pipe Maintenance	Pump Outlet Pipe Maintenance	Pump Inlet Pipe Inspection	Pump Outlet Pipe Inspection	Pump Inlet Pipe Testing	Pump Outlet Pipe Testing	Pump Inlet Pipe Certification	Pump Outlet Pipe Certification	Pump Inlet Pipe Compliance	Pump Outlet Pipe Compliance	Pump Inlet Pipe Standards	Pump Outlet Pipe Standards	Pump Inlet Pipe Regulations	Pump Outlet Pipe Regulations	Pump Inlet Pipe Codes	Pump Outlet Pipe Codes	Pump Inlet Pipe Specifications	Pump Outlet Pipe Specifications	Pump Inlet Pipe Drawings	Pump Outlet Pipe Drawings	Pump Inlet Pipe Manuals	Pump Outlet Pipe Manuals	Pump Inlet Pipe Training	Pump Outlet Pipe Training	Pump Inlet Pipe Safety	Pump Outlet Pipe Safety	Pump Inlet Pipe Hazards	Pump Outlet Pipe Hazards	Pump Inlet Pipe Risks	Pump Outlet Pipe Risks	Pump Inlet Pipe Controls	Pump Outlet Pipe Controls	Pump Inlet Pipe Measures	Pump Outlet Pipe Measures	Pump Inlet Pipe Procedures	Pump Outlet Pipe Procedures	Pump Inlet Pipe Plans	Pump Outlet Pipe Plans	Pump Inlet Pipe Policies	Pump Outlet Pipe Policies	Pump Inlet Pipe Objectives	Pump Outlet Pipe Objectives	Pump Inlet Pipe Results	Pump Outlet Pipe Results	Pump Inlet Pipe Achievements	Pump Outlet Pipe Achievements	Pump Inlet Pipe Challenges	Pump Outlet Pipe Challenges	Pump Inlet Pipe Opportunities	Pump Outlet Pipe Opportunities	Pump Inlet Pipe Threats	Pump Outlet Pipe Threats	Pump Inlet Pipe Weaknesses	Pump Outlet Pipe Weaknesses	Pump Inlet Pipe Strengths	Pump Outlet Pipe Strengths	Pump Inlet Pipe Lessons	Pump Outlet Pipe Lessons	Pump Inlet Pipe Experiences	Pump Outlet Pipe Experiences	Pump Inlet Pipe Knowledge	Pump Outlet Pipe Knowledge	Pump Inlet Pipe Skills	Pump Outlet Pipe Skills	Pump Inlet Pipe Attitudes	Pump Outlet Pipe Attitudes	Pump Inlet Pipe Values	Pump Outlet Pipe Values	Pump Inlet Pipe Beliefs	Pump Outlet Pipe Beliefs	Pump Inlet Pipe Opinions	Pump Outlet Pipe Opinions	Pump Inlet Pipe Attitudes	Pump Outlet Pipe Attitudes	Pump Inlet Pipe Values	Pump Outlet Pipe Values	Pump Inlet Pipe Beliefs	Pump Outlet Pipe Beliefs	Pump Inlet Pipe Opinions	Pump Outlet Pipe Opinions	Pump Inlet Pipe Attitudes	Pump Outlet Pipe Attitudes	Pump Inlet Pipe Values	Pump Outlet Pipe Values	Pump Inlet Pipe Beliefs	Pump Outlet Pipe Beliefs	Pump Inlet Pipe Opinions	Pump Outlet Pipe Opinions	Pump Inlet Pipe Attitudes	Pump Outlet Pipe Attitudes	Pump Inlet Pipe Values	Pump Outlet Pipe Values	Pump Inlet Pipe Beliefs	Pump Outlet Pipe Beliefs	Pump Inlet Pipe Opinions	Pump Outlet Pipe Opinions	Pump Inlet Pipe Attitudes	Pump Outlet Pipe Attitudes	Pump Inlet Pipe Values	Pump Outlet Pipe Values	Pump Inlet Pipe Beliefs	Pump Outlet Pipe Beliefs	Pump Inlet Pipe Opinions	Pump Outlet Pipe Opinions	Pump Inlet Pipe Attitudes	Pump Outlet Pipe Attitudes	Pump Inlet Pipe Values	Pump Outlet Pipe Values	Pump Inlet Pipe Beliefs	Pump Outlet Pipe Beliefs	Pump Inlet Pipe Opinions	Pump Outlet Pipe Opinions	Pump Inlet Pipe Attitudes	Pump Outlet Pipe Attitudes	Pump Inlet Pipe Values	Pump Outlet Pipe Values	Pump Inlet Pipe Beliefs	Pump Outlet Pipe Beliefs	Pump Inlet Pipe Opinions	Pump Outlet Pipe Opinions	Pump Inlet Pipe Attitudes	Pump Outlet Pipe
---------	-----------	-----------	----------------	---------------	-------------	---------------	------------------	-------------------	------------	--------------------	-----------------------	-----------------	---------------------	------------------	---------------------	------------------	-------------------------	---------------	----------------------------	------------------------------	---------------------------	----------------------------	-----------------------------	------------------------------	-------------------------------	--------------------------------	---------------------------	----------------------------	---------------------------	----------------------------	--------------------------	---------------------------	----------------------------	-----------------------------	-------------------------	--------------------------	------------------------	-------------------------	------------------------	-------------------------	----------------------	-----------------------	-----------------------	------------------------	----------------------	-----------------------	---------------------------	----------------------------	------------------------	-------------------------	------------------------	-------------------------	-----------------------------	------------------------------	------------------------------	-------------------------------	-------------------------------	--------------------------------	---------------------------------	----------------------------------	-----------------------------	------------------------------	-------------------------	--------------------------	--------------------------	---------------------------	---------------------------	----------------------------	-----------------------	------------------------	-------------------------	--------------------------	-----------------------------	------------------------------	----------------------------	-----------------------------	-------------------------	--------------------------	-------------------------------	--------------------------------	----------------------------	-----------------------------	---------------------------	----------------------------	-----------------------------	------------------------------	-----------------------	------------------------	--------------------------------	---------------------------------	--------------------------	---------------------------	-------------------------	--------------------------	--------------------------	---------------------------	------------------------	-------------------------	-------------------------	--------------------------	-----------------------	------------------------	--------------------------	---------------------------	--------------------------	---------------------------	----------------------------	-----------------------------	-----------------------	------------------------	--------------------------	---------------------------	----------------------------	-----------------------------	-------------------------	--------------------------	------------------------------	-------------------------------	----------------------------	-----------------------------	-------------------------------	--------------------------------	-------------------------	--------------------------	----------------------------	-----------------------------	---------------------------	----------------------------	-------------------------	--------------------------	-----------------------------	------------------------------	---------------------------	----------------------------	------------------------	-------------------------	---------------------------	----------------------------	------------------------	-------------------------	-------------------------	--------------------------	--------------------------	---------------------------	---------------------------	----------------------------	------------------------	-------------------------	-------------------------	--------------------------	--------------------------	---------------------------	---------------------------	----------------------------	------------------------	-------------------------	-------------------------	--------------------------	--------------------------	---------------------------	---------------------------	----------------------------	------------------------	-------------------------	-------------------------	--------------------------	--------------------------	---------------------------	---------------------------	----------------------------	------------------------	-------------------------	-------------------------	--------------------------	--------------------------	---------------------------	---------------------------	----------------------------	------------------------	-------------------------	-------------------------	--------------------------	--------------------------	---------------------------	---------------------------	----------------------------	------------------------	-------------------------	-------------------------	--------------------------	--------------------------	---------------------------	---------------------------	------------------

# Energy System

## Recommendation: Solar

### Pros

Low maintenance

No health and environmental risks associated

### Cons

High upfront cost  
(\$205-\$500/panel)

High GHG emissions from production

## Alternative: Diesel

### Pros

Low upfront cost

### Cons

Consistent shipments needed,  
\$325/shipment and frequent maintenance

Burning diesel has high GHG

Health and environmental risks associated with diesel



# Chemical Disinfection

## Recommendation: Ozone

### Pros

Annual maintenance

No health and environmental risks associated

### Cons

High upfront cost (\$4000)

High energy usage

## Alternative: Chlorine

### Pros

Low upfront cost

### Cons

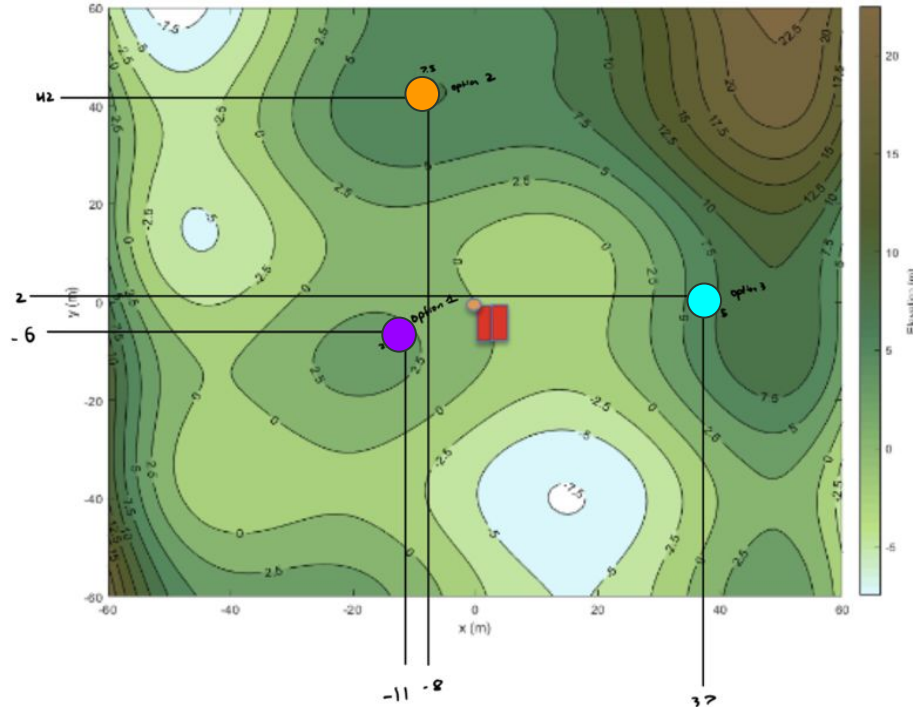
High cumulative costs (shipments are required almost biweekly)

Extreme health and environmental risks associated with chlorine

Frequent maintenance



# Storage Tank Locations



● **Option 1:**  
Coordinates : (-11, -6)  
Elevation: 2.5 m  
Pipe Length: 25.554 m

● **Option 2:**  
Coordinates: (-8, 42)  
Elevation: 7.5 m  
Pipe Length: 86.816 m

● **Option 3:**  
Coordinates: (37, 2)  
Elevation: 5.0 m  
Pipe Length : 74.780 m

# Storage Tank Locations - Con't

## Alternative

### Option 1: Unchanged

- No extra cost needed, so relative cost is **lower**
- Significantly lower on-demand flow rate (**satisfaction ~10%**)

## Recommendation

### Option 2: Option 1 + 6.2m Tower

- High upfront cost (\$6875)
- Increases on-demand flow rate by **over 200%**
- **Significant boost** in satisfaction

## Alternative

### Option 3

- With the long pipe length, on-demand flow rate is **reduced**
- Satisfaction was **lower than option 1** with the tower





Created separate spreadsheets for each parameter to be determined and measured satisfaction for all 8 attributes.

Estimated min & max water consumption per household → determine consumption value (initial)

Utilized rainfall data in weather station 1 in 2014 and 2015 →

- Selected multiple potential locations for storage tank placement → land use

- Evaluated pump performance for each pump (flow rate, pressure, efficiency)

- Calculated energy usage for powering system

- Examined maintenance for all filter combinations

- On-demand flow rate

- Calculated all associated costs (initial + maintenance)

- Assessed risks and greenhouse gas emissions



# Final Recommendation

Rainwater collection	100 m <sup>2</sup> rain catchment
	2.5 m <sup>3</sup> collection tank
Storage	26 m <sup>3</sup> storage tank on 6.2 m tower
Pumping	Pump B
Filtration	3-step: 1 µm + 5 µm + 200 µm filters
Disinfection	Ozone + UV
Power System	9 HES - 260 Solar panels
	4 12V Deep Cycle Wet Lead Acid Batteries
	2.8kW DC - AC Power Inverter

# Rainwater collection

## Collection Tank

Capacity: 2500L

Cost: \$900

collects up to **5X** the amount of daily water consumption (500L), taking advantage of rainy seasons



## Roof Catchment

Area: 100m<sup>2</sup> (whole roof)

Cost: \$350



**reduces dry days**, saving approximately **\$5000** in water shipment costs alone

only uses the roof, **no extra space required** for additional catchment area

# Distribution and Storage



After testing all three pumps, **Pump B** resulted in the highest overall **stakeholder satisfaction**.

Pump B was selected for its **low maintenance** and **high flow rate**



# Filtration



1  $\mu\text{m}$



System Requirement

5  $\mu\text{m}$



Reduces fouling rate of  
1  $\mu\text{m}$  filter

200  $\mu\text{m}$



Reduces fouling rate of  
5  $\mu\text{m}$  filter

Using **all 3** filters **reduces frequency for maintenance by 50%.**

# Disinfection

## Ozone



- Annual maintenance
- No health and environmental risks associated

## Ultra-Violet (UV)

50W UV System:

- Max treatable flow rate: 40 LPM
- Insignificant relative energy and cost differences



# Final Recommendation (Test Case)

## Cost

Total cost over five years is  
**\$50,000** relative to **\$105,000**  
for the previous system

## Reliability

Confident in providing clean, safe  
water for **over 90%** of the year

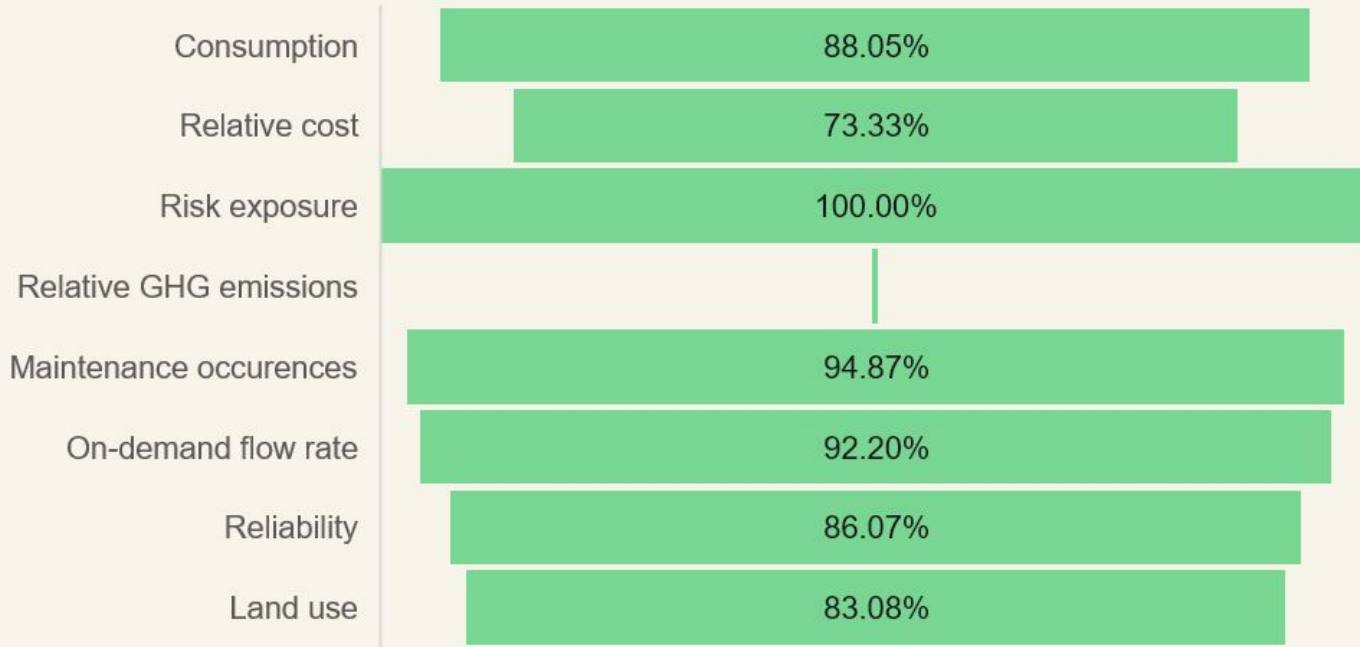
## Maintenance & Risk

Around **16 maintenance days** per  
year, and **0 health/environmental  
risk** associated with ozone and  
solar

## Greenhouse Gas (GHG)

Initial GHG emissions are **7932 kg**  
compared to **8339 kg** from the  
existing system

# Stakeholder Satisfaction



**Total Weighted Stakeholder  
Satisfaction: 82.3%**



# Conclusion



**Thank you**