CLEAN ENERGY WATER DISINFECTION SYSTEM

Prepared for the Waste-Management, Education, & Research Consortium Environmental Design Competition

JAMM, Inc. Environmental Engineering

Meshal Hussain

Ashley Ullstrom

Marilla Lamb

Jo-Anne Barcellano

Project Understanding

- Problem Statement
  - Water-borne diseases
    - Result in 3.6 million deaths each year
    - Cause one child to die every 20 seconds
- Therefore we must
  - Design a universally applicable water disinfection system for use in rural, third-world areas and in emergency situations
- WERC held a competition to find a solution which would
  - Use existing technologies in a new, creative way
  - Disinfect water to World Health Organization (WHO) drinking water guidelines

JAMM Inc.

Design Criteria

- The system must:
  - Use renewable energy
  - Be a mobile unit
  - Be cost effective
  - Be applicable to rural, third-world settings
  - Meet a flow of 3,000 gallons per day
  - Be easy for ordinary citizens in third-world environments to implement, operate, and maintain

Scope of Work

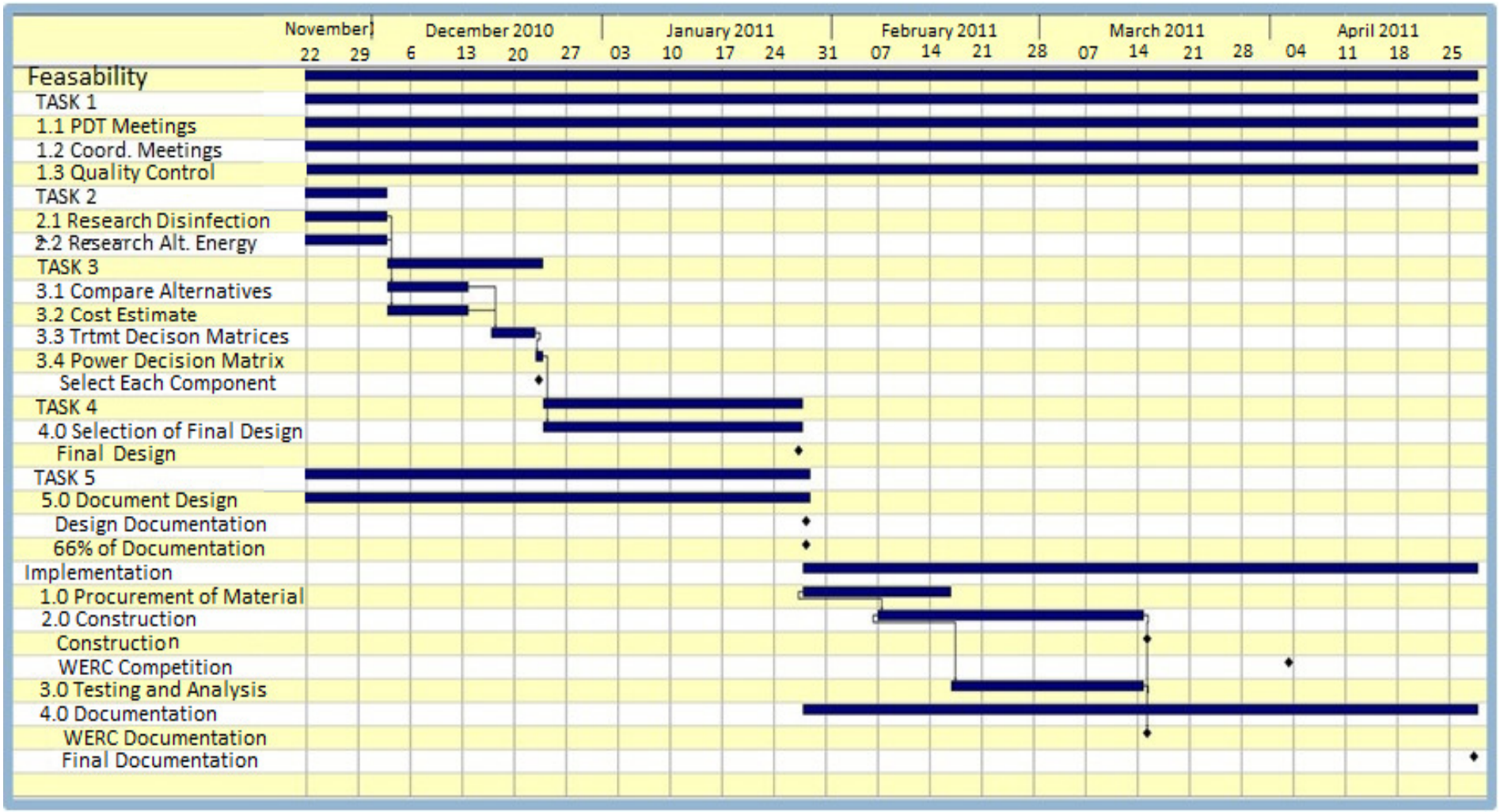
- Project Management
- Research
- Evaluation of Solutions
- Design
- Construction
- Testing & Analysis
- Documentation

Project Management

- Team Structure
  - Project Manager – Meshal Hussain
    - Delegating tasks, client communication, scheduling
  - Construction Manager – Marilla Lamb
    - Construction schedule, procuring materials
  - Research Manager – Ashley Ullstrom
    - Delegating research, gathering documents, lab management
  - Documents Editor – Jo-Anne Barcellano
    - Report management, meeting minutes, compiling and editing documents
- Coordination & Communication
  - Weekly meetings with PDT members
  - Ongoing correspondence with client via email

Scheduling

- Created a Gantt Chart



Quality Assurance & Quality Control

- QA/QC plan developed
  - Turbidity and bacteria tests
  - Calculations
  - Written documents
  - Schematics

Selection of Design

- Research
- Identification of potential solutions
  - Pretreatment
    - Rapid sand filters, roughing filters, sedimentation, washable sediment filters
  - Disinfection
    - Ozone generator, ceramic filter, ultraviolet disinfection, ultrafiltration
  - Renewable energy
    - Wind power, solar power, man power

Selection of Design

- Evaluation of potential solutions
- Results from decision matrices
- Final design
  - Pretreatment: rapid sand filter & roughing filter
  - Disinfection: ultraviolet (UV) disinfection
  - Renewable energy: solar power & human power

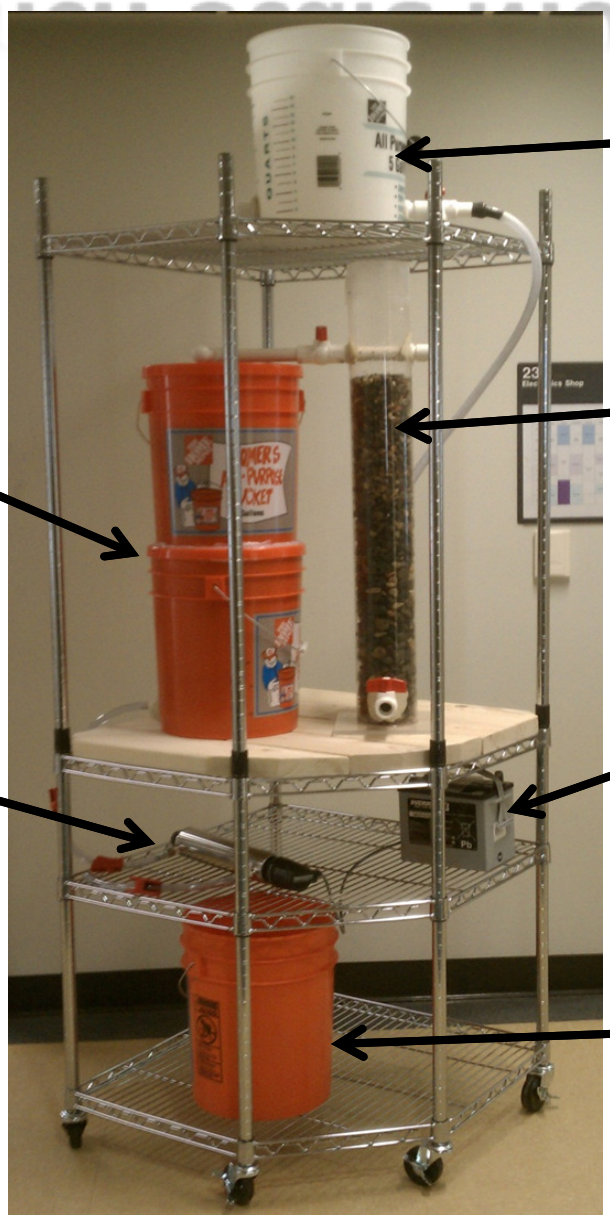
Potential Solutions	Score
Pretreatment	
Rapid Sand Filter	4.38
Roughing Filter	3.83
Sedimentation	4.44
Washable Sediment Filter	4.33
Disinfection	
Ozone Generator	3.39
Ceramic Filter	2.61
Ultraviolet Disinfection	3.70
Ultrafiltration	3.12
Renewable Energy	
Wind Power	3.02
Solar Power	4.16
Man Power	4.00

Design Development

- Built and tested many configurations for roughing filters and rapid sand filters until finalizing each component

- Integrated all components into a final bench-scale model
  - Used for testing and analysis
  - Used sizes and flow rates to design the full scale system
  - Used for demonstration purposes at the competition

Bench-Scale Model

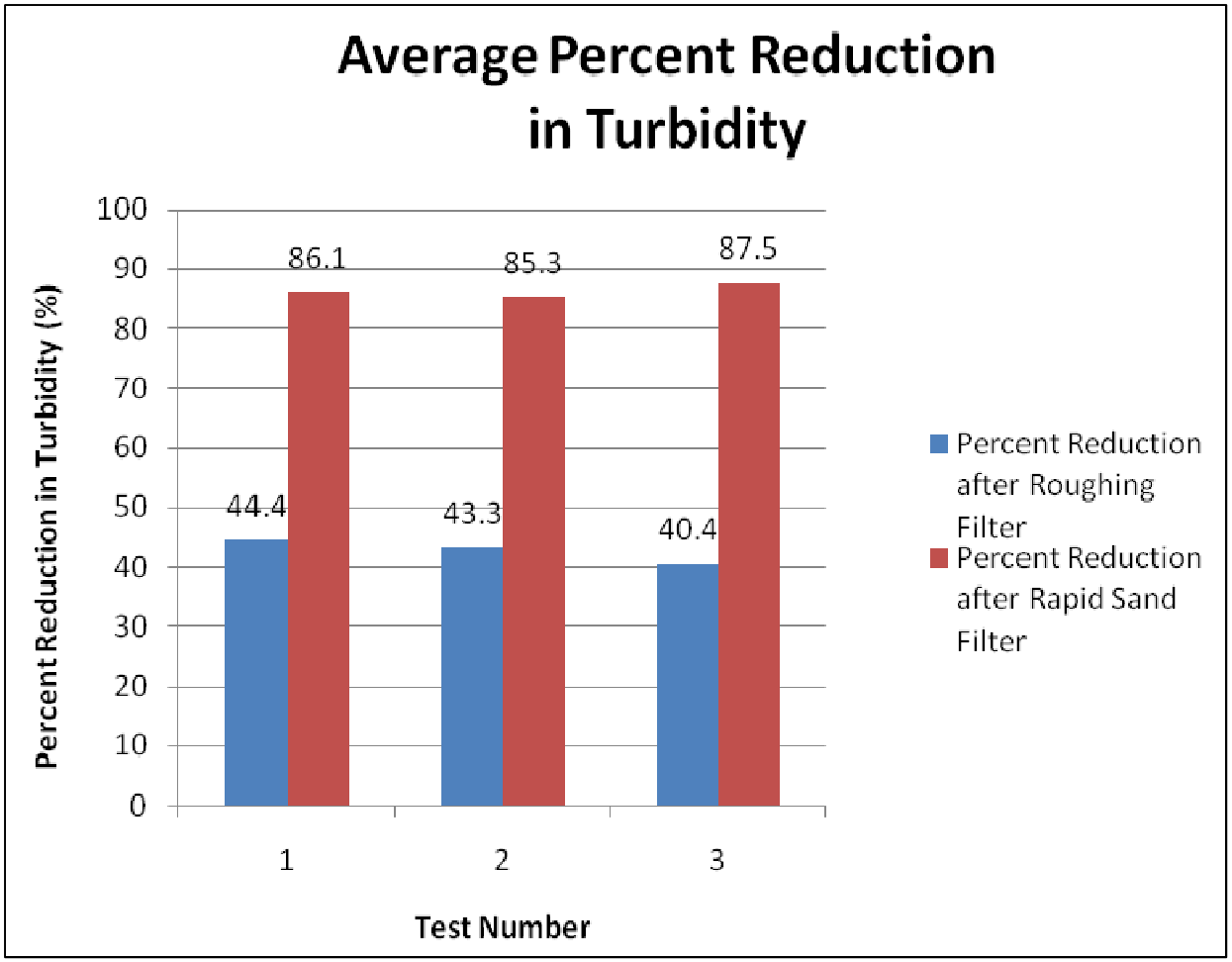


Quality Assurance & Quality Control

- Turbidity testing
  - Used blanks and a calibration curve to ensure validity of the data
  - Performed multiple tests
- Bacteria testing
  - Used the heterotrophic plate count method
  - Performed multiple tests and used blanks
  - Appropriate procedures were followed to ensure no contamination

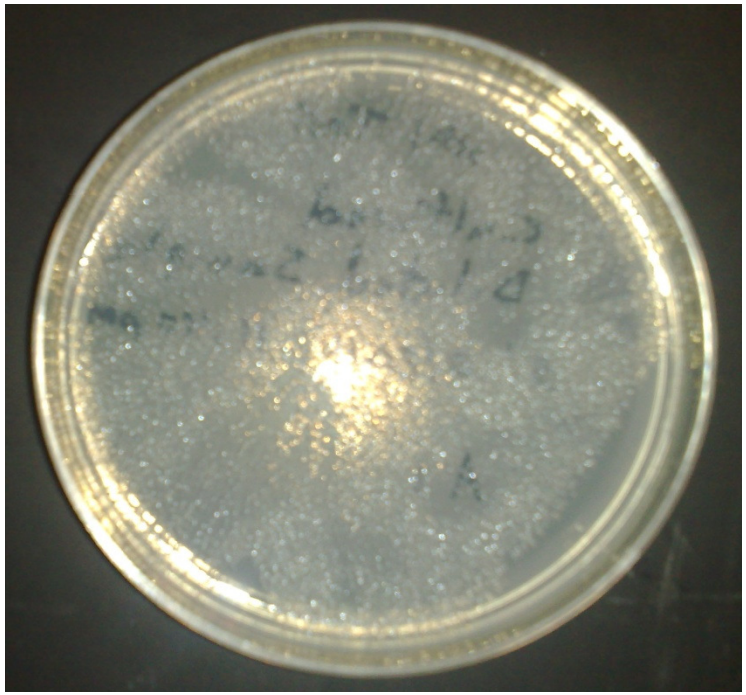
Technical Evaluation

- Turbidity results
  - Input water: 25 NTU
  - Total reduction in turbidity by more than 85%
  - Output water: 3.5 NTU

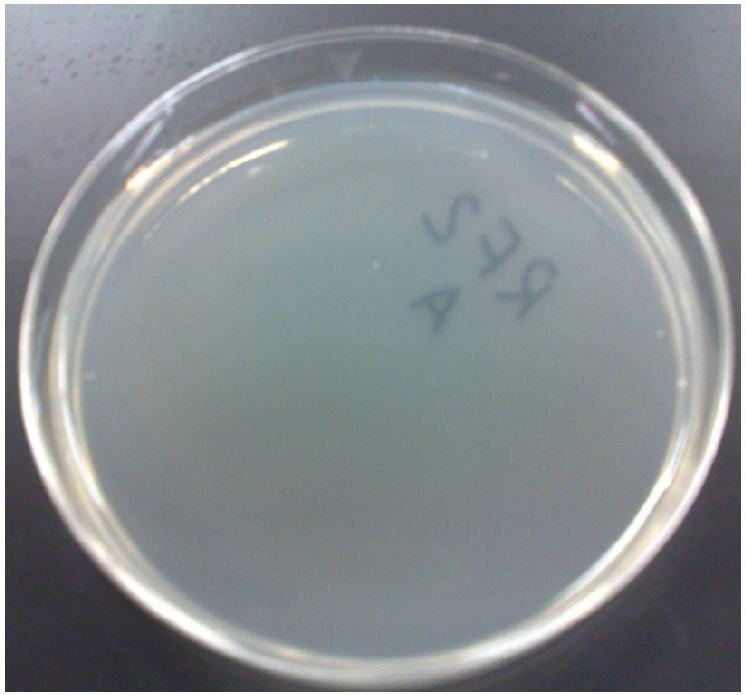


Technical Evaluation

- Bacteria results
  - Total removal of bacteria

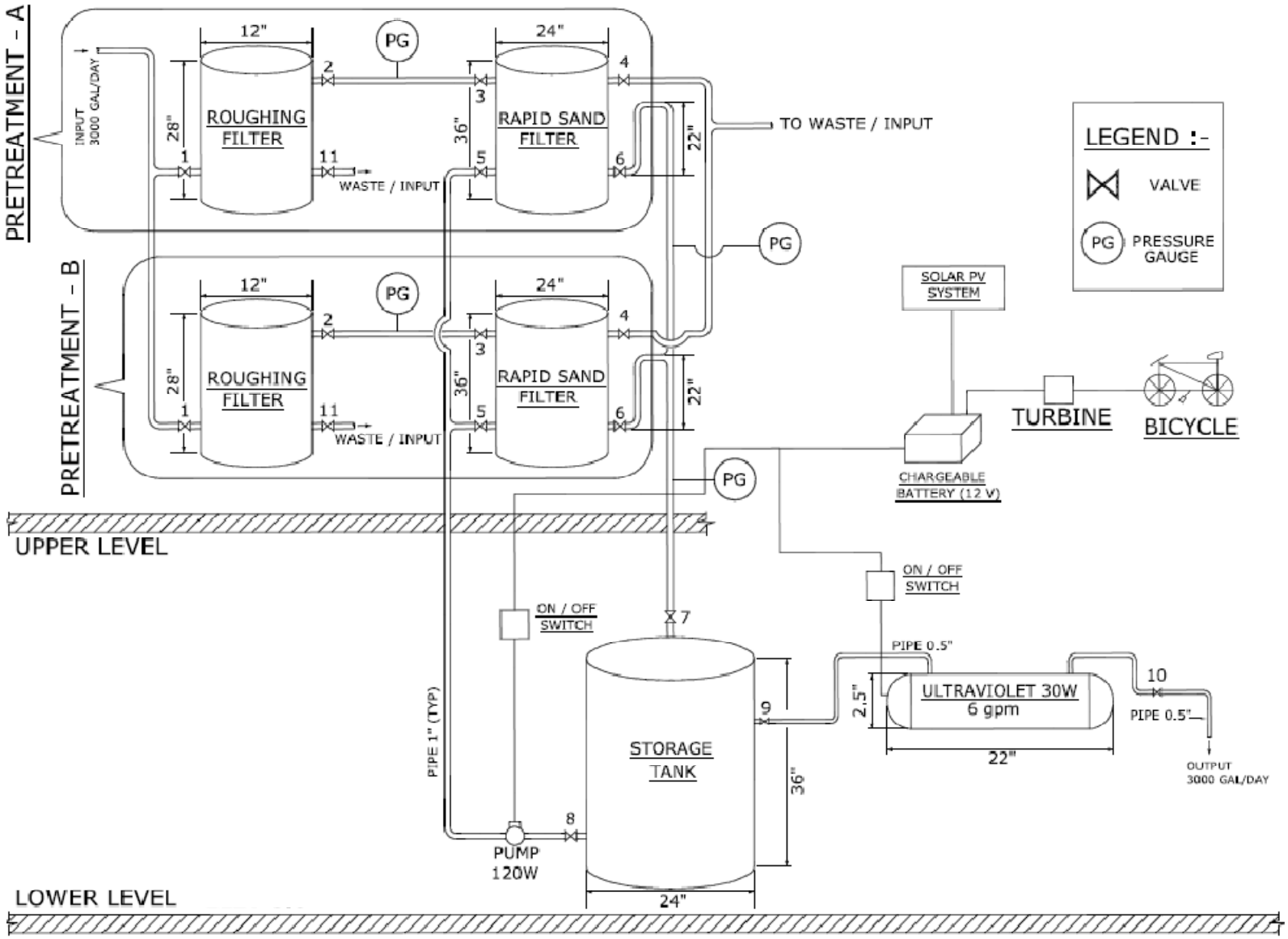


Input Water Bacteria Growth



Output Water Bacteria Growth

Description of Design



Operation & Maintenance

- Community members will operate the system
- Trained system operator for repairs and maintenance
  - Pretreatment
    - Clean roughing filter
    - Backwash rapid sand filter
  - Disinfection
    - Clean quartz sleeve
    - Replace UV bulb
  - Power
    - Periodic replacement of battery
- Lifetime of 6 years

Cost of Implementation

- Labor costs
  - Community education, field and system analysis, system implementation, construction
- Cost of materials: $2,250

Item	Quantity	Unit Price	Sub-Total
1" PVC Ball Valve	18	$ 2.00	$ 36.00
1" Pipe (20 feet)	1	$ 5.00	$ 5.00
Tank, 25" Diameter, 36" Height	3	$ 45.00	$ 135.00
Tank, 12" Diameter, 28" Height	2	$ 47.00	$ 94.00
Backwash Pump 12V	1	$ 150.00	$ 150.00
UV Disinfection Device 5 GPM	1	$ 274.00	$ 274.00
Chargeable Battery 12v 150 Amp-H	1	$ 200.00	$ 200.00
ON/OFF 12v Switches	2	$ 3.50	$ 7.00
PV Panel & Battery Charger 230W	1	$ 690.00	$ 690.00
Man Powered Bicycle 200W DC Generator	1	$ 660.00	$ 660.00
		Total	**$2,251.00**

Cost of Operation

- Cost of operation after 6 years: $1.41/day
  - Equivalent to disinfecting 20 gallons for $0.01

Maintenance Parts	Replacement Frequency	Unit Price	1 Year Cost	3 Year Cost	6 Year Cost
Initial Capital Cost		$ 2,251.00			
UV Disinfection Lamp	Every 2 Years	$ 61.00	-	$ 61.00	$ 183.00
Chargeable Battery 12v	Every 3 Years	$ 200.00	-	$ 200.00	$ 400.00
Others	Every 1 Year	$ 45.00	$ 45.00	$ 135.00	$ 270.00
	Cost of Operation per Day		$ 6.29	$ 2.42	$ 1.41
	Cost of Operation per Gallon		$ 0.00210	$ 0.00081	$ 0.00047

- System is cost effective
  - Low initial cost: ~ $4.00/person
  - Low cost of operation: $400 every 3 years
  - Payout period of 7 months
  - Rate of return of 196%

Recommendations for Implementation

- Implementation stages will take about 3 months
  - Education of community members
  - Site analysis
  - Development of construction plan
  - Construction
  - Testing of disinfected water
  - Training of system operator & community
  - Development of maintenance plan

Project Schedule

- Initial Estimate

	Task	Ashley Ullstrom	Jo-Anne Barcellano	Marilla Lamb	Meshal Hussain	Total
PHASE 1	1.1 PDT Meetings	16	16	16	16	**64**
	1.2 Coordination Meetings	10	10	10	10	**40**
	1.3 Quality Control	7	7	7	7	**28**
	2.1 Research Disinfection Systems	16	-	16	16	**48**
	2.2 Research Types of Alternative Energy	-	16	-	-	**16**
	3.1 Comparison of Alternatives	8	8	4	4	**24**
	3.2 Cost Estimates	-	-	4	4	**8**
	3.3 Pretreatment Disinfection Decision Matrix	8	4	8	4	**24**
	3.4 Power System Decision Matrix	-	4	-	4	**8**
	4.0 Selection of Final Design	10	16	16	16	**58**
	5.0 Documentation of Design	6	6	6	20	**38**
PHASE 2	1.0 Procurement of Materials	10	-	6	-	**16**
	2.0 Construction	16	16	14	16	**62**
	3.0 Testing and Analysis	14	14	14	4	**46**
	4.0 Documentation	12	16	12	12	**52**
	TOTAL HOURS	**133**	**133**	**133**	**133**	**532**

Project Schedule

- Final Hours = 728 hours

Task		Ashley	Jo-Anne	Marilla	Meshal	Total
PHASE 2	1.0 Procurement of Materials	10	-	6	16	**32**
	2.0 Construction	64	64	56	64	**248**
	3.0 Testing and Analysis	28	28	28	8	**92**
	4.0 Documentation	12	16	12	12	**52**
	TOTAL HOURS	**182**	**182**	**182**	**182**	**728**

- 12 hours per person per week for 16 weeks

Project Schedule

	Milestone	Date
PHASE 1	Disinfection system and power source	12/23/2010
	Selection of Final Design	1/27/2011
	Documentation of Design	1/28/2011
	66% of Project Documentation	1/28/2011
PHASE 2	WERC Documentation	3/15/2011
	Construction Complete	3/15/2011
	WERC Competition	4/3/2011
	Final Documentation	4/28/2011

Project Budget

- Our total cost increased by $9,791 due to the additional time spent on the project

	Total Estimated Cost	Total Final Cost
Labor	$ 47,953.68	$ 57,744.78
Non-Labor	$ 1,666.46	$ 1,666.46
Total	$ 49,620.14	$ 59,411.23

- Additional hours and costs were approved by the client

Conclusion

- Disinfection System:
  - Meets all of WERC's criteria
  - Disinfects 3,000 gallons of water in 12 hours to WHO's guidelines
  - Will be very useful in rural, third-world areas
- Competition Results:
  - No results were given at the competition
- Project Completion:
  - Completed scope of work
  - Stayed on schedule
  - Communicated and worked together effectively as a team

Acknowledgements

- Advisors
  - Dr. Wilbert Odem
  - Dr. Marti Blad
  - Dr. Terry Baxter
- Additional thanks to
  - Dr. Bridget Bero
  - Dr. Monroe Weber-Shirk
  - Evan Thomas
  - Kevin Davenport
- WERC Environmental Design Competition

Questions?