



2020 Mid-Pacific Conference

Water Treatment Competition

Competition Date: Saturday, April 24, 2020

Competition Location: University of California, Berkeley





SUMMARY

Protecting water quality and providing clean water is the fundamental focus of the ASCE Mid-Pacific Water Treatment Competition. Students from civil and environmental engineering, related majors, and those passionate about providing clean water come together to participate in the competition each year. The competition gives students a chance to gain hands-on experience with research, design, and laboratory testing involved with water treatment principles as well as an opportunity to develop professional skills such as technical writing and public speaking. It provides students the opportunity to develop leadership and project management skills in the water/wastewater field by engaging students with faculty and water/wastewater professionals.

The ASCE Mid-Pacific Student Water Treatment Competition includes the research, design, presentation, and hands-on construction of a filter made from supplies commonly found in homes/businesses. The filter is loaded with standardized simulated wastewater to test and rank the participants from ASCE student chapters across California, China, and Canada. Students must collaborate in order to apply wastewater treatment principles and provide a solution for a real-world situation. During the competition, the project is judged on sustainability, treatment efficiency, cost, and a technical oral presentation.

CONTACT

Water Treatment Director: Amanda Lee
Midpac2020watertreatment@gmail.com

**Please send any questions or inquiries about the water treatment competition to the above email. Messages/emails sent to any other account will NOT be addressed. Expect replies to take up to 3 business days.*





IMPORTANT NOTES

- If teams have questions or are unclear about rules, please email the Water Treatment Director (Amanda Lee). It is better to ask for clarification than to have points deducted at competition!!!
- The Water Treatment Director has the right to make final decisions about point deductions, rule discrepancies, team order, etc.
- Please send the names and emails of your team's water treatment leads. The Director will be sending out updates and will schedule a video conference call to answer questions.
- Any violations of the rules will result in a 5-point deduction from the team's final score unless otherwise stated.
- Please email the Director if you spot any errors/typos with the water treatment rules.

*****Please remember that the Director is a student. The Director is voluntarily dedicating time to organize this competition so please be patient and understanding as the Director will make mistakes. *****

IMPORTANT DEADLINES

- Registration: See Deadline Information
- Questions & Materials Requests: Emailed by 11:59pm (Pacific Time) Sunday January 12th, 2020
- Design Report: Submitted electronically in PDF format by Sunday March 22, 2020 by 11:59pm (Pacific Time)
- Presentation: Submitted electronically in PowerPoint format by Wednesday April 15, 2020 by 11:59pm (Pacific Time)

The Director will send teams confirmation emails when team presentations and design reports are received.

**Failure to comply with the deadlines listed above will result in a 5-point deduction from the team's final score*





SCENARIO

You own a water system design firm that specializes in building water recycling units for commercial buildings. You and your team of water engineers are hired by a tech startup in the Bay Area to construct and implement a water recycling system in their new LEED certified building that can hold 200 occupants. The water reuse plant will recycle greywater from break room and restroom sinks and turn it into potable drinking water. Over the next couple of months, you design and construct the system and see that it is operating well. However, an unforeseen design flaw arises and causes the system to overflow and spill. Fortunately, your team has contained the spill but the system needs to remain offline until a solution can be found to correct the design flaw. While the recycling system is being repaired, you and your team have to manually treat the building's greywater and provide potable drinking water for the building's occupants.

INFLUENT CONSTITUENTS

Two (2) 5-gallon buckets total will be prepared for each team. All constituents will be added and stirred 24 hours prior to competition and stirred 5 minutes before construction/treatment.

Per 5-gallon bucket:

- 4.5 Gallons of tap water
- 8.0 oz of Folgers Classic Roast Ground Coffee
- ¼ cup of Gatorade Thirst Quencher Fruit Punch Powder
- 5.5 oz Campbell's tomato juice
- 1 18.4 oz box of Betty Crocker Milk Chocolate Brownie Mix
- 3-cups Quaker Quick 1-minute Oats

Pictures of wastewater constituents can be found in Appendix B.





COMPETITION SCORING

The point distribution is listed in Table 1 and is described in the following sections:

Table 1: Point Breakdown Summary

Category	Sub-Category	Points
Water Quality	pH	10
	Turbidity	10
	Electrical Conductivity	5
	Dissolved Oxygen	5
	Volume	5
	Subtotal	/35
Design Report	Filter Design & Analysis	15
	Materials /Cost Analysis	3
	Sustainability	5
	Professional Quality	2
	Subtotal	/25
Construction	Construction Time	8
	Cost of Treatment System	10
	Orderliness of Construction Site	2
	Safety	3
	Overall Teamwork	2
	Subtotal	/25





Oral Presentation	Technical Content	5
	Visuals	1
	Oral Presentation	4
	Q&A Session	5
	Subtotal	/15
Total		/100





WATER QUALITY TESTING

Immediately after construction and loading, the final treated water will be tested using university laboratory equipment. The following five (5) water quality parameters of your final treated product will be graded based on the scoring methods described below. Water quality is worth 35 total points.

pH (Max: 10 points)

pH Ranges	Points Allocated
$7 < \text{pH} < 7.5$	10
$6.5 \leq \text{pH} < 7$ or $7.5 < \text{pH} \leq 8$	8
$6 \leq \text{pH} < 6.5$ or $8 < \text{pH} \leq 8.5$	6
$5.5 \leq \text{pH} < 6$ or $8.5 < \text{pH} \leq 9$	4
$5 \leq \text{pH} < 5.5$ or $9 < \text{pH} \leq 9.5$	2
All other pH ranges	0

Turbidity (Max: 10 points)

Turbidity Ranges	Points Allocated
$\text{NTU} \leq 15$	10
$15 \leq \text{NTU} < 50$	8
$50 \leq \text{NTU} < 85$	6
$85 \leq \text{NTU} < 120$	4
$120 \leq \text{NTU} < 155$	2
$\text{NTU} > 155$	0





Electrical Conductivity (Max: 5 points)

Target: Minimal $\mu\text{S}/\text{cm}$

Grading: (Your rank / number of teams) * 5 points

Teams will be ranked from worst to best with #1 being the team with the electrical conductivity furthest from the target value.

Dissolved Oxygen (Max: 5 points)

DO is measured as % saturation.

DO Range	Points Allocated
100% < DO < 90%	5
91% < DO < 80%	4
81% < DO < 70%	3
71% < DO < 60%	2
All other DO values outside of these ranges (e.g. The DO meter is out of range because an excessive quantity of oxidant was added)	0

Volume (Max: 10 points)

Target: 9 gallons

Grading: (Your effluent volume in gal / 9 gallons) * 5 points

Note: There is a maximum of 5 points allotted for volume. It is conceivable, however unlikely, that a team could have a volume greater than 9-gallons; in that case, the team would still only receive 5 points.





DESIGN REPORT

Each team is required to submit a design report detailing the overall project. The report must include a description of the design process, treatment principles utilized, environmental impacts, a cost analysis, and tables of material and operational costs. The design report is worth 25 total points. Please submit an electronic version of your report in PDF format via email to midpac2020watertreatment@gmail.com by no later than 11:59 PM Pacific Time on Sunday March 22, 2020. Hard copy submittals will not be accepted.

Formatting

The following format is required:

- **Report Cover Page:** Must contain school name, team name, and competition name: “2020 ASCE Mid-Pacific Student Water Treatment Competition”
- **Table of Contents:** Limited to a total of one (1) page.
- **Body of Work:**
 - Must be a minimum of 1,000 words
 - May not exceed ten (10) pages. Cover page, table of contents, and appendices are not included in the page count.
 - Use 12-point Times New Roman font, single spaced, using normal width character spacing, and 1-inch margins on all sides
 - Headings may be of any font, size, or color
 - Body pages shall be numbered, beginning with ‘1’
 - Captions used for any photographs, tables, line drawings, graphs, or other figures shall have normal width character spacing and be no less than 10-point font
 - All work, figures, or tables not generated by the authors must be cited.
 - A list of references or works cited page should be included is used. This list will not be counted as part of the report page limit.
 - Acknowledgements: any assistance received from others not on the team shall be recognized. Acknowledgements will not be counted as part of the report page limit.
 - Appendices: Pages shall be numbered in such a way that the appendix and page number are clearly listed (i.e. A1, A2, B1, B2, etc.). There is no limit to appendix length but it must only contain relevant materials.
 - Paper: The report and appendices shall be presented on 8.5”x 11” pages using portrait or landscape orientation as appropriate.





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- Miscellaneous: Photographs, tables, line drawings, graphs, headers, and footers are permitted and shall be counted as part of the page limits defined above.

One (1) point will be deducted from the team's design report score for each format violation.

Report Content

The design report must include the following content. The point distribution for grading of each section is presented in Table 1.

- **Treatment System Discussion:** The body of the design report shall contain a description of the treatment system and how it works. The system design will be judged based on the approach each team used to solve the problem as well as the industry treatment principles implemented in the design process. This section must include clear descriptions of engineering design processes, lab techniques used, and test results obtained.
- **Materials & Cost Analysis:** The design report must include a material list with a brief explanation and justification of each material selected. See Appendix A for a list of permitted materials. The design report must include a cost analysis which must include both a material cost estimate and an operational cost estimate. The total cost will be taken as a sum of the material and labor costs. Teams will be ranked by the lowest cost estimate. Material cost will be determined by the number of units bought regardless of how much was used. For example, if you buy a 12 oz. bottle of hydrogen peroxide but only use 5 oz, the total cost will be for the 12 oz. bottle.
- **Sustainability:** The design report must include an explanation of the sustainability aspects of the treatment system. This section must include a life cycle assessment (LCA) where the sustainability of materials, tools, and waste products are assessed. Include the environmental impacts of materials used and decisions made regarding choices to minimize cost or reduce environmental impact.
- **Professional Quality:** Professional quality of the design report will be based on organization, presentation, quality of writing, and effectiveness of figures, tables, and other resources presented in the report.

Plagiarism of any kind will not be tolerated. Teams caught plagiarizing any portion of their design report will be disqualified.





CONSTRUCTION & TREATMENT

Teams will construct their treatment system as described in the project report. This will include construction, chemical treatment, loading, and filtration. Construction and treatment are worth 25 total points and will be judged based on orderliness of construction site, construction and treatment time, cost of the treatment system, safety, and overall teamwork - see scoring and deduction methods presented below and in Table 1 for point distribution.

Construction & Treatment Time

Construction & Treatment time will include:

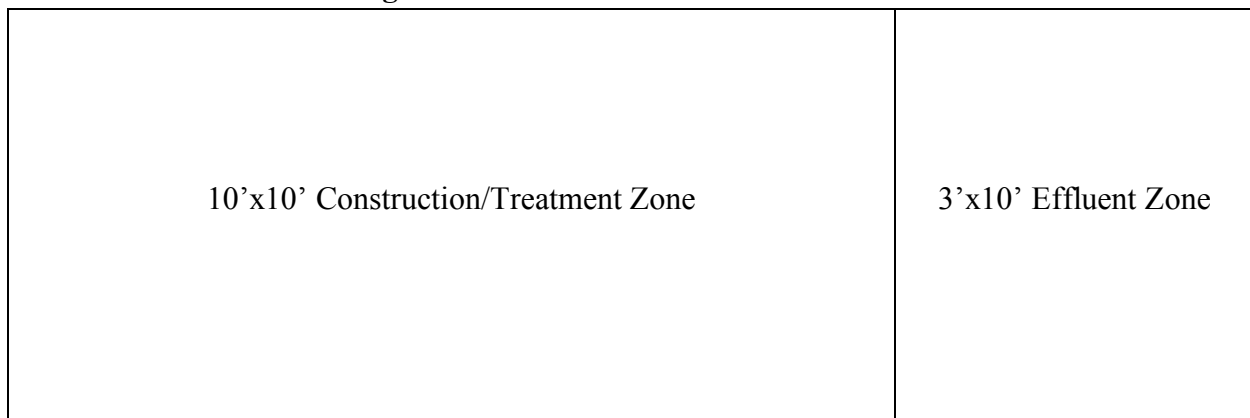
- Construction
- Chemical measuring & mixing
- Loading
- Filtration

Teams may choose to allocate their time to these components as they see fit.

Construction Details

Teams will each be given a 10'x13' area which will be marked on the floor as shown in Figure 1. The site limits will be measured from the inside of the boundary marker. Sites are not guaranteed to be completely flat or level. Sites will be located on either concrete, pavement, or bricks. Teams must conform to and use all university provided sites.

Figure 1: Construction Area Breakdown





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- Operators must stay within the 10'x10' area. All construction materials, equipment, and chemicals must stay within the 10'x10' construction/treatment zone. Only the effluent basin and treated water may enter the effluent zone.
 - Only one operator is allowed in the construction area at a time (teams will only be charged for one operator for labor). However, teams may have as many operators as needed. Teams may switch out operators as many times as needed and repeat operators. Operators are only allowed to leave the construction area if switching out with another operator. For example, a team can have three operators but only have one operator in the construction area at a time. The team can substitute the first operator (in charge of opening materials) with the second operator (in charge of mixing chemicals) as long as only one operator is in the construction area at one particular time.
 - Construction/treatment time will start once the head judge says "go" at which each judge will start the clock. Construction/treatment time will end after operators move the effluent basin to the effluent zone, and once all operators leave the 10' x 13' space and say "time." No further water or chemicals can be added to the basin once the basin is moved to the effluent zone.
 - Teams will place all their unassembled raw materials and tools in their designated 10'x10' construction/treatment zone along with two provided 5-gallon buckets of contaminated water and two provided stirring sticks. Prior to beginning the construction phase, judges will compare the provided materials list in the team's technical report to the materials present at the competition.
 - Teams shall not pre-assemble, pre-cut, pre-label, or tamper with materials prior to beginning of the construction, although decorations are encouraged. Teams must provide their own markers, tape measure, measuring cups, and scales, as needed. Items used for measuring or marking should not be included in the cost estimate.
 - All prewashed materials must be dried and must be placed in their original packaging with the exception of loose sand, GAC, pebbles, and lava rocks which can be placed in clear containers based on the predetermined quantity sizes in Appendix A. The original containers and/or bags should accompany these items. Packaging shall not be added to the materials list or the cost analysis portion of the design report. All materials not prewashed should be in original sealed packaging, as if purchased from the store. For example, if hydrogen peroxide is purchased, the hydrogen peroxide bottle should be sealed in the manner bought from the store.
 - With the exception of materials delivered in their original packaging, all materials shall be delivered to the construction area in unit quantities that match the unit quantities provided in the Competition Rules. For example, 2" x 4" lumber is specified in 4 ft lengths in the Materials List (see Appendices). Therefore, 2" x 4" lumber placed in the competition area shall be in 4 ft sections, regardless of the initial length of purchase. Play sand is specified in a per pound





basis. Therefore, if used, play sand must either be in the original packaging, or if washed, then must be delivered in 1-lb. quantities.

- Battery-powered tools are NOT permitted. This includes but is not limited to power saws, power blades, and cordless drills.
- Teams must provide their own tools based on the approved list given in Appendix A.
- Construction/treatment time may not exceed 40 minutes.
- To avoid damage to floor materials, each team must provide a back-up basin to collect any effluent discharged after the end of the treatment system. The back-up basin will not be included in the cost of the system. Any effluent collected after the effluent basin is moved to the effluent zone will not be included in volume or water quality testing.

Scoring

The Construction category is worth 25 points out of the 100 total points in the competition and the point allocations are shown in Table 1. The orderliness of the site during the construction phase, the operators' overall teamwork, and the safety will be determined based on the judge's discretion.

Points for construction time will be awarded based on the following guidelines:

Operation Time (minutes)	Points Allocated
Construction/Treatment Time ≤ 20	8
$20 < \text{Construction/Treatment Time} \leq 22.5$	7
$22.5 < \text{Construction/Treatment Time} \leq 25$	6
$25 < \text{Construction/Treatment Time} \leq 27.5$	5
$27.5 < \text{Construction/Treatment Time} \leq 30$	4
$30 < \text{Construction/Treatment Time} \leq 32.5$	3
$32.5 < \text{Construction/Treatment Time} \leq 35$	2
$35 < \text{Construction/Treatment Time} \leq 37.5$	1
$37.5 < \text{Construction/Treatment Time} \leq 40$	0





Cost of Treatment System

The cost of the treatment system is worth 10 points. The lowest cost treatment system will receive 10 points. The cost of the treatment system includes the cost of materials, tools and labor (\$30 regardless of construction time and number of operators used) used for construction as listed in the Appendices. Trash or recycling receptacles do not need to be included in the cost of the treatment system. Cost will be based on how much material is purchased; it does NOT consider how much is used. For example, if you buy a 12 oz. bottle of hydrogen peroxide but only use 5 oz, the total cost will be for the 12 oz. bottle. (Your rank / number of teams) * 10 points. Teams will be ranked from worst to best with #1 being the team with the cost furthest from the target value.

Safety

Safety is critical to any engineering project. Operators must wear personal protective equipment including hard hats, safety gloves, safety glasses, closed-toed shoes, and long pants at all times during the construction and treatment phases. Any person handling chemicals must wear a long-sleeved shirt or other article of clothing to cover arms and hands must be protected using chemical hazard protection gloves (i.e. latex or nitrile). During any process involving chemicals, the operator must wear nitrile/latex gloves. During building/any part of the construction phase, the operator must wear safety gloves. If teams only have one total operator, the operator must switch gloves during the chemical and construction phase. If at any point a judge deems safety is being violated by a team, the judge may stop the team from proceeding and will review safety practices. The stopwatch measuring the team's construction time will continue running during this time.

ORAL PRESENTATION

Each team shall make an oral presentation on their treatment system. Presentations will be evaluated on technical content and delivery. Oral presentations shall be presented in English. Presentation order shall be randomly selected before the competition begins and shall be provided at the time of on-site registration. A maximum of two team members may make the presentation. No other members may stand up with the presenters. Only members of the presenters' school shall be allowed to attend the presentation of that school. No notes or visual aids other than the PowerPoint (i.e. posters) are allowed during the presentation. The presenters will only be allowed to use their PowerPoint during the presentation. Teams must bring their own clickers and should bring a USB drive as a backup with their presentation. The Director will have a Mac laptop for teams to use and will load all team PowerPoints. Teams will not be allowed to use their own laptops.





Teams are required to use PowerPoint to present their projects. Please submit your team's PowerPoint presentation via email to midpac2020watertreatment@gmail.com by 11:59 PM (Pacific Standard Time) on Wednesday April 15, 2020. Two points will be deducted from the overall Oral Presentation score for changes submitted after the deadline.

Scoring

The presentations will be scored by the parameters listed below. Point distribution is denoted in Table 1.

- **Technical Content:** Presentations must include, at least, the system design and treatment process used, materials used, a cost analysis, and a discussion of sustainability. The content may be presented in any order and is not limited to these components.
- **Oral Presentation:** The presentations shall be five (5) to six (6) minutes in duration. There will be a 5-second grace period to account for timer (stopwatch) reaction. A maximum of two team members may present the PowerPoint and answer questions. No notes or visual aids other than the PowerPoint (i.e. posters) are allowed during the presentation. The presenters will only be allowed to use their PowerPoint during the presentation. The Director will give time cues when the time is at 5-minutes and 5:30-minutes.
- **Visuals:** Teams may only use PowerPoint for their presentations. Teams may use visual aids on the PowerPoint including graphs or photographs to enhance the presentation. Video clips may be included but the team should troubleshoot any technical difficulties before. If technical difficulties arise from video troubleshooting during the presentation, the time will keep running. NO visuals other than the PowerPoint can be used.
- **Question & Answer:** There will be a 5-minute question-and-answer session immediately following the presentation. Only the panel judges will be permitted to ask questions.
- Points shall be deducted if the duration of the presentation is less than 5-minutes or more than 6-minutes, as follows.

Presentation Time	Points Deduction
4:45 – 4:54 or 6:06 – 6:15	1
4:35 – 4:44 or 6:16 – 6:25	2
4:25 – 4:34 or 6:26 – 6:36	3
So on...	





WATER TREATMENT COMPETITION APPENDICES

Appendix A: Materials List

Each team is permitted to submit a request to add two (2) materials or tools to this list. Please submit for approval to midpac2020watertreatment@gmail.com by January 12, 2020. These requests will be evaluated for appropriateness in the competition. If your suggestions are accepted, these materials will become accessible to all teams. Teams requesting additional material must also provide the unit of measure and the unit cost which will be verified by the competition host.

All items must be in its original packaging (see exceptions). For example, if a store sells hardware cloth in 10 square foot sizes, bring the unopened packaging to the competition. The hardware cloth will therefore be charged as \$6.70 in the cost analysis section of the design report regardless of how much is used during the construction phase.

Table 2: List of Materials and Associated Costs

Item	Unit	Cost (\$/unit)
1/2" Hardware Cloth	/sq. ft.	0.67
1/4" Hardware Cloth	/sq. ft.	0.67
4 Gallon Trash Can	/unit	2.50
13 Gallon Trash Can	/unit	5.00
20 Gallon Trash Can	/unit	7.00
32 Gallon Trash Can	/unit	13.00
2' Ladder	/unit	30.00
4' Ladder	/unit	40.00
6' Ladder	/unit	50.00
2" Adjustable Spring Clamp	/unit	6.00
2" PVC Pipe Elbow	/unit	3.00
2" x 4" 3M Steel Wool	/unit	0.83





2" x 4" Dimensional Lumber	/4 lin. ft.	2.00
2" x 6" Dimensional Lumber	/4 lin. ft.	2.50
4" x 4" Dimensional Lumber	/4 lin. ft.	3.00
3/4" Black Electrical Tape	/lin. ft.	0.06
3/4" Thick Plywood	/4 sq. ft.	1.00
3/8" Thick Plywood	/4 sq. ft.	2.00
3/8" Nylon Rope	/lin. ft.	0.20
30 Gallon Tote	/unit	12.00
36 Gallon Garbage Bag	/unit	0.60
5 Gallon Bucket	/unit	3.00
5 Gallon Bucket Lid	/unit	1.50
5/8" Carpet Pad	/sq. ft.	0.50
8" x 6" x 2" Grout Sponge	/unit	2.00
Alum (McCormick)	/oz.	1.50
Aqueon Water Clarifier	/oz.	2.50
All Purpose Gravel (Quickrete)	/50 lb.	10.00
Astroturf	/sq. ft.	4.00
Baking Soda	/oz.	0.10
Borax (20 Mule Team)	/oz.	1.00
18 cup Brita Filter	/unit	12.00
1" 3 Ring Binder	/unit	3.00
2" 3 Ring Binder	/unit	5.00
Vinegar	/1 cup	1.00
Bounce Dryer Sheet	/20 units	5.00
Bentonite Clay	/oz.	1.50





Paper Towels	/roll	1.50
Burlap	/sq. ft.	0.30
Canvas Drop Cloth	/sq. ft.	0.50
Charcoal	/lb.	0.50
Clorox Bleach, Concentrated	/5 cups	2.50
Clorox Disinfecting Wipes	/15 units	1.25
Clorox Water Clarifier	/oz.	2.50
Clorox pH Up	/oz.	3.00
Coarse Compost	/gallon	3.00
CoCo Liner, 18"	/unit	4.00
Coconut Fiber Husk	/gallon	1.50
Coffee Filter	/unit	0.05
Cotton Fabric	/sq. yard	3.00
Commercial Grade Fine Sand	/lb.	0.20
Commercial Grade Sand	/lb.	0.15
Cotton Balls	/50 units	0.50
Diatomaceous Earth	/lb.	2.50
Duct Tape	/yard	0.50
Epsom Salt	/oz.	0.50
Fiber Twine	/ft.	0.15
Gelatin (Knox Unflavored)	/5 oz.	1.50
Granular Activated Carbon	/oz.	0.50
Gypsum	/lb.	0.25
Hydrogen Peroxide	/3 cups	1.50
Lava Rock	/cu. ft.	5.00





Lemon Juice	/5 fl. oz.	2.50
8 oz. Mason Jar	/unit	1.50
Masking Tape	/yard	0.20
Mylar Emergency Sleeping Blanket	/unit	3.00
Milk of Magnesia	/oz.	3.00
6.5 Gallon Milk Crate	/unit	5.00
Paint Tray	/tray	2.00
Packing Tape	/yard	0.25
Peat Moss	/cu. ft.	5.00
Powdered Activated Carbon	/oz.	0.50
Powdered Chalk	/oz.	0.50
Pebbles, Large	/5 lb.	2.50
Pebbles, Pond/Landscape	/0.5 cu. ft.	2.50
Pickling Lime	/oz.	0.20
Plaster of Paris	/lb.	0.50
Plastic Tarp	/sq. ft.	0.10
Play Sand	/lb.	0.10
Plumbing Epoxy Putty	/putty	2.50
OxiClean Stain Remover	/lb.	1.00
Potassium Permanganate	/5 oz.	5.00
ABS Pipe, 1-1/2" Diameter	/5 lin. ft.	1.50
ABS Pipe, 2" Diameter	/5 lin. ft.	2.50
Copper Pipe, 1/2" Diameter	/5 lin. ft.	5.00
Copper Pipe, 1" Diameter	/5 lin. ft.	10.00
Corrugated Pipe, 3" Diameter	/5 lin. ft.	2.50





Corrugated Pipe, 4" Diameter	/5 lin. ft.	4.50
PVC Pipe, 1" Diameter	/5 lin. ft.	1.00
PVC Pipe, 1-1/2" Diameter	/5 lin. ft.	1.50
PVC Pipe, 2" Diameter	/5 lin. ft.	2.00
Pool Sand Filter	/lb.	0.20
Pumice Stone (1 CF)	/cu. ft.	3.00
Rubbing Alcohol	/3 cups	1.50
Salt (Morton Iodized Table Salt)	/20 oz.	1.00
Sham-Wow	/sq. ft.	3.00
Stainless Steel Safety Wire	/lb.	3.00
Standard Air Conditioning Filter	/unit	5.00
Sterilite 3 Drawer Medium Countertop (13 5/8" x 11" x 10")	/unit	10.00
Scotch Tape	/yard	0.10
Terrycloth Rag	/lb.	2.50
Tote, 5 Gallon	/unit	6.00
Tote Lid, 5 Gallon	/unit	1.00
Tote, 10 Gallon	/unit	8.00
Tote Lid, 10 Gallon	/unit	1.00
Tote, 13 Gallon	/unit	10.00
Tote Lid, 13 Gallon	/unit	1.00
Tote, 18.5 Gallon	/unit	12.00
Tote Lid, 18.5 Gallon	/unit	10.00
Toilet Paper	/roll	1.50





TSP/90	/lb.	3.00
Turtle Wax Hard Shell Paste Wax	/fl. oz.	0.50
Upholstery Fabric	/sq. yard	4.00
Weed Control Fabric	/sq. ft.	0.10
Window Screen Mesh	/3 sq. ft.	0.50
Wood Mulch	/cu. ft.	5.00
Vanity Fair Napkins	/10 napkins	0.10

Table 3: Labor and Tool Costs

Item	Cost (\$/unit)
Operator	30.00 (flat fee)
Adjustable Wrench	3.00
Basic Socket Set	5.00
Caulking Gun	2.00
Channel Locks	1.50
Hand Saw	10.00
Pliers	1.50
Scissors	2.00
Screwdriver	1.00
Standard Builder's Hammer	5.00
Utility Knife	2.00
Wire Cutters	2.00



Pipe Cutters	10.00
Pipe Wrench	5.00

Appendix B: Wastewater Constituents

All wastewater constituents can be bought from Amazon. Pictures shown here are for reference only when purchasing constituents.

1. Folgers Classic Roast Ground Coffee



Folgers Classic Roast Ground Coffee (48 oz.) Single Can

by [Folgers](#)

Price: **\$23.25** ✓prime

Get \$70 off instantly: Pay **\$0.00** \$23.25 upon approval for the Amazon Prime Rewards Visa Card. No annual fee.

Note: Available at a lower price from [other sellers](#), potentially without free Prime shipping.

- Medium roast
- Mountain grown beans
- Makes up to 380 - 6 oz. cups
- Easy open lid and grip handle
- Interlocking AromaSeal lid

19 new from **\$23.07**

[Report incorrect product information.](#)

AMAZON FRESH

2. Gatorade Thirst Quencher Fruit Punch Powder





Gatorade Thirst Quencher, Fruit Punch, 51 Ounce Powder

by [Gatorade](#)

★★★★★ [184 ratings](#) | [7 answered questions](#)

Price: **\$8.38** (\$0.16 / oz)

In Stock.

Ships from and sold by Prime Pantry.

Want it Friday, Oct. 4? Order within the next **6 hrs 7 mins** [Details](#)

- 51 ounce powder, makes 6 gallons
- Fruit Punch
- When you sweat, you lose more than water. Replace what has been lost with Gatorade
- There's more to sweat than water. To properly rehydrate and refuel, you need to replace lost fluids, electrolytes and carbohydrates.
- Trusted by some of the world's best athletes

3. Campbell's Tomato Juice



Campbell's Tomato Juice, 5.5 Fluid Ounce (Pack of 6)

by [Campbell's Tomato Juice](#)

★★★★★ [11 ratings](#)

Price: **\$2.47** (\$0.07 / oz)

In Stock.

Ships from and sold by Prime Pantry.

Want it Friday, Oct. 4? Order within the next **6 hrs 6 mins** [Details](#)

- 100% tomato juice
- 30 calories per can
- Good source of antioxidant vitamins A & C
- Made only with peak season tomatoes
- Gluten Free

4. Betty Crocker Milk Chocolate Brownie Mix





by Betty Crocker

General Mills Betty Crocker Milk Chocolate Brownie, 18.4 oz

★★★★☆ 10 ratings

Price: **\$1.79** (\$0.10 / Ounce)

In Stock.

Ships from and sold by AmazonFresh.

- Bowl to Oven in Minutes!
- Betty Crocker FAVORITES
- Kosher

Freshness Guarantee

We guarantee that you will be satisfied with the freshness and quality of this product, and that it will be delivered to your home within any applicable use by sell by best by or expiration dates.

5. Quaker Quick 1-minute Oats



by Quaker

Quaker Quick 1 Minute Oats, 100% Whole Grain, 42 oz

★★★★☆ 14 ratings

Was: \$4.19

Price: **\$3.49** (\$0.08 / Ounce)

You Save: **\$0.70 (17%)**

In Stock.

Ships from and sold by AmazonFresh.

- Made from just ONE ingredient - 100% natural and whole grain oats
- A healthy breakfast option ready in 60 seconds
- Naturally sodium-free
- Can be added as a healthy ingredient to a number of recipes
- Try topping with fresh or dried fruits, nuts or cinnamon

