Rethinking Water at UCLA UniCamp

Environment 180 Senior Practicum

Hunter Connell, Charles Falconer, Daniel Fong, Kyle Graycar, Diana Nguyen, Emily Parker, Nathan Tsang

Advisor: Dr. Michael McGuire

Client: UniCamp (Mr. Wally Wirick, Executive Director)

June 13, 2014

Table of Contents

Table of Figures

EXECUTIVE SUMMARY

UCLA UniCamp is a nonprofit 501.c3 organization that brings about 1,000 Los Angeles-area students from low-income families to summer camp each year. UniCamp is the official charity of UCLA students and over 500 UCLA students volunteer as counselors each year. UniCamp takes place at Camp River Glen, a small site located on National Forest land in San Bernardino County. Camp River Glen is operational for about three months (June-August) out of the year. During the 2013 – 2014 school year, a group of undergraduates in the UCLA Environmental Science Senior Practicum worked closely with UniCamp's executive director, Wally Wirick, to make recommendations to improve the camp's water and wastewater systems.

The mission statement for this project is to better manage UniCamp's water and wastewater through new infrastructure, technology, and education. To achieve this goal, the practicum team looked to practical engineering solutions to improve Camp River Glen's aging water infrastructure. The team also focused on increasing the camp's sustainability through improved operations and education about water conservation. The primary issues addressed in this report are related to both drinking water and sanitary waste at Camp River Glen.

The first area of analysis was the current drinking water infrastructure at Camp River Glen. Currently, Camp River Glen receives its drinking water from the Santa Ana River, which runs adjacent to camp. A cistern draws water indirectly from the river, and the water is then treated onsite. Water treatment at Camp River Glen is a two-step process and includes chlorine disinfection and filtration. The current water treatment system poses several problems. In 2012, San Bernardino County cited UniCamp for insufficient contact time in the chlorine disinfection system. The chlorine is not in contact with the water long enough to adequately disinfect it, due to the fact that water can be distributed to camp directly from the water treatment shed without first going to the drinking water storage tank. Another issue with the current system is that the valve controlling the amount of chlorine entering the water frequently vibrates open due to vibrations from a nearby pump. Finally, heavy rainstorms significantly increase the turbidity in the Santa Ana River, forcing UniCamp to shut down its treatment system and rely only on excess water stored in the tank.

By calculating CT (concentration x contact time), it was found that installing a second pipe between camp and the holding tank would address the citation, as water would flow to the storage tank before reaching camp. It is also recommended that one sample tap and flow meter be installed in each of the new pipes to allow UniCamp to measure the daily chlorine residual, turbidity, and overall water use. To fix the loosening of the chlorination valve, the valve should be fixed so that it does not vibrate open. Adding a pre-filter directly upstream of the current filters will address the increased turbidity after a rainstorm.

All wastewater produced at Camp River Glen is piped directly into underground holding tanks. The tanks themselves sometimes overflow and contaminate the surrounding areas with wastewater. The tanks may also be slowly leaking underground, unnoticed by camp staff. It is recommended that UniCamp conduct monthly sampling of the Santa Ana River to ensure the camp is not contaminating the river.

In addition to analyzing UniCamp's drinking water infrastructure and management, the practicality of onsite alternative energy was also considered. It was found that both solar and micro hydroelectric energy systems would be impractical for Camp River Glen and should not be installed.

Each day that camp is in session, wastewater must be pumped out of the tanks and trucked away for proper sewage disposal. Each truck trip costs $320 and removes about 2,000 gallons of sewage. Thus, mechanisms to minimize the cost of wastewater removal were analyzed. For example, a wide array of possible graywater systems was explored. It was found that a cabin graywater irrigation system would be an effective method for managing wastewater. A cost-benefit analysis indicated that the payback period for this system is just one season of camp. The feasibility of installing a composting toilet was also investigated. It was found that a composting toilet may be feasible but is more expensive than a graywater system. Both San Bernardino County and the US Forest Service must approve a composting toilet before it is implemented. Based on these findings, UniCamp should consider a composting toilet pilot program in the long term.

Other methods for improving sustainable water management were also researched. It was found that behavioral changes at UniCamp could increase water conservation significantly. Changing personal hygiene habits and conducting routine water leakage checks are among those changes. Operational changes could also decrease water use at UniCamp. For example, it was found that installing water meters and low-flow water fixtures would have a significant impact at UniCamp. Spreading awareness to campers through educational activities will also yield significant water conservation benefits.

Recommendations

The final recommendations for UniCamp are as follows:

- Repair the dosage valve for chlorine disinfection system, to prevent it from vibrating open
- Install Rosedale Model NCO8-30 pre-filter bag into treatment system to handle high levels of turbidity after storms
- Measure chlorine residual daily directly downstream of bag filters using DPD Colorimetric method (also measure residual in downhill sample tap for CT calculations)
- Take daily turbidity measurements at same time and place as chlorine residual
- Sample river water once per month to test for evidence of septic tank leakage or other contamination
- Monitor off-season wastewater levels in underground tanks for evidence of leakage
- Install a pilot graywater irrigation system in one cabin and install additional systems if pilot is successful
- Install a pilot composting toilet and install additional composting toilets if pilot is successful
- Install water meters throughout camp to collect water use data
- Implement water-conserving operational changes such as the installation of low-flow fixtures
- Incorporate water conservation activities into camper education programs

INTRODUCTION

UCLA UniCamp was founded in 1934 by a group of 11 students, and was named the official charity of UCLA students by the UC Regents in 1947. UniCamp is a nonprofit organization that brings about 1,000 low-income students from underserved neighborhoods to summer camp each year. The campers, ranging from 10 - 18 years old, get the chance to experience nature and engage in activities like archery and mountain biking, while also developing character and leadership skills. UniCamp takes place at Camp River Glen, which is located about two and a half hours from UCLA in the mountains of San Bernardino County on National Forest Service land. During the past year, a group of students from the UCLA Environmental Science Senior Practicum has worked closely with the camp's executive director, Wally Wirick, to make recommendations for the camp's water systems.

The mission of the senior practicum group is to better manage water and wastewater at UniCamp through new infrastructure, technology, and education. To achieve this goal, the practicum team looked at practical engineering solutions to improve Camp River Glen's aging water and wastewater infrastructure. See Figure 1 for a simplified site plan of the water infrastructure at Camp River Glen. Additionally, the team focused on increasing the camp's sustainability through operational improvements. The hope is that the recommendations presented here can also be incorporated into UniCamp's new environmental education program, called Outdoor Science Opportunities, to improve water conservation at camp. Since UniCamp only operates during the summer months, the recommendations presented in this report consider the camp's seasonality.

Since this is the first practicum team to tackle this project, many of the recommendations consist of collecting baseline data for use by future teams. This team envisions a future for UniCamp that includes a fully integrated environmental curriculum, energy independence, and zero truck trips for hauling out waste.

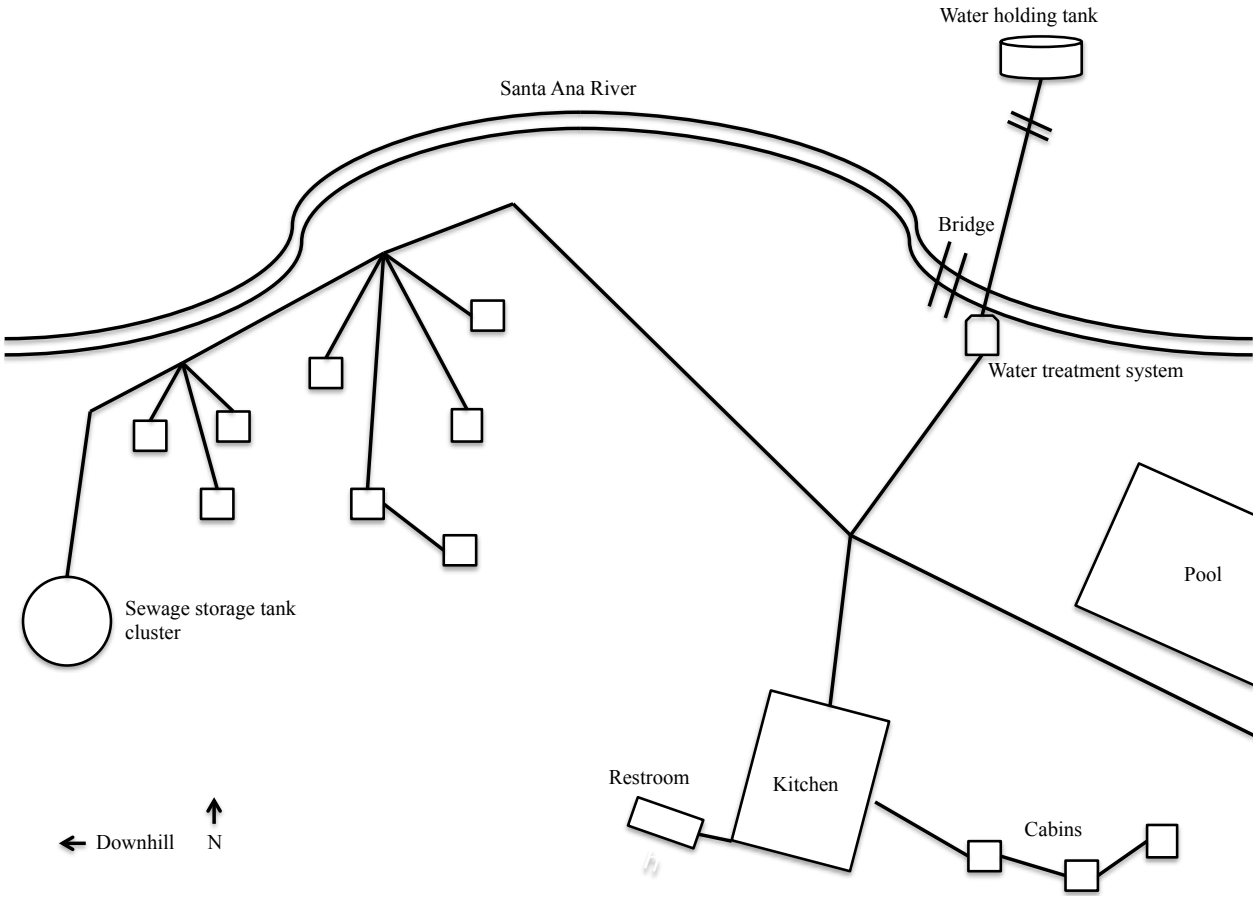


Figure 1: Simplified schematic of Camp River Glen.

WATER QUALITY AND TREATMENT

To ensure the health of its campers, it is essential that UniCamp have a reliable and safe drinking water system. The current treatment system has three issues: inadequate disinfection, inconsistent chlorination, and the inability to handle turbid water. Infrastructural and operational changes were explored to address these flaws. Additionally, since all wastewater is stored in underground sewage tanks, the possibility of tank leakage into the Santa Ana River was addressed.

Water Treatment

CURRENT WATER SYSTEM

UniCamp's water system is only operational during the summer season. A small branch of the Santa Ana River runs through Camp River Glen and serves as UniCamp's water source. An enclosed cistern pulls water from the river. Because water is not removed directly from the river, the water source is considered "groundwater under the direct influence of surface water"

(GWUDI). UniCamp's water treatment system is classified as a transient non-community water system. It consists of two main parts: chlorine disinfection and bag filtration.

A small pump diverts a portion of the water from the cistern to a calcium hypochlorite chlorinator and then back to the cistern, as shown in Figure 2. A valve on the water pipe that connects the cistern and the disinfection system controls the flow of water through the chlorinator. Increasing water flow through the chlorinator increases the amount of chlorine dissolved in the water.

The system uses calcium hypochlorite in the form of solid tablets manufactured by Accu-tab. Each tablet resembles a hockey puck and is about 3 inches in diameter. UniCamp uses a tablet feeder made out of a plastic PVC pipe (see Appendix A). Water flows across the bottom of the feeder pipe and erodes the bottom tablet, causing chlorine to dissolve into the water. The chlorinator is set to maintain 1 part per million (ppm) of chlorine residual in the cistern (see Appendix B1). However, past data shows that the residual ranges from 0.1-5 mg/L, with an average of 1.08 mg/L (1 mg/L is equivalent to 1 ppm).

The majority of the water flows from the cistern to the filtration system through a separate pipe. UniCamp uses a Rosedale stainless steel bag filtration system for particulate and pathogen removal (see Appendix C). This system consists of 2 cartridge pre-filters and 2 giardia bags. These bags rid the water of pathogens and turbidity through size exclusion. Two of the main pathogens regulated by the Surface Water Treatment Rule are *Cryptosporidium* and *Giardia.* When operating at optimal performance, the filtration system removes 1-log *Cryptosporidium*, 2-log *Giardia*, and 0-log viruses. The accumulation of chemicals, particles, and biological growth on the filter, known as fouling, negatively affects filtration performance and water quality. To prevent any complications from fouling, the four filter bags are replaced annually in June before the first session of camp.

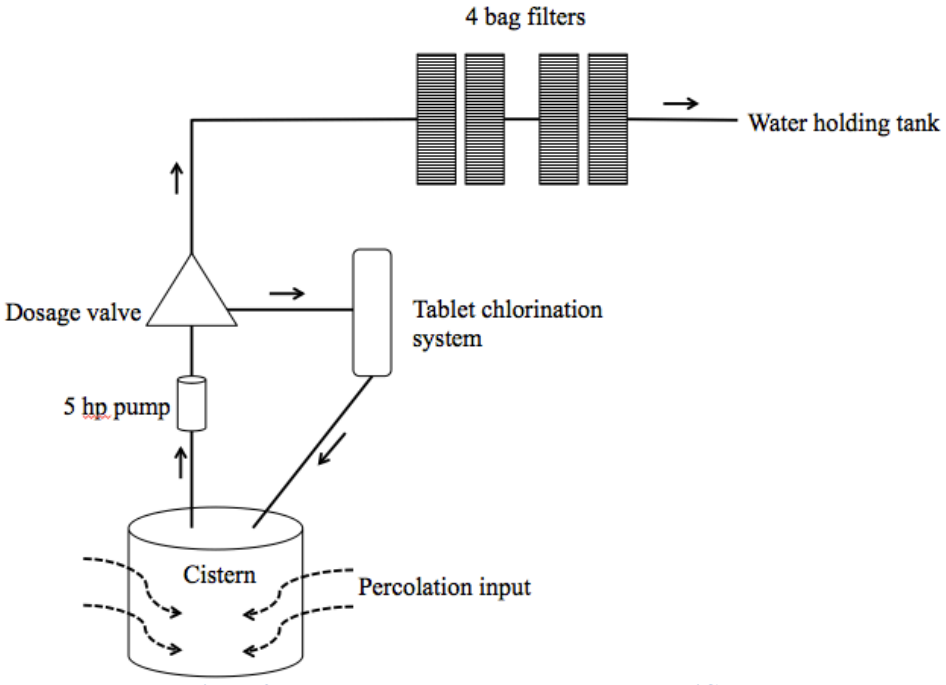


Figure 2: The water treatment system used by UniCamp.

Figure 3 shows the single-pipe system currently in place at Camp River Glen. The cistern and chlorination and filtration systems are housed in a shed located next to the river. After passing through the filtration system, water flows up a 4-inch pipe to the drinking water storage tank. A 5-horsepower pump propels water to the 32,000-gallon tank (see Appendix D) during non-peak hours. The storage tank is located uphill of Camp River Glen, nearly 2,000 feet from the shed. Water flows via gravity from the storage tank down into camp through the same 4-inch pipe. However, newly treated water can also flow directly to camp from the shed instead of first reaching the storage tank.

Flow rate is the volume of fluid (i.e. water) that passes through a given surface per unit time. The filtration units are limited to a flow rate of 20 gallons per minute (gpm) (see Appendix B1). Engineers from Hazen and Sawyer found that the system has the capacity to operate at 40 gpm because the system has a tandem pair of filter units. This is contrary to the San Bernardino County Environmental Health Services citation report (see Appendix B1-3). Data from a flow meter in the treatment shed shows that the system's average flow rate is 26.3 gpm.

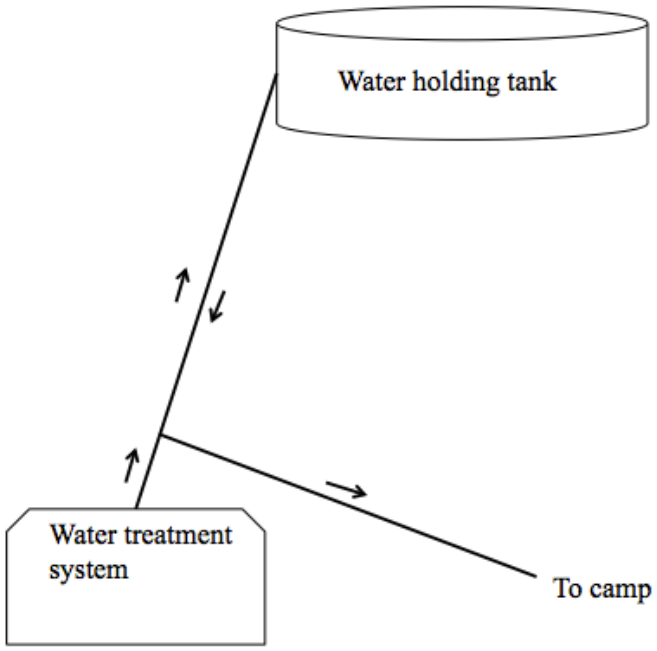


Figure 3: The single-pipe water system used by UniCamp.

INADEQUATE CONTACT TIME IN CURRENT SYSTEM

The San Bernardino County Environmental Health Services Department cited UniCamp's water system on August 15, 2012, for failing to meet the minimum disinfectant contact time required to inactivate waterborne pathogens (see Appendix B2). The inadequate contact time is due to the fact that water can be distributed directly to camp from the treatment shed without first flowing to the storage tank.

UniCamp's water treatment system must achieve a minimum of 3-log reduction (99.9%) of *Giardia* as required by the Surface Water Treatment Rule. Because the bag filters only remove 2-log *Giardia*, chlorine disinfection must reduce *Giardia* levels by an additional 1-log. To meet this level of *Giardia* reduction, the chlorination system must meet a minimum CT (see "Calculating CT for Proposed Two-Pipe System"). For example, given a water temperature of 50

degrees Fahrenheit, pH of 7.5, and a residual chlorine level at 1.0 mg/L, chlorine must be in contact with the water for 45 minutes to reach 1-log inactivation.

Solution to Inadequate Contact Time

UniCamp is currently working with engineers from Hazen and Sawyer to design a new two-pipe system (Figure 4), in which one pipe connects the water treatment system to the holding tank and a second connects the holding tank to camp. Passing water through the storage tank before it is delivered to camp will ensure the required disinfectant contact time is met. According to Ian Mackenzie, Senior Associate at Hazen and Sawyer, the existing pipe used in the one-pipe system will be abandoned but will remain in the ground to reduce cost and damage to the forest. Lynn Grijalva, Vice President of Hazen and Sawyer, stated that both pipes in the two-pipe system will be 4 inches in diameter and made of high-density polyethylene (HDPE) because it is pliable and can be easily transported for construction. The two pipes will be attached to the bottom of the bridge at the entrance of camp, and then placed underground, following the paved road that leads to the holding tank. According to Ms. Grijalva, following an existing road when laying pipe in the ground, as opposed to digging directly through a hillside, is preferable because the majority of major obstacles, such as trees and boulders, have already been cleared. Additionally, the US Forest Service prefers changes that disturb the land as little as possible.

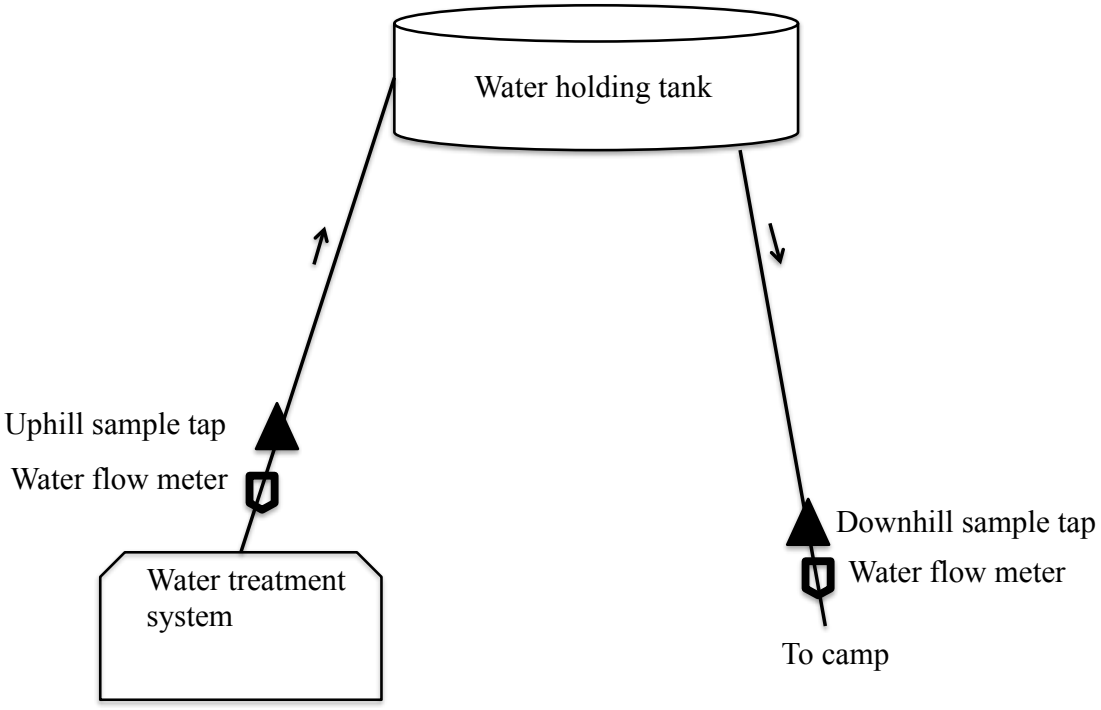


Figure 4: The proposed two-pipe water system at UniCamp.

UniCamp is responsible for paying for the proposed two-pipe system. UniCamp is currently applying for a grant supported by state revolving funds to pay for the construction. A past UniCamp contractor estimated the project would cost around $100,000.

Calculating CT for Proposed Two-Pipe System

CT is a measure of the disinfection effectiveness for the time that the disinfectant and potential pathogens are in contact.[1] "C" is the residual disinfectant concentration measured in mg/L at peak hourly flow. "T," or contact time, is the amount of time that the disinfectant is in contact with the water at peak hourly flow. Contact time is measured in minutes, from the point of disinfectant injection to the point before the water meets the first customer.

To ensure that the two-pipe design will meet disinfection requirements, its CT (CT_{act}) must meet the minimum CT (CT_{req}) required by the EPA. The following parameters were used in these calculations.

Known Parameters

- The total linear length of pipe is 2100 feet
- The diameters of both the uphill and downhill pipes are 4 inches
- The peak flow used in the calculations is 20 gpm
- The water holding tank has a total capacity of 32,000 gallons
- The minimum residual chlorine concentration is 1.0 mg/L (see Appendix B1)

Assumed Parameters

- The holding tank is approximately 50% full at peak flow
- The minimum temperature of the water undergoing treatment is 5°C
- The maximum pH of the water undergoing treatment is 8.0
- The baffling factor (BF) for the tank is 0.3 due to inconsistencies in water flow through the tank
- The baffling factor for the pipes is 1.0

Determining CT_{req}

Based on the temperature and pH of the water and the 1-log giardia inactivation requirement, CT_{req} tables indicate that CT_{req} is 72 mg-min/L.[2] (See Appendix E)

Calculating CT_{act}

The formula for calculating CT is as follows:

CT = concentration x contact time

C = Concentration

T = Contact Time = Theoretical Detention Time (TDT) x Baffling Factor

TDT = Volume / Peak Flow

To calculate CT_{act} in the proposed two-pipe system, contact times for three parts of the system were determined: the uphill pipe, the water holding tank, and the downhill pipe.

To determine TDT of the two pipes, divide the volume in both pipes by the assumed peak flow. If the diameter of each pipe is 4 inches, and each pipe is 2100 ft long, the volume of each pipe is 180 ft^3 or 1300 gallons. At peak flow, both pipes are entirely full. The volume divided by the flow for one pipe yields a TDT of 65 minutes, or 130 minutes for two pipes. Multiplying by the baffling factor of 1.0 yields a contact time of 130 minutes.

The volume of the tank is 32,000 gallons, but the assumed water level of the tank does not exceed 50% of that volume. Therefore, the maximum volume of water in the tank is 16,000

gallons. The detention time value is multiplied by a baffling factor of 0.3. This yields a contact time of 240 minutes in the tank.

To find the total contact time, the contact times of the two pipes and holding tank are added. This yields a total time of 370 minutes. To calculate CT, contact time is multiplied by the minimum residual concentration of chlorine: 1.0 mg/L. Thus, CT_{act} is 370 mg-min/L.

To ensure that CT_{act} is sufficient, CT_{act}/CT_{req} must be greater than 1. In this case, $CT_{act}/CT_{req} = 5.1$, meaning that the proposed two-pipe system will meet disinfection requirements.

ADDITIONAL PROBLEMS WITH CURRENT WATER SYSTEM

In addition to not meeting minimum CT, UniCamp's water system has two other significant issues. As mentioned previously, a small valve controls the amount of water that enters the chlorinator. Although the chlorinator is supposed to maintain 1 ppm of chlorine residual in the cistern, UniCamp has no way of accurately controlling this because the valve frequently opens due to mechanical vibrations from the adjacent 5-horsepower pump. Consequently, too much chlorine is eroded and enters the water, forcing Mr. Wirick to manually tighten the valve periodically.

Another issue with UniCamp's current water treatment system is that it is ineffective after rainstorms. About once every three years, Camp River Glen experiences heavy rainstorms, in which high levels of sediment are washed into the Santa Ana River. The high turbidity (a measure of the cloudiness of water caused by suspended and dissolved materials) causes UniCamp to shut off the filter system to prevent fouling of the bag filters. When this occurs, Mr. Wirick estimates that the water stored in the tank can meet the camp's water demand for a few days. If the water stored in the tank cannot satisfy the demand of camp, UniCamp turns on the treatment system and replaces the filter bags after they become fouled.

RECOMMENDATIONS FOR WATER TREATMENT

Assuming that the two-pipe system is installed, it is recommended that the engineers from Hazen and Sawyer include two sample taps in their system design (one on each pipe) to allow UniCamp to test daily turbidity and chlorine residual levels of the water. It is also recommended that two totalizing flow meters be installed near the sample taps to measure water use.

To address UniCamp's chlorine dosage problem, it is recommended that UniCamp fix or replace the dosage valve. If necessary, UniCamp should move either the valve or the adjacent motor to decrease vibrations. It is important that the valve does not periodically open so that a controlled amount of chlorine is being added to the water.

In order to allow UniCamp to keep its filtration system running after a rainstorm, it is recommended that UniCamp install a pre-filter, as shown in Figure 5. In particular, UniCamp should install a Rosedale Model NCO bag filter as a pre-filter. The NCO8-30 housing has a large dirt-holding capacity and is rated at 150 psi. The filter can use a number 1, 3 or 12 size bag, which vary based on surface area. It is recommended that UniCamp use a 1-micron, 2 size filter bag. A quote from Valin Corporation indicated that the additional housing system costs $1,675.00 and the filter bags cost $7.45 each (see Appendix F).

This additional bag filter is coarser and will be placed directly in-line with the current bag filters. Filtering the source water using pre-filter bags will significantly reduce turbidity before it reaches the current filters. This will prevent fouling in the current filters and will allow UniCamp to continue treating water after a rainstorm. However, treating high turbidity water may cause

fouling of the pre-filter bags. Replacing these bags at around $8 each is quite inexpensive in comparison to UniCamp's standard filter bags, which cost $200-300 each.

Crazzy's Wasewagen Camp is directly downstream from UniCamp and uses a similar water treatment system and a pre-filter to decrease turbidity in the river water. According to Wasewagen employee Steve Landrus, the camp switches out the pre-filter bags every 2-3 weeks.

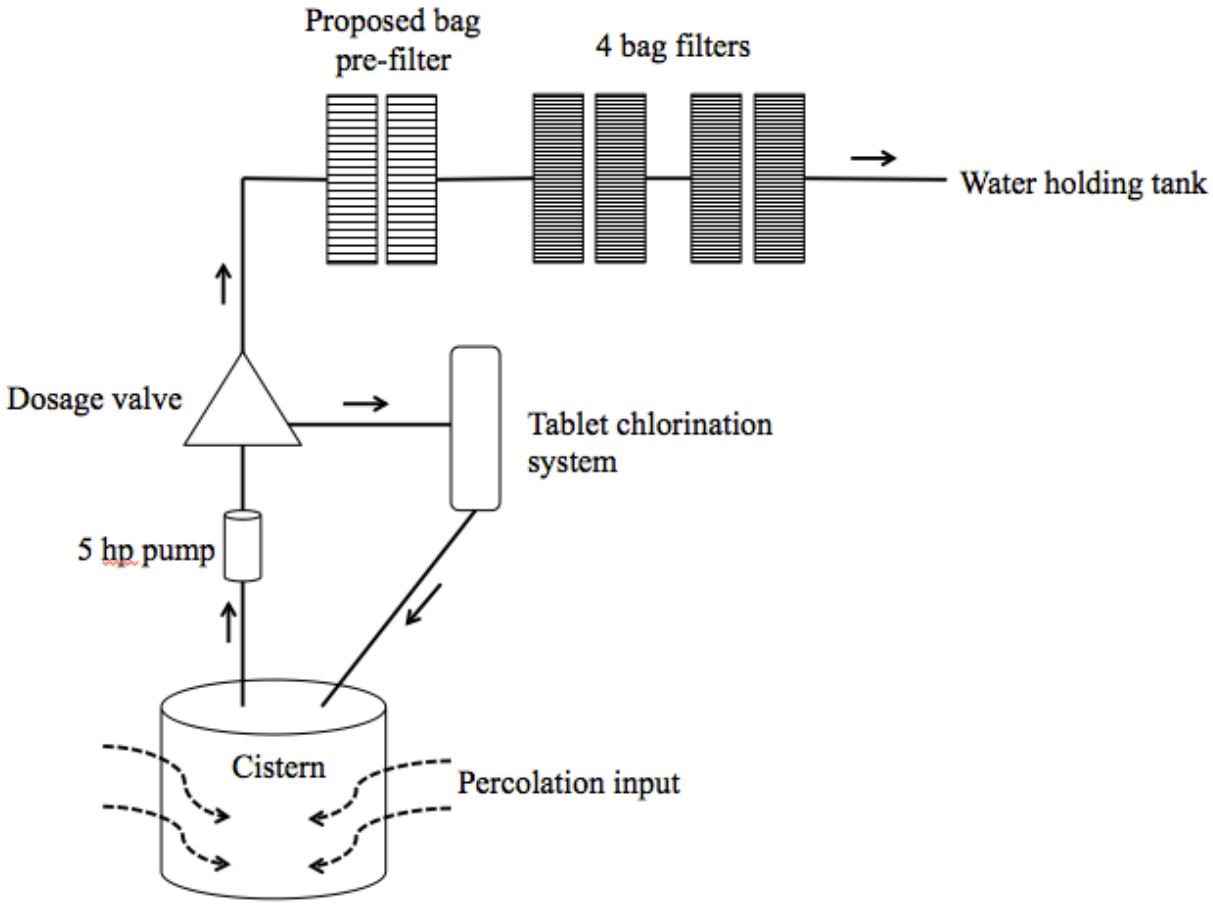


Figure 5: The recommended pre-filer bag in-line with the water treatment system at UniCamp.

Water System Sampling

CURRENT TURBIDITY AND CHLORINE RESIDUAL SAMPLING

Turbidity is measured daily at Camp River Glen to ensure that turbidity does not exceed levels set by the Safe Drinking Water Act (see Appendix B1). UniCamp measures turbidity from the faucet in the infirmary using a Hanna portable turbidity meter, model HI 93703. This meter shows that daily effluent turbidity is always 0.0 NTU, which is highly unlikely. Joy Chakma from San Bernardino County Environmental Health Services measures UniCamp's turbidity levels every month. He monitors turbidity directly downstream from the bag filters and records values of 0.01 - 0.02 NTU. The discrepancy between the two readings is probably because the Hanna turbidity meter has an accuracy of ± 0.5 NTU.

A UniCamp employee measures daily chlorine residual levels downstream of the filtration system, using AquaChek test strips. Using these pool/spa test strips to measure chlorine residual is not an EPA-approved method.

RECOMMENDATIONS FOR WATER SYSTEM SAMPLING

It is advised that UniCamp use the DPD Colorimetric method to measure free chlorine residual because this method is accurate and EPA approved.

It is recommended that UniCamp analyze both daily effluent turbidity and chlorine residual directly downstream from the filters to comply with the Surface Water Treatment Rule. Turbidity and chlorine residual should be measured at the same time and location (see Appendix Q for data collection sheet). If UniCamp receives potentially unreliable readings, they should monitor turbidity and chlorine residual using the uphill sample tap. Additionally, chlorine residual must be measured at the downhill sample tap to calculate CT.

Santa Ana River Sampling

CURRENT WASTEWATER TANK INFRASTRUCTURE

Although septic systems were originally allowed at Camp River Glen, they were later deemed unacceptable because leach fields can contaminate the surrounding water sources and environment. UniCamp has only been in operation at Camp River Glen since 1999 and has no data on the pre-existing infrastructure. The potential impacts of this infrastructure and methods for identifying these impacts are discussed in this section.

Camp River Glen currently has 10 underground sewage tanks of varying ages. Five of these are holding tanks installed in 2005 when UCLA UniCamp increased its capacity and added bathrooms in each of the 10 existing and 8 new cabins. The ages of the other five septic tanks are unknown, though these tanks have been sealed to prevent the seepage of sewage into their preexisting leach fields. UniCamp proposed the installation of new leach fields; however after percolation tests revealed the water table to be at approximately 4 feet, holding tanks were installed instead. Thus, the old tanks are now used as additional waste holding tanks. The septic tank infrastructure at Camp River Glen is depicted in Appendix G and shows seven leach fields that were proposed and the holding tanks that were installed in their stead.

It is unclear exactly how these septic tanks were sealed and Mr. Wirick suspects that the sealing process may have been inadequate. If Mr. Wirick is correct, wastewater could be leaking into the old leach fields and could be contaminating the nearby Santa Ana River and the water table. The newer tanks may have also developed small leaks that could contribute to contamination. Strategically sampling the Santa Ana River can help determine whether or not these tanks are leaking.

SAMPLING METHOD

The suggested sampling method consists of three components: frequency, site of withdrawal, and laboratory analysis.

Frequency

Testing should occur once per month, with 30 days between each sampling date, during the 2014 summer season. The sampling should occur four times over the summer starting in June (see Appendix M).

Withdrawal Sites

The sampler must withdraw samples at three sites on the river. The three blue arrows in Appendix G indicate the points of suggested access to the river.

Laboratory Analysis

At the beginning of the summer, UniCamp should collect an initial sample of graywater from the kitchen sink. This sample should be sent to a laboratory to be tested for the presence of soap markers such as MBAS (Methylene Blue Activated Substances), sodium, phosphate, and boron.

The river water samples should be sent to a lab to be analyzed for the following: pH, conductivity, total Coliform, *E. coli*, and whichever soap markers are found in the initial graywater sample. Examination of the Material Safety Data Sheets for the detergents used at camp (see Appendix H) show that sodium, phosphate, boron, and MBAS may all be potential indicators of soap. The initial sink graywater sample will help determine which specific compounds will be most useful for indicating the presence of kitchen or laundry soap. These compounds may also indicate if the graywater irrigation system is discharging any runoff into the river. Total coliform and *E. coli* tests will indicate whether pathogens of fecal origin are present in the river. Comparisons between results from upstream, adjacent, and downstream river samples will help determine which tanks or leach fields might be leaking into the river. For example, if the levels of fecal indicator bacteria from the adjacent testing point are higher than levels measured upstream, then it is probable that source of contamination is located between the upstream and adjacent sampling sites.

POTENTIAL SAMPLING SCHEMES

Option 1

Two options for the sampling scheme are suggested here. The first is to have a UniCamp employee conduct sampling per the instructions of the designated lab for analysis. The laboratory that is most effective and economically feasible is American Environmental Testing Laboratory in Burbank, California (see Appendix I). This laboratory is suggested because it provides a 45% student discount. The sample must be delivered within a five-hour time frame to preserve the coliform bacteria. To achieve this, a camp employee can either deliver the samples directly to the lab or to a courier service. The most efficient and feasible courier service is called Flash Courier of San Bernardino County (see Appendix J). The courier service will make the delivery for $135 per trip to American Environmental Testing Laboratory.

Option 2

Arrowhead Consulting, based in San Bernardino County, could also conduct the sampling and analysis. Arrowhead Consulting is responsible for UniCamp's monthly testing of drinking water and is willing to conduct monthly river sampling at no additional cost. Arrowhead Consulting would likely send the samples to E.S. Babcock & Sons, a laboratory located in Irvine. E.S. Babcock and Sons is significantly more expensive (see Appendix K) but they provide a free courier service to Arrowhead Consulting.

Recommendation for Sampling Scheme

It is recommended that camp staff deliver the samples to American Environmental Testing Laboratory for analysis because it is the most cost effective option (see Appendix L).

POTENTIAL NEXT STEPS

If contaminants are detected in the river samples collected during the summer, the next practicum team must decide the appropriate steps to take. Here, some suggestions are offered.

If high levels of fecal indicator bacteria (total coliforms and *E. coli*) are consistently present in the river, then it must be determined whether these bacteria are from human feces or animal feces. Water samples collected the following summer could be sent to a lab for DNA testing to identify if the bacteria is human or animal. If the upstream samples contain fecal indicator bacteria, this could be the result of human discharge further upstream, or this could just be the result of animals living in the area.

If fecal indicator bacteria levels rise downstream of camp and are found to be from human sources, one or more of Camp River Glen's underground sewage tanks may be leaking. In this case, the next step is to determine which specific tanks are leaking. This could be accomplished by monitoring the levels of wastewater in each tank over time or conducting soil sampling near the tanks. Once the leaky tanks have been identified, they will need to be repaired or replaced.

If high levels of boron, phosphate, MBAS, or sodium are present, soap from the kitchen, bathrooms, or washing machine may be contaminating the river. In this case, the tanks should be tested for leaking, and the fate of wastewater from the kitchen and washing machine must be investigated. Soil excavation may be needed to determine if the abandoned leach fields are still active.

High conductivity may also indicate leaking wastewater because the presence of chloride, phosphate, or nitrate in the river could increase its conductivity.[3] This would also be a reason to further investigate if the tanks are leaking.

RECOMMENDATION FOR TANK LEVEL MEASUREMENTS

In addition to the river sampling scheme, it is also recommended that tank wastewater levels be measured and recorded regularly when Camp River Glen is not in operation. UniCamp leaves the tanks partially full during the off-season to prevent any of the tanks from surfacing. Since the wastewater in these tanks is untouched for about nine months out of the year, it provides an opportunity to determine if any leaks exist that are allowing wastewater to seep out of the tanks. If a leak exists above the wastewater level, it will not be detected by this method, so the tanks should be kept at least half full during the off-season. The measurements can be taken by inserting a long metal rod into the tank, and then withdrawing the rod and measuring the length that is wet.

These measurements should be taken twice per year: once at the end of summer when Camp River Glen is closed and once in May, prior to the opening of camp. It is important that the May measurements be conducted before the water system is turned back on and the pipes are flushed out, as the extra water would interfere with the data collection. If the wastewater level in any tank changes significantly during these nine months, it could indicate a leaking tank and should be followed up with further investigation.

Note: An initial series of tank measurements was recorded during a January 2014 site visit, but no group members were able to return to the site to take follow-up measurements before the camp water system had already been turned on for the 2014 summer season.

ALTERNATIVE ENERGY

Although Camp River Glen is a remote camping location, it still requires some electricity, as shown in Figure 6. Components of Camp River Glen that require electricity include the water pump, the lights, the appliances in the kitchen area, and the washing machine. The electricity used at camp comes from Southern California Edison's electrical grid. This electricity is partially generated from the combustion of coal and other unsustainable and environmentally unfriendly sources. Having alternative energy sources on site would reduce Camp River Glen's carbon footprint and decrease the amount of money they pay for utilities. Implementing technologies such as solar photovoltaic, solar water heating, or micro hydroelectric systems would help the camp be more sustainable.

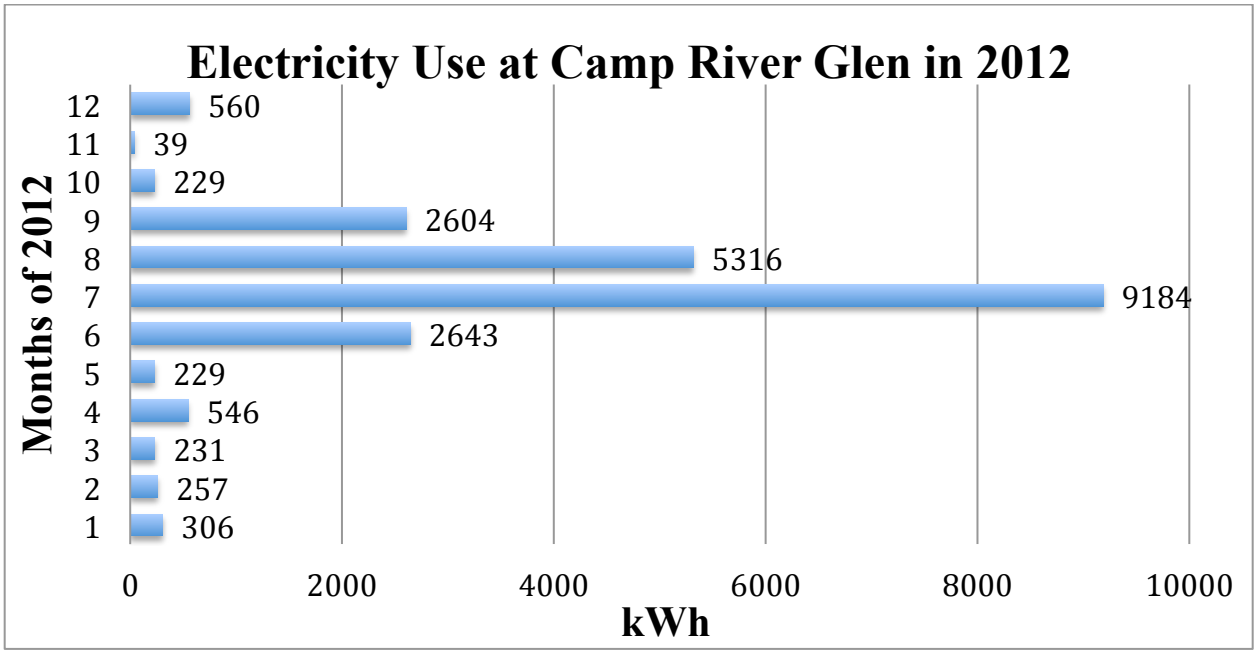


Figure 6: Camp River Glen's electricity use.

Micro Hydropower

Given the recent proliferation of hydropower in the United States and the close proximity of the Santa Ana River to Camp River Glen, the feasibility of installing a micro hydropower system was assessed.

RUN-OF-THE-RIVER SYSTEMS

The most common micro hydropower system is a run-of-the-river system, which relies on the natural flow of a river or stream to feed a turbine. Figure 7 shows a standard layout of a run-of-the-river micro hydropower system. The design of the system depends on the characteristics of the site, most importantly the head, or the vertical distance the water flows. Typically, high head systems are more efficient and economical,[4] as less water and cheaper equipment are required to produce the same amount of energy as an equivalent system with a lower head.

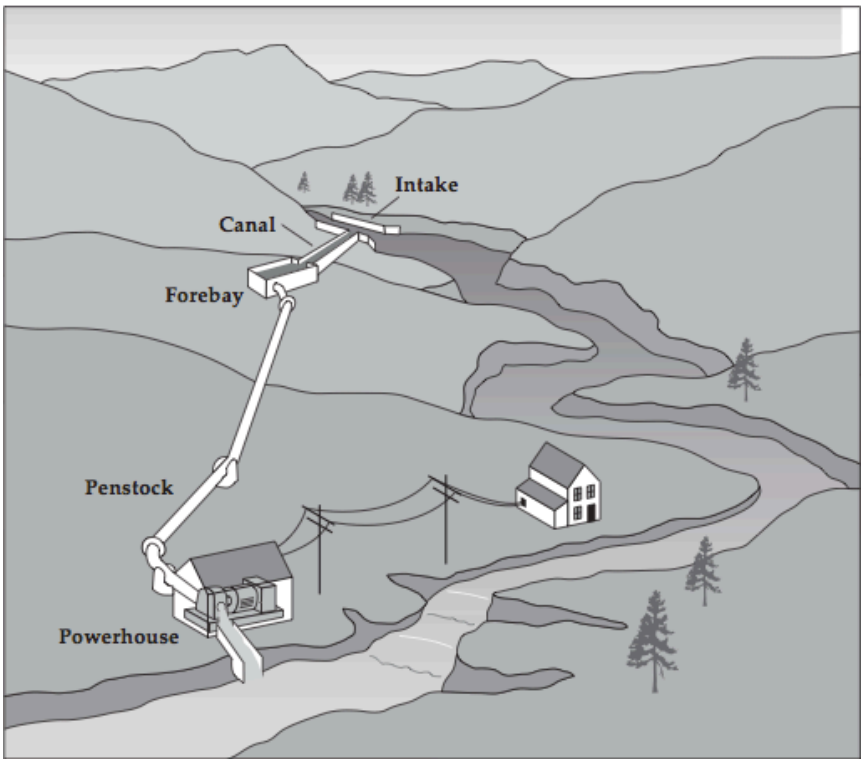


Figure 7: Components of a run-of-the-river micro hydropower system.

In a high head system, a man-made barrier called a weir diverts the water from the river into an intake passageway. Via a leat, a small canal connected to the intake, the water travels to the forebay, a settling tank that removes sediment and debris. From the forebay, the water travels to the turbine via the penstock, a pressurized pipe. In a low head system, the water from the river enters the penstock directly from the weir. Penstocks are usually designed to follow the natural trajectory of the river and are constructed using mild steel or HDPE.

The turbine in run-of-the-river systems is located downstream of the intake, where water spins a runner, or wheel, that effectively converts the energy of the flowing water into mechanical shaft power.[14] As the discharge flows back into the river, the mechanical shaft power generated by the turbine is used to power a generator, which creates a direct electrical current. This electricity can then be stored locally via batteries or sold back to the electrical grid through Southern California Edison's Net Energy Metering program.

IN-PIPE TURBINE SYSTEMS

Within the last few years, some start-up companies have launched pilot programs consisting of "water-to-wire energy recovery solutions."[5] These energy systems do not require all of the components of a run-of-the river system, instead consisting of only a single reaction-type turbine or series of turbines that harvest the excess head pressure in gravity-fed water pipes. Figure 8 shows the layout of a typical in-pipe turbine micro hydropower system. The penstock of a run-of-the-river system is effectively replaced by the downhill-flowing water pipe of a water distribution system; the turbine is built into the existing water pipe. The downhill flow of water in the pipe spins the runner of the turbine, and the discharge continues to flow through the pipe. The turbine does not disrupt the flow of water in the pipe. The turbine then powers a generator, which produces direct electrical current. Similar to run-of-the-river systems, the electricity can be sold back to the grid or stored locally. Every company that offers these systems uses a

different brand or patented style of reaction turbine in their systems; consequently the design of in-pipe systems is dependent upon the sponsoring company.

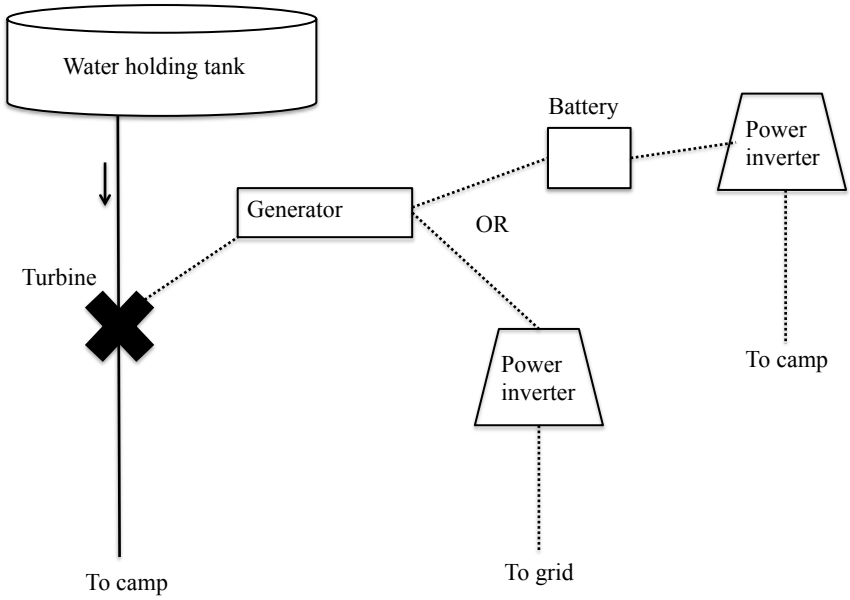


Figure 8: Components of an in-pipe turbine system.

PERMIT PROCESS

The permitting process for run-of-the-river systems and in-pipe turbine systems is the same. According to Section 23 (b) (1) of the Federal Power Act, the Federal Energy Regulatory Commission, or FERC, must license or grant an exception from licensing on all hydropower projects in the United States. Because Camp River Glen resides on US Forest Service land, any systems UniCamp wishes to install are under the jurisdiction of FERC and must undergo the Traditional Licensing Process, or TLP. According to Shana Murray, a FERC Western Region representative, UniCamp must first submit a Notice of Intent, Preliminary Application Document, and a request to use the TLP. UniCamp must then schedule a joint meeting with federal and state agencies, including the Unites States Department of Fish and Wildlife, the California Department of Fish and Wildlife, the State Historic Preservation Office, the NOAA Fisheries Services, and the San Bernardino County Environmental Health Services Department, among others. The joint meeting allows the individual resource agencies to comment on the application and raise their concerns. UniCamp must then revise its application, taking into account the concerns of the resource agencies before submitting a final copy to FERC. At the same time UniCamp submits a final copy of the application, UniCamp must also apply for Water Quality Certification from the California State Water Quality Board. After receiving UniCamp's final application, FERC can comment on the application and suggest revisions. Once UniCamp revises the application, FERC declares it "Ready for Environmental Analysis," which allows FERC to recommend further changes to the application if there are environmental impact concerns. Once a successful environmental analysis is performed and UniCamp receives a Water Quality Certification, FERC issues a license that is valid for thirty to fifty years. According to Murray, the permitting process could take 120 days to upwards of a year depending on the feedback given to UniCamp throughout the application process. UniCamp must repeat this

permitting process to renew the license when the license expires. More information can be found at http://www.ferc.gov/industries/hydropower/gen-info/licensing/small-low-impact.asp.

CASE STUDY: CAMP STURTEVANT

Camp Sturtevant, a United Methodist camp located in the Angeles Forest above Sierra Madre, is completely disconnected from the electrical grid. The camp operates on weekends only during the year. According to Paul Whitman, Associate Director of Camp Sturtevant, the camp is rented out to paying guests around twenty-five weekends a year.

Camp Sturtevant utilizes a run-of-the-river system as its primary source of electricity. Camp Sturtevant also has a Multiquip 2500-Watt portable diesel generator as a secondary source of electricity when the run-of-the-river system cannot produce enough electricity to supply camp. Their run-of-the-river system costs around $10,000, which includes all of the electrical components, cables and wires, and pipes. An engineer who was part of the Camp Sturtevant staff designed the system, which drastically reduced the system's initial cost. The system was installed by the camp manager and volunteers, which eliminated initial labor costs. Figure 9 shows a layout of the run-of-the-river system used by Camp Sturtevant. The system operates continuously during the week and produces 24-volt direct current, which is stored locally in six 8A27-DEKA batteries. The stored electricity is converted to 110-volt alternating current and fed back to camp on weekend evenings.

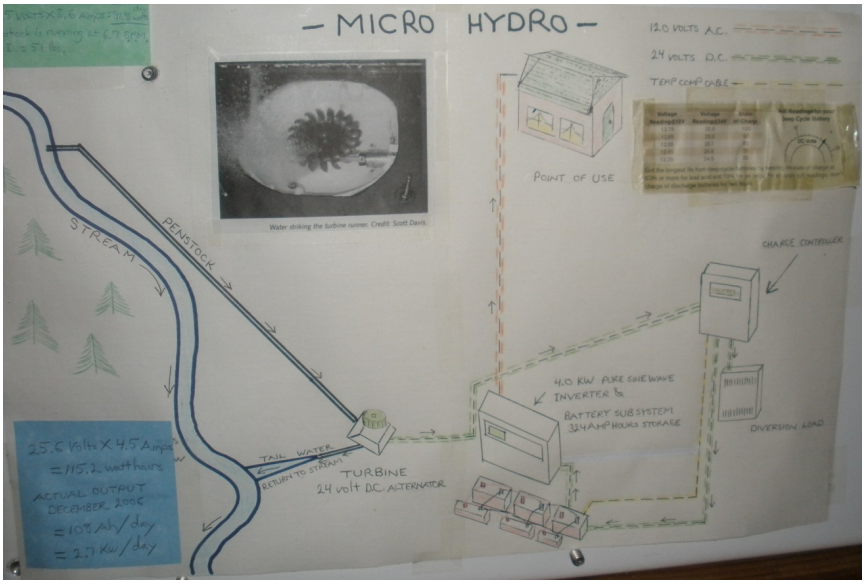


Figure 9: Diagram of the run-of-the-river system used by Camp Sturtevant.

Camp Sturtevant's run-of-the-river system is effective because of ideal site characteristics and the efficient management of electricity demand at camp. The system's head is 137 feet, which makes the run-of-the-river system more efficient and cost effective. Camp Sturtevant also manages the demand for electricity at its campsite. To prevent excess electricity use, campers are not allowed to bring outside appliances to camp, such as hair dryers and curling irons. When the camp needs to use high-draw appliances such as the washing machine, Mr. Whitman runs the secondary diesel generator to prevent the rapid draw of electricity from the batteries.

Camp Sturtevant has recently run into some problems with its system. The current drought in California has led to decreased water flowing in the river, resulting in decreased water flow in the system. As a result, the run-of-the-river system is currently not producing any

electricity, and Camp Sturtevant must rely on the secondary diesel generator to charge the batteries until a better solution is found.

RECOMMENDATIONS FOR MICRO HYDROPOWER SYSTEMS

Run-of-the-river System

It is not recommended that UniCamp pursue the installation of a run-of-the-river micro hydropower system at this time. Camp River Glen does not have ideal site characteristics for a run-of-the-river system, as the head of the system would be 30-40 feet, which is much less than the 137-foot head of Camp Sturtevant's system. This reduced head, combined with the reduced flow of water in the Santa Ana River due to the drought, would lead to severely decreased electricity production.

The operation of a run-of-the-river system is also not feasible due to UniCamp's security issues. In the past, copper piping, as well as brass valves on emergency fire hydrants, have been stolen when UniCamp is not in operation. The components of a run-of-the-river system are fully exposed, and if a component were to be stolen, the electricity production would be interrupted.

Lastly, installing a run-of-the-river system is intensive, and the installation and operation of a run-of-the-river system would require UniCamp to hire an experienced technician. If UniCamp built a system comparable to Camp Sturtevant's system, it would cost around $10,000 initially, and UniCamp would be responsible for the design, installation, and maintenance of the system. UniCamp could hire an engineer to design and install the system, but the initial cost would increase multiple times over. Maintenance of the system over its lifetime would also require a trained technician, further increasing the costs of the system. Finally, the permitting process through FERC is time consuming and would require a considerable amount of work from UniCamp.

In-pipe Turbine System

It is not recommended that UniCamp proceed with the installation of an in-pipe turbine system at this time. According to Dr. Daniel Farb of Leviathan Energy, the materials required for an in-pipe turbine system would cost around $10,000, which includes the turbine, turbine controls, small water container, air compressor, flow meters, battery charger, inverter, and cables, among other parts. Dr. Farb stated that he is willing to charge UniCamp only for the materials. However, UniCamp would need to then purchase additional batteries to store the electricity, or interconnect with the electrical grid.

Because Camp River Glen's water holding tank is situated 100 to 120 feet vertically above the camp, the proposed in-pipe system would have a head of 100 to 120 feet. San Bernardino County rates Camp River Glen's current water system at 60 psi (see Appendix B1). According to Ian Mackenzie, Senior Associate at Hazen and Sawyer, 60 psi is a standard pressure rating for domestic systems like Camp River Glen's system. However, according to Dr. Farb, 60 psi is more pressure than would be generated from the downhill flow of water in the proposed two-pipe system, and he claimed maintaining 20 psi downstream of the system should be sufficient to deliver water to camp. When estimating the electricity production of the proposed in-pipe turbine system, Dr. Farb used 20 psi in his calculations.

Dr. Farb's proposed in-pipe turbine system would produce an average of 150 watts of power per hour. However, the in-pipe turbine system would generate electricity only when UniCamp is operating three months of the year. Over the course of a summer, the proposed system would generate 324 kilowatts of power. The price per watt of the system is $66.67, well

outside the $1.50 to $3 per watt range for desirable micro hydropower systems.[6] The price per kilowatt-hour of electricity produced by the in-pipe turbine system is $59 (see Appendix N). UniCamp currently pays Southern California Edison a rate of $0.18 per kilowatt-hour. UniCamp would pay 324 times as much for the electricity produced by the in-pipe turbine system than it currently pays Southern California Edison. UniCamp is eligible for a one-time $72 rebate from Southern California Edison, which would only reduce the initial cost of the system by 0.72%. Thus, the proposed in-pipe turbine system is not economically feasible.

The ongoing evolution of in-pipe turbine technology will likely lead to increased efficiency and power production, making these systems more economically feasible in the future. It is therefore recommended that the engineers design a modular section of the downhill flowing pipe in the proposed two-pipe water system that can be accessed if UniCamp wants to install an in-pipe turbine system at a later time.

Solar Power

The two solar systems investigated for Camp River Glen were solar photovoltaic (PV) systems and solar water heating systems. The solar PV system would be off-site, disconnected from the electrical grid, and used to power existing camp features. Excess energy produced would be sold back to the grid. The solar water heating system would be used to heat the showers in the counselors' and staff members' cabins, as well as the swimming pool.

CAMP CULTURE AND LOW ELECTRICITY USE

Low energy usage is ingrained in camp culture, as UniCamp is meant to be an outdoor experience. This is a problem for solar PV because the low energy usage reduces the viable size of the solar PV array. The main uses of electricity at camp include refrigeration, water pumps in the pool and water system, fans for the convection ovens, and two water heaters.

GEOGRAPHY AND WEATHER

Geography and weather at camp also make solar power infeasible. The trees surrounding Camp River Glen shade the camp area, which decreases the efficiency of solar PV and water heating systems alike. Decreased efficiency would make these systems less cost effective.

Additionally, due to the location and elevation of Camp River Glen, the campsite is covered in snow for part of the winter. Snow accumulates on solar PV panels and solar water heating installations, drastically decreasing their efficiency and in turn increasing the duration of time required to pay back the investment. An important consideration when purchasing solar PV is to compare the payback period to the lifetime of the solar panel. If the payback period is less than the lifetime of the system, the system is considered economically viable.

SEASONALITY

UniCamp only operates for three months out of each year. This increases the payback period for solar PV by decreasing the amount of time the solar panels will produce electricity in a single year. While the solar panels continue to degrade at the same rate, they will be generating electricity at one third to one fourth of the rate they could be for a given year.

SECURITY

Finally, security at Camp River Glen limits the feasibility of implementing a solar system. Due to the remote location of the camp and lack of surveillance, UniCamp already

experiences problems with theft. Thieves could target the solar arrays due to their high value and external placement. Without a way to ensure the security of these solar panels, they would be an unnecessarily risky investment.

RECOMMENDATIONS FOR SOLAR POWER

It is not recommended that UniCamp pursue the installation of a solar photovoltaic or solar water heating system at this time.

SUSTAINABLE WATER MANAGEMENT

In addition to alternative energy and water quality, water conservation and sustainability at Camp River Glen is of concern. Camp River Glen currently relies on ten underground sewage holding tanks to collect all wastewater produced at the site, which includes graywater from sinks and showers as well as blackwater from toilets. During camp season, the wastewater must be pumped out of holding tanks and trucked away daily. Each truck trip costs about $320 and hauls out about 2,000 gallons of wastewater. Figure 10 shows the total gallons of wastewater pumped out each summer between 2009 and 2013. The immense amount of wastewater pumped out equates to an immense expense as well, which is less money that can be spent on sending children to camp. Sometimes the storage tanks reach capacity and overflow, which has serious environmental implications. Bathrooms sometimes have to be closed until the tanks to which they discharge have been emptied. The goal of this section is to provide innovative solutions that save water and reduce the amount of wastewater being sent to the underground storage tanks, thereby reducing the cost of wastewater disposal, and improving camp sustainability.

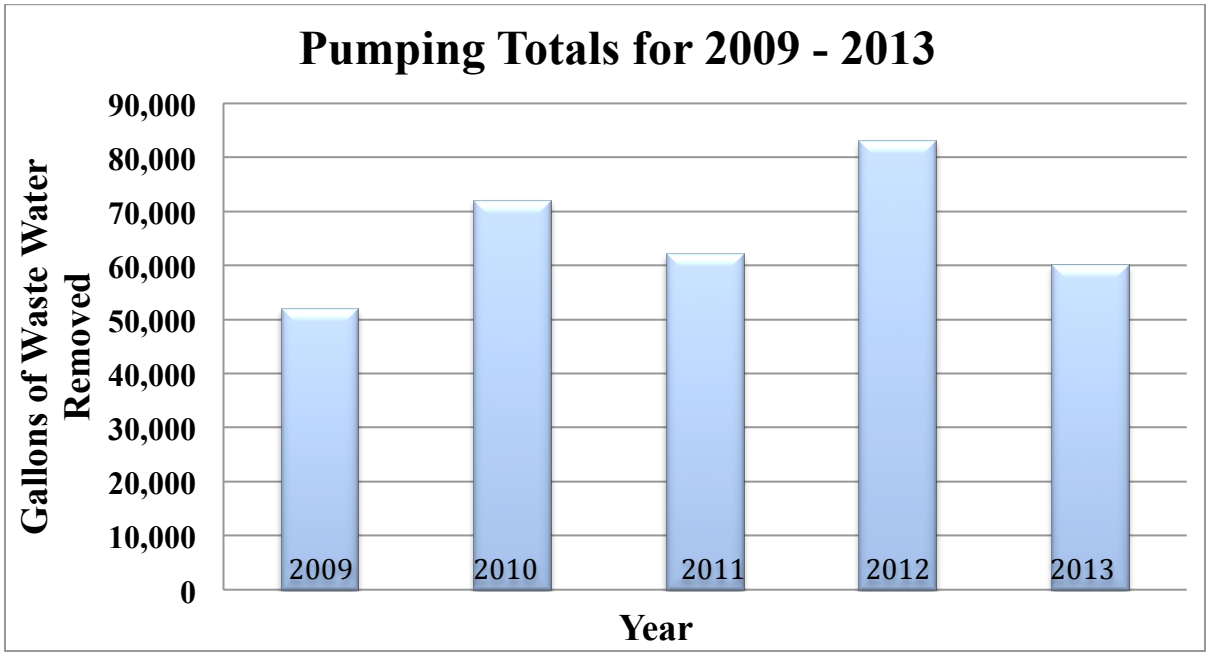


Figure 10: The number of gallons of wastewater pumped from holding tanks at Camp River Glen over the last five years.

Graywater System

Graywater is household wastewater that has not come in contact with human waste.[7] Sources of this type of wastewater include bathroom sinks, showers, baths, laundry machines and dishwashers.[7] This water is not safe to drink, but can be reused in a number of ways ranging from toilet flushing to irrigation.[8] Research shows that graywater can account for 50-80% of total wastewater volume, making it a significant consideration for sustainable water management solutions.[9] At Camp River Glen, the primary sources of graywater are bathroom sinks and showers. The site also has one dishwasher, and one washing machine used by the staff.

BACKGROUND

Graywater systems can range from large multi-family systems to simple clothes washer systems. In California, permits for system construction are distributed and mediated through county-level policymakers.

The primary guidelines for designing a graywater system are found in the California Plumbing Code, part 5 of Title 24 of the California Code of Regulations.[10] Chapter 16, "Alternate Sources for Nonpotable Applications," outlines the rules and regulations for graywater system design.

Graywater systems on a per-cabin basis have been determined to be the most sensible scale for Camp River Glen. Systems on a multi-cabin basis would require a considerable amount of infrastructure (underground piping, etc.). Furthermore, because the water table is only 4 feet below ground level, graywater dispersal needs to be spread out across multiple sites to reduce the chance of penetrating groundwater and risking contamination. An additional concern is that released graywater might contaminate surface water bodies such as the nearby Santa Ana River. Cabins located further away from the river would help reduce this risk.

From a behavioral perspective, cabins that have electricity and hot water would be more desirable to shower in and thus have longer shower duration, higher shower frequency, and ultimately a greater volume of graywater output. Thus, cabins with hot water have been noted as cabins with the highest graywater savings potential. If UniCamp decides to install more hot showers in the future (currently most cabins only have cold water), graywater systems could help divert the additional graywater produced.

The viable cabins for a pilot project were narrowed down to the executive director's cabin and the "head counselor" or camp counselors' leadership cabin, which both have hot water. However, further investigation revealed that in accordance with camp culture, the counselors at UniCamp usually do not shower during the weeklong sessions they lead. In an interview with Mr. Wirick, it was determined that he showers consistently for the duration of the camp season, making his cabin the ideal target for a graywater pilot project.

In addition to cabin graywater, the other major sources of graywater are the dishwasher and clothes washer. Washing machines use up to 45 gallons per load depending on the make and model, and according to Mr. Wirick the washing machine at Camp River Glen runs several times per day. Further investigation revealed that the washing machine is located in a portion of the camp where graywater is leached directly into the ground instead of held in wastewater storage tanks, meaning UniCamp does not need to pay for the removal of graywater produced by the washing machine.

PROPOSED GRAYWATER SYSTEMS

Cabin Graywater Reuse System

Figure 11 shows a typical cabin graywater reuse system that takes graywater from the bathroom sink and shower and pumps it to the toilet to be reused for toilet flushing.

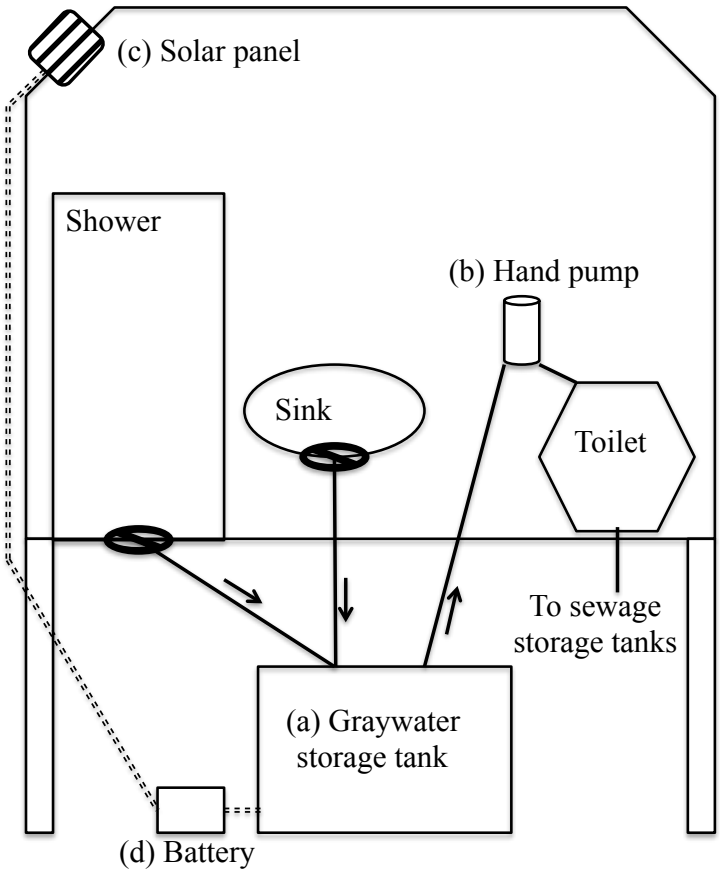


Figure 11: Schematic of a cabin graywater reuse system.

Individual pipes flow from the sink and shower below the cabin, where they join into a 4-inch pipe. This system utilizes a removable mesh screen seen in Figure 12 (a1) to remove any particulate matter that may later clog the system. This mesh screen is accessible from the side of the pipe to allow removal for cleaning. Primary screens would also be placed in the shower and the sink.

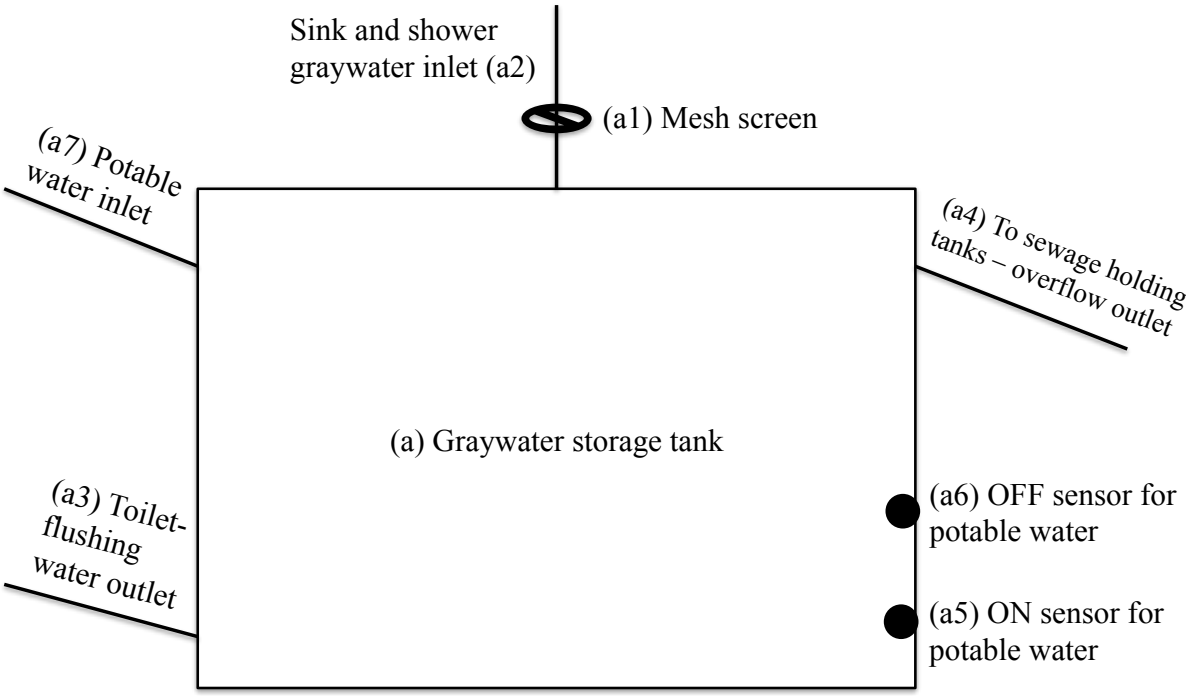


Figure 12: Schematic of graywater storage tank for cabin reuse system.

After the secondary mesh screen, the water passes through an extension of the 4-inch pipe (a2) into the graywater storage tank (a). This water is then pumped out through a pipe exiting from the lowest part of the storage tank (a3) using a hand-powered crank/pump, which can be seen in Figure 11 (b). The hand pump is located slightly above the toilet, allowing the water to flow into the toilet via gravity. This water fills the toilet's tank, which is set up to automatically flush at a certain volume with a buoyant float that is attached to the valve lid in the toilet tank.

This design requires two different backup mechanisms, one to supply the toilet with potable water if there is insufficient graywater to flush the toilet, and a second to drain water from the graywater storage tank (a) into the wastewater holding tanks if an excess of graywater accumulates. The first mechanism takes the form of a series of valves and water level sensors within the graywater tank. The sensors will be powered by a battery (d), which will be charged by a micro solar panel (c). The second backup mechanism consists of an outlet pipe leading to the wastewater storage tanks (a4). If graywater accumulates up to the level of the outlet, it will drain water to the wastewater storage tanks to prevent graywater overflow.

Cabin Graywater Irrigation System

Figure 13 shows a simple cabin graywater irrigation system that diverts graywater from the cabin shower and sink via gravity into an irrigation field.

As in the previous system, this graywater system uses mesh screening to remove gross solids such as hair and coagulated shampoo and conditioners. Primary screens will be placed on the drains of both the shower and sink, which can be easily cleaned and replaced depending on need. These screens should be replaced once every two years.

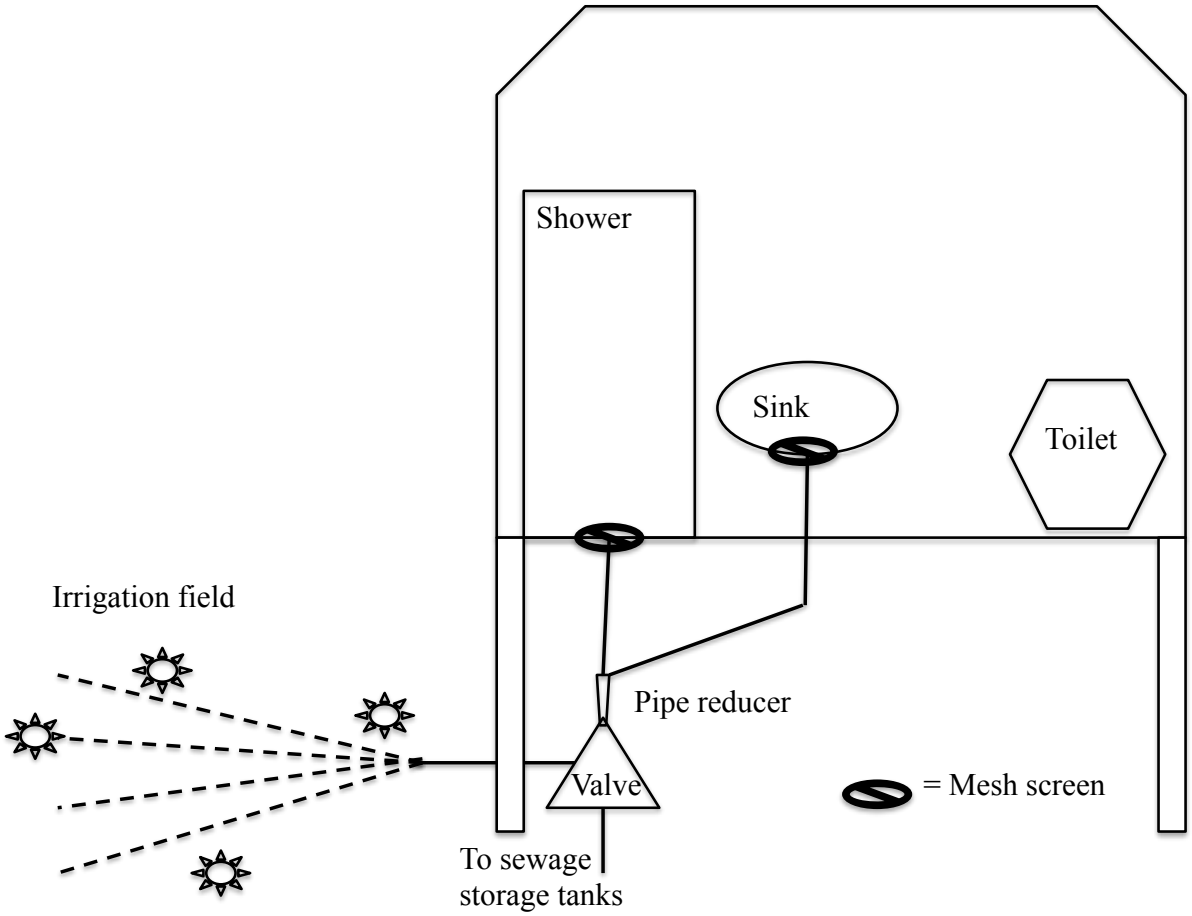


Figure 13: Schematic of a cabin graywater irrigation system.

After the secondary in-pipe mesh screen, the 4-inch PVC pipe will be reduced via a pipe reducer to one inch. A pipe reducer is necessary because the 3-way valve component will be composed of only 1-inch openings. However, if a valve with one 4-inch opening and another 1-inch opening exists or could be custom-made, a pipe reducer would not be necessary.

The 3-way valve, required by the CA Plumbing Code for graywater systems, can direct graywater to an irrigation field or to the sewage storing tanks. When the system is active, graywater is released into an irrigation field via a perforated pipe, as shown in Figure 14. This piping should be designed to maximize the spreading area of the graywater, to allow for maximum evaporative effect, and to reduce the chance that large quantities of graywater will penetrate the water table. When the system is inactive, the valve lever should be switched to direct graywater to the sewage storage tanks. This may be necessary if the perforated piping clogs or if blackwater enters the graywater system.

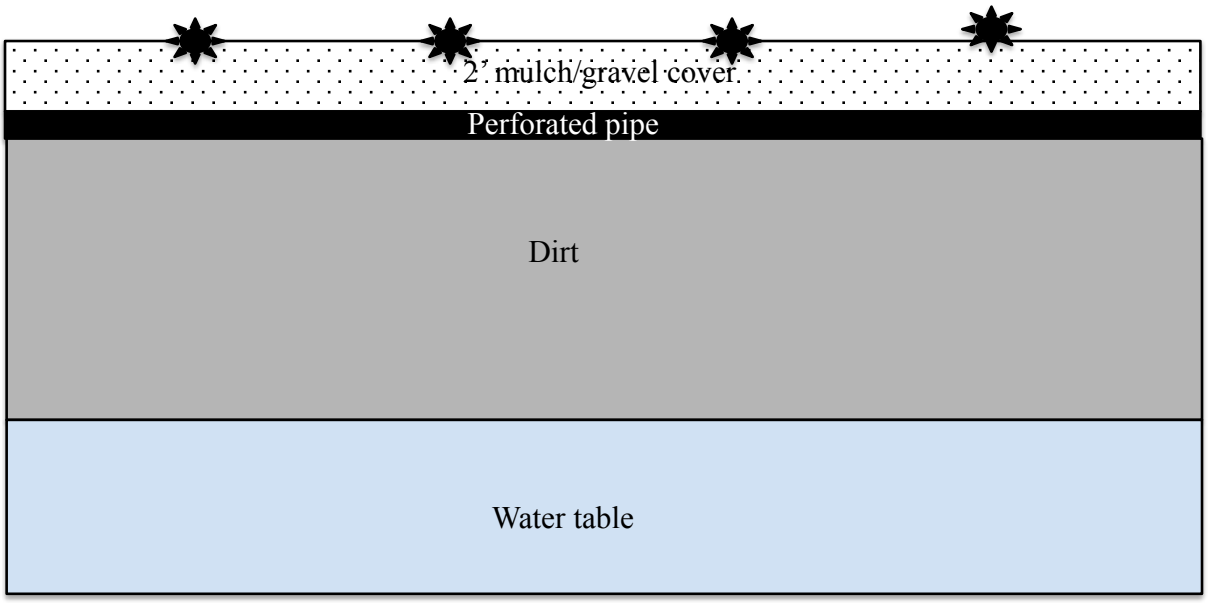


Figure 14: Schematic of an irrigation field of a cabin graywater irrigation system.

It should be noted that although this is being termed an "irrigation field," the system is not intended to irrigate water-intensive landscaping. Rather, this field will be irrigating the plants that are already present around the cabins within the semi-arid, deciduous forest ecosystem; besides large oak and pine trees, the majority of camp flora consists of hardy, low-lying shrubs. The term "irrigation field" is used here to be consistent with the language used in the Plumbing Code for graywater systems.

If this system is installed, it is recommended that Unicamp counselors and campers use biodegradable soaps, shampoos, and toothpaste to reduce any possible effects on the environment. This is not a requirement within the CA Plumbing Code or with the San Bernardino County offices for graywater systems. While most shower products will have a negligible effect on the environment, standardizing the graywater composition will be a proactive safeguard against unintentional environmental harm.

Clothes-Washer Graywater Irrigation System

This system has the same components and design as the cabin graywater irrigation system, but the source of graywater is a clothes-washer, as shown in Figure 15. Standard natural, non-toxic laundry detergent is recommended for this system.

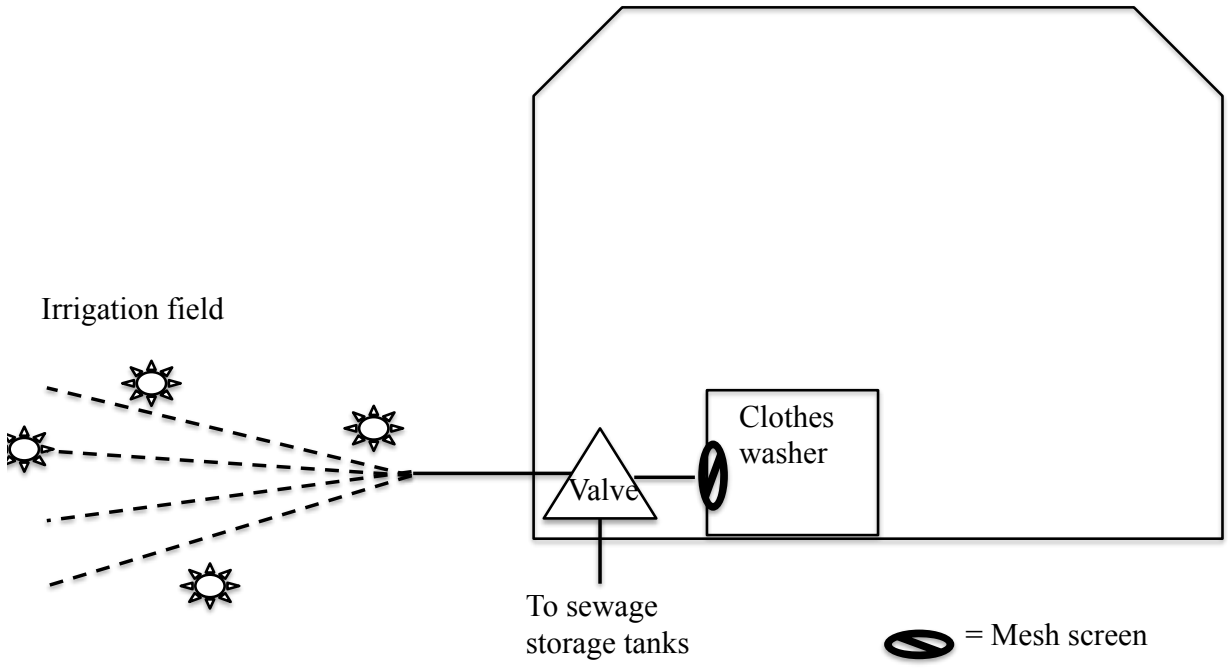


Figure 15: Schematic of a clothes-washer graywater irrigation system.

DISCUSSION

Complexity and compliance were considered in order to determine which system is most feasible as a pilot at Camp River Glen.

The graywater irrigation systems are far less complex than the cabin graywater reuse system due in part to their lack of moving components. The irrigation systems also do not require a storage tank, nor do they require electrical components. This makes them easier to maintain, and less expensive to install.

The 2013 California Plumbing Code contains specific guidelines as to what types of systems can be constructed, and which require permitting. Simple irrigation systems do not require permitting for construction. Rather, only notification is necessary before beginning construction work. Notifications must be sent to the San Bernardino County Land Use Services, which is the determined "enforcing agency" for non-potable reuse applications in the code. This notification must include a letter of approval from the US Forest Service, as the camp is located on Forest Service land (see "Approval Process Checklist").

Cabin graywater reuse for toilet flushing is addressed in Chapter 16A of the Plumbing Code.[11] According to this chapter, only water that has been disinfected and has received tertiary treatment is permitted for toilet flushing. Although graywater is considerably cleaner than blackwater, it does not qualify for this standard and thus is not permitted for reuse as toilet flushing.

ANALYSIS

Washing Machine Graywater Irrigation System

While both of the previously described graywater irrigation systems would be comparably simple, inexpensive, and compliant, the installation of the washing machine system would have no economic benefit because UniCamp does not pay for the removal of graywater

from the washing machine. The system may have ecological benefits, but those are nearly impossible to calculate as a price cannot be fixed on ecological health, and the scope of any damage that is being done is unknown.

Cabin Graywater Irrigation System

The cabin graywater irrigation system is the most feasible option. It is less complicated and more readily complies with regulations. The cabin graywater irrigation system promises to be an economically viable pilot project, as shown in the following cost-benefit analysis.

Cost

Table 1 shows the cost of individual components of the cabin graywater irrigation system, as well as the total cost of the system (including maintenance over the first 10 years after installation). No installation cost was included as it is recommended that operations and maintenance staff at UniCamp install the system.

System Component	Quantity	Cost	Initial purchase	Replacements/decade	Source	Notes
Shower/sink mesh screen	2	$4.00	1	4	Amazon	
In-pipe strainer	1	$50.00	1	0	Mcsdirect	
Pipe reducer	1	$10.00	1	0	Amazon	2"x0.5"
Valve	1	$45.00	1	0	PoolSupplyWorld	3-way, 2-inch
Piping	1	$5.30	1	0	Lowes	2" PVC. Cost is per 10ft of piping.
Irrigation piping*	0.04	$42.97	1	0	Lowes	Cost is per 500ft.
Mulch covering*	3	$2.50	1	9	Lowes	One bag covers 8ft^2, 3" deep
Total Initial Cost			$127.52			
Total Maintenance Cost				$99.50		
Total System Cost (10yr)					**$227.02**	
Total System Cost (20yr)					**$326.52**	
*Assume irrigation field area of 20ft^2						

Table 1: The individual components of a cabin graywater irrigation system.

Benefit

Mr. Wirick indicated that he showers a minimum of twice per day for 5 minutes each time, equating to at least 10 minutes of showering per day. Unfortunately the flow rate of the showerheads at Camp River Glen is unknown, so a range of flow rates was used to calculate a potential range of costs associated with showering. Showerheads range anywhere from low flow (1.5 gallons per minute) to high pressure/high flow (8 gallons per minute). With this level of usage, the amount of water used in the sink is trivial in comparison. Because Camp River Glen obtains its water for free from the Santa Ana River, cost is based exclusively off the cost of waste removal via waste pumping trucks. Each truck carries approximately 2000 gallons of waste and costs $320. Therefore, the cost function for the current disposal system is as follows:

Cost = (Minutes Showering/Day) X Gallons per Minute X ($320/2000 Gallons Pumped Out)

For one day, the function becomes:

Cost = (10 Minutes/day) X 1.5-8 GPM X ($0.16/Gallon) = $2.4 - $12.8 per day

The cost of showering per day is between $2.40 and $12.80.

Mr. Wirick is at Camp River Glen for approximately 70 days per season, making the estimated cost of showering for a single season with the current disposal system to be between $168 - $896.

It is unlikely that the showerhead is low flow, since Mr. Wirick's cabin has not been renovated recently. Additionally, this benefit analysis is based off of Mr. Wirick's minimum estimated shower time of 5 minutes. It is likely that he frequently showers for more than 5 minutes per shower. Based on these speculations, the estimated cost of showering for one summer is well over $300.

Cost-Benefit Analysis

The cabin graywater irrigation system would cost a total of around $230 (including maintenance) for 10 years of operation, and would save UniCamp at least $168 per season once installed. It is likely that the system would actually save UniCamp more than $300 per season.

RECOMMENDATION FOR GRAYWATER SYSTEMS

The following changes are recommended:

- Install a single cabin graywater irrigation system on the camp director's cabin (following approval process checklist below) to serve as pilot project for this coming camp season
- Mandate the use of non-toxic, natural, biodegradable soap and shampoo at Camp River Glen to minimize the ecological impacts of the cabin graywater irrigation system
- Mandate the use of non-toxic, natural, biodegradable detergent for the washing machine at Camp River Glen to minimize ecological impacts of the graywater being deposited into the ground

Other recommendations include:

- Utilize water metering (described in "Behavior, Operations and Education") to refine the cost-benefit analysis for graywater irrigation systems
- Add an additional cabin graywater irrigation system to the head counselors' cabin depending on the success of the graywater irrigation system pilot project
- Install a washing machine graywater irrigation system to help minimize ecological effects of the disposed graywater

Approval Process Checklist

- Refine cost benefit analysis with enhanced data from water metering of cabins
- Using the CA Plumbing Code as reference, create a system operations and maintenance manual (see Appendix O1)
- Send manual to and request letter of approval from Forest Service stakeholders (see Appendix O2)
- Send Forest Service letter and manual to County Land Use Services
- Await notification approval (camp director signature may be required)
- Upon approval, begin construction

Composting Toilets

This section examines the feasibility of installing composting toilets at Camp River Glen to decrease the amount of blackwater that is sent to the storage tanks.

BACKGROUND

Composting toilets are primarily used in rural areas and in areas of water shortage.[12] As shown in Figure 16, a typical composting toilet unit includes a toilet, composting tank, fan, vent pipe, and access door. No water is required to flush or operate the toilet. When waste is deposited into the toilet, it enters the composting tank by gravity, where it undergoes aerobic digestion by bacteria. The size of the tank should be selected based on the expected number of users, so the larger the composting tank the larger the capacity of the bathroom. A small solar panel on the roof operates a ventilation fan, which keeps the unit completely odorless. Some models also include manually operated rotating tines or mixing arms to stir the composting waste and keep it aerated. Several different styles and variations of composting toilet exist, including self-contained toilets, multi-chamber toilets, electric toilets, and urine-separating toilets.[12]

The aerobic composting process itself is influenced by several factors, including aeration, water content, temperature, pH, particle size, carbon to nitrogen ratio, oxygen concentration, and porosity.[12] Composting toilets reduce waste to 10 – 30 % of its original volume.[13] During winter, the contents of the composting tank will freeze and composting will cease, but it will automatically resume as soon as temperatures rise and the waste thaws out; thus seasonal use of composting toilets at Camp River Glen will not cause problems. North Cascades National Park has encountered several problems with the park's toilet units collapsing under heavy snow, according to a facility operations specialist for the park. However, since the composting toilet recommended for Camp River Glen will be housed within an existing structure that is built to withstand snow, UniCamp should not encounter this issue.

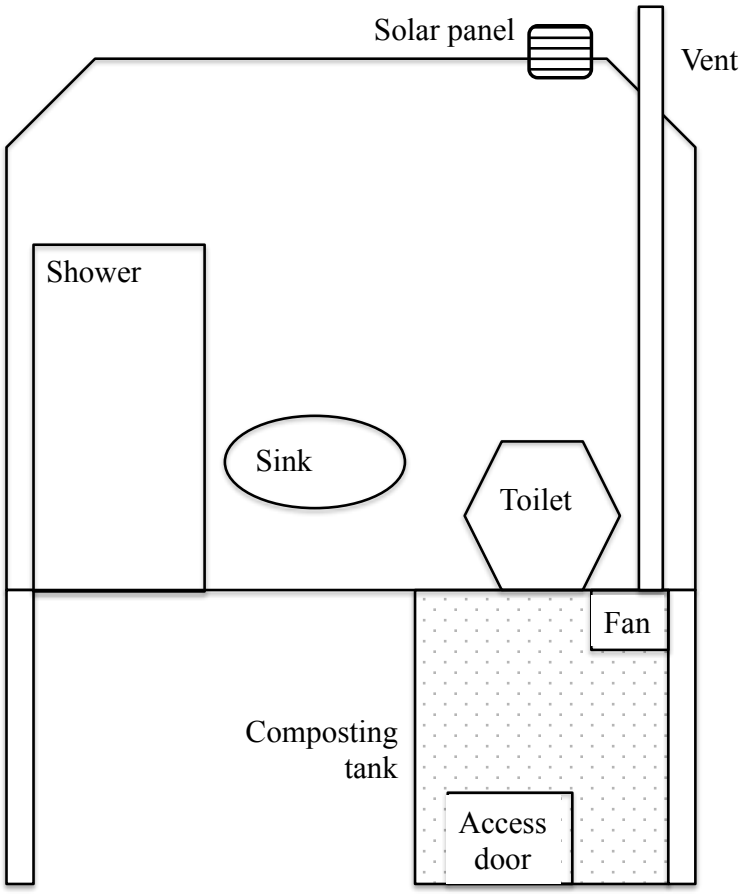


Figure 16: Schematic of a composting toilet.

Composting toilets require little maintenance, usually about 5 – 10 minutes per week. Bulking agents, such as sawdust or leaves, must be added to the composting tank every other day to help with the composting process and adjust the carbon to nitrogen ratio.[12] The compost may also need to be stirred occasionally, depending on the toilet's design. Any trash in the toilet should be removed regularly. The end product must also be removed, though the frequency of removal depends on how heavily the toilet is used. In most cases, the end product is only removed once every one or two years.

After the waste has been composted, the end product is "considered ready for application to non-edible plants as natural fertilizer."[12] According to the EPA, however, the end product must be "either buried or removed by a licensed septage hauler in accordance with state and local regulations."[13] Using the produced compost as a soil amendment or fertilizer does lead to safety considerations, most importantly the risk of exposing humans to pathogens or toxic chemicals (from pharmaceuticals excreted by humans).[12]

BENEFITS

UniCamp would reap multiple benefits from the installation of a composting toilet at Camp River Glen.

Researchers from Lawrence Berkeley National Laboratory determined that composting toilets are one of the best available technologies for water-conserving toilets.[14] Compared to other water-saving toilet technologies, composting toilets use the least energy and have the

smallest carbon footprint.[15] Thus, they are an environmentally friendly option for more reasons than just water conservation, which is ideal for a camp that is looking to become more sustainable in general.

A composting toilet would be an invaluable educational tool for teaching campers about water conservation and waste disposal. Exposing campers to the idea of composting their own waste will help open their minds to new ways of thinking about water and waste disposal. Once the composting toilet is installed, it can become part of UniCamp's new Outdoor Science Opportunities program, which will debut in August 2014.

According to the California Code of Regulations, Title 17, Article 2, Section 30710, organized camps must have "a dependable supply of potable water adequate to furnish 50 gallons of water per person per day." However, the next sentence states that "where pit or chemical toilets are used, this number may be reduced to 30 gallons per person per day." Composting toilets, just like pit or chemical toilets, do not require any water for flushing, and thus installing composting toilets throughout camp would significantly reduce the camp's water use and the camp's legal obligation to have a larger amount of water present.

In the past, Camp River Glen has experienced problems with running toilets. Sometimes a running toilet will go unnoticed for several hours or even overnight. In fact, the running toilets were such an issue during the summer of 2012 that the total amount of wastewater pumped was 10,000 gallons greater than any other summer between 2009 and 2013, as shown in Figure 10. Because composting toilets do not use any water, running toilets will no longer be a problem.

A composting toilet also reduces the risk of environmental contamination at Camp River Glen. The current underground storage tank system has the potential to release harmful pathogens into the environment, whether through a leaking tank or through the tank overflowing. The composting system is well contained and allows for straightforward removal of the compost, so the chances of any pathogens entering the environment are significantly decreased.

COST AND PAYBACK PERIOD

Composting toilets are not only an environmental solution, but also a cost-effective solution. A 2010 study comparing the costs of alternative water-saving toilet technologies found that composting toilets were the best investment, based on analysis of both net present value and payback period.[15] The study showed that compared to options such as rainwater-flushed toilets and high efficiency toilets, composting toilets had a higher initial investment but also a shorter payback period of only 5 years.[15] Based on initial calculations, this should hold true for Camp River Glen.

Given that each truck trip costs $320 and pumps out 2,000 gallons, simple division reveals that UniCamp is paying $0.16 for each gallon of wastewater pumped out. Camp River Glen uses older yacht-style toilets (estimated at about 0.5 gallons per flush) and more modern, 1.2 gpf toilets. The payback period of a composting toilet will differ depending on which type of toilet is replaced. Estimating that a heavily-used toilet at camp is flushed 100 times per day, with a camp season of about 60 days, this translates to a total summer pumping cost of about $1,150 for a single 1.2 gpf toilet and $480 for a single 0.5 gpf toilet. These totals could easily be higher when taking into account water used by running toilets. Thus, the purchase of a $5,000 composting toilet will start paying off after 5 years for a 1.2 gpf toilet and after 11 years for a yacht toilet. It should be noted that payback period depends on factors such as how often the toilet is flushed, how often the toilet is left running, and what type of composting toilet is installed, so the payback period may be slightly longer or shorter than the above calculation.

Many different makes and models of manufactured composting toilets are available on the market, as shown in Table 2. Selection of the appropriate model depends on price and capacity, as well as other factors including required maintenance and location of installation.

Manufacturer	Capacity	Approximate Cost ($USD)
BioLet	3 – 4 people	1000 – 2500
Clivus Multrum	3 – 7 people	2500 – 5000
Eco John	3 – 10 people	3000
Phoenix	2 – 8 people	5000 – 7000
Sun-Mar	1 – 8 people	2200 and up

Table 2: A comparison of commercially available composting toilets (adapted from Anand and Apul (2010)). The range in capacity reflects different models available from a single manufacturer.

REGULATION

Composting toilets can be found in many national parks, including Sequoia, Grand Canyon, Yosemite, and North Cascades National Park. However, composting toilets are neither a widely used nor widely accepted technology in San Bernardino County. Many of the county representatives interviewed for this report had never heard of composting toilets and did not know if any county regulations existed.

A plan checker from San Bernardino County Building and Safety stated that composting toilets are not allowed in the county, but then said it was also important to talk to the county's environmental health services department. A county inspector from Environmental Health did not have a clear answer either, but directed inquiries to the California Code of Regulations.

No specific mention of composting toilets exists in the CCR. However, since the goal is to install the toilet as a research pilot project, it can be considered a research composting operation. According to the CCR, Title 14, Section 17852, a "research composting operation" is defined simply as "a composting operation that is operated for the purpose of gathering research information on composting." The process and permits necessary to conduct a research composting operation are outlined in Section 17862. However, Section 17855 states that, "within-vessel composting process activities with less than 50 cubic yard capacity are excluded" and thus not required to meet the requirements set forth within Chapter 3.1 (Compostable Materials Handling Operations and Facilities Regulatory Requirements). Since the composting toilet tanks considered in this report have a volume less than 50 cubic yards, this project is technically excluded from having to comply with any of the specified requirements (permits, notification, etc.) for composting operations outlined in the CCR.

At this point, San Bernardino County is not embracing composting toilets as an alternative to septic tank systems. However, the county may be willing to consider a research project, especially since this project is small enough to be considered an exclusion, as stated in the previous paragraph. When and if UniCamp raises the funds to purchase a composting toilet, this dialogue will have to be continued with both the county's Building and Safety and Environmental Health Services departments, stressing the importance and value of a UCLA research project. With time, local governments should realize the importance of alternative water-saving technologies and create the necessary bureaucratic pathways for technologies such as composting toilets to be implemented, especially as California faces drought and climate change.

In addition to complying with San Bernardino County regulations, the installation of a composting toilet at Camp River Glen also requires an authorization letter from the Forest

Service. In order to obtain an authorization letter, UniCamp must fill out the "Request for Forest Service Approval" form (see Appendix P). Once the form is submitted to the Forest Service, specialists will review the proposal and the authorized officer will determine whether or not to allow the project and provide the authorization letter.

Another bureaucratic obstacle arises when considering how the produced compost should be dealt with. The end product produced by composting toilets is considered Class B biosolids under the Federal Sludge Rule (Code of Federal Regulations, Title 40, Part 503). Class B biosolids, while treated, still contain detectable levels of pathogens and thus their use is subject to many restrictions. Class A compost has no detectible levels of pathogens and only very low levels of metals content, so it can generally be used as compost without any restrictions. According to San Bernardino County Environmental Health Services, anything that is not Class A compost is waste and cannot be used for other purposes. Interviews with National Park Service staff revealed that many of the national parks send the end product from their composting toilets to nearby composting facilities. A county recycling specialist stated that there are no composting facilities in San Bernardino County that accept Class B biosolids for further composting. Again, the county is not ready to deal with new technologies such as composting toilets, but will hopefully put new procedures in place in the future.

RECOMMENDATION FOR COMPOSTING TOILET

A single, high-capacity, composting toilet should be installed at Camp River Glen as a research pilot project, with the understanding that this undertaking is highly dependent on fundraising and on getting the project approved by the county and the Forest Service. The toilet should be installed in one of the cabins located nearest to the center of camp. The cabins located near the center of camp receive frequent bathroom use and currently contain 1.2 gpf toilets, which means installing a composting toilet here will save more water compared to other locations. Since a small solar panel is necessary to operate the fan, the composting toilet should be installed in the cabin that receives the most direct sunlight. The cabins at Camp River Glen are supported above ground on stilts, which will make it much easier and cheaper to initially install the composting tank, and to access the tank and remove compost in the future. Digging a basement to hold the composting tank underneath the kitchen bathrooms, for example, would be costly and impractical.

Future teams should use cabin water-metering data collected during the summer (see section titled "Behavior, Operations and Education") to gain a better understanding of daily toilet use and water consumption in various cabins. This information should be used to reevaluate the payback period of a composting toilet. If the recommendation is still found to be favorable, which is likely, then the team should recommend a specific toilet model based on capacity and cost, as well as determine the best location for installation.

At this point, the only approved way to handle the produced Class B compost is to dump it as waste. This is disappointing because it defeats the purpose of composting toilets in that they allow waste to cycle through and return nutrients to the environment. However, research yielded no facilities even moderately close to camp that would accept the end product for further composting, nor is UniCamp allowed to simply bury the Class B compost in the ground since it is not Class A. As such, it is recommended that the compost be removed by the same pumping service that currently empties the underground storage tanks. This is still a major improvement compared to the current flush toilet situation, given that the compost may only need to be removed once every two years and that the waste will have been dramatically reduced in volume, which means fewer truck trips.

Additional composting toilets should be installed in the following years if the initial toilet performs well and is well received by the staff and campers. By replacing conventional toilets with composting toilets, UniCamp can reduce the need for trucks to pump out wastewater on a daily basis as well as help educate the younger generation about alternative ways of handling waste.

Behavior, Operations and Education

WATER CONSERVATION AND CONTEXT

Only 1% of global water is available for human consumption – it is a valuable resource, and people should treat it as such. The World Bank reports that, "80 countries now have water shortages that threaten health and economies while 40 percent of the world — more than 2 billion people — have no access to clean water or sanitation." People who are unaware of these issues, however, do not worry about limiting their water use. Effective education and behavioral changes can reverse this perception, making every drop count.

BACKGROUND

Some water conservation practices are already in effect at Camp River Glen. For instance the well-known rhyme, "If it's yellow let it mellow, if it's brown flush it down," is taught and enforced at camp. Campers also take part in the "Woodsey Challenge," where they do not shower during the entire week of camp. Campers are taught to scrape unwanted food off the plates so washing the dishes requires less water. When washing dishes, campers use buckets of water versus running faucets. The following recommendations provide additional options for water conservation.

RECOMMENDATIONS FOR BEHAVIOR AND OPERATIONAL CHANGES

Changing behaviors as well as camp operations will help decrease the camp's water use.

Behavioral Changes

- Communicating the crucial need for water conservation
- Getting rid of unnecessary items, like water cups (less dishwashing)
- Changing personal hygiene habits
- Alternative ways to preparing food and defrosting meat
- Routine leak detection

The first recommendation is to get the volunteers, staff and supporters of UniCamp on board about water conservation. It is important to let them know how essential reducing water use is and get their help to advocate it to the campers. Since all volunteers and staff must complete mandatory training before camp starts, it is recommended that the importance of water conservation be introduced during these training hours.

The next recommendation is to encourage the use of reusable water bottles. Although every camper knows that they should bring a reusable water bottle, it is not enforced. Making it a mandatory and essential item will help the camp with both sustainability and water conservation because the bottles do not need to be washed, thus reducing water use. There are about 1100 campers in total for the 7 sessions (not including the volunteers and workers at camp). They eat 3 meals a day, which means they use 15 cups a week per camper. In total, this is 16,500 cups that

would need to be washed for the 7 sessions. At least one gallon of water is used each time solely to clean dishes. This means that up to 16,500 gallons of water can be saved in total for one summer by simply eliminating the use of these cups. The water bottles will be rinsed occasionally, but the amount of water that is used to wash a bottle does not compare to the 16,500 gallons.

Personal hygiene activities, such as hand washing, taking showers, and teeth brushing, use a lot of water, but adjustments in behavior can help reduce water use. Turning off the faucet while brushing your teeth can save up to 4 gallons of water per brush, which is about 1,680 gallons a month. Turning off the faucet while lathering your hands with soap can save up to 30 gallons a month.[16] Instead of constant hand washing under running water, using hand sanitizer when practical would save up to a gallon per camper per day. Alcohol-based hand sanitizers can quickly reduce the number of microbes, but do not eliminate all types of germs. It is important to note that hand sanitizers are not as effective when hands are visibly dirty or greasy. Since bathroom and shower use is already regulated, sticking to the camp tradition would be recommended. It is recommended that an incentive should be used to get the campers to take the "traditions" more seriously, such as public recognition for completing the Woodsey Challenge.

Defrosting meat without using excessive water is another mechanism to conserve water. The current process used for defrosting chicken is to let cold water run over it in the sink for hours. About 100 pounds of chicken needs to be defrosted per week. A total of 8 hours of running water is needed for the chicken to fully defrost, and with an estimated 2.5 gallons per minute faucet flow, this method is currently using about 1200 gallons of water a week. A different approach to defrosting meats, recommended by a representative from the United States Department of Agriculture (USDA) would be putting the meats in tightly sealed bags and suppressing them under water. The water would then need to be changed every 30 minutes to keep the meat temperature in a safe range. This new and improved method would take about 30 hours in total but would only use 600 gallons of water. That means that the camp would be able to save 600 gallons a week and a total of 4200 gallons over 7 weeks. Although this method takes more time, the reduction in water use alone saves two truck visits or $640 dollars.

Another behavior change that can conserve water is simply conducting daily routine checks for leaks. Sinks, showers and toilet leaks are the principal cause of water loss. A leaky faucet that drips at the rate of one drip per second can waste more than 250 gallons per month. A showerhead leaking at 10 drips per minute wastes more than 45 gallons per month. A silent leak in a toilet can waste up to 70 gallons of water per toilet per month.[16] It is recommended that having campers help detect and report leaks become part of UniCamp's daily routine.

Behavioral changes can be difficult, simply because some people just do not care and live in a society where water conservation has not been a priority. With consistent education and exposure, people can begin to understand the crucial need for saving water.

Operational Changes

- Install low flow faucets, showerhead, and toilets
- Installation of water meters
- Making posters, decorating t-shirts, awareness stickers

In addition to behavioral changes, operational changes would also increase water conservation. One example would be changing fixtures to low flow showerheads and toilets and installing faucet aerators, such as the one mentioned below. These changes could help save hundreds of dollars a month in wastewater trucks and maintenance.

Low Flow Dual-Thread Faucet Aerator

- Cost $2.74 on Amazon
- High-pressure 0.5 or 0.25 GPM flow rate
- Saves 77% more water and energy then a standard 2.5 GPM aerator, which is 1,335 gallons monthly
- 10-year guarantee
- Meets or exceeds ASME standards
- California Energy Commission Certified Member of the Water-Smart family of products
- Amount of sinks: 48
- Total cost of: $5 x 48 sinks = $240
- Pay back period: two trucks at $320 per trucks for 2,000 gallons

It is recommended that UniCamp install water meters, such as the $16 meter mentioned below, in the cabins to record water usage data. Installing water meters in some of the cabins would be crucial to establishing a baseline for water use at UniCamp. Over time, water meters can be installed in every cabin to monitor all water use. Once that is secured, a fun component of camp education can be a competition between cabins to see which cabin can use the least amount of water. Not only would this teach the campers about water conservation, but it would also inspire them to practice water conservation at home.

It is recommended to install water meters in every fifth cabin (three cabins total) with two meters per cabin, one measuring the total input into the cabin and one measuring just the toilet input to distinguish between black water usage and graywater usage. As shown in Figure 4, another place to install meters is near the water storage tank, one meter on the main pipe of water going into the water storage tank, and one meter measuring the total amount of water coming out of the main water storage tank. This way there will be data on the total amount of water usage at camp. Comparing the total amount of water going into the water tank and the total amount of water taken out by trucks can also give information about tank and pipe leakage.

Rainwave Water Flow Meter

- Costs $16 on Amazon
- 8 pilot installments: $128

Incorporating arts and crafts with operational changes will introduce water conservation in an entirely new way. It is recommended that campers make posters and hang them up in the cabins, bathrooms, and even in the kitchen. Sticker reminders above every faucet would remind campers, volunteers, and staff to think twice about using water. Other fun and creative ways to publicize water conservation would be decorating t-shirts and reusable water bottles.

Discount School Supply Online Store

- Construction Paper (100 pack) 8 packs at $320
- Markers (200 pack) 3 packs at $150
- Sticker labels (1000 pack) at $80
- Total Cost: $415

RECOMMENDATIONS FOR EDUCATION

Currently, there is no education curriculum at Camp River Glen. Mr. Wirick requested that recommendations include educational activities that incorporate hands-on learning for the new Outdoor Science Opportunities program.

Leaky Faucets

A game can be created to show campers how faucet leaks are the number one reason for wasted water. For instance, the game can consist of an assembly line of three different types of leaks: a small 5 drips per minute, a medium 30 drips per minute, and a small constant stream leak. Campers can work in pairs and their goal is to work together using 16oz cups to catch all the "water leaks." The team that catches the most water in their cups within a minute wins. It is also recommended to have the leader in charge of this game bring up the idea of water conservation and discuss with campers what the game represents. This activity would teach the campers teamwork, strategy, patience, and most importantly, how much water is wasted by leaking faucets.

Photography and Film

As another fun and interactive learning idea, the tech savvy campers can make a short video on water conservation. They should work together in groups of 5-6 campers and create a short 30-second video that relates to water conservation. For example, films can be created about what water conservation consists of, how one can save water on a daily basis, or what small changes can be implemented to use less water. These videos can then be broadcasted to all camp attendees. Campers will learn how to communicate the need for water conservation to different audiences, plus gain experience with teamwork, creativity, and technology.

Make Your Own Water Filtration System

This recommended rotation activity would involve visually learning about water filtration and graywater. This project would require a 2-liter soda bottle cut in half, coffee filters, gravel, sand, and cotton balls, as shown in Figure 17. The top half of the bottle would need to be layered with the materials in the order of cotton balls at the bottom, then fine sand, gravel and topped off with a coffee filter. The next step would be to have the campers pour dirty water (which can easily be made with dirt and water) into the top. The campers can then witness the dirty water make its way through the layers and exit as much cle aner water. This activity would teach the campers about groundwater and water filtration. The filtered water can be used to water plants, illustrating the concept of graywater reuse.

Figure 17: Creating a water filtration system; the water before and after filtration.

CONCLUSION

To better manage water and wastewater at UniCamp, research was conducted in three overarching areas: water quality and treatment, alternative energy, and sustainable water management.

UniCamp's current methods for measuring turbidity and chlorine residual were analyzed for their accuracy and compliance with regulation. UniCamp is installing a two-pipe system to address a citation from San Bernardino County. One sample tap should be installed on each pipe to allow Unicamp to properly gather chlorine residual data for CT calculations. It is important that UniCamp measure residual using the DPD Colorimetric method.

It was found that a pre-filter could be useful for treating high turbidity water in the Santa Ana River after a rainstorm. Based on UniCamp's current filtration system, it was found that a coarser Rosedale pre-filter bag could be installed in-line with the current bag filters.

The feasibilty and economics of micro hydroelectric and solar systems were investigated. It was found that micro hydroelectric, solar photovoltaic, and solar water heating systems were not financially viable for UniCamp.

Three types of graywater systems were analyzed based on complexity and compliance with the 2013 California Plumbing Code. It was found that a cabin graywater irrigation system would most efficiently reduce the amount of wastewater sent to sewage holding tanks, which would reduce the number of waste pumping truck trips and save UniCamp money. A cost-benefit analysis indicated that the payback period for this system is one season of camp.

The feasibility and economics of a composting toilet were also analyzed. It was found that a composting toilet is feasible but is more expensive than a graywater system. Both the county and US Forest Service must approve a composting toilet before it is implemented. These findings demonstrate that the addition of a composting toilet at UniCamp would be most practical as a long-term pilot program.

Other methods for improving sustainable water management were researched. It was found that behavioral changes at UniCamp could significantly increase water conservation. Changing personal hygiene habits and routine water leakage checks are among those changes. Operational changes, such as installing low flow water fixtures, could also decrease water use at UniCamp. Education activities that incorporate water conservation should be included in UniCamp's new Outdoor Science Opportunities program.

If UniCamp makes the necessary improvements that are outlined in this report, UniCamp could significantly improve the management of its water and wastewater at Camp River Glen.

FINAL RECOMMENDATIONS

Improvement Area	Recommendation
Treatment system	➢ Fix the dosage valve so that it does not open from pump vibrations ➢ Install Rosedale Model NCO8-30 pre filter bag to remove turbidity after storm
Chlorine residual testing	➢ Use the DPD Colorimetric method to measure free chlorine residual ➢ Measure daily residual directly downstream from filters ➢ Measure residual on downstream sample tap for CT calculation
Turbidity testing	➢ Measure daily turbidity at same time and place as daily chlorine residual
Sewage Tank Leak Detection	➢ Sample river water once a month during camp season to determine if septic tanks are leaking and if kitchen and washing machine runoff is deposited into the river ➢ Monitor tank wastewater levels for evidence of leaking
Graywater systems	➢ Use Approval Process Checklist from this report to install a single cabin graywater irrigation system ➢ If the pilot project is successful, install additional cabin graywater systems ➢ Consider installation of a pilot graywater reuse system as a case study
Composting toilet	➢ Install a single composting toilet at Camp River Glen as a research pilot project, after obtaining the necessary permits and funding ➢ If the pilot project is successful, install additional composting toilets as funds allow
Behavioral and operational changes	➢ Initiate water metering across camp ➢ Eliminate unnecessary items like cups for water ➢ Initiate routine leak detection ➢ Install low-flow faucets and showerheads ➢ Explore alternative food preparation methods
Education	➢ Include "Make your own water filtration system" activity in camp activity rotation cycle ➢ Incorporate water conservation into Outdoor Science Opportunities curriculum

RECOMMENDATIONS FOR FUTURE PRACTICUM TEAMS

It is recommended that next year's team investigate the following.

WATER TREATMENT AND DISINFECTION

- Analyze chlorine residual and flow rate data from sample taps and flow meters
- If fecal bacteria is found in the Santa Ana River, determine whether fecal indicator bacteria are from human or animal feces
- If fecal indicator bacteria is from humans, determine whether or not it is coming from Camp River Glen
    - Test soil extensively around old leach fields
    - Monitor wastewater in tanks over time
- If high levels of boron, phosphate, MBAS, or sodium are present in the river, investigate tank leakage and the fate of wastewater coming from the kitchen and washing machines
- Analyze alternative pre filter methods, and compare them to the Rosedale pre filter bag that was suggested

SUSTAINABLE WATER MANAGEMENT

- Determine flow rates of shower heads and faucets around camp
- Use water metering data to assess economic viability of installing additional cabin graywater irrigation systems
- Use water metering data to assess viability of installing a composting toilet, or additional composting toilets if one has already been installed
- Analyze water metering data to determine if UniCamp is reducing water usage
- Survey campers and camp staff on effectiveness of recommended educational components

ACKNOWLEDGEMENTS

Thank you to advisor Dr. Michael J. McGuire for his assistance and advice throughout the year. Thank you to client Mr. Wally Wirick for his time and cooperation. Additional thanks go to Kerri Cook (National Park Service), Erika Ellis (SB County), Dr. Daniel Farb (Leviathan Energy), Lynn Grijalva (Hazen and Sawyer), Sarah Hanson (USDA), Steve Landrus (Spring Water Systems), Ian Mackenzie (Hazen and Sawyer), Heather Mobley (USFS), Shana Murray (FERC), Dr. Razmara (UC Irvine), Paul Whitman (Camp Sturtevant), Mike from Camp Wasewagen, and the San Bernardino County Environmental Health Services Department.

References

(1) Michael J. McGuire. Design of Water Treatment Plants, Lecture 9: Disinfection, 2014.
(2) Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Sources, **1991**.
(3) Conductivity. http://water.epa.gov/type/rsl/monitoring/vms59.cfm.
(4) Paish, O. Small hydro power: technology and current status. *Renew. Sustain. Energy Rev.* **2002**, *6*, 537–556.
(5) William Pentland. Water-to-Wire Turbine Produces Power From Pipes http://www.forbes.com/sites/williampentland/2012/04/05/water-to-wire-turbine-produces-power-from-pipes/ (accessed Jan 28, 2014).
(6) Ghanashyam Ranjitkar; Jinxing Huang; Tony Tung. Application of Micro-hydropower Technology for Remote Regions. *EIC Clim. Change Technol.* **2006**, *1*, 10–12.
(7) Gross, A.; Wiel-Shafran, A.; Bondarenko, N.; Ronen, Z. Reliability of small scale greywater treatment systems and the impact of its effluent on soil properties. *Int. J. Environ. Stud.* **2008**, *65*, 41–50.
(8) Surendran, S.; Wheatley, A. D. Grey-water reclamation for non-potable re-use. *Water Environ. J.* **1998**, *12*, 406–413.
(9) Ahmed, M.; Al Sidairi, S.; Prathapar, S. A.; Al-Adawi, S. Evaluation of custom-made and commercial greywater treatment systems: a case study from Oman. *Int. J. Environ. Stud.* **2008**, *65*, 33–40.
(10) CA Building Standards Commisson. *2013 California Plumbing Code*; 2014.
(11) CA Building Standards Commisson. *CPC Chapter 16A*; 2014.
(12) Anand, C. K.; Apul, D. S. Composting toilets as a sustainable alternative to urban sanitation – A review. *Waste Manag.* **2014**, *34*, 329–343.
(13) Water Efficiency Technology Fact Sheet: Composting Toilets, **1999**.
(14) Williams, A.; Dunham Whitehead, C.; Lutz, J. A crosscutting review of plumbing products-related water efficiency and conservation. *J. - Am. Water Works Assoc.* **2013**, *105*, E51–E61.
(15) Anand, C.; Apul, D. S. Economic and environmental analysis of standard, high efficiency, rainwater flushed, and composting toilets. *J. Environ. Manage.* **2011**, *92*, 419–428.
(16) Fix a Leak Week Fact Sheet (USEPA)

Appendix A

The client's current calcium hypochlorite disinfection system. The chlorine tablets are housed in the white cylinder. Water enters the system through the green pipe and exits through the white pipe.

Appendix B1

The citation report from the County of San Bernardino Environmental Health Services Department.

County of San Bernardino
DEPARTMENT OF PUBLIC HEALTH
ENVIRONMENTAL HEALTH SERVICES
SAFE DRINKING WATER PROGRAM
NON-COMMUNITY WATER SYSTEM SANITARY SURVEY REPORT

System Name:	UCLA Unicamp (Camp River Glen)	Date: 08/15/2012	Last inspection: 08/16/2011
Location:	1N4S Santa Ana River Rd. Angelus Oaks	MFR # 3600772	Phone # 626-233-6434
Mailing Address:	900 Hilgard Ave. Suite 301 Los Angeles, CA 90024	Pressure: 60 psi	Flow rate: 20 gpm
Person Contacted	Wally Wirick, Ed BeVante	APPLICABLE LAW- California Code of Regulations, Title 22, Water Code, Health & Safety Code. San Bernardino County Code	

WELL STATUS	1	Annular seal	☐
	2	Well seal	☐
	3	Well cap	☐
	4	Check valve	☐
	5	Electrical conduit	☐
	6	Slab	☐
EQUIPMENT AND STRUCTURES	7	Leaks	☐
	8	Storage tank(s)	☐
	9	Booster / well pump(s)	☐
	10	Distribution lines	☐
	11	Cross connections	☐
	12	Production capacity	☐
	13	Flow meter	☐
	14	Insufficient pressure	☐
	15	Treatment / chlorination	☒
SOURCE PROTECTION	16	Septic system/ sewer	☐
	17	Animal enclosure	☐
	18	Underground tanks	☐
	19	Solid waste disposal	☐
	20	Pond, lake, or stream	☐
	21	Abandoned well	☐

This water system is classified as a transient non-community water system. The water source is groundwater under the direct influence of surface water (Santa Ana River). The storage is comprised of a 32,000 gallon gravity storage tank across from the campground on Forest Services' land. Source water percolates into a cistern, which is located approximately 50-feet from the Santa Ana River. The system serves up to twenty employees and up to 250 campers while in operation. The campground has 30 buildings, and operates May through end of August.

The water is treated with a Rosedale Bag filtration system. The filtration system consists of 2 cartridge pre-filters and 2 giardia bags. The filtration system is given 1-log cryptosporidium, 2-log giardia, and 0-log virus removal credits. Performance standards for this alternative filtration system requires that the treatment system shall be operated in such a manner that 95% of effluent turbidity readings do not exceed 0.2 NTU and that any effluent turbidity reading does not exceed 0.5 NTU at any time. The operation criteria allow a maximum flow rate of 10 gallons per minute (gpm) per filter for a 20 gpm total production. The operator has a Hanna portable turbidity meter (model HI93703) to measure finished water turbidity. Source water flows through cistern. A pump draws water from the cistern to the filtration system. A portion of this water is diverted to calcium hypochlorite erosion chlorinator and returned to the cistern. The chlorinator is set to maintain 1 ppm chlorine residual in the cistern. The effluent is pumped to the storage tank. The water system has a single line going up to the storage tank underneath the Santa Ana River. The condition of the water line is unknown below the river. Water treated at the filtration system can go directly to the campground if demand exists. Thus newly treated water going to the campground does not meet the minimum disinfectant contact time required to inactivate waterborne pathogens.

The water system does not meet the requirements of the surface water treatment

Appendix B2

	22	Other well	☐	rule for pathogen inactivation. For an example, water temperature at 50°F, pH at 7.5, and residual chlorine level at 1.0 mg/L, minimum CT (disinfection concentration X disinfectant contact time) value required for giardia cysts inactivation is 45 minutes for 1-log reduction. A minimum of 3-log reduction of Giardia Cysts (99.9%) is required. Therefore, 1 log of inactivation is required in the disinfection stage. **§64652. Treatment Requirements and Compliance Options.** (a) Each supplier using an approved surface water shall provide multibarrier treatment that meets the requirements of this chapter and reliably ensures at least: (1) A total of 99.9 percent reduction of *Giardia lamblia* cysts through filtration and disinfection; and (2) A total of 99.99 percent reduction or viruses through filtration and disinfection. The operator shall submit a plan to this department on how the operator plans to bring the system in compliance with the Surface Water Treatment Rule. A compliance order is issued. **Below is the on-going water quality analysis frequency for the UCLA Unicamp water system:** 1. **Bacteriological:** monthly (section 64423 (a)(5), 22 CCR), last analysis 07/23/2012 2. **Nitrate:** annually (section 64432.1 (a), 22 CCR) , last analysis 06/18/2012 3. **Nitrite:** once every three years (section 64432.1 (b) (3), 22 CCR), last analysis 06/18/2012 4. **Turbidity and Residual Chlorine Level**: record daily (section 64664, 22 CCR) The above listed "Last Analysis" dates are the most recent analyses results in the UCLA Unicamp WS file. If these dates are incorrect and more recent water analyses have been conducted, submit copies of the most recent analyses results to this Department. Measure and record turbidity and residual chlorine levels on a daily basis. Submit a copy of the monitoring results to this department by the 10th day of the following month. EHS has not received any turbidity and chlorine residual monitoring log for 2012 season. A sample monthly report form is enclosed.

SOURCE DATA	Sources	Status	Capacity (gpm)	Comments and descriptions
	Santa Ana River	**Active**	**20 GPM**	**GPM limited by filtration treatment unit, cistern is covered and watertight**

Appendix B3

-Non-community System Report Continued-

STORAGE

Tank name or #	Capacity	Comments and descriptions
Storage Tank	**32,000 gallons**	**Surface features appear in good condition, same inlet and outlet.**

WATER QUALITY REQUIREMENTS

23	Coliform bacteria	☐
24	E-Coli	☐
25	Secondary standards	☐
26	Nitrate as NO_3	☐
27	Inorganic chemicals	☐
28	Volatile organic chemicals	☐
29	Synthetic organic chemicals	☐
30	Radiological standards	☐
31	Lead and copper	☐
32	MCL violations	☐
33	Emergency notification plan	☐
34	Consumer confidence report	☐

Corrections and Comments

15. The operator shall meet minimum CT value required for pathogen inactivation. A compliance plan shall be submitted to this department by 06/30/2013. The water system shall be in compliance by 06/30/2014.

The operator shall disinfect either at the influent or effluent line of the filtration system (relocate the effluent end of the chlorinator from cistern to either influent or effluent line of the filtration system).

On-going: continue analyzing the water for total coliform bacteria on a monthly basis when the camp is in session, and nitrate on a yearly basis. Nitrite sample is required once every three years. Ensure to sample before opening the campground to the public. Submit daily turbidity and residual chlorine measurements to this department on a monthly basis.

WATER SYSTEM STATUS

NO reinspection required	☒
Reinspection required	☐
Supervisory review required	☐

Submit all required documents and test results to:
San Bernardino County
Environmental Health Services
385 N. Arrowhead Ave., 2nd Floor
San Bernardino, CA 92415
Attention: **Joy Chakma, R.E.H.S.**

Phone: 1-800-442-2283
Fax: (909) 387-4323
jchakma@dph.sbcounty.gov

If you would like to request an extension, or have any questions, please call 1-800-442-2283.

Signature: J. Chakma

Date: **10/01/2012**

Appendix C

The client's current water filtration system, containing two sets of Rosedale bag filters.

Appendix D

The drinking water holding tank at Camp River Glen.

Appendix E

CT values for giardia inactivation at 5 ° Celsius.

Table C-2. CT Values for Inactivation of Giardia Cysts by Free Chlorine at 5°C

CHLORINE CONCENTRATION (mg/L)	pH<=6 Log Inactivation						pH=6.5 Log Inactivation						pH=7.0 Log Inactivation						pH=7.5 Log Inactivation					
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
<=0.4	16	32	49	65	81	97	20	39	59	78	98	117	23	46	70	93	116	139	28	55	83	111	138	166
0.6	17	33	50	67	83	100	20	40	60	80	100	120	24	49	72	95	119	143	29	57	86	114	143	171
0.8	17	34	52	69	86	103	20	41	61	81	102	122	24	49	73	97	122	146	29	58	88	117	146	175
1	18	35	53	70	88	105	21	42	63	83	104	125	25	50	75	99	124	149	30	60	90	119	149	179
1.2	18	36	54	71	89	107	21	42	64	85	106	127	25	51	76	101	127	152	31	61	92	122	153	183
1.4	18	36	55	73	91	109	22	43	65	97	108	130	26	52	78	103	129	155	31	62	94	125	156	187
1.6	19	37	56	74	93	111	22	44	66	88	110	132	26	53	79	105	132	158	32	64	96	128	160	192
1.8	19	38	57	76	95	114	23	45	69	90	113	135	27	54	81	108	135	162	33	65	98	131	163	196
2	19	39	58	77	97	116	23	46	69	92	115	138	28	55	83	110	138	165	33	67	100	133	167	200
2.2	20	39	59	79	98	118	23	47	70	93	117	140	28	56	85	113	141	169	34	68	102	136	170	204
2.4	20	40	60	80	100	120	24	48	72	95	119	143	29	57	86	115	143	172	35	70	105	139	174	209
2.6	20	41	61	81	102	122	24	49	73	97	122	146	29	58	88	117	146	175	36	71	107	142	178	213
2.8	21	41	62	83	103	124	25	49	74	99	123	148	30	59	89	119	148	178	36	72	109	145	181	217
3	21	42	63	84	105	126	25	50	76	101	126	151	30	61	91	121	152	182	37	74	111	147	184	221

CHLORINE CONCENTRATION (mg/L)	pH=8.0 Log Inactivation						pH=8.5 Log Inactivation						pH=9.0 Log Inactivation					
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
<=0.4	33	66	99	132	165	198	39	79	118	157	197	236	47	93	140	186	233	279
0.6	34	68	102	136	170	204	41	81	122	163	203	244	49	97	146	194	243	291
0.8	35	70	105	140	175	210	42	84	126	168	210	252	50	100	151	201	251	301
1	36	72	108	144	180	216	43	87	130	173	217	260	52	104	156	208	260	312
1.2	37	74	111	147	184	221	45	89	134	178	223	267	53	107	160	213	267	320
1.4	38	76	114	151	189	227	46	91	137	183	228	274	55	110	165	219	274	329
1.6	39	77	116	155	193	232	47	94	141	197	234	281	56	112	169	225	281	337
1.8	40	79	119	159	198	238	48	96	144	191	239	287	58	115	173	230	288	345
2	41	81	122	162	203	243	49	98	147	196	245	294	59	118	177	235	294	353
2.2	41	83	124	165	207	248	50	100	150	200	250	300	60	120	181	241	301	361
2.4	42	84	127	169	211	253	51	102	153	204	255	306	61	123	184	245	307	368
2.6	43	86	129	172	215	258	52	104	156	208	260	312	63	125	189	250	313	375
2.8	44	88	132	175	219	263	53	106	159	212	265	318	64	127	191	255	318	382
3	45	89	134	179	223	268	54	108	162	216	270	324	65	130	195	259	324	389

Source: AWWA, 1991.

Appendix F

Quote from Valin Corporation for a Rosedale pre-filter bag.

QUOTATION

Valin Corporation
1701 E. Edinger Ave Bldg. J
Santa Ana, CA 92705
Phone: 714-953-1635
Fax: 714-953-2126
eMail: jbodle@valin.com

VALIN
PROCESS CONTROL & AUTOMATION

Quote Number	
2156021	
Quote Date	Page
4/28/2014 08:52:31	1 of 2

****Quote valid for 30 days from quote date ****

Bill To:
UCLA UNI-Camp
Attn: Accounts Payable
900 Hilgard Ave.
Los Angeles, CA 90024

310-208-8252

Ship To:
UCLA UNI-Camp
1361 Ontario Ave.
Pasadena, CA 91103

Customer ID: 149143 **Requested By:** Nate Tsang

PO Number	*Ship Route*	*Taker*
RFQ: Nate - GLR Pre-Filter	10	JOSBOD

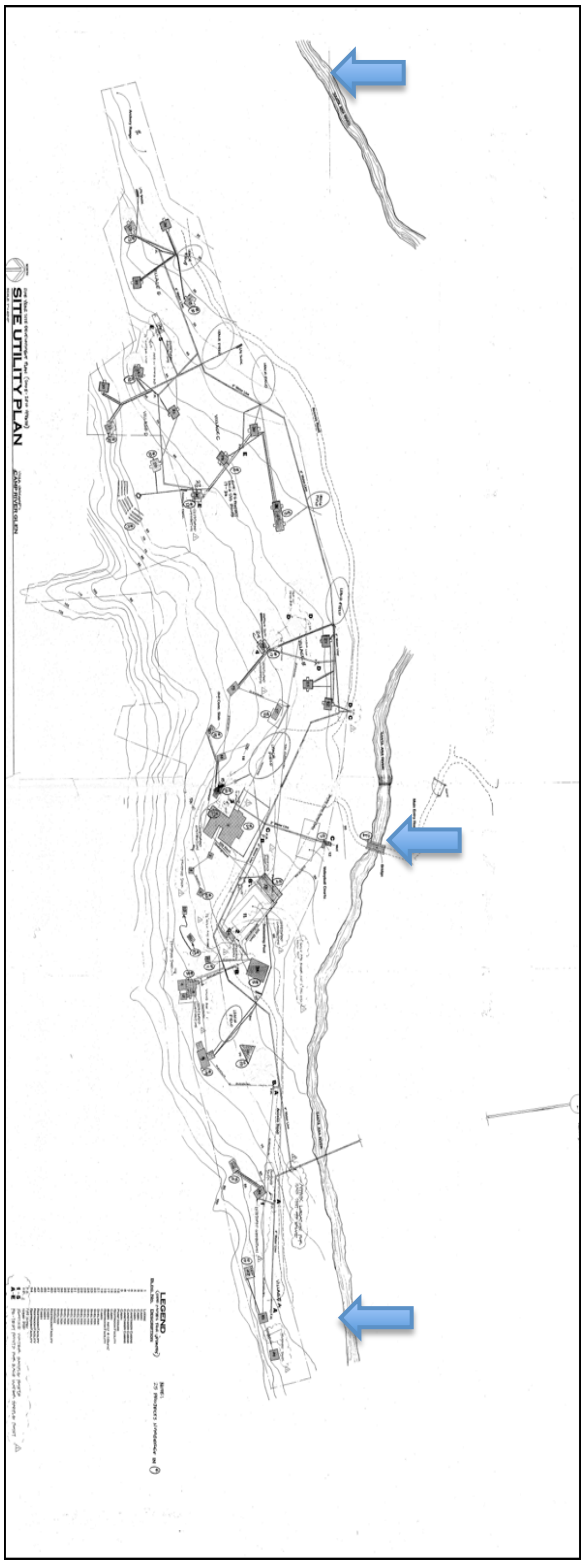
Quantities					*Item ID* / *Item Description*	*Pricing UOM* / *Unit Size*		*Unit Price*	*Extended Price*
Ordered	*Allocated*	*Remaining*	*UOM* / *Unit Size*	*Disp.*					
		Delivery Instructions:			Ship UPS				
1.0000	0.0000	1.0000 EA	1.0		M8-1502-NC ROSE Rosedale NCO8-30-2P-*-150-S-B-PB Size 2 bag housing, 2 in NPT connections, side in/side and bottom out, 150 psi, 304SS, Buna-N seal, swing bolt cover	EA	1.0	1,675.0000	1,675.00
		Order Line Notes:			Stock Item: Santa Ana, CA				
25.0000	0.0000	25.0000 EA	1.0		PE-001-P2S ROSE Rosedale Bag	EA	1.0	7.4500	186.25
		Order Line Notes:			Stock Item: Santa Ana, CA				
1.0000	0.0000	1.0000 EA	1.0		M8-1011 ROSE Rosedale LCO8-30-2P-*-125-S-B-B Size 12 bag housing, 2 in NPT connections, side in/side and bottom out, 125 psi, 304SS, Buna-N seal, clamp cover	EA	1.0	1,627.0000	1,627.00
		Order Line Notes:			Lead Time: 1-2 weeks				
25.0000	0.0000	25.0000 EA	1.0		PE-001-P12S ROSE Rosedale Bag	EA	1.0	8.9000	222.50
		Order Line Notes:			Stock Item: Santa Ana, CA				

Total Lines: 4

SUB-TOTAL:	3,710.75
TAX:	334.60
PACKAGING AND HANDLING FEE :	6.95
QUOTE AMOUNT:	**4,052.30**

Appendix G

The river sampling locations are indicated by the blue arrows.



Appendix H1

Material Safety Data Sheet for Keystone Liquid Rinse Additive.

SAFETY DATA SHEET

KEYSTONE LIQUID RINSE ADDITIVE

Section 1. Chemical product and company identification

Product name	:	KEYSTONE LIQUID RINSE ADDITIVE
Recommended use and restrictions	:	Rinse additive Use only for the purpose on the product label.
Product dilution information	:	Up to 311ppm in water
Supplier's information	:	Ecolab Inc. Institutional Division 370 N. Wabasha Street St. Paul, MN 55102 1-800-352-5326
Code	:	913640-14
Date of issue	:	**26 Mar 2013** EMERGENCY HEALTH INFORMATION: 1-800-328-0026 Outside United States and Canada CALL 1-651-222-5352 (in USA)

Section 2. Hazards identification

		Product AS SOLD	Product AT USE DILUTION
GHS Classification	:	SERIOUS EYE DAMAGE/ EYE IRRITATION - Category 2B AQUATIC TOXICITY (ACUTE) - Category 2	Not classified.
GHS label elements			
Signal word	:	Warning	No signal word.
Hazard statements	:	Causes eye irritation. Toxic to aquatic life.	No known significant effects or critical hazards.
Precautionary statements			
Prevention	:	Avoid release to the environment. Wash hands thoroughly after handling.	Wash thoroughly after handling.
Response	:	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists: Get medical attention.	Get medical attention if symptoms appear.
Storage	:	No other specific measures identified.	No other specific measures identified.
Disposal	:	See section 13 for waste disposal information.	See section 13 for waste disposal information.
Other hazards	:	None known.	None known.

Section 3. Composition/information on ingredients

Substance/mixture : Mixture

Product AS SOLD

Hazardous ingredients	Concentration Range (%)	CAS number
alcohols, c10-16, ethoxylated	5 - 20	68002-97-1

Section 3. Composition/information on ingredients

Product AT USE DILUTION

Within the present knowledge of the supplier, this product does not contain any hazardous ingredients in quantities requiring reporting, in accordance with local regulations.

Section 4. First aid measures

	Product AS SOLD	Product AT USE DILUTION
Eye contact	: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Get medical attention if irritation persists.	No known effect after eye contact. Rinse with water for a few minutes.
Skin contact	: No known effect after skin contact. Rinse with water for a few minutes.	No known effect after skin contact. Rinse with water for a few minutes.
Inhalation	: No special measures required. Treat symptomatically.	No special measures required. Treat symptomatically.
Ingestion	: Get medical attention if symptoms occur.	Get medical attention if symptoms occur.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

See toxicological information (section 11)

Section 5. Fire-fighting measures

Product AS SOLD

Suitable fire extinguishing media : Use water spray, fog or foam.

Specific hazards arising from the chemical : In a fire or if heated, a pressure increase will occur and the container may burst. This material is toxic to aquatic life. Fire water contaminated with this material must be contained and prevented from being discharged to any waterway, sewer or drain.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
carbon dioxide
carbon monoxide

Specific fire-fighting methods : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

	Product AS SOLD	Product AT USE DILUTION
Personal precautions	: Use personal protective equipment as required.	Use personal protective equipment as required.
Environmental precautions	: Avoid contact of large amounts of spilled material and runoff with soil and surface waterways.	Avoid contact of large amounts of spilled material and runoff with soil and surface waterways.
Methods for cleaning up	: Use a water rinse for final clean-up.	Use a water rinse for final clean-up.

Section 7. Handling and storage

	Product AS SOLD	Product AT USE DILUTION
Handling	: Avoid contact with eyes, skin and clothing. Wash thoroughly after handling.	Wash thoroughly after handling.
Storage	: Keep out of reach of children. Keep container tightly closed. Store between the following temperatures: 0 and 50°C	Keep out of reach of children.

Section 8. Exposure controls/personal protection

Control parameters

Ingredient name	Exposure limits
None.	

	Product AS SOLD	Product AT USE DILUTION
Appropriate engineering controls	: Good general ventilation should be sufficient to control worker exposure to airborne contaminants.	Good general ventilation should be sufficient to control worker exposure to airborne contaminants.
Personal protection		
Eye protection	: No protective equipment is needed under normal use conditions.	No protective equipment is needed under normal use conditions.
Hand protection	: No protective equipment is needed under normal use conditions.	No protective equipment is needed under normal use conditions.
Skin protection	: No protective equipment is needed under normal use conditions.	No protective equipment is needed under normal use conditions.
Respiratory protection	: A respirator is not needed under normal and intended conditions of product use.	A respirator is not needed under normal and intended conditions of product use.

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing.

Section 9. Physical and chemical properties

	Product AS SOLD	Product AT USE DILUTION
Physical state	: Liquid.	Liquid.
Color	: Green [Dark]	Clear
Odor	: Odorless	Odorless
pH	: 3.17 (100%)	7.5 to 8.5
Flash point	: > 100°C Product does not support combustion.	> 100°C
Explosion limits	: Not available.	
Flammability (solid, gas)	: Not available.	
Melting point	: Not available.	
Boiling point	: Not available.	
Evaporation rate (butyl acetate = 1)	: Not available.	
Vapor pressure	: Not available.	
Vapor density	: Not available.	
Relative density	: 1.007 to 1.027 (Water = 1)	

Section 9. Physical and chemical properties

Solubility : Easily soluble in the following materials: cold water and hot water.

Partition coefficient: n-octanol/water : Not available.

Auto-ignition temperature : Not available.

Decomposition temperature : Not available.

Odor threshold : Not available.

Viscosity : Not available.

Section 10. Stability and reactivity

Product AS SOLD

Stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : No specific data.

Materials to avoid : Not available.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Route of exposure : Skin contact, Eye contact, Inhalation, Ingestion

	Product AS SOLD	Product AT USE DILUTION
Symptoms		
Eye contact	: Adverse symptoms may include the following: irritation watering redness	No specific data.
Skin contact	: No specific data.	No specific data.
Inhalation	: No specific data.	No specific data.
Ingestion	: No specific data.	No specific data.
Acute toxicity		
Eye contact	: Causes eye irritation.	No known significant effects or critical hazards.
Skin contact	: No known significant effects or critical hazards.	No known significant effects or critical hazards.
Inhalation	: No known significant effects or critical hazards.	No known significant effects or critical hazards.
Ingestion	: No known significant effects or critical hazards.	No known significant effects or critical hazards.

Toxicity data

Product/ingredient name	Result	Species	Dose
alcohols, c10-16, ethoxylated	LC50 Inhalation Dusts and mists	Rat	>50 mg/l
	LD50 Dermal	Rat	>2000 mg/kg
	LD50 Oral	Rat	>1000 mg/kg

Chronic toxicity

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Section 11. Toxicological information

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Section 12. Ecological information

Product AS SOLD

Ecotoxicity : This material is toxic to aquatic life.

Aquatic and terrestrial toxicity

Product/ingredient name	Result	Species	Exposure
alcohols, c10-16, ethoxylated	Acute EC50 >0.1 mg/l	Daphnia	48 hours

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods

Product AS SOLD: Diluted product can be flushed to sanitary sewer. Discard empty container in trash.

Product AT USE DILUTION: Diluted product can be flushed to sanitary sewer. Discard empty container in trash.

Section 14. Transport information

Certain shipping modes or package sizes may have exceptions from the transport regulations. The classification provided may not reflect those exceptions and may not apply to all shipping modes or package sizes.

DOT

DOT Classification **Not regulated.**

IMO/IMDG

IMO/IMDG Classification **Not regulated.**

For transport in bulk, see shipping documents for specific transportation information.

Product AT USE DILUTION
Not intended for transport.

Section 15. Regulatory information

Product AS SOLD

U.S. Federal regulations

TSCA 8(b) inventory : All components are listed or exempted.

SARA 302/304/311/312 extremely hazardous substances: No listed substance

SARA 302/304 emergency planning and notification: No listed substance

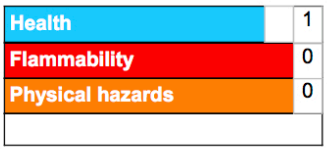
SARA 313	Product name	CAS number	Concentration
Form R - Reporting requirements	: No listed substance		

California Prop. 65 : No listed substance

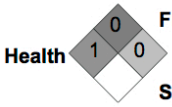
Section 16. Other information

Product AS SOLD

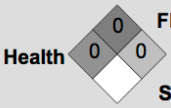
Hazardous Material Information System (U.S.A.) :



National Fire Protection Association (U.S.A.) :



Product AT USE DILUTION



Date of issue : **26 Mar 2013**

Prepared by : Regulatory Affairs
1-800-352-5326

Notice to reader

The above information is believed to be correct with respect to the formula used to manufacture the product in the country of origin. As data, standards, and regulations change, and conditions of use and handling are beyond our control, NO WARRANTY, EXPRESS OR IMPLIED, IS MADE AS TO THE COMPLETENESS OR CONTINUING ACCURACY OF THIS INFORMATION.

Appendix H2

Material Safety Data Sheet for Keystone Liquid Dishmachine Detergent

SAFETY DATA SHEET

ECOLAB

KEYSTONE LIQUID DISHMACHINE DETERGENT

Section 1. Chemical product and company identification

Product name	:	KEYSTONE LIQUID DISHMACHINE DETERGENT
Recommended use and restrictions	:	Machine Warewashing Detergent Use only for the purpose on the product label.
Product dilution information	:	Up to 1.4 oz/10 gal or 1 mL/L in water
Supplier's information	:	Ecolab Inc. Institutional Division 370 N. Wabasha Street St. Paul, MN 55102 1-800-352-5326
Code	:	986216-13
Date of issue	:	**12 Feb 2013** EMERGENCY HEALTH INFORMATION: 1-800-328-0026 Outside United States and Canada CALL 1-651-222-5352 (in USA)

Section 2. Hazards identification

		Product AS SOLD	Product AT USE DILUTION
GHS Classification	:	CORROSIVE TO METALS - Category 1 SKIN CORROSION/IRRITATION - Category 1 SERIOUS EYE DAMAGE/ EYE IRRITATION - Category 1	Not classified.
GHS label elements			
Signal word	:	Danger	No signal word.
Symbol	:		
Hazard statements	:	May be corrosive to metals. Causes severe skin burns and eye damage.	No known significant effects or critical hazards.
Precautionary statements			
Prevention	:	Wear protective gloves. Wear eye or face protection. Wear protective clothing. Keep only in original container. Wash hands thoroughly after handling.	Not applicable.
Response	:	Absorb spillage to prevent material damage. IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Immediately call a POISON CENTER or physician. IF SWALLOWED: Immediately call a POISON CENTER or physician. Rinse mouth. Do NOT induce vomiting. IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water or shower. Wash contaminated clothing before reuse. Immediately call a POISON CENTER or physician. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact	Get medical attention if symptoms appear.

Section 2. Hazards identification

		lenses, if present and easy to do. Continue rinsing. Immediately call a POISON CENTER or physician.	
Storage	:	Store in corrosive resistant container with a resistant inner liner.	Not applicable.
Disposal	:	Dispose of contents and container in accordance with all local, regional, national and international regulations.	Not applicable.
Other hazards	:	None known.	None known.

Section 3. Composition/information on ingredients

Substance/mixture : Mixture

Product AS SOLD

Hazardous ingredients	Concentration Range (%)	CAS number
SODIUM HYDROXIDE	23	1310-73-2

Product AT USE DILUTION

Within the present knowledge of the supplier, this product does not contain any hazardous ingredients in quantities requiring reporting, in accordance with local regulations.

Section 4. First aid measures

		Product AS SOLD	Product AT USE DILUTION
Eye contact	:	Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Get medical attention immediately.	No known effect after eye contact. Rinse with water for a few minutes.
Skin contact	:	Take off immediately all contaminated clothing. Rinse skin with water or shower. Get medical attention immediately. Wash clothing before reuse. Clean shoes thoroughly before reuse.	No known effect after skin contact. Rinse with water for a few minutes.
Inhalation	:	Remove victim to fresh air and keep at rest in a position comfortable for breathing. Get medical attention immediately.	No special measures required. Treat symptomatically.
Ingestion	:	Get medical attention immediately. Rinse mouth. Do not induce vomiting.	Get medical attention if symptoms occur.
Protection of first-aiders	:	No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Wash contaminated clothing thoroughly with water before removing it, or wear gloves.	
Notes to physician	:	Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.	

See toxicological information (section 11)

Section 5. Fire-fighting measures

Product AS SOLD

Suitable fire extinguishing media : Use water spray, fog or foam.

Specific hazards arising from the chemical : In a fire or if heated, a pressure increase will occur and the container may burst.

Hazardous thermal decomposition products :

Section 5. Fire-fighting measures

Decomposition products may include the following materials:
carbon dioxide
carbon monoxide
phosphorus oxides
metal oxide/oxides

Specific fire-fighting methods : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

	Product AS SOLD	Product AT USE DILUTION
Personal precautions	: Initiate company's spill response procedures immediately. Keep people out of area. Put on appropriate personal protective equipment (see section 8). Do not touch or walk through spilled material.	Use personal protective equipment as required. Do not touch or walk through spilled material.
Environmental precautions	: Avoid contact of spilled material and runoff with soil and surface waterways.	Avoid contact of large amounts of spilled material and runoff with soil and surface waterways.
Methods for cleaning up	: Follow company's spill procedures. Keep people away from spill. Put on appropriate personal protective equipment (see section 8). Absorb/ neutralize liquid material. Use a tool to scoop up solid or absorbed material and put into appropriate labeled container. Use a tool to scoop up solid or absorbed material and place into appropriate labeled waste container. Use a water rinse for final clean-up.	Absorb with an inert material. Use a water rinse for final clean-up.

Section 7. Handling and storage

	Product AS SOLD	Product AT USE DILUTION
Handling	: Do not get in eyes or on skin or clothing. Do not breathe vapor or mist. Use only with adequate ventilation. Wash thoroughly after handling. SAFETY REMINDER: * Never pour product into unlabeled containers * Use only for recommended uses. Read label. * Never take product home. Use only in workplace.	Wash thoroughly after handling.
Storage	: Keep out of reach of children. Keep container tightly closed. Keep container in a cool, well-ventilated area. Store between the following temperatures: 0 and 50°C	Keep out of reach of children. Keep container tightly closed. Keep container in a cool, well-ventilated area.

Section 8. Exposure controls/personal protection

Control parameters

Ingredient name	Exposure limits
SODIUM HYDROXIDE	**ACGIH TLV (United States, 3/2012).** C: 2 mg/m³ **OSHA PEL (United States, 6/2010).** TWA: 2 mg/m³ 8 hours. **NIOSH REL (United States, 6/2009).** CEIL: 2 mg/m³

	Product AS SOLD	Product AT USE DILUTION
Appropriate engineering controls	: Use only with adequate ventilation. If user operations generate dust, fumes, gas, vapor or mist, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. Provide suitable facilities for quick drenching or flushing of the eyes and body in case of contact or splash hazard.	Good general ventilation should be sufficient to control worker exposure to airborne contaminants.
Personal protection		
Eye protection	: Use chemical splash goggles. For continued or severe exposure wear a face shield over the goggles.	No protective equipment is needed under normal use conditions.
Hand protection	: Use chemical-resistant, impervious gloves.	No protective equipment is needed under normal use conditions.
Skin protection	: Use synthetic apron, other protective equipment as necessary to prevent skin contact.	No protective equipment is needed under normal use conditions.
Respiratory protection	: A respirator is not needed under normal and intended conditions of product use.	A respirator is not needed under normal and intended conditions of product use.
Hygiene measures	: Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing.	

Section 9. Physical and chemical properties

	Product AS SOLD	Product AT USE DILUTION
Physical state	: Liquid.	Liquid.
Color	: Red [Dark]	pink [Light]
Odor	: Odorless	Odorless
pH	: 13.5 (100%)	10.6 to 11.3
Flash point	: > 100°C Product does not support combustion.	> 100°C
Explosion limits	: Not available.	
Flammability (solid, gas)	: Not available.	
Melting point	: Not available.	
Boiling point	: Not available.	
Evaporation rate (butyl acetate = 1)	: Not available.	
Vapor pressure	: Not available.	
Vapor density	: Not available.	
Relative density	: 1.25 (Water = 1)	

Section 9. Physical and chemical properties

Solubility : Easily soluble in the following materials: cold water and hot water.

Partition coefficient: n-octanol/water : Not available.

Auto-ignition temperature : Not available.

Decomposition temperature : Not available.

Odor threshold : Not available.

Viscosity : Not available.

Section 10. Stability and reactivity

Product AS SOLD

Stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : No specific data.

Materials to avoid : Highly reactive or incompatible with the following materials: acids.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Route of exposure : Skin contact, Eye contact, Inhalation, Ingestion

	Product AS SOLD	Product AT USE DILUTION
Symptoms		
Eye contact	: Adverse symptoms may include the following: pain watering redness	No specific data.
Skin contact	: Adverse symptoms may include the following: pain or irritation redness blistering may occur	No specific data.
Inhalation	: Adverse symptoms may include the following: coughing Respiratory tract irritation	No specific data.
Ingestion	: Adverse symptoms may include the following: stomach pains	No specific data.
Acute toxicity		
Eye contact	: Causes serious eye damage.	No known significant effects or critical hazards.
Skin contact	: Causes severe burns.	No known significant effects or critical hazards.
Inhalation	: May give off gas, vapor or dust that is very irritating or corrosive to the respiratory system.	No known significant effects or critical hazards.
Ingestion	: May cause burns to mouth, throat and stomach.	No known significant effects or critical hazards.

Toxicity data

Product/ingredient name	Result	Species	Dose
Not applicable.			

Chronic toxicity

Section 11. Toxicological information

Carcinogenicity	:	No known significant effects or critical hazards.
Mutagenicity	:	No known significant effects or critical hazards.
Teratogenicity	:	No known significant effects or critical hazards.
Developmental effects	:	No known significant effects or critical hazards.
Fertility effects	:	No known significant effects or critical hazards.

Section 12. Ecological information

Product AS SOLD

Ecotoxicity : No known significant effects or critical hazards.

Aquatic and terrestrial toxicity

Product/ingredient name	Result	Species	Exposure
sodium hydroxide	Acute EC50 40 mg/l	Daphnia	48 hours

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Product AS SOLD

Disposal methods : Avoid disposal. Attempt to use product completely in accordance with intended use. Disposal should be in accordance with applicable regional, national and local laws and regulations.

RCRA classification : Unused product is D002 (Corrosive)

Product AT USE DILUTION

Diluted product can be flushed to sanitary sewer. Discard empty container in trash.

Section 14. Transport information

Certain shipping modes or package sizes may have exceptions from the transport regulations. The classification provided may not reflect those exceptions and may not apply to all shipping modes or package sizes.

DOT

DOT Classification	UN1824
DOT Proper shipping name	Sodium hydroxide solution
Class	8
Packing group	II

IMO/IMDG

IMO/IMDG Classification	UN1824
IMO/IMDG Proper shipping name	SODIUM HYDROXIDE SOLUTION
Class	8
Packing group	II

For transport in bulk, see shipping documents for specific transportation information.

Product AT USE DILUTION

Not intended for transport.

Section 15. Regulatory information

Product AS SOLD

U.S. Federal regulations

TSCA 8(b) inventory : All components are listed or exempted.

SARA 302/304/311/312 extremely hazardous substances: No listed substance

SARA 302/304 emergency planning and notification: No listed substance

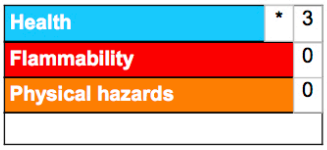
SARA 313	Product name	CAS number	Concentration
Form R - Reporting requirements	: No listed substance		

California Prop. 65 : No listed substance

Section 16. Other information

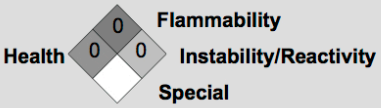
Product AS SOLD

Hazardous Material Information System (U.S.A.) :



National Fire Protection Association (U.S.A.) :

Product AT USE DILUTION



Date of issue : **12 Feb 2013**

Prepared by : Regulatory Affairs
1-800-352-5326

Notice to reader

The above information is believed to be correct with respect to the formula used to manufacture the product in the country of origin. As data, standards, and regulations change, and conditions of use and handling are beyond our control, NO WARRANTY, EXPRESS OR IMPLIED, IS MADE AS TO THE COMPLETENESS OR CONTINUING ACCURACY OF THIS INFORMATION.

Appendix H3

Material Safety Data Sheet for Keystone Sanitizer

SAFETY DATA SHEET

ECOLAB

KEYSTONE SANITIZER

Section 1. Chemical product and company identification

Product name	:	KEYSTONE SANITIZER
Recommended use and restrictions	:	Sanitizer. Use only for the purpose on the product label.
Product dilution information	:	Not applicable
Supplier's information	:	Ecolab Inc. Institutional Division 370 N. Wabasha Street St. Paul, MN 55102 1-800-352-5326
Code	:	900043-43
Date of issue	:	**25 Feb 2013**
EPA Registration No.	:	1677-52
		EMERGENCY HEALTH INFORMATION: 1-800-328-0026 Outside United States and Canada CALL 1-651-222-5352 (in USA)

Section 2. Hazards identification

		Product AS SOLD	**Product AT USE DILUTION**
GHS Classification	:	SKIN CORROSION/IRRITATION - Category 1B SERIOUS EYE DAMAGE/ EYE IRRITATION - Category 1	Data not available - Refer to Product AS SOLD
GHS label elements			
Signal word	:	Danger	
Symbol	:		
Hazard statements	:	Causes severe skin burns and eye damage.	
Precautionary statements			
Prevention	:	Wear protective gloves. Wear eye or face protection. Wear protective clothing. Mixing this product with acid or ammonia releases chlorine gas. Wash hands thoroughly after handling.	
Response	:	IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Immediately call a POISON CENTER or physician. IF SWALLOWED: Immediately call a POISON CENTER or physician. Rinse mouth. Do NOT induce vomiting. IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water or shower. Wash contaminated clothing before reuse. Immediately call a POISON CENTER or physician. IF IN EYES:	

Page: 1/7

Section 2. Hazards identification

Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a POISON CENTER or physician.

Storage : No other specific measures identified.

Disposal : See section 13 for waste disposal information.

Other hazards : None known.

Section 3. Composition/information on ingredients

Substance/mixture : Mixture

Product AS SOLD

Hazardous ingredients	Concentration Range (%)	CAS number
sodium hypochlorite	10	7681-52-9

Product AT USE DILUTION

Hazardous ingredients	Concentration Range (%)	CAS number
Data not available - Refer to Product AS SOLD		

Section 4. First aid measures

	Product AS SOLD	Product AT USE DILUTION
Eye contact	: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Get medical attention immediately.	Data not available - Refer to Product AS SOLD
Skin contact	: Take off immediately all contaminated clothing. Rinse skin with water or shower. Get medical attention immediately. Wash clothing before reuse. Clean shoes thoroughly before reuse.	
Inhalation	: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Get medical attention immediately.	
Ingestion	: Get medical attention immediately. Rinse mouth. Do not induce vomiting.	

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Wash contaminated clothing thoroughly with water before removing it, or wear gloves.

Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

See toxicological information (section 11)

Section 5. Fire-fighting measures

Product AS SOLD

Suitable fire extinguishing media : Use water spray, fog or foam.

Specific hazards arising from the chemical : In a fire or if heated, a pressure increase will occur and the container may burst. Fire water contaminated with this material must be contained and prevented from being discharged to any waterway, sewer or drain.

Section 5. Fire-fighting measures

Hazardous thermal decomposition products : Decomposition products may include the following materials:
halogenated compounds
metal oxide/oxides

Specific fire-fighting methods : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

	Product AS SOLD	Product AT USE DILUTION
Personal precautions	: Initiate company's spill response procedures immediately. Keep people out of area. Put on appropriate personal protective equipment (see section 8). Do not touch or walk through spilled material.	Data not available - Refer to Product AS SOLD
Environmental precautions	: Avoid contact of spilled material and runoff with soil and surface waterways.	
Methods for cleaning up	: Follow company's spill procedures. Keep people away from spill. Put on appropriate personal protective equipment (see section 8). Absorb/ neutralize liquid material. Use a tool to scoop up solid or absorbed material and put into appropriate labeled container. Use a tool to scoop up solid or absorbed material and place into appropriate labeled waste container. Use a water rinse for final clean-up.	

Section 7. Handling and storage

	Product AS SOLD	Product AT USE DILUTION
Handling	: Do not get in eyes or on skin or clothing. Do not breathe vapor or mist. Use only with adequate ventilation. Mixing this product with acid or ammonia releases chlorine gas. Wash thoroughly after handling.	Data not available - Refer to Product AS SOLD
Storage	: Keep out of reach of children. Keep container tightly closed. Store between the following temperatures: -10 and 40°C	

Section 8. Exposure controls/personal protection

Control parameters

Ingredient name	Exposure limits
sodium hypochlorite chlorine	**AIHA WEEL (United States, 10/2011).** STEL: 2 mg/m³ 15 minutes. **ACGIH TLV (United States, 3/2012).** STEL: 2.9 mg/m³ 15 minutes. STEL: 1 ppm 15 minutes. TWA: 1.5 mg/m³ 8 hours. TWA: 0.5 ppm 8 hours. **OSHA PEL (United States, 6/2010).** CEIL: 3 mg/m³

Section 8. Exposure controls/personal protection

	CEIL: 1 ppm **NIOSH REL (United States, 6/2009).** CEIL: 0.5 ppm 15 minutes. CEIL: 1.45 mg/m³ 15 minutes.

	Product AS SOLD	**Product AT USE DILUTION**
Appropriate engineering controls	: Use only with adequate ventilation. If user operations generate dust, fumes, gas, vapor or mist, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. Provide suitable facilities for quick drenching or flushing of the eyes and body in case of contact or splash hazard.	Data not available - Refer to Product AS SOLD
Personal protection		
Eye protection	: Use chemical splash goggles. For continued or severe exposure wear a face shield over the goggles.	
Hand protection	: Use chemical-resistant, impervious gloves.	
Skin protection	: Use synthetic apron, other protective equipment as necessary to prevent skin contact.	
Respiratory protection	: A respirator is not needed under normal and intended conditions of product use.	
Hygiene measures	: Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing.	

Section 9. Physical and chemical properties

	Product AS SOLD	**Product AT USE DILUTION**
Physical state	: Liquid.	Data not available - Refer to Product AS SOLD
Color	: Yellow [Light]	
Odor	: chlorine	
pH	: 12.5 (100%)	
Flash point	: > 100°C	
Explosion limits	: Not available.	
Flammability (solid, gas)	: Not available.	
Melting point	: Not available.	
Boiling point	: Not available.	
Evaporation rate (butyl acetate = 1)	: Not available.	
Vapor pressure	: Not available.	
Vapor density	: Not available.	
Relative density	: 1.154 (Water = 1)	
Solubility	: Not available.	

Section 9. Physical and chemical properties

Partition coefficient: n-octanol/water : Not available.

Auto-ignition temperature : Not available.

Decomposition temperature : Not available.

Odor threshold : Not available.

Viscosity : Not available.

Section 10. Stability and reactivity

Product AS SOLD

Stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : No specific data.

Materials to avoid : Extremely reactive or incompatible with the following materials: acids.
Slightly reactive or incompatible with the following materials: metals.
Mixing this product with acid or ammonia releases chlorine gas.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Route of exposure : Skin contact, Eye contact, Inhalation, Ingestion

Product AS SOLD

Symptoms

Eye contact : Adverse symptoms may include the following:
pain
watering
redness

Skin contact : Adverse symptoms may include the following:
pain or irritation
redness
blistering may occur

Inhalation : Adverse symptoms may include the following:
coughing
Respiratory tract irritation

Ingestion : Adverse symptoms may include the following:
stomach pains

Acute toxicity

Eye contact : Causes serious eye damage.

Skin contact : Causes severe burns.

Inhalation : May give off gas, vapor or dust that is very irritating or corrosive to the respiratory system.

Ingestion : May cause burns to mouth, throat and stomach.

Product AT USE DILUTION

Data not available - Refer to Product AS SOLD

Toxicity data

Product/ingredient name	Result	Species	Dose
sodium hypochlorite	LD50 Dermal	Rabbit	>10000 mg/kg
	LD50 Oral	Rat	5230 mg/kg

Section 11. Toxicological information

Chronic toxicity

Carcinogenicity	:	No known significant effects or critical hazards.
Mutagenicity	:	No known significant effects or critical hazards.
Teratogenicity	:	No known significant effects or critical hazards.
Developmental effects	:	No known significant effects or critical hazards.
Fertility effects	:	No known significant effects or critical hazards.

Section 12. Ecological information

Product AS SOLD

Ecotoxicity : Water polluting material. May be harmful to the environment if released in large quantities.

Aquatic and terrestrial toxicity

Product/ingredient name	Result	Species	Exposure
sodium hypochlorite	Acute EC50 0.071 mg/l	Daphnia	48 hours

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Product AS SOLD

Disposal methods : Avoid disposal. Attempt to use product completely in accordance with intended use. Disposal should be in accordance with applicable regional, national and local laws and regulations.

RCRA classification : Unused product is D002 (Corrosive)

Product AT USE DILUTION

Data not available - Refer to Product AS SOLD

Section 14. Transport information

Certain shipping modes or package sizes may have exceptions from the transport regulations. The classification provided may not reflect those exceptions and may not apply to all shipping modes or package sizes.

DOT

DOT Classification	UN1791
DOT Proper shipping name	Hypochlorite solutions
Class	8
Packing group	III

IMO/IMDG

IMO/IMDG Classification	UN1791
IMO/IMDG Proper shipping name	HYPOCHLORITE SOLUTION. Marine pollutant (sodium hypochlorite)
Class	8
Packing group	III

For transport in bulk, see shipping documents for specific transportation information.

Product AT USE DILUTION

Not intended for transport.

Section 15. Regulatory information

Product AS SOLD

U.S. Federal regulations

TSCA 8(b) inventory : All components are listed or exempted.

EPA Registration No. : 1677-52

SARA 302/304/311/312 extremely hazardous substances: No listed substance

SARA 302/304 emergency planning and notification: No listed substance

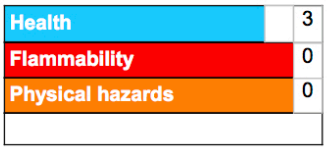
SARA 313	Product name	CAS number	Concentration
Form R - Reporting requirements	: No listed substance		

California Prop. 65 : No listed substance

Section 16. Other information

Product AS SOLD

Hazardous Material Information System (U.S.A.) :



National Fire Protection Association (U.S.A.) :

Date of issue : **25 Feb 2013**

Prepared by : Regulatory Affairs
1-800-352-5326

Notice to reader

The above information is believed to be correct with respect to the formula used to manufacture the product in the country of origin. As data, standards, and regulations change, and conditions of use and handling are beyond our control, NO WARRANTY, EXPRESS OR IMPLIED, IS MADE AS TO THE COMPLETENESS OR CONTINUING ACCURACY OF THIS INFORMATION.

Appendix I

Quote from American Environmental Testing Laboratory.

American Environmental Testing Laboratory Inc.
2834 North Naomi Street Burbank, CA 91504 • DOHS NO: 1541, LACSD NO: 10181
Tel: (888) 288-AETL • (818) 845-8200 • Fax: (818) 845-8840 • www.aetlab.com

April 9th, 2014

Hunter Connell
UCLA UniCamp Consulting
(707) 570-5450

Monthly Surface Water Testing

ANALYTE	METHOD OF ANALYSIS	UNIT PRICE $	No. of SAMPLES	TOTAL COST $
MBAS (Surfactants)	SM-5540C	50.00	4	200.00
pH	SM-4500-H-B	10.00	4	40.00
Fecal Coliform	SM-9221A-E	35.00	4	140.00
Total Coliform	SM-9221A-D	35.00	4	140.00
E. Coli	MPN (EC)	35.00	4	140.00
TOC	SM5310B	50.00	4	200.00
Sodium & Boron by ICP	200.7	39.00	4	156.00
Chloroform	624	85.00	4	340.00
Total Phosphate	SM-4110B	30.00	4	120.00
			Grand Total	**$1476.00**
			Special 45% Student Discount	**- $664.20**
			Grand Total with Discount	**$811.80**

STANDARD TURN AROUND TIME (TAT) IS FIVE WORKING DAYS.
THERE IS A 75% SURCHARGE FOR NEXT DAY TAT.
THERE IS A 50% SURCHARGE FOR 2 DAYS TAT.
THERE IS A 45% SURCHARGE FOR 3 DAYS TAT.
THERE IS A 35% SURCHARGE FOR 4 DAYS TAT.
All surcharges apply to cost of analysis only.

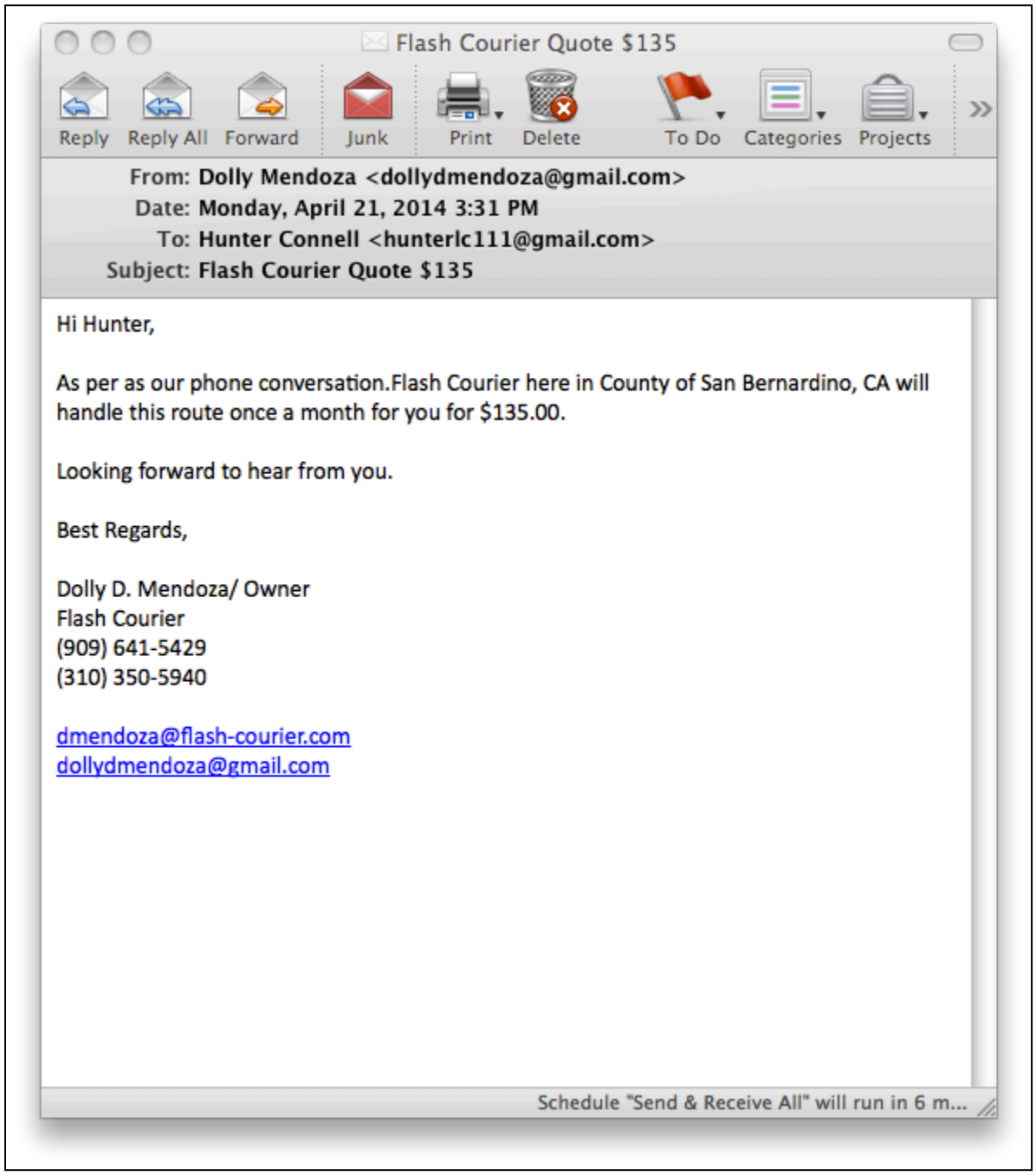
PRICES INCLUDE QA/QC DATA, LABELS, CHAIN OF CUSTODY FORMS, COOLER, BLUE ICE, AND COMPLIMENTARY SAMPLE PICKUP IN SOUTHERN CALIFORNIA.

C. Razmara

Cyrus Razmara, Ph.D.
CEO & Laboratory Director

Appendix J

Quote from Flash Courier.



Appendix K

Quote from Babcock Laboratories, Inc.

BABCOCK Laboratories, Inc.
The Standard of Excellence for Over 100 Years

ISO/IEC 17025 #3232.01 ELAP #2698
6100 Quail Valley Court Riverside, CA 92507-0704
P.O. Box 432 Riverside, CA 92502-0432
PH (951) 653-3351 FAX (951) 653-1662
www.babcocklabs.com

Analytical Services Quotation

Roger Smith
Arrowhead Group, Inc.
3424 N. Del Rosa Avenue, Ste. B
San Bernardino, CA 92404

Printed: 5/7/2014
Effective: 05/06/14
Expires: 11/02/14

UCLA Surface Waters

Pricing Summary

Parameter	Method	Quantity	TAT (days)	Unit Price	Extended Price
Liquid					
Boron by ICP	EPA 200.7	12	10	$15.00	$180.00
E coli by MD/MTF	SM 9221E	12	10	$25.00	$300.00
Methylene Blue Active Substance	SM 5540C	12	10	$45.00	$540.00
pH	SM 4500H+ B	12	10	$15.00	$180.00
Sodium by ICP	EPA 200.7	12	10	$15.00	$180.00
Specific Conductance	SM 2510 B	12	10	$15.00	$180.00
Total Organic Carbon	SM 5310B	12	10	$45.00	$540.00
Total P as PO4	varies	12	10	$30.00	$360.00
Total/Fecal Coliform by MD/MTF Package	SM 9221B	12	10	$75.00	$900.00
				Bid Total:	**$3,360.00**

Cathleen S. Iijima
Director of Client Services

Page 1 of 2

Appendix L

Comparison of 2 recommended river sampling options.

Option 1: American Environmental Testing Laboratory Analysis

Service	Cost
River Sampling Analysis	$437.80
Courier Service	$540.00
Total	$977.80

Option 2: E.S. Babcock and Sons Laboratory Analysis via Arrowhead Consulting

Service	Cost
River Sampling Analysis	$2820 (eliminated TOC)
Additional Arrowhead Consulting Fees	$0
Total	$2820

Appendix M

Summary of river sampling methodology

Goal: To sample river water and determine if septic tanks are leaking, and if kitchen and wash machine runoff is deposited into the river.

Parameter	Details
Frequency	Obtain 4 sample sets over the course of one camp season, once per month with 30 days between each
Withdrawal Sites	Sample water in three different places on the Santa Ana River: upstream, adjacent to, and downstream from Camp River Glen
Analysis	Ensure delivery of samples within a 6 hour time frame to be analyzed for MBAS, pH, total Coliform, E. Coli, Sodium, total Phosphate, Boron, and Conductivity

Appendix N

Dr. Farb's analysis of in-pipe turbine micro hydropower system.

UCLA Unicamp Project:

There will be a 4-inch wide pipe flowing down from a storage tank of 32,000 gallons to supply water to a camp.

"San Bernardino County Environmental Health Services Department rated the current system at 20 gpm on their citation report. Last summer, the actual minimum flow rate was 18.8 gpm, max of 31.5 gpm, and an average of 26.3 gpm. For estimation purposes, we can assume 20 gpm for the proposed 2-pipe system flow rate. The input head is about 100 - 120 feet (stays constant). The pressure required downstream is 60 psi."

Operation is June, July, August.

I am assuming that the 60 psi figure is incorrect, and will work with 20 (=46 feet) which may still be too high. PLEASE MAKE ABSOLUTELY SURE.

Calculation of energy:

	Head in feet-exit	Flow in gpm	Potential watts	At 50% efficiency
Min	100-46	18.8	199	100
Max	100-46	31.5	334	167
Average	100-46	26.3	279	140
Min	120-46	18.8	273	137
Max	120-46	31.5	457	229
Average	120-46	26.3	382	191

Let's say the average is 150 watts per hour. If the camp is running June, July, August, that is 2160 hours. That makes 324000 watts or 324 kilowatts. The official cost per kilowatt is actually over $0.18 according to the bill because of all the taxes and fees!! So the energy is worth 324x $0.18 = $59.

Note: the efficiency might be lower because the flow is very small.

Appendix O1

1601.6 Operation and Maintenance Manual for graywater systems.

An operation and maintenance manual for graywater, rainwater, and on-site treated water systems required to have a permit in accordance with Section 1601.3 shall be supplied to the building owner by the system designer or *installer*. The operating and II maintenance manual shall include the following:
(1) *Diagram(s)* of the entire system and the location of system components.
(2) Instructions on operating and maintaining the system.
(3) *Instructions* on maintaining the required water quality *for on-site treated nonpotable water systems.*
(4) Details on *startup, shutdown, and* deactivating the system for maintenance, repair, or other purposes.
(5) Applicable testing, inspection, and maintenance frequencies in accordance with *Section* 1601.5.
(6) A method of contacting the *installer and/or* manufacturer(s).
(7) *Directions to the owner or occupant that the manual shall remain with the building throughout the life cycle of the structure.*

Appendix O2

Graywater System Stakeholders

San Bernardino County	Don Baker	Building Inspector II	dbaker@lusd.sbcounty.gov	(909) 387-8311	Land Use Services Department
US Forest Service	Heather Mobley	Special Uses Administrator	hmobley@fs.fed.us	(909) 382-2804	Mountaintop Ranger District

Appendix P

Request for Forest Service Approval form to obtain authorization letter for changes made at Camp River Glen.

Request for Forest Service Approval - Organization Camps

☐Maintenance ☐Improvement

Organization Camp:
Contact Name:
Contact Address:

Phone: ( )
Email:
Date:
Short Description of Requested Project:

Discussion of Requested Project: (Provide as much detail as possible, including materials and colors to be used. Attach paint chips, samples, brochures, web links, sketches, or plans when necessary. Plans of new construction should be completed by an architect or contractor. Attach additional pages as necessary. Project proposals with insufficient detail will be returned and will not be considered.):

For Forest Service Use Only

Date Complete Proposal Received:

Reviews Required (Y/N): Botany: Wildlife: Hydro: Heritage: Recreation: Range: Fuels: Engineering:

Date Approval Letter Signed:

Notes:

What to include for a complete proposal

Repainting:
Attach Paint Chip or color sample or include name of Paint Company and color name

Replacing Roof:
Current Roofing Type? Desired Roofing Type?
Company name of roofing materials?
Color name? (or attach sample or brochure)

Replacing siding:
Current siding type? Desired siding type?
(Attach picture, brochure, sample, or other example)

Replacing deck:
If you will be replacing deteriorated boards but leaving the design of the deck exactly as is, please note this in your proposal.
If you will be changing the design of the deck in any way, please attach a sketch prepared by your contractor showing the existing deck, and the desired new deck. Label all dimensions on both the associated building and the deck.

New Windows or Doors:
Current type of window/door?
Can the existing window/door be repaired?
Desired type of window/door?
Attach picture, brochure, web link, or other example.

Repairing/Replacing water and sewer tanks and/or pipes:
Provide a lot sketch showing the any camp buildings, and indicating where new tanks or pipes will be installed. Include information about what kind of equipment will be used to move tanks or excavate, and how the equipment will access the site.

Repairing roads or driveways:
Please ensure that the color of any gravel or material that you bring in matches the color of the natural road bed as closely as possible. Let us know if any material will be brought in, if any earth needs to be moved, what equipment will be used, etc.

Camp Additions or expansions:
Provide a detailed plan, prepared by an architect preferably, showing the current structure as built, and the plans for the desired structure. Camps should maintain the historic character and

architectural style of the camp and the time in which the camp was established. Plans must be reviewed and signed off by the Forest Archeologist.

The Forest Service may require that proposals for additions or expansions be reviewed and approved by an Architectural Historian. Submit the plans and the accompanying letter from the architectural historian or historical architect to this office. We will respond with either an authorization letter, or a request for changes in the design.

DO NOT PROCEED WITH ANY CHAGES TO THE STRUCTURE EXTERIORS UNTIL YOU HAVE AN AUTHORIZATION LETTER SIGNED BY THE DISTRICT RANGER.

Appendix Q

Data collection sheet for daily water sampling directly downstream of bag filters.

Month:_____			**Year:_____**		
Date	**Time**	**Temperature (degrees Celsius)**	**pH**	**Free Chlorine (mg/L)**	**Turbidity (NTU)**