**LAGI Submission 2020**

**Aqua Planterra**

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**Introduction**

Earthen pillars emerge from the reservoir, shrouded in an array of plants. Moss and lichen cover these pillars, purifying the water within, while shrimp cling below as new habitats are formed. Sprouts are collected from some pillars, while others are watered. Once a day, someone collects drinking water from the bottom vessels for use at the Ranch. When a vessel becomes too old it is replaced and recycled, used to form new habitats that support the array of flora and fauna that call Fly Ranch home.

Located in the North Reservoir, Aqua Planterra is a proposed installation that would facilitate the on-site generation of drinking water and small-scale food production at Fly Ranch. In keeping with the Ranch’s ethos of sustainability and low-impact self-reliance, Aqua Planterrais an interactive installation that utilizes passive vernacular technologies to tackle these issues. While the primary goal of the installation is to support the day to day functionality at Fly Ranch, the concept as a whole (from fabrication to afterlife) is meant to involve the local community, helping enrich and educate everyone on the craft, science, and sustainable attributes employed at each stage of this project.

**Activities Supported**

1. Potable water sourcing: the bottom vessel of each pillar is a filter and cistern for potable reservoir water that gets purified through clay osmosis. Upper vessels employ the same process for rainwater collection.
2. Small-scale food production/recycling: several edible plants can be grown in vessels to be harvested.
3. Community education and craft: The local community will be involved in the fabrication of the installation allowing them to learn about sustainable water filtration while also participating in its fabrication.
4. Create alternative economies: allow local craftsmen to create their own products through the techniques taught.
5. Habitat creation and research: The vessels can provide shelter and food for a variety of creatures, allowing ecological and agricultural research to take place.

**Technology, Materials, Dimensions**

Aqua Planterrais primarily constructed from clay which is an ideal passive filter because it is made up of very fine grains 0.002 - 0.05mm in diameter. These particles form a small sieve-like structure which removes approximately 99.88% of water-born disease agents through osmosis, making the water in the vessel potable. The lower vessel also employs a silver nitrate coating that is glazed onto the clay prior to firing. This strengthens the vessels’ ability to trap bacteria and protozoan in its pores.

Although molds that form the internal modular structure will be provided, participants are encouraged to express themselves through the fabrication of the outer wall, utilizing a traditional pottery technique known as coiling. This is a hand building method that requires no specialized equipment. Participants roll coils by hand and stack them onto one another to produce free-form shapes. After the installation is complete they may cast more vessels for use outside the Fly Ranch site.

The watering of vegetation involves scooping water from the reservoir and pouring it into the vessels. The vessels have an opening at the top as well as a natural porosity that allows permeation of moisture through the surface to the plants. This diffusion is the ideal way to water plants, as it provides constant, slow irrigation.

The bottom vessels utilize this same method of osmosis to create potable water. Contaminated water in the reservoir permeates into the vessel, moving from a high to low water concentration zone. As the water diffuses through the clay pores they trap contaminants, making the water potable. The water can then be extracted by removing the lid and lowering a container to fill.

Each above water vessel is approximately 650 x 600 x 800 mm, and weighs ~120 lbs. Each below water vessel is approximately 850 x 850 x 1200 mm, and weighs ~250 lbs.

A perforated 1.2m wide metal walkway supported by stilts winds over the reservoir to access the pillars via the north-east bank. The walkway has 2 tiers that help provide access to the vessels at varying heights.

Both the pillars and walkway are fastened to the reservoir bed with low-impact helical piles, used in ecologically sensitive areas.

**System Inputs**

The installation’s main input is the runoff and rainwater collected by the reservoir. The yearly average rainfall is 1,512mm, spread over the reservoir’s 0.158sqkm, means the reservoir can collect approximately 238,896m³ of rain per year. There is also run-off from the surrounding landscape, which increases this figure significantly.

The vessels should be maintained twice a year by scrubbing the internal and external surfaces. This helps to unclog the pores of film and buildup to ensure filtration standards. If any vessels are damaged or deemed non-functional, the pillar can be unstacked, the defunct vessel removed/ replaced, and reassembled.

**Systems Outputs**

The following calculations are focused on the below water vessels. Based on a study of silver-impregnated clay by Potters for Peace, we calculate the ideal flow rate of our vessels to be ~8.7L/hr.[[1]](#footnote-1) With an average volume of 500L for the underwater vessel, it would take 57 hours to replenish it entirely if completely emptied. Another metric to understand the capacity of each vessel is to measure potential usage. Given that the average car camper uses 11L of water within a 24 hour time span, a single vessel would therefore filter enough water for 19 campers’ daily use.

Each vessel can grow approximately 10 cups of sprouts every 3-5 days. Given a growing season of three quarters of the year, this translates to approximately 684 cups of sprouts per vessel per year. Since this is a hydroponic system there’s no secondary waste product.

The CO² level embodied in the firing of the vessels can be approximated by taking the CO² used in an 8 hour kiln firing. At 10kW/hr firing for 7 hours[[2]](#footnote-2), a large electric kiln fitting two below water vessels will use 35 kW per vessel. This translates to 46 kg of CO² per vessel[[3]](#footnote-3), which is the equivalent of 1.9 BBQ propane tanks. As Aqua Planterra is completely passive, the initial carbon footprint from construction will be offset by the water generated. The CO² footprint of bottled water for one person’s daily consumption is 0.7kg.[[4]](#footnote-4) Since one below water vessel generates enough water for 19 peoples’ daily use, the amount of time for the vessel to offset its embodied carbon is 3.5 days if used at maximum capacity.

**Prototype Development**

1. Prior to arrival on site a set of molds for the internal structure will be tested and created. This involves 3D printing or CNCing the molds from our digital models. Modules will be cast and fired to evaluate the structural integrity of the vessels. Tests on water filtration and plant grafting will be conducted here at smaller scale. The molds and any operable vessels created during this phase will be shipped for on-site use.
2. Following this phase, we will work with local pottery studios like Planet X Pottery, and any possible schools in the area to refine the fabrication pprocess. Local professional potters will create the bottom vessel that is used for potable water filtration, as it requires a higher level of finish application, accuracy, and water-tightness.

On-site installation will require a contractor to install the boardwalk and foundation for each pillar by drilling low-impact helical piles into the reservoir bed, assembling the prefabricated boardwalk on top, and bolting plates to the pillars’ bases. Then each vessel will be placed manually and secured.

Our approach is to prototype a minimum of 1 pillar, consisting of one below water vessel and three above water vessels, along with a length of boardwalk. As such the following cost estimate is provided for 1 pillar, however if more were to be tested there would be cost savings since initial costs for mold creation, transportation, and testing would not be duplicated.

**Cost Estimate (All Values in USD)**

***Mold Creation and Testing****:*

1. 3D printing/injection molding molds (dependant on fidelity)

$2,000 - $10,000

1. Clay, tools, and plants

$300

1. Kiln firing time

$2,000

1. Shipping prototype and molds to site

$400

Tax (Ontario Sales Tax @ 13%)

$611 - $1,651

*Total Mold Creation and Testing Cost*

*$5,311 - $14,351*

***Pillar Prototyping (1 Bellow Water and 3 Above Water Vessels with a Small Boardwalk):***

1. Clay for 4 vessels (1 box of clay @ 1 ft³ = $24)

Upper vessels = 1.5 ft³ x 3 vessels = 4.5 ft³ (1.5 m³) clay

$24 x 4.5 ft³ = ~$110

Lower vessel = 2.2 ft³ x 1 vessel =2.2ft³ (0.7 m³) clay

$24 x 2.2 ft³ = $53

1. Kiln firing time
   1. vessels x 50$/firing = $200
2. Glazes/Paints (silver nitrate)

$100

1. Tools

$75

1. Metal base plate, 12x12”, ½” thick (05 12 00)

$75 x 1 = $75

1. Metal fasteners for base plates

$175

1. Helical piles (31 66 00)

$250 x 8 = $2,000

1. Prefabricated perforated metal deck, 4’ span (05 53 00)

$12.74/sf x 18 sf = ~$230

1. Plants

$100

Tax (8.27%)

$258

*Total Pillar Prototyping Cost*

*$3,376*

1. Contractor fee (15-25%) Including Tax

$700 and upwards

1. Contingency (12%) on Prototyping and Construction

$1,585

1. Wheelbarrow (1) Including Tax

$90

1. Truck rental and gasoline for transportation (12 days)

$45/day x 16 days + $200 fuel = $500

1. Lodging (dependant on length of stay)

~$1500

1. Flights (dependant on amount of people on team)

~$1500

**Total Project Cost**

**~$11,562-$20,602  (potential additional $3000 for travel and lodging)**

**Environmental Impact Summary**

Aqua Planterra’s main environmental goal is to help reduce the need for sourcing off-site drinking water by harnessing the water on-site. If left with driving in bottled water, the CO² footprint of one person’s drinking water weekly would be around 5 kg.[[5]](#footnote-5) This is the equivalent of just over half a gallon of gasoline consumed, or 12 miles driven in a car. Compared to driving in water, one pillar is able to generate potable water  for 19 person’s daily use, that means the amount of time it takes for the vessel to offset its embodied carbon is approximately 3.5 days if used at maximum capacity. Secondary environmental benefits of the installation like food recycling (sprouting new shoots from scraps), food production, and habitat creation are also an important part of the project.

Attention has been paid to reduce the impact the installation has on site. From a materials perspective clay is naturally-sourced, easily recyclable, and low-tech. While structurally, helical pile foundations cause minimal disturbance to the reservoir soil and can be disassembled and recycled. As Aqua Planterra operates completely passively once installed, it generates no pollution from energy consumption.

The local community can get involved in casting and customizing the vessels as well. This can help teach school children pottery skills by complementing their art classes. The community can also create planters and other water filters from the molds they were given. When vessels get old or damaged in the community or in Fly Ranch, they can be broken into pieces and either deposited in the Fly Ranch reservoir to encourage habitat formation for the native wildlife, or recycled.

Another environmental factor of the project is scalability. The project can be scaled to accommodate many pillars in the main reservoir and middle reservoir, or kept small, with a few pillars in one location, depending on the needs of Fly Ranch. Ease of construction and installation on site is crucial as well. The boardwalk and base plate installation is not complicated and requires the assistance of a contractor or knowledgeable Ranch member.

As previously mentioned, the installation’s food-generating capacity is another beneficial feature. The generation of 10 cups of sprouts every 3-5 days from one vessel would help feed a group of ten people consistently. The 684 cups of sprouts per vessel per year could have a potential economic benefit via selling vegetation grown on site to visitors or in markets around Gerlach. Other vegetation grown by the installation can also help the development of Fly Ranch’s ecology which could have future research and teaching potential.

1. https://static1.squarespace.com/static/5d17d0ef2ce108000124dbc8/t/5d963341c6bd9c75a5ab3f25/1570124610500/Review%2Band%2Bsummary%2Bof%2Bstudies%2Band%2Breports%2Benglish-%2BJan112+copy.pdf [↑](#footnote-ref-1)
2. https://www.soulceramics.com/pages/cost-of-firing-ceramic-kiln?fbclid=IwAR1andKKMi6uFtTMh7SsPazDTB9BWihTJhDX0peFzK-AjSzMMRC0wAbk35M [↑](#footnote-ref-2)
3. https://ceramicartsnetwork.org/wp-content/uploads/sites/6/2017/02/048\_053\_Feb11\_CM-1.pdf [↑](#footnote-ref-3)
4. https://medium.com/@magnusjern/dirty-secret-about-the-carbon-footprint-of-bottled-water-a13a0737dc0e [↑](#footnote-ref-4)
5. https://medium.com/@magnusjern/dirty-secret-about-the-carbon-footprint-of-bottled-water-a13a0737dc0e [↑](#footnote-ref-5)