

**An Investigation into ECO-TEK's Solar Aquatics System (SAS) for
the UBC Farm Centre Building**

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APSC 262 FINAL REPORT

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the UBC Farm Centre Building**

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ABSTRACT

The University of British Columbia Farm (UBC Farm) has always been known to practice and promote the concept of sustainability. Currently, it plans to construct a new farm centre building to be used for food production operations and educational purposes. This building is exploiting the use of an appropriate wastewater treatment system to help reduce water costs and consumption. This report looks at the ECO-TEK Solar Aquatics System (SAS) as a potential solution and conducts a triple bottom line (TBL) assessment on this system, and analyzes the quality of such a solution.

Using past research, an in-person interview with the Kimron Rink, the president of ECO-TEK and the designer of the SAS, and a short social survey, it can be seen that the SAS is an existing quality solution with high potential to scale and adapt into the new UBC farm building. Environmentally, the SAS is a good technological solution to treat wastewater, reduce energy consumption, greenhouse gases, and other resources needed. Economically, the SAS is not currently viable with the amount of water the farm requires, although it will reduce its annual water consumption expenditure. Socially, the SAS provides great opportunities for research development, promoting sustainable engineering design, and potential work and volunteer jobs and positions for the community. As a result, the SAS is recommended as an acceptable solution for meeting most of the UBC Farm's goals.

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LIST OF ABBREVIATIONS

CBU	Community Based Utilities
GVWD	Greater Vancouver Water District
SAS	Solar Aquatics System
TBL	Tripe Bottom Line Assessment
UBC	University of British Columbia

GLOSSARY

Bioremediation:

The use of microorganisms to remove pollutants

Effluent:

The outflowing of water or sewage from a building

Ultraviolet:

Electromagnetic radiation with wavelength shorter than visible light but longer than X-rays

1.0 INTRODUCTION

The University of British Columbia (UBC) Farm is currently in the planning stages of constructing a new farm centre building that will serve as a “living laboratory” for food production operations and educational purposes. As a part of the building plans, one of the facilities of this building is to utilize a waste water treatment system that will treat storm water, grey water, black water, and sewage which can then be used for a variety of purposes.

Currently, the UBC Farm’s water usage amounts to approximately \$70,000 per year (A. Rushmere, personal communication, March 27, 2012). This is a costly figure and a suitable wastewater treatment system would theoretically allow the UBC Farm to be independent from sourcing its water from the Greater Vancouver Water District (GVWD). If successful, this wastewater treatment system would help work towards UBC’s campus plan of minimizing water consumption impact.

The ECO-TEK Solar Aquatics System (SAS) is one such wastewater treatment system under consideration. It is a bioremediation process that tries to replicate a natural wetland environment in order to produce a useful end product that can be used for a variety of applications. ECO-TEK is the company behind the SAS that focuses on Community Based Utilities (CBU) which treats waste and converts it to resources.

The purpose of our report is to investigate the SAS and provide a summary of our conclusions and recommendations to the UBC Farm. Our main contacts for this project were Andrew Rushmere, our stakeholder from the UBC Farm, and Kimron Rink, the president of ECO-TEK and designer of the SAS system.

2.0 OPERATION

Solar Aquatics is an advanced sewage treatment method that uses plants and bacterial life to produce water that is reusable for a variety of purposes, such as irrigation, concrete, frac water, greenhouses, hydroponics, support for wetlands and aquatic life, and potentially drinking water.

2.1 HOW IT WORKS

A climate-controlled room or greenhouse is used as the main base for sewage treatment housing tanks, pumps, and man-made streams and marshes. This design is used to mimic the way nature purifies water.

First the sewage collected from the building is pumped into the greenhouse where it is bubble aerated to remove the sewage odour. As a result of the process, the sewage solids rise to the surface and it make it easier to biologically break down. This sewage is then pumped into several large solar tanks connected to each other, which are filled with aquatic plants that are used to naturally absorb and break down the sewage for nutrients.

In the tanks, aquatic plants, such as water hyacinths, are used because they have a large surface area and absorb a relatively large amount of nutrients. In other words, they are more effective at breaking down sewage water. In addition to the natural bacteria breaking down the sewage, snails and zoo plankton are also found in these tanks to help the process. The sewage water is bubbled in the tanks to provide oxygen to the plants as well as mixing the sewage solids into the roots of the plants to be absorbed more easily.

Next, the sewage water is then passed through a gravity clarifier tank to separate the bacteria from the clarified water. The clarified water is then passed through a sand filter, constructed wetland, and ultra filter to remove fine particles and some metals from the water. In the final step, the water is disinfected in two ways - using a small amount of chlorine and using an ultraviolet light to kill any pathogens. At this point, the water is ready to be used for purposes such as irrigation and urinal/toilet flushing (Rink et al, 2012).

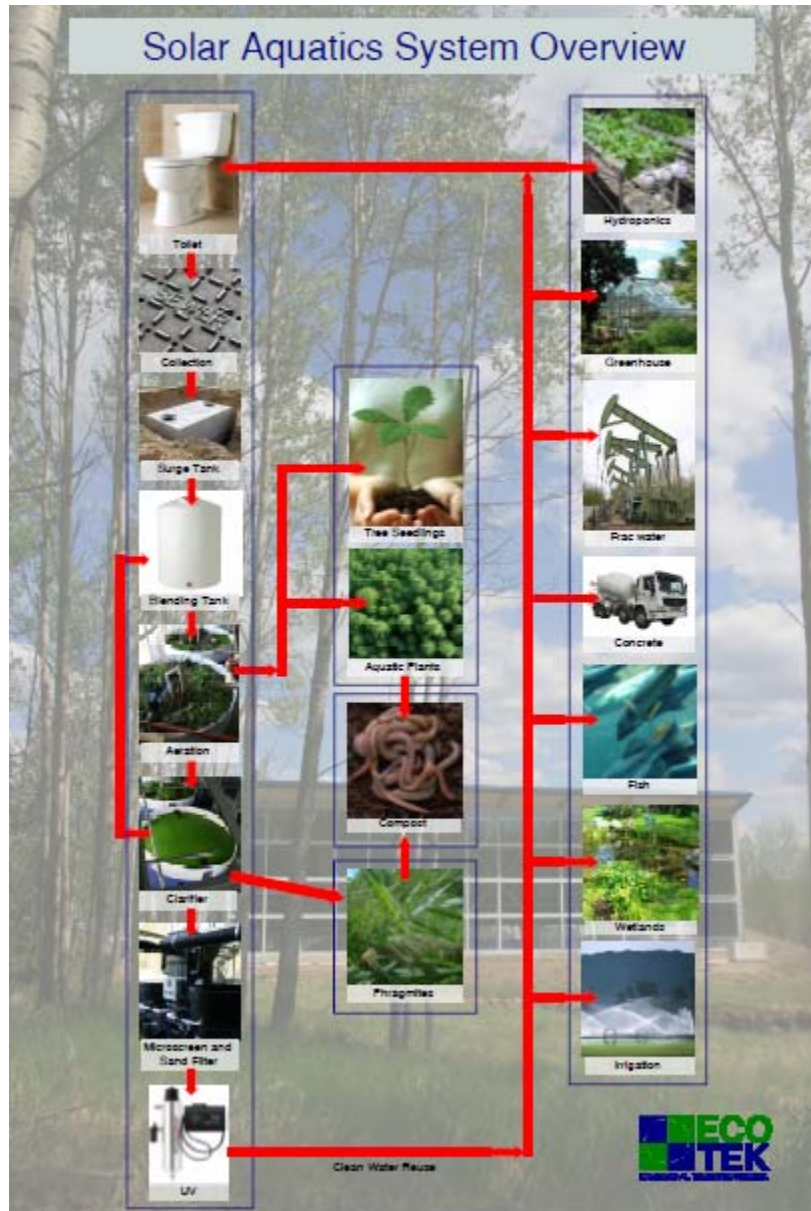


Figure 1 Solar Aquatics System Overview

3.0 ENVIRONMENTAL ASSESSMENT

3.1 TREATED WASTEWATER

Effluent from the farm building can be reused after it has been treated by the filters in the SAS. For example, the treated water can be used as grey water in the toilets of the proposed building. The filter process also removes the nitrogen, phosphorus, additional suspended solids, refractory organics, heavy metals, and dissolved solids. This solid organic waste can be used as manure and the chemicals, such as potash or nitrogen, can be used as fertilizer. This would be very practical for an organic farm because no synthetic chemicals are involved in the process (Wilderer, 2004).

3.2 REDUCTION IN ENERGY

The SAS is considered net positive or very minimal in terms of energy requirements. The only energy required to run the system is the solar power required to run the filtration process and the energy required to pump the effluent. As additional potential, heat or biogas can be extracted from the effluent and can be used for various purposes, such as heating (Binns et al., 2011).

3.3 REDUCTION IN GHG

The SAS can reduce transport emissions caused by the transfer of wastewater from UBC farm to the Iona Treatment Plant. Greenhouse gasses (GHG) can also be reduced from the primary treatment of wastewater at these treatment plants.

The constructed wetland component of the SAS may produce moderate amounts of methane but is not considered harmful to the environment (Binns et al., 2011).

3.4 REDUCTION IN RESOURCES AND CONSTRUCTION MATERIALS

The most obvious benefit of the SAS is that the treated wastewater can be recycled, re-entered into the system for treatment, and re-used. The SAS may also eliminate or reduce the materials and energy required from construction and piping that is normally needed to pump sewage from the UBC Farm to the treatment plant (Binns et al., 2011).

4.0 ECONOMIC ASSESSMENT

4.1 IMPLEMENTATION ON A LARGE SCALE

The implementation of the SAS is very much dependant on the economic benefits associated with it. Currently, the UBC Farm's water usage amounts to approximately \$70,000 per year. An implementation of the SAS will aim to make the farm independent from sourcing water from the GVWD, allowing UBC to minimize cost and water consumption. However, low rates of water consumption and a high capital cost for a large scale building indicates that the SAS is currently not scalable to such a massive size.

According to the Metro Vancouver Utilities website (UBC Utilities, 2011) the city applies a rate of \$0.03403 per ft³ which means that the annual water consumption of the UBC farm is approximately 2.1 million ft³ or 58,000 m³. According to the SAS designers, the SAS is capable of filtering out 200 m³ of water which costs approximately \$1.3 million. At this rate, the cost of implementing a SAS large enough to make the farm completely self-sufficient would cost \$377 million dollars with a simple payback period of over 5000 years. This result indicates that the implementation of the SAS at such a large scale is currently not feasible.

4.2 IMPLEMENTATION ON A SIMILAR SCALE TO CIRS BUILDING

Although the system is not feasible for a scale as large as the entire farm, the SAS can still be installed at a smaller scale to re-use grey water, black water, and storm water for the farm building and to aid with supplying clean water to part of the farm. When taking a closer look, the benefits of the implementation of this system are two-fold.

Firstly, this connection saves the cost of including a large holding tank in case the building experiences a sudden surge of wastewater or the system has unexpected technical problems. More importantly, the connection allows the Solar Aquatics to process more sewage than the building produces. For example, if a green roof is in need of more irrigation during summer months when building usage is lower, the system can accept sewage from the sanitary line and more reclaimed water can be produced.” (Maginnis et al., 2010)

The UBC Farm building is to be built on approximately 1800 m² of area and has 3 floors (A. Rushmere, personal communication, March 27, 2012). If we consider a similar project completed by ECO-TEK in Christina Lake, BC (Rink et al., 2010) then the installation of the SAS in the UBC Farm Center Building has an approximate capital cost of \$440,000 and an operating cost of \$15,000 per year.



Figure 2 Solar Aquatics System – Christina Lake BC

A system of this scale has a daily flow capacity of 22 m³, 10 more than that of the system currently installed in the CIRS building. Installation of this system will not only ensure that the UBC Farm Center Building has a net-zero water consumption, but it also has the ability to provide irrigation water to nearby areas such as surrounding greenery and gardens. At this scale the system is capable of yielding yearly savings of approximately \$2500 in sale of plants grown and approximately \$150 in irrigation water savings (Grant et al., 2002).

5.0 SOCIAL ASSESSMENT

The SAS will no doubt introduce some key social impacts. At a glance, some of the major social advantages and disadvantages are listed below:

Major Social Advantages:

- Promotes sustainability awareness
- Potential new positions, jobs, and volunteer opportunities for students and citizens
- Integrates the UBC learning experience into a sustainable environment
- Promotes more further research
- Decentralized model for wastewater treatment

Major Social Disadvantages:

- Quality of the water generated from this technology not as good as fresh water
- The resources and time spent on this technology could be used for other areas
- The management for this system introduces additional tasks for the farm
- The maintenance of this system requires specialized personnel to monitor

In general, the social impact of this technology can be divided into three areas, and these sections are described below.

1. Promoting sustainability towards engineers and the general public
2. Educational value for further research development in the area of sustainable technology
3. Community impact inside and outside of UBC

5.1 PROMOTING SUSTAINABILITY TOWARDS ENGINEERS AND THE GENERAL PUBLIC

The Solar Aquatics wastewater treatment provides recycle awareness for engineers. The importance here is not only to create the most resource efficient design, but rather having the concept of sustainability through recycling as a key focus in all designs. The Solar-Aquatics wastewater treatment does this well because the input is common wastewater, which resides

through all buildings, and converts it back into a valuable resource. Hence, it enforces the recycle awareness concept for engineers when designing a building.

The Solar Aquatics wastewater treatment also provides sustainability awareness for the general public, especially the UBC students. UBC students, particularly those that have an engineering background, generally have sustainability integrated into their education. This technology demonstrates that one can take even one of the lowest level forms of wastes, and transform it into a valuable resource. As for the general public, everyone can certainly relate wastewater and fresh water into their lives. The concept that recycling one into the other does not require detailed knowledge to understand its effects, yet the result is powerful. Now combining this technology with the UBC farm, which is well known for practicing sustainability concepts, makes a solid case for sustainability technology in general.

5.2 EDUCATIONAL VALUE FOR FURTHER RESEARCH DEVELOPMENT IN THE AREA OF SUSTAINBLE TECHNOLOGY

The Solar-Aquatics system provides significant research values and development. During an interview with Kimron Rink, the president of ECO-TEK and designer of the SAS system, he concluded that while the current system is functional and meets the required goals, many of its components can still be improved (K. Rink, personal communication, March 6, 2012). Ranging from an electronic chemical control, to the types of membrane used for the filter, much research and development can still be done to make this a better system.

In addition to the Solar-Aquatics system improvements, SAS itself leads to more research in the area of recycled waste water for two reasons. First, the idea of recycling waste water provides significant research values because of the importance of water and the lack of use of wastewater. Second, the SAS is a proven working solution in this field, so other parallel research and development can be built on top of this system. This adds importance to the field of recycling wastewater management.

5.3 COMMUNITY IMPACT INSIDE AND OUTSIDE OF UBC

The Solar-Aquatics wastewater technology can create new positions and jobs for the community. At the very least, the system requires a skilled technician for on-going maintenance. The skills and knowledge involved is quite specialized – from chemical processes to control systems and others important engineering concepts. The overall system itself is still mainly automated, so it does not require any labour to run the system.

5.4 SOCIAL SURVEY RESULTS

Finally, a short survey has been conducted for engineer undergraduates in various fields. The sample size (38 in total) is not very large, nor is it very diverse to draw any strong conclusion; however, the result does reflect some interesting views and attitudes from these future engineers. The actual survey can be found in the appendix, while some interesting points surfaced from the survey are presented below:

1. While over 90% of the participants views sustainability as an important concept both in general and for the UBC farm, only 39% of the students are willing to learn more about the Solar-Aquatics technology. This shows that while engineering students have been taught to see sustainability as an important engineering concept, many lack the time and passion to allocate their time to research on their own. As a result, promoting sustainability is just as important as sustainability itself.
2. After students realize how much the water costs are for the farm and how this can be saved by implementing the Solar-Aquatics system, over 82% of the students now wants to learn more about this system. This suggests that engineers are very result-oriented. By proving a certain sustainable technology works well using dollar values and other efficiency measurements, it raises great awareness and interest for learning.
3. 74% of the students believe that wastewater treatment is an impactful technology for the farm, and 66% of the students wish to volunteer or work on this system. This difference of 8%

may suggest that student likes to volunteer or work on a system they believe will make large impact on their community.

6.0 CONCLUSION

In this report, a Triple Bottom Line (TBL) Assessment was used to determine both the feasibility of the Solar Aquatics system and also if it met the goals of the UBC Farm.

From an environmental assessment, the SAS is capable of producing various useful end-products, such as water to be reused for flushing, organic solids for manure, and specific metals for fertilizer. The SAS is also capable of reducing the energy and GHG emissions that are normally required to pump sewage from a building to the treatment plant.

From an economic assessment, the SAS has a very high capital cost and annual maintenance cost which both contribute to a very large payback period. However, past projects have shown that combined with government subsidies and the possibility of selling end-products of the SAS (e.g. frac water, or water to concrete companies), this will significantly reduce the payback period and may allow the system to be economically viable. It is also concluded that while the SAS is not scalable to a large enough size for it to be a feasible replacement for the UBC Farm's current water supplier (because of an unreasonable payback), it can definitely be used at a scale similar to the CIRS building and implemented successfully at the UBC Farm's Center Building.

From a social perspective, there was a positive response from the social survey conducted. The survey indicated that most students believed that the system would not only have a sustainable impact for the farm, but that it would also help promote the concept of sustainability to the community.

In summary, using past research, interviews with key people, and a TBL assessment, it is recommended that the UBC Farm implement the Solar Aquatics System. While the SAS may not be currently economically viable and scalable to be completely independent from the city's water supply, many other positive benefits can be generated, such as promoting sustainability, research opportunities into the effectiveness of the SAS end product for agricultural purposes, and reduction in environmental footprint.

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8.0 APPENDIX A: INTERVIEW WITH UBC FARM STAKEHOLDER ANDREW RUSHMERE

The purpose of this interview was to learn about the proposed UBC farm and the need for a wastewater management plant. We met with Andrew Rushmere (UBC Farm Stakeholder) which took place at the UBC Farm on March 20, 2012.

Topics discussed in the meeting:

1. The UBC Farm has 60 acres of land and is a frequently visited place on campus. In one year it had approximately 40,000 visitors, 25 full time staff members, and 250 volunteers. During the summer it experienced approximately 500-800 visitors on weekends. The proposed building covers an area of approximately 1800 m² and will have 3 floors. It has been proposed to be built next to the north-eastern entry of the farm and will replace the current storage shed.

2. The Farm sources its irrigation water from the city pipeline (which runs parallel to the north fence of the farm) which costs UBC \$70,000 annually. Possible solutions to reduce this expenditure :
 - a) Bore into the water table that exists and can be easily accessed.
 - b) Gather the rainwater in certain ditches to be used later
 - c) From building usage rain water, grey water, and wastewater can be used for irrigation

3. Various uses/spaces that will be incorporated in the building:
 - a) Office
 - b) Lab space
 - c) Classroom
 - d) Food washing and processing space
 - e) Wet and dry lab space
 - f) Wood work, machine and metal works shops
 - g) Community and lab kitchen space
 - h) Storage

Treated wastewater from the SAS can be used in these spaces where usage of fresh water can be prevented (e.g wet labs).

4. According to Canadian standards, any water that has come into touch with any human waste cannot be used for irrigation purposes even though this waste water is a potential source for many essential nutrients.

5. With a large number of visitors and other people in the farm we also explored the idea of sending out the human waste to the existing digesters at the farm which can then produce methane which is flammable gas and can be used in the kitchen.

9.0 APPENDIX B: SOCIAL SURVEY QUESTIONS

1. How important do you view sustainability?
 - a. Not important at all
 - b. Not that important
 - c. Neutral
 - d. Important
 - e. Very Important

2. How important do you view sustainability for the UBC farm?
 - a. Not important at all
 - b. Not that important
 - c. Neutral
 - d. Important
 - e. Very Important

3. Have you heard of the Solar-Aquatics Technology for wastewater treatment?
 - a. Yes
 - b. No

4. How well do you see the Solar-Aquatics Technology promote sustainability practice?
 - a. Not at all
 - b. Not very
 - c. Promotes somewhat
 - d. Promotes greatly
 - e. Not sure

5. Would you accept the Solar-Aquatics wastewater treatment technology as a suitable technology for the further research?
 - a. Yes

- b. No
 - c. Not sure
6. Would you be interested to volunteer for the UBC farm using the Solar-Aquatics wastewater treatment technology?
- a. Yes
 - b. No
 - c. Not sure
7. Would you be interested to work for the UBC farm using the Solar-Aquatics wastewater treatment technology?
- a. Yes
 - b. No
 - c. Not sure
8. How comfortable are you with the Solar-Aquatics wastewater treatment technology used as a UBC farm water source?
- a. Not comfortable
 - b. Neutral
 - c. Comfortable
9. How much do you think the annual water cost is for the UBC farm?
- a. Below \$25 000
 - b. Between \$25 000 - 50 000
 - c. Between \$50 000 - \$75 000
 - d. Between \$75 000 - \$100 000
 - e. Above \$100 000
10. Knowing how much impact the Solar-Aquatics system provides now, would the answers to the previous questions change?

- a. Yes
- b. No