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LIVE&LEARN Environmental Education

A collaboration in innovation

Sanitation in Floating Communities in Cambodia

Live & Learn Environmental Education Cambodia Engineers Without Borders Australia

Prepared for the Ministry of Rural Development – October 2010

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BoP ASIA
SCIENCE AND TECHNOLOGY INNOVATIONS FOR THE BASE OF THE PYRAMID IN SOUTHEAST ASIA

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Executive Summary

This project is focused on developing an innovative sanitation solution that is affordable for implementation within floating communities on the Tonle Sap in Cambodia.

Between the project start in 2008 and today, the partnership between Live & Learn Environmental Education Cambodia and Engineers Without Borders Australia has:

- Developed a relationship with a the Phat Sanday Commune in Kampong Thom Province, which has allowed us to develop the community's idea of sanitation, use their input to help develop a culturally appropriate sanitation solution for floating communities.
- Conducted a comprehensive review of existing sanitation options used around the world in floating and land based situations. Selected Urine Diversion Desiccation as the most appropriate for the floating communities.
- Designed a basic floating latrine and developed a manufacturing technique using locally available materials. The current Material cost is US$35 and labour cost is US$5 per latrine.
- Built and trialled 14 prototype floating latrines (12 in the Phat Sanday community) and regularly followed up their use. Each new prototype has incorporated improvements learnt from construction and use of earlier models.
- Educated users of the floating latrine about the importance of total sanitation and how to use and maintain the latrine. Including classes at both Phat Sanday primary and secondary school.
- Conducted water quality testing of the water used by the Phat Sanday communities and the surrounding environment in both high and low water level seasons. These test have demonstrated that in particularly the low water season, the Phat Sanday community is exposed to levels of E. coli and Coliforms well above recommended World Health Organization levels.
- Designed and built the Floating Community Waste Management Stations that will demonstrate technologies and practices for human waste treatment that provide an incentive for the community to take up improved sanitation by generating social, economic and environmental dividends for the floating communities.

Quotes from the community

Mr Sok Sueng:
"Good Sanitation means good health and livelihood"

Mr Sok Sovann:
"My floating toilet is good for my health, is more convenient and private"

Mrs Yan Yeoun:
"Clean water is important for our health"

Ms Lai-Im:
Community Liaison Officer
"Clean water is the most important thing to our community"

Mr Pich Vongsa:
Principle of the Phat Sanday Secondary School
"Our community wastes money on health care, that we wouldn't need to spend if the water was clean"

Mr Hakley Ke:
Teacher at the Secondary School
Community Liaison Officer
"I want everyone in the community to have a toilet."

Introduction

Currently there are no affordable sanitation options available for the floating communities of the Tonle Sap in Cambodia, and many other communities that live in challenging sanitation environments. In these areas a normal pit latrine is not adequate. These areas include rocky, high water table, flood affected and mountainous areas around the world.

These communities usually urinate and defecate directly into their environment, contaminating the water source for drinking, washing, bathing, swimming and fishing. Beyond the commonly accepted challenges of implementing sanitation in land based communities such as – creating demand and behaviour change, affordability, and sustainability of systems – sanitation in these floating communities is further challenged through the total absence of technology options and multiple generations who have been without any exposure to sanitation practices in their homes.

Figure 1- A Typical Floating House (Phat Sanday)

In response to this situation, Live & Learn Cambodia (L&L) and Engineers Without Borders Australia (EWB) have been in partnership since 2008 to develop appropriate technology for this problem. In 2009 the Phat Sanday community in Kampong Thom province of Cambodia was selected to be the trial implementation community.

The initial focus of this project has been on floating and silted communities that surround the Tonle Sap Lake in central Cambodia. Between 1.1 and 1.5 Million people are living in flood affected areas on and around the Tonle Sap and Mekong River with many millions more in Bangladesh, Myanmar, Laos, Philippines, Vietnam and Indonesia.

Our work has shown that:

- There are few sanitation options for people living in these areas.
- Residents in these areas have high rates of diarrhoea and other water borne diseases.
- Residents of floating communities are exposed to levels of E. coli in their environment well above recommended WHO levels.

Therefore we are focusing on developing innovative technologies and practices for the human waste management for the floating communities. This project will demonstrate technologies and practices that provide an incentive for the community to take up improved sanitation by generating social, economic and environmental dividends for the floating communities.

The options developed will:

- Remove faecal matter from the water source
- Improve livelihoods of floating communities
- Be self-sustaining and reliable
- Provide opportunities to develop a market-based solution.
- Be culturally appropriate, and environmentally viable and affordable

Through a strong process of community and stakeholder engagement L&L and EWB have developed and commenced trial of appropriate waste management cycle for the floating communities

Low cost, local production, using familiar and locally available materials has been an initial consideration in design methods to ease transition into new technologies and allow for ongoing growth in uptake into the future. Community engagement through the design process is also considered important to successful designs. The project seeks to be a demonstrator of innovative sanitation solutions that emerge from within the community itself. Additionally, the project is considering water quality and water borne disease risk holistically, and is therefore opening discussion with the community on management of solid waste and methods of accessing and treating water, as well as considering links with energy production.

Figure 2 - Sunrise over the floating village (Phat Sanday)

A Personal Story

Mr LY Hakley
School Teacher from Phat Sanday Secondary School

The practice of defecating directly into the lake is convenient but degrades the quality of water the community shares. Few public buildings have toilets facilities. School children have trained themselves to hold on during the school day only to relieve themselves in the evening. This causes a particular problem for girls once they reach menstruation. Studies have show that lack to private sanitation is one the key causes of school drop out girls.

Hakley knows the lack of sanitation in floating villages is a problem and is very passionate out improving this situation for his community. He is a teacher at Phat Sanday Secondary School and has been very helpful and inspiring to the team from Live & Learn who are working to develop sanitation options for the floating communities. He has allowed Live & Learn to trial one of their floating toilets at the school and has been teaching the students about how to use the toilet and why sanitation is important in their community.

With Hakley's encouragement, the sanitation message has been filtering through the village's students and their families. For this reason L&L and EWB have been able to successful trial floating toilets and change the sanitation behaviour of 14 households. Hakley has also been very supportive of the project's efforts to build a Floating Community Waste Management Station that will demonstrate safe treatment and reuse of the human waste. Once this is complete Hakley, the Phat Sanday Community and L&L can work together to continue build supply and demand for floating toilets in Phat Sanday and other floating communities on the Tonle Sap.

Figure 3 - Mr LY Hakley in August 2010

Project Implementation and Management

The project is a collaboration between three key project partners, the Phat Sanday Community, Live & Learn Environmental Education Cambodia (L&L) and Engineers Without Borders Australia (EWB). Key achievements of this relationships has been:

- Two members of the Phat Sanday Community have been assigned as key liaison officers to facilitate communication between Live & Learn and the community. This has help build our relationship with the community and speed issues resolution. We have assigned one male and one female liaison officer.
- Established a new team of Engineers Without Borders Volunteers, called the EWB Innovators. This builds upon the success of EWB's Challenge program that challenges 5000+ engineering students each year to develop appropriate technology for developing communities.

Figure 4 - The project team in August 2010. Michael Brown (EWB), HONG Sodaneath (L&L), LAY Im and LY Hakley (Phat Sanday)

The project implementation and management is structured as below:

Project Stakeholder	Role
Live & Learn Environmental Education Cambodia (L&L)	Project Coordinator, Relationship Building, Community Engagement
Engineers Without Borders Australia (EWB)	Technical and design support. Provide in country Project Manager.
Ministry of Rural Development (MRD)	Access to WATSAN forum and linkages to other organisations working in Cambodia. Grant provider.
Phat Sanday Community	Community Engagement, Support and Wiliness, Input into local design and materials
Science and Technology Innovations for the Base of the Pyramid in Southeast Asia (iBoP Asia)	Project Grantee, Supervision, Monitoring and Evaluation. Development of relationships with other iBOP Grantees in South East Asia.
Resource Development Institute Cambodia (RDI)	Prototyping and design development expertise in the Cambodian environment. Lab testing.
Royal University Phnom Penh (RUPP)	Lab testing, Relationship Building and Capacity Development

Community Involvement

The unique Tonle Sap environment has driven a strong need for local information and feedback throughout the innovation process. This has been obtained through a two way consultation process between all partners. Local knowledge has been and remains a critical factor governing the successful implementation of not only an appropriate system design, but also accompanying sanitation education for the local community.

We have involved the community at he following stages:

- **Concept and Planning:** We have conducted five focus groups and workshops with different members of the community. We conducted separate Men's and Women's focus groups. Workshops villages leaders, school teachers and environmental rangers.
- **Design:** The community has been consulted throughout the design process and their feedback feed back into the design developed by the engineers from Engineers Without Borders Australia.
- **Execution:** We employed the services of two members of the community on a part-time basis to help with execution of the project. Their assistance has enabled improved community feedback on the project and allowed to access local skills and labour during construction phase of the project.

Methodologies we have undertaken to involve the community have been:

- Employing local staff members to build relationship with community
- Engaging local community members through out the planning, design and execution stage of the project.
- Employing two members of the target community to help facilitate the project.
- Regular field trips to the community by all project members to build relationships and understand context of the communities.
- Using local communities skills and experience in their environment to complement development and project management skills of Live & Learn.

We have learnt from the community:

- Innovative and cost effective construction methods for building floating barges.
- Details about appropriate local materials
- Local customs and practices
- Feedback from our designs.

This level of community involvement has made it much easier and quicker to develop a solution that is sustainable, affordable and cultural affordable. It has enabled our design team in Australia to understand the context and challenges of working in the floating communities.

Without this level of community involvement the project would be very difficult to complete and without it the project almost certainly be a failure as the solution most likely would have been inappropriate for the communities' needs.

Figure 5 - Community Workshop in July 2010

Selection of the Target Community

An assessment of village location was undertaken to determine an appropriate village for community engagement, education, establishing working groups, gaining feedback on design approach, and trial of the floating toilet prototype.

Following the assessment of many villages of the Tonle Sap, including site visits to eight villages, Phat Sanday Commune, Kampong Thom Province was selected based on the Village's:

- Apparent high level of awareness of environmental concerns and interest in the establishment of latrines within their commune,
- Link to the ADB's Tonle Sap Sustainable Livelihoods Programme which provided some early funding to the project,
- High priority environmental status due to location within the Tonle Sap Biosphere Stung Sen Core Area,
- Link to the Tonle Sap Conservation Project including opportunities for sustainable implementation through community self-help groups,
- Link to UNICEF core province and therefore the ability to assist UNICEF in meeting its commitments to sanitation in all schools, and
- Proximity to Phnom Penh via Kampong Chhnang.

Phat Sanday is located about 30 mins across the Tonle Sap by boat from Chhnok Trou, which is where supplies arrive from and goods are transported to. The villages of the Commune are located along a number of river tributaries of the Tonle Sap, primarily the Stung Sen River. Small amounts of land are available during the low water season. Much of this retains flooding forests. There are small amounts of land are available to rest housing, and to grow crops such as corn.

Field Surveys

In 2008 and 2009 Live & Learn and Engineers Without Borders Australia conducted field surveys to understand water quality around the floating villages of the Tonle Sap and to find out about practices in water, sanitation and waste management. Surveys were taken in Chhnok Trou and Phat Sanday Commune.

The surveys where designed to identify existing knowledge, attitudes and practices across the Commune with regards to drinking water, sanitation, bathing, and waste management as well as associated information. The survey method selected random households and was conducted in Khmer, utilising Vietnamese interpreters where necessary.

In 2009 we undertook surveys in 45 houses in four villages of Phat Sanday Commune, Neang Sav, Kampong Chamlang, Phat Sanday and Koh Tapov.

Results from Field Surveys

The results from the 45 surveys can be summarised into six themes:

Theme 1:

Most people living in the floating village are long term residents, having been born there or lived there greater than 20 years and are planning to stay in the Commune forever.

Theme 2:

Most of families who live on the floating village they use the water around their home for drinking, bathing, washing or cleaning, and cooking etc.

Theme 3:

Most households boil, or filter water, or buy treated water for drinking.

Theme 4:

In the low water season some people treat lake water with alum for bathing.

Theme 5:

There is no sanitation treatment. Community members urinate or defecate directly into the lake waters, sometimes through a hole in their floor, and sometimes from the edge of the house or a boat.

Theme 6:

Neither authorities nor community members have sanitation options that are available to the community protect their environment.

Community Focus Groups

Following from the field surveys L&L and EWB conducted several community focus groups throughout the period from July to October 2009. The purpose of these focus groups was to:

- Learn in detail from the community about existing knowledge, attitudes and practices towards sanitation;
- Promote community understanding of the value of sanitation through dialogue and action;
- Seek ideas and solutions from within the community to improve sanitation and hygiene; and to
- Facilitate through discussion and demonstration a desire and an opportunity for effective and sustainable sanitation within the community.

Focus Group 1 – Men's Group

The focus group was chosen to represent different: socio/economic groups (based on house type), different villages, Khmer and Vietnamese community members, different age groups (including youth, elderly).

Discussion focused on working environment, managing hygiene and sanitation when fishing, teaching sons, issues of management – carrying waste, paying to transport waste, constructing own latrine, maintaining latrines.

Focus Group 2 – Women's Group

The focus group was chosen to represent different: socio/economic groups (based on house type), different villages, Khmer and Vietnamese community members, different age groups (including youth, elderly)

Discussion focused on different needs of women, privacy, dignity, menstrual hygiene management, bathing, related to newborns and post birth hygiene requirements, cooking.

Figure 6 - Community Focus Group (October 2009)

Results from Community Focus Groups

Men's Focus Group

Sense of Community:

Most people living in the Commune that we spoke to are long-term residents. They were born here or have lived here for more than 20 years, and are planning to stay in the Commune forever.

They have a basic understand of how their community is polluting the surrounding waterways, however there was a poor association linking a good environment with good livelihoods. There was little knowledge about their community development situation with little relevance drawn to Government Departments and NGOs such as UNICEF who work with the community but not regularly.

They would like to improve their community and recommend working individual with each household in the beginning. When the whole household understand and are aware of situation issues they will try to clean their community especially for the water clean, but now have little choice.

They feel there are good opportunities to create a good livelihood in the village especially for fishing. The biggest problem is seen as difficult access to a health service.

Family and Neighbours:

We found that the number of people living in each household varied. The average household size is 7 people, made up of 4 adults and 3 children.

We found that generally relatives live next door to each other. Generally 2 or 3 families live close to each other and share household duties such as constructions and maintenance of their homes, cooking child care and lending money when necessary. They always help each other even if their houses are separated during flooded season.

Figure 7 - Community Focus Group (October 2009)

Floating and Grounded Houses:

We found out that 80% of houses in the villages float all year and 20% rest on the ground during the low water season.

Most of people who live in floating villages think that it's good to live on the water especially during the flooded season. Those households that partake in fishing also exchange services as required. They said that during the flooded season they can access water for use every where around their house and each households is separated so they freedom can do their daily activities.

Each household comes close together during the dry season and it is difficult to live when the is water low. The challenges for this season are: disease, bad smells, pollution, transportation, conflict, and market exchange etc. Although, they can help each other when their neighbours are in need.

Household Plan:

We asked each focus group member to draw a plan of his or her house. A typical large wood house with zinc roof is 4.5 m x 12 m. We noticed generally the toilet is located near kitchen at the rear of the house. Water cooking and bathing was taken near to the toilet. Some members noted they took water for drinking at the front of their house. Waste is generally disposed all around the house and even sometimes dead animal bodies are disposed in to the water.

A typical small bamboo house with palm leaf roof is 4.5 m x 8 m. The design is similar to the large wood house but generally the small homes do not have toilet room and people defecate from the edge of the house.

They are concerned that anything big and heavy could upset the balance of their home, particularly for people who live in small houses.

Sanitation:

Sanitation is not a big concern as it is convenient to urinate and defecate directly in to the water, however most focus group member expressed an interest in having a toilet for their family. They think that the toilet room should be at behind of the house and far a way from the kitchen, bathing, drinking places.

After they urinate they never wash but after defecated they wash by using the water from the lake.

They mentioned that sometimes there are conflicts in the village when one person's waste floats past another person's house.

Sanitation away from home:

Most of the men's group where fishermen and spend a lot of there time away from the home. They typically travel between 5km and 30km away from the village to fish.

Figure 8 - Community Focus Group (October 2009)

When away from home they urinate and defecate directly from the edge of the boat. They feel it's good to defecate away from home because they can reduce the pollution in their village.

Bathing:

Most people bathed at their house during the flooded season, but some travelled a short distance away during low season. They generally bathed once or twice per day. The time for bathing is about 5pm.

Most homes can not accommodate a large amount of water, as the weight could unbalance their home so they take the risk of bathing around their house. In the low season the water is not clear so some treated bathing water with alum and some travelled short distant to bathe.

Generally participants in the focus group wanted a safe place for bathing in their home, but most are not suitable for a bathroom. If they could install a bathroom they feel it would be best located at the side of the house so it is far from the toilet and kitchen.

Water Quality:

All participants noted that generally the water quality had degraded over the years. They associated this decline with an increasing population in their village and their practice of disposing waste directly into the water.

However pollution varied in different location and seasons and is heavy dependant on the flow of water.

Health is one of the biggest issues for the floating communities as it common to have diarrhoea and other intestine, stomach and blood diseases. It is believed that Cholera occurs during the rainy season because of the water pollution from up stream such as Kampong Thom town and through pesticides used by farmers surrounding the Tonle Sap.

They feel it is important to access to medicine, but usually they do not have access or can not afford it.

They would like to improve the water quality for their families and also for the next generation. But now they don't know how to address this issue because they lack of knowledge and technology. They feel it is important people understand the issues they face so they can start to change their attitude to disposing waste into the river. They also need to have suitable toilet for their family and the place for keeping their waste.

Discussion of Sanitation Options:

All participants felt that removing faeces from their water will improve water quality a lot. They would like to have a toilet.

They would like to have a good sanitation system for their home and community because it can improve their health so they can save money currently spend on health care. They said they would install a latrine if it could cost less than 60,000 Riel (US$15).

They feel it is not appropriate to store the waste from the toilet in their home and would like a place to store it at a safe place away from their home. They suggest a small fee could be paid to a community member to collect and take away the waste.

Managing Sanitation at Home:

Every person in the house can help each other to build and care the toilet.

Results from Women's focus group

The results for women's focus group was similar to the men's group, however key differences where notes for their views on cooking, bathing, menstrual hygiene and children.

Cooking:

Some families took cooking water directly from the lake while others filtered the water before cooking. Most of people use wood to cook.

Bathing:

Young women generally do not change out of their clothes when bathing, so it is difficult to clean well.

Menstrual hygiene:

Generally women will stay at home during their Menstruation period. During their period they take water directly from the river to wash but not all the women use soap. After use each napkin pad is put into a plastic bag then they throw in to the water. If they do not have a private place to defecate or change napkin they ask to use someone's toilet room. Some people said that defecation at home is easier than outside.

Children:

Any toilet should be easy to use for small children as children are often left to manage themselves when their parents go to.

Discussion of Sanitation Options:

They agreed we should try to remove faeces from the water because they need to have a good quality of water. They were reluctant to share a price they were willing to pay for a toilet. But they are willing to pay a small amount for someone to collect waste containers.

Key messages from the community focus groups:

- All community members want to remove faeces and other waste from the water
- Desire to improve the water quality and to make a good environment for the community.
- Participation from each household in the whole community is required
- Need to work together with Commune Council, The Environmental Centre and Schools to coordinate this goal.
- Need to start education and awareness building for the community members on sanitation.

Consultation with Community Groups

To undertake the project, agreements, both formal and informal, been developed with relevant authorities and community groups at different levels of government, and within the community.

Ministry of Rural Development

Through membership of the Ministry of Rural Development's WATSAN forum this project has been able to build relationships and share experiences with the key players in the development of Water and Sanitation policy and infrastructure in Cambodia. It has also allowed this project to operate within the policy and recommendations developed by the ministry and other organisations working in Water and Sanitation in Cambodia.

Phat Sanday Commune Council

The Commune Council operates directly and has daily interaction and oversight with the Community. Working in Phat Sanday will need to occur in conjunction with the Commune Council.

An agreement with the Commune Council allows planning permission and community support for the project. One of the key reasons for working with the Phat Sanday community has been the willingness to participate on an ongoing basis with the project.

Phat Sanday Secondary School

The school is a key public facility for the establishment of the project. The school is in need for appropriate sanitation facilities to make going to school safe, dignified, and convenient and therefore to appropriate and attractive to attendance by students. The school also provides a good, institutional environment to trial the latrine where there are a number of users, and a system can be set up for maintenance.

The school has been the central in the development of the Floating Community Waste Management Centre, which is located at the school. We have also conducted several community training sessions with the staff and students of the school.

Kampong Thom – Department of the Environment

The environment centre in Phat Sanday Commune is another important public facility that has been very active in the developing and trial of the floating toilet. The Rangers working at the station already have a strong awareness of the issues in the community. An agreement has been reached with the Provincial Director in Kampong Thom

Staff at the centre has provided support for the project, feedback on the latrine design and cooperation in considering long term communal aspects to sanitation management – such as waste storage and transport.

Savings Groups

Savings groups have been set up through the UNV/UNDP program the Tonle Sap Conservation Project. This group has active community membership, with a membership base that meets regularly to save money together, and to make loans to members. The Savings group has previously been a means for communal support for members to purchase important hygiene items such as water filters, and has provided good insight on products that are attractive to the community and that are affordable.

Water Quality Testing

To evaluate the effects of the usage of the latrines, water quality testing of the water used by the Phat Sanday communities and the surrounding environment was undertaken in both high and low water level seasons.

A summary of our results can be found below. Refer to Appendix 1 for full results.

These tests have demonstrated that in particularly the low water season, the Phat Sanday community is exposed to levels of E. coli and Coliforms well above recommended WHO levels.

E.Coli per 100ml	Drinking Water	Washing Water	Bathing Water	Environmental Water
WHO Standard	0	N/A	N/A	N/A
High Water Level	1.5	2900	3630	2650
Low Water Level	46	7050	6100	4700

Floating Toilet

Development of Floating Latrine Concept

Upon conducting the community field surveys and focus groups it was determined that a novel technical approach is required to address this sanitation issue with appropriate low cost technology and materials while being sensitive to cultural factors.

It was decided to first design and trial a floating toilet, which would be the basis for a larger and holistic approach to sanitation in floating communities in Cambodia.

Success of the project is sensitive to solutions being readily acceptable by the local community an emphasis on local input throughout the design process was taken. The project team developed a strong relationship with a the Phat Sanday Commune in Kampong Thom Province, which has allowed the design team to deeply understand the community's idea of sanitation and use their input to help develop a culturally appropriate sanitation solution for the floating communities.

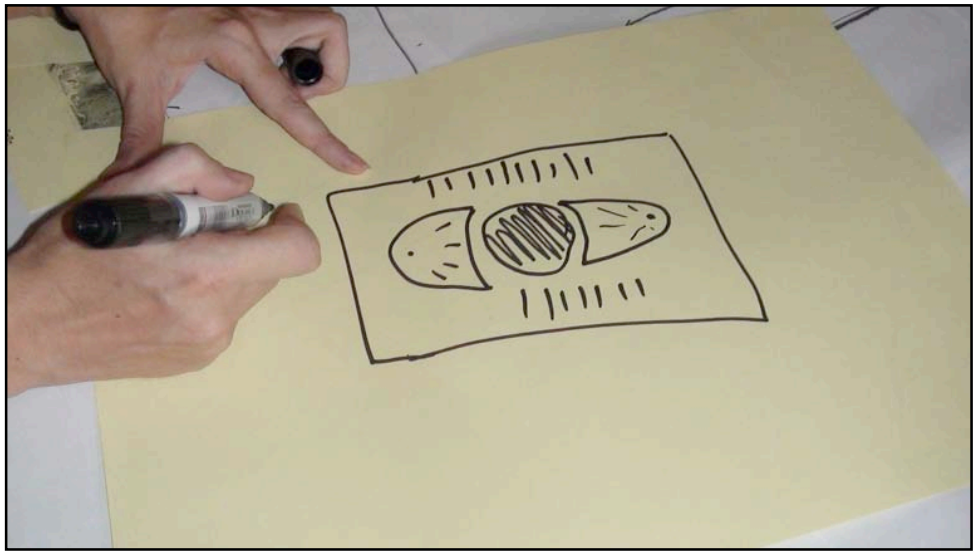


Figure 9 - The floating toilet concept under development at a community focus group in September 2009

Throughout 2009 EWB team conducted a comprehensive review of existing sanitation options used around the world in floating and land based situations. Urine Diversion Desiccation (UDD) as determined the most appropriate for the floating communities was selected for initial trial.

Next a basic UDD floating latrine was designed and a manufacturing technique developed using locally available materials. The manufacturing technique was developed in collaboration with EWB and RDIC in Cambodia. The pan was fabricated using cement and other materials commonly available in Cambodia. Using local materials was determined to be better than importing a latrine pan, as it would empower the community to improve the design themselves. It would also give the opportunity for local entrepreneurs to develop, improve and sell the latrines to the local community. This philosophy is inline with successful sanitation marketing projects undertaken in Cambodia by other organisations such as IDE and WTO.

For our small-scale trial the material cost for the pan, frame and buckets is US$35 with a labour cost of US$5 per latrine.

Once the prototype-floating toilet had been developed, a pilot study implemented to test the prototype in the target community.

The project team built and trialled 14 prototype floating latrines and regularly followed up their use. Each new prototype has incorporated improvements learnt from construction and use of earlier models. The team educated users of the floating latrine about the importance of total sanitation and how to use and maintain the latrine. This included classes at both Phat Sanday primary and secondary school.

Floating Toilet Design Philosophy

Due to space, weight, and process constraints, a urine diverting option has been designed, as the UDD process results in a lower weight and of volume of stored weight requirements, as well as a reduced time for storage. This

method separates faeces from urine, and wash water. Treatment is based on a desiccation process that incorporates drying of faeces, with increased pH through the addition of wood ash. Previous application of this design in land-based settings indicates treatment of 6 months is sufficient to kill faecal pathogens.[1]

Readily available 20L buckets have been chosen as a core component of this design due to material limitations, cost, and ease of handling and management. The bucket is suspended below the pan, with a 3-hole urine diverting squat pan placed over it a floor level.

This system requires

- 20L bucket for storage of waste (diameter 0.32m, height 0.35m)
- 2 or 3 hole pan for diversion of urine and wash water
- Disposal method for urine and wash water
- Storage method for waste for faecal waste for sufficient period of time under desiccating and alkaline conditions
- An appropriate additive to assist the desiccation process.
- An effectiveness means to incorporate the design into existing houses, structures

Floating Toilet Design Specifications

Super Structure

Requirements:

Provide privacy and safety for users, allow for storage of faecal matter above the water line, support the pan and user safely, provide sufficient room for: pan, anal washing, wash water storage, ash storage, menstrual hygiene management.

[1] Biological Study On Retention Time Of Microorganisms In Faecal Material In Urine- Diverting Eco-San Latrines In Vietnam, Chien, 2002.

Design:

Use and adapt (if needed) existing super structure where it exists.

Where no super structure exists, incorporate onto corner of floating home/building utilising existing walls, eaves where possible.

Minimum dimensions are:

- floor area – 1m x 1m allowing room for a 3-hole squat pan, and storage of ash and solid waste.
- floor height 0.5m above water line while floating,
- Roof height needs to allow easy access to step in for all users, approximately, 1.8-2.0m.

Figure 10 - A floating toilet prototype under trial in Phat Sanday in March 2010

Pan

Requirements:

Separate liquids from faeces to enable desiccation and the most efficient destruction of pathogens. Currently community members use water to wash their hands and for anal cleansing after defecation, therefore options to dispose of wash water is required.

Specification:

3 hole UD pan diverting urine away from faeces hole, a straight hole for faeces, and large pan area and hole for wash-water. Preferably lightweight. To be raised to remove the faeces storage bucket, strong, scratch resistant, light coloured, shiny.

Local production is currently limited to cement pans.

The pan needs to be light enough to raise and remove the storage bucket.

Dimensions: 50cm x 70cm

Wash water delivery

Requirements:

Ready source of water, including a 1L ladle (commonly found in the market) for pouring of water to allow anal washing.

Specification:

Bucket of water outside the cubicle with a rope. It can be readily filled over the edge of the house by an adult, and provide accessible water for all including children.

Ash/paper delivery

Requirements:

As a desiccation latrine, there is a need to increase the pH of the stored faeces to assist with the inactivation of pathogens. Wood ash is to be used, with the recommendation of a cup added for each faeces visit.

Specification:

A bucket for ash with a plastic cup/ladle of about the size of a cup should be available for use within the cubicle and within reach when standing over the pan.

Faeces Management

Requirements:

Storage that will fit directly below pan. Storage should be above the water level for safety during storms and to reduce heat loss and accompanying reduced evaporation if immersed in water.

Storage able to be lifted and sealed, and sufficient for a minimum of 6 months storage.

Faeces storage must be kept water free to maximise effectiveness of treatment.

Specifications:

20L paint bucket with lid, commonly found in the market. For a household of 5, it is estimated 19 buckets will be required in total, allowing buckets to be stored for 6 months of treatment.

Buckets to be dated and stacked potentially 6 columns X 3 buckets high. Consideration of under floor storage could also be made.

Urine Management

Requirements:

Take urine from pan hole, around the faecal storage bin and into water or storage container. Any storage container would have to be sealable, transportable of sufficient size to practical for maintenance.

Specifications:

Option 1: Allow for urine collection with flexible hose to transport urine from hole to container for reuse. Need to allow for around 1.2L per person per day. Store in 2 alternating plastic jerry cans (20-30L) and change every 5 days or so. No washing of urine allowed as water in urine adds to smell and risk of bacterial contamination before adding to plants. Use of condom or similar material can create a self-sealing pipe to prevent release of urine odours when no liquid is passing through.

Option 2: Direct disposal of urine into lake via flexible hose. Washing or urine component of pan permissible, but would need to be clear faecal hole cannot take water.

Wash Water Management

Requirements:

Allows for traditional self washing with hands and water following defecation. Wash water will have minimal bacteria and can be disposed of directly into the lake water.

Design:

Flexible hose, elbow jointed pipes, or diagonal pipes feeding wash water from pan into lake.

Menstrual Hygiene Management

Requirements:

Menstrual hygiene management is a fundamental aspect of sanitation for women between the ages of about 12 and 50. Our surveys and workshops indicate that women in the floating villages almost universally use disposable paper/plastic napkins for menstrual hygiene management and either throw them directly into the water, or bag them with other solid waste and dispose of into the water. Initially women need access to a private disposal option for paper napkins.

Specification:

Bucket or container for disposing of napkins within the cubicle. A metal bucket, with lid would be preferable and facilitate burning of the material.

Children, Elderly and Disability Considerations

Requirements:

Use of squat pans can be difficult for children, elderly and those with physical disabilities such as leg amputees.

Design:

Where required, the addition of strong galvanized pipe, or properly constructed wooden handrail can be added on either side of the latrine pan to allow users to lower themselves and raise themselves more easily. Consideration to the use of a seat (Design 1b) could be made for families implementing a latrine for elderly or disabled family members.

Trial of Floating Latrine in Phat Sanday

Once the initial design was complete and construction method determined we build and trailed several prototype latrines in late 2009 and early 2010. The final version cost US$35 including labour and weighted 26kg.

We installed 14 prototype latrines in the following places:

- Live & Learn Office and RDIC, Phnom Penh – October 2009
- Phat Sanday Environmental Centre – November 2009
- Phat Sanday Secondary School – January 2010
- Phat Sanday Primary School – February 2010
- 4x households in Phat Sanday and Kampong Chamlong village – March 2010.
- 4x households in Neang sav and Kaoh Tapov village – April 2010.
- 2x households in Phat Sanday and Kampong Chamlong village – July 2010.

For each latrine we regularly inspected and gathered feedback from the users. At each visit we discussed with users their feelings of using the latrine and gathered any suggestions they had to improve the latrine.

Key impacts of the this implementation trial have been:

- Excellent feedback received from Floating Latrine users. Users very happy and more people in the community want to take part in the trial.
- Users surprised about the lack of smell.
- Gained feedback to improve latrine design. Key improvements: Wider footprint, Higher lip around defecation and urine hole and reduced weight
- Strong Community engagement. Community supporting floating barge concept and are helping with design. Strong and mutual agreeable relationship developed with key members of the community

Figure 11 - A floating toilet under trial in Phat Sanday May 2010

- Increased awareness of sanitation in the community due to informal and formal discussions and education sessions we have held. This has increased association with other sanitation promotions, such as Hand Washing with Soap etc…

Lessons Learned

Community involvement has been at the centre of the project from the beginning. The community was at all stages integrated in the innovation process and provided valuable input complementing the formal technical expertise of the L&L and EWB teams.

When we first commenced this project in 2008, initial community surveys showed little demand of latrines or toilets in the floating communities. However working closely with the Phat Sanday community for over 12 months the desire for latrines has improved greatly. We have worked closely with key members of the community such as members of the Commune Council, School Teachers and Rangers from the Environmental Centre to improve their knowledge of sanitation of the need for total sanitation in their community

Although feedback from the latrine itself has great, the community felt that storing and disposing the waste was the main problem. The current design requires waste to be stored in buckets for 6 months. This is a burden to the community and is a disincentive for latrine adoption.

Our surveys showed that demand for latrines in the floating communities would be higher if there were incentives to use the waste from latrines. Need to consider reuse of waste and conserving nutrients by using as fertiliser in land based or floating gardens.

To get more insight into this feedback we held a number of informal workshops and brainstorming sessions with latrine users and other members of the community to discuss waste disposal and treatment methods. These discussions lead to the creation of the Floating Community Waste Management Cycle, which will be covered in detail in the next section.

Figure 12 - Michael demonstrating how to use the latrine to the community

Floating Community Waste Management Cycle

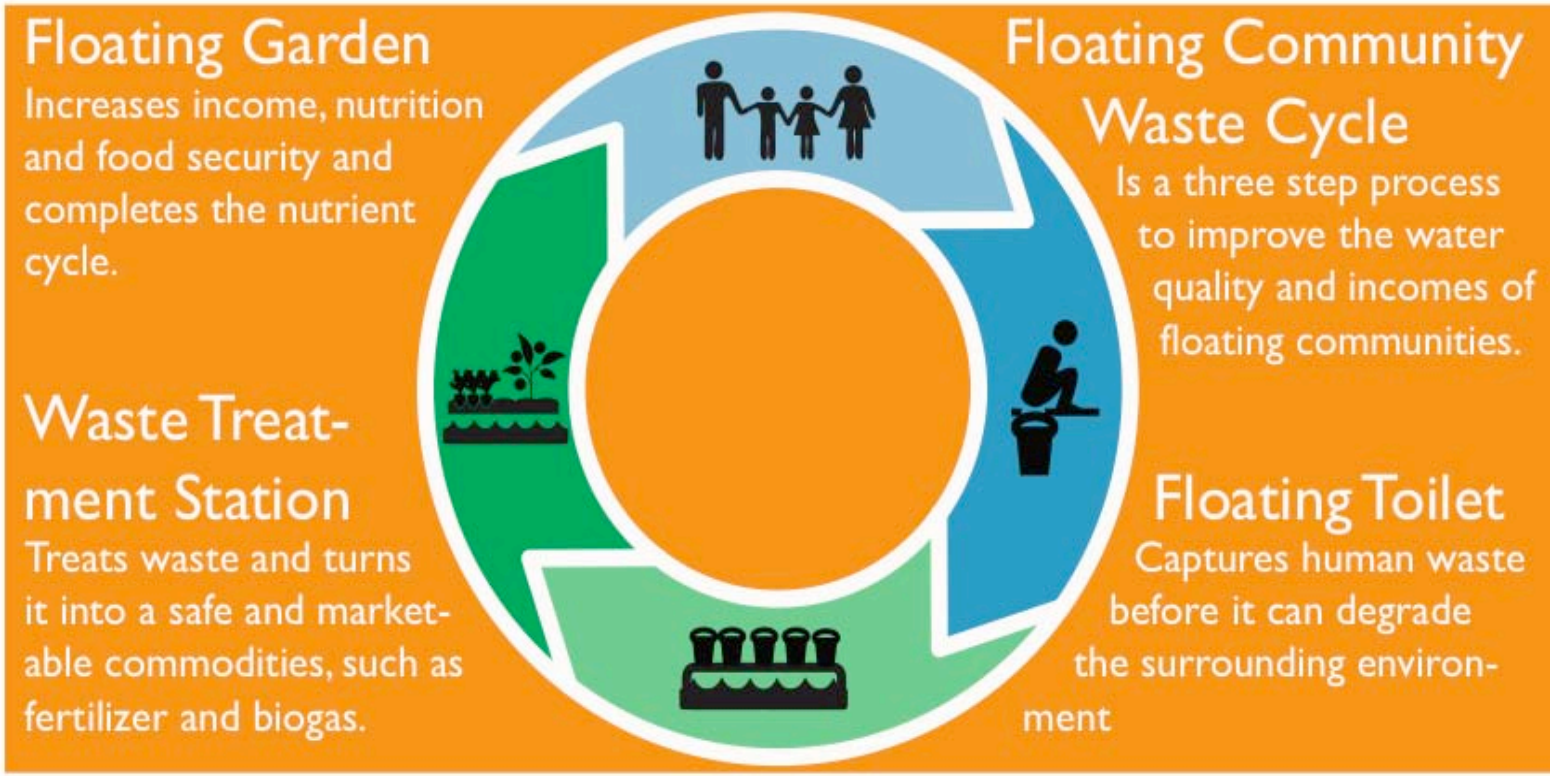
Upon testing of the floating toilets in the Phat Sanday community it quickly became apparent that the waste life cycle of the waste needed to be considered holistically to ensure the maximum value could be extracted, providing an incentive for the community to take up sanitation. With close consultation with EWB, Live & Learn and the Phat Sanday floating community, the Floating Community Waste Cycle was developed.

Not only have the Phat Sanday community been essential in developing the process, they have been very willing and supportive in the trial each phase and are providing good feedback and suggestions to improve the process and design of each element. In mid 2010 the team commenced design of second element of the cycle, the Floating Community Waste Treatment Station. This was completed in September 2010. The aim of the Waste Management Station is to treat the waste and turn it to a safe and marketable product, such as fertiliser or Bio-gas.

We have started to treat the waste from the toilets by simply storing and drying the waste. This was selected from a variety of methods as the as the most cost effective and reliable, over we will trial other methods such as solar heat treatment and bio digestion in late 2010.

In December the 2009 EWB Challenge winners will visit Cambodia and build and trial their floating bio-digester concept at the Waste Management Station to produce biogas for the floating communities.

Once waste is treated it will be used as fertilizer in a floating garden bed, which has also been, build on the Waste Management Station. We hope to have enough treated waste to start planting vegetables in late 2010 or early 2011.



Waste Management Station

This Floating Community Waste Management Station aims to address part two of the Waste Management Cycle by:

- Capturing harmful human waste from the floating toilet before it can degrade water quality of the Tonle Sap and the surrounding environment.
- Treating waste using appropriate technologies and techniques for return to the environment.
- Where feasible, safely reuses and recycles waste thereby conserving nutrients.
- Providing a platform for the development of new and innovative technologies and management practices for the floating communities. If the community chooses to invest in the methods and technologies demonstrated they can be scaled up appropriately and will generate social, economic and environmental dividends for the floating communities.
- Providing solutions for waste management that are culturally appropriate, reliable, economically efficient and environmentally viable into the future.

Development of Waste Management Station Concept

In the first half of 2010 our team has concentrated on developing a treatment method for human waste for residents of the Tonle Sap lake in Cambodia, that is culturally appropriate, reliable, economically efficient and environmentally viable.

To achieve this research goal, we utilised a team professional and student engineers from EWB to conduct a comprehensive review of existing waste treatment options used around the world in floating and land based situations and provide recommendations on which is the most practical for our application. Throughout this process the team of local staff at L&L conducted several community workshops and discussion forums to get feedback from the target community on each treatment method and the suitability for the community. Regular meetings between the two teams ensured a consistence approach.

Waste Treatment methods that were researched include:

- Small scale waste water
- Incineration
- Dehydration
- Bio-digestion
- Composting
- Chemical Treatment
- MineArc System
- Physical Storage

Each proposed treatment method was generated and reviewed against our selection criteria by both a team of experienced water and sanitation engineers and the Phat Sanday community.

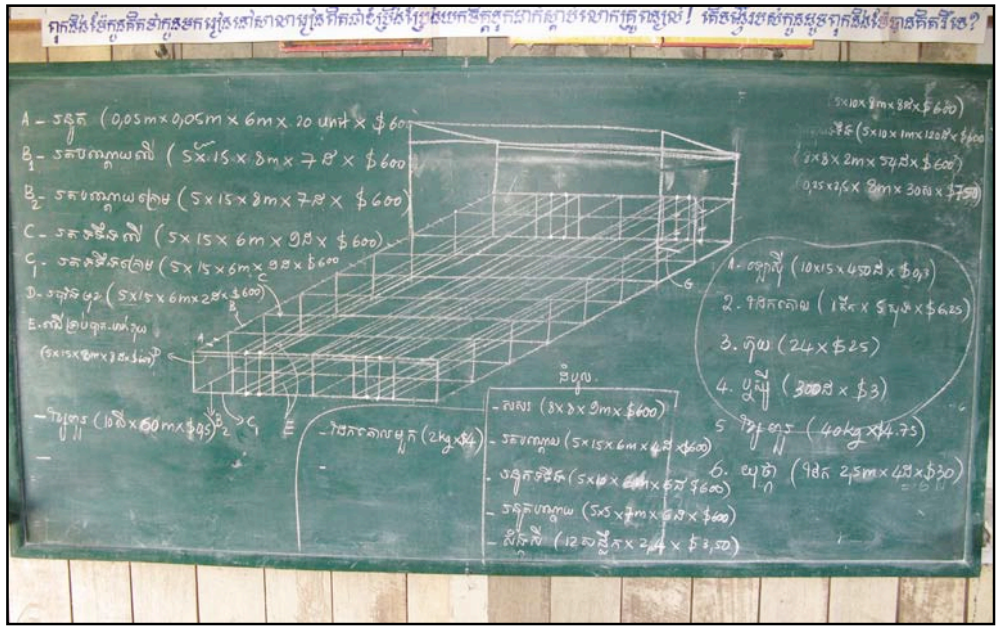


Figure 13 - First design concept of the Floating Community Waste Management Station after workshop with the community in June 2010

Following this review a desiccation and storage of waste in the same buckets used in the Floating Toilet was selected as the most suitable for the community. This process relies on the drying of the waste and the lack of oxygen to kill off the pathogens. Research from Vietnam has shown that the waste is safe for secondary use after six months of storage. However we will verify this in our environment in late 2010. We will test this waste for chemical parameters and E.Coli using facilities at the Royal University of Phnom Penh. We anticipate first results in December 2010.

Figure 14 - The project team developing the design for the Floating Community Waste Management Station on CAD in July 2010

Key reasons why this was selected as the most practical are:

- Waste can be reused as fertiliser once the treatment process had been completed. This will provide the community to grow vegetables on floating gardens to improve their diet and health or provide the community with a marketable commodity, which they can sell to farmers or market gardens on the land.
- The treatment process does not involve any physical, chemical or cost inputs during the treatment process. Waste is simply stored in buckets in the sun.
- This method also avoids double handling of waste buckets and empting and washing of buckets while the pathogens in the waste are still active. As the waste is stored in 20 litre bucket, this minimises the risk of injury to community members as they deliver full waste buckets. As the buckets are sealed until the pathogens are killed this reduces the risk of disease transmission from the waste to human from handling the buckets.
- Simple, low-tech and affordable.

Two other treatment methods researched were not selected for the initial trial, but showed significant promise and will be trialled at a later date.

- **Chemical Treatment with Lime:** This method treats the waste quickly, but disadvantages are it cannot then be reused as a fertiliser but disposed as land fill or directly into the lake. It will also occur ongoing cost to purchase lime. This method will be suggested to the community to use in case of emergency, or when a large amount of waste needs to be treated quickly. The waste disposal barge will be design to accommodate this.
- **Floating Bio-digestion:** This method holds much promise, but we have not reached a mature enough design yet to commence a trial. However the EWB team will continue to work on the design with the aim to commence a trial on the Waste Management Station in December 2010. The key advantage is the production of biogas, which the community could use for cooking or lighting. This could

reduce the dependence on biomass such as wood or charcoal for cooking which has negative effects on health and the environment. The disadvantage is bio-digestion is a complex chemical process that requires stable operating conditions which is especially difficult to maintain in the floating environment.

Figure 15 - Final design for the Floating Community Waste Management Station

Construction of Floating Community Waste Management Station

Once the best treatment method for the waste had been determined the team started to work with the local community member to develop the design for the Waste Management Station. We quickly realised that floating structures required very different structure to accommodate floating during the high water season and sitting on land during the low water season. It also needs to be strong enough to withstand tropical storms and the several wave action caused.

Due to these environmental factors we worked very closely with experience tradesmen from the Phat Sanday community. The storage capacity and thereby the size of the barge was determined by the number of community members and the minimum of 6 month which is required to re-use human waste safely in fertilisers.

Materials were selected based on availability, price, strength, expected life and ease of construction factors. For this reason wood was chosen as the primary material.

All of these factors where critical in developing an affordable design which is accepted by the community and offers the opportunity of marketability is often envisaged but difficult to achieve.

Figure 16 - The L&L team inspecting the Waste Management Station during construction in September 2010

Determining the strategic location of the waste management station in order to have a cost-effective, efficient collection and storage scheme and the management and maintenance of the station was considered in conjunction with the community. It was chosen to locate the waste management station with the Phat Sanday School.

Trial of Waste Management Station in Phat Sanday

The Floating Community Waste Management Station was completed in September 2010. The construction phase developed strong Community engagement by helping with the design and construction. Strong and mutual agreeable relationship developed with key members of the community.

Anticipated Impacts of the Waste Management Station include:

- Successful trial of sanitation and waste management facilities on the barge – including storage, and use in floating gardens
- Assessment of the most appropriate methods for collecting, treating and using waste for the floating communities
- Positive environmental and health impacts of improved sanitation practices
- Develop lessons learnt and recommendations for similar communities.

We plan to be able to report more in depth about the trial of the Waste Management Station once we have more feedback in early 2011.

Figure 17 - The Waste Management Station under construction in August 2010

Floating Garden

The community lacks access to land for most of the year, which reduces opportunities for growing vegetables and supplementing diet of fish and rice. Therefore the final phase of the Floating Community Waste Management cycle is Floating Gardens.

We have also conduced research into floating garden beds and benchmarked their use in Myanmar and Bangladesh. We have established a feasible approach and will commence a trial of a floating garden in December 2010. This offers the advantage of completing the nutrient cycle in the community and providing the community to grow vegetables in the high water season when access to land is limited.

We can report more on this implementation in early 2011.

Figure 18 - Floating Garden Bed under construction in Bangladesh (Source: Practical Action)

Figure 20 - Floating Gardens on Inle Lake in Myanmar April 2010

Figure 19 - Garden beds have been constructed on each side of the Waste Management Station

Sanitation Upscale

The collaboration between Live & Learn and Engineers Without Borders Australia with the support of the MRD has achieved success in trialling a floating latrine in a floating community and will demonstrate a waste treatment cycle by the end of 2010.

Our key knowledge and lessons learnt from the project so far are centred on:

- Community education and training to promote the use of latrines.
- Community engagement and capacity building around sanitation and waste management and reuse.
- Small-scale construction techniques using local materials.
- Development of a waste life cycle that has the ability to turn waste into a marketable commodity.

The scale up method to enhance sanitation in the floating and flood affected communities will build upon the Sanitation Marketing methods currently undertaken in Cambodia by organisations such as IDE and WTO to suit the circumstance of the flooding and flood affected communities. Live & Learn also has experience planning and executing Sanitation Marketing campaigns in Vietnam and Indonesia, which we will be able to draw upon.

The scale up recommendations will be developed in consultation with communities to ensure a truly sustainable uptake process. The project will also address waste life cycle and reuse, hand washing, menstrual hygiene management to ensure a holistic approach is undertaken to maximise the value of the sanitation solution and to reinforce messages of protecting water quality for the protection of the environment and human health.

The waste life cycle will generate social, economic and environmental dividends for the floating communities. The ability for the community to turn waste into marketable commodities such as fertiliser and biogas will drive demand to use floating latrines and provide additional income. This is an important factor as currently floating communities are highly dependent on fishing as their sole source of income.

Build Demand for Floating Latrines:

When we first commenced this project in 2008, initial community surveys showed little demand for latrines or toilets in the floating communities. However since working closely with the Phat Sanday community for over 2 years the desire for latrines has improved greatly. We have worked closely with key members of the community such as members of the Commune Council, School Teachers and Rangers from the Environmental Centre to improve their knowledge of sanitation of the need for total sanitation in their community. We will incorporate proven CLTS techniques and recommendations from the soon to be published National Hygiene Guidelines.

Build Supply of Floating Latrines:

Our current work on building floating latrines has been on a very small scale and focused on the prototyping of designs. To meet the demand for sanitation, then the supply of these latrines will need to be improved. We envisage working with Cambodian small and medium sized enterprises to manufacture and sell latrines to the floating communities. We currently expect a price of between US$30-$40 for each latrine is both achievable and affordable for the floating communities.

The Project Future

This next phase will be the forth phase and will focus on developing the supply and demand of floating latrines. To enable a wider rollout of Floating Latrines in the community both the demand and supply for floating latrines will need to be developed.

The current work on building floating latrines has been on a very small scale and focused on the prototyping of designs. If the CLTS and Sanitation Marketing techniques are successful in creating a demand for latrines in the floating communities, then the supply of these latrines will be need to be improved. Based on the experience of Sanitation Marketing in Cambodia by IDE and WTO and our work with the floating communities we expect a price of between US$25-$30 for each latrine to be both achievable and

affordable for the floating communities and thereby enabling the scale up of this innovation.

In 2011 Live and Learn expects to develop a business model using techniques such Community Led Total Sanitation (CLTS) and Sanitation Marketing to build supply and demand for floating toilets for floating communities in Cambodia and beyond.

For the future of the project, the challenge is to improve the design to such a degree that it will be an attractive option for steadily improving the health and sanitation of communities on Tonle Sap lake, and other communities in similar situations around the world.

Appendix 1 – Water Quality Testing Results

Water Quality in Phat Sanday Commune

No	Parameter	WHO Standard	Testing 1 November 2009 High Water Level					Testing 2 March 2010 Low Water Level				
			POU	B	W	DWS	Environmental	POU	B	W	DWS	Environmental
1	E-coli	0	1.5	240	149.23	325	76	45.83	1,253.85	1,564.17	1,043.75	1,201.11
2	Total-coliform	0	102.9	3620.38	2903.46	3256.88	2650.5	2,832.46	6,098.08	7,076.67	4,655.63	4,696.67
3	pH	6.5-8.5	7.5	7.32	7.33	6.95	7.2	N/A	6.78	6.76	6.64	6.56
4	DO	-	N/A	5.35	6.04	5.38	5.25	N/A	5.25	5.07	5.57	4.83
5	Conductivity(µs/Cm)	500	13.67	13.31	19.92	24.06	4.022	N/A	46.10	46.32	44.98	40.50
6	Temperature(^{o}C)	-	N/A	29.71	29.85	29.71	30.4	N/A	30.59	30.60	30.66	30.70
7	Turbidity (NTU)	5	10.06	6.04	5.87	5.64	5.92	41.83	93.31	93.83	90.38	89.78
8	NH3-N (mg/L)	1.5	0.01	0.02	0.02	0.02	0.02	1.07	0.41	0.28	0.33	0.20
9	Nitrite (mg/L)	3	0	0	0	0	0	0.04	0.00	0.00	0.00	0.00
10	Fluoride (mg/L)	1.5	1.49	0.04	0.03	0.03	0.04	2.52	0.14	0.14	0.14	0.15
11	Chloride (mg/L)	250	4.38	2.7	2.68	2.36	2.69	7.91	3.26	3.32	3.24	3.19
12	Nitrate (mg/L)	50	0.31	0.06	0.01	0.24	0	2.78	0.50	0.53	0.46	0.52
13	Phosphate (mg/L)	-	0.8	0	0	0.15	0.07	3.39	0.10	0.11	0.11	0.16
14	Sulphate (mg/L)	250	3.86	2.67	2.71	2.29	2.65	22.11	1.61	1.60	1.66	1.54