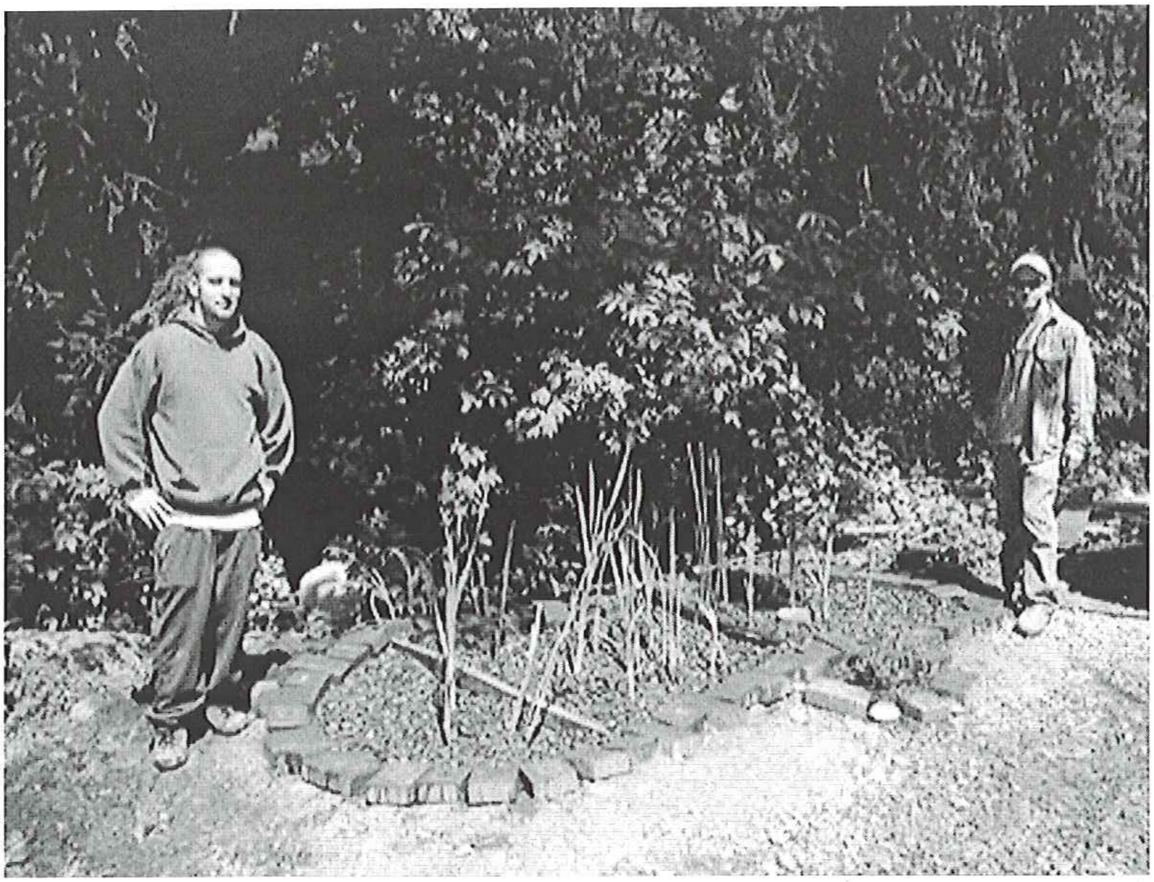
Loleta Greywater Problem



A Project By:

Ben Wishnoff & Chris Fivecoat

ENVS 410
Spring 07'
Hansis

Table of Contents

1.0 Problem Background

Currently, a household's greywater is being diverted away from the septic system and is draining over the side of a hill on the property. This water comes from resident's showers, sinks, and a washing machine. This waste water contains soaps and other substances that may be harmful to the ecosystem. If left untreated, the greywater could possibly contaminate the groundwater and create a problem for the well. In addition, the current greywater is completely saturating the side of the hill. The surfacing stagnant greywater can cause a potential problem for differential settling in the foundation of the house.

1.1 Context

We were approached by a neighboring homeowner who recently purchased a home in Loleta, CA. They noticed that their greywater was being diverted from the septic system and piped to a location they recently discovered to be the side of a hill that the house is built on. It is obvious that being piped to the side of the hill is not adequate nor an appropriate solution for their greywater. They were concerned that, if left untreated, it could possible cause the hillside to erode and could contaminate their well. Their greywater comes from a collection of three sinks, the washer machine, and the shower. The household consists of one child and two adults. The house is approximately 1000 sqft and located on a 2 acre parcel in Loleta, CA property surrounded by Agriculture land. Through calculations and observations of the behavior of the property owner, the load on the system was estimated to be approximately 130 gallons per day.

1.2 Background Information:

Greywater is considered all household wastewater excluding black water which comes from the toilet. Approximately 50-80% of residential wastewater is greywater and if treated can be reused in non-potable applications (Oasis Design). In urban areas, conventionally greywater is piped with your black water from your house or business to the city's municipal treatment plant. In some cases the sewage travels miles before entering the city's treatment plant. In rural areas, greywater may combine with black water and enter into a septic system. At some point in time, the greywater from this house was diverted away from the septic system for unknown reasons before the property was purchased. The rerouting could have possibly been to reduce the strain on the old failing septic system.

2.0 Goals and Objectives

2.1 Goals

As a group, we have many goals that we would like to fulfill during the course of our project. These goals include the following:

-We would like to effectively treat the greywater of a single household in Humboldt County preventing local groundwater contamination. Treatment would include removal of harmful pathogens and harmful bacteria including fecal coliform.

- We would like to reduce and possibly eliminate further erosion to the hillside located on the property. This would require that the exiting water be diverted away from the current location.

-We would like to use the reclaimed water to irrigate their fruit trees and ornamental garden and recharge the ground water. Reclaimed water exiting the system will be suitable for irrigation purposes. This will effectively reduce freshwater use.

2.2 Objectives

As a group we also established objectives by which we will accomplish our previously stated goals. These objectives include the following:

-We would like a system built from local materials that could be easily maintained, repaired, and can act as a model for other people in the community. Local materials are to be used in every situation that is possible. When local materials are not available, recycled materials from local sources will be utilized. Easy maintenance can be defined as simple routine maintenance which does not involve any heavy equipment. Furthermore, we would like the solution to the problem to act as a model for the community by encouraging alternative sustainable technology.

-We would like to create a solution to the problem which minimizes area. By minimizing the area to be disturbed, this will minimize overall impact to the environment. We would like to size the system appropriately for the amount of water the household consumes. This will require careful calculations as well as close observation. Sizing of the system is very important because it dictates the holding capacity and the rate at which the system cycles wastewater.

-We would like to create an visually appealing solution to their greywater issue that works with the ecosystem while satisfying the needs of the property owner. The aesthetics of the proposed solution are to be judged by the property owner and based on the overall appearance of the proposed solution, as well as the values of the property owner.

-We would like to use the reclaimed water to irrigate their ornamental garden and fruit trees and also recharge the groundwater.

3.0 Weighing Alternatives:

3.1 Tie to existing septic tank

This alternative would require the current greywater to be diverted to the existing septic system on the property. This is a common system for this area. This alternative would not meet the objectives of the project. Although this alternative would prevent further erosion on the property it would not be an environmentally appropriate choice because it will create additional load on the septic tank and would likely overload the system causing possible contamination from the leach lines. In addition, the greywater would not be able to be recovered for use on the landscape.

3.2 Tie to municipal sewer system

This alternative would require the current greywater to be diverted to the municipal sewer system. The current municipal sewer system is not connected to or near the property. This alternative would require that an extremely long pipe be connected from the house to the sewer system. This alternative is not feasible because the municipal sewer system in not within a reasonable distance and would not meet the objectives of the project. Cost for property owner for connection would be hundreds of thousands of dollars.

3.3 Traditional greywater system

This alternative would require the current greywater to be diverted to a system of above or below grade greywater storage tanks. Several large storage tanks would have to be installed in series. This alternative would not meet all of the objectives of the project. This is because it would require energy in the form of electric pumps that are necessary to move and aerate the water. Although this system would allow the reuse of the greywater and prevent erosion and contamination, this would require constant maintenance as well as the purchase of large storage containers. This alternative would create a burden and an eye sore for the property owner and would surely not be visually pleasing.

3.4 Biological greywater system

This alternative would require the current greywater to be diverted to a small scale marsh or constructed wetlands. This system would mimic the biological processes that occur in nature. Filtration of the water would occur as the water passes through gravel housing biofilm on the surfaces. Additional filtration would occur as the water travels through the dense roots of aquatic plants that are growing in the marsh. The roots of the plants are able to remove harmful pathogens and make the water reusable. The space required for these processes will be minimized through the implementation of a system of baffles which increases the length of time the water remains in the system to insure greywater is biologically treated. This system would effectively treat the households' greywater and create an aesthetic feature in their yard. The greywater would be act as a source of nutrients that would fertilize the aquatic plants. The water would be fully recoverable and diverted to existing fruit trees on the property.

4.0 Selected Solution:

Our selected solution is to construct a greywater marsh at the Loleta residence. The marsh we designed is approximately 10ft long by 3.5ft. wide and 3 feet deep. The marsh consists of 4 baffles to slow the water flow through the system to allow for the cattails *(Typha latifolia),* and bulrush *(Scirpus spp)* to treat the water. Cattails and bulrush can remove pathogens that are harmful to humans and rejuvenate the water for reuse in non-potable applications. The marsh will be backfilled with gravel and planted. Decorative stone will surround the marsh to cover the overlapping pond liner. The final design of the greywater marsh was a guitar shape (see figure 1). The guitar shape was decided on in the attempt to mimic a natural river habitat which is more rounded than square. The bottom of the marsh is rounded and angled to further prevent stagnation of water by facilitating flow.

Figure 1 Guitar Shape Marsh mimic natural curves of a watershed

5.0 Implementation Strategies:

Our solution was decided on with the client to insure properly matching system to need so implementation was smooth. Our strategies include using recycled materials whenever possible to minimize our impact. Our plan is to construct the system before we tie into the existing system to insure a safe work environment. Once constructed, greywater will enter our system through an initial filter and settling tank and flow to the marsh through a 2in PVC pipe. We provided the residence a maintenance manual to assist in future maintenance of the system. We have monitored the marsh after construction to insure the system is working properly. We have verbally expressed to the client that this project is not approved by the county, and if discovered, may need to have the greywater tied back into septic system. Our strategy is to construct a functional marsh and a beautiful addition to the landscape. The marsh has been created by Ben Wishnoff and Chris Fivecoat. Construction took about a month of working every Tuesday and Thursday as well as most weekends.

5.1 Construction Methods and Materials

In creating the marsh, materials obtained were recycled materials whenever possible to minimize environmental impact. The Marsh was excavated with shovels and pickaxes rather than renting a backhoe. This significantly added to labor time, but substantially cut the costs while lessening the impacts of carbon emissions the tracker would produce.

5.1.1 Site Preparation

The proposed site was in a location that had easy access to the existing greywater pipe (see figure 2). For the system to properly function sufficient head must be provided in the system. Therefore, we decided to locate the proposed site at a lower elevation than the house to provide the necessary head to insure flow. Grass was mowed and branches and brush were cleared from the site prior to excavation. Blocks of wood were used to mark the edges of the decided shape and dimensions of the marsh.

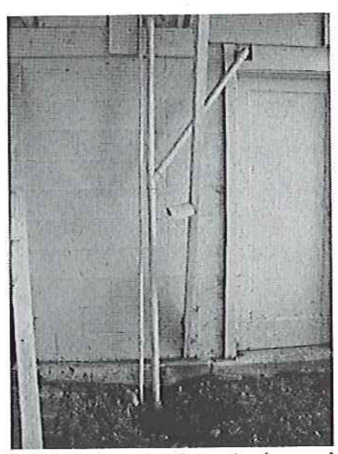


Figure 2 Greywater piping combining before being piped to hillside for release

5.1.2 Excavation of Marsh

The marsh was completely excavated by hand to reduce environmental impact and to cut costs for the project. The marsh constructed measured 10 feet in length and 4 feet in width at the largest point. The bottom of the marsh is sloped at an angle to encourage flow through the system. The entry point depth of the marsh measures 2.5 feet sloping down to 3 feet at the deepest point. Tools used in the excavation of the marsh included a pickaxe and shovels. The ground consisted of a 2' layer of compacted gravel and 1' layer of clay making the excavation a difficult task.

Figure 3 Digging and creating guitar shape for marsh

5.1.3 Lining of Marsh

To purpose of the pond liner is to prevent percolation prior to biological treatment. The liner that was purchased was a conventional pond liner available at hardware stores. It is made of 45 mil HDPM Synthetic rubber and measures 12 x 16 feet, slightly larger than was necessary for the marsh. A larger liner was used because the smaller liner cost more after being special ordered at our local source. After excavation the liner was worked to fit into guitar shaped hole (see figure 4). The access liner was trimmed off so after completion the liner would not be visible to home owner.

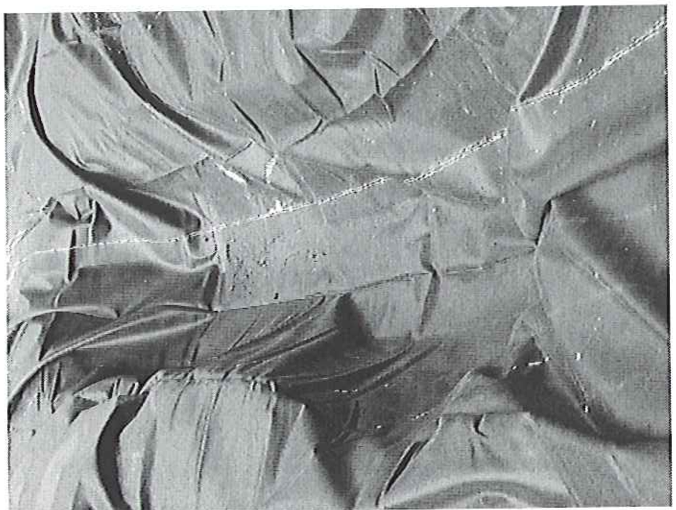


Figure 4 Pond Liner getting fitted into the excavated hole

5.1.4 Baffles

The installation of the baffles proved to be the most technically challenging process of the construction of the marsh. Difficulty came in the form of attempting to seal the baffles to the pond liner ensuring that the greywater would follow its intended path necessary for purification. The baffles were constructed from recycled old growth redwood recovered from the property (see figure 5). The baffles were first carefully measured to be slightly shorter than was able to fit. There are two sets of baffles. There are two upper baffles and two lower baffles. The upper baffles allow water to travel underneath, while the lower baffles force water to fill area and travel over the baffles into the next area. The bottom baffles fit snugly against the ground creating a tight seal forcing water to travel over the initial baffle, under the second baffle which was supported by 2 half bricks, and repeated for the remaining two baffles. The top baffles had to be held by one person while the other person carefully backfilled soil under the pond liner creating a tight seal between the sides of the baffle to the liner.

Figure 5 Redwood baffles being adjusted after gravel was shoveled in

5.1.5 Initial filter and Settling Tank

The initial greywater filter is used to collect large particles, preventing system back up. The tank acts as a primary settling tank for sediment and works as a grease trap for preventing fats and oils from entering the system. The filter trap was carefully designed to perform these operations. The filter consisted of a recycled 55 gallon food grade container obtained from a recycled material dealer. The container was cut open to allow attachment of the inside plumbing and for easy access for maintenance. The outlet for the plumbing attached near the bottom of the container was cut using a jigsaw and sealed using a soft rubber gasket surrounding both sides of the tank and allowing additional plumbing to be threaded in on both sides.

Figure 6 Settling Tank and plumbing design to keep sediment, grease, oil and fats out of the marsh

5.1.6 Plumbing

The 2 inch PVC pipe was laid underground at a slope extending 13 feet to the beginning of the marsh. In order to maintain head, the PVC pipe was sloped from the settling tank to marsh to code at ¼ inch per foot. The inlet of the marsh was covered in a series of large rocks to prevent sediment build up and possible clogging. The outlet pipe is also 2 inch PVC pipe attached to flexible drainage pipe where it is then diverted toward fruit trees. The entrance of the outlet pipe was also surrounded by larger rocks and was installed at a level that would maintain proper water level in the system.

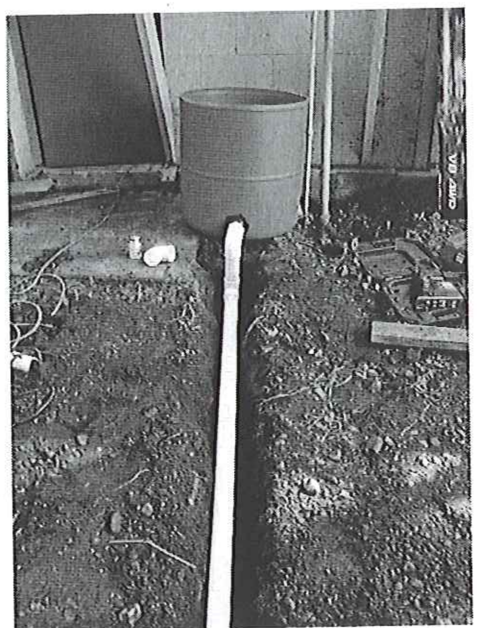


Figure 6 PVC runs from settling tank into marsh

5.1.7 Gravel Placement

Gravel was used to fill the marsh to inhibit rapid transfer through the system, prevent mosquito breeding, and provide a medium for aquatic plants to thrive in. We chose to use standard #2 round river gravel for the largest portion of marsh volume (see figure 7). The round gravel was chosen to facilitate flow. Crushed gravel was considered, but deemed inappropriate because it may slow system to a point that the tank would overflow. Larger rocks were also used to surround pipe as described in plumbing section. Gravel was carefully placed to minimize negative impacts to baffle system.

Figure 7 Gravel being shoveled into marsh prior to planting

5.1.8 Planting

Due to easy access, we decided to use cattails and bulrush as our primary source of treatment in the greywater marsh. These cattails and bulrush were transplanted from a similar marsh area in Arcata, CA. We acquired a large root clumps to ensure success in transplanting. The plants were transplanted into the marsh and topped off with gravel (see figure 8).

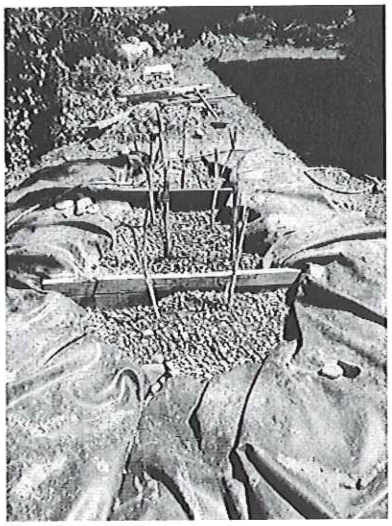


Figure 8 Planting cattails and bulrush into gravel

5.1.9 Finish Site Work

The marsh was decorated with cobble stone as a border around the marsh to add to aesthetics while covering the top of the pond liner. Gravel was backfilled over the underground plumbing after testing proved that there were no leaks in the system. Additional plants were planted around the perimeter of the marsh as a final step to accentuate the marsh.

5.3 Costs

The total cost of the greywater marsh was significantly less than previously expected. The original estimate for the project would cost $728.45, which would include the rental of a tractor, and more gravel than was necessary to complete the project. The home owner had a budget of around $500.00. By digging the marsh by hand and taking individual truckloads of gravel, costs were significantly reduced to fit the budget of the homeowner. Final cost for the project totaled $438.72 (see table 1), a savings of $289.73 from the initial projection.

Qty	Material Needed	Source	Cost	Total cost
120	Pond liner (40mil plastic)10X12ft.	Pierson's Hardware	$0.80 /sq.ft	$196.42
60	Decorative Coble Stones	Pierson's Hardware		$62.44
2	Plants	Pierson's Hardware		$26.77
1	Screen	Pierson's Hardware		$0.67
3	Gravel	Eureka Sand and Gravel	$20.00 per yard	$60.00
1	Water drum	Resale Lumber	$25.00	$25.00
1	Pipe and fittings 2"	Pierson's Hardware	$67.42	$67.42
			Total:	438.72

Table 1 Budget for all materials required for project

5.3.1 Time

The research and construction of the marsh took approximately 70 hours each for both Ben Wishnoff and Chris Fivecoat (see table 2).

Name	Research hours	Labor hours	Report preparation
Chris Fivecoat	13.0	52.0	4.5
Ben Wishnoff	12.0	50.0	6.0

Table 2 Time spent on all parts of project reported in hours

6.0 Monitoring and Evaluation:

Since completion of the system 4/11/07 we have been monitoring the system daily watching for leaking, back-ups, and general flaws in the system. Currently, the system is functioning smoothly. Daily monitoring will continue for the duration of one month. Our daily monitoring includes a visual inspection of system components, including the plumbing, filter, and water levels. After the one month, monitoring will continue on a monthly basis until we feel system is stable and operating to our expectations. Also, coliform bacteria testing will be done annually to monitor systems effectiveness of treatment. If our client calls with problems, they will be addressed immediately. The Client is happy with system and will also continue to monitor and evaluate to ensure a properly functioning system. A maintenance manual will be provided for client stating necessary measures to prevent problems (see appendix A).

6.1 Results:

The project resulted in creation of a beautiful marsh and has greatly improved the existing greywater system on the property. Our filter design, to help trap sediment in the drum to minimize possibility for obstructing flow to the marsh, was successful. Sediments and oils are collecting on the top layer and unable to continue though the system due to the innovated plumbing design used in the settling tank. Cattails and bulrush are thriving and beginning to show new growth. Water exiting the final drainage appears clearer than the sample taken directly from greywater pipe prior to entering implemented system. Coliform tests concluded that the marsh is making the water cleaner and safer. The water being released from the marsh had results of 30 coliforms per 100mL of water. The number is quite impressive. Typical household grey water is considered to be at 4,000 coliforms per 100mL of water. According to Oasis Design drinking water in some third world countries have recorded coliforms levels 100 coliforms to 100 mL of water.

6.2 Conclusions:

The marsh project proved very successful. Next time we would set up drainage on the bottom of the settling tank for easy maintenance and to drain sediment away rather than shoveling it out. A more earth friendly liner must be discovered. The pond liner is our biggest failure in our project. Using some sort of natural liner would not only lessen our environmental impact, but would also cut costs almost in half. The hillside where the greywater once drained is finally drying out. The area where the previous greywater was released stayed wet for almost a month after system was implemented due to the ground being over saturated for years. The system is working efficiently in treating the greywater.

7.0 Literature Review

7.1 Introduction to Literature Review

The literature review was created and used as research in determining possible solutions for the greywater problem. Research included reading articles, books, and websites gathering information that would help form an appropriate solution.

7.2 Greywater Marsh

A greywater marsh is an alternative method by which water is treated for secondary use or disposal. A greywater marsh consists of components which follow a natural model of water purification. This model of water purification is present in natural marshes throughout the world's wetlands. Greywater systems can take many shapes and sizes; however the goal of every system is sufficient treatment. The two common types of greywater systems include an underground system of manufactured storage tanks connected by rigid pipes, and a more natural system consisting of filters, above ground settling ponds, and a system of biological treatment.

7.3 Regulations Regarding Greywater

Title 24, Part 5 of the California Administrative Code sets guidelines for greywater systems as it applies to residential applications. Types of systems to be used are based on location, soil type, and ground water level. Permits to proceed with greywater construction are granted on the basis of a plot plan with the appropriate data satisfactory to the Administrative Authority. Finally, installers of gray water systems are to provide an operation and maintenance manual that specifies instructions for routine maintenance of the system. (http://www.owue.water.ca.gov/docs/Revised_Graywater_Standards.pdf, 2/4/07)

7.4 Treatment

The greywater marsh must sufficiently treat the water to an acceptable level. This acceptable level is reached through several stages. First, the water must be filtered of solids that may have been washed down the drains. This includes hair, food, or any other type of organic matter. The system must also have enough room to store sludge and scum that accumulates over time. Once the water has made its way through the filter, remaining suspended solids will settle out in a settling tank. The second stage of the treatment process includes biological treatment. This is accomplished through a system of vegetation which filters out the remaining impurities. These impurities act as the source of nutrients for the plants which thrive in these conditions. (Winneberger 41-50)

7.5 Soil

In order to determine the appropriate area in which to construct a greywater system, many tests and observations of soil characteristics must be performed. A percolation test quantifies the appraisal of soil absorption capacity. Observation and evaluation of these results will provide the relative capacity of the soil to absorb the liquid. Many other factors will contribute to the site selection including soil texture, color, swelling characteristics, and the depth or thickness of permeable strata. (Winneberger 55-57)

7.6 Greywater

Greywater is untreated household wastewater that has not come into contact with black water. Specifically, greywater includes water from bathtubs, showers, bathroom sinks, and water from clothes washing machines. Wastewater from kitchen sinks, dishwashers, or laundering of soiled diapers typically is heavily contaminated. It is usually recommended that water from those sources be sent to the septic system for treatment and not the greywater system.

7.7 Advantages

Advantage of a greywater system is that it can recover otherwise lost nutrients beneficial for plant growth and also can increase the life of the existing septic system through reduction of load. Advantages of the system are quite obvious. The system utilizes a natural system of treatment which does not consume energy, and the end result is water that is cleaner than it entered the system.

7.8 Disadvantages

Disadvantages of greywater systems include the potential for spreading disease through human contact if greywater is not properly handled or treated. Also, damage to the soil caused by long-term use. Disadvantages of the system are space restrictions and the frequent maintenance that is required.

7.9 Greywater source

According to Water Conservation Systems of Concord, Massachusetts, the 40 to 50 gallons of wastewater the average U.S. household generates per person per day can be contained, reclaimed, and recycled to nourish plants. (P.G. 24-31) A filter is set up as the first stage before the greywater is drained into ecologically engineered gardens of indigenous plants. Such indigenous plants include grasses, rushes, reeds, typhas, sedges, cat tails, and other herbaceous plants. These plants can then use the oxidized nutrients from the water to grow.

Appendix A

Maintenance Manual

Weekly – screen filter should be scraped off weekly.

Remove lid of settling tank. Pick up the screen filter by the handle and scrap debris into compost pile. Notice the water level and monitor it weekly to watch for any backing up in the system. Place filter back on top of the tank and place lid back on top of filter.

Monthly – sediment needs to be removed from bottom of settling tank.

Take off top of blue settling tank. Grab screen filter by handle and use scrap off debris and place to side. Use shovel to remove sediment that has settled to the bottom of the tank.

Yearly – test water for fecal coliform to monitor water quality of reclaimed water.

North Coast Labs will provide a sampling container. Take a sample off of the drainage pipe near the fruit trees. Samples must be taken to lab within 6 hours of sampling. Samples are taken M-TH 8-5 and F 8-3:30. The test for fecal coliform is $35 and takes approximately 3 day for results. The results will show the effectiveness of the marsh. If results reach limits of unsafe magnitude, the marsh design must be re-evaluated.

Yearly – marsh should be weeded

The marsh should be weeded yearly or as needed. Also, cattails and bulrush should be thinned to maximize healthy environment to remaining cattails and bulrush.

8-12 Years – Gravel should be removed and refilled with new gravel.

Gravel should be dug out of marsh and disposed of and refilled with new gravel. At this time baffles should also be inspected and replaced if necessary. New plants should also be obtained at this time. Pond liner should be inspected for tears or holes. If in bad condition pond liner should be replaced.

Bibliography

Books-

Barnes, D., and F. Wilson. The Design and Operation of Small Sewage Works. 2nd edition. London: E. & F. N. Spon Ltd., 1978.
(Barnes and Wilson 58-66)

Gloyna, Earnest F.. Waste Stabilization Ponds. 1st edition. Geneva: World Health Organization, 1971.
(Gloyna 56-88)

Winneberger, John H. Timothy. Manual of Grey Water Treatment Practice. 1st edition. Ann Arbor: Ann Arbor Science Publishers, Inc., 1974.
(Winneberger 41-50)

Ludwig, Art. Create an Oasis with Greywater. Revised and Exapanded 5th Edition. (Book ordered.)

Ludwig, Art. Builder's Greywater Guide. (Book ordered).

Journals-

Noah, Marilyn. "Graywater Use Still a Gray Area." Journal of Environmental Health Vol. 64 (2002): 22-26.

P.G.. "Recycling grey water into color." Environment Vol. 36 (1994): 24-31.

Internet-

http://www.owue.water.ca.gov/docs/Revised_Graywater_Standards.pdf, 2/4/07

http://www.appropedia.org/AEF_greywater, 2/2/07

http://oasisdesign.net/greywater/misinfo/index.htm, 2/3/07

http://www.greywater.com/index.htm

http://grey-water.tripod.com/

http://www.greenbuilder.com/Sourcebook/GreyGuidelines.html