CCAT greywater marsh (current)

From Appropedia

Contents

Introduction

Welcome to the CCAT Greywater Marsh Project Continued! This page will record the efforts made by Linsey Payne and Tyler Ebright during the Spring 2009 semester at HSU to research, complete, and provide an end-use for the treated greywater at CCAT.

Criteria

Description	Weight (0-10 highest)	Constraints

Appropriateness	9	Fits CCAT's Mission
Educational Value	7	
Safety	9	Water remains sub-surface
Ease of Maintenance	8	Weekly maintenance or less
Functionality	10	Provides end-use
Durability	7	Continues working for 5 to 10 years
Aesthetics	6	

Existing Conditions

The Campus Center for Appropriate Technology (CCAT)'s greywater marsh we inherited has been an on-going project since 2007 when it was relocated to its current location. It is a subsurface marsh off the

Fig 1: Marsh before renovation

southwest corner of the house. The greywater comes from the sinks, the shower, and the laundry machine inside the house. The original design had a settling tank first with a sock filter and a siphon system. The siphon was to draw water up out of the tank through the piping over to the second tank, which was about 15 feet away to the south located directly adjacent to the subsurface rock marsh. This second tank was to act as a surge tank. Please see the CCAT greywater marsh (2008) webpage to get the full description of the work that was done as of June of 2008. The current wetland portion of the marsh was left incomplete in anticipation of an end-use for the treated greywater. The surge and settling tanks were also left in need of final adjustments and appurtenances, such as a filter, secure lids, and the completion of the siphon system. Options for the use of the treated water include, gravity fed irrigation or pumping the filtered water into the rainwater catchment system tank for use on all CCAT landscapes and/or for greenhouse irrigation.

Anticipated Issues

- Punctures and/or wear of existing pond liner.
- Elevation of outlet pipe from existing marsh (approx. 4' below soil surface).
- Location and collection of appropriate end-use landscaping vegetation.
- Settling tank access lid is not secure.
- Filter has likely deteriorated. (made of burlap)
- Surge tank is in a deep hole with little access and is covered by two heavy metal grates.

Unanticipated Issues

- The siphon system that was planned for in the original design did

not work for us with the siphoning method we tested. This method included the testing of a bilge pump and a siphon-hand pump sealed to the top of the tank-to-marsh pipe inside the first tank.

- While testing to see how much water was needed in the first tank for water to flow to the second tank, we discovered that the initial inlet in this tank was not completely sealed. Water leaked from the space between the inlet pipe and the hole cut in the tank. This can be seen more clearly in Figure 2a below.
- While digging the trench for the end use pipe, we encountered a pipe crossing our trench (Fig. 2b). We contacted HSU Plant Operations and found out that there were more pipes that we would encounter. Plant-Ops informed us that to legally dig on this site, we needed to contact USA DIG North for their officials to check out the site before we continued digging.

Fig 2a: The hole cut in the first tank was a bit larger than the inlet pipe and was not sealed completely, water can be seen falling out and filling up the

Fig 2b: In the center of the image inside the trench you can see a metal pipe running through it

Background Research

See Literature Review for research.

Vision and Proposal

The vision for this project was to confidently present a fully functioning, low-maintenance graywater treatment and irrigation system by the end of the semester in June 2009. The area around the marsh was to be terraced and landscaped with native or naturalized non-invasive vegetation. The water entering the system from the house would be filtered as it entered into the initial surge tank and then flow into a settling tank before entering into the rock marsh. Once in the marsh, the water would flow over two baffles and under three to increase greywater-to-oxygen contact. The greywater would then be released into a third tank where the water could be tested and then released into the gravity fed irrigation system. In case of any overflow during the rainy season, the treated and filtered water would flow down into the storm drain at the base of the driveway, which runs

along the west side of the CCAT property.

Fig 3a: Layout of entire greywater treatment system.

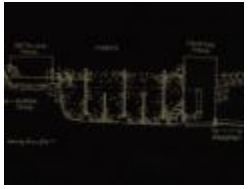

Fig 3b: Section of surge tank (tank #1).

Fig 3c: Section of settling tank (tank #2), the treatment marsh, and the water testing tank (tank #3).

Fig 3d: Irrigation layout plan.

Proposed Scope of Work:

1. Site Analysis
2. Discussion with CCAT Directors to determine initial ideas for marsh improvement and greywater end-use.
3. Determine functionality of existing system with testing.
4. Complete surge/grease trap/settling tank.
5. Complete terracing and landscaping of area directly surrounding existing marsh.
6. Research potential end-use of greywater and present findings to CCAT Directors and Lonny Grafman.
7. Construct and implement determined end-use of greywater.
8. Complete webpage on appropedia describing all aspects of the project renovation and completion.

Proposed Time Line

Task	Completion Date

Buy Materials	April 9, 2009
Connect End-Use Barrel to Marsh	April 17, 2009
Draft Website Due	April 20, 2009
Dig Irrigation Trench	April 21, 2009
Complete System	May 11, 2009

Project Requirements

Project Goals:

- Surge Tank
- Metal Mesh Filter
- Settling Tank
    - FOG (Fats, Oil, and Grease) Trap
- Seal all Marsh Inlets and Outlets
- Greywater End-Use

- Gravity Fed Irrigation
- Alkaline Tolerant Vegetation
- Terracing and Landscaping
  - Native Vegetation
- Education
  - How-to Webpage
  - Safety Signage at CCAT
  - Maintenance Manual for CCAT

Design

Amount of greywater generated by CCAT

1. **Calculate the number of occupants of your home:**
   - 4 people (we added 1 to accommodate for the water use of visitors at CCAT)
2. **Estimated daily greywater flows for each occupant are:**
   - Shower: 15 gal/day/person = 60 gal/day
   - Clothes washer = 7 gal/day

- Kitchen sink: 10 gal/day/person = 40 gal/day
- Bathroom sink: 3 gal/day/person = 12 gal/day

3. **CCAT daily use total = 119 gal/day**

Note: Collecting this data with a daily water-use log would have been more accurate and would be recommended for future greywater projects.

Issues Addressed

- Pond Liner: There were no punctures or wear and tear. Although there was an area of liner in the southeast corner of the marsh that was only a few inches taller than the top baffles (which you can see on the right side of the marsh in figure 4a), the level of water in the marsh is not anticipated to reach that height, and is therefore no longer a concern.

Fig 4a: Marsh

pond liner

- Surge Tank Leakage: Rubber washers included in the bulk head union sets in addition to rubber toilet tank seals keep the water from leaking out the holes for the inlet and outlet piping in the sides of the surge tank.

Fig 5a: Surge tank 4" bulk head union seal.

Fig 5b: Surge tank 4" rubber toilet tank seal.

Fig 5c: Surge tank 2" bulk head union seal.

- Marsh Outlet Elevation: The elevation of the outlet pipe from the existing marsh is approximately 4' below the surrounding grade. This limits the area of the CCAT property that can be irrigated using the greywater. However, it will be able to provide irrigation water for the landscaping directly next to the road and around the signage at the driveway entrance from the 14th street parking lot.
- Surge Tank: The surge tank (2nd Blue Barrel) will now be used as the settling and FOG catching tank and now has hinges and a latch to secure its lid.

- Filter: There was no burlap filter when the settling tank (which is now the surge tank) was initially inspected. A metal mesh filter has replaced the proposed sock/burlap filter.
- Settling Tank: The settling tank (1st White Barrel) will now be used as the surge tank

Fig 6a: Mesh and plastic filter

and has been raised so that the bottom of the barrel is only slightly below the inlet pipe from the house. In addition, the decorative heavy metal grates were removed, which resulted in easier maintenance access.

- Once we rejected the siphon method for bringing water from the first tank to the marsh, our options included:

1. raising the first tank to a level where the water filling it would create enough pressure to force flow through the tank-to-marsh pipe,
2. using an electric powered pump,
3. digging up the existing tank-to-marsh pipe to realign it, and
4. moving the first tank closer to the marsh and connecting the inlet pipe to the pipe-to-marsh pipe.
    - Because the top of the surge tank and the inlet and outlet pipes were within 12 inches of one another and because there were about 2.5 feet between the pipes and the bottom of the tank, we decided to raise the first tank. If this tank had not

been raised, a large volume of greywater would have been left to ferment and turn into blackwater if the system was ever left unused for more than 24 hours. It also did not provide sufficient room for large surges of water. To raise the tank we removed the existing unions attaching the pipes to the tank, cut out the tank to allow its removal, and filled in the hole with dirt and rocks until the tank sat with the pipes about three inches up from the bottom of the tank. The first tank, originally being the settling tank became the surge tank upon this raising and will finally allow water to easily flow from the tank to the marsh.

- Raising the tank meant that we would be cutting a new hole for the inlet pipe, which solved part of the leaking problem mentioned above. To make sure no leaking would occur we put rubber rings on either side of the tank and the existing union keeps these secure.

Design Process

Excavation

The gravel was removed from the end of the marsh behind the last baffle and dirt was excavated directly behind the end of the marsh to a depth of approximately 4 feet. Any water in the marsh was removed using a 1 1/2" Bilge Hand Pump and a bucket (see Figure 7d). The beginning of the irrigation trench was also excavated. Tank #3 was then placed in the hole. This tank was placed vertically with its base approximately level with the bottom of the marsh. The marsh and the barrel were connected through piping a few inches above their bases using a bulk head union. The gravel was replaced between the last baffle and Tank #3. The gravel throughout the marsh was redistributed evenly.

Fig 7a: To begin end use renovation, removing the rocks and water from the area after the last baffle was necessary

Fig 7b: And we needed a place to put all those stinky rocks

Fig 7c: The water that had gathered at the end of the system with no place to go

Fig 7d: Removing the water with a bilge pump

Fig 7e: Irrigation trenching begins

Fig 7f: Main stem of irrigation system

Surge Tank

The Surge Tank (aka Tank #1) was initially designed as the settling, filtration, and FOG catching tank. The plan was to have a sock filter attached to the initial greywater outlet from the house and a siphon system to draw water from the barrel and over to Tank #2. The issue with a sock filter is that it requires frequent maintenance and often

needs to be replaced. The Oasis Graywater Design Manual states that the "drum with pump and mesh filter [bag] is pretty much a discredited technology at this point due to longevity problems." We have changed the purpose of Tank #1 to be a surge tank with a metal mesh filter to catch large debris. This required that the barrel be raised approximately three feet to bring the bottom of the barrel just a few inches below the inlet and outlet pipes. This will provide at least two feet of surge capacity and will encourage water to flow rapidly through the piping over to Tank #2.

Fig 8a: Location of the

surge tank with supporting earth already raised to six inches below the outlet pipes from the house.

Fig 8b: Unattached surge tank with connection pipe fittings.

Fig 1: Fitting the surge tank back into place.

Fig 8c: Surge tank with sealed connections.

Fig 8d: Surge tank filter that

Fig 8e: Surge tank sealed

Fig 8f: Completed surge tank

Fig 8g: Completed surge tank

easily slides on and off outlet pipe from tank.	connection pipe fitting.	with filter connected to the tank outlet pipe.	with concrete and filter next to outlet pipe.

Settling Tank

The settling tank (aka Tank #2) was initially designed as the surge tank. Hinges were added to the maintenance opening and the existing duct tape was removed. A larger maintenance opening was added, also with hinges and a latch. This tank mimics a restaurant grease trap with an aluminum baffle trapping the FOG on the water surface, while letting the underlying water flow underneath this baffle, free of FOG, out and into the marsh. This baffle will also slow down the water and allow sediment to settle at the bottom of the tank. The outlet pipe from Tank #2 was attached to the pond liner using a bulk head union (see fig. 9b).

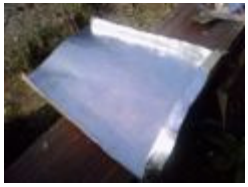

Fig 9a: The aluminum we formed into the baffle to be fit in the settling tank.

Fig 9b: Water-tight union between the pump coming from the settling tank and the rubber marsh liner.

Fig 9c: Settling tank without metal baffle.

Fig 9d: Settling tank with metal baffle.

Water Testing Tank

Initially improvements were focused on the end-use portion of the marsh system. This required the addition of a water testing site (aka Tank #3) for the cleaned water exiting the marsh. This water will then exit the tank and continue on through an irrigation system to water landscaping plants in the southwest corner of the CCAT property. A blue 55-gallon barrel was donated by CCAT for use as Tank #3. The water testing tank has several functions. The primary function is an access point to the water once it has been cleansed by the biological and physical processes occurring in the marsh for water quality testing. Additional functions are to allow adjustments to be made to the height of the water in the marsh using piping and to be a connection and access point for the beginning of the irrigation system.

Fig 10a: The location of tank #3

Fig 10b: The interior of tank #3

Fig 10c: Piping to allow for adjustment of marsh water height, which is attached to the outlet pipe from the marsh on the inside of tank #3

Fig 10d: The final exterior look of tank #3

Mosquito Prevention

Each tank would have some standing water and needed protection from mosquitoes. We gathered some fiberglass mesh, 16 gage wire, and a two inch spring to create protective barriers around the tank openings.

Fig 11a: The springs and wire used for the mosquito screens.

Fig 11b: The settling tank with plastic door closed and mesh screen secured.

Fig 11c: The settling tank with plastic door open and mesh screen secured.

Fig 11d: Shows one of the screws that washers are placed over to secure the screen.

Fig 11e: Testing tank with mesh screen secured.

Fig 11f: Mesh screen clasp open. Loose wire is placed through the open side of the spring and bent back over itself away from the spring.

Fig 11g: Mesh screen clasp closed.

Fig 11h: Testing tank with mesh screen and plastic lid secured.

Fig 11i: Surge tank with mesh screen.

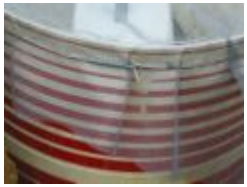

Fig 11j: Surge tank screen clasp.

Fig 11k: Surge tank with mesh screen and metal lid secure.

Irrigation System

The gravity-fed irrigation system was built to provide water for several alkaline-tolerant plants at the southwest corner of the CCAT property. The irrigation begins at the marsh outlet water testing barrel (aka Tank #3) and flows through ABS piping in a branching pattern at various depths underneath the soil. The depths range from 6" to 4'-0" underneath the surface of the soil. In this system there are 5 outlet points with water being released through holes that were drilled into

the last 2' of each pipe branch. These perforated pipes were surrounded by gravel and held in place by heavy rocks or bricks. Dirt was then replaced over the top of the pipes and compacted by walking. 2" to 6" rocks were placed over the branches and main stem of the system to indicate for future users where the pipes are located and as an art piece. The main stem of the system continually slopes gradually downward, while the branches have either a neutral or negative slope.

Fig 12a: Irrigation trenches

Fig 12b: Irrigation pipe layout

Fig 12c: Fitting the pipes into the trenches

Fig 12d: Piping support

Fig 12e: Gravel filler

Fig 12f: Covering piping with soil

Fig 12g: Adding rocks to highlight the piping layout on surface of soil. This adds an artistic element to the system and allows for easy location of the system for

Fig 12h: Placing rocks around tank #3 to cover the pond liner.

maintenance.

Landscaping

Drought tolerant California native plants were used to landscape the area between the rock wall on the east side of the marsh. These plants will only be receiving rain water after establishment (2 years). Prior to establishment, these plants will need to be watered weekly the first year and monthly the second year. Water loving, alkaline tolerant plants were used to landscape the area receiving the treated gray water. These included small trees, shrubs, and ground covers. Our focus was to use plants that provided food, such as berry bushes or orchard trees. The plants used were: (1) Apple tree, (1) Currant: Ribes speciosum (3) Monkey flowers: Mimulus aurantiacus, (4) Evergreen huckleberries: Vaccinium ovatum, (4) Toyon: Heteromeles arbutifolia, and (2) Coffeeberry: Rhamnus californica. The coffeeberry shrub starts were too small to plant right away and are maturing in

their pots as of May 2009. Two rose bushes were already planted on-site and will remain in place.

Fig 13a: Dwarf apple tree

Fig 13b: Seep monkeyflower shrub

Fig 13c: Evergreen huckleberries that will provide yummy purple berries

Fig 13d: Evergreen current

Fig 13e: Toyon shrub

Fig 13f: Completed terrace landscaping without mulch

Fig 13g: Sedum groundcover terrace planting with mulch

System Activation

There are two valves directly north of the surge tank that turn the water flowing into the greywater system and the sewer system flow on

or off from the house (see fig. 14a). If the greywater valve is closed and the sewer valve is open (fig. 14b), the greywater will flow directly into the sewer. If both valves are closed (fig. 14c), the greywater will flow into the house and out the floor drain in the basement bathroom. If the greywater valve is open and the sewer valve is closed (fig. 14d), all of the greywater will flow into the greywater marsh system. If the greywater valve is open and the sewer valve is open (fig. 14e), the greywater will split equally between the greywater and sewer systems due to the plumbing configuration. A gadget (fig. 14f) was made to switch the valves on and off from two pieces of wood. This gadget is inserted all the way into the valve access pipe and fits over the top of the valve handle. The gadget is then turned, using the handle, the desired direction (fig. 14g).




Fig 14a: Sewer and greywater on/off valves.

Fig 14b: Sewer ON and greywater OFF.

Fig 14c: Sewer OFF and greywater OFF.

Fig 14d: Sewer OFF and greywater ON.

Fig 14e: Sewer ON and greywater ON.

Fig 14f: Key to help turn the valves.

Fig 14g: The key fits over the valves and is turned using the handles.

Fig 14h: Diagram of the different settings for the system activation

valves.

Signage

Soap warning and reminder for CCAT household: Soap Recommendations

Costs

Material	Location	Unit Cost	Quantity	Total Cost
Plastic trash bin	Arcata Community Recycling Center	Free	1	Free
Metal mesh screen	Arcata Scrap & Salvage	Free	1	Free
	Arcata Scrap &			

Metal frame	Salvage	Free	1	Free
Aluminum sheet	Arcata Scrap & Salvage	$4.00	1	$4.00
55 Gallon drum	HSU CCAT	Free	1	Free
4oz E6000 glue	Hensel's Hardware	$6.49	1	$6.49
Hinges	Hensel's Hardware	$4.29	1	$4.29
Bulk screws and nuts combo	Hensel's Hardware	$0.54	4	$2.16
Hex Bolt	Hensel's Hardware	$0.30	6	$1.80
Washer	Hensel's Hardware	$0.09	12	$1.08
Nut with Nylon	Hensel's Hardware	$0.17	6	$1.02
Tank Gasket	Hensel's Hardware	$2.49	2	$4.98
45 Elbow Sch40 1"	Hensel's Hardware	$1.49	2	$2.98
Plastic Rain Collar	McKinleyville Ace Hardware	$4.79	2	$9.58

Backwash KOHLE	McKinleyville Ace Hardware	$2.49	1	$2.49
ABS Adapter	West Coast Plumbing	$1.59	1	$1.59
Rubber 4" x 1.5" coupling	West Coast Plumbing	$4.95	1	$4.95
ABS Coupling Reducer 2" x 1 1/2"	West Coast Plumbing	$2.15	1	$2.15
ABS Standard Adapter 1 1/2"	West Coast Plumbing	$1.35	1	$1.35
Bulkhead Compet 1 1/2"	West Coast Plumbing	$12.95	2	$25.90
ABS Male Adapter 1 1/2"	West Coast Plumbing	$1.19	2	$2.38
ABS 1/4 Bend 1	West Coast	$1.19	1	$1.19

1/2" Plumbing ABS Pipe 1 1/2"	West Coast Plumbing	$0.69	3	$2.07
Valve Ball Sch40 1"	Sunny Brae Ace Hardware	$7.99	2	$15.98
Tee Sch40 1"	Sunny Brae Ace Hardware	$0.99	2	$1.98
Cross Slip Sch40 1"	Sunny Brae Ace Hardware	$3.29	1	$3.29
Pipe Sch40 1"x10'	Sunny Brae Ace Hardware	$4.49	5	$22.45
Low-VOC PVC Cement	Sunny Brae Ace Hardware	$3.99	1	$3.99
Adapter Sch40 1.5"	Sunny Brae Ace Hardware	$1.29	1	$1.29
Female Adapter	Sunny Brae Ace	$1.29	1	$1.29

Sch40 1.5"	Hardware			
Adapter Sch40 1.5" to 1"	Sunny Brae Ace Hardware	$1.29	1	$1.29
45 Elbow Sch40 1"	Sunny Brae Ace Hardware	$1.49	2	$2.98
"O" Ring	Sunny Brae Ace Hardware	$0.56	2	$1.12
Spring 2" Long	Sunny Brae Ace Hardware	$3.79	1	$3.79
16 Gage Galvanized Wire	Sunny Brae Ace Hardware	$2.99	1	$2.99
Fiberglass Wire Mesh	Sunny Brae Ace Hardware	$0.89	6 Feet	$5.34
Toyon shrub	Freshwater Farms	$2.50	4	$10.00
Monkeyflower shrub	Freshwater Farms	$3.50	3	$10.50

Evergreen Huckleberry shrub	Freshwater Farms	$4.50	4	$18.00
Coffeeberry shrub	Freshwater Farms	$2.50	2	$5.00
Red Flowering Current shrub	Freshwater Farms	$4.50	1	$4.50
			Grand Total	**$198.23**

Final Thoughts

The completed marsh system is a success, but is not perfect. We provided an end-use for the treated water, vegetated the terrace on the east side of the marsh, connected and sealed each component of the system to one another, and provided the ability of the marsh owners to adjust the level of the marsh water as needed. The system has been simplified from the original version, by the removal of the burlap filter and the siphoning system in the original settling tank.

Many of the remaining imperfections are due to the original constraints of the system such as the location of the system, the height of the greywater outlet from the house, a concrete driveway cutting across the connection point between the surge tank and the rest of the system, and the "Y" connection with the overflow valve into the sewer being horizontal instead of vertical. The location and the low elevation of the initial outlet severely restricted the use of the final cleansed water, because most of landscaped portion of the property was located on the eastern side of the house or was above the level of the marsh. The "Y" connection of the sewer and greywater pipes right before the connection with the greywater system hinders the success of the system, because this is the only location for sewer overflow before backing up into the house. This "Y" had been laid horizontally instead of vertically with the sewer connection on top and means that with both valves open the water will split between the two pipes and reduce the efficiency and effectiveness of the greywater system. It also means that if the sewer valve is shut to make sure all greywater leaving the house enters the treatment system and anything goes wrong to clog the surge tank or settling tank, then the water will overflow the surge tank or back up into the house. It is unlikely that

the filter in the surge tank will clog, because it is large and not completely sealed. However, if the filter is left for more than a few months without cleaning the danger of clogging has the potential to increase significantly. This will need to be observed by the CCAT co-directors.

Next Steps

Testing

1. Next steps would include water testing from the surge and/or settling tanks as compared to the water in the marsh and then in the final collection tank (tank #3) before the water is released for irrigation.
2. Testing the soil around the vegetation absorbing water from the irrigation system should also be done and compared to the surrounding soil to determine whether or not the greywater is lowering the pH and adding salt compounds to the soil.

Maintenance

- Here is a comprehensive maintenance video: http://www.youtube.com/watch?v=PQsiXyZn2a0
- Surge tank filter to be cleaned twice a month with adjustments as needed.
- FOG (Fats, Oils, and Grease) will need to be cleaned from the settling tank at least twice a month, depending on CCAT cooking habits.
- The surge tank and settling tanks will need to be completely drained and cleaned once a year.
- The water level in the marsh will need to be adjusted every three months from lower to higher to encourage different levels of root growth.
- The rocks in the marsh will need to be replaced every 5-10 years as based on water quality testing results.
- The landscaping plants will need to be watered twice a month for

the first year and once a month during the second year. After the second year, the plants will only need to be watered during a sustained drought period or if they appear to need another year of watering before they are established enough to rely only on the weather.

- http://www.harvestingrainwater.com/greywater-harvesting/greywater-compatible-soaps-and-detergents/

Recommended Improvements

- The baffle in the settling tank may be too small and too low in the barrel. This will need to be observed over time to determine its effectiveness or lack thereof.
- In the irrigation system there are check valves to help distribute the water more evenly between the various outlets. Access pipes should have been placed above them to the top of the soil for future maintenance and adjustment.

- The surge tank will have approximately three inches of greywater sitting inside of it, which is significantly less from the original design, but will still likely turn in to blackwater if the system is left unused for any period longer than 24 hours. The main issue with this will be smell. Concrete has already been added to the tank in order to reduce the amount of excess space. We would recommend an additional fitting to further reduce the extra space. This could be made out of rocks, foam, or more concrete, but the filter will still need to be able to be easily removed and replaced.
- The plumbing in tank #3 has parts that have not been glued to allow for easy adjustment to the level of water in the marsh. As the system ages it may be more effective to have screwing parts or to glue more of the pieces together.
- The fencing around the surge tank and the marsh will need to be replaced or reinforced by Fall of 2009.
- Stairs or easier access points to the surge tank and the settling tank also need to be constructed.

References

See Works Cited for bibliography.

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