BSF Based Urban Water Supply Station V 1.0
Using Concrete Ring and Base Construction

By

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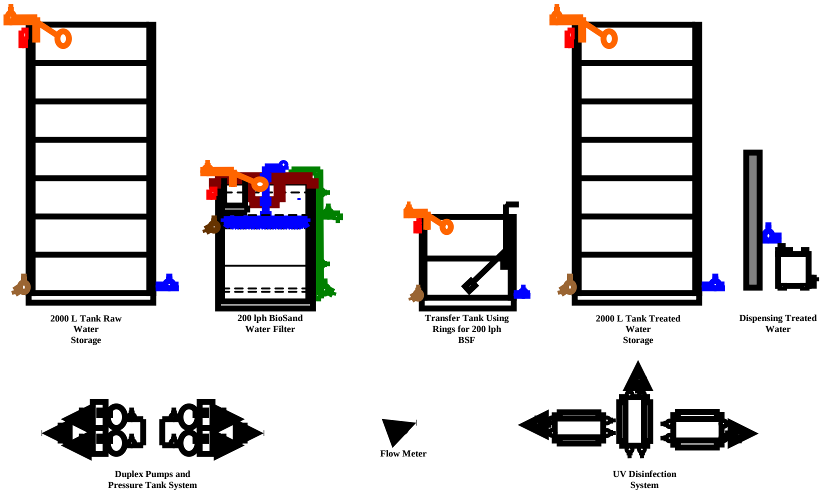
July 22, 2005

Factory for manufacturing concrete rings and bases for latrines, wells and water storage tanks.



1.0 Background

Water supplied or otherwise available for domestic use in urban communities in most of the warm climate developing countries is not safe for drinking. It may be perfectly adequate for laundry, bathing, toilets, etc. but not for drinking, cooking and washing of fresh vegetables, eating utensils, cooking utensils and eating area. Often the water that is supplied is available irregularly in an unpredictable fashion. Water pressure may vary from satisfactory to zero – again, in an unpredictable fashion. Residents accommodate the situation by using temporary storage in the form of water tanks on the roofs of their homes or apartments often in combination with an underground water storage facility. The delivered water (whether by the municipal water distribution system or by some other form of water delivery) is contaminated by sediment and parasites; and, depending on the nature of the system chlorination (at the source where the water is usually very safe to drink), the water may also be contaminated with bacteria and viruses. The water that is supplied directly to urban dwellers is of much better quality than any other available in the community.

Treatment of domestic water supplies to a quality that renders it safe for drinking has traditionally been an onerous task. Boiling water may not be an affordable option for all. If water is boiled it must be cooled and stored before it is acceptable for drinking. Additional chlorination or other form of chemical disinfection may not kill parasites. Sediment must be removed with some form of filtration (candle filters are often used). These sediment filters may or may not remove bacteria and cannot be relied on to remove viruses. Silver impregnated ceramic filters are effective for only a short period after which the silver has negligible effect. If maintained according manufacturers instructions, sediment filters can be very effective for parasite and sediment removal. Ultra violet disinfection does not function if there is no electricity and is not practical without appropriate voltage regulation and maintenance. Pressure is not adequate to operate reverse osmosis systems and significant concentrations of sediment make these systems impractical. Bottled water supplies may be expensive and of questionable quality but have become an option of choice.

The BioSand Water Filtration technology has been developed over a period of more than fifteen years for applications in developing countries (all over the world) and developed countries such as Canada and the United States of America. The BioSand Water Filtration (BSF) technology has proven its utility several times in independent laboratory evaluation and field testing programs around the world. Household BSF's, for use in developing country environments, has been limited to manually operated systems due to the significant cost associated with importing automated systems or developing the capacity to manufacture the automated systems in the local market. The BSF technology has frequently been used to produce large amounts of safe drinking water in both rural and urban environments.

The BSF technology was adapted for use in Canada and the USA or it would not have been accepted in the households or small communities there. The adaptations incorporated into the North American models of the BSF use aesthetically acceptable and manufacturable plastic filter bodies, introduction of automation and high standards for quality control in manufacturing and installation.

A major challenge has been how to adapt the BSF technology to serve the needs of the larger communities in developing countries while considering the formidable design constraints associated with need to meet World Health Organization (WHO) Water Quality Guidelines, very low capital costs, very low operating costs, very low cost of product to intended consumer, local manufacture, limited reliability of raw water supply and quality, limited power requirements, ease of operation and finally, appropriateness and sustainability.

Experience with the BSF technology and other supporting technologies in both developed and developing countries have provided sufficient guidance. The following observations are important:

1. Community scale water treatment systems such as those mandated in Europe and North America are just not practical in most of the regions of the world. Of course there are several exceptions but they are not the communities of interest. The economies, which support water treatment and distribution systems that are capable of providing sufficient water to the consumer that is safe for drinking, are very substantial by world standards. Most of the countries in the world do not maintain economies capable of meeting and sustaining the same drinking water standards. This means that most of the world cannot afford to establish water treatment and distribution systems that can guarantee safe water delivery to the home; and, cannot afford to contemplate the establishment of such a water treatment and distribution system in their community.
2. Most of the consumers in the world who are obliged to cope with supplies of water that is unsafe for drinking, do what is necessary to either treat the unsafe water so that it is safe for drinking or purchase special water that they believe or know is safe to drink. The latter alternative is usually quite expensive and may, in the lower income segments of the community, constitute a considerable fraction of their disposable income. The expense is justified in that it is much less costly to provide safe drinking water than it is to purchase the medical services (often not available) and drugs necessary for the treatment of water borne diseases.
3. There is no hope that safe drinking water will ever be provided through distribution systems throughout the developing world. It is just too expensive.
4. Household treatment systems for the production of safe water are expensive when considering household incomes and demands on that income. Small cash outlays for what is considered an essential, sustaining food, such as water, are justified.
5. With the exception of the household BioSand Water Filter, most water treatment technologies made available to households for point of use treatment are too expensive to buy, too expensive to operate or simply don’t work. As inexpensive as the household BioSand Water Filter is, consumers in developing countries still find the cost of purchasing one difficult to accommodate.

6. Community water treatment systems are difficult to sustain. Many communities are simply not accustomed to collecting fees (taxes) for any reason including the operation and maintenance of a community water treatment system, much less a community water distribution system. Many of the same individuals are quite prepared to purchase safe drinking water if it is available to them.
7. A very large proportion of the populations in the developing world have very small amounts of disposable income.

The BSF Urban Drinking Water Supply Station is able to meet the safe drinking water needs of all. The BSF Based Urban Drinking Water Supply Stations can meet the needs of the most disadvantaged consumers in a manner that they can afford, and they can participate in, while benefiting local economies and providing local employment opportunities.

The concrete ring technology used world wide to construct storage tanks, line shallow wells and line pit latrines is ideal for the construction of the containers that may be used to construct the larger BSF's. The lessons learned from automating BSF water treatment facilities in North America may be readily adapted for use with these concrete containers. The various elements needed to automate these filters are inexpensive and available locally.

2.0 Design Criteria for the BSF Based Urban Drinking Water Supply Station V 1.0

The following design criteria are proposed:

1. A single water treatment system must provide water for 200 families.
2. Each family consists of 5 persons.
3. Each family will require up to 20 litres of water per day of safe drinking water.
4. The ‘foot-print’ of the treatment system must be less than 10 square meters.
5. The capital cost for the water treatment plant should be minimal.
6. All construction materials must be locally supplied.
7. All equipment must be able to pass through normal doorways to allow installation of the TP without need for major structural changes (temporary or permanent) to the facility where it will be located.
8. All administration, operation and maintenance must be locally supplied.
9. Water treatment should guarantee water free of toxins and pathogens while still being aesthetically pleasing to consume.
10. The sale of water from the plant must be suitably profitable.

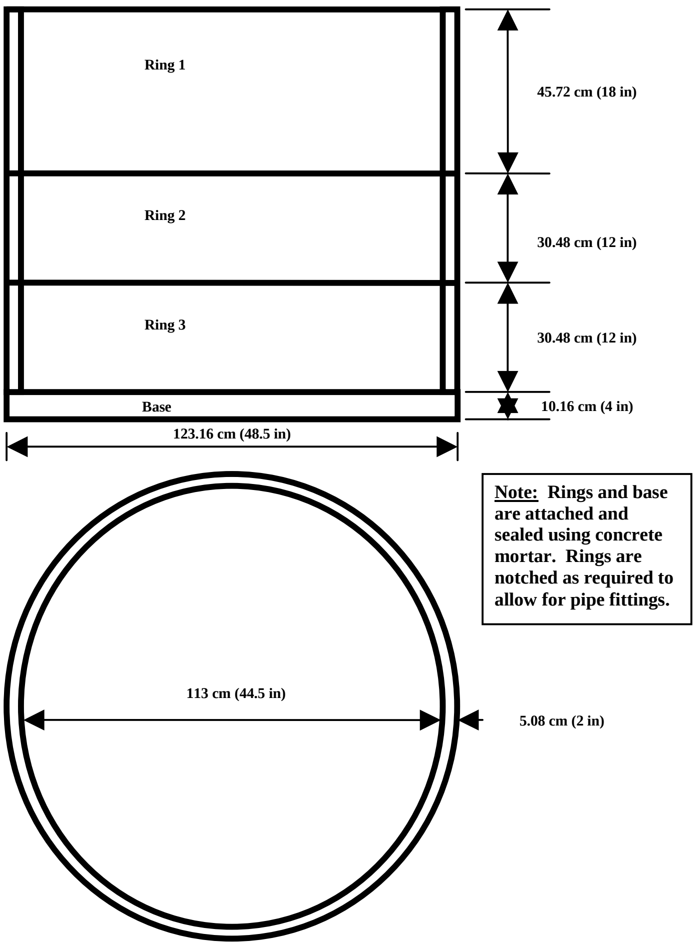
The BSF Based Urban Drinking Water Supply Station Concept meets all of these criteria.

3.0 Design of Containers Using the Pre-cast Concrete Rings and Base

1. Use of pre-cast concrete rings to form tanks.

The following sketch illustrates the use of pre-cast concrete rings to form tanks. If the tanks are constructed such that openings for piping are located near the edges, the rings may be used to construct virtually any type of tankage required. The design for the 600 lph BSF is shown. Other capacity BSF's use similar construction technology.

The front cover of this report shows a number of the concrete rings and various base designs available for purchase in a small manufacturing facility in Bangladesh.



Note: Rings and base are attached and sealed using concrete mortar. Rings are notched as required to allow for pipe fittings.

Concrete Ring Design for 600 litre per hour BioSand Water Filter
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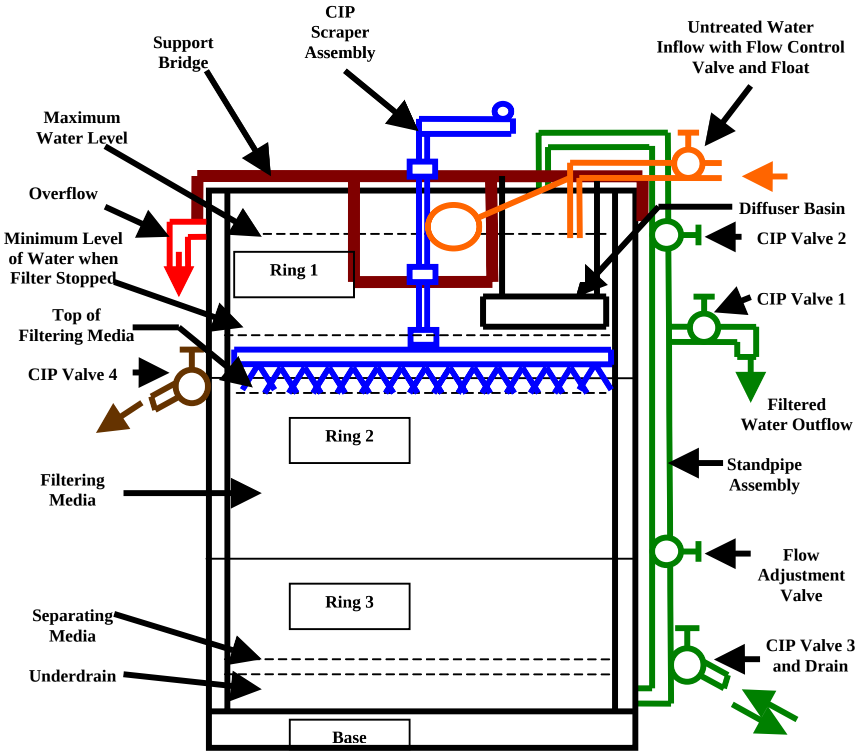
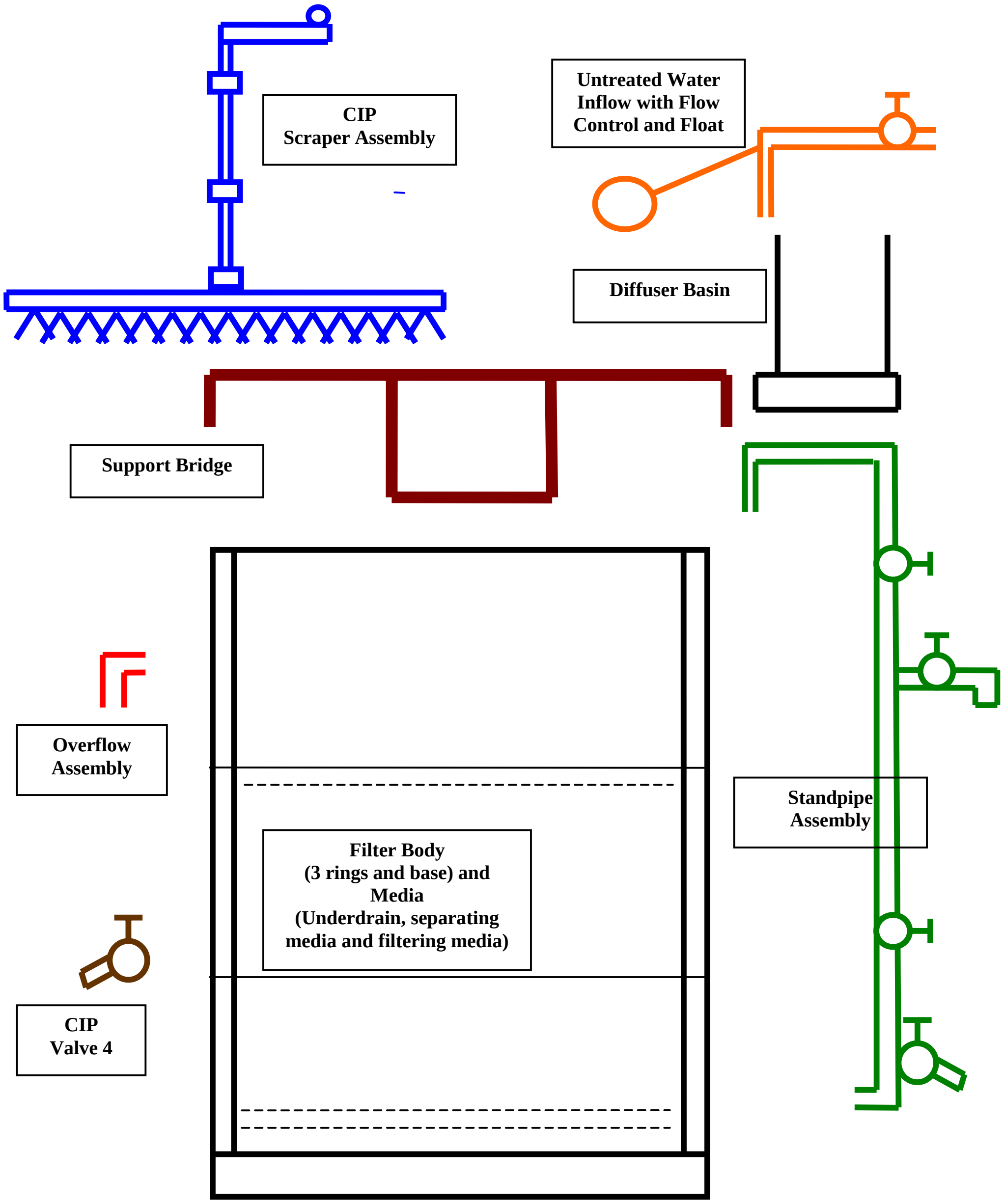
2.0 BSF

The larger scale BSF was designed to use local products and technologies. The use of pre-cast concrete rings that could be stacked as required on a pre-cast concrete base met these criteria. In Bangladesh the cost of a single ring is around $3.00. The cost of an entire BSF filter body, assembled, that could be used to treat up to 600 litres per hour is slightly more than $15.00. All of the elements used in the 600 lph BSF are readily available or capable of being manufactured locally. The total cost for a single 600 lph BSF is estimated to be in the order of $150.00.

The design of this the 600 lph filter, which is automated and incorporates clean-in-place (CIP) provisions, is shown below. Other scales of automated BSF's using concrete ring construction technology have identical appropriately scaled features.



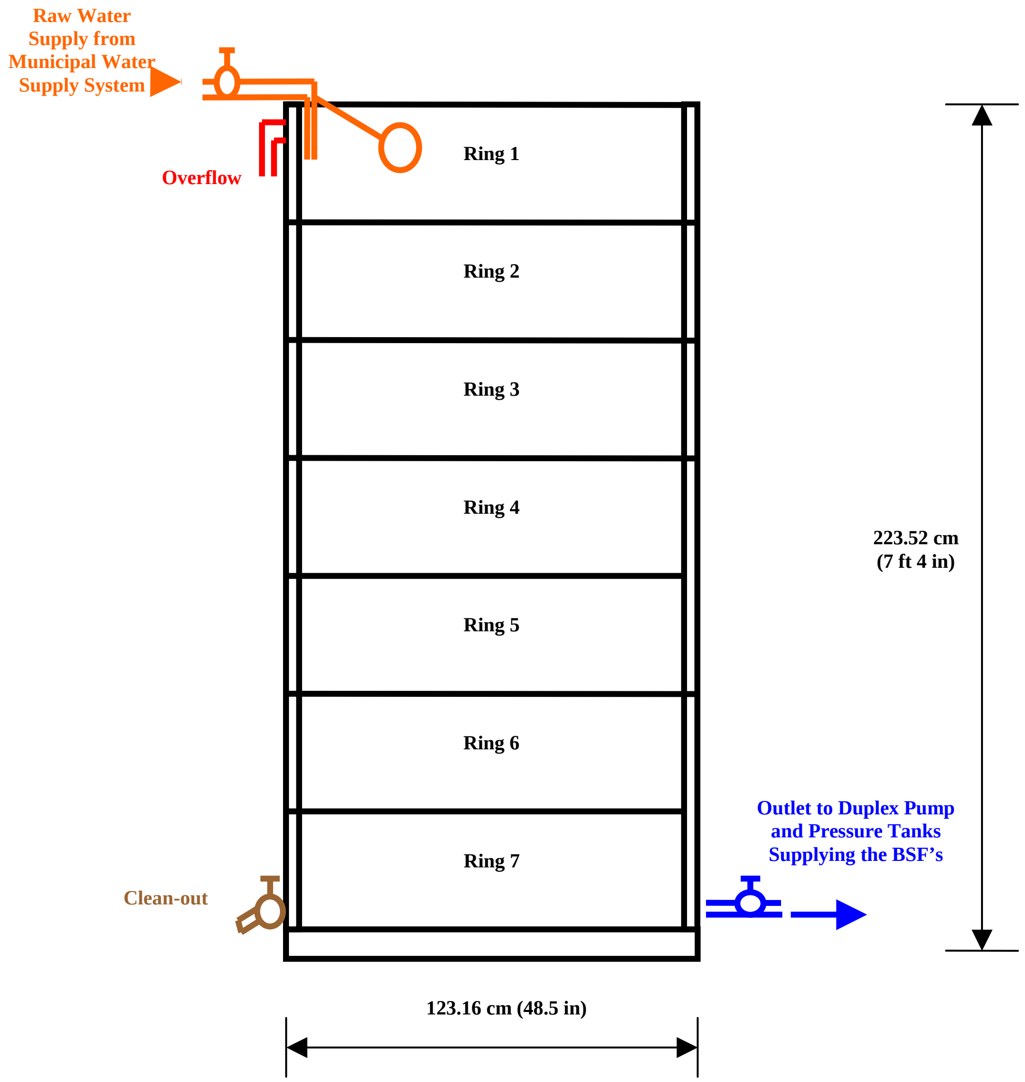
Assembled 600 lph BioSand Water Filter, (Fully Automated c/w CIP) Constructed Using Pre-cast Concrete Rings (Copyright claimed: Dr. David H. Manz, P. Eng. July 12, 2005)



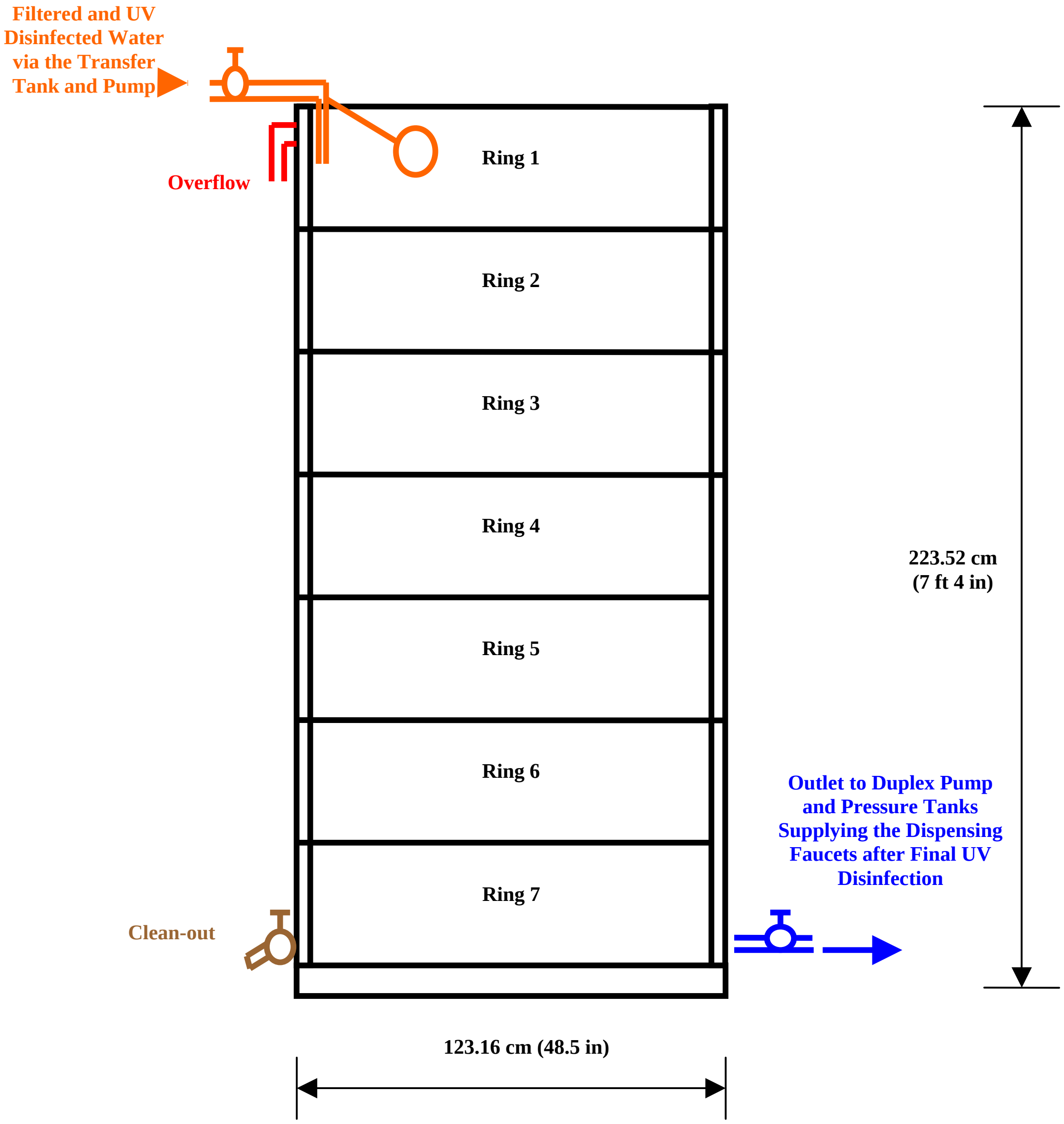
**Exploded View of the 600 lph BioSand Water Filter
Constructed Using Concrete Ring Technology
(Copyright claimed: Dr. David H. Manz, P. Eng. July 12, 2005)**

3.0 Construction of 2000 L Capacity Raw Water Storage Tank and Treated Water Storage Tank Using Pre-cast Concrete Rings.

Designs for the 2000 L Raw Water Storage Tanks (used to hold untreated water before the BioSand Water Filters) and 2000 L Treated Water Storage Tanks follow. Note that these tanks use the same diameter concrete rings as used to construct the 600 lph BSF.



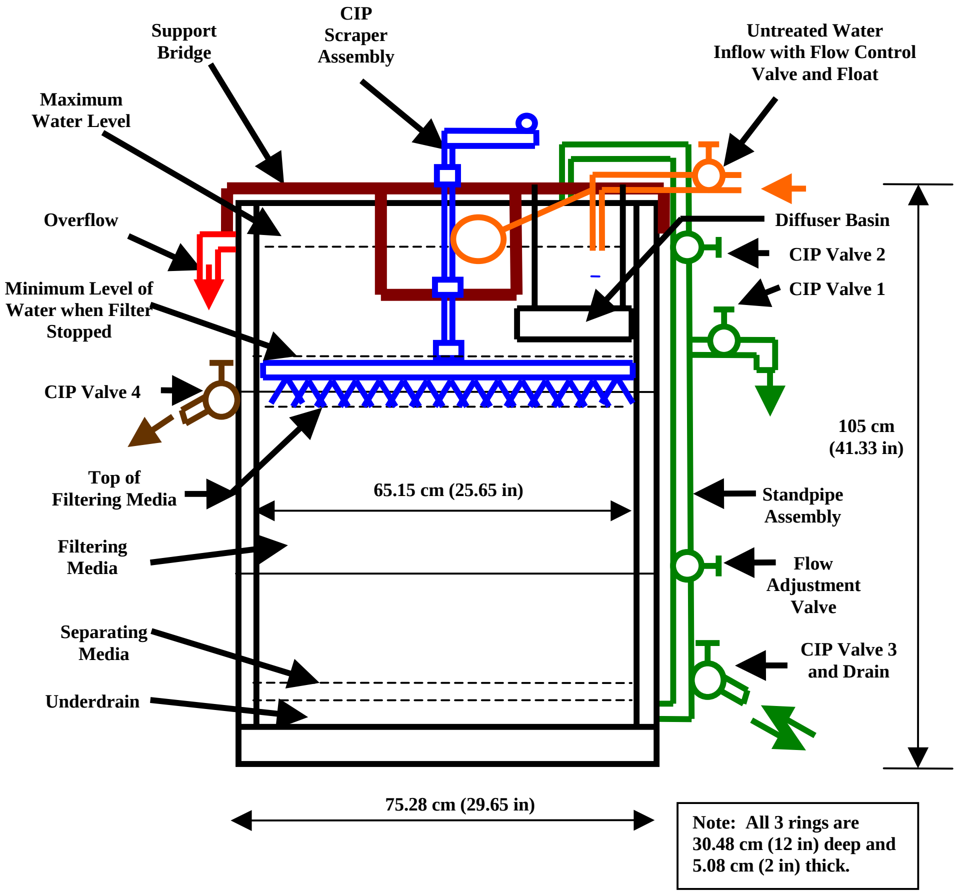
2000 Litre Raw Water Storage Tank for Urban Water Supply Station (Copyright claimed: Dr. David H. Manz, P. Eng. July 21, 2005)



2000 Litre Treated Water Storage Tank for Urban Water Supply Station (Copyright claimed: Dr. David H. Manz, P. Eng. July 21, 2005)

4.0 Construction of the 200 lph BSF (automated with CIP) Using Concrete Rings.

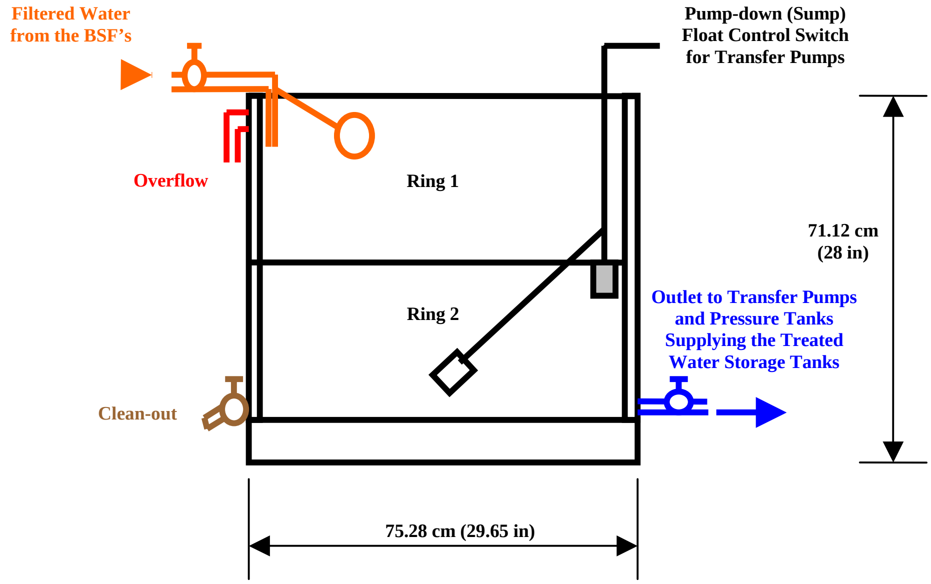
The 200 lph BSF is required in situations where space is a premium and the larger capacity BSF's, though not much more expensive, use much more space than is justifiable.



200 lph BioSand Water Filter Constructed Using Concrete Rings, Automated Using a Mechanical Float Valve Intake and Includes CIP (Copyright claimed: Dr. David H. Manz, P. Eng. July 21, 2005)

5.0 Transfer Tank Construction Using Concrete Rings

A transfer tank is required when transferring water from a low elevation to a higher elevation. These circumstances are common. The tank does not need a very large capacity as the filtered water is transferred out very soon after the tank is filled. The tank shown below uses the same concrete rings as the 200 lph BSF.

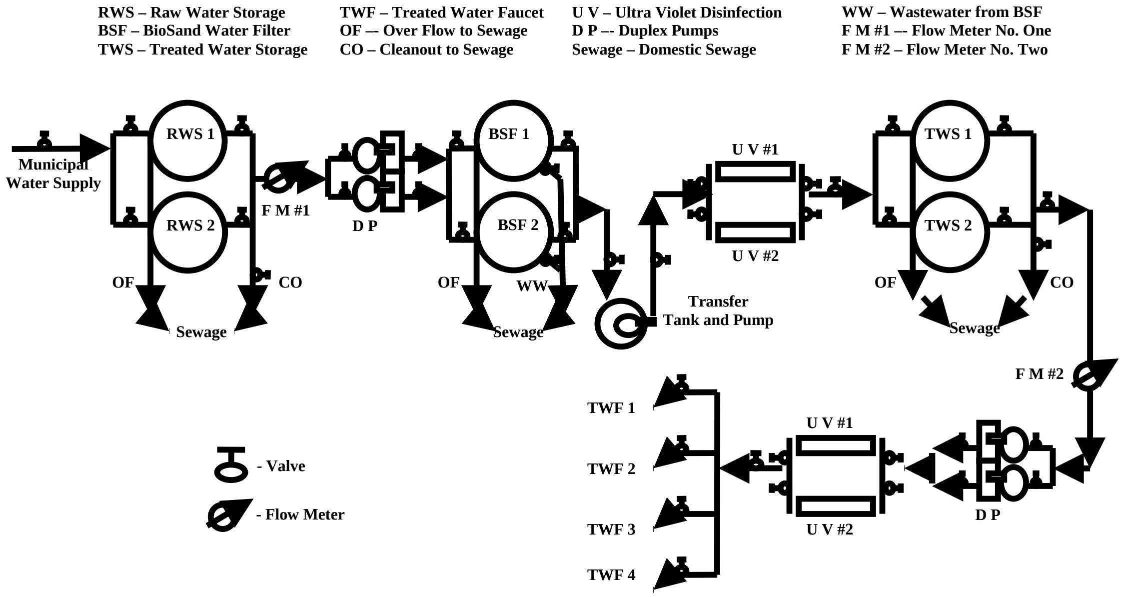


Note: The Transfer Tank uses the same concrete rings as the 200 lph Concrete BSF.

Transfer Tank for Urban Water Supply Station
(Drawn approximately to scale.)
(Copyright claimed: Dr. David H. Manz, P. Eng. July 21, 2005)

4.0. Process and Flow Diagram for BSF Based Urban Drinking Water Supply Station

A process and flow diagram of the BSF Based Urban Drinking Water Treatment Station and dispensing system is shown below.



RWS – Raw Water Storage
BSF – BioSand Water Filter
TWS – Treated Water Storage

TWF – Treated Water Faucet
OF –- Over Flow to Sewage
CO – Cleanout to Sewage

U V – Ultra Violet Disinfection
D P –- Duplex Pumps
Sewage – Domestic Sewage

WW – Wastewater from BSF
F M #1 –- Flow Meter No. One
F M #2 – Flow Meter No. Two

Process and Flow Diagram – BSF Urban Drinking Water Station – V 1.0
(Not drawn to scale.)
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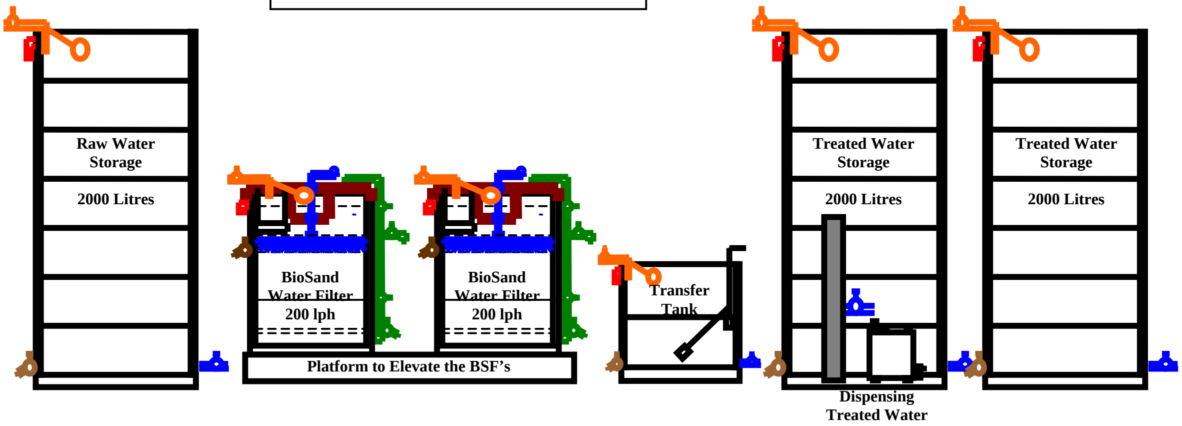
5.0. Elevation and Plan Views of BSF Based Urban Drinking Water System.

Note that pumps, UV disinfection, flow meters, and piping are not shown as they are not relevant to the elevation view.



Note: The space required will need to be approximately 243 cm (8 ft) in height, 600 cm (19.7 ft) long by 300 cm (9.8 ft) in width. The vertical dimension is fixed while the length and width may vary with circumstances.

Elevation View of the Urban Water Station Concept (4000 LPD) July 2005

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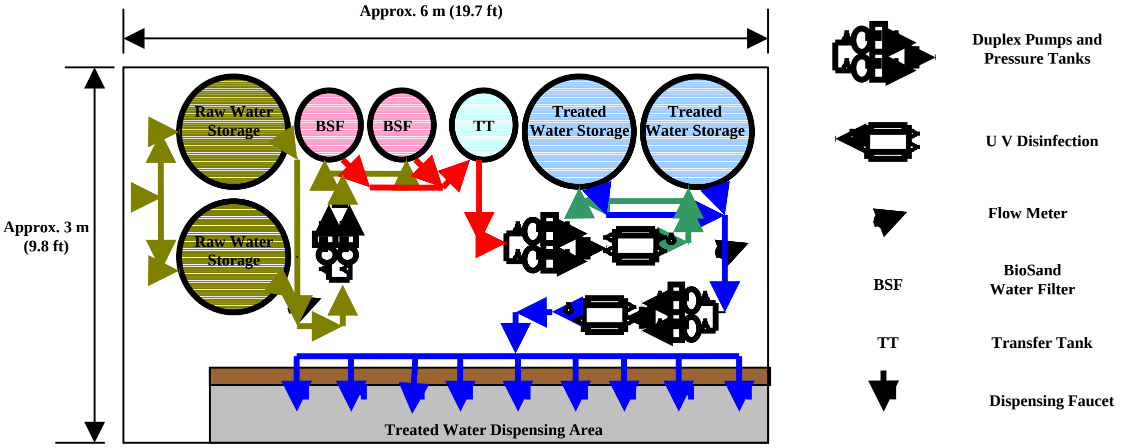

General Layout for Urban Water Station Concept (4000 LPD) July 2005

(Copyright claimed by Dr. David H. Manz, P. Eng. July 21, 2005)

6.0. Explanation of Treatment Plant Design and Operation.

This plant is designed and operated as follows:

1. Each treatment plant (TP) would have its own well or water supply.
2. Electricity would be available.
3. Access to domestic sewage disposal would be available.
4. The two 2000 L Raw Water Storage (RWS) Tanks would be kept filled using available municipal water supplies or private well.
5. Water is pumped from the RWS tanks using a centrifugal pump (and pressure tank) to the inlet of the 200 litre per hour BSF's. A flow meter is used to monitor the volume of water treated.
6. Filtered water from the BSF's flows to the Treated Water Transfer (TWT) Tank.
7. When the depth of water in the TWT tank exceeds a previously determined level, the centrifugal transfer pump (and pressure tank) transfers the water to the Treated Water Storage (TWS) Tank. This water is disinfected using a ultra-violet disinfection system prior to entering the TWS tank.
8. Water is dispensed to consumers on demand from the TWS tank. Water is pumped from the TWS tank using a centrifugal pump (and pressure tank) and disinfected again by a ultra-violet disinfection system. Another flow meter monitors the volume of water dispensed to consumers. The centrifugal pump are not damaged because of the use of pressure tanks.
9. Consumers must pay for water before they are permitted to fill their containers.
10. As the TWS tanks are emptied they are filled from the TWT tanks. The flow of water to the TWS tanks is controlled by mechanical float controlled valves. Once the TWS tanks are filled the centrifugal pump/pressure tank system cannot transfer water into the tanks. The pumps will not be damaged because of the use of the pressure tanks. The water level in the TWT tank will increase and the mechanical float will stop the flow of water from the BSF's. The BSF's will eventually fill at which time their mechanical floats will stop the flow of water from the RWS tanks (again the pumps will not be damaged because of the use of the pressure tanks). Flow to the RWS tanks will continue until they fill and their mechanical floats stop the flow of water from the municipal water supply.
11. The BSF's normally operate in parallel (together). They can each be isolated when they need to be cleaned or maintained while the other BSF is producing filtered water.
12. The BSF's should normally be cleaned (maintained) once a week or when the production is not acceptable (as determined by the operator). Wastewater resulting from the BSF cleaning is sent to domestic sewage.
13. The TP is intended to be operated seven days a week for up to 24 hours per day.
14. The TP operated automatically. It cannot flood or fail catastrophically unless there is significant failure of the piping system. Power failures simply prevent the pumps from operating and the system will simply stop producing water when the TWT tank is filled. When power failures do occur, water can still be dispensed provided there is sufficient depth of water in the TWS tanks; however, this water would not receive additional UV disinfection.

15. Operator integrity is guaranteed by the use of the two flow meters, located before the BSF's and immediately before dispensing.
16. If the BSF's in combination produce a minimum of 300 litres of filtered water per hour, 10 hours (normal working day) of production will yield 3000 litres of filtered water. The TWS tanks will be completely filled (approximately 4000 L) by morning. The RWS tanks should also be completely filled (approximately 4000 L) by morning.
17. Assume that 2 minutes will be required to fill a 20 litre container or two 10 litre containers. Each dispenser can deliver the equivalent of 30 twenty litre containers per hour or 600 litres per hour.
18. Assume that a maximum of 3000 litres will be dispensed per hour. This will require at least 5 dispensers.
19. As soon as water is taken from the TWS tanks the TP begins to produce safe drinking water to the TWS tanks.
20. Total daily production could reach 7000 litres per day. (Initial 4000 L plus 3000 L produced during the day.)
21. Since the TP will need to operate 7 days a week at least 2 operators will be required.
22. All money collected during the day and all other sales and purchasing records should be removed from the TP at the end of each day for safe keeping and/or deposit.
23. The TP discussed can be expanded as required. Much larger capacity plants may be designed.
24. The water produced from the TP can be further treated using reverse osmosis to produce a 'bottled water quality' type product. This is not necessarily 'better' water from a health perspective.
25. It is very simple to further treat the water with ozonation (a requirement for bottling water safely) and produce to a bottling operation.
26. Any of these TP's can also sell containers for holding and dispensing treated water, household BSF's and any other product complementing the business.
27. Quality control is maintained using a laboratory operated specifically for this purpose. (It should be kept in mind that independent water testing will likely be carried out by government regulatory bodies and clandestine water testers, such as news media, consumers and competitors.)

7.0 Financial Assessment Model

1. Capital cost

It is estimated that a single TP, as proposed in this document, capable of producing approximately 7000 litres per day will cost approximately $10,000. Facility renovation and other similar costs are not included in this estimate.

2. Operating costs per day

Operating costs should consider the following:

i. Property leasing
ii. Utilities
iii. Regulatory
iv. Laboratory testing and other quality assurance measures undertaken
v. Operators
vi. Administrator
vii. Misc. operating costs
viii. Administration costs
ix. Security (24 hours per day)
x. Maintenance of TP (UV bulbs, etc.)
xi. Marketing and advertising
xii. Interest on investment

3. Revenue per day

This will depend on how much is charged for the water. The TP proposed can produce up to 350 fills per day.

8.0 Conclusions

The BSF Based Urban Drinking Water Supply Station V 1.0 meets or exceeds the design criteria imposed.

The TP may be easily constructed anywhere in the world. The actual construction methods used are readily adapted to use local materials and expertise.

The TP can be constructed in most available commercial spaces with a minimum of renovation.

The TP may be expanded to include reverse osmosis and other treatment technologies to

In order to implement the technology it will still be necessary to acquire the detailed construction drawings of each of the containers and the TP itself. Also, very detailed installation, commissioning, operation and maintenance procedures will need to be developed for each plant in English and in the local language. A training program will need to be developed.

Finally, an overall organization to implement a development program that would be responsible for the creation of TP's of the type described would need to be established.