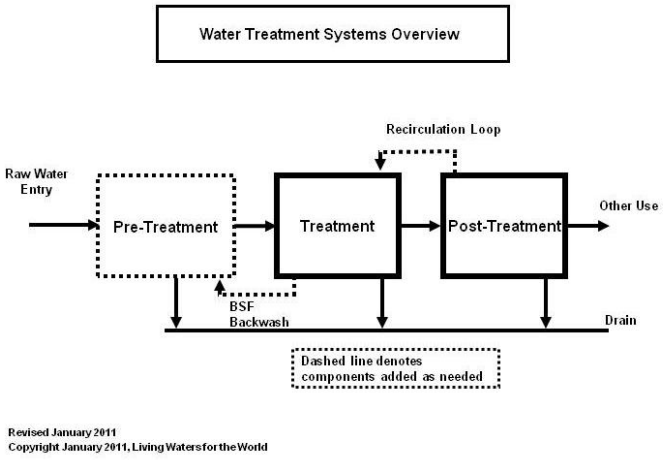
2 Clean Water Systems

2.1 *LWW's Treatment Approach*

Because the solution to any particular water contamination problem is unique, Living Waters for the World has adopted a *Whole Systems Approach* to solving the worldwide water crisis. As shown in the Water Treatment Systems Overview block diagram, LWW has divided their Whole Systems Approach to focus on three areas of water treatment:

- Pre-Treatment,
- Treatment, and
- Post Treatment

Please note that the LWW In-home Systems have not been integrated into this approach. Consult Volume 3 of the Clean Water Systems Handbook for more information.



The **Pre-Treatment** block deals with the raw water after it has reached the site of the system. Pre-Treatment technologies focus on removing contaminants that could adversely affect the equipment and components in the treatment system. The Barrel Sand Filter (BSF) is a good example of a pre-treatment technology to remove solids that may adversely impact pumps, filters, and other downstream equipment.

The **Treatment** block refers to the equipment and components that remove the contaminants, including chlorine resistant contaminants, from the source water. Filtration, micro-filtration, disinfection, softening, and reverse osmosis are examples of LWW treatment technologies.

The **Post-Treatment** block includes supplemental chlorination required by some regulations and other equipment that determines how the treated water will be used or distributed for use. Batch water bottling versus On-demand delivery of the water are the typical choices for post treatment.

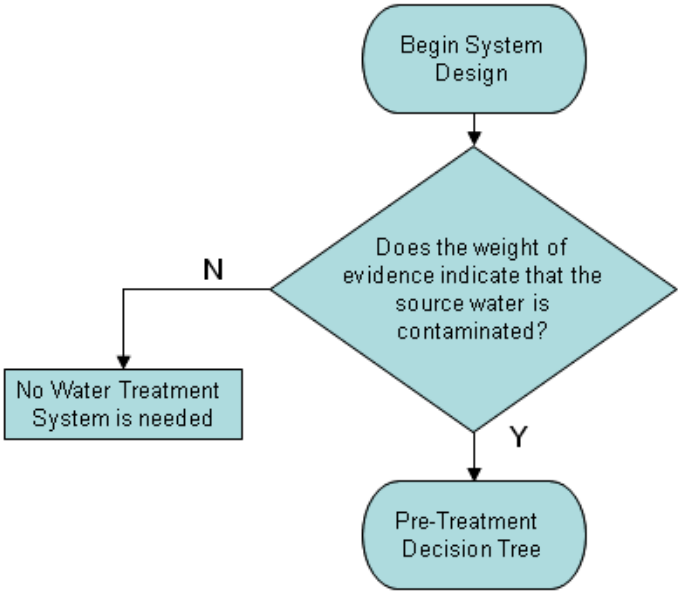
2.2 *Decision Trees*

In order to assist teams in selecting the system and/or technology that is right for their mission project, LWW has developed the following Decision Trees.

- Begin System Design
- Pre-Treatment
- Treatment System
- Core Board, Post Treatment, and Use

Each Decision Tree is a flow chart of questions that lead to a final solution. The Decision Trees are patterned after the Block Diagrams and are intended to be used together to make the system decision.

By using these tools, teams should be able to make the choices necessary to designate which LWW Clean Water System is best for their mission project. For more information on the Weight of Evidence, please consult the Field Test Kit manual, Section III.

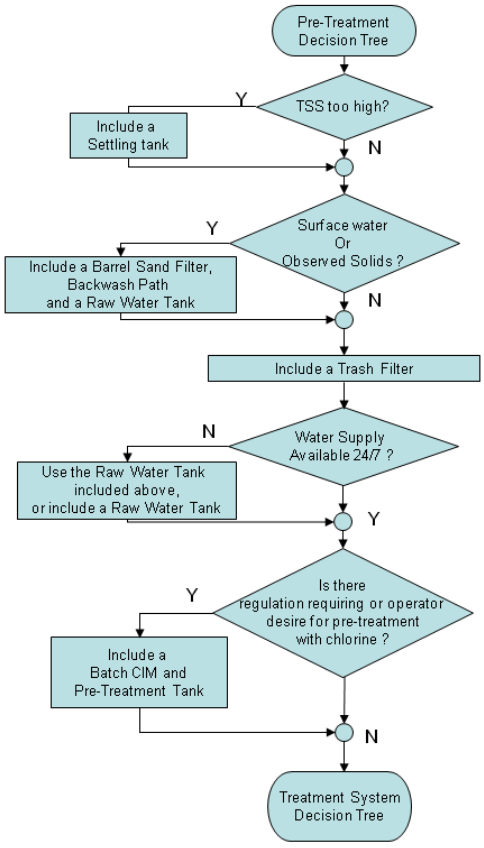


2.3 *Pre-Treatment*

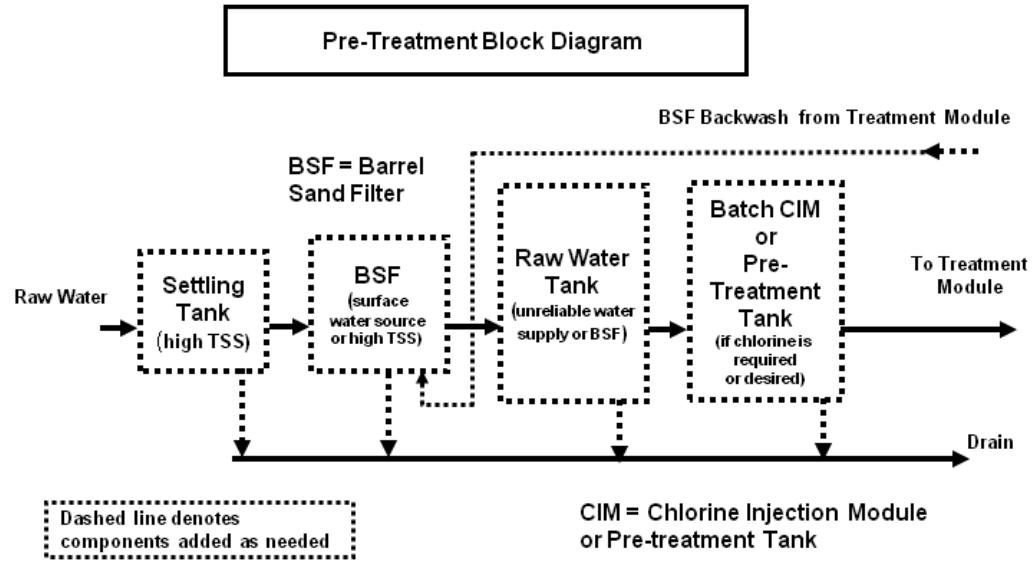
Pre-Treatment decisions involve the raw source water that is delivered to a Clean Water System. There are a number of parameters that teams must consider before deciding what pre-treatment will be appropriate for their system. These source water parameters include:

- Total Suspended Solids (TSS)
- Source of the raw water – underground or surface
- Supply & reliability of the source water – this includes flow and water pressure
- Regulatory requirements

Most of these requirements should be determined by the Water Issues Survey (WIS) or during the Survey/Partnership Development trip. The availability of water includes not only the 24/7 basis, but also is the water supplied at a flow and pressure sufficient to supply the system? If there are any questions about the TSS (Total Suspended Solids) of the water, then the site water sampling should include TSS testing by a certified laboratory. See Section IV in the Field Test Kit Manual.



The Pre-Treatment Block Diagram shows the different treatment options available. Blocks indicated with dotted borders are optional. If no pre-treatment technologies are indicated by the Decision Tree, LWW recommends that a system include a Trash Filter as a minimal precaution to keep solids out of the system. The Trash Filter is shown on the treatment block diagram.



Block Diagrams show the connectivity of different elements within a clean water system. In the Yucatan, for example, local regulations require that source water for a system contain a residual amount of chlorine to disinfect the water. The block diagram indicates that a Chlorine Injection Module (CIM) should be added as the last component of a pre-treatment system. Blocks indicated with dotted borders are optional. Raw water that is supplied by a municipal authority, for example, may be filtered before it is piped to the site and only the Trash Filter is required.

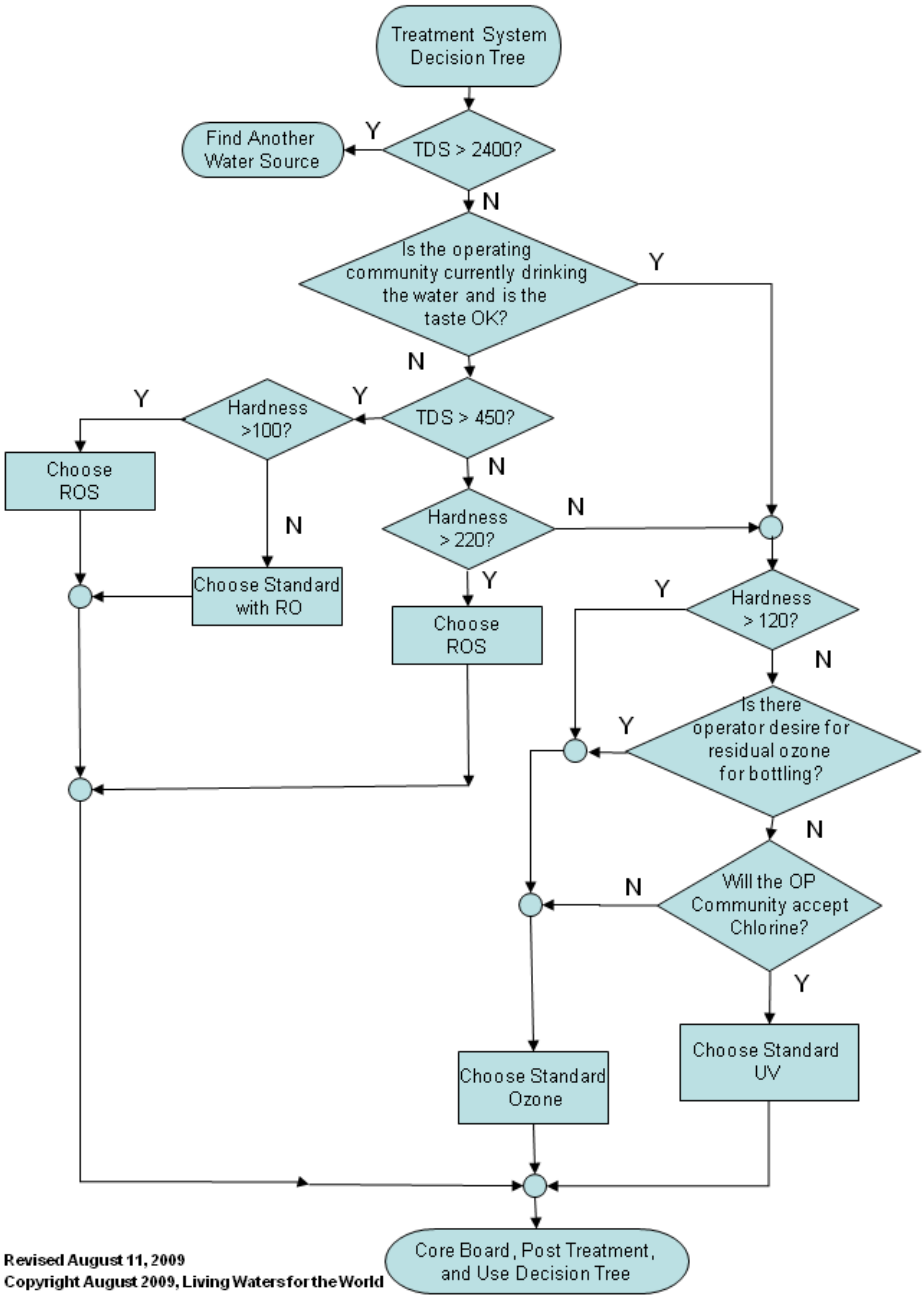
2.4 *Treatment*

Treatment decisions involve source water that has been processed through pre-treatment equipment and technology specified in the previous section. There are a number of parameters that teams must consider before deciding what Treatment will be appropriate for their system. These water parameters include:

- Total Dissolved Solids (TDS)
- Water Hardness expressed in terms of calcium carbonate
- The taste of the water and other aesthetics

Most of these requirements will be determined by sampling the water and testing it for those parameters. The Water Issues Survey (WIS) and/or feedback from the Survey/Partnership

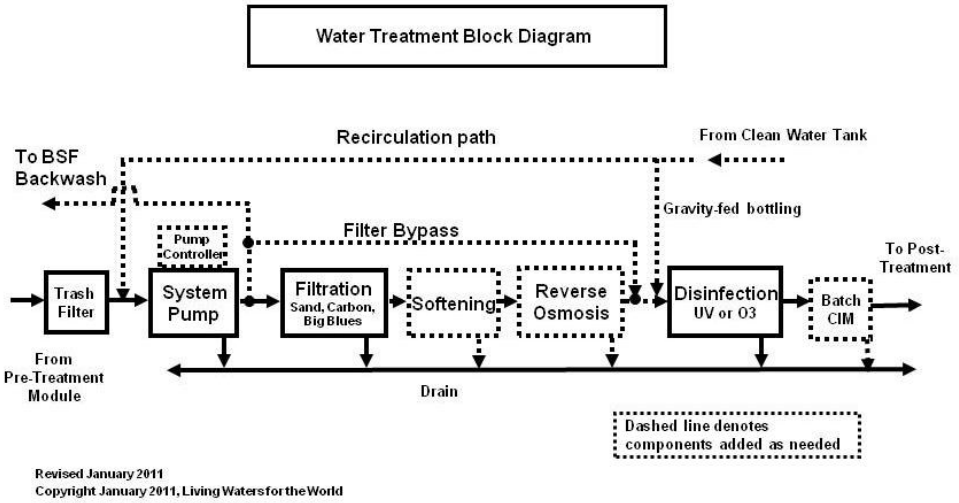
Development trip will provide other information. Sometimes testing for other parameters will impact the Treatment options. Consult the Field Test Kit Manual for those parameters.



This decision tree will lead teams to select three basic treatment options:

- LWW Standard System with UV Disinfection
  - With chlorine
- LWW Standard System with Ozone Disinfection
- LWW Standard System with Reverse Osmosis (RO) for heavy metals removal
- LWW Reverse Osmosis and Softening System (ROS)

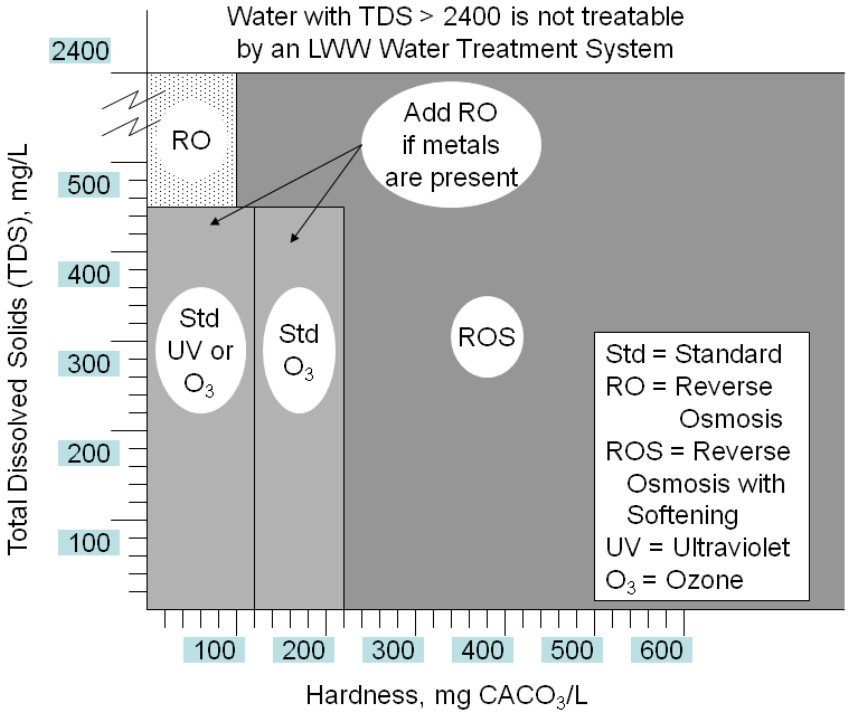
The Water Treatment Block Diagram shows the technology and treatments available with LWW Clean Water Systems. Blocks in dashed lines indicate equipment or components that can added as needed.



Block Diagrams show the connectivity of different elements within a clean water system. It is important that the UV or Ozone Disinfection module be placed at the end of the treatment process to keep it as close to the end of the process as possible.

Because TDS and Water Hardness are the two most important parameters to consider when selecting a Reverse Osmosis and Softening (ROS) system, the following two charts should be consulted to confirm that selection.

Using the chart below and knowing the TDS and Hardness levels at a potential site, teams can confirm their equipment needs for their project.



This Treatment Effectiveness Guide details what each treatment module will accomplish.

Treatment Effectiveness Guide

	Std	ROS
Disease - causing organisms	Yes	Yes
Sediment/suspended solids	Yes	Yes
Pesticides	Incidental	Yes
Tannins/color	Incidental	Incidental
Odors	Incidental	Incidental
Brackish water, TDS up to 2500 ppm	No	Yes
Hardness	No	Yes
Heavy metals	No	Yes
Arsenic	No	Yes
Alkalinity	No	Incidental

2.5 *Post Treatment*

Post Treatment decisions involve water that has been processed through pre-treatment and treatment equipment and technology specified in the previous sections. There are a number of parameters that teams must consider before deciding what Post Treatment will be selected for their system. These water parameters include:

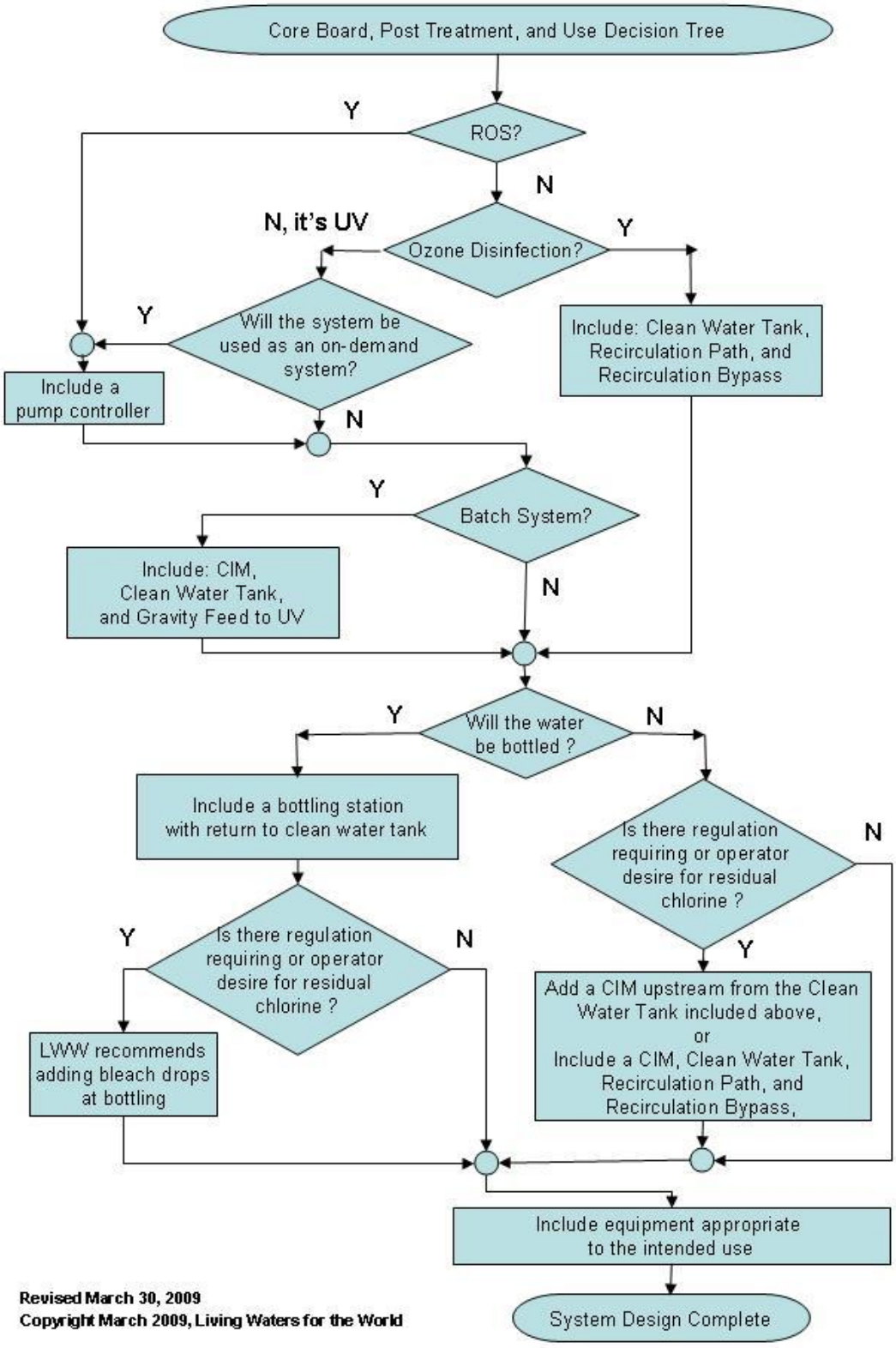
- Disinfection technology selected for Treatment – UV or Ozone
- Will the system be operated as a batch system with water bottling or water on demand
- Are there any regulatory requirements for additional chlorine disinfection

Most of these requirements will be determined by the decisions made with the Treatment section of the system. The Water Issues Survey (WIS), feedback from the Survey/Partnership Development trip, and items agreed to in the Clean Water Covenants will provide other information.

The Post Treatment and Use Decision Tree is for the LWW Core Board. The Core Board refers to the primary options for LWW Clean Water Systems:

- The Standard Board (System) with UV Disinfection
- The Standard Board (System) with Ozone Disinfection and
- The Reverse Osmosis and Softening System

Again this Decision Tree does not include the In-home systems used in the Appalachia Network.

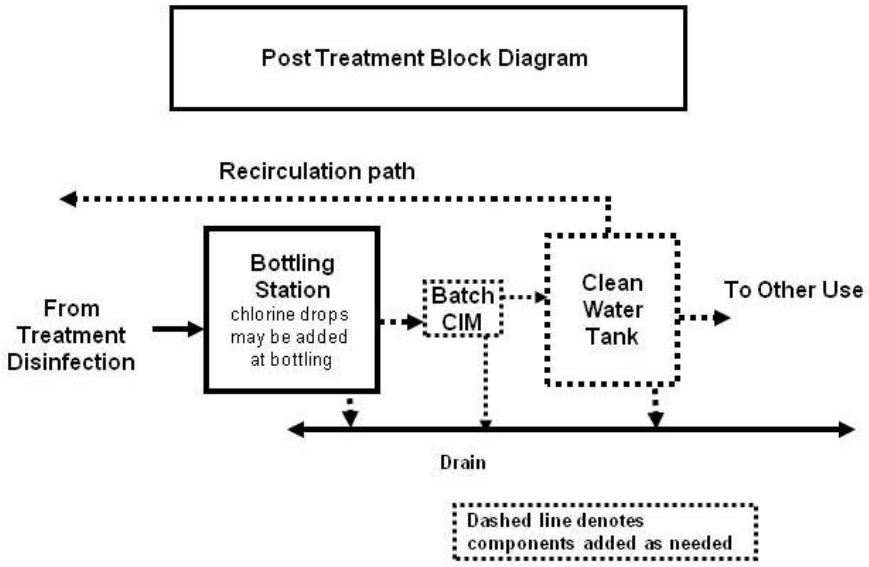


Revised March 30, 2009

This decision tree will lead teams to configure the equipment at the end of the process.

The Water Post Treatment Block Diagram shows the technology and possible equipment options. Blocks in dashed lines indicate equipment or components that can added as needed.

For a detailed description of Post Treatment and Bottling options, please consult Sections 6 and 8 in this handbook.



2.6 *Standard System*

Our **Standard (Std)** design is at the heart of all of our **small-scale, community-sized systems** which are owned and operated by local partnerships. This arrangement empowers a community or organization to provide its own clean water with a system that is simple, affordable and sustainable.

Std System:

Purpose:	bacteriological disinfection; removal of chlorine-resistant organisms
Design:	batch treatment process, with an integrated bottling station
Capacity:	based on tank size; typically a 1100-liter (290 gal.) tank
Process time:	1100 liters per hour at 18.3 lpm (4.5 gpm) per batch
Delivery:	tanks may be ground-mounted for use as a bottling station or elevated for a gravity-feed system, up to 10 meters away
Key methods:	filtration, microfiltration and UV/Ozone disinfection
Electrical:	1 KW needed and may be operated by generator or solar power, 110 / 60 electricity is standard, 220 / 50 & 60 equipment is available
Installation cost:	hardware - $3000; tank stand, if necessary – approximately $1200, hardware is more for solar powered systems (See Section 7)
Operational costs:	per 100,000 gallons: one-half cent to one cent per gallon, including replacement parts (not labor)
Micro-business option:	possibilities and particulars spelled out in our **Covenants**
Parts availability:	key components provided at cost, plus shipping & handling, through LWW's Fulfillment Center in Louisville, KY (see LWW's web site).

2.7 *Softening – Sof - System*

High test levels of hardness – indicating the presence of calcium and magnesium – in raw water has no known health problems for human consumption. However, increasingly higher levels of hardness will enhance scale formation and can significantly shorten the life of the filter cartridges, which increases the operational cost of maintaining a Standard clean water system. A softening module is then added to the Standard board.

Depending on the magnitude of hardness of the water and the extent of the ion exchange between Calcium/Magnesium and Sodium, the softening of that water will cause it to become salty in taste. Because it is likely that softened water will become salty tasting, LWW does not recommend installing a stand-alone water softener in any of its LWW Clean Water Systems. Please consult with LWW before deviating from this recommendation.

2.8 *Reverse Osmosis – RO - System*

As the preceding chart indicated, there are some situations where a RO module may be used without adding the softening module. These applications include the removal of some heavy metals, nitrates, and arsenic. Because the percent removal can vary by equipment and contaminant concentration, LWW requests that Initiating Partners consult with them before deciding on a particular RO technology.

2.9 *Reverse Osmosis and Softening – ROS - System*

This *clean water system* combines all three elements, the Standard system with both the Softener and RO modules added.

There is one variation of the LWW ROS System, the Yucatan Reverse Osmosis and Softening (YROS) System that LWW endorses. This system uses UV for final water disinfection. Please check Volume 2 of this handbook for details on these systems.

2.10 *In-Home Systems*

In response to specific needs in the Appalachian Mountains of eastern Tennessee, Kentucky, and West Virginia, LWW's Design Team has developed two 'in-home' treatment systems designed to provide clean water for individual homes. Unlike the community-sized 'batch' treatment methods described above, these in-home systems provide an 'on-demand and continuous' supply of water to a home.

2.10.1 Standard

This system provides filtration and UV disinfection of the water. An in-line chlorine 'shocking' mechanism is integral to disinfect house plumbing before use.

2.10.2 Standard with iron removal

Because of the excessive presence in one community, an iron and sulfide removal module – and sometimes a small softening unit – is added to treat the water.

For details on the LWW In-home Systems used in the Appalachia Network, please check Volume 3 of this handbook.