# **OPERATIONS MANUAL**

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## OPERATION, SET-UP AND MAINTENANCE OF BACKFLOW MODEL

Correct procedures must be followed in the use of this model to ensure operational success and for maximum visual effect. The operations section includes step-by-step instructions on set-up, tear down, cleaning, inspection and storage

#### **BEFORE DEPARTURE**

Before departure to each site it is important to understand the resources of the location you will be presenting in. Water, electricity and space availability are all important considerations to take into account. If water is not readily available you will have to fill the inlet reservoir container before departure and bring an additional carboy of water. If electricity is not available a small generator should be purchased to power the model. An extension cord may also be necessary to plug in the power strip if the nearest outlet is a large distance from the presentation space. If a level table is not provided for the presentation you should bring one at least  $60^{\circ} \times 32^{\circ}$  in size.

#### SET-UP OF THE MODEL

Place the model on a flat, level table clear of obstructions to the area where the audience will be viewing the model. You will need at least a 60"x 32" work space. There are several valves you will need to turn throughout the operation of the scenarios so you will want to keep the model at waist height.

Place the empty water tower on the table adjacent to the inlet of the model. It is important that these two components are level because the system is powered by gravity head from the water elevation in the tower. Next, fill the inlet reservoir and place the inlet and outlet containers in their respective locations as diagramed in Figure 1. The inlet reservoir should be on the floor next to water tower while the outlet reservoir should be near the main break at the opposite side of the model.



FIGURE I. POSITION OF MODEL, WATER TOWER & RESERVOIRS

#### SET-UP OF WATER TOWER

The water tower consists of two major acrylic pieces: the stand and the reservoir, and a series of flexible tubing and quick disconnections. To assemble the water tower, place the reservoir on top of the stand. There should be three lengths of tubing inside the inlet reservoir bucket with labels signifying which socket they connect to. Thread the  $\frac{1}{4}$ " flexible tubing from the pump (Q2), and the  $\frac{1}{2}$ " tubing (Q1) from the reservoir through the rectangular hole in the base of the water tower stand up to the bottom of the water tower reservoir and connect them to their respective quick disconnect sockets as is shown in Figures 2 and 3.



FIGURE 2. CONNECTING WATER TOWER INLETS (ABOVE VIEW)



FIGURE 3. CONNECTING WATER TOWER INLETS (SIDE VIEW)

The last flexible tubing section in the inlet reservoir should be a  $\frac{1}{4}$ " flexible tubing segment (Q3). Connect one of its quick disconnects to Q3 on the base of the water tower reservoir and thread it down the water tower stand and through the small hole in the base of the water tower to later be connected to Q5 on the model. Once all tubes are connected to the water tower basin, stand the water tower upright and make sure each piece is secure and that the tubes are free from crimps.

The mechanism of the water tower works as follows: the pump in the reservoir bucket pumps water in through the <sup>1</sup>/<sub>4</sub>" line. It fills the reservoir and the "To Model" line. It will continue to fill the reservoir until the water level reaches the elevation of the overflow tube. Once the water reaches that level, it begins to overflow back to the inlet reservoir under the table. When the "To Model" ball valve is opened, water from the reservoir enters the system but the water level in the water tower remains constant providing a constant pressure to the model system. This is shown in Figures 4-7.



FIGURE 4. EMPTY WATER TOWER



FIGURE 5. WATER TOWER FILLING



FIGURE 6. WATER LEVEL REACHING OVERFLOW



FIGURE 7. WATER OVERFLOWING

Connect the "To Model" line which exits the water tower through the small hole to the inlet quick disconnect (Q5) on the model.



#### FIGURE 8. QUICK DISCONNECTS

Next gather the four remaining flexible tubing sections which are stored in the inlet reservoir. There should be two 1/4" tubes (Q6 and Q8), one 1/2" tube(Q13) and one 3/8" tube (Q14). Thread both 1/4" lines from through the hole in the bottom of the model to their matching quick disconnect sockets. Each tube and socket should be labeled. Q6 can connect immediately, but Q8 will not connect until the scenarios have been connected. The other two tubing and quick disconnect plugs connect at Q14 and Q13. Once each of these quick disconnects are locked, gather the opposite ends of the flexible tubing and insert them into the mouth of the outlet reservoir making sure there are no kinks in any of the tubes. Figures 8 and 9 give an overview of where each tube should run.



FIGURE 9. TUBING SET-UP SIDE VIEW

#### Set-up of Scenarios

Next, retrieve each scenario and the house from storage and connect to appropriate locations using the attached quick disconnect fittings. Appropriate locations for each scenario are shown in Figures 10 and 11. Once Scenario C is attached Q8 can be connected. Both Scenario A and D have Velcro pads to secure their reservoir. Make sure both scenarios are oriented correctly and secured with this Velcro connection.



FIGURE 10. SCENARIOS (ABOVE VIEW)



FIGURE II. SCENARIOS (SIDE VIEW)

Scenarios:

- A: Back-Pressure Private Water Well Pump
- B: Back-Pressure Pressurized Vessel, Boiler in Office Building
- C: Back-Siphon Subsurface Cracked Pipes Contamination Scenario
- D: Back-Siphon- Submerged Inlet at Cow Water Trough/Truck Fill Station

#### SET-UP OF ACCESSORY PIECES

All of the decorative accessory pieces should be found in the large storage container accompanying the model. Photo 12 is provided to demonstrate appropriate placement of each piece. Each tree should have a Velcro patch on the bottom with a corresponding patch placed on the encasing's surface. The traffic set, cows, truck, fire hydrant and well all attach using sticky tack which should remain on the bottom of the piece and be placed on the Xs marked along the model. The greenery rings are to be placed on the reservoirs of scenario A and D.



FIGURE 12. PHOTO OF MODEL ARRANGEMENT

## MODEL OPERATION

To begin, make sure each of the ball valve is in its correct position as outlined in Figure 13.



FIGURE 13. SET UP: ORIENTATION OF BALL VALVES

A ball valve in the OFF position will have its handle perpendicular to the shaft of the valve. A ball valve in the ON position will have a handle in line with the shaft of the ball valve. Before using each scenario, familiarize yourself with the ways each ball valve turns. This is shown in Figures 14 and 15.



FIGURE 14. SET-UP: BALL VALVE ON



FIGURE 15. SET-UP: BALL VALVE OFF

Once the ball valves are in their correct orientation, all quick disconnects have been connected and the inlet reservoir is full, plug in the main pump to the power strip and plug the power strip into the nearest outlet. The water tower will begin to fill at this point.

Once the water in the water tower has reached the overflow level, turn BVI to the ON position to activate the model (Figure 16).



FIGURE 16. SET-UP: MODEL BASIC SET-UP WITH WATER

The acrylic tubing within the model should fill with water and the house should begin to fill and drain. At this point you will need to rid the system of air bubbles and flush each scenario. To do this close all ball valves. Slowly open BV7 on the house to barely let any water escape. Keeping the ball valve in this

position gently tip the corner of the model with the house up so that all trapped air bubbles can exit through the house. Gently tap the model if necessary.

One by one open the ball valves leading to each scenario (BV4, BV3, BV5) to get water to fill the lines. It is not necessary to open BV6. Open BV5 and BV4 until water has filled  $\frac{3}{4}$  of the reservoir. Fill the small reservoir on the subsurface back-siphon scenario (C) with water.

#### Adding Dye to Scenarios

In each of the reservoirs for scenarios A, C, and D add 5 drops of different colored food dye. Suggested colors are shown in Figure 17. Instructions for adding dye to scenario B are found in the following section.



FIGURE 17. SET-UP: SUGGESTED SCENARIO DYE COLORS

FILLING PRESSURIZED VESSEL



FIGURE 18. PRESSURIZED VESSEL

Before connecting the quick disconnects for Scenario B, the pressurized vessel in the office building, you will need to fill the vessel (Figure 18). This may not be necessary for each demonstration of the model, because once filled the reservoir should contain enough liquid for five demonstrations of the scenario. To fill the scenario, remove the sprayer tank from the office building. Unscrew the lid and fill the reservoir <sup>3</sup>/<sub>4</sub> full. Add 10 drops of dye and recap the vessel. Put the vessel back in the office building and thread the flexible tubing through the hole in the office building and connect it to Q9. The pressurized vessel does not need to be flushed with water but simply pumped 4-5 times before its demonstration.

The model is now ready to use. The mechanics and instructions for each scenario are outlined below.

## **OPERATION OF EACH SCENARIO**

The overall layout and scenario location is demonstrated in Figures 19 and 20.



FIGURE 19. LOCATION OF SCENARIOS (ABOVE VIEW)



FIGURE 20. LOCATION OF SCENARIOS (SIDE VIEW)

#### Scenarios:

- A: Back-Pressure Private Water Well Pump
- B: Back-Pressure Pressurized Vessel, Boiler in Office Building
- C: Back-Siphon Subsurface Cracked Pipes Contamination Scenario
- D: Back-Siphon- Submerged Inlet at Cow Water Trough/ Truck Filling Station

#### NORMAL FLOW CONDITIONS

First, a demonstration of the model in normal flow conditions without any scenarios activated is shown in Figures 21 and 22.



FIGURE 21. NORMAL FLOW CONDITIONS (SIDE VIEW)



FIGURE 22. NORMAL FLOW CONDITIONS (ABOVE VIEW)

The scenarios can be presented in any order upon demonstration. Between demonstrations of scenarios sufficient time must be given for dye to flush fully from the house reservoir. This should take no longer than 30 seconds after scenario demonstration is complete. When presenting each scenario, it is best to

do most of the explanation for the scenario before activating it, as each scenario can only run for roughly 45 seconds-1 minute.

#### SCENARIO A: BACK-PRESSURE CONTAMINATION THROUGH PRIVATE WATER WELL

Before running this scenario, please make sure all of the steps have been followed in the set-up section of the operation and parts manual. Also, check to make sure that ball valves, I, 7, and 8 are open and that water is collecting and overflowing through the house outlet as diagramed in Figures 21 and 22.

Scenario A is a depiction of a back-pressure private water well scenario. To run the scenario, first plug in the pump. The pump can be plugged in at the initial setup of the model or right before running Scenario A. The pump should be plugged in to the supplied power strip which the main pump is also connected to. Turn BV4 to the open position releasing dyed water into the system. You should be able to see dye within the acrylic tubing and also entering the house reservoir. Figures 23-26 depict this scenario. After explaining the scenario, shut BV4 and allow the system to run until all dye has been flushed from the system. The scenario can be left on as long as there remains water in Reservoir A. Once the water level falls below the level of the pump, turn BV4 to the OFF position.



FIGURE 23. SCENARIO A: SET-UP (SIDE VIEW)



FIGURE 24. SCENARIO A: STEP I - TURN ON BV4



FIGURE 25. SCENARIO A: SET-UP (ABOVE VIEW)



FIGURE 26. SCENARIO A: STEP I - TURN ON BV4

#### SCENARIO B: PRESSURIZED VESSEL, BOILER IN OFFICE BUILDING

Before running this scenario, please make sure all of the steps have been followed in the set-up section of the operation and parts manual. Also, check to make sure that ball valves, 1, 7, and 8 are open and that water is collecting and overflowing through the house outlet as diagramed in Figures 21 and 22.

Scenario B is a depiction of a boiler in an office building which creates backpressure contamination into the main system. To run this scenario, first, make sure that the pressurized vessel has been filled and pumped 5 times. Do not pump the vessel more than 5 times. If the pressurized vessel has to high of a pressure, dye will enter the entire system and may make it into the water tower reservoir. Not only is this inaccurate for demonstrational purposes it could also affect future scenario demonstrations. If it has not been filled refer to page 14 on preparing the pressurized vessel. When ready to operate the scenario turn ON BV6 and dyed water will enter the system through the pressurized vessel. Allow the dye to enter the house reservoir and then close BV6. Permit all dye to flush from the system before moving to the next scenario. This should take no more than 30 seconds. Figures 27- 30 depict this scenario.



FIGURE 27. SCENARIO B: SET-UP (SIDE VIEW)



FIGURE 28. SCENARIO B: STEP I - TURN ON BV6



FIGURE 29. SCENARIO B: SET-UP (ABOVE VIEW)



FIGURE 30. SCENARIO B: STEP I - TURN ON BV6

#### Scenario C: Back-siphon Subsurface Contamination through Pipe Leak & Main Break

Before running this scenario, please make sure all of the steps have been followed in the setup section of the operation and parts manual. Also, check to make sure that ball valves, 1, 7, and 8 are open and that water is collecting and overflowing through the house outlet as diagramed in Figures 21 and 22.

Scenario C demonstrates water contamination which occurs at the time of a main break from cracks in sanitary and sewage pipes through subsurface contamination. This is one of the more complex scenarios to demonstrate. To achieve a successful demonstration, steps should be followed exactly. The small reservoir on top of Scenario C should be filled with dyed water. To demonstrate the contamination within a sewage line turn the ball valve under the reservoir ON. At this point dye should enter the subsurface box and contaminate the entire box with dyed water. Turn ON BV3 and allow water to fill the box and drain through the overflow. As long as a higher pressure is kept in the drinking water line, no contamination should enter the system. Now it is time to simulate a break in the water main. To do this, disconnect the flexible tubing section in the main break area. The trough should begin to fill with water and drain. To allow for necessary maintenance on the main valves below and above the main break are closed. To demonstrate this turn OFF BV8 and BV1. This should prevent flow to the side of the model where Scenario C is located. After the main valves are closed, dye should flow from Scenario C into the main lines towards the main break. Once this takes place "fix" the main by reconnecting it and once it is reconnected turn ON BV8 and BV1. The dye within the lines should travel towards the house and contaminate the bathtub reservoir. These steps are shown in Figures 31-41.



FIGURE 31. SCENARIO C: STEP 1- DYE ENTERING SCENARIO (ABOVE VIEW)



FIGURE 32. SCENARIO C: STEP 2 – DYE OVERFLOW IN SCENARIO (ABOVE VIEW)



FIGURE 33. SCENARIO C: STEP 3 – REMOVE SEGMENT FOR MAIN BREAK (ABOVE VIEW)



FIGURE 34. SCENARIO C: STEP 4 - TURN OFF BVI & BV8 (ABOVE VIEW)



FIGURE 35. SCENARIO C: STEP 5 - REATTACH SEGMENT ("FIX" BREAK) (ABOVE VIEW)



FIGURE 36. SCENARIO C: STEP 6 - OPEN BVI & BV8 (ABOVE VIEW)



FIGURE 37. SCENARIO C: SET-UP (SIDE VIEW)



FIGURE 38. SCENARIO C: STEP I - DYE ENTERING SCENARIO (SIDE VIEW)



FIGURE 39. SCENARIO C: STEP 2 - DYE OVERFLOW IN SCENARIO (SIDE VIEW)



FIGURE 40. SCENARIO C: STEP 3 - REMOVE SEGMENT FOR MAIN BREAK (SIDE VIEW)



FIGURE 41. SCENARIO C: STEP 5 - REATTACH SEGMENT ("FIX" BREAK) (SIDE VIEW)

#### SCENARIO D: BACK-SIPHON THROUGH SUBMERGED INLET

Before running this scenario, please make sure all of the steps have been followed in the set-up section of the operation and parts manual. Also, check to make sure that ball valves, 1, 7, and 8 are open and that water is collecting and overflowing through the house outlet as diagramed in Figures 21 and 22.

This scenario demonstrates back-siphonage through a fire-flow incident coupled with a submerged inlet either on a stock tank or a truck fill station. To run this scenario, first open BV5 and allow water to enter the reservoir of Scenario D. During normal flow conditions the water pressure will not allow contamination in to the system through this submerged inlet. To simulate a fire-flow condition where a large water demand for firefighting is needed turn BV2 to the ON position. Water in the system will begin to drain to the outlet reservoir through this fire-flow line and contaminated water from Scenario D will enter the water lines. When sufficient dye has entered the water line close BV2 and BV5. Contaminated water should flow from the lines to the house and contaminate the bathtub reservoir. Step-by-step depictions of this can be found in Figures 41-48.



FIGURE 41. SCENARIO D: SET-UP (ABOVE VIEW)



FIGURE 42. SCENARIO D: STEP I- OPENING BV5 & BV2 (ABOVE VIEW)



FIGURE 43. SCENARIO D: STEP 2 - CLOSING BV5 & BV2 (ABOVE VIEW)



FIGURE 44. SCENARIO D: SET-UP - DYE IN RESERVOIR D (SIDE VIEW)



FIGURE 45. SCENARIO D: STEP I- OPEN BV5 & BV2 (SIDE VIEW)



FIGURE 46. SCENARIO D: STEP 2 - DYE IN RESERVOIR D (SIDE VIEW)

### CLEAN-UP & MAINTENANCE

#### AFTER USE

- 1) The system must first be flushed to rid the piping and scenarios of any remaining dye. Run the system continuously after demonstration for at least one minute or until all traces of dye have visibly exited.
- 2) Unplug each pump from the power source.
- 3) Close the ball value on the inlet line (BVI) connecting the water tower and the encased model. At this point the water tower will drain into the inlet reservoir. Figure 47 shows correct orientation for all ball values for draining of model.
- 4) Make sure BV8 is open to allow a free drainage path within the acrylic pipe network.
- 5) Check to make sure each ball valve to a scenario is closed. (BV3, BV4, BV5, BV6). Keep the ball valve to the house unit open (BV7).
- 6) Disconnect the flexible tubing section which simulates the main break. All of the system's remaining water should be drained through this connection.
- 7) Gently lift the model on the side closest to the water tower to drain the remaining water in the acrylic lines to the main break trough.
- 8) Check to make sure water has drained from the house and each acrylic junction.
- 9) Empty each back-siphonage scenario by disconnecting the flexible tubing from the model. These scenarios can be cleaned separately. It is recommended to remove all dye and water from these scenarios.
- 10) The water tower should drain once the pump is unplugged but check to make sure it is cleared of water.
- 11) Water from both inlet and outlet reservoirs water may be disposed of.



FIGURE 47. BALL VALVE ORIENTATION FOR DRAINING MODEL

#### CLEANING

The model should be cleaned before long-term storage (upwards of a month). It should also be cleaned after every five or six uses with a water and vinegar solution to avoid dye build up or bacteria. Cleaning the model involves filling the inlet reservoir with a water-vinegar mixture of one part vinegar to 5 parts water and running the entire model, making sure to activate each scenario. A total volume of one gallon of the vinegar cleaning solution is recommended. After cleaning, the model should be flushed with tap water and completely emptied.

It is not recommended to leave stagnant water within the system when the model is not in use. It is also not recommended to leave any dyed water within the system when not in use. This could lead to permanent discoloration of the acrylic infrastructure. An air tank can be attached to the inlet and used for more efficient drying.

If any discoloration of the system occurs follow the outlined cleaning procedure and if discoloration persists refer to Parts Manual to replace discolored model parts.

#### INSPECTION

It is recommended that model is examined after every 5 uses and joints are examined carefully. If a leak is detected within the acrylic/acrylic fittings, fusing the acrylic joints by applying acrylic glue is recommended for repairs. If any leaks are found at threaded junctions, it is recommended that clear silicone glue is applied to the threads and the seal retightened.