**Summary report for July 20, 2017 fish kill at RainFresh Harvests**

On July 10, we experienced heavy rains of almost 3 inches in a 24 hour period. This was after several days of off and on again showers and overcast days. Additionally, power production due to overcast weather resulted in depletion of battery backup storage which is needed for aeration and biofiltration of fish tanks. Topping off of the water levels in fish tanks with pond water in the Passive Solar Greenhouse (PSG) resulted in significant fish mortality.

Here are the observed contributing factors and results:

* Power interruptions due to aging batteries combined with lower amounts of sunlight occurred over the previous week. Interruptions included one period of about 8 hrs and 3 or 4 periods of 4 hrs or less. The backup gas generator was run once on July 12th, then again for a longer recharge on July 13th.
* Previous to July 10th we had several weeks where hot day weather required topping off (about 6 inches) of the pond with geothermal system well water. Due to the hardness and sodium in the well water this was effective in killing off some of the surface algae bloom.
* Pond water at that time had a somewhat sulfur, methane, rotten eggs aroma.
* After the heavy rains, the pond probably turned over even more, stirring up anaerobic bacteria that was decomposing the dead algae, resulting in a stronger sulfur aroma and sewage like smell.
* Because of the reduced power, regular weekly topping off of the fish tanks in the PSG did not occur for a couple weeks and the water levels were approaching 3-6 inches low. T**he decision was made to top them off with pond water on July 17th**. Most all tanks except for PSG IBC #2 BG required about 3-6 inches of pond water. Tank PSG IBC #1 P was accidentally overfilled and water was running over for a brief period of probably less than 15 minutes, likely resulting in a higher percentage of pond water transfer to this tank, than to the other tanks.
* Immediately after filling 2 fish jumped out of LTW indicating that something was wrong.
* Subsequently over the next several days fish kills were significant, with the loss of about 450 fish ranging in size from 3-9 inches. Most of the dead floaters happened within the first 48 hrs after filling with pond water. Dead fish were first observed within a few hours of topping off the tanks.
* Fish kill rates were most severe for Yellow Perch.
* The percentage of loss was higher for the mealworm fed tank than the Aquamaxx tank.
  + Almost 100% mortality of yellow perch in those tanks having pond water added.
    - Tank PSG IBC #1 lost 100% or about 50 yellow perch (4-6”)
    - Tank PSG 8’ tank lost 100% or about 100 yellow perch (4-6”)
  + Approximately 200 of the 300 bluegills in LTE were lost (4-9”, mostly 6-8”)
  + Approximately 100 of the 300 bluegills in LTW were lost (4-9”, mostly 6-8”)
  + Tank PSG IBC #2 had bluegills and did not have any pond water added and there was no mortality.
* The difference in mortality rate for yellow perch may have been due in part to the amount of water held in respective fish tanks. PSG IBC #1 holds 200 gallons, PSG 8’ tank holds 700 gallons, while both of the LT tanks hold 1500 gallons of water.
* The percentage of fish closer to the 5-6” size was greater for those fed mealworms only (LTE tank), while the size of the Aquamaxx fed fish were skewing to the slightly larger 7-9” range (LTW tank). Total fish lost was double in the mealworm fed tank (LTE).

It was difficult to determine after the fact, whether the total percentage of added pond water was different for each tank and if this quantity had more of an effect, rather than the difference in feeding regimes for the higher mortality rate in LTE versus LTW.

* Additionally, the amount of feed to LTW and LTE was gradually increased by 100% during the previous week from 1.0 oz fresh weight of mealworms to 2.0 oz, and 0.5 oz of Aquamaxx to 1.0 oz due to the rapid feeding rate observed, as the fish were observed eating all the feed within 1 minute of feeding.
* Feed rates were subsequently decreased and recalculated based on the fish loss. It was estimated that the total remaining fish in LTE was 100, while LTW has 200. Since the fresh weight analysis from earlier testing indicated that the fresh weight of mealworms needed to be double that of the Aquamaxx to deliver the same rate of protein, the revised rates resulted in 0.5 oz of both mealworms and Aquamaxx to the respective tanks.
* Water samples should have been taken immediately, but this was not done until July 20. The extremely sewer like, rotten egg smell from the pond water and subsequent death of fish was initially thought to be due to a sudden increase in nitrate/nitrite levels and extreme depletion of oxygen. However, subsequent water analysis indicates extremely high levels of sulfates and not significant nitrates, suggesting that the death of fish occurred suddenly and was due to toxic gas in the pond water. The tanks were topped off with hose pumping directly into the fish tank water. The likelihood is that hydrogen sulfide gas was in a high enough concentration to cause acute mortality the fish and that it took several days for all the dead fish to eventually float to the surface. The rotten egg smell is typical of hydrogen sulfide gas and the heavy rains several days previous to using the pond water to top off the tanks likely resulted in pond turnover of the organic matter, releasing the gas. The levels were high enough to cause a significant decrease in the numbers of frogs observed in the retention pond.
* Subsequently any pond water added to fish tank is being directed through the biofiltration trays holding water celery to allow for diffusion of gas prior to being added to the fish tank water.