WATER MANAGEMENT IN AQUACULTURE PONDS: USE OF RAINFALL THROUGH FIELD APPLICATION OF THE 6/3 METHOD

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Introduction

Through the 1970's and 1980's the emergence of the aquaculture industry has had a dramatic effect on the Mississippi Delta. An ideal value-added industry, local jobs, and other economic benefits were created in production, processing, distribution, marketing, and support industries such as equipment, manufacturing, and feed production. However, the large acreages of ponds, in excess of 100,000 acres, has placed a new demand on the groundwater supplies of the region. During the same period of time, irrigation of crops grew substantially. This high demand for groundwater has apparently exceeded the recharge rate of the aquifer resulting in a fall in the water table. Aquaculture has been estimated to account for approximately 24% of the groundwater pumped in the region. While other crops (rice, soybeans, and cotton) can use surface water if available, at this time aquaculture is dependent on clean groundwater.

Ponds lose water through several uncontrollable means including seepage and evaporation. This water must be replaced to maintain water levels. Theoretical analysis of weather data and pond management by Pote et al. (1988) shows that pumping needs of ponds could be reduced from an average of 40" to an average of 15" annually by managing the water level in the ponds to maximize the capture and beneficial use of rainfall. This method of managing water levels reduces the happenstance by which ponds managed otherwise may or may not have freeboard. This method is aimed at maximizing the beneficial use of rainfall.

In the 6/3 scheme, water levels are managed within two zones: 0"-3" and 3"-6" below the outflow elevation (Figure 1). In this scheme the water level is allowed to fall 6" below the outflow point before water is pumped in. The pond is then only pumped up 3", leaving 3" of freeboard available to capture, store, and utilize rainfall. Since the well is not turned on until the water level is 6" below the overflow point, the amount of freeboard available to capture rainfall will vary between 3" and 6". The only time outflow should occur is when greater than 3" of rainfall during a few days has completely filled the available freeboard.

This paper will discuss the application of the 6/3 method on commercial production ponds, including results, implementation problems, and recommendations for application on a large scale.

Field Methods

Two blocks of four ponds each (each pond was approximately 17 acres) were monitored during the summer of 1991. One block of four ponds was managed by farm labor on the 6/3 method (ponds 3,4,5,6) with water level indicators being installed in sight of the well. An additional block of four ponds was managed as they had been traditionally managed (ponds 7,8,9,10 See Figure 2). Each block of four ponds was supplied by its own well. Wells were monitored for run time using electronic totalizers and flow rates were obtained to determine total water pumped. Water level recorders were installed in one pond of each set (ponds 3 and 7) to provide a continuous record of the water level in each. The water level was manually measured in all ponds once per week. A tipping bucket rain gage was installed to measure rainfall. No measurement of evaporation other than the ponds was obtained.

The 6/3 water level markers were made of a 2" aluminum tube for the post and a 3" (vertical) by 6" (horizontal) steel plate pop riveted to the post. The ponds were surveyed and the elevation of the outflow pipes established (Figure 1). The 6/3 water level indicators were then surveyed in so that the top of the plate was 3" below the outflow point. In this way, if the top of the plate was submerged the pump should be off (water level within 3" of outflow). If the entire plate was above the water, the well should be turned on (water level 6" below outflow). The farm labor was informed of the operational procedure.

Results

The water levels of the ponds were monitored between April 8, 1991, and November 4, 1991.

Monitoring of pumped water began on April 15 and continued until October 7. The spring of 1991 was extremely wet, causing extensive flooding. From April 8 to May 29, 19.48" of rain was recorded at the pond sites. This exceeded evaporation and kept all ponds filled.

Between April 8, 1991, and August 21, 1991, the 6/3 well ran a total of 153 hours and the traditional well ran 420 hours. The traditional well has a flow rate approximately 73% of the 6/3 well (1770 gpm versus 2230 gpm) so that the traditional ponds received 100% more pumped water (40.9 million gallons) than the 6/3 ponds (20.5 million gallons), the traditional ponds had received 22" of pumping and the 6/3 ponds 11". The rainfall during this period was 27.8". This rainfall is above normal for the area (21.1 inches) so that in most years more pumping would be expected.

Between August 21 and October 7, the traditional well had run an additional 93 hours while the 6/3 well had run 116 additional hours. Part of the large water use in the 6/3 ponds occurred during a 96 hour period, when the 6/3 markers were ignored in two ponds. Night and day personnel miscommunicated about the need for additional water for an oxygen problem. A brief lapse in the management of the 6/3 ponds caused the difference between management schemes to close significantly. Even with this management lapse, the traditional ponds still received 40% more water than the 6/3 ponds for the period April 8 to October 7.

Measurements of water pumped into the ponds during the summer are given in Figure 3. The traditionally managed ponds consistently received more water than the 6/3 ponds. Over the period of June 11 to August 21, the traditionally managed ponds received 0.27 inches of water per day while the 6/3 ponds received only 0.14 inches per day.

Figure 4 shows the water levels in ponds 3 and 7 along with rainfall for the period June 13 to September 17. These two ponds are represented since they had continuous monitoring of the water level. Pond 3 shows a continual water level decrease during the season. The water level in this pond was brought up at several points but finished well below the 6" mark. Its adjoining pond (normally two ponds are watered at the same time) also dropped significantly (Figure 5). Ponds 5 and 6 were kept in or above the 3"-6" range but below overflow almost continually through the season. Pond 7 bordered on the overflow point for longer periods eliminating freeboard for any potential rain capture and pond 7 overflowed twice from pumping. The other traditional ponds (Figure 6) were basically incapable of overflow since their overflow points were at or above the corresponding pond levee height. These high overflow points allowed for 100% capture of rainfall but caused a visible increase in levee erosion due to wave action high on the levees. It appears that the traditional ponds with their high overflow levels had the potential for higher beneficial use of rainfall than the 6/3 ponds; however, two factors negate this.

First, ponds 8, 9, and 10 captured all rainfall and had steady to increasing water levels but still had water pumped into them. Apparently the absence of a water level reference made it difficult to track water needs. The levees were constantly eroding so that they could not serve as a water level reference.

Second, on September 19 water levels in all ponds were pulled down for fall and winter to reduce wave action high on pond levees. Thus any excess water that had accumulated through the summer was drained out. For the traditional ponds 8, 9, and 10, this means that captured rain and unnecessarily pumped well water that had been added to an already full pond was lost in the end.

Water drained from ponds on September 19 are given in Table 1. The 6/3 ponds lost only a total of 8.84 acre feet while the traditionally managed ponds lost 31.96 acre feet. Pond 7, in the traditionally managed block, lost as much water as the four combined 6/3 ponds. The traditional ponds had 3.6 times more water drained from them than from the 6/3 ponds.

Summary

This field trial indicates that the potential reduction in water demand by following the 6/3 management scheme is obtainable, but several practical problems must be overcome. Cost of applying this method are minimal (cost of water level indicator and installation) and should be more than offset by reduction of pumping costs.

Problems to be resolved in applying this management scheme include: establishing a rational overflow point on each pond; developing water level indicators that are easy to install, set, and read and that do not interfere with harvesting operations; training pond managers on the 6/3 operation scheme.

The use of only 22" of pumped water in the traditionally managed ponds was lower than expected. With rainfall 7" above normal for this period, water use in an average year could conceivably be 30". The only additional water to account for in a full year will be that required to raise the pond levels in the spring to summer operating depths. Based on fall drawdowns at this location, this additional water would be from one-half to 1 foot. This would place typical annual water use for catfish in the range of 35 to 40 inches.

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References

Pote, J.W., C.L. Wax, and C.S. Tucker. "Water in Catfish Production: Sources, Uses, and Conservation". Special Bulletin 88-3, Mississippi Agricultural and Forestry Experiment Station, November, 1988. 16 pp.

Pond number	Decrease in Water Level (Feet)	Acre Feet Lost	Millions of Gallons Lost
6/3			
3	0.16	2.72	0.89
4	0.08	1.36	0.44
5	0.17	2.89	0.94
6	0.11	1.87	0.61
Total		8.84	2.88
Traditional			
7	0.52	8.84	2.88
8	0.06	1.02	0.33
9	0.65	11.05	3.60
10	0.65	11.05	3.60
Total		31.96	10.42

Table 1. Water losses from individual ponds on or near September 19, 1992.

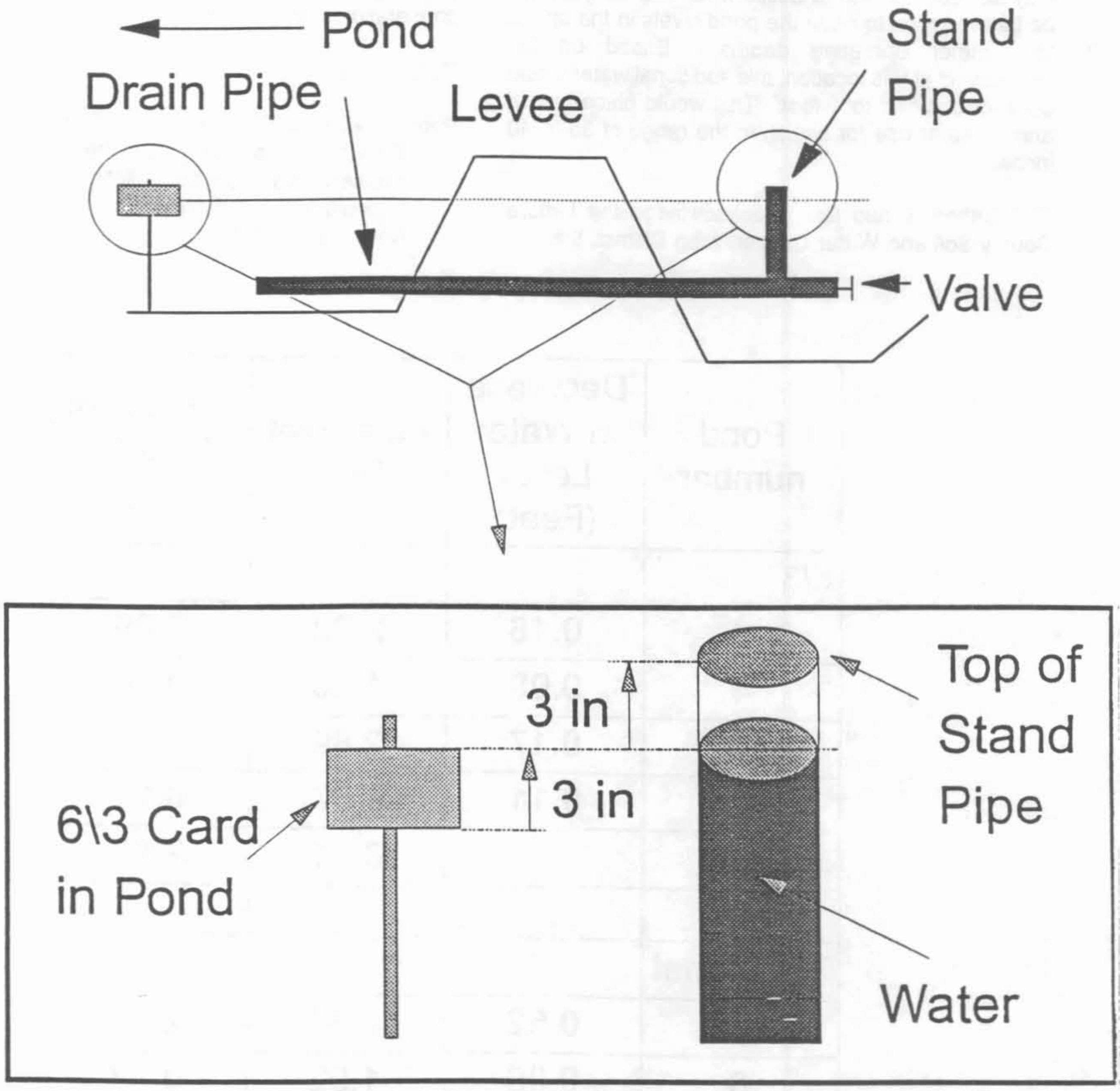

Fig. 1. Water level marker and stand pipe configuration (not to scale). Depicted example is for stopping of pumping condition.

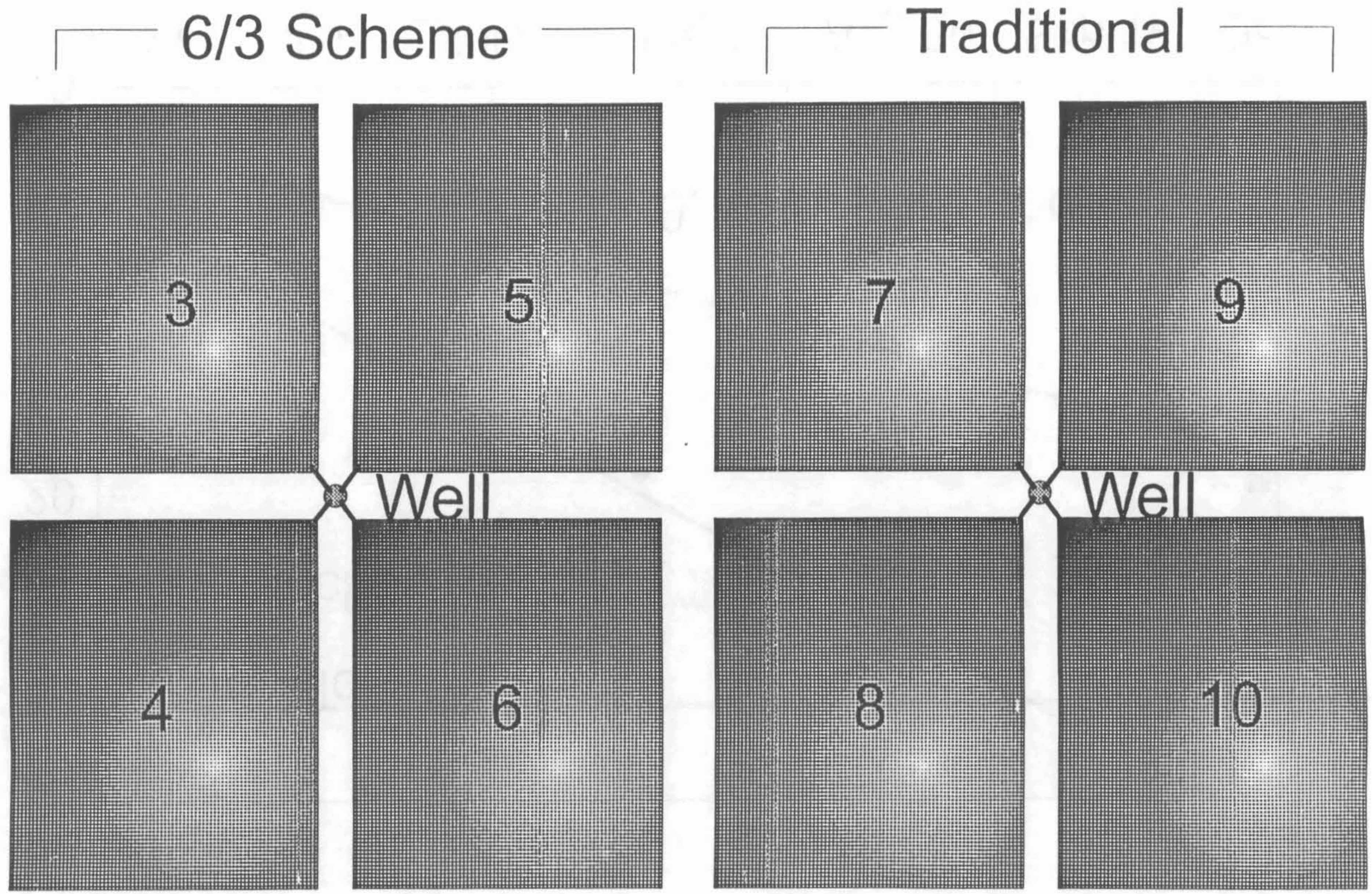

Fig. 2. Approximate layout of ponds.

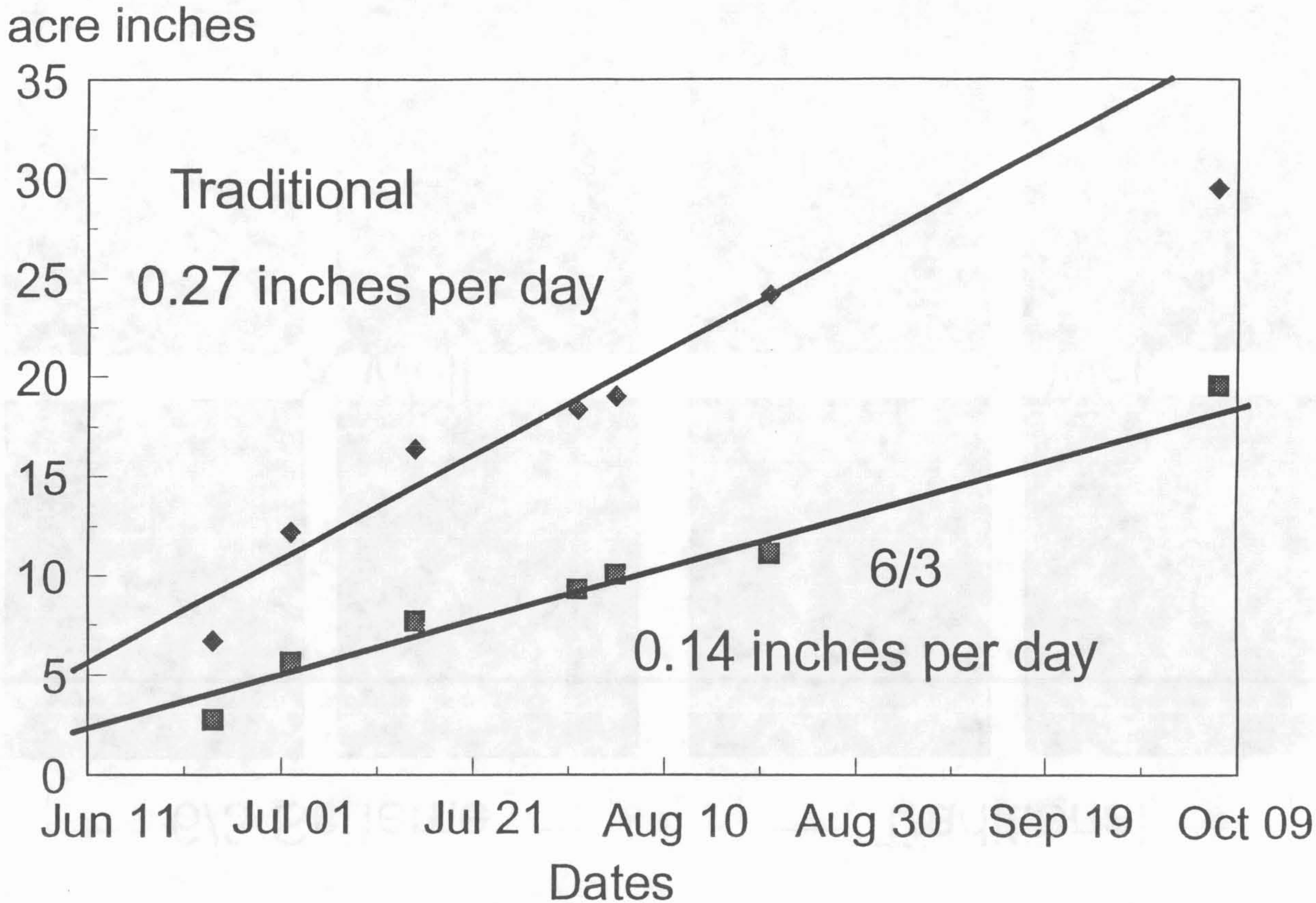

Fig. 3. Cummulative acre inches and average daily applied.

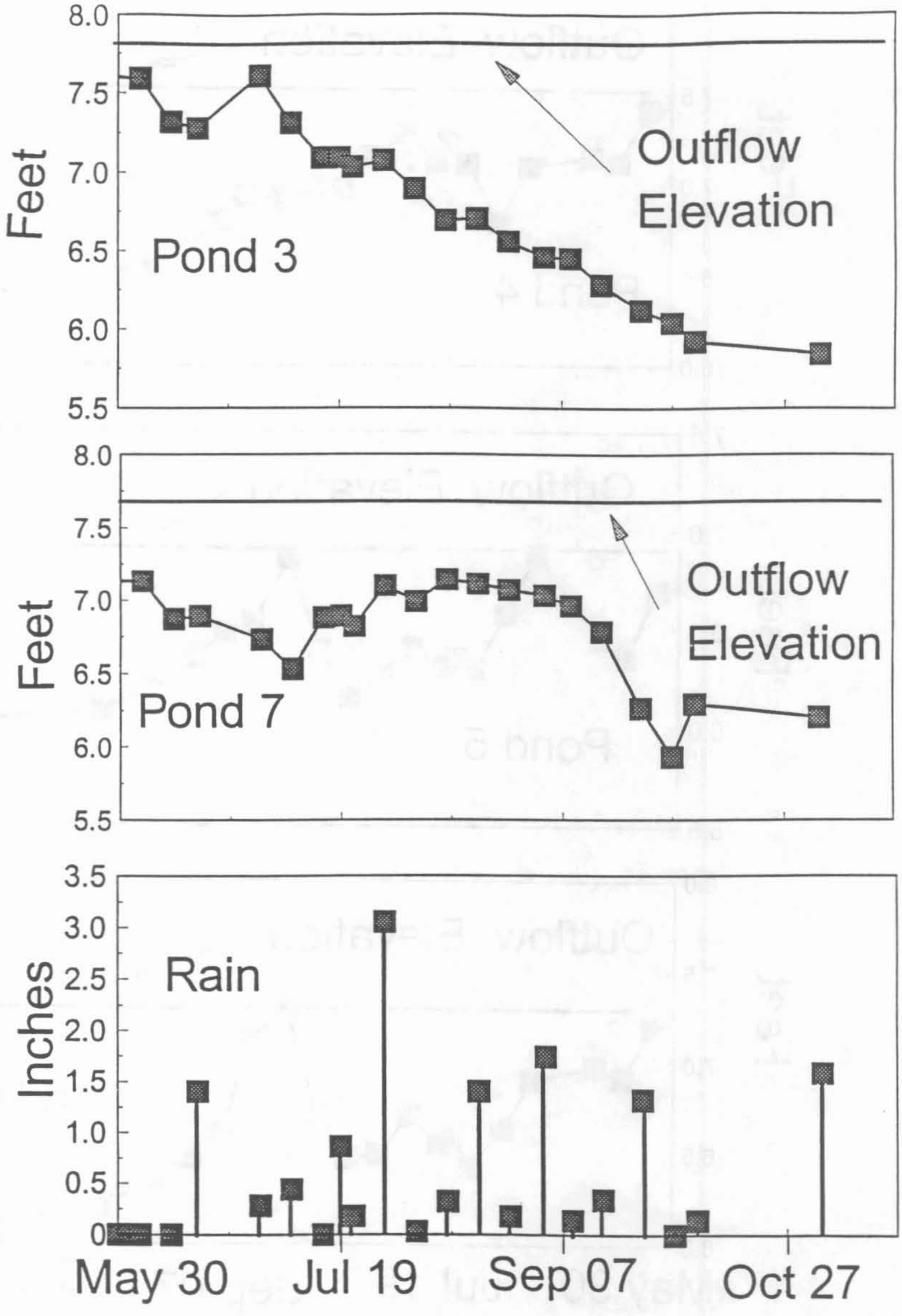

Fig. 4. Rainfall and water levels in ponds 3 and 7

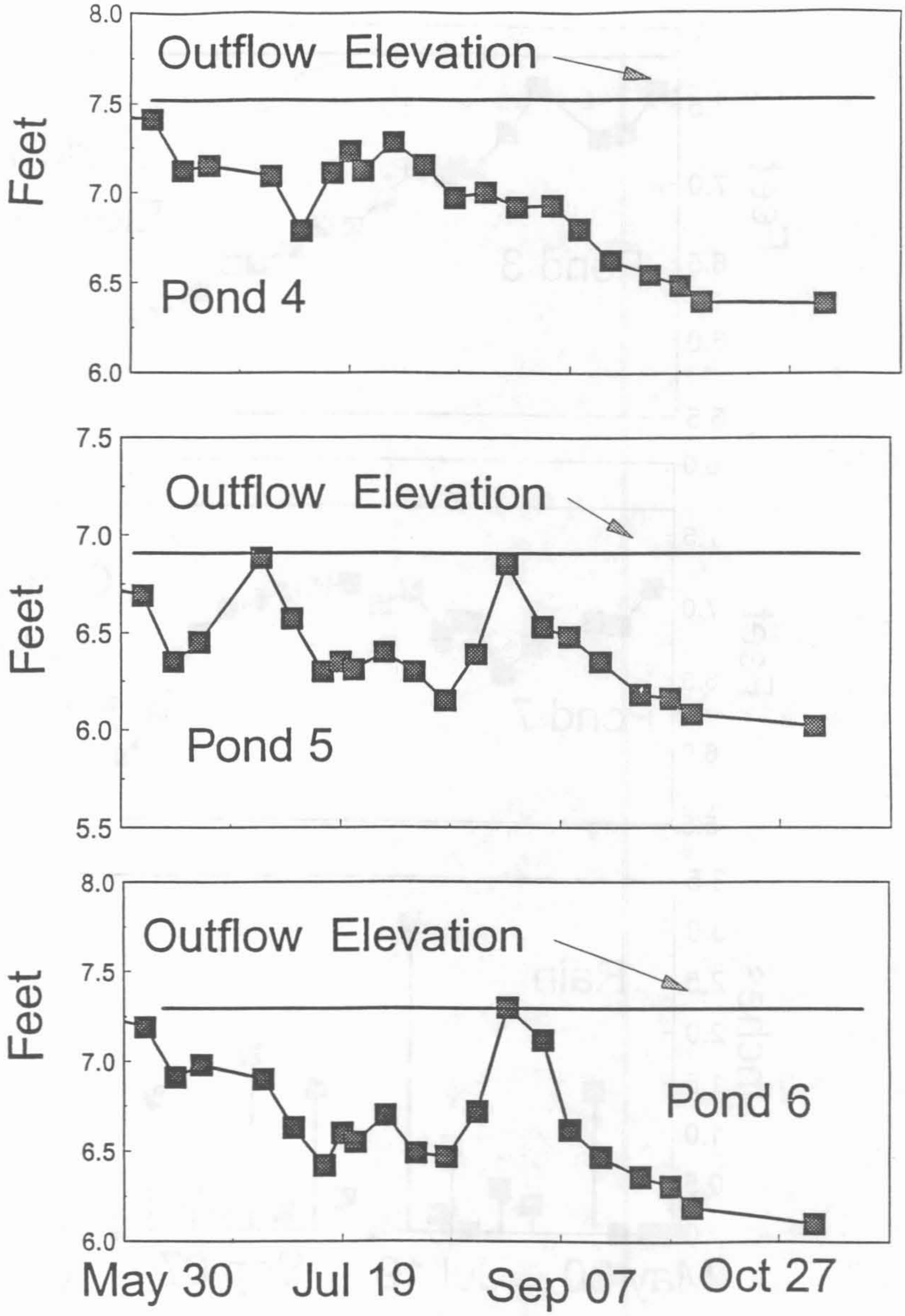

Fig. 5. Water levels of 6/3 ponds.

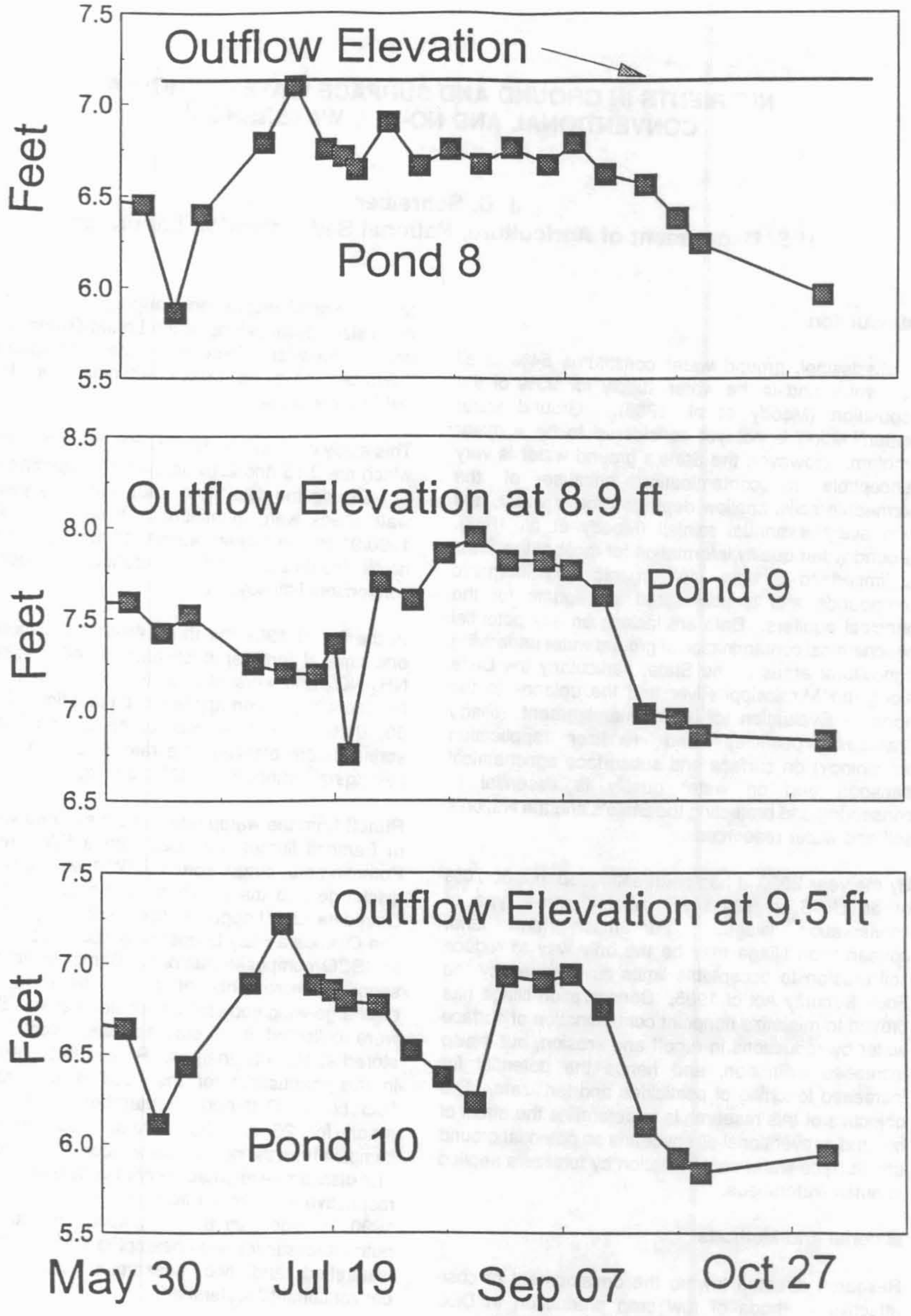

Fig. 6. Water levels of traditional ponds.