Water Recycling Trials in Hardy Nursery Stock Production

Paul J. Labous and Stephen J. Willis
Writtle College, Chelmsford, Essex, CM1 3RR

Concern over potential ground water pollution and the cost of water in hardy ornamental nursery stock (HONS) production have initiated trials which started in 1992. The 1994 experiment consisted of three systems where water was recycled and compared with a standard Efford capillary bed (control bed). The objectives of the trial were to measure water usage, to monitor for pest and disease, to monitor nitrate levels in leachate, to assess plant growth and quality, and to assess rooting through (growth of roots out of the bottom of the container).

The four beds constructed were the standard Efford capillary bed, a capillary bed with water recycled, an overhead-watered bed with recycled water, and a flood bed (ebb and flow system) with recycled water.

***Pyracantha rogersiana* and *P.* 'Orange Glow' were the two trial plants potted in 3-litre pots into compost containing controlled-release fertiliser.**

The recycling-capillary bed showed a significant water saving. There was no significant build-up of pests and diseases in any treatment. Although nitrate levels increased during the season, some of the rise was due to a rise in the levels in the mains water used and at no time did the levels reach phytotoxic concentrations. There was no significant difference in plant growth and appearance between the four treatments and this suggests that the use of recycled water does not adversely affect the plants while offering potential savings in water and fertiliser costs. It is recognised that commercial nurseries will treat the water to avoid the risk of disease.

INTRODUCTION

Over the past few years there has been considerable concern about water pollution. The agricultural industry cannot be held solely responsible for the levels of fertilisers and pesticides which may be found in ground water supplies. However, several member countries of the European Union have enforced legislation in recent years in order to reduce the quantity of pollutants released by the horticultural industry. These countries include Germany and Holland, and in the latter, legislation is built into the Dutch Horticulture Structural Bill (Vale, 1993). It is quite possible that enforcement of legislation which is designed to reduce nitrate release into ground water will occur in the United Kingdom before the year 2000 and it was with this in mind that water recycling trial work was started at Writtle College in 1992. A secondary objective in recycling is to conserve water supplies and thus reduce the cost of water for use in the production of hardy nursery stock. A trial aimed at assessing the effects of recirculating overhead-applied water was conducted in 1992, and a follow-up trial based upon recirculated flood bed irrigation was conducted in 1993. Results from these trials appeared promising showing no significant difference in plant growth, no pest or disease build-up, and additional savings in water used.

Details of these trials are not within the scope of this report but are available upon application to Writtle College. The 1994 trials are described in the following report.

MATERIALS AND METHODS

The 1994 trials had the following objectives:

1) To measure water usage in three systems where water is recycled compared with a standard capillary bed.

2) To monitor for pest and disease build-up.

3) To monitor nitrate levels within the leachate.

4) To assess plant growth and quality between the systems.

5) To compare rooting through (i.e., growth of roots out of the bottom of the container) between the systems.

Four trial beds were arranged as shown in Fig. 1. Each bed was 4 m × 5 m × 0.15 m deep and had an independently metered water supply.

The standard Efford capillary bed, the control bed, was constructed on a level site using 60-mm plastic field drainage pipe over 125 µm (500 gauge) black polythene sheeting. The pipes were covered with Agrifleece (spun polyester) in order to prevent the entry of sand and the bed was filled to a depth of 75 mm and levelled. In this bed both irrigation and drainage were achieved through the same pipe with the excess drainage water running to waste. This is illustrated in Fig. 2.

The capillary bed with water recycled used the same layout as the control plot, but provision was made for the storage of spring and summer rainwater which could then be recycled for irrigation (Fig. 3).

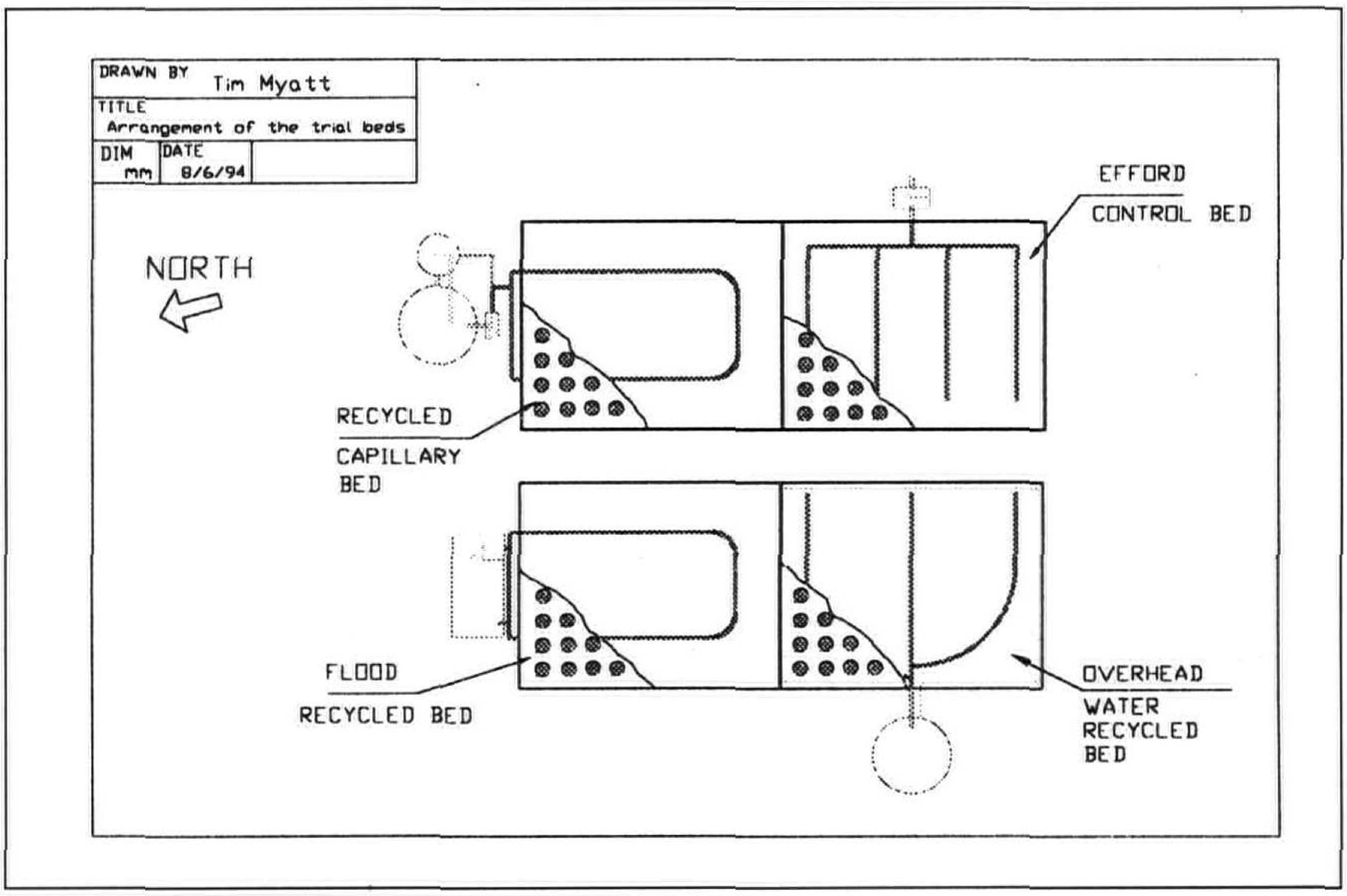

Figure 1. Arrangement of the trial beds.

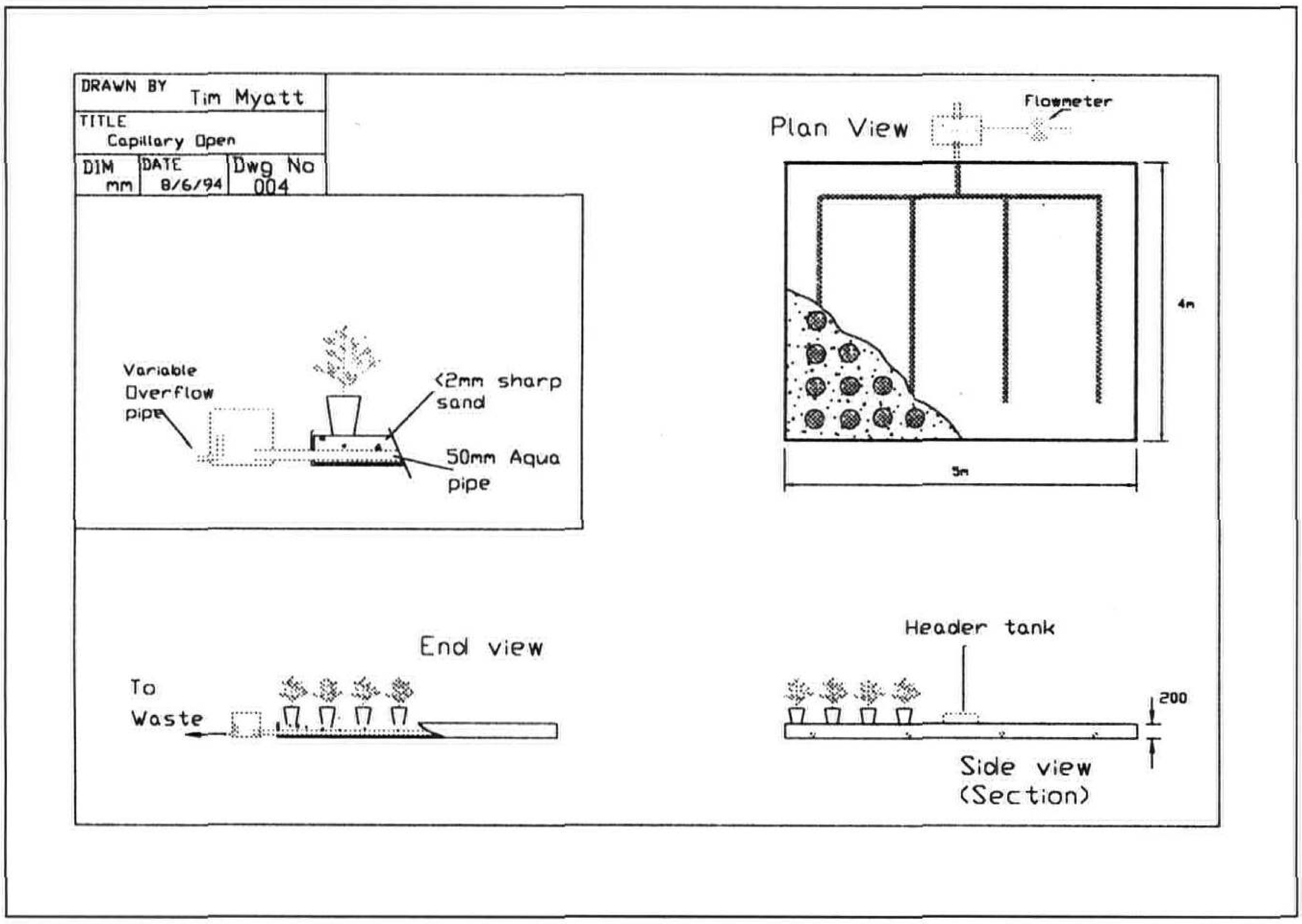

Figure 2. Details of the Efford bed (control plot).

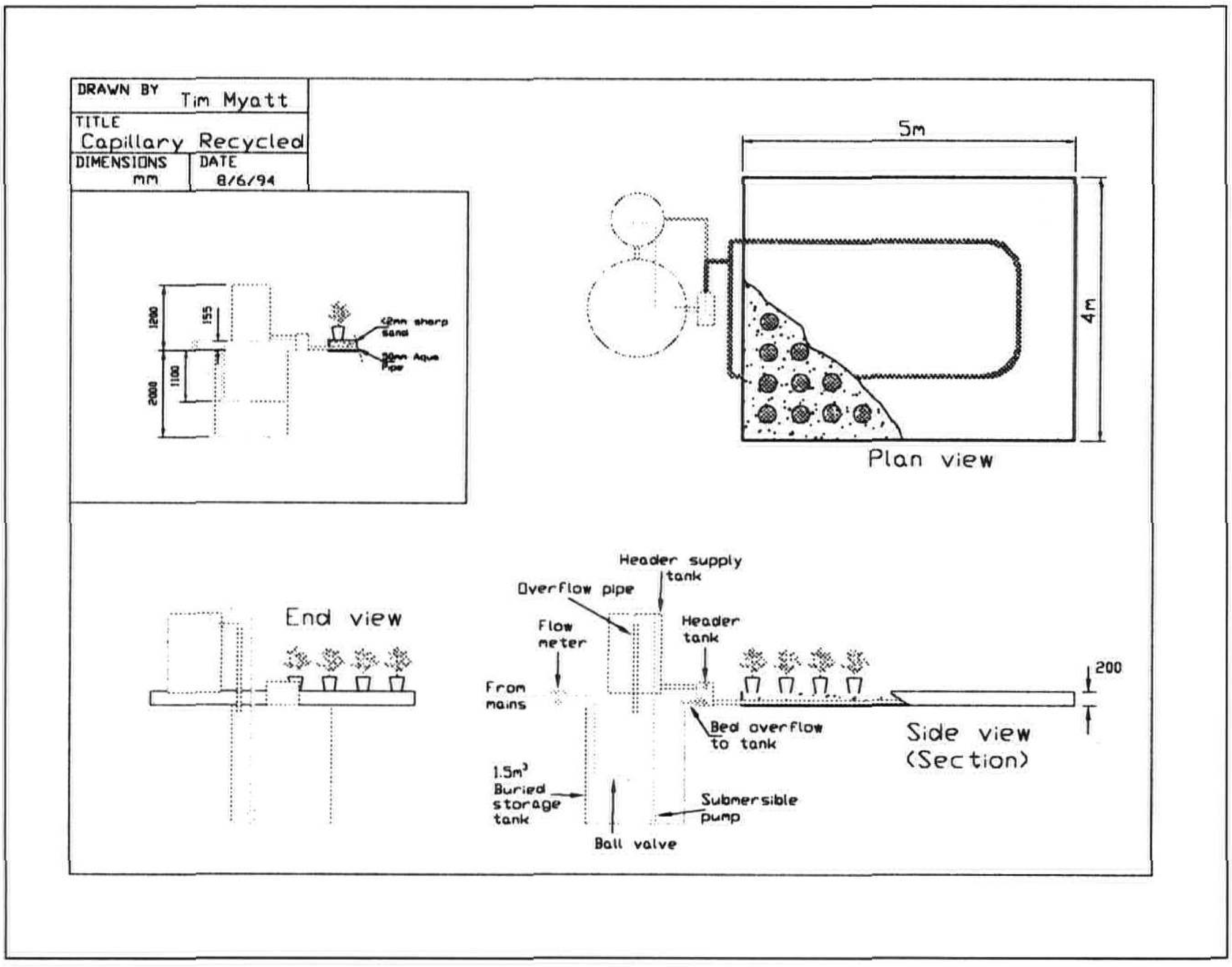

Figure 3. Details of the capillary bed with water recycled.

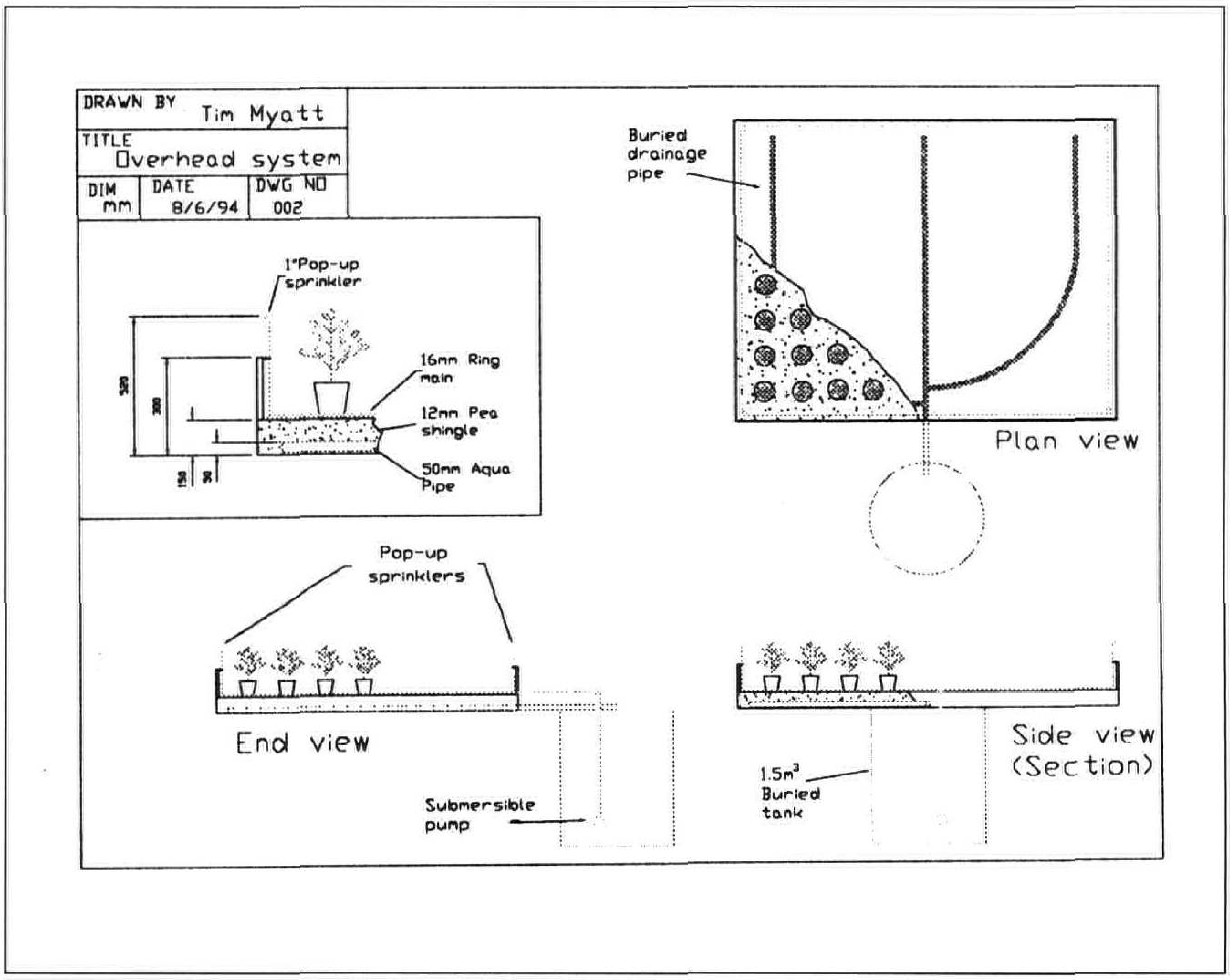

Figure 4. Details of the overhead recycled bed.

The overhead-watered bed with recycled water also had drainage pipes installed, as described for the other beds in the trial, but the substrate was gravel rather than sand. Spring and summer rain and irrigation water were channelled back to a reservoir tank to be recycled through the overhead sprinklers. This is illustrated in Fig. 4.

The flooded bed (ebb and flow system) with recycled water was constructed in the same way as the overhead water bed with recycled water system. In this case rainwater was collected and held in a reservoir tank and was applied to the base of the plant pots by flooding the bed to a depth of 12 mm above the surface of the gravel for 1 h daily. This is illustrated in Fig. 5.

In all of the recycling systems provision was made to supplement the water level in the storage tanks from the mains supply via a flow meter.

Pyracantha rogersiana and *P.* 'Orange Glow' were used throughout the study. These were potted in 3-litre pots in a medium mixed from: 9 peat : 2 bark : 1 grit (by volume). Three kilograms of Osmocote 12 - 14 month with 0.5 kg Micromax and 1.2 kg Dolodust per cubic metre were added to the compost. Final potting and standing down was completed on 31 March 1994. Ronstar 2G (oxadiazon) herbicide granules were applied at 20 g m^{-2} after standing down. Water usage and rainfall data were recorded daily and nitrate analysis was carried out weekly, as was testing for the presence of *Phytophthora* and *Pythium*. Gloquat (trimethylammonium chloride) was applied at the rate of 20 ml $litre^{-1}$ to the Efford capillary bed and the water recycled capillary bed on 30 March 1994.

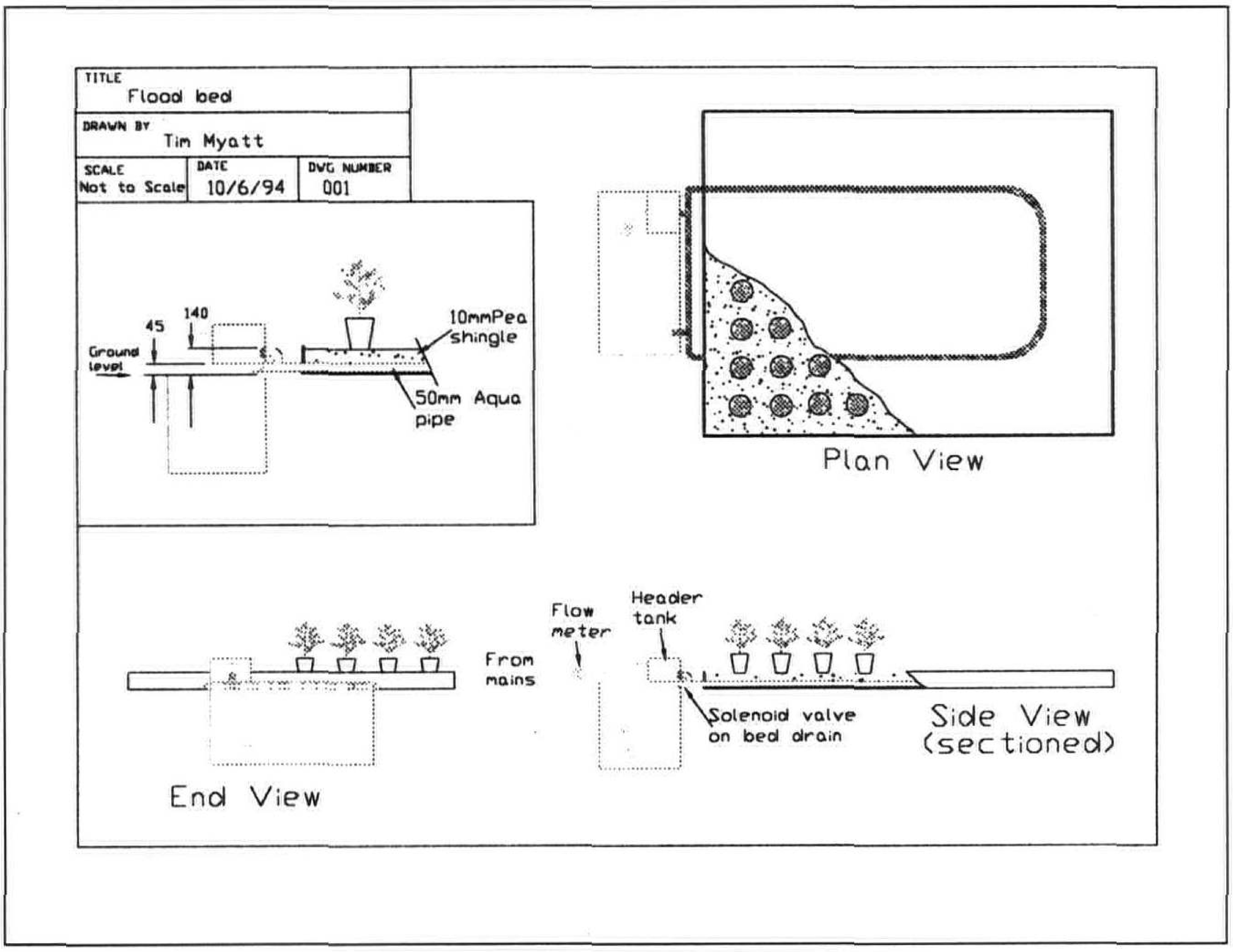

Figure 5. Details of the flood bed (ebb and flow system) with recycled water.

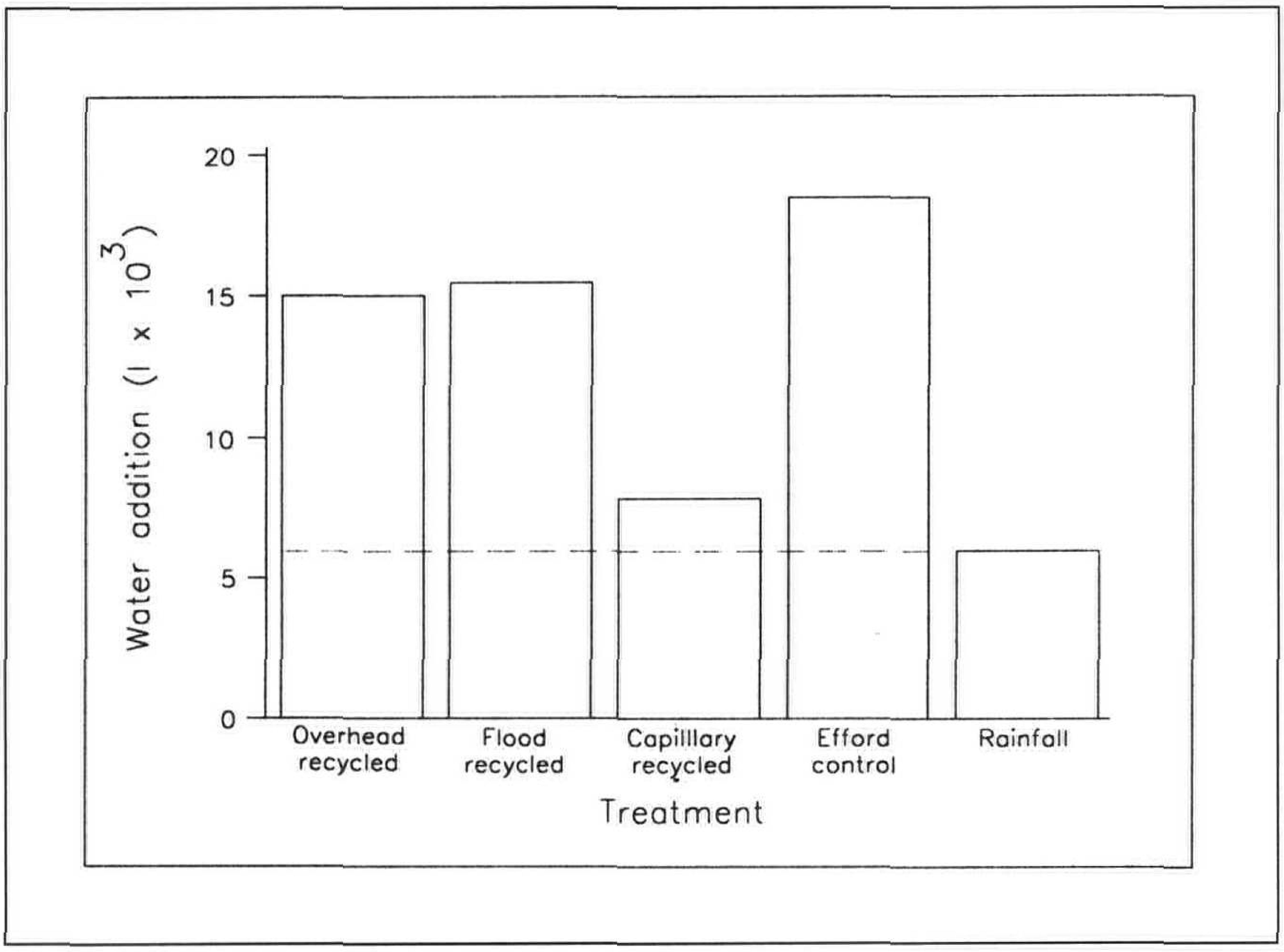

Figure 6. Cumulative water added to the plots during 1994 (1×10^3).

RESULTS

Table 1 shows the comparative performance of the four treatments in terms of fresh weight of plant, plant colour, rooting through, and pot cleanliness. The values represent the means from the trial data. The classifications for the last three parameters are:

- Plant colour, assessed from "0"— having a pale leaf colour unacceptable to the trade, to "5"— being above market standard for both colour and gloss.
- Rooting through, assessed from "0"— no rooting through, to "5"— severe rooting through with a majority of roots in excess of 200 mm long.
- Pot cleanliness, assessed from "0"— exterior of the pot free from potting media or substrate, to "5"— material adhering to the pot around full circumference.

Table 1. Table of the means of the results from the four test beds.

Pyracantha 'Orange Glow'

	Overhead recycled	Flooded recycled	Capillary recycled	Efford capillary
Weight (g)	58.78	61.78	57.3	73.42
Colour (0-5)	3.5	3.17	3	3.83
Rooting through (0-5)	0.83	1.33	2.5	1.5
Pot cleanliness	Clean	Clean	Very dirty	Dirty

Pyracantha rogersiana

	Overhead recycled	Flooded recycled	Capillary recycled	Efford capillary
Weight (g)	74.25	85.27	73.42	95.61
Colour (0-5)	4.17	4	3.83	4.17
Rooting through (0-5)	1.5	1.17	1.5	1.67
Pot cleanliness	Clean	Clean	Very dirty	Dirty

Figure 6 shows the quantity of metered mains water required by the different treatments. These quantities are shown in addition to rainfall collected by recycling, which was approximately 6 m^3. The control bed did not collect the rainfall which was allowed to run to waste.

Figure 7 shows the change in N levels for the four treatments (ppm) as monitored on a weekly basis during the irrigation season.

DISCUSSION

Effects on Plant Growth and Appearance. Analysis of the results in Table 1 show that there was no significant difference in plant growth or colour between the treatments, thus it can be safely assumed that there is no detrimental effect in using recycled water for irrigation. The degree of rooting through varied predominantly with the bed substrate material rather than the method of water application and was found to be severe in both the sand capillary beds and negligible in the gravel beds. The substrate also influenced pot cleanliness. Pots from the gravel beds could have been sold to the retail trade without the need for a pot-cleaning operation, those from the sand beds had sand from rainfall splash adhering around the lower section of the pots.

Water Usage. The mains water used by the treatments varied from 2 m^3 to 12.8 m^3 with the recycled capillary bed using the least. This variation may be accounted for in two ways. The difference between the recycled beds and the control bed reflects the amount of drainage water (from rainfall or excess irrigation) collected and re-used rather than run to waste, thus reducing the volume of mains water required to meet the plant's water demand and evaporation. The variation between treatments may, in part, be accounted for by wind drift from the overhead sprinklers and direct evaporation from the free water surface in the flood bed during its flood cycle. It is also accepted that any leakage due to imperfect sealing of the beds would be greater in the flood bed due to the greater head and mass of water in the bed, whereas in the capillary bed, water is held under tension within the substrate matrix and is slower to drain. Consideration of the total volumes of water used clearly indicates the water savings that can be made.

Water Nitrate Levels. An initially high nitrate level drops off very rapidly then slowly increases during the season (Fig. 7). The trend in nitrate levels is similar for all treatments. These high values are thought to be a result of nitrate from the initial residues in the compost being flushed out of the system, and because this was during the start-up phase of the trial, the addition of quantities of mains water to the systems reduced the nitrate concentration rapidly as the total stored volume increased. The gradual increase in nitrate during the season is thought to be a result of two combined factors. The first is the increase of nitrate levels in the incoming mains water, such a change is accepted as normal by the local water supplier. The second is the Osmocote, which is designed to give an increased release of nitrate as temperatures increase during the season, thus making more nitrate available for leaching through the potting media to gradually build up in the water. There are also some peaks in the nitrate levels (e.g., 13 May, 1 July) and as these occurred after periods of rainfall it is suggested that these peaks are a result of a thorough flushing of the potting media. The capillary bed was the system least subject to these peaks. This is thought to be due to the salts having been concentrated in the upper layers of the sand through capillary rise and evaporation thus requiring a greater amount of rain to flush them out of the bed.

Water savings can obviously be made by recycling rain/irrigation without the build-up of nitrate, pests, and disease to levels detrimental to the plants. This could

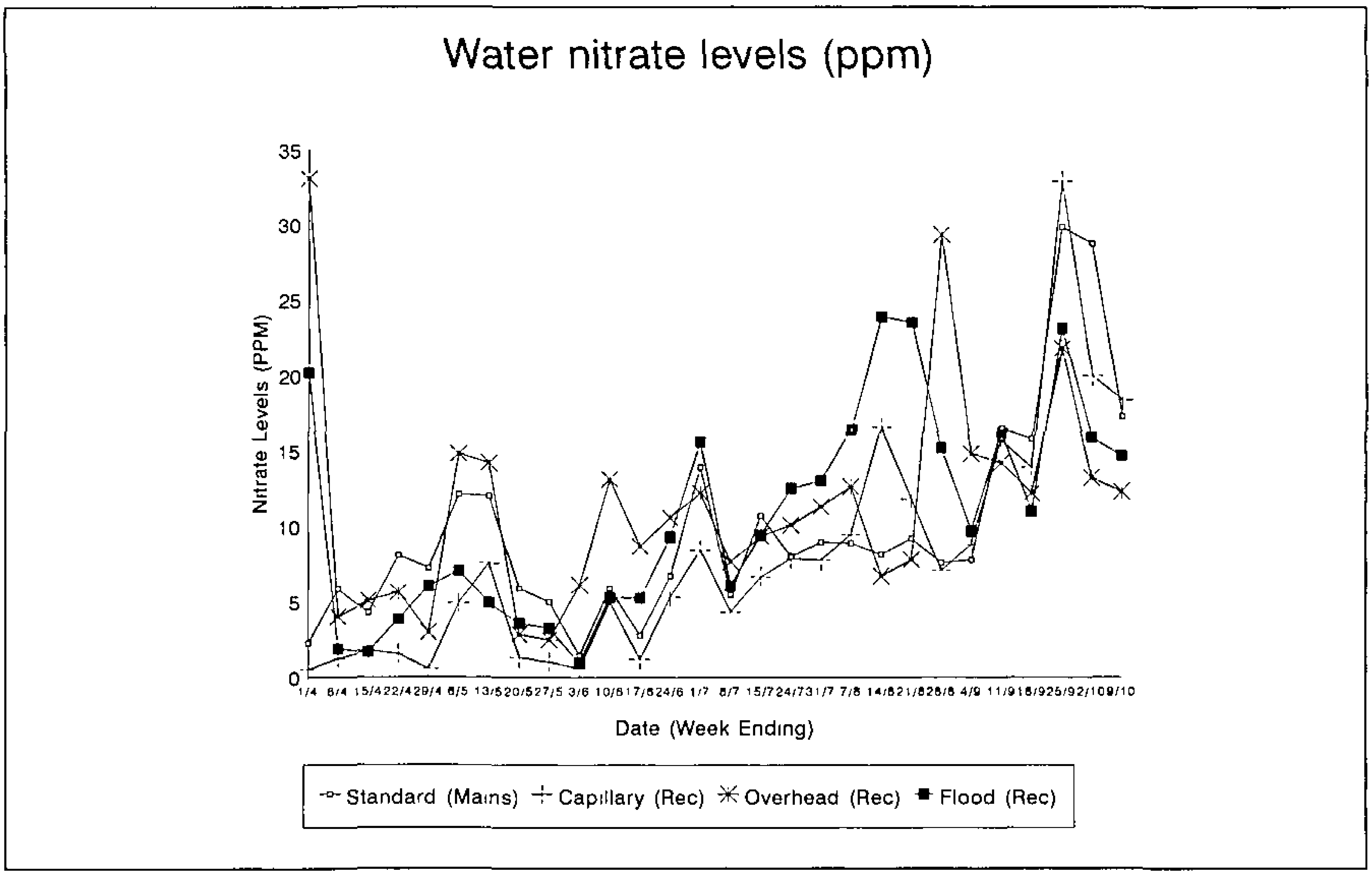

Figure 7. Water nitrate levels during 1994.

suggest that sterilisation is not always necessary. The reuse of the nitrate-laden water also offers the potential to save money through reduced nitrate losses and the costs associated with nitrate discharges to a watercourse. The work will continue at Writtle in 1995, with beds planted to an increased density and trials to attempt to limit rooting through into the sand beds. A commercial scale nursery has expressed an interest in installing a large flood bed system and this will also be monitored.

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REFERENCES

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