THE CALCULATION OF CONTRIBUTING AREAS FOR CHALK CATCHMENTS

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Since the inception of WaPUG considerable discussion has taken place concerning the calculation of the percentage impermeability, PIMP, for a catchment and the treatment of pervious areas. This brief paper is intended to contribute to this discussion with particular reference to sand or chalk catchments in WRAP Class 1.

Figure 1 shows a typical area of suburban development served by a single drainage system. The area comprises:

Roads	0.4 ha)	Total impermeable area
Roofs	0.6 ha)	1 ha
Verges	0.4 ha	
Front gardens	0.6 ha	
Rear gardens	1.0 ha	
Playing fields	2.0 ha	
Total	**5.0 ha**	

Whether drives and paths should be treated as permeable or impermeable is not considered in this discussion.

Within the Wallingford Procedure the area can be treated in a number of ways:

1) All contributing — PIMP = 20%

2) Playing fields non-contributing — PIMP = 33%

3) Playing fields and rear gardens non-contributing — PIMP = 50%

4) Playing fields, front and rear gardens non-contributing — PIMP = 70%

Before deciding which approach to take it is worthwhile looking at the implications of these four values of PIMP. The Wallingford Procedure calculates runoff using the well-known equation:

$$PR = 0.829\,PIMP + 25\,SOIL + 0.078\,UCWI - 20.7 \qquad (1)$$

For unit impermeable area (1ha) and a SOIL value of 0.15 for a chalk catchment the runoff (m^3/mm rain) is given by:

$$Runoff = 8.29 + 10\,(0.078UCWI - 16.95)/PIMP \qquad (2)$$

Figure 2 shows the variation of total runoff with UCWI for the four cases considered.

For South Eastern England, where most of our chalk catchments lie, the average annual rainfall is between 600 and 800mm and the UCWI for design rainfall events will be around 70. At this value the estimated runoff from our typical catchment varies between 4.0 and 6.7 m^3/mm rain depending on how much pervious area has been included.

The dangers are apparent from the behaviour at high values of UCWI. A model may accurately simulate the response to observed winter rainfall when UCWI is high and yet underestimate runoff by 50% when UCWI is low.

This variation is somewhat greater than desirable when designing sewerage works and so when we first encountered chalk catchments we were faced with the question "How much pervious area should be included?"

The original Wallingford Procedure documentation is unequivocal and says "all" but is this correct?

WaPUG User Note 9 says exclude large pervious areas such as playing fields but this still leads to a PIMP of only 33% and low predicted runoff.

WaPUG User Note 21 says include pervious area within 10m of contributing paved areas. Roof areas are not used to define this. In the example given in Figure 1 this is equivalent to case (3), i.e., a PIMP of 50%.

Our first step in trying to answer the question was to look at the alternative PR equation given in the Wallingford Procedure, which was derived from the same data:

$$PR = 0.662\,PIMP + 0.00219(100 - PIMP).SOIL.UCWI \qquad (3)$$

Figure 2 also shows the variation between total runoff from our typical catchment and UCWI using equation (3). At high values of PIMP the results are similar but at low values the spread of values of runoff is increased even more.

Having failed to find help from the alternative PR equation we decided to look at the original data set from which both PR equations were derived. We reasoned that if PIMP was calculated in the same way as for that data, this would give us the best prediction of runoff.

The data is described in IoH Report No 60 and Road Research Technical Paper No 55. Of 17 experimental catchments used, only one had a SOIL index of 0.15. This was a Government Training Centre at Kidbrooke and is shown in Figure 3. The impermeability was 68%. This figure is well above commonly met values and thus provides little assistance in identifying contributing areas.

Conclusions

The result of our investigation was that little guidance can be given as to how to estimate runoff from highly pervious areas but the following conclusions can be drawn:

1) The PR equation is not applicable to normal residential development in highly pervious catchments.

2) Provided that PIMP is greater than 50%, the amount of pervious area included has little effect on predicted runoff.

3) There is an urgent need for the collection of long term data from catchments with a low soil index.

Recommendations

Until more data has been collected, we recommend that for design purposes any pervious areas which would reduce PIMP below 50% be excluded from the contributing area.

Postscript

There is evidence (e.g., FSSR4) that chalk catchments can have a high runoff during extreme rainfalls. However, to the authors' knowledge there is little quantitative information available.

Figure 1. Typical sub-catchment.

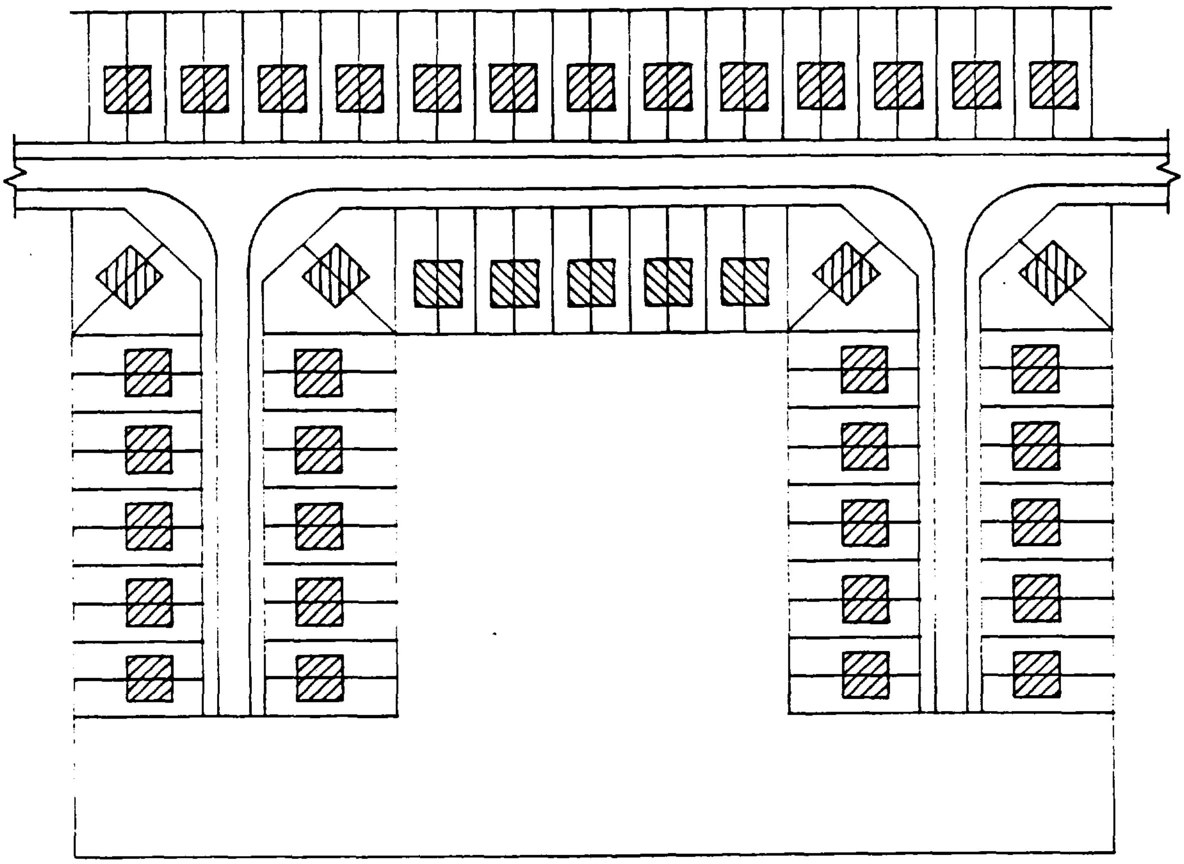

FIGURE 2

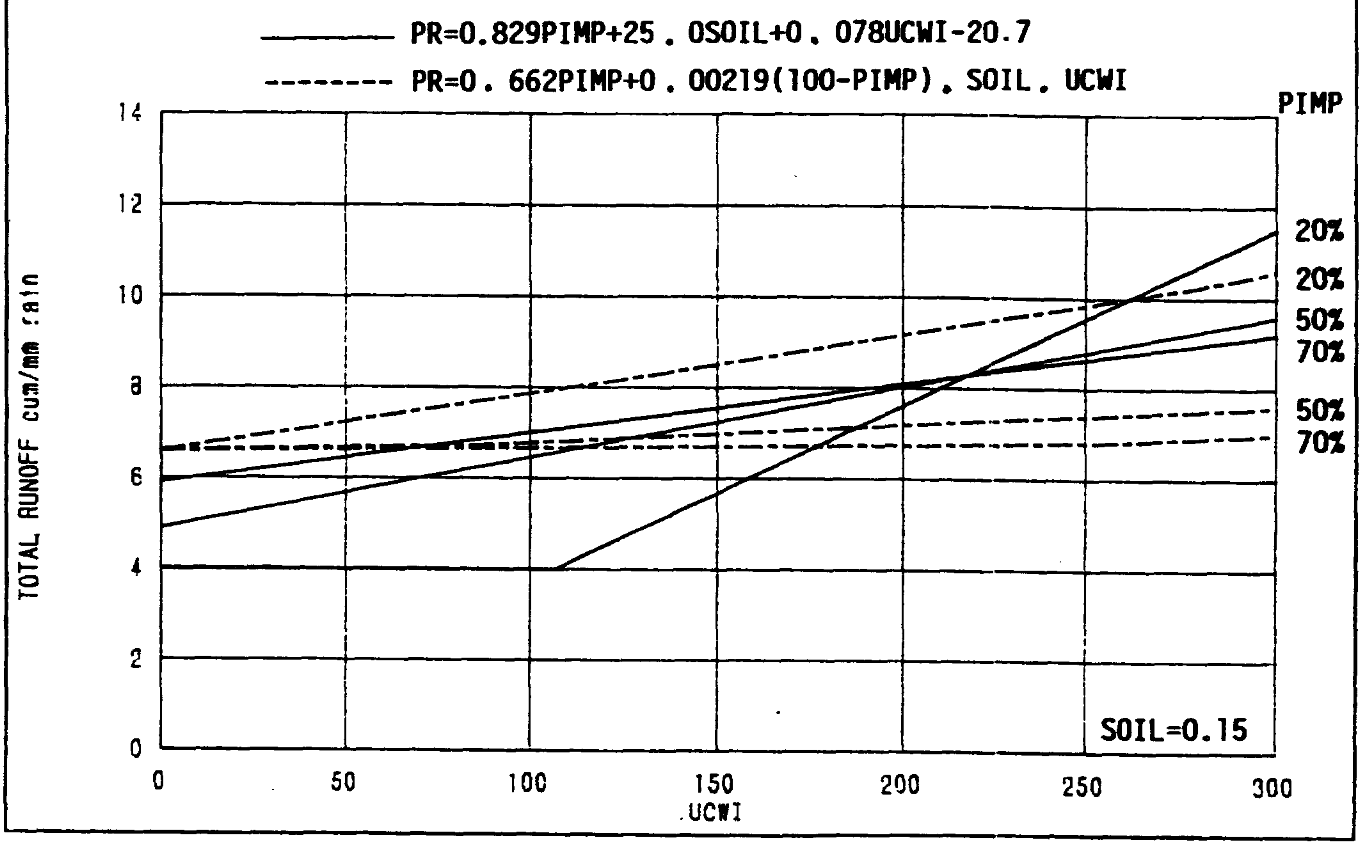

Figure 3

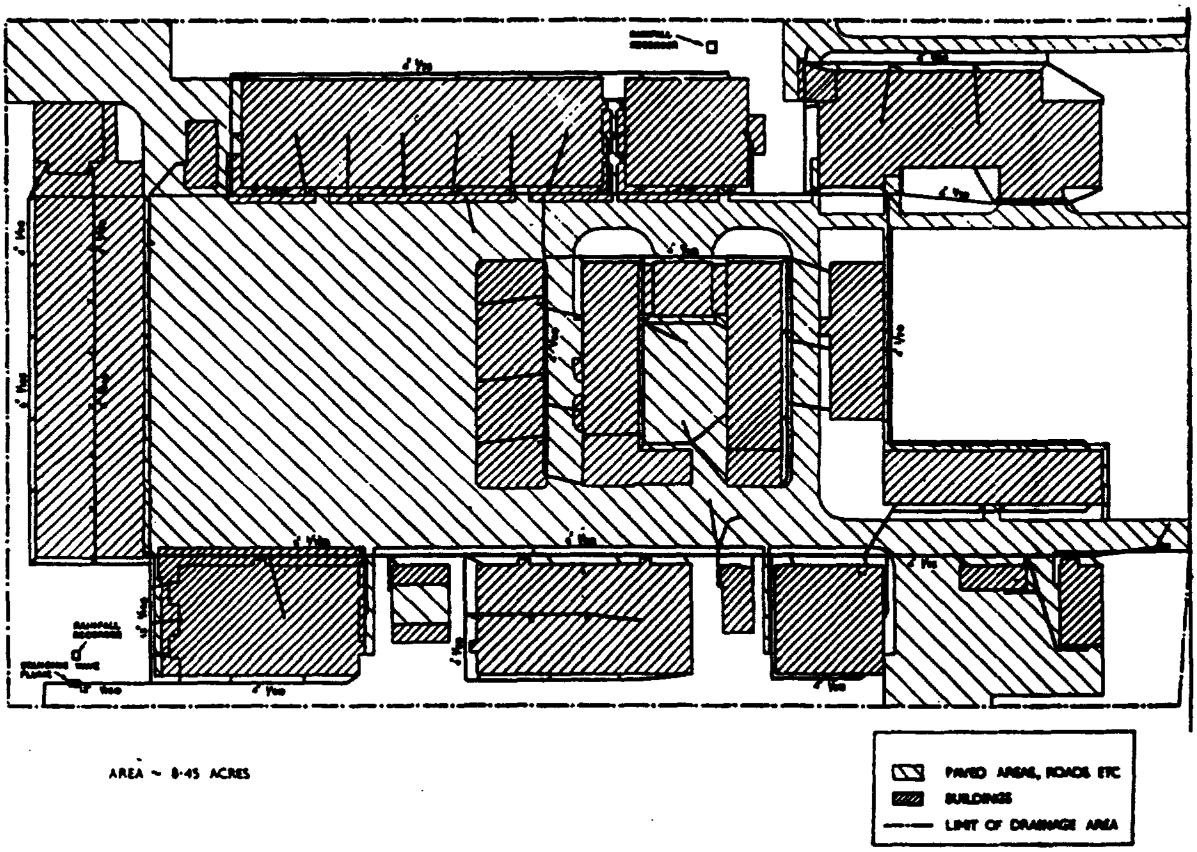

FIG. 7. Kidbrooke Government Training Centre (Area 3)
from Road Research Technical Paper No 55