DESCRIPTION OF THE HOUSE BLOCK MODEL WITHIN OVERSEER® NUTRIENT BUDGETS

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Introduction

OVERSEER® Nutrient Budgets (hereafter referred to as *Overseer*) is used to develop nutrient budgets and assess the environmental impact of a range of agricultural land uses. On many agricultural properties, there is a house block, which is defined as the area of a farm containing the house and associated land occupied for personal use.

The house block model was originally developed to align with a model Environment Bay of Plenty was using to assess the impact of different land uses on water quality. There was evidence that septic tank effluent may have been an important contributor to stream N loading on pumice soils. For example, Hoare (1984) noted that nitrate concentrations in urban streams were higher than those from rural streams, and this was consistent with the loads discharged to septic tanks in the stream catchment. Ray (2000) noted reports of similar or higher levels of N in stream water that was attributed to septic tanks in the Lake Taupo area. A school science fair project also indicated that losses from urban house property could be significant (these results are presented later in this paper).

A house block was therefore created within OVERSEER® so that the full range of range uses on agricultural properties could be modelled. Three general types of losses were considered to be important for house blocks, namely from the sewage system, from vegetated areas (lawn and gardens) and ‘miscellaneous’ losses. This paper outlines the model used to derive house block nutrient budgets.

Model background

Septic Tanks

Effluent entering septic tank system is reported to have a relatively constant composition (USEPA, 2002; Whelan and Titammis, 1982). The study of Whelan and Titammis (1982) was the only study found that reported nutrient concentrations that cover the range of nutrients modelled in *Overseer*. Annual per person nutrient loadings to septic tanks can be estimated from the concentrations of Whelan and Titammis (1982) and wastewater flow allowance.

A typical wastewater flow allowance is 180 l/person/day (ARC Technical Publication No.58). This reduces to 140 litres per person per day for houses with only roof water supply, and to 115 litres per person per day for houses with roof water supply and using water reduction fixtures. It is probably that most rural areas are on a roof tank, or on farm bore or low-pressure reticulated systems where the water use is expected to be similar to those that use roof tank systems. Hence, a value of 140 litres per person per day was considered the most appropriate value to use.

Septic tank nutrient loading rates based on a wastewater flow allowance of 180 l/person/day, and the concentration data of Whelan and Titammis (1982) are shown in Table 1,

Table 1. Average concentration of effluent entering a septic tank system (Whelan and Titammis, 1982), and effluent load based on wastewater flow allowance of 140 l/person/day.

	N	**NH_4-N**	**Total P**	**Sol P**	**Na**	**K**	**Ca**	**Mg**
Concentration µg/ml	125.4	109	17.08	16.56	150.4	34.74	39.3	13.7
Load kg/person/year	6.40	5.56	0.87	0.85	7.68	1.77	2.00	0.70

The dominant N form in septic tank effluent is NH_4. However, total N changes quickly from NH_4 to predominantly NO_3 form when septic tank effluent enters the soil via the drains (Whelan and Barrow, 1984a; USESPA, 2002). Most of the P is present as soluble P (Whelan and Titammis, 1982; Whelan and Barrow, 1984a; USESPA, 2002). Given the dates of many of the studies and the general reductions in phosphate levels in detergents in recent decades, P loss is expected to be lower than that shown here, although the degree of the reduction could not be assessed.

USEPA (2002) reported that in a fine sand, nutrient concentrations in soil water as a percent of effluent concentrations in added effluent 0.6 m from the source was 50% for total N and Cl, and 5% for P. At 1.2 m, reduction was 31% and 41% for N and Cl respectively, and 2.5% for P. This indicates that the soil has some ability to reduce N and P concentrations. It was assumed that cations (K, Ca, Mg, Na) are similar to N and Cl. The reduction in Cl, a free moving ion with low soil sorption affinity, indicates that some processes other than those normally associated with the reduction of N may be present, and that the actual reduction in N may be about 30% as estimated from the different reductions for N and Cl. On sandy soils in Perth, there was no reduction in total inorganic N below the drains of septic tanks (Gerritse et al., 1995; Geary 2005). Gunn (2003) indicated that there was a 15% reduction on coarse grained soils, and 25% on fine grained soils.

Therefore, the discharge of N from septic tanks to ground water was estimated using the per person loading data in Table 1, but reducing N loading by 30% to account for loss processes, to give a septic tank emission to ground water of 4.48 kg N/person/year.

P from septic tanks appears to contribute little to stream loads in the Rotorua Lakes area (Hoare, 1984), with Ray et al. (2000) noting that phosphorus is strongly bound to soil types found in the Rotorua Lakes area. On sandy soils in Perth, there was a correlation between the ability of the soil to sorb P, and the amount of P absorbed below the septic tank (Whelan et al., 1981; Whelan and Barrow, 1984b; Gerritse et al., 1995; Geary, 2005). However, the ability of these sandy soils to remove P appeared to be limited to between 1 and 8 years (Geary 2005, Gerritse et al. 1995), and P can readily move through to the water table (Geary 2005, Gerritse et al. 1995, Whelan et al 1981). USEPA (2002) presented results that indicate P penetration into soils could be 52 cm per year on sands and 10 cm/year on silt loams. It is also probably that P losses will be lower on soils with high phosphate retentions, although it was noted that there was no simple method for predicting phosphorus removal rates at site levels (USEPA 2002). Thus, it would appear that the loss of P from the soil is driven by the ability to absorp P and a drainage factor. Therefore, as an initial estimate, P loading in Table 1 was multiplied by the standard rainfall factor already used in *Overseer*, and then reduced by 1 minus the anion storage capacity divided by 120 to take account of the ability of the soil to sorb P.

Lower emissions can be obtained from new advanced septic tank systems (Scholes, 2007, USEPA 2006). The average reduction in N in effluent was 60% in advanced septic tank systems, which was about twice that in conventional systems (USEPA 2006). For the Rotorua lakes, a target of 15 mg/l has been set which is equivalent to 1 kg N/person/year. However, measured data indicates a typical loss of 1.5 kg N/person (Scholes, 2007). Advanced septic tank systems was added to the model by assuming the loss to water for N was 1 kg N/person/day with a 30% reduction as above was applied. For P, the effluent loading was multiplied by 0.70 (median loss reported by Scholes, 2007), and the scaling for p reported above applied. For the other nutrient, loading was also multiplied by 0.7. It will be up to regional council to define systems that meet the advanced system criteria.

For reticulated systems, discharge from septic tanks to ground water was set to zero for all nutrients.

It should be noted that the performance of septic tanks is dependent on proper installation and maintenance of the tank and soak fields. For example, Environment Bay of Plenty noted that some systems in the Rotorua area behave more like soak holes, which could have much higher emissions than septic tank systems.

Losses from lawns and gardens

In a school science fair project, six 100 mm cores were taken from three separate areas (lawn, flower garden, and vegetable garden) from the author's property in Hamilton in May. The vegetable garden is largely a compost-driven system. The flower garden gets a little fertiliser once a year. These columns were leached over 10 days, leachate collected and analysed for NO_3-N and NH_4-N. The proportion of lawn, flower garden, and vegetable garden on the property was also measured. Annual N loss was estimated as the N concentration in the leachate times the surface area of the lysimeter times the average drainage Hamilton (Table 2). This gave an average annual section N loss of 22 kg N/ha/yr.

Table 2. N concentration in leachate, annual and N loss and % coverage of the section for lawns, flower and vegetable garden.

Source	N concentration in leachate (ppm)	Annual N loss (kg N/ha/yr)	% coverage of section
Lawn	2.7	4	28
Flower	58	87	9
Vegetable	170	258	5

The design of the experiment means that these results must be used with caution, but the high losses from a compost driven vegetable garden does indicate the potential for high N losses from cultivated areas on small blocks.

Although there are several references that suggest that house lawns can be a significant contributor to nutrient loadings, little measured data was found. King and Balogh (2006) reported runoff and drainage losses of 2-4 kg N/ha/yr and up to 1 kg P/ha/yr from golf courses, and included a reference to a loss of 3.8 kg N/ha from lawns in Illinois. In a report prepared for Environment Bay of Plenty by Elliott, it was noted that:

> *"The storm yield for residential catchments in Rotorua was 1.9 kg N/ha/annum and 2.3 kg N/ha/annum for urban areas (Macaskill et al. 2002). Some of this runoff probably comes from road surfaces. A typical stream concentration measured at the outflow is 0.5 g N/m*^{3}*, although this is probably influenced by a rural component. With a base flow runoff of 500 mm, the base flow yield would be 2.5 kg/ha/annum. Hence, the total yield from an urban property is 4.8 (2.3 + 2.5) kg N/ha/annum."*

The *Overseer* cut and carry model indicated that losses from no fertiliser systems were generally in the 5-10 kg Na/yr range. Modelling the rotations and management practices of the home vegetable garden using the *Overseer* crop model indicated losses could range from 40-150 kg N/yr range.

Based on this information, N loss for lawns was set at 3 kg N/ha/yr and for cultivated areas at 87 kg N/ha/yr. Both were adjusted for rainfall using standard procedures within the *Overseer* model. The area under cultivation is calculated as the block area, which is a user input, multiplied by the percentage of the block under cultivation, which is a user input. The area of lawns was estimated as the block area, less the area under cultivation, less an estimated area under buildings or hard surfaces (drives and paths).

For other nutrients, it was assumed that loss by leaching was equal to input from rainfall. The input from rainfall using estimated using standard procedures within the *Overseer*.

Miscellaneous losses

Miscellaneous losses were taken as the nutrient losses from hard surfaces such as drive and roofs via their drainage systems. It was assumed that the difference in storm yield between residential catchments and urban areas noted above was due to runoff from hard surfaces. Hence, a miscellaneous base loss of 0.5 kg N/ha/yr was used for a rainfall of 1500 mm (average rainfall in Rotorua area) and weighted for rainfall.

Conclusions

The described model captures nutrient losses from a house block. The required inputs are block area, rainfall (mm) and distance from the coast (which can be copied from other blocks within *Overseer*), number of people on the property, the effluent management system (options are septic tank, advanced septic tank, and reticulated) and the percentage area under cultivation. It was noted that much of the information used to develop this model was in internal reports that are not readily found using normal search methods. Thus, it is probably that some of the underlying estimates will change as further data become available.

The N leaching loss per ha from the house block, particularly those with cultivated areas and/or older style septic tank systems, can be similar to losses from dairy farms. Thus, on small blocks (< 10-20 ha) the losses from the house block can be a significant contributor to total property nutrient losses. For large farms, the losses from the house block are normally insignificant and can be ignored. The model is not intended to be used for urban areas.

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