MODELLING THE PREDICTED CONTAMINANT CONTRIBUTION OF ON-SITE WASTEWATER MANAGEMENT SYSTEMS TO SURFACE AND GROUNDWATER AT LOCH SPORT IN THE GIPPSLAND LAKES, VICTORIA, AUSTRALIA.

J H Whitehead
School of Environmental & Life Sciences, University of Newcastle, NSW 2308, Australia.
joe.whitehead@newcastle.edu.au

P M Geary
School of Environmental & Life Sciences, University of Newcastle, NSW 2308, Australia.
phil.geary@newcastle.edu.au

Abstract

Loch Sport is a coastal town of approximately 1,600 houses located in the Gippsland Lakes region of Victoria, Australia and is the single largest unsewered community in Victoria. The community comprises a relatively small permanent population whilst the remaining houses are holiday homes. The holiday homes are occupied intermittently, but commonly by quite large numbers of occupants, predominantly during the major holiday periods. Historic data has identified elevated nutrient levels in both groundwater and surface water. Whilst there are other possible sources of elevated nutrient levels in both groundwater and surface water, on-site wastewater management systems have been suggested as a possible source.

A recent study has, for the first time, combined a systematic and detailed audit of approximately 150 on-site wastewater management systems and their performance with both surface water and groundwater sampling and testing for a range of water quality parameters. Data from the study has been used to populate and calibrate the Decentralised Sewage Model, an innovative and sophisticated catchment scale model which can be used for detailed assessment of catchment scale impacts of large numbers of on-site systems. The model has been used to demonstrate the extent to which on-site wastewater management systems contribute to both surface and groundwater contamination in the catchment for the current and possible future maximum development.

Keywords: On-site wastewater management systems, Loch Sport, Gippsland Lakes, nutrients, Decentralised Sewage Model.

INTRODUCTION

Loch Sport is a small coastal town in the Gippsland Lakes, Victoria, Australia. The town is approximately 5.5 km long and 0.5 km wide and is situated on a narrow spit bounded by Lake Reeve to the south, Lake Victoria to the north and The Lakes National Park to the east and west. Both Lake Reeve and Lake Victoria are listed as Zones of International Significance under the international RAMSAR convention for the protection of wetlands. Residents rely on rainwater collection tanks for water supply and on-site wastewater systems (OWMS) for sanitary service. There are a number of groundwater bores, in both a deep aquifer and a shallow unconfined aquifer which are typically only used for non-potable purposes. Loch Sport has a permanent population of approximately 1,000 increasing to approximately 6,000 in holiday periods. Presently some 1,600 lots are developed but there remain a further 1,200 lots with potential for future development.

Approximately 90% of all OWMS comprise septic tanks and disposal trenches, with approximately 10% being aerated wastewater treatment systems (AWTS), commonly with surface drip irrigation. A small number of larger scale treatment systems service commercial premises. For almost two decades OWMS have been suspected of contributing to poor public and environmental health outcomes in Loch Sport (East Gippsland and Wellington Shire Councils, 2006). For the first time, in a recent study undertaken by the authors, detailed audits of some 150 OWMS have been undertaken together with a program of surface water and groundwater monitoring in an attempt to quantify and model more accurately, the contribution of OWMS to contaminant loads in the catchment.

METHODS

150 OWMS at a selection of both permanently occupied houses and holiday homes were inspected during the January holiday period in 2009 to determine OWMS performance following peak usage. Approximately 20% of the inspected properties were permanently occupied. Detailed data obtained from the system inspections relating to system integrity, performance and measures of failure, including observed or potential discharge to surface or groundwater and size and performance of the trenches or irrigation area, was recorded and used to calibrate the Decentralised Sewage Model (DSM).

Seven groundwater and three surface water locations were sampled to ascertain contamination levels. Samples were analysed for pH, EC, ortho-P, nitrate, Total Coliform (TC) and E.coli.

The Decentralised Sewage Model (DSM) (Whitehead et al., 2007), a GIS based decision support tool designed to assess and compare a range of wastewater servicing options, was used examine the relative risks of and to quantify the contaminant discharge from OWMS. The DSM is a rapid-assessment tool which predicts the performance of on-site and decentralised wastewater management systems under varying environmental conditions. It does this by simulating the movement of pollutants (nitrogen, phosphorus and pathogens) within the effluent load as it travels from the point source down the catchment as surface or subsurface flow. The model simulates a 20 year period and is designed to provide conservative estimates of wastewater system performance. The model takes information relating to the slope, nature of soils, rainfall and evapotranspiration and, considering the nature of effluent being generated by each property and the type of on-site system servicing each property, determines how much of that effluent can be disposed of within a given land area using water and nutrient modelling and how much will surcharge.

RESULTS AND DISCUSSION

Many septic tanks were old and are undersized by current standards. Much greywater is discharged to the ground surface and in wet weather is very likely to be washed into street drains and into Lake Victoria and Lake Reeve. More than 45% of the systems were found to require minor to major works in order to bring the system to an acceptable standard of performance and 4.6% of systems required immediate major works as these systems were observed to be failing. The most common works required was trench reconditioning or replacement, as the existing trenches were underperforming or failing for a variety of reasons. A total of 65% of the land application systems inspected were undersized, with field investigations suggesting their size to be commonly as little as $35m^2$. Best-practice design criteria require between $273m^2$ and $409m^2$ of land application area to successfully assimilate generated wastewater on each lot, depending on house size. The present onsite wastewater management framework requires a much smaller area for land application. This substantially reduced area available for effluent management results in a direct and significant increase in surplus hydraulic, nutrient and pathogen loads from each property. Given the relatively small lot sizes and existing development on many lots along with required buffer distances, many lots within Loch Sport would not have sufficient area available for a suitably sized land application area. Sixteen AWTS were inspected and all had no effective disinfection. Those systems with surface spray or surface drip irrigation do not comply with regulatory requirements for surface irrigation which requires effluent quality to have <10 cfu/100ml E.coli. Table 1 summarises surface and groundwater sampling data.

The DSM contains a specific module which can provide an estimate of average long-term generation of nutrients (total nitrogen and phosphorus) and virus by point wastewater discharges to land (representing on-site wastewater land application systems). The results of the preliminary risk assessment modelling using the DSM demonstrate that the majority of developed lots in Loch Sport are likely to be surcharging surplus effluent for at least part of each year. Consequently, a large proportion of the total nutrient and pathogen load is also expected to be discharged as surplus, potentially contributing to off-site environmental and public health impacts. Table 2 shows the average annual hydraulic and pollutant surpluses for the current development in Loch Sport and estimated surpluses based the development of all available lots.

Table 1 Surface and groundwater sampling data

Sample type	pH	EC (uS/cm)	E.Coli (MPN/100 ml)	TC (MPN/100 ml)	Turbidity (NTU)	NO_3-N (mg/L)	Ortho P (mg/L)
Groundwater Bore	5.85	1183	0	0	53	<0.150	<0.150
Groundwater Bore	4.57	3540	-	-	6	0.655	0.211
Groundwater Bore	4.62	2510	0	1100	4	3	<0.150
Groundwater Bore	5.99	3650	0	46	2	1.25	<0.150
Groundwater Bore	5.35	728	1	870	6	0.611	<0.150
Groundwater Bore	6.15	2510	980	>2400	110	<0.150	1.64
Groundwater Bore	5.84	1010	770	>2400	3	8.85	0.151
Surface Water	8.5	125,400	<10	52	12	0.853	<0.150
Surface Water	7.71	36,200	10	870	2	<0.150	0.249
Surface Water	7.65	135,800	170	780	56	1.65	<0.150
Groundwater Bore	6.22	2870	-	-	14	3.24	0.164
Groundwater Bore	6.43	1820	-	-	2	3.28	<0.150
Groundwater Bore	5.47	11,650	-	-	45	0.301	<0.150
Drinking Water Guidelines (NHMRC & NRMMC 2004)	6.5-8.5	781-1562	0	0	-	10	-
Aquatic Ecosystems (Estuaries) (ANZECC & ARMCANZ 2000)	7-8.5	-	-	-	-	0.015	0.03*
Recreational Water (ANZECC & ARMCANZ 2000)	6.5-8.5	1562	35	150	-	10	-
*Guideline for Total Phosphate	Value exceeds drinking water guideline			TC Total Coliforms		NO3-N Nitrate as N	

Table 2 Average annual hydraulic and pollutant surpluses in Loch Sport

Parameter		Annual pollutant load (% total annual load)	
		Present development of 1600 lots	Full development of 2700 lots
Surface Discharge	Hydraulic (ML/year)	16.39 (15%)	185.22 (83.6%)
	TN (kg/year)	1,821 (44.6%)	1,956 (22.7%)
	TP (kg/year)	1,115 (68.2%)	1,210 (42.7%)
	Virus (org/year)	1.952 x 1014 (1.8%)	1.43 x 10^{15} (>100%)
Subsurface Discharge	Hydraulic (ML/year)	18.81 (17.3%)	20.44 (9.2%)
	TN (kg/year)	239 (5.9%)	196 (2.3%)
	TP (kg/year)	698 (42.7%)	590 (20.8%)
	Virus (org/year)	7.032 x 1011 (0%)	1.98 x 10^{15} (>100%)
Total Discharge	Hydraulic (ML/year)	35.2 (32.3%)	205.7 (92.8%)
	TN (kg/year)	2,060 (50.4%)	2,152 (25.0%)
	TP (kg/year)	1,813 (100.0%)	1,800 (63.5%)
	Virus (org/year)	1.959 x 1014 (1.8%)	3.41 x 10^{15} (>100%)

CONCLUSIONS

The model predicts significant pollutant surcharge in the current development scenario. With full development of all available lots, approximately 92.8% of the total annual hydraulic load generated is likely to surcharge in an average year, 83.6% as surface surcharge and 9.2% as subsurface surcharge. DSM modelling predicts that in an average year only 15 lots are considered capable of managing the entire hydraulic load, 42.5% of total lots generate a surplus hydraulic load (overflow) on up to 25% of days of the year, 22.6% of total lots generate a surplus 25 and 50% of days of the year, 0.5% of total lots generate a surplus between 50% and 75% days of the year, and 34.4% generate surplus hydraulic load for more than 75% of days of the year. 373 lots are expected to surcharge effluent every day of the year. These values demonstrate the ultimate consequences of continued approval and implementation of undersized land application systems.

REFERENCES

East Gippsland and Wellington Shire Councils (2006). Domestic Wastewater Management Plan. http://www.egipps.vic.gov.au/Files/TOCES.pdf

Whitehead, J.H., Asquith, B. and Kidd, L. (2007). Quantitative Risk Assessment of Decentralised Wastewater Management Systems in a Drinking Water Catchment. In 11th National Symposium on Individual and Small Community Sewage Systems Proceedings (Ed. K. Mancl), American Society of Agricultural Engineers, St. Joseph, Michigan.