Zero Discharge of Great Barrier Campground Greywaters

Clive Rowe

Pattle Delamore Partners Ltd, PO Box 9528, Auckland 1149
Email: clive.rowe@pdp.co.nz

ABSTRACT

The Department of Conservation has six camping grounds on Great Barrier Island, in the Hauraki Gulf, at which it has been upgrading amenities for users. One of the six is served by a communal waterborne sewerage scheme, but at the other five the existing wastewater systems are limited to waterless, composting toilets. There is no electricity supply at any of the five. The new amenities include new ablution and communal meal-place facilities, where there were none before.

This paper describes the planning for and design of new total evapotranspiration systems that have been built to treat and dispose of the new flows of sullage that are generated at the five unsewered sites.

Keywords: Greywater; evapo-transpiration; camping; appropriate technology; onsite disposal.

INTRODUCTION

The Department of Conservation (DOC) operates camping grounds at six popular beaches on Great Barrier Island in the Hauraki Gulf. Figure 1 shows their locations.

Figure 1. Campground locations

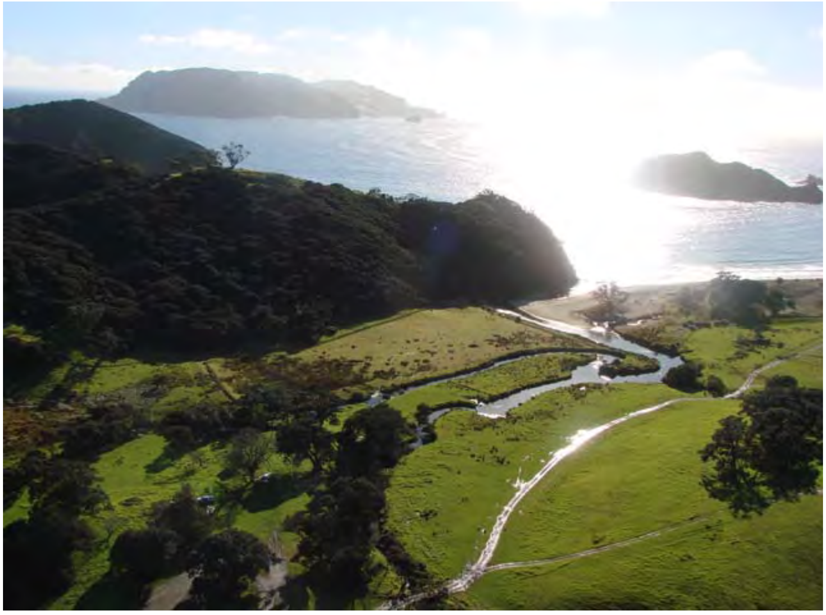

Figure 2. Harataonga Site

The two camps on the western side are in sheltered harbours and are used primarily by kayakers and trampers, while the four on the eastern side are at ocean beaches and are favoured more for surfing, swimming, skin-diving and fishing. Figure 2 shows an aerial view of the Harataonga site, on the eastern side.

There are no public electricity, water supply or sewerage systems on the island, and even places where food and other basic provisions can be obtained are few and far between. Facilities for campers are very basic and until 2007 were generally limited to untreated water supplies from upland streams, cold showers, outdoor hand-basins and wash-tubs and waterless, composting toilets.

In 2007, DOC embarked on a programme of upgrading the camp-ground amenities by providing shelters for communal kitchen, laundry and ablution purposes. The same basic cross-sectional design was used for all sites, with the number of modules lengthwise being varied according to the numbers accommodated at each camp. Figure 3 shows the typical construction of the shelters.

Figure 3. Typical new shelter.

At the Awana, Harataonga and Medlands campgrounds, where camp management and remoteness from home-base would sometimes necessitate over-night stays by the camp attendant, the shelter includes a small bunkroom (behind the end wall in Figure 3). The most distant camps from DOC's base at Akapoua, in Port Fitzroy, are about an hour's drive away, over some 30 km of windy narrow roads, mostly of gravel.

DOC required systems to be designed to treat and dispose of the greywaters that would be generated in the shelters at five of the six campgrounds. The sixth, at Akapoua, is part of DOC's headquarters village community, which has its own departmental power supply and a conventional water-borne sewerage scheme with ample capacity to accommodate its new greywater flow.

As discussed in more detail below, all of the new greywater disposal systems disperse their effluents to the atmosphere, by the process of evapotranspiration so, in a pure sense, the "zero discharge" of the title is a misnomer. However, in the common contexts of disposal to water or the land, the discharges are indeed zero.

CAMP OCCUPANCIES

All of the campgrounds are the subject of highly variable occupancy rates. In summary, the individual occupancies are characterised as follows:

- The busy season for all grounds is the peak summer holiday period each year, typically from 26 December to about 6 January. During that time, typically:
  - Akapoua typically has about 50% occupancy and
  - Awana, Harataonga and Medlands are full.
- Akapoua, Harataonga and Medlands are the most popular of the campgrounds during off-season times of the year, but never reach maximum outside the December-January peak. Akapoua is becoming popular as a staging point for kayakers, and is regularly occupied by groups of up to twenty for a couple of nights on some weekends.
- The Green generally attracts only kayakers and trampers and is very seasonal and never full.
- Whangapoua is a surfers' campground. As such, its occupancy is highly dependent on weather and surf conditions and, like The Green, it is never full.

DOC has recorded daily occupancies during the peak December-January periods for all campgrounds, since the summer of 2000/2001. The collected information has been analysed, and a "worst-case" wastewater load scenario determined for each campground. In summary, those worst-case scenarios, are represented by the data in Table 1.

Table 1. Camp occupancy data.

Camp Name/Location	Peak occupancy period 26 December to 12 January			
	For the peak overall season[1] during the seven years of record (2000/2001 to 2006/2007)		On single day of peak occupancy[1] during the seven years of record (2000/2001 to 2006/2007)	
	Total person-days	Average persons per day	Peak persons per day	Peak persons per campsite [2]
Akapoua	513	29	65	2.3
Awana	1120	62	170	1.3
The Green	360	20	20	2.0
Harataonga	1031	52	124	1.8
Medlands	1257	70	164	2.9
Whangapoua	323	18	30	0.6

(1) That dates of peak daily camp occupancies vary, between December 29 and January3, from campground to campground and from year to year.
(2) Based on an area allowance of 77 sq.m. per campsite.

WASTEWATER VOLUMES

One wash-hand basin and one kitchen sink was installed at each shelter, and greywater flows were based on the following assumed rates of usage:

From wash-hand basins: .... 10 litres per person daily
(based on notional averages of 5 uses and 2 litres per use, per person daily)

From sinks: .... 15 litres per campsite daily
(based on notional averages of 3 uses and 5 litres per use, per campsite daily)

Adjusted for the variable numbers of persons per campsite and rounded-up to provide a reasonable margin level of safety, the following per capita flows were adopted for design:

Awana and Whangapaoua: …………………….. 25 litres per person daily
The Green, Harataonga and Medlands: ..……. 20 litres per person daily

These flows related to the shelters only, and did not include volumes generated by other greywater sources in the campgrounds, such as showers and laundry tubs. Those other greywater flows were disposed of separately, via existing systems.

Moreover, in assessing the above figures, account was taken of:

- the fact that plumbing to the basins and sinks in the shelters will supply only cold water and
- the presumption that (recommended) spring-loaded, timed-flow taps would be installed to prevent wastage and minimise the volumes discharged. The recommendation was duly implemented, and such taps were installed throughout.

In a similar context to the timed-flow taps issue, a recommendation to install water meters on the water supplies to all campgrounds was also made. This was for two reasons, the first being to enable the validity of design assumptions to be checked, and the second being to provide firm rather than theoretically derived data for the planning and design of any future developments.

Akapaoua is excluded from the above figures because, as already indicated, its greywater disposal was adequately catered for by the existing wastewater system there.

INFLUENT WASTEWATER QUALITY

Greywater from each shelter is discharged via a new septic tank that is fitted with an effluent filter-screen. The filter-screen's 3mm apertures prevent any suspended solids larger than that size from discharging onwards to the disposal system.

No analytical details of the qualities of the campground greywaters were determined. It was assumed that they were similar to that commonly recognised (eg. Winneberger, pp 68-88).

SYSTEM DESIGN - GENERAL

While there are high numbers of campers over the Christmas holiday period each year, that peak starts and ends very abruptly, typically on 12 December and 12 January respectively, and there are virtually no "shoulder" periods of occupancy before or after those dates.

After that December-January peak, apart from short blips of occupancy that occur again around the statutory Anniversary and Waitangi Day holidays, the campgrounds are virtually deserted for the remainder of the year. Of particular relevance is that this prolonged period of virtual zero occupancy includes the hottest and driest weeks of summer between mid-January and the end of March.

In that period between mid-January and March, the high temperatures and low humidities combine to produce the highest annual rates of evaporation. That factor, coupled with the abrupt termination of peak effluent loading around 12 January, made evaporation and, more particularly, evapotranspiration an attractive option for effluent disposal.

The concept of total evapotranspiration (TET) was duly adopted for detailed design, such that the entire volume from each shelter is dissipated to the atmosphere, leaving no discharge of effluent being required to either water or land.

The TET at each site is effected via a specially constructed bed that is:

- made up of courses of media:
  - that collectively replace the top layers of soil, to a nominal depth of 400mm,
  - whose respective particle sizes are chosen to enhance the particular drainage, capillary evaporation and vegetation root uptake processes desired at the different levels in the bed, so as to maximise of the storage and evapotranspiration processes,
- lined over its bottom and around its sides with a synthetic impermeable membrane, to prevent both any leakage of effluent into the underlying soil, and any ingress of groundwater if there should be a high water table in the winter months
- mounded at the ground surface so as to maximize the runoff and minimise the infiltration of rainfall and
- planted in native shrubs that are chosen for their high rate of uptake and transpiration of groundwater, and rooting systems appropriate to the depths of the constructed beds.

Drawing on its in-house expertise in forest and wetland conservation, DOC's own specialists managed the selection, raising, planting-out and maintenance of the beds with appropriate species of shrubs and flaxes.

The same basic form of TET bed was adopted for all sites. A typical cross section is shown in Figure 4.

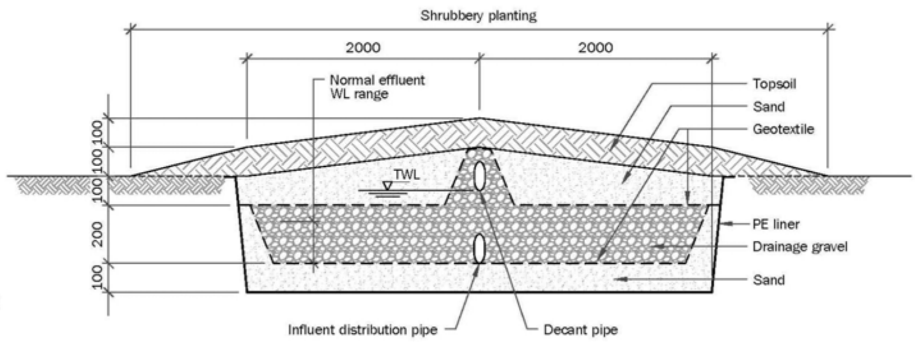

Figure 4. TET bed cross section (*Note, different horizontal and vertical scales*).

The various layers in the bed are, from the top down:

- A topsoil layer in which the shrubs are planted.
- A bed of sand chosen for its particle size distribution, designed (from Bernhart) so that the inter-granular pore size was a compromise between:
  - On the one hand, being small enough to retain moisture in the near-surface unsaturated/root zone, by capillary action, while
  - On the other hand, being not too small to accommodate the larger soil microbes, whose activities are dominant in the maintenance of porosity and prevention of clogging.
- A bed of drainage gravel of narrow, no-fines, particle size distribution, designed for the hydraulic buffering, storage capacity of its pores.
- A cushion course of sand, to prevent course particles of the overlying drainage gravel from puncturing the
- The synthetic membrane liner mentioned above.

The beds at all campgrounds are constructed to the same widths and cross sectional details. The lengths of the beds varied at the different campgrounds, in proportion to their respective flows.

The entire system, common to all of the five campgrounds involved, is designed to operate completely passively, driven only by the forces of nature. There are no electrically powered or mechanical components in the systems and only minor, once-a-year operational attention is required. These functionality and operational aspects are discussed below.

As already mentioned, the beds are mounded so that as much as possible incident rainfall is shed by the cambered sides. While it is acknowledged that intense summer rainstorms are a feature of the local climate, even during the already-mentioned hot and dry weeks of January through March, the effects of those summer storms are mitigated to a degree by the:

- Normal ample forewarning of approaching storms, and consequent departure of campers and
- The facts that summer rainstorms do tend to be particularly intense, and runoff tends to be more rapid (and infiltration correspondingly lower) from short intense storms than from longer, less intense rainfall events, even if total precipitation is the same (Chow et al, p.498).

SYSTEM DESIGN - CLIMATE DATA

Inasmuch as climate in general, and evapotranspiration in particular, are vital influences on the efficiencies of the TET and evapo-transpiration/seepage (ETS) disposal systems discussed below, climatalogical data relevant to Great Barrier has been obtained from national records. While there is a weather station on Great Barrier, unlike some others around the country, it does not measure evapotranspiration. ET data from the nearest stations that do collect it, at Leigh, Cape Colville and Whitianga were used for design (NIWA).

The standard climatological parameter, potential evapotranspiration (PET), was determined to be 4.5 mm/day during the mid-December to mid-January period.

SYSTEM DESIGN – TET BED SIZING

The TET bed sizes were based on the above-mentioned climate data and on design parameters that take account of advection and clothes line effects, based on the work by a number of practitioners and researchers in the technology (Beck; Bernhart; Linacre; Patterson), as well as on local regional guidelines (ARC, s10.3.4). These sources variously indicated actual ET, depending on factors such as the advection and clothes line effects mentioned, as being anything from “2-to-3” to 10 times the PET.

Having regard to the bed planting mentioned above, an actual ET rate of 15mm/day was adopted for design, i.e., approximately three times the PET.

The bed designs also provided, in the pores of the media courses, for storage of peak flow and infiltrated rain, based on conventional storage methodology (Bernhart; Rippl).

SYSTEM OPERATION

In mid-December, a week or two before the influx of campers, the water level in each TET bed is inspected by a DOC attendant. By the end of the previous summer season, around

March, evapotranspiration will have drawn the water-table in the bed down to or below the top of the coarse gravel layer. If infiltration of rainfall should have exceeded evapotranspiration during the following April-December period, the water-table in the bed will have risen accordingly.

If there is any such accumulation of infiltrated off-season rainfall in the bed, it is decanted by the DOC attendant during the December visit, using a simple siphon, and discharged into the ground via an adjacent a soakage drain. This leaves the bed effectively empty, in readiness for the flow generated by the influx of campers around Christmas.

Voids in the layers of media in the bed provide hydraulic balancing storage, and allow 17 or 18 day peak flow of wastewater to be dissipated by evapotranspiration over the January-to-March period. A safety margin of media voids is also allowed to cater for the contingency of summer rain infiltration.

By the end of each March, evapotranspiration will have emptied the bed, and the annual cycle will begin again.

PERFORMANCE SINCE COMMISSIONING

Construction was completed and the beds were grassed in the spring of 2008, and planted with flaxes and shrubs in the winter and spring of 2009 respectively.

First season of service was summer of 2008-2009 and, at the time of writing, the last significant loading was over the Easter weekend of 10-13 April 2009. While there is no quantitative data on performance to date, advice (DOC) is that no problems were evident and all disposal beds appeared to performing as they were designed to do.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the Department of Conservation for its permission to publish this paper.

REFERENCES

ARC, On-site Wastewater Systems: Design and Management Manual; Auckland Regional Council, Technical Publication No 58; 3rd Ed; Aug 2004.

Beck AF, Evapotranspiration Bed Design, (pp 411-415 in) *J. Envir. Engineering Div Proc Vol 105 No EE2*; American Society of Civil Engineers; April 1979.

Bernhart AP, Treatment and Disposal of Wastewater from Homes by Soil Infiltration and Evapo-transpiration; University of Toronto Press; 1973.

Chow VT, Maidment DR, Mays LW. Applied Hydrology; McGraw Hill Book Company; 1st Ed, 1988.

DOC, Pers.com.; Department of Conservation, Port Fitzroy Area Office (K Scott); July 2009.

Linacre ET, Swamps, (pp 329-347 in) Vegetation and Atmosphere, Volume 2: Case Studies (JL Monteith Ed); London Academic Press; 1976.

NIWA, National Institute of Water and Atmospheric Research; national climatology data base.

Patterson RA, Evapotranspiration Beds for Inland Areas; New South Wales Department of Local Government, Technical Sheet 05/15; March 2002.

Rippl W, The Capacity of Storage Reservoirs for Water Supply; *Proc Inst Civil Engrs*, 71 (1883), p270. (See in: Water and Wastewater Engineering, Fair Geyer and Okun, John Wiley and Sons (1966); Vol 1, p8-3).

Winneberger JHT, Manual of Greywater Treatment Practice; Ann Arbour Science; 1974.