APPROPRIATE SANITATION SYSTEMS FOR ARNHEM LAND OUTSTATIONS

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Abstract

This paper examines sanitation systems on remote Aboriginal outstations of Arnhem Land. A case study is presented to highlight the stages of inappropriate and appropriate technologies which have developed over recent decades. Systems evolved from nothing in the mid-1980's to waterborne flush toilet systems in the early 1990's. These proved extremely problematic and were subsequently abandoned in favour of dry pit toilet systems which are currently functioning well. Greywater management has also evolved from surface disposal to current trials of subsurface disposal and irrigation of fruit trees. The trial is described in detail. The entire case study presents a strong argument for planning and designing sanitation systems to suit the lifestyle of residents and maintenance capabilities of service providers, rather than utilising standard on-site wastewater systems as prescribed by regulators.

Keywords

aboriginal, appropriate, Arnhem Land, greywater, outstations, re-use, sanitation,

1 Introduction

Inadequate sanitation management is a major problem on remote Aboriginal communities across Australia. Failing sanitation systems contribute significantly to illness (Miller & Torzillo, 1996) making them health hazards rather than health providers as intended. This paper concentrates on sanitation systems in remote Aboriginal outstations.

1.1 Outstation overview

Outstations are small satellite settlements dispersed around larger remote Aboriginal communities. Most have less than 50 inhabitants, and are occupied by extended families with traditional links to the surrounding land. They generally have unique sanitation requirements compared to other remote Aboriginal communities due to their small size, extreme remoteness, semi-traditional lifestyle of residents, generally underdeveloped infrastructure and difficulty in providing maintenance services. There are approximately 900 outstations in WA, NT, SA and Qld with a combined population of 13,700 people, or 18% of the total remote Aboriginal population (Marshall & Lloyd, 1999). Services are generally provided to groups of outstations by Outstation Resource Centres (ORCs) based in larger, central communities. This includes provision and maintenance of sanitation infrastructure. In the Northern Territory, 31 major ORCs provide services to around 520 outstations.

2 Outstation Sanitation Systems

The type of sanitation system used by outstations is essentially limited to on-site septic tank & trench systems, pit toilet systems (basic or improved) or nothing. A sewage survey by the Centre for Appropriate Technology (CAT) in 1998 found that of 900 outstations and small communities in WA, NT, SA and Qld, 47% used on-site septic systems, 32% had pit toilet systems, 5% had no sanitation systems and 16% remained undetermined (CAT, 1998).

2.1 Septic systems

Septic systems are known to have significant problems on all Aboriginal communities where utilised, including outstations. Problems stem mainly from undersizing, poor installation, inadequate maintenance and inappropriate use of infrastructure (Marshall & Lloyd, 1999). Tightened regulations are improving the sizing and installation of systems, but many communities still do not have adequate

maintenance regimes in place. Maintenance appears to be a particular problem for outstations where ORCs must maintain systems over vast areas, often with limited equipment, budgets, communication, time and access (e.g. during the wet season in the tropics). Flush toilets are often dysfunctional as a result, and can stay that way for extended periods. Research indicates that inappropriate use by residents often only occurs *after* systems become dysfunctional, rather than before as commonly believed (Pholeros *et al*, 1993). It seems people accept failing flush toilets as a fact of life, along with so much other inappropriate infrastructure or social programs introduced to 'improve' the lives of remote Aboriginal people. Regulators, plumbers and funding bodies still regard flush toilets as the system of choice for Aboriginal housing, regardless of size, location, lifestyles or maintenance capabilities.

2.2 Pit toilet systems

Pit toilet systems have proved to be far more successful than septic systems at providing continuous, robust sanitation to outstations. With no moving parts, no water requirements and virtually no maintenance, they are imminently suited to outstation life. Ventilated improved pit (VIP) toilets, when designed and constructed correctly, nullify the problem of flies and odours in toilets, making them acceptable and healthy for outstation residents (Pickford, 1985). In the Top End of the NT, 9 of 13 major ORCs have a policy of using only VIP pit toilets (no flush toilets) due to better performance and minimal maintenance. Interestingly, in the remainder of the NT, 16 of 18 major ORCs use septic systems in at least some outstations, with no policy on systems used (CAT, 1998). Many report significant problems keeping flush toilets functional, including the need to supply water in arid regions.

Unfortunately, pit toilets suffer from a poor image amongst many Aboriginal people. They are often referred to as 'bush toilets' compared to 'proper (flush) toilets'. This attitude appears to be far more common where people already have flush toilets, or where basic (unventilated) pit toilets are used such as on poorly resourced outstations of Cape York Peninsula (CAT, 1998). In Top End communities where good VIP pit toilets are used, the author is not aware of any strong calls for flush toilets to replace VIP pit toilets.

2.3 Greywater systems

Until recently, many outstations in the NT had few formal showers, kitchens or laundries which generated greywater. Yard taps were (and still are) often the only reticulated source of water. Even where infrastructure is now installed, formal greywater management is largely ignored. For outstations with flush toilets, any greywater may be directed into septic tanks. For outstations with pit toilets, *ad hoc* surface disposal of greywater into exposed trenches or open rubble drains seems common. Regulators appear to have turned a blind eye to this. In recent times though, funding for outstation housing is conditional on regulator-approved sanitation systems being installed, including greywater systems. In WA, SA and Qld, both blackwater and greywater can be directed to the same septic tank system. In the NT however, the 1996 Code of Practice stipulates that for remote Aboriginal communities greywater must be managed separately from blackwater, and sizes must be based on 300 litres per person per day (to help overcome problems with overcrowding and leaking taps - both very common). The preferred system of NT regulators is a large volume sullage tank and trenches. For a three bedroom house on sandy loam soils in the NT, this means a 4,000 litre sullage tank and 40 metres of standard absorption trenches (THS, 1996).

2.4 Alternative systems

There are very few alternative sanitation systems documented for outstations, either for human wastes or greywater. Composting toilets were trialled on Torres Strait communities in 1996 but were not successful due to inadequate user education and lack of maintenance (ICC, 1996). Aqua privies have recently commenced manufacture in Townsville, but are not known on any outstations yet. Aerated wastewater treatment systems were trialled in Coen, Qld (not an outstation) and were unsuccessful due to intermittent power supplies and lack of maintenance (Downs, 1997). Sand filters and reedbeds are not documented for any remote outstations. Septic systems with passive pre-filtration are currently being trialled on Pitjantjatjara communities of South Australia, and some work with modified absorption trenches has been undertaken in Western Australia to improve reuse of septic tank effluent (Anda *et al*, 1997). No trials are known to have been resoundingly successful and subsequently

utilised by local outstations. Alternative greywater systems are currently being developed on Bawinanga outstations of Arnhem Land, as described in this paper.

3 Evolution of Sanitation Systems on Bawinanga Outstations

This section of the paper describes a detailed case study of the evolution of sanitation systems on Bawinanga outstations surrounding Maningrida in Arnhem land, NT. Systems have changed significantly since first installed in the 1980's, reflecting a history of inappropriate and appropriate technology development. All stages can be found in contemporary outstations across Australia, and many lessons can be drawn from the Bawinanga experience.

3.1 Bawinanga outstations

Bawinanga outstations is the collective name for thirty three outstations surrounding Maningrida, an Aboriginal community of 1,100 people on the Arnhem Land coast of the Northern Territory. Most of the outstations are extremely remote, being dotted over 10,000 sq.km. of pristine woodland, rainforest, wetlands, floodplains, river corridors and coastal habitats. The furthest outstation is 100 kilometres from Maningrida. Roads are rudimentary, and impassable for up to six months each year during the monsoonal wet season. Access is then limited to barge and/or light aircraft.

The total Bawinanga outstation population is 700 to 800 in the dry season, reducing to 300 to 400 people in the wet season when many people move into Maningrida. Approximately 100 houses will exist across all outstations by the end of 1999, making this one of the better resourced outstation groups in Australia. The largest Bawinanga outstations have 9 to 10 houses and approximately 60 inhabitants, while five outstations have a single house.

People on Bawinanga outstations continue to lead a semi-traditional lifestyle, hunting game, gathering bush tucker, looking after country and undertaking ceremonial activities. Six local languages and English are spoken across the outstations, with English often being people's second or third language. The provision of appropriate infrastructure on outstations to facilitate this lifestyle is regarded as vital by residents and the outstation resource centre, Bawinanga Aboriginal Corporation (BAC), alike.

BAC is overseen by elected outstation representatives, and employs eighteen non-Aboriginal staff who co-ordinate services and infrastructure across outstations. Local CDEP (work for the dole) participants are trained to undertake building and service jobs, while external contractors are employed for specialist jobs such as installation of plumbing infrastructure.

3.2 Water supply

Bawinanga outstations were first established around surface waters in the 1960's. BAC began sinking bores in the early 1970's to ensure good water quality and continuity of supply. All outstations now have bore water supplies, pumped by solar pumps to header tanks when the sun shines. This system has proved reliable and BAC is extremely satisfied with it. Continuity of supply from header tanks to taps is still problematic, due to people leaving taps on and fully draining the tanks. BAC is seeking to improve this situation through ongoing user education.

3.3 Water reticulation

All outstations originally had only yard taps for reticulated water, and many outstations retain this situation. Others have had water reticulated to communal ablution blocks over the years, and recent houses have water reticulated to individual showers, laundry tubs and kitchen sinks. Even where dedicated infrastructure exists, yard taps remain the preferred water point for bathing, washing clothes, irrigation and other water-related activities on outstations. This may change as other facilities are installed, but may not based on existing prolonged exposure of people to dedicated infrastructure in Maningrida where all houses have individual showers, kitchen sinks and laundry tubs.

3.4 Sanitation overview

No outstations had formal toilets, showers, tubs or basins until the late 1980's. Prior to this, residents used surrounding bush land or rudimentary pit toilets for human wastes, and used yard taps for washing, cleaning and general water-related activities. BAC staff indicated many people still prefer

the bush and yard taps even now, despite the increasing availability of formal facilities on most outstations and the long-term exposure to these in Maningrida. Perhaps this choice is in *response* to the exposure at Maningrida, where facilities and plumbing are often dysfunctional and unpleasant.

3.5 Yard tap wastewater

Wastewater from yard taps is an overlooked area of sanitation management on all Aboriginal communities, big and small, including Bawinanga outstations. The common yard tap activities of washing, cleaning, preparing food and children playing create permanently wet areas with substantial organic matter, which are good conditions for a range of disease vectors to exist. Hookworm is a good example of this, being common in tropical Aboriginal communities, harboured in permanently damp soils and entering people through their feet.

There are no regulations in any state or the NT concerning yard tap wastewater management, and in reality this would be met with hostile reactions by ORCs who often feel they are over-governed already. The author feels this area warrants further research, and at least communities should be educated to the potential health risks and appropriate solutions to yard tap wastewater disposal and reuse.

Bawinanga outstations have perceived a need to actively manage yard tap wastewater, and have enacted several strategies which are in the process of evolving to sustainable solutions. Yard taps on new houses are no longer located in high foot traffic areas next to houses. Several yard taps have open spoon drains leading from them, originally to remove wastewater from the immediate vicinity of the tap. Drains have been planted with fruit trees to utilise the resource and grow fruit with minimal active input. Problems have been encountered with drains clogging up, and with trees planted too close to taps which shade the tap area, slowing evaporation of water on the ground. Trials are planned where yard taps will be sited on raised earth mounds, with wastewater flowing some distance away to fruit trees.

3.6 Flush toilets

In 1988, five communal ablution blocks were constructed on four of the largest Bawinanga outstations, following an increased national focus on Aboriginal health. These cost $50,000 per unit and in hindsight BAC considers this money poorly spent. Each had men's and women's flush toilets, showers, laundry tubs, a suspended floor with exposed plumbing underneath (for ease of maintenance), septic tanks, absorption trenches and were constructed to regulatory standards of the time. All units became dysfunctional very quickly, attributed to intermittent water supplies, inadequate toilet paper and subsequent misuse of facilities. Toilets often lacked water for flushing, and a lack of toilet paper led to use of rags, rocks, cardboard and other materials which clogged toilets. Maintenance of the blocks was infrequent due to a lack of resources and wet season access, and only occurred when emergency repairs were needed. Only one of the blocks is still partially functional, and BAC does not intend to continue maintenance on these systems.

In the early 1990's, five other outstations received smaller communal toilet/shower blocks, comprising separate men's and women's facilities with one flush toilet and shower per unit. Wastewater was directed to 2,000 litre septic tanks then absorption trenches. All units received only emergency servicing until 1996, but nothing since. Only one is still known to be functional. BAC staff indicated that maintenance was an 'ongoing nightmare' due to a lack of water and frequent clogging of toilets and plumbing. The long distances between outstations often prevented an immediate maintenance response from BAC, and the wet season precluded any maintenance at all. It is suspected systems were poorly installed (by contractors) as evidenced by one septic tank and absorption trench system installed on a floodplain immediately adjacent to an outstation. This floodplain is permanently waterlogged or flooded in the Wet season, and contravened regulatory requirements of the time.

In 1995, BAC staff and outstation residents met to discuss the inadequate state of waterborne sewage systems. Residents elected to trial dry toilets after a range of options were presented.

3.7 Ventilated improved pit toilets

In 1995, BAC began installing ventilated improved pit (VIP) toilets on outstations. These have proved

very successful and now are the only toilet installed on outstations as a matter of policy. Toilets are generally located within 20 metres of houses, and have been communal in the past. Individual houses are now receiving toilets as they become available. Bawinanga residents have generally expressed satisfaction with the units, and BAC personnel are extremely pleased with the robustness and lack of maintenance required. Toilet superstructures are now manufactured at Maningrida by CDEP (work for the dole) participants, providing employment in the community.

BAC staff have indicated that the VIP toilets could still be improved to better suit the needs of residents. In particular, toilets do not currently have any night-time lighting which restricts their use at night because people are often scared to enter a dark enclosed area because of cultural beliefs. BAC has costed the installation of stand-alone solar lighting for the toilets, but has not yet installed any. The author has seen human faeces immediately outside VIP toilets, most likely deposited at night.

3.8 Greywater

Until 1995, the few communal ablution facilities which had been installed had combined black and greywater disposal in single septic tanks. Since then, the construction of VIP pit toilets has meant no blackwater is generated, and the recent installation of shower-laundry and kitchen facilities has necessitated the independent management of greywater.

Shower-laundry units constructed in 1995 and 1996 had surface disposal of greywater which flowed directly from slabs to open spoon drains and then to fruit trees. Regulations did not allow surface disposal of effluent, but BAC personnel saw this as a more workable system than installing septic systems which had given so much trouble in recent years. BAC staff argued that the surface systems were visual, easily maintained, inexpensive, simple to install and not prone to failure. Health risks were not considered to be high by BAC, provided the systems were properly managed. Inspection of some of these systems by the author, however, showed that adequate maintenance was not occurring by residents or BAC staff and spoon drains were not functioning as originally built. Pet pigs, dogs and chickens were scratching in the drains, causing them not to drain properly. As a result, greywater was pooling and creating a site for mosquito breeding, animal activity and potentially other disease vectors (such as hookworm). This was particularly the case under trees where sunlight was not evaporating the greywater. The systems certainly would have been viewed unfavourably by Territory Health Services, if they had ever inspected them. It must be noted however, that fruit trees were growing very well with minimal human input, which was an encouraging sign for greywater reuse.

4 Current Greywater Trials

Regulation-approved greywater systems ultimately had to be installed on Bawinanga outstations in 1996 due to funding conditions set for new houses. BAC was not satisfied with Code-stipulated systems of the time, so a trial was undertaken of an alternative system. The process of designing and monitoring the systems is described below, to give an insight into designing sanitation systems appropriate for Aboriginal outstations.

4.1 Code-stipulated systems were inappropriate

In 1996, BAC was granted National Aboriginal Health Strategy (NAHS) funding to construct 28 new houses on Bawinanga outstations over three years. One condition of the grant was that Code-approved sanitation systems must be installed with all houses. VIP pit toilets are allowed by the current NT Code of Practice and so were no problem to install. For greywater however, the Code of Practice stipulates that each three bedroom house required a sullage system comprising 4,000 litre septic tank and 40 metres of trenching (soil LTAR = 25 L/ m^2.day). The Code has no provision for performance-based assessment of non-standard systems, although permission can be sought for trials of alternative systems. If trials are successful, the system is considered for more widespread use.

BAC personnel felt that septic tank systems were totally inappropriate for Bawinanga outstations because of past problems (although most problems had stemmed from flush toilets), the perceived high cost and difficulty of installing such large systems, the difficulty of obtaining local gravel for trenches, the lack of maintenance equipment owned by BAC (especially no pump-out truck), the lack

of personnel hours to undertake maintenance (which was perceived to be very high) and the inability to conduct emergency repairs during the wet season.

BAC staff seriously considered installing only yard taps at new houses, which are not governed by any regulations. BAC staff felt the septic systems were more trouble than they were worth, and they were being strung into a corner by far-away bureaucrats. They argued that current management of greywater by surface disposal was adequate, and that money could be far better spent building extra houses for Bawinanga. Ultimately Bawinanga staff elected to employ an external wastewater consultant (me) who specialised in appropriate, low technology sanitation systems for remote communities (we are a rare breed) to design, seek approval and monitor more appropriate greywater systems.

4.2 Negotiations with regulator

Negotiations with Territory Health Services took twelve months before THS committed themselves to a trial. The author suspects they were reluctant to approve the trialling of small capacity greywater systems only months after releasing the new NT Code of Practice for on-site sanitation systems. This Code had moved substantially towards very large capacity systems for remote Aboriginal housing in an attempt to overcome problems of high wastewater volumes due to overcrowding and leaking taps & toilets. The author of this paper feels it is not appropriate for the Code to attempt to cover the entire Northern Territory with one prescriptive sizing of systems and system types, given the extremes of climate and Aboriginal lifestyles. The author feels the site specific approach of the draft AS1547 document is a far better method to use in a place as large and diverse as the NT.

4.3 Design process for appropriate systems

BAC staff and residents had strong ideas on what the main criteria for appropriateness were. The greywater systems had to be:

- appropriate to lifestyles. Firstly, systems were expected to suit the lifestyle of residents and not vice-versa. This is a fundamental requirement and there is a long history of failed technologies in Aboriginal communities which have ignored this. People do not easily change their habits, whether they are Aboriginal or non-Aboriginal. Septic systems which have served the needs of non-Indigenous Australian households for many years did not seem suitable for the current lifestyles of Bawinanga residents.

To suit lifestyles, systems had to withstand extended periods of no use when people were absent in Maningrida, or were away on ceremonial business, or the house was temporarily abandoned as a 'sorry camp'. The system also had to withstand periods of high use if large numbers of people were occupying the house. Indications were that this is not and will not be common, because enough houses would soon be installed to relieve gross overcrowding, and that gatherings for ceremonial purposes did not tend to last too long. The systems also had to be robust to withstand the rigours of outstation life, which preferably meant no moving parts in the system, strong construction and certainly no power or chemical requirements.

- appropriate for pollutant load. Another significant lifestyle factor on Bawinanga outstations is that all cooking of food is still conducted on open fires. No stoves or cook tops are installed in houses. Pots and pans are often used on open fires to cook foods such as rice and beans, with food eaten directly from pots using utensils. Meat, however, is generally freshly killed (such as buffalo or magpie goose) and cooked directly on coals. It is eaten without plates being used. Utensils are often washed under yard taps, this being the long-standing water source on outstations. As such, BAC staff felt there would be little fats or greases being washed down kitchen sinks, which turned out to be the case. For showers, BAC staff felt most people still did not use them, preferring to wash in natural water bodies or under a yard tap. They suspected there would be few solids being washed down shower drains as a result, and would most likely be limited to fine muds from hunting trips. This also proved correct. Of course, the long-term habits of people are not yet known, and may change because of the increasing availability of showers, laundry tubs and kitchen sinks on outstations. Greywater systems may have to change with changes in lifestyle, but it is not expected that lifestyles will change radically in a short time.

• appropriate for irrigation reuse. For food production based on greywater irrigation, there were also strong requirements based on lifestyle factors. Traditionally Aboriginal people in Arnhem Land move between food resources on a seasonal basis. Often areas are managed in bursts of activities (e.g. burning of country in early dry season), and food is harvested seasonally (e.g. waterfowl and eggs collected from wetlands in late dry season). Little management occurs at other times. This tradition seems to have continued on Bawinanga outstations. People are happy to intensively establish crops and harvest food from them later, but undertake little management in between. Vegetable growing has not been a success as a result, but tropical tree crops have been more successful using mangoes, bananas and paw paws.

• appropriate for maintenance capabilities. The second main criteria was that systems had to fit within the maintenance capabilities of service personnel. In the past, this has been another main reason why technologies have failed on Aboriginal communities. Not only must service equipment be affordable and available, but personnel must also have the time and budgets to undertake the work. At Bawinanga, the lack of road access for up to six months each year meant that emergency maintenance on systems had to be possible by outstation residents using common tools (each outstation has a telephone which can be used to contact the ORC to explain problems with infrastructure, and receive maintenance instructions by phone). The systems had to be able to have a routine maintenance program developed which was both achievable and affordable by Bawinanga personnel.

• appropriate for health. Systems also had to provide no health risks or inconveniences to outstation residents. The author concluded that greywater had to be directed underground and kept there to preclude any contact by people, kids, dogs, chickens, pet pigs, pet jabirus, pet buffaloes, pet magpie geese and even a pet crocodile on one outstation. There was certainly little chance of Territory Health Services approving any surface disposal of greywater, for justifiable reasons. Despite being underground, the greywater still had to be accessible for irrigation reuse.

4.4 Greywater system design

New houses were designed by Build Up Design in Darwin. Shower-laundry blocks have been designed as stand-alone units containing one shower and one laundry tub. They are separated from the house by several metres so that any problems with greywater drainage does not impact directly on the living environment, and shower-laundry blocks can be used communally if required. Kitchen sinks are incorporated into open verandas on the ends of houses, to allow for outdoor food preparation and again to keep greywater away from the living rooms if problems occur. For the trial, independent greywater systems were constructed for shower-laundry blocks and kitchen sinks. This was to examine the performance of the different sectors of greywater generated.

Shower-laundry greywater is directed via standard floor wastes to a 200 L then 300 L silt trap in series (to determine adequacy of first trap) then split from the last trap to two parallel evapotranspiration trenches within an evapotranspiration gravel bed. The evapotranspiration bed is shallow to allow easier access by tree roots to greywater. For shower systems, the evapotranspiration beds are 10 m long by 4 m wide. Kitchen systems have the same configuration as shower-laundry systems, with two traps in series followed by a single trench evapotranspiration bed. The kitchen beds are 2.5 m long by 2 m wide (soil LTAR of 25 L m^{-2}.day at all sites).

Silt traps are constructed of reinforced concrete to make them trafficable if need be, and have heavy concrete lids in two parts which can only be removed by a strong adult (not by kids or dogs). Lids fit snugly to prevent insect access or odour escape. The traps are baffled and baffles are removable so the trap can be easily emptied and desludged with a sludge pump or bucket and shovel. One kitchen trap desludged in May 1998 took approximately 20 minutes from start to finish using a bucket and shovel. Contents of the traps are deposited under mulch which covers the greywater reuse area. Diagrammatic 'how to clean out' signs have been attached to all shower-laundry block walls for residents to use if need be.

4.5 Performance of Systems

Trial systems were installed at three houses on Jimarda, Gamardi and Nangak outstations between

November 1997 and February 1998. Systems were monitored quarterly between February 1998 and June 1999 for greywater volumes, number of users, physical performance, robustness, sludge and scum accumulation in traps, necessity and ease of maintenance, performance of fruit trees, signs of odours and acceptance by residents and Bawinanga staff. Detailed performance data is not given here.

In general, systems have performed as expected, and confirmed the observations of Bawinanga staff before the systems were designed. There has not been heavy use of the shower-laundry blocks, with the three houses averaging around xx litres of water used per day. There has been very little organic matter or silt washed down showers or laundry tubs, as evidence by a maximum of 40 mm of silt accumulated in the first traps, with no visible scum layers forming. Trenches still have pristine dirt bases, with no build up of silt or a slime layer on the bottom of the trench. Evidence suggests there is little need for any pre treatment of greywater before entering trenches. Bananas, paw paws and sugar cane planted on the beds have grown exceptionally well and have produced a large volume of fruit which has been consumed by residents. The trial showed that by planting trees over the greywater beds at the start of the wet season, the trees had their roots in to the greywater by the end of the wet season (a prolific growing season) and required no additional watering during the six month dry season of 1998. Maintenance of shower-laundry systems was restricted to removing wet season grass growth from beds (conducted by residents at two houses, BAC staff at the other).

The kitchen systems accumulated more sludge and scum in traps, as expected. However the accumulation rate was still slow and only one trap required desludging after 13 months of operation to February 1999. Second kitchen traps show some sludge and scum accumulation, indicating carry-over from first traps. Kitchen trenches however remain pristine with no sign of a slime layer developing.

Water supply has been intermittent on all outstations throughout the trial , perhaps hampering he use of systems. Yard taps are still observed to be heavily used for shower, laundry and kitchen related activities, despite trial systems being functional most of the time. All systems show no signs of abuse, although one shower wall did receive a hole at one time. It is thought there was no periods of extended high use on any systems throughout the trial, which means this likely scenario was not trialled.

4.6 Modifications based on trial

Based on trial results, modifications will be proposed when final approval is sought from Territory health Services. It will be argued that the two systems at each house should be combined into two 300 litre silt traps in series, with kitchen greywater discharging to the first trap and shower -laundry water greywater discharging directly to the second trap. The total area of the evapotranspiration bed will be argued to be 40 m^2 , based on trial performance. This set up is expected to retain sustainable performance, and will reduce the cost of systems and make installation and maintenance easier and reduce maintenance checks.

BAC is currently working with an external consultant to develop a routine maintenance program for all infrastructure on Bawinanga outstations. Maintenance of greywater systems will be included in this, and is expected to involve pump-out of silt traps at the beginning and end of each Dry season.

4.7 Regulatory response

The response of Territory Health Services to the trials and proposed modifications is not yet known. The final THS inspection is scheduled for mid-June 1999, after this paper is written. An addendum describing the THS response will be distributed at the On-site 99 conference, or is available from the author by request.

5 Conclusion

This paper has highlighted the evolution of appropriate sanitation systems on remote Aboriginal outstations of Arnhem Land. The process is applicable for other outstations, regardless of differences in climate, lifestyle or maintenance capabilities. Bawinanga outstations continue to evolve more appropriate systems, based on observation, trials and a commitment to improved lifestyles for Aboriginal people.

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