CRC for Water Quality
and Treatment

Cooperative Research Centre For Water Quality and Treatment

Summer Research Scholarship:

Assessing the Feasibility of Monitoring Chemical and Microbiological Hazards in Bodies of Water used for Recreation in Remote Aboriginal Communities

By Nigel Vivian

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Supervisors:

Bob Lloyd
Centre for Appropriate Technology
Alice Springs

Gabriele Bammer
National Centre for Epidemiology and Population Health
The Australian National University
Canberra

Executive Summary

The main tasks in pool management are to keep the water clean and at correct pH and chlorine levels. If this is properly managed the pool is generally safe for swimming. In remote communities appropriate monitoring becomes more problematic, as it may be difficult to get samples to laboratories in a timely manner. The distance and heat also makes storage of chemicals more challenging.

The aim of this study was to document the difficulties involved in monitoring chemical and microbiological levels at a pool at Ltyentyre-Apurte (Santa Teresa). Although this community is only 80 kilometers from Alice Springs, it gives some indication of the difficulties which will also be incurred at more remote communities. Comparisons were also made with pools in Alice Springs and natural swimming holes.

This study shows that key physical and water quality parameters for swimming pools in remote communities can be monitored on site. The experience of Ltyentyre-Apurte shows that pools in remote locations can be properly monitored so that they are safe for swimming.

However both in Ltyentyre-Apurte and in Alice Springs chlorine levels in pools are generally lower than recommended in the Northern Territory guidelines. This is because the levels given on pool test kits are too low and these tend to be followed rather than the guidelines. Although this does not seem to have led to health problems, it should be addressed.

Contents

1. Introduction

The purpose of this study was to begin to investigate the feasibility of maintaining safe swimming pools in remote Aboriginal communities. Anecdotal evidence indicates that the presence of pools may reduce the incidence of eye, ear and skin infections in such communities, particularly among children. Placing pools in remote communities, however, may place a large burden on the community in terms of maintenance. Thus there is a need to see if the basic maintenance in terms of chemical and microbiological monitoring of the pool can be carried out at sites remote from main centres. For logistical reasons, it was not possible to undertake this study at a very remote community, but it was possible to examine the difficulties involved in monitoring chemical and microbiological levels at a pool at Ltyentyre-Apurte (Santa Teresa), an Aboriginal community eighty kilometres east of Alice Springs. Comparisons are made between this pool, pools in Alice Springs, and natural swimming holes.

2. Background

The main tasks in pool water management involve keeping the water clean and at the correct pH and chlorine levels. Chlorine addition is the main method of keeping the pool free from pathogens. Generally it is assumed that if these factors are properly managed, the pool is safe to swim in. The chlorine will also attack nitrogenous compounds in sweat and urine which act as nutrients for algae. However if there is a large bathing load in the pool, or faecal contamination, higher doses of chlorine (super-chlorination) may be required.

In poorly chlorinated pools pathogenic microorganisms may be sustained. Pathogenic bacteria such as *Staphylococcus, Streptococcus, Pseudomona aeruginosa, Mycobacterium marinum, Klebsiella, Yersinia* and *Legionella* can all be found. Adenoviruses associated with conjunctivitis, pharyngitis and fever and enteroviruses such as polio, coxsackie and hepatitis A may also be present. In addition there is growing concern about chlorine-resistant and potentially lethal bacteria and parasites, such as *Cryptosporidium.* The latter organismforced the temporary closure of several pools in Australia last summer. Harmful protozoa such as *Giardia* may survive in recommended operating levels of chlorine. Consequently, it is not always sufficient to assume that a pool is safe based purely on compliance with chlorine guidelines. Microbiological testing of swimming pool waters may give a better indication of how safe it is to swim. Comparisons with natural water bodies will give an indication of the value of swimming pools as a community health asset.

Even in main centres comprehensive testing of pools for specific organisms can be difficult and expensive. In remote communities it is made more difficult by the distances and times involved for sample transfer. In Alice Springs a laboratory is available to test for *Eschericia coli (E- coli)*, the biological indicator of faecal contamination, as well as total coliforms (TC) and total bacterial plate count (TPC). Samples should preferably be tested for coliforms within 6 hours of collection, but may still be tested within 24 hours (AS2031.2, 1987). Remote communities with swimming pools then have access to microbiological tests, as long as the sample can get to a laboratory within 24 hours. This service is generally possible for most of the larger communities as the drinking water is usually regularly tested for bacterial content. In most cases mail or flying doctor air services transport the samples. Alternatively presence/absence tests for *E. coli* or coliforms may be performed on site with only an incubator and minimal expertise required. The presence of protozoa or other specific non-bacterial pathogens can usually be identified only by health centre admissions.

In this study the results of chemical and microbiological tests are compared to the guidelines for swimming pools developed by Territory Health Services and the Australian Water Quality Guidelines for recreation water.

This study has been completed in conjunction with a separate audit of remote communities with and without swimming pools undertaken by medical students Andrew Peart and Cassandra Szoeke (1998). The study is also intended to be a companion to a report on the technical issues associated with the construction and maintenance of public swimming pools by Jonathon Duddles (1998).

3. Study Method

The following water quality parameters were tested on site at Alice Springs Swimming Centre and the Ltyentyre-Apurte Swimming Pool:

Parameter	**Testing method**
temperature	electronic thermometer (accuracy ±0.20 °C)
pH	pH meter (accuracy ±0.1 pH units)
free chlorine	Hach DPD colorimetric kit (accuracy ±10%)
total chlorine	Hach DPD colorimetric kit (accuracy ± 10%)
salinity	conductivity meter (accuracy ± 10%)
coliforms	Millipore “Colisure” presence/absence test kits

On site tests for temperature, pH, free and total chlorine and salinity were taken at a frequency of every hour between 12pm and 6pm at Alice Springs and every one to three hours from 6am to 6pm at Ltyentyre-Apurte. This enabled daily patterns to be identified for before and after chlorination, and before and after pool opening. A pool supply and maintenance company in Alice Springs also conducted independent chemical testing (Marriott Agencies).

Water samples for bacterial testing were taken by standard methods at three-hour intervals in most cases. The samples were delivered to the Northern Territory Department of Lands Planning and Environment laboratory in Alice Springs for analysis. Tests were done for total coliforms, faecal coliforms and total plate counts by membrane filtration. In addition some bacterial tests were done on site using the Millipore presence/sense test kit.

The ambient air temperature was measured on site, as well as the presence or absence of clouds and wind, since these factors affect chlorine levels. The number of swimmers (bathing load) was recorded to indicate the significance of possible contamination sources. The tap water used for filling the pool was also tested to indicate the starting condition of the pool water.

Interviews were conducted with the caretakers of the Alice Springs and Ltyentyre-Apurte pools to determine how the pools were managed. Conversations with many members of the Ltyentyre-Apurte community were also conducted to determine the community's reaction to the pool, and any concerns they may have. Additional information was also obtained from with representatives of the Santa Teresa Catholic Church, Spirituality Centre, health clinic and the school.

Natural water holes in the Alice Springs region were tested for temperature, pH, conductivity, and bacterial counts. The location of the water holes tested were the popular swimming centres: Ormiston Gorge, Glen Helen, Ellery Creek Big Hole and the Alice Springs Telegraph Station water hole.

4. Results and Discussion

4.1 Alice Springs Swimming Centre

4.1.1 Pool characteristics and conditions at testing

The Alice Springs Swimming Centre consists of an Olympic size swimming pool, as well as toddler and babies pools, giving a total area of 1614 m^2 and a total volume of 2.8 ML. The pool was opened in 1974 and serves a population of approximately 25,000. The pool is open every day of the week during summer, from 9 to 13 hours per day and has between 250 and 800 visitors daily. There were 381 visitors of all ages on the day of testing.

Testing was conducted on March 15 from 12pm to 6pm. The maximum air temperature in Alice Springs that day was 34.9 degrees, and maximum wind speed was 19 knots (Source: Bureau of Meteorology, see Appendix E). These conditions were fairly typical for March which has an average maximum temperature of 34.7 degrees and average maximum wind speed of 23 knots. The day was cloudy in the afternoon with a total of 6.8hours of sunshine for the day, compared to an average of 9.5 hours per day for March.

4.1.2 Test results

Free chlorine levels were measured at between 1.5-1.8 mg/L. These levels are under half the 1996 Northern Territory guideline of 4.0 mg/L. (Note measurements before 3pm lacked accuracy due to the use of the wrong scale on the colorimeter). The pH, alkalinity and salinity were shown to be slightly above the relevant guidelines, while the concentration of stabiliser was quite low. Temperature, hardness, combined chlorine and bather loads were within the guidelines (see Tables 2.1 and 2.2. for physical and chemical test results).

All microbiological samples taken from the pool were well within the Northern Territory guidelines with no coliforms detected (see Appendix A for microbiological results).

Generally the pool was clear and found to be in good condition, although on the day of testing some of the chemical levels required some adjustment. The free residual chlorine levels were maintained at a fairly stable level of around 1.5 mg/L, by the use of automatic chlorination equipment. The value was maintained even with large swimmer numbers over a long period (see Appendix A). The reason for the lower level of chlorine was because the pool manager was working to the level specified on the pool test kit used. This kit specified 1.5 mg/L as the safe operating condition. This chlorine concentration, however, is considerably lower than the relevant Northern Territory guideline concentration ie 4.0 mg/L, (where the temperature was above 26 degrees and stabiliser is used in the pool). The particular test kit used could not be used to maintain the NT recommended levels as the maximum concentration it can detect is only 3.0 mg/L. The Australian Guidelines for Disinfecting Private Swimming Pools (National Health and Medical Research Council, 1989) state that a free chlorine concentration of 3.0 mg/L is sufficient for pools using stabiliser and at a temperature greater than 26 degrees. Despite lower chlorine concentrations, the microbiological analyses were all well within the Northern Territory guidelines.

Testing by Marriott Agencies indicate that greater amounts of stabiliser could be used to reduce the chlorine requirement. The pH levels were a little high. High levels tend to reduce the effectiveness of the chlorine as a disinfectant. In addition high pH levels may cause some problems with maintenance of pumps and filters. High salinity levels were also evident, which could also contribute to maintenance problems.

The salinity of the pool was over four times that of the Alice Springs water supply (Table 1), indicating that after being initially filled, nearly three times the pool volume was lost by evaporation over the summer. It might be noted that the chemicals added to the pool do not have a significant effect on the salinity, since they are at relatively low concentrations. The manager estimated that the amount of water lost from the pool is close to its total volume. The actual figures for the topping up water were difficult to obtain since water passing through the meter also supplies a domestic residence. To manage the salinity problem in the long term the pool is emptied and refilled with fresh supply water before it is opened each season.

4.1.3 Pool maintenance

The pool manager, Ian O'Leary, tests pH and the free and total chlorine levels daily. The water quality testing equipment used by the manager is a standard 'Aquality' pool test kit, which was less accurate than the equipment used in this study, yet fine enough for effective management. Other less important factors such as alkalinity were tested less frequently. Occasional samples were sent to Marriott Agencies for independent testing and advice. Microbiological samples are not taken at the Alice Springs pool. Although both the manager and the Environmental Health Officer from the Alice Springs Town Council would like to see microbiological testing done regularly due to the expense it has yet to be organised. There is no legislation regarding mandatory microbiological testing of swimming pools in the Northern Territory, although the Territory Health Services guidelines recommend a periodic bacteriological analysis.

For the Alice Springs pool, the manager typically adds 25 kg of soda ash and 12 to 18 kg of gaseous chlorine per day to a total pool volume of 2.8 ML. Small amounts of stabiliser are added when required. The water from all the pools is re-circulated continuously, 24 hours per day, through a high rate sand filter. Water re-circulation time was estimated at 6.5 hours. In addition the babies' pool was emptied once per week and cleaned out as a separate exercise. The filters were back-washed each afternoon. The manager noted that some algal problems have occurred in the past. Management of such problems has been by chlorination and vacuuming as the manager prefers not to use algicides.

Water used to top up the pool is from the town water supply which has a relatively high salinity and hardness (Table 1). The level of hardness could be reduced by fine filtration at the supply tap.

Table 1: **Analysis of Alice Springs tap water.**

Conductivity mS/cm	Salinity mg/L	Hardness (mg/L as $CaCO_3$)	PH	Free residual chlorine (mg/L)	Total residual chlorine (mg/L)
0.747	448	194	7.22	0.10	0.16

Solar heating is used at the beginning and end of the season to maintain comfortable water temperatures. The water passing through the solar heating system could reach high enough temperatures to effectively sterilise it. However it may take several days to sterilise the entire volume of the pool.

4.2 Other Public Pools in Alice Springs

The Alice Springs Town Council conducted a random sample of 25 pools at various motels and other accommodations during the 1997/98 season (see Appendix B for full results. Of these 40% did not meet the minimum Northern Territory guidelines for a free residual chlorine concentration of greater than 1.0 mg/L and a combined residual chlorine concentration of less than 1.0 mg/L (see Appendix B). Over 60% of the pools tested had free residual chlorine levels of less than 4.0 mg/L, which is the relevant standard if the pool temperature is greater than 26 degrees and stabiliser is used. Considering that most of the pools were outdoors stabiliser is most probably used, and the temperatures would normally be above 26 degrees during the summer.

4.3 Ltyentyre-Apurte Swimming Pool

4.3.1 Pool characteristics

Ltyentyre-Apurte is a community of approximately 500 to 700 Aboriginal people and a small population of people of European descent.

The pool at Ltyentyre-Apurte is open for six months of the year from the start of October until late March. The main pool measures 33m x 17m, with a diving area of 10m x 8m, a wading pool of 12m x 6m and a toddlers' pool of 5m x 5m. The total surface area is 738 m^2 and the total volume of water is 550 cubic metres, or 0.55 ML.

The Ltyentyre-Apurte Pool was opened in 1980. This was a greatly welcomed development in the town, where temperatures often exceed 40 degrees in the summer, and there are no permanent water holes nearby. Primarily children from 2 to 12 years old use the pool. According to information obtained from the Ltyentyre-Apurte School the number of children in this age bracket in the community is around 120. During the peak of the season approximately 50 to 60 children use the pool each weekday afternoon between 3pm and 5pm and sometimes on weekends. AdultAboriginal women and men rarely use the pool, since it is not considered appropriate. It was, however, found that a few older Aboriginal women used the pool during the study period. In addition, teenagers of either sex rarely used the pool since they were too modest to wear shorts. Some of the Europeans working in the community also used the pool, usually at night or early in the morning.

The community sees the pool as an important asset, since it gives the children a means of healthy recreation. The pool is seen as partly responsible for the fact that there is no petrol sniffing in the community. The children are noticeably more happy and outgoing when the pool is open. On the days when the pool was open the children seemed to be less likely to indulge in destructive behavior such as throwing stones. When children from other communities visit they are generally impressed with the pool.

The main pool and wading pool water are treated and re-circulated separately. Four pumps, rated at 2 horsepower each (3kW), are used on the main pool and one pump, of the same size is used on the wading pool. Each pump is connected to a sand filter with a filtration rate of 76 litres per minute. The turnover rate for the main pool is around 28 hours. This rate is considerably lower that the turnover rate of 4 hours suggested by Duddles (1998). The wading pool has a turnover rate of about 6 hours, which also falls short of the guidelines for the Northern Territory (two hours). The two hour turnover rate recommended for wading pools is because small children are very susceptible to infection (Territory Health Services, 1996). An upgrade of the pumping system for the pool then would be needed to meet Northern Territory Guidelines.

During the survey some children mentioned that the pool was not big enough for them although the amount of space for each child during peak season was well within the guidelines of 4 m^2 per swimmer (Duddles, 1998).

The Ltyentyre-Apurte pool is an outdoor, concrete lined pool. The caretaker mentioned that he preferred an outdoor pool since he wouldn't have to worry about vandalism of lights or fittings. Many of the outdoor lights at the pool had already been vandalized, so are no longer used. Another reason given for not using the lights was because they attract a large number of insects, which cause additional filtering problems, when they end up in the pool. One advantage of an outdoor pool is that incident sunlight contains UV light that kills bacteria in the pool. The disadvantage is that sunlight also causes greater losses of chlorine and high evaporation rates. Also an outdoor pool may be more difficult to secure against unauthorized usage. The Ltyentyre-Apurte pool has a 2.4m fence with barbed wire on the top. Children break through the fence at times, so holes need to be fixed as soon as they are identified.

The pool at Ltyentyre-Apurte is open for just five months since the cold dry desert nights causes the water temperature to drop too low for comfort outside this season. As for the Alice Springs pool solar heating could be used to extend the season to enable greater utilisation of the pool. However, the caretaker was very reluctant to have heating installed since it may become a possible target of vandalism and require extra maintenance. Solar heating would only be appropriate if it was well secured and had a fully automatic thermostat. Maintenance requirements would also have to be minimal. The expense of the solar heating unit would have to be shown to be worthwhile, with the children taking advantage of a considerably longer swimming season. The Alice Springs pool extends its season by only a few weeks using solar heating

4.3.2 Pool Maintenance

The present pool caretaker, the Essential Services Officer (ESO) Jack Wallace, has been working in the community for six years. During the summer season he tests the water daily at around 8am for chlorine and pH with a standard pool test kit. Liquid chlorine (Sodium hypochlorite with 125g/L of chlorine) and 32% w/w hydrochloric acid are added according to how much is required. On an average day 40 L of sodium hypochlorite (or 5kg of chlorine) is required. The chlorine and pH levels are rechecked after an hour to see if more chemicals are required. Extra acid is used on weekends, to improve the disinfecting ability of the chlorine. Stabiliser is added less frequently, and 1-1.5 litres of algicide is used per week to keep algae levels down. The algicide was applied at a rate of about four times that specified by the supplier (ie 1- 1.5 litres per week instead of per month). Since the algicide contains copper sulfate, which is potentially poisonous at high levels, tests for copper were taken.

Top-up water from the bore is required on most days. The caretaker stated that the daily water requirement on hot days (around 45 degrees) to account for backwashing, evaporation, splashing was 1,500 L. However for an evaporation rate of 2.08m over the 6-month period (as measured at Alice Springs Airport by the Bureau of Meteorology - see Appendix D), the expected evaporation alone should be in the region of 8,400 L per day. The increase in salinity levels of a factor of four in a season indicates that the evaporation rate is closer to the mark. Thus the top up water use estimated by the ESO is probably a low figure. The analysis of the bore water is shown in Table 3:

Table 3: Analysis of Ltyentyre-Apurte supply water.

Conductivity mS/cm	Salinity mg/L	pH	Free residual chlorine (mg/L)	Total residual chlorine (mg/L)	Copper (mg/L)
0.517	310	7.49	0.02	0.04	0.25

Although the bore water is not chlorinated, there have been no coliforms detected in the monthly tap water samples sent for analysis by the ESO in the last five years.

The amount of chlorine used in the Ltyentyre-Apurte pool was less than the amount used in the Alice Springs pool, but was high relative to the number of pool users, and pool volume. This is partly because much of the chlorine is lost in manual dosing, but possibly also due to a higher organic loading. The liquid chlorine used at Ltyentyre-Apurte is purchased in 200 L containers which require a front end loader to be moved. Chlorine may, however, be purchased in smaller containers if a front-end loader is not available. Depending on storage temperatures, the concentration of chlorine in the liquid form is estimated to decay at a rate such that it may be less than a third of the specified concentration by the end of the season, (information from Adelaide Pool Resources). Consequently the chlorine used at Ltyentyre-Apurte is probably not at the concentration which is specified on the container. The distributor recommended that chlorine be used as quickly as possible and stored in an open shaded area so that available breezes can cool it. Presently chemicals are stored in a locked shed with good shade and ventilation. Buckets used to hold and transfer chemicals are rinsed after use to minimize the possibility of a poisoning occurring.

The filters operate continuously, on a total volume of 550 cubic metres (0.55ML) and are back-washed each day from Monday to Friday, at 9am. Treatment is normally finished by 10am so that the pool has stabilised by 3pm when it normally opens.

4.3.3 Results

Pool temperature, salinity, combined chlorine levels, hardness, copper concentration and bather loads were all found to be within the NT guidelines. As for the Alice Springs, pool free chlorine levels of 0-2.9 mg/L, were below the NT guidelines (1996) of 4.0 mg/L. Alkalinity and stabiliser concentrations were slightly below recommended levels (see Tables 4.1 and 4.2. for physical and chemical test results).

All but one of the microbiological samples was well within the Northern Territory guidelines. The one that failed, due to a high total plate count, was taken while the pool was closed (Monday, March 23rd 6am). Appendix C gives the complete set of microbiological results.

Generally it was thought that the pool was well maintained and kept. The results of the chemical testing are given in Appendix B. Despite apparently quite warm air and water temperatures, the pool was only opened to the community children on three days over the study period. Less than 20 children swam on these days, which was much lower than observed by the caretaker during the peak of the season. The community children thought the water was too cold even if though it was constantly over 26 degrees during the study period.

Since the swimming load was relatively low and the temperature was also somewhat low the study results may show a best case scenario for the pool. In addition, lower levels of sunlight at this time of year would cause reduced chlorine losses.

Chlorine levels were generally maintained above 1 mg/L, although the concentration dropped significantly on sunny days, especially when the children were swimming. Children swimming in the pool caused the free residual chlorine levels to drop below 1 mg/L while the pool was open on the 19th of March (see Figure 1), even though the levels were well above this in the morning when the manager sampled the pool. The caretaker does not normally monitor the chlorine levels while it is open, so the state of the pool during normal operation is unknown. Because of losses throughout the day, the chlorine levels need to be quite high at the start of the day to ensure safe levels in the afternoon. Again, as for the Alice Springs pool, the caretaker was adding chlorine to the level recommended by the pool test kit used and was unaware of the NT guidelines.

Despite the lower than recommended low chlorine levels, no coliforms were detected in the samples sent to the laboratory. The total plate count was also well below the specified limit of 100 organisms per mL for most samples (Territory Health Services, 1996). These results would suggest that the pool was generally safe to swim in. However, one sample, taken on Monday, March 23rd at 6am, exceeded the guideline for total plate count with 2500 organisms detected in 1mL. This sample was taken when the pool had a very low chlorine level (0.04 mg/L). The pool had not been open since the previous Saturday, almost two days beforehand. Since the pool was not treated on Saturday the chlorine levels that afternoon would have been well below the 1.5 mg/L measurement taken on the Friday afternoon (March 20th). The low chlorine levels at this stage may not have been enough to disinfect the bacterial load from the children on the Saturday. However, by 9am on Monday, March 23rd, after chlorination had taken place, the total plate count dropped back to zero when the free residual chlorine level was 2.4 mg/L. So in this case the chlorine level was apparently sufficient to restore safe swimming conditions in the pool.

None of the tests for bacteria done on site using the “Colisure” presence/absence kits were positive. Combined chlorine levels were high after chlorination, but were maintained less than the Northern Territory guidelines of 1mg/L in all samples.

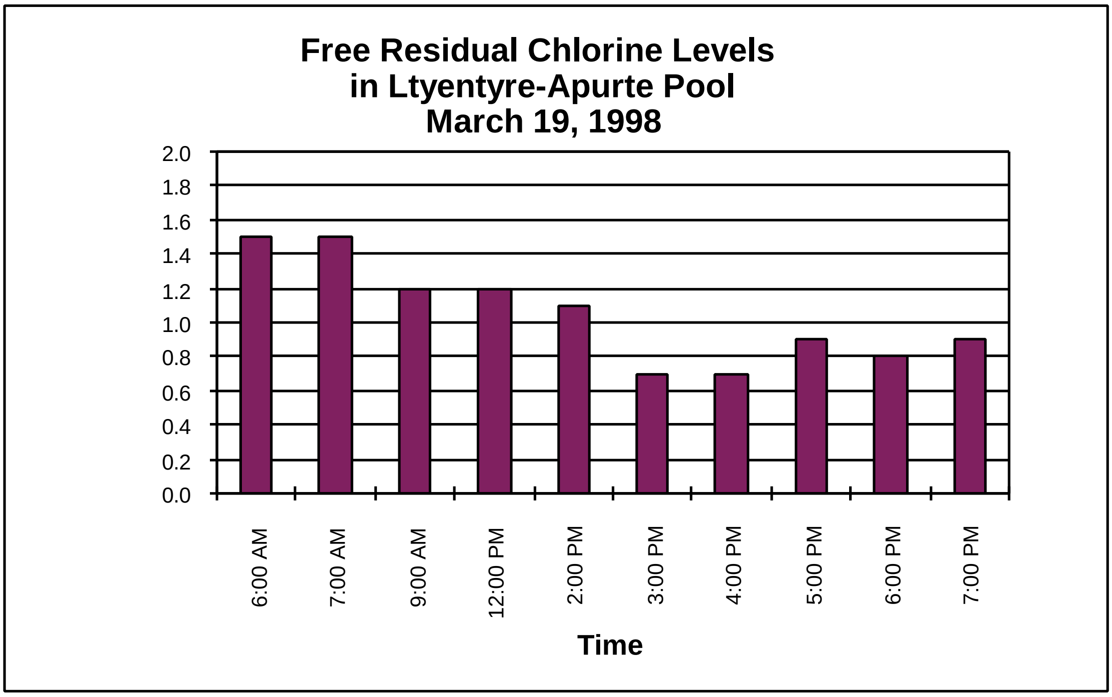

Figure 1.

The copper concentration detected in the pool water at the end of the season was 0.8 mg/L. This value was a bit lower than the expected level due to evaporation of the supply water. With a concentration ratio of 4:1 over the season and an initial water supply concentration of 0.25 mg/l a level of 1.0mg/l might be expected. The value was lower than the Australian Water Quality Guidelines (1992) for drinking water (1.5 mg/l). The addition of the algicide would indicate a higher level than 0.75 mg/l suggesting that most of the extra copper was precipitated out of suspension and removed by filtration and vacuuming.

The salinity of the pool water (1260 mg/L) at the end of the season was about four times the salinity of the water supply (310 mg/L). This indicates that the evaporation rate over the summer was about 3 times the pool volume, giving the same concentration ratio as found for the Alice Springs Pool. This concentration is consistent with an evaporation rate of around 2.0 m per season (i.e. 738m^2 x 2 = 1500 m^3 compared with the volume of the pool of 550 m^3). The caretaker mentioned that the pool is emptied about every 6 months to keep salinity levels manageable. No samples of pool water were sent on a regular basis to Alice Springs for testing.

The pH levels were generally within limits, although a bit low at times. The caretaker had a tendency to keep the pH low in order to improve the effectiveness of the chlorine.

During the study period the pool water temperatures were between 26 and 30 degrees (see Figure 2).

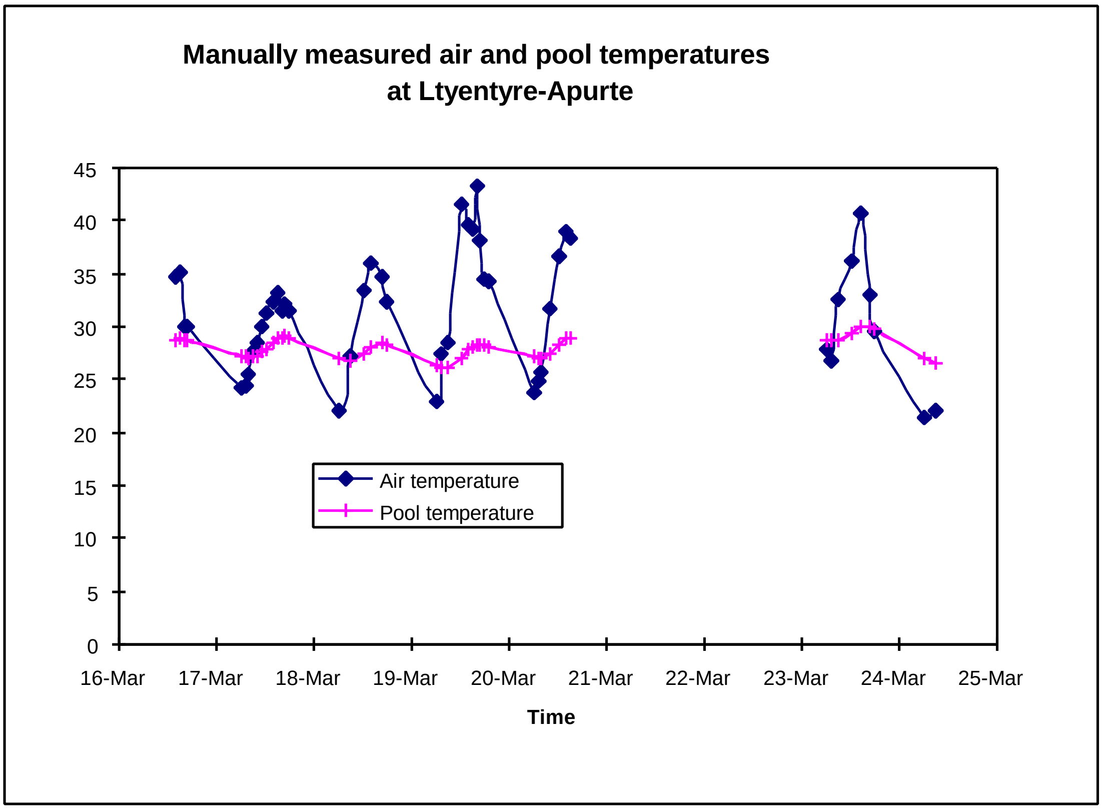

Figure 2.

The results showed that the Ltyentyre-Apurte Pool was in better condition than about 40% of the public pools randomly sampled in Alice Springs. Obviously the health of a pool is more dependent on how it is managed rather than where it is located, or who swims in it. Even though the pool may normally be safe at the low chlorine levels measured, if faecal matter enters the pool and is not identified, several children may become seriously ill. Although faecal matter has often been found in the Lytentyre-Apurte pool, no illnesses have been attributed to the pool as yet. Normally the caretaker checks and cleans all the skimmer boxes daily, and super-chlorinates the pool if faecal matter is found. Maintaining chlorine levels at the NT recommended guidelines will reduce the risk posed by faecal contamination.

4.3.4 Auto-dosers

The responsibilities of the pool caretaker could be lessened by the use of auto-dosing equipment. This device would allow automatic adjustment of the pH and chlorine levels to ensure safe swimming. With this equipment the caretaker would only need to clean the pool, backwash the filters and replace chemicals when they are low. The caretaker would still have to visit daily, but the time spent at the pool would be considerably reduced. Further savings might be expected due to less chemical wastage, since much of the chlorine is currently lost within the first few hours after manual dosing. Another advantage of the auto-dosing equipment is that such a device is prepared to work weekends, whilst the caretaker may not be. The caretaker at Ltyentyre-Apurte has requested that auto-dosing equipment be installed at the pool, so that he is free to take care of his other responsibilities. Reports from managers of public pools, which have installed auto-dosers, indicate that they work well, and that no maintenance of the equipment is required. However, the use of such devices seems to be untested in remote communities. Also this equipment can only be of benefit to water quality at Ltyentyre-Apurte if the pumps and filters are upgraded to improve water turnover rates. At the current turnover rate, the lag time between detecting low chlorine levels and bringing them up to standard is too long to ensure safe swimming conditions.

The only identified problem with auto-dosing equipment is that only liquid chlorine may be used, which has a relatively short shelf life. This would not prevent effective disinfection since the auto-chlorinator will just add more chlorine to keep the concentrations up, but is more expensive than other chlorination methods. Salt water auto-chlorinators are also available, but several salt pool operators have reported problems with salt water pools because of the generally high level of hardness of the supply water in central Australia.

4.3.5 Dust

A major factor in the cleanliness of pools in remote desert locations is the level of dust present in such situations. Like many central Australian communities Ltyentyre-Apurte has regular dust storms which creates a lot of work in maintaining water quality. During the study period the pool had up to 5% of the pool bottom covered in dust, with the toddlers' pool being the worst affected. Some of the dust was obviously wind borne, but a lot was also carried in by the children from the dusty surrounds of the pool area. Pool vacuuming did not occur in the study period, and was apparently not done regularly. The caretaker indicated that vacuuming the entire pool was very labour intensive and normally took about a day to complete. One of the reasons for the long time was because the circulation pump is undersized. One option to reduce the level of imported dust would be to incorporate wind breaks attached to the security fence. An automatic pool cleaner (eg. a "Kreepy Krawly") could be used when the pool is closed to keep the bottom clean with minimal labour. This option would, however, also require the pump to be correctly sized to operate the unit.

4.3.6 Supervision and health effects

Supervision of the swimmers was found to be a very important consideration in operating a pool in a remote Aboriginal community. In the pool under consideration the children were supervised, during opening hours, by a community member (an Aboriginal woman), who enforced the rules of the pool. The rules were that the children must shower before entering the pool, and wear clean shorts (t-shirts if they wish). It was observed that these rules were mostly obeyed during the study period. The presence of the supervisor is important to ensure the safety of the children, and to give proper regard to hygiene requirements. The social consequences of a death or accident occurring to a child using the pool would be serious and may result in the supervisor being beaten and/or expelled from the community. Permanent closure of the pool could result from such an unfortunate situation. Consequently the availability of adequate local supervision must be allowed for since it may determine the long-term viability of any pool.

Apparently it has been difficult in the past to get Aboriginal people to take the responsibility of looking after the pool at Ltyentyre-Apurte. Pools can only be of benefit to the community if they are well maintained and supervised. If they are not they can pose a serious health risk to those that use it. According to the health centre staff there have been no illnesses or accidents directly associated with the Ltyentyre-Apurte pool since its opening. The Health Centre staff also commented that there seemed to have been a reduction in the number of ear, eye and skin infections among children in the community during the season when the pool was open.

4.3.7 Other comments

Ltyentyre-Apurte has been a designated alcohol-free community since the pool was first opened in 1980. Drinking still occurs outside the town, and some people enter the community under the influence of alcohol. People who have been drinking are, however, not allowed in the swimming pool area, as this may be a threat to the safety of the children. From conversations with several community members, petrol sniffing is not considered to be a problem in the community.

Poor hygiene habits in the pool that were observed during the study included spitting, profuse nasal discharge, and beverage containers being thrown into the pool. Some vandalism has occurred at the pool involving graffiti, breaking windows, light and sprinkler fittings and throwing stones into the pool and on the roof. Maintenance required on the pool has included fixing pipes, filters and pumps, mowing lawns, and repairing vandalism. Sand and acid in the water causes a great deal of stress on the pumps, so bearings and impellers need to be replaced periodically. The caretaker is responsible for identifying and repairing any such problems.

4.3.8 Summary

Overall the observations of the pool at Ltyentyre-Apurte are consistent with the results of an audit of swimming pools in other remote communities in the Northern Territory, Queensland, South Australia and Western Australia (Peart and Szoeke 1998). The health and social benefits found at Ltyentyre-Apurte were also found in other communities with swimming pools. The pool was found to be well run, under the guidance of an enthusiastic and responsible caretaker. It was found to be quite feasible to do on site testing for the key chemical parameters that affect the pool water quality. In addition bacterial testing at a laboratory 80 km away posed no problems.

There were some aspects of the community at Ltyentyre-Apurte, however, that might not be considered typical for remote Aboriginal communities. The centre has been established for over 45 years as a Catholic Church run mission with considerable influence from the religious order. Ltyentyre-Apurte is designated as a dry community, and sniffing is not considered to be a problem. And lastly, the centre is relatively close to Alice Springs, so supply of chemicals and equipment and maintenance are not major problems.

4.4 Comments regarding a possible swimming pool for Kintore

Kintore is a remote Aboriginal community of approximately 300 people situated some 450 km west of Alice Springs, near the West Australian border. The community has been requesting a swimming pool for some time. The present study shows that the pool could offer considerable benefits to the community if it is properly maintained. Being in a more remote location than Ltyentyre-Apurte, there may be some increase in difficulties with the supply of chemicals, materials, and the maintenance of equipment but none that could not be overcome. Kintore drinking supply water is regularly sampled, with the water analysed in Alice Springs. Thus swimming pool water could be analysed as well.

The key feature would be to ensure the availability of a responsible caretaker. Installing auto-dosing chlorination equipment would reduce the responsibilities and the level of expertise required of the manager.

Presently at Kintore children swim in a nearby creek after sufficient rains, or in a small pond on an excavation site 10 km out of town. These sites do not meet the community's desire for a large, clean, safe pool within the town. The health service at Kintore have noticed an increase in skin sores and maybe ear infections after the first few days of swimming after rain (Peart and Szoeke 1998). Also a set of sewerage ponds are about to be installed at Kintore. Evidence elsewhere suggests that there is a considerable risk that the children will swim in these ponds in hot weather despite warning signs and security fences. Thus the installation of swimming pool may avoid the significant health risk to the children which the appearance of the sewage ponds would provide.

Kintore is known to be quite windy and dusty. A minimum requirement to reduce the amount of sand dropped into the pool might be windbreaks. Even these may not keep the dust out sufficiently to avoid excessive cleaning and the requirement for a high capacity filtration system. The introduction of large amounts of dust can cause the pool to go green with algae. Treatment involves super-chlorination, which is expensive and may require closure of the pool until proper water quality is regained. One method of overcoming such problems would be to consider an indoor pool. To avoid vandalism and maintenance problems, skylights would be more preferable than electric lights. An indoor pool would also have the advantage of reducing the possibility of children breaking into the pool and swimming unsupervised.

If a pool were built at Kintore, it would provide a valuable opportunity to conduct an epidemiological study before and after it is opened to see if improvements in the health of the children can be shown to be statistically significant.

Another significant problem that would affect the viability of a pool at Kintore is the sustainability of the present water supply. The current sustainable yield of the aquifer at Kintore is estimated at 235 m^3/day, (Wischusen, 1995). According to the ESO at Kintore the current demand regularly exceeds this value in the summer months. The installation of the deep sewerage system may increase the present demand for water. The water requirement for a pool of the same size as the one at Ltyentyre-Apurte, is 550 m^3 to be filled over several days, then more than 10 m^3 per day to account for losses from backwashing, evaporation and splashing. An indoor pool would have lower evaporation losses.

4.5 Natural swimming holes

4.5.1 Results

The results for the physical testing of the water holes are shown in Table 5.

Table 5: Test results for natural swimming holes.

Name	Date	Time	Water temp.	pH	Cond.	Salinity	Colour

			deg C		**EC**	**mg/L**	
Glen Helen	5/4/98	14:30	23.4	8.01	2060	1236	grey-green
Ormiston	5/4/98	15:30	22.2	7.45	322	193	grey-green
Ellery Creek	5/4/98	18:00	21.4	7.22	164	98	tea
Telegraph Stn	6/4/98	09:00	18.6	9.10	262	157	brown-green

See Appendix D for the Microbiological test results.

4.5.2 Discussion

Water holes are not managed in any way, so that if they are contaminated with faeces, or dead animals there is a real possibility of transmission of infection. Also, since the children are not supervised whilst swimming in these pools, there is a greater chance of injury, or drowning.

There are no permanent water holes close to Ltyentyre-Apurte where people may swim. However, after large rains when the local creeks fill up, a lot of people of all ages from the community jump in for a swim. Health centre staff at Ltyentyre-Apurte have noticed higher rates of infections after large rains, when the community has been swimming in the creeks. Problems with discharges from septic system have been cited as the possible cause of these infections. Obviously it would be preferable to have the community swimming exclusively in the pool. There is, however, an aversion amongst adult Aboriginal people towards swimming in supervised swimming pools.

Contamination of water holes can also come from animals and stock in the area, from faecal contamination of the water. On the day of testing, cattle stock were noticed grazing beside the water holes at Glen Helen and Ellery Creek. People had also been swimming the same day at Ellery Creek, and possibly at the other holes.

Faecal coliforms were detected in all water holes and plate counts were between 230 and 4500 organisms per 1 mL. The higher level of microorganisms in the water holes relative to the swimming pools tested indicated that there is a greater possibility of infection from swimming in the water holes. However the National Water Quality Guidelines for Recreation Waters (1992), which is the relevant standard for the water holes, is less stringent on microbiological standards for recreational waters. All of the water holes had faecal coliform counts less than the guideline of 150 coliforms per 100 mL, which indicates they are probably safe for primary contact.

The physical conditions measured at each of the water holes were mostly fine for swimming, according to the National Water Quality Guidelines for recreation waters (1992). The water at the Telegraph Station Water Hole had a pH of 9.1, which is just above the guideline of 9.0, however at the time of testing the water was too shallow to allow any more than wading, so the high pH should not be a problem.

4.6 Relevent Water Quality Regulations/Guidelines

4.6.1 Key parameters

The Northern Territory Guidelines for Water Quality and Hygiene Standard for Swimming, Diving, Water Slide and Paddling Pools (1996) are the primary guidelines for swimming pools in the NT. The Australian Guidelines for Disinfecting Private Swimming Pools (NH&MRC, 1989) are stated where they differ from the Territory guidelines. Where the limits are not stated the Australian Water Quality Guidelines (1992) for recreational waters (primary contact) are given. Only the latter set of guidelines is applicable to natural swimming holes.

The guidelines are as follows:

Microbiological: The Northern Territory guidelines states that there should be no coliforms, *Pseudomonas aeruginosa* or pathogenic *Naegleria* detectable in 100mL, and the total plate count should be less than 100 per 1 mL. The Australian Water Quality Guidelines suggest that the median bacterial content should not exceed 150 faecal coliform organisms/100mL or 35 enterococci organisms/100mL. Pathogenic free-living protozoans should be absent (only important if temperatures exceed 24^0C).

pH: Territory Health Services guidelines (1996) state that pH should be between 7.2 and 7.6 for swimming pools. Low pH values can cause eye irritation. High pH values reduce the effectiveness of chlorine dosage.

Temperature: Range of 15-35^{0}C for prolonged exposure. Low temperatures may induce cramps or hypothermia. High temperatures encourage growth of harmful microorganisms.

Chlorine: Where the water temperature is above 26 degrees Celsius, the minimum concentration of free residual chlorine should be greater than 2.0 mg/L. If the pool is stabilised with cyanuric acid, the minimum free residual chlorine concentration should be 4.0 mg/L. The combined residual chlorine level should be maintained at less than 1 mg/L. (Territory Health Services Guidelines, 1996).

The Australian Guidelines for Disinfecting Private Swimming Pools (NH&MRC, 1989) specify a lower minimum free residual chlorine concentration of 3.0 mg/L for pools with stabiliser and at greater than 26 degrees. Higher levels may be maintained without detrimental effects, but this is expensive and considered unnecessary.

Stabiliser: Should be less than 50 mg/L. Levels greater than this reduce the disinfection efficiency.

Total alkalinity: Should be maintained between 60-200 mg/L, and between 150-200 mg/L in pools using gaseous chlorine disinfection. Levels higher than 200 mg/L will cause scaling of fittings and surfaces, which may cause pump failure.

Salinity: Should be maintained less than 1500 mg/L. Higher levels reduce the efficiency of disinfection.

Water clarity: Should be maintained so that lane markings and other features on the pool bottom at its greatest depth are clearly visible when viewed from the side of the pool.

Toxic chemicals: Should not exceed concentration for untreated drinking water. Chemicals may be ingested or absorbed through the skin. Heavy metals especially copper, may be present in significant concentrations due to treatment for algae.

Oil and petrochemicals: Should not be noticeable as a visual film, or be detectable by odour. The skin may absorb some organics.

Algae: Should not exceed 15,000-20,000 cells/mL depending on algae type. Algal blooms, especially blue-green algae, can cause contact dermatitis, and influenza-like symptoms in swimmers. Ingestion of blue-green algae may induce gastro-intestinal disorders.

4.6.2 Sampling methods

Standard sampling methods should be used.

4.6.3 Preservation of samples

4.6.3.1 Microbiological samples

An ice-brick cooled esky should be used to transport samples. Samples should have sodium thiosulfate added to neutralise all residual chlorine (APHA Method 9060, 1989). Microbiological samples should ideally be analysed within 6 hours. However, in the extreme circumstances of remote community pools, samples may be still valid if tested within 24 hours as long as the elapsed time is recorded. (AS2031.2, 1987).

A chelating agent should be used in bottles receiving water containing copper, zinc or other heavy metals. Bottles should not be filled to the top (an air space of at least 2.5cm should be left).

4.6.3.2 Physical and chemical samples

Temperature, pH, conductivity and chlorine samples should be analysed immediately on site to reduce chance of contamination or deterioration.

Sampling for heavy metals and toxic chemicals can be sent to Darwin for laboratory analysis. Some indication of chemical levels in the pool should be shown by the analysis results for the bore water used to fill the pool. However, the addition of chemicals and evaporation, may tend to increase concentrations. The constituency of all chemicals added to the pool should be identified, and testing should be done for those, which are suspected to be at significant concentrations.

4.6.4 Testing location

Samples sent to Alice Springs, Department of Lands Planning and Environment may be tested for faecal coliforms, total coliforms, and total plate count.

Samples should only be delivered to the laboratory on Mondays, Tuesdays and Wednesdays, before 1.30pm, unless advance notice is given.

Samples sent to the Darwin office of the Power and Water Authority may be tested for all of the indicators measured in Alice Springs, as well as: *Pseudomonas aeruginosa, Enterococci, and* complete chemical analysis.

4.6.5 Cost of testing

4.6.5.1 Alice Springs:

Microbiological tests for faecal coliforms, total coliforms, and total plate count combined: $45 per sample.

Chemical testing can be done at Marriott Agencies in Alice Springs for free. However samples may deteriorate if they must travel considerable distance to Alice Springs.

4.6.5.2 Darwin:

Microbiological tests for faecal coliforms, total coliforms, total plate count and *Pseudomonas aeruginosa* combined: $60 per sample.

Test for *Enterococci,* $20 per sample.

Limited chemical analysis: including pH, conductivity, total hardness, chlorine, total alkalinity, colour and turbidity: $45 per sample.

Flame Atomic Absorption Spectrometry tests for metals eg. Copper: $10 per sample or for low levels by Graphite Furnace Atomic Absorption Spectrometry:$25 per sample.

Other chemical tests may be done for a specified price.

Samples arriving at Darwin on Thursdays, and Fridays, or outside normal working hours attract a levy.

Delivery costs should also be added. Communities reasonably close to a laboratory may send in samples by road, but more remote communities may need to use a mail plane to ensure that samples are processed within 24 hours.

If microbiological samples were sent to Alice Springs once per month over a six month swimming season (October to March inclusive) the total processing cost would be $270. This should be sufficient if the pool is operated correctly, and frequent chemical testing is performed.

Chlorine, pH and alkalinity can be checked on site with a standard pool test kit, which costs $33.

5. Conclusions

- This study has shown that key physical and chemical water quality parameters for swimming pools in remote communities can be monitored on site.

- Microbiological samples can be sent regularly to the nearest laboratory for analysis to ensure that the disinfection process is effective.

- The pool at Ltyentyre-Apurte shows that with proper maintenance a remote community pool can be made safe for swimming.

- There appears to be a lack of awareness of the relevant safety levels, in the NT, for free chlorine amongst pool caretakers. This lack is partly due to many pool test kits indicating a chlorine level that is lower than the relevant guidelines.

- Swimming pools in remote communities can be a community asset that provide considerable social and health benefits to the children.

- Well-managed swimming pools provide a safe alternative to natural swimming holes.

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7. References

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Note: The appendices are not available electronically.

For hard copies please contact:

Karen Alarcon
National Centre for Epidemiology and Population Health
The Australian National University
Canberra ACT 0200

Phone **61 02 6249 5627**
Fax **61 02 6249 0740**
Email Karen.Alarcon@anu.edu.au