Sources and pathways of bacteria affecting water quality on Darwin Harbour beaches and waterways

DARWIN HARBOUR
BEACH WATER QUALITY TASK FORCE

Final Report

June 2012
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Document Control

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Executive summary

In June 2010, following the detection of levels of bacteria above recreational water quality guidelines in water samples taken from Lake Alexander by the City of Darwin, the Department of Health initiated weekly bacteria monitoring at 11 public beaches around Darwin Harbour. The detection of bacteria levels above recreational water quality guidelines subsequently led to the Department of Health issuing precautionary advice against swimming at several Darwin Harbour beaches during the 2010 and 2011 Swimming Seasons.

In June 2011, the Northern Territory Government engaged Professor Andrew Campbell, of Charles Darwin University, to oversee the investigation of sources of bacteria on beaches and the development of actions to address these sources. Professor Campbell chaired a Taskforce of senior officers from the Department of Health; Natural Resources, Environment, The Arts and Sport; Power Water Corporation; the City of Darwin and the City of Palmerston.

In December 2011, the Taskforce released an initial report, which outlined:

• What we know and what we need to know about the likely sources of bacteria on Darwin Harbour beaches;
• Investigations needed to find out about the most likely sources of bacteria on beaches and the risks to public health;
• ‘No regrets’ measures that could be taken in the short term to start to address sources of bacteria, while these investigations are undertaken.

This document represents the final report of the Taskforce and provides:

• Recommendations on measures to address sources of bacteria on Darwin Harbour beaches;
• A recommended beach monitoring and management program; and
• Succinct key messages to underpin an education program for the wider community.

The key findings of the Taskforce were:

• We need to keep this problem in perspective as a threat to human health, in that few, if any, incidences of gastrointestinal illness outbreaks in Darwin can be linked to swimmers’ exposure to bacteria in beaches and waterways, whereas dangerous aquatic animals, particularly Box Jellyfish and crocodiles, present a greater risk to people and cause hospitalisations in the Northern Territory every year.
• Nevertheless, as Darwin continues to grow and as pressures on the Harbour intensify, it is critical that the systemic issues identified in this report are addressed in order to maintain the long-term status of Darwin Harbour as a beautiful, healthy harbour with generally very good water quality.

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• There is no single ‘smoking gun’ cause of bacterial pollution on Darwin Harbour beaches, and hence no single simple solution.

• There are multiple causes of bacterial pollution on Darwin Harbour beaches and in tidal creeks, and the relative contribution of different sources of pollution varies in different parts of the Harbour and its catchment.

• Consequently a range of measures are suggested in this report that target stormwater management, discharge from ships and boats, sewage system upgrades at household and system-wide scales, and management of dispersed sources of faecal pollution from dogs and illegal campers.

• An important conclusion of this study is the need for a comprehensive community education campaign to help the wider Darwin community and visitors to understand the factors that affect water quality in a tropical, monsoonal, macro-tidal harbour with high water temperatures — in particular in relation to rainfall events — and to encourage and assist people to adopt measures that would reduce the risks of bacterial contamination of waterways and beaches.

Measures to address sources of bacteria

The Taskforce recommends the following actions to address sources of bacteria on Darwin Harbour beaches:

• Enact Part Five of the Marine Pollution Act and prescribe Darwin Harbour as a Sensitivity Zone under the Act, to prohibit the discharge of sewage from ships;

• Implement a Stormwater Management Strategy for Darwin Harbour and its catchment;

• Ensure the Healthy Harbour Education Campaign targets stormwater management, pollution and domestic animal faeces;

• Continue investigating reports of pollution, encouraging compliance and enforcing legislation;

• Continue investigating bacteria hot spots;

• Implement improvements to the Ludmilla sewage treatment plant and Leanyer Sanderson sewage treatment plant;

• Ongoing management and monitoring of sites with septic systems within 100m of waterways and encourage connection to sewer;

• Continue Power and Water Corporation program of inspecting the sewer collection network;

• Install sewage pump-out facilities at Cullen Bay and other locations in Darwin Harbour;

• Review appropriateness of sewage dump points for caravans and motor homes;

• Maintain vigilance in management of illegal campers;

• Install bins in foreshore areas for disposal of dog faeces.
Beach monitoring and management program

The Taskforce recommends the following:

- Weekly microbiological monitoring (enterococci) should continue over the 2012 Swimming Season (June – September) at the most popular swimming beaches in the Darwin Harbour region;

- Results of 2012 Dry season beach water quality results should be reviewed and beaches classified according to National Health and Medical Research Council (2008) Guidelines for Managing Risks in Recreational Water and signposted accordingly. Beach water quality sampling frequency in 2013 and in ensuing Swimming Seasons should be undertaken in accordance with the guidelines and monitored under the Darwin Harbour Integrated Monitoring and Research Program.

- Signage should be erected at all beaches advising people to avoid swimming at Darwin beaches for at least 3 days after rainfall events, as conditions are unlikely to be suitable for swimming. Additional precautionary advice should be added to signage erected at Nightcliff, Vestey’s and Rapid Creek beaches advising of fluctuating water quality conditions.

Key messages

The Taskforce recommends that the following key messages should underpin the Healthy Harbour education campaign:

- Dangerous aquatic animals (especially Box Jellyfish and crocodiles) pose a greater risk to human health on Darwin Harbour beaches than bacterial loads;

- It is common in Australia and overseas for authorities to routinely advise against beach swimming in urban areas on the days immediately after heavy rain;

- Play it safe when swimming, by avoiding swimming after heavy rainfall; and
  - Avoiding swimming next to stormwater drains or sewage outfalls;
  - Avoiding swallowing water or putting your head under water if you are unsure about its quality.

- We all play a part in protecting our Harbour from pollution and can help by:
  - Putting rubbish, including wrapped dog faeces, in the bin;
  - Washing the car on the lawn, not in the driveway;
  - Putting vegetable scraps and garden clippings in the compost, rather than hosing them into the stormwater system;
  - Installing sewage containment devices on your boat, caravan or motor home and ensuring facilities are regularly pumped out;
  - Getting involved in a local community group and helping to monitor and manage Darwin Harbour and its catchment.
**Introduction**

In June 2010, following the detection of levels of bacteria above recreational water quality guidelines in water samples taken from Lake Alexander by the City of Darwin, the Department of Health (DoH) initiated weekly bacteria monitoring at 11 public beaches around Darwin Harbour during the 2010 Swimming Season (June – September) and added Lameroo Beach to the program in the 2011 Swimming Season. The detection of bacteria levels above recreational water quality guidelines subsequently led to DoH issuing precautionary advice against swimming at several Darwin Harbour beaches during the 2010 and 2011 Swimming Seasons.

In June 2011, the Department of the Chief Minister (DCM) engaged Professor Andrew Campbell, of Charles Darwin University (CDU), to oversee the investigation of sources of bacteria on beaches and the development of actions to address these sources.

In undertaking this work, Professor Campbell chaired a Taskforce of senior officers from DoH, the Department of Natural Resources, Environment, The Arts and Sport (NRETAS), Power Water Corporation (PWC), the City of Darwin and the City of Palmerston (CoP). Membership and Terms of Reference of the Task Force are at APPENDIX A. The Darwin Harbour Advisory Committee (DHAC) and the Rapid Creek Catchment Advisory Committee (RCCAC) were the key stakeholder reference groups for the Taskforce. Professor Campbell reported to the Minister for Natural Resources, Environment and Heritage and the Minister for Health directly.

The initial report of the Taskforce, released in December 2011, outlined:

- the existing state of knowledge about likely sources of bacteria on Darwin Harbour beaches;
- gaps in the knowledge base that needed to be filled and an investigation program to fill these gaps in the knowledge base, to determine the most probable sources of bacteria on beaches and the actual nature and level of public health risks;
- complementary measures such as public education activities that could be initiated in parallel; and
- recommendations for actions to be undertaken in the short term.

This document represents the final report of the Taskforce and provides:

- recommendations on a range of measures to address sources of bacteria on Darwin Harbour beaches;
- a recommended long-term monitoring system for assessing water quality on Darwin Harbour beaches and to provide an early warning system for any future risks to public health from bacteria on beaches; and
- a succinct summary of key messages to underpin an education program for the wider community.
Monitoring and investigations to identify sources of bacteria

The initial report of the Taskforce provided a comprehensive summary of the programs underway for the monitoring of bacteria levels at Darwin Harbour beaches and tidal creeks, and the investigations underway to determine the sources of bacteria. This chapter provides an update on the latest monitoring and investigation data.

Darwin Harbour beach monitoring

In December 2011, the third annual Darwin Harbour Report Cards were released. These outlined the results of Darwin Harbour water quality monitoring for the period May 2010 to June 2011 and beach water quality monitoring from 3 May to 24 October 2011.

Ten Darwin Harbour beaches were monitored weekly over the Swimming Season, with two beaches (Wagait and Mandorah Beaches) monitored monthly (see Figure 1).

Figure 1. Beach water sampling sites
Summary

This section presents the results of beach water quality monitoring for the period of 3 May to 24 October 2011.

From 4 July 2011, beaches were monitored to determine the risk to swimmers associated with bacteria levels, using the criteria drawn from the National Health and Medical Research Council (2008) Guidelines for Managing Risks in Recreational Water, which were formally adopted on 6 July 2011 under the NT Public and Environmental Health Act 2011. The following trigger levels were used by DoH to determine whether beaches were suitable for swimming:

- Green Mode (open for swimming) – All samples to be less than or equal to 50 enterococci per 100mL;
- Amber Mode (open for swimming) – All samples between 51 and 200 enterococci per 100mL;
- Red Mode (closed for swimming) – Two consecutive samples within 24 hours greater than 200 enterococci per 100mL.

It should be noted that between 1 October and 31 May, precautionary advice against swimming in Darwin beaches is issued by DoH throughout this period due to the higher danger posed to swimmers by the presence of Box Jellyfish and other marine stingers. During this period, the beaches are essentially closed to swimming, as they would be at patrolled beaches across Australia for the presence of sharks or large swells. During the ‘buildup’ and Wet season period in 2011–12, investigatory sampling of bacteria at beaches was also conducted to study the impact of rainfall on bacteria levels and inform public health advisories. Further information is provided later in this section.

Figure 2 below provides a summary of the beach closures between 3 May and 24 October 2011. Most beaches were sampled weekly with the exception of Mandorah and Wagait which were sampled monthly. During the 2011 Dry season, Casuarina Beach and Lee Point Beach were closed once to swimming and Rapid Creek Beach was closed on two occasions. All other beaches remained open.

![Figure 2. Beach closures for 2011](image-url)
Tidal creek monitoring

Monitoring of tidal creeks for public health indicators as well as a range of nutrients and ecological health parameters was also undertaken over 2010 and throughout 2011.

Tidal creeks are not generally considered recreational water bodies in the Darwin area with the exception of Rapid Creek. There are a number of popular swimming holes along Rapid Creek which are used, particularly after heavy rainfall when the microbial water quality is at its lowest.

An analysis of the levels of both E. coli and enterococci in these creeks revealed that they are likely to be a significant contributor to elevated levels recorded at the beaches where they discharge. Mean and median indicator bacteria levels from significant creeks and stormwater detention systems discharging to beaches are shown in Table 1.

These results, coupled with results in early 2012, clearly indicate that during the Wet Season, the National Health and Medical Research Council (2008) Guidelines for Managing Risks in Recreational Water were seldom met in Darwin’s tidal creeks.

Table 1. Bacteria results from tidal creek monitoring 2010, 2011 & 2012

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* Single sample results from Tidal Creek sampling undertaken on 24 January 2012.
Investigations into the influence of rainfall on bacteria levels

Scientific literature and monitoring of beaches in other parts of Australia and overseas suggests that bacteria counts at beaches are higher following rainfall events. To confirm and quantify this relationship for Darwin Harbour beaches, investigatory sampling was undertaken during the 2011-12 monsoon or ‘Wet season’. While beaches are normally recommended by DoH to be closed to swimming during the Wet season because of the presence of Box Jellyfish, the additional sampling provided evidence and information to inform the ongoing beach monitoring and management program.

Results of Build up/Wet season investigatory sampling identified that enterococci levels were generally within guideline levels for recreational water (see Table 2). Enterococci levels above recreational water quality guidelines were detected following the first rains of the Wet season, in October 2011, and again in February and March 2012, during rain after periods of very low rainfall. In particular, the very high enterococci readings detected on 24 October 2011 came after several days of heavy rainfall.

Rainfall events in Darwin can be quite localised. For consistency of reporting it should be noted that the rainfall data in Table 2 is from the Darwin Airport rain gauge. This however is not always representative of the rainfall in the local area. For example, in December 2010, 80 mm of rain fell at Royal Darwin Hospital, the closest rain gauge to Casuarina Beach, while less than 20 mm fell at Darwin Airport. Rainfall analysis for Nightcliff Beach using the local rainfall gauge is shown in Figure 3. Based on this limited sampling, it appears water quality deteriorates following rainfall events in excess of 10mm. These results are consistent with the Taskforce’s theory that rainfall, particularly after a dry period, is likely to lead to elevated levels of bacteria on Darwin Harbour beaches. Given the frequency of rainfall, the microbial quality of the water at Darwin Harbour beaches is unlikely to meet recreational water quality guidelines for much of the Wet season, nor after any unseasonal rainfall in the Dry/Build up seasons.

Figure 3. Nightcliff Beach: Relationship between Enterococci and Local Rainfall (Nightcliff Pool)
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Table 2. Build up/Wet Season investigatory beach sampling results

As pathogens may appear in recreational water following a lag period with respect to indicator bacteria (Flesiher et al., 2010), the Taskforce recommends a conservative public
health advisory notice (such as that in the Figure below) be issued to the effect that swimming is not recommended for 3 days following significant rainfall (>10mL) during the Swimming Season (June-September). This is consistent with the advice provided in Western Australia and New South Wales for Harbour beaches. Tasmania recommends a longer period of 5 days, while Victoria recommends a 24 hour withholding period in Port Phillip Bay. South Australia and Queensland do not issue standard precautionary advice following rainfall.

![Beach Advisory](image)

**Beach Advisory**

Do not swim at this beach for at least 3 days after rainfall as bacteria levels could be high and pose a risk to swimmers.

*Northern Territory Government*

**Figure 4. DRAFT Beach Advisory after rainfall**

### Integrated Monitoring and Research Program

In June 2010, the Darwin Harbour Advisory Committee (DHAC) and the Northern Territory Government agreed to facilitate an Integrated Monitoring and Research Program for Darwin Harbour. This Program will foster promotion, sharing and coordination of existing and new monitoring and research programs among its members, to improve understanding of the health of the Harbour and to improve capacity to plan for and manage the Darwin Harbour region.

Several organisations have agreed to be part of the Program, including NRETAS, PWC, Darwin Port Corporation, DoH, Department of Defence, ConocoPhillips, OZ Minerals, Inpex, City of Darwin, the Australian Institute of Marine Science and CDU. These organisations have formed an Interim Management Committee to manage the Program and NRETAS has provided staff towards a Program Design Team to design and develop the Program. It is expected that the Program will be designed and running by December 2012.

A long-term beach monitoring program and ongoing review of such should be included in the Integrated Monitoring and Research Program. It is anticipated that the Darwin Harbour Integrated Monitoring and Research Program will assist in interpreting the seasonal results of the beach monitoring program.
Charles Darwin University study to determine sources of bacteria

In July 2011, NRETAS, DoH and City of Darwin engaged Professor Karen Gibb, head of the Environmental Analytical Chemistry Unit of CDU, to investigate the most likely sources of bacteria on Darwin beaches using genetic fingerprinting.

The study addressed the following questions:

- Does the contamination on Darwin beaches originate from human faeces?
- What are the most likely source/s of *E. coli* and enterococci on Darwin beaches?

Following is the Executive Summary of this study, extracted from the Draft CDU Report. While these results are very useful in identifying the sources of bacteria on Darwin Harbour beaches, there are limitations associated with this study as samples were collected on one day only.

**Summary**

The objective of this study was to examine the sources of bacterial inputs on Darwin Harbour beaches. Thirty sites in the Darwin region were sampled on 20 June 2011, which was the expected height of Dry season faecal indicator counts based on previous years’ records. The timing and scope of this study precluded a Wet season follow-up sample. The 30 sites included three sewage discharges (Leanyer Sanderson, Ludmilla and Larrakeyah), other potential inputs and several beaches.

Physical environmental data and nutrient data were gathered at each of the sites. Two different laboratories determined the specific abundances of *E. coli* and *Enterococcus spp*. Similarities between the *E. coli* and *Enterococcus spp.* communities were measured using a DNA fingerprint method to link sites and track possible sources. Faecal markers were used to identify contamination and the likelihood that it was human waste. The information provided in this summary is also presented in Table 3.

The *E. coli* community in the Darwin inshore catchment was too complex to effectively track microbial sources. This result supports the growing body of evidence that *E. coli* is a very successful environmental bacterium that can multiply under a wide variety of conditions and is thus not useful for source tracking. The *Enterococcus* genus marker was more informative for microbial source tracking and was developed as part of this study. Using genetic community comparative analysis, CDU found no compelling evidence that the beach sediment was a source of bacteria for the overlying water column (the water above the sediment) at the time of sampling. This may differ during the Wet season.

Two genetic markers proved particularly useful as indicators of an enteropathogen (a pathogen of the gut) and human faeces. A third marker was a useful indicator of faeces but is not specific enough to be used as a human faecal indicator. Of note, none of the markers were demonstrated to be uniquely specific to human faeces. As such, the results presented indicate where bacteria from animal faeces, and likely to be from human faeces, were located.

Rapid Creek, from its mouth to McMillans Road, is a hotspot of faecal indicators, enteropathogens and at two sites, likely human waste indicators. The *Enterococcus* community profile was very similar along this stretch of the creek, which suggests single
or related localised sources of faecal bacteria between McMillans Road Bridge and the mouth of Rapid Creek. It is very likely that Rapid Creek was the source of the faecal marker and enteropathogen detected on Rapid Creek Beach on the day of sampling. CDU obtained no evidence that the likely human waste indicator present at two locations in Rapid Creek was also present in Rapid Creek Beach at the time of sampling. Based on the *E. coli* and *Enterococcus* profiles, there is no evidence to link the Leanyer discharge with Rapid Creek Beach. There was also no evidence to link the Chapman Road stormwater drain bacterial profile to Rapid Creek Beach, although again, this may differ in the Wet season.

*E. coli* and *Enterococcus* from the Ludmilla discharge could not be cultured due to the chlorine gas treatment used at this site and therefore could not be compared with other sites. Despite this, the likely human faecal marker (*B. thetaiotaomicron*) was positive at both the Ludmilla discharge and Ludmilla Creek and from this CDU cannot rule out the possibility that the discharge is impacting upon Ludmilla Creek.

The Larrakeyah discharge is a significant source of bacteria, including likely human faecal bacteria, that impacts Lameroo Beach and Doctors Gully. The closure of this discharge in 2012 will afford an opportunity to measure recovery at Lameroo Beach and Doctors Gully.

There is no compelling evidence for a link between the Larrakeyah discharge and Mindil Beach. Instead, the specific faecal markers and *Enterococcus* community profile suggest that Vesteys Creek, the Botanic Garden drain, and Little Mindil Creek are likely to be the cause of the elevated Mindil Beach bacteria counts and may be sources of likely human faecal indicators. At the time of sampling, water collected from near the boat clubs was positive for the likely human faecal bacteria, so CDU cannot discount this area as a source. There are other times of the year when many more boats are moored near this location and it would be worth sampling water during those times.

The East Point Reserve site near the toilets was positive for the likely human faecal marker. Despite this, the intake and Lake Alexander had relatively unique bacterial profiles and there was no evidence of faecal or human faecal indicators at the time of sampling.

There is some evidence for human faecal contamination at Cullen Bay, which is likely to be coming from within the Bay rather than from Larrakeyah.

There was no evidence that the Leanyer-Sanderson sewage treatment site was having any impact on the boat ramp at Buffalo Creek, Rapid Creek or Rapid Creek Beach.

The desired outcome for Government and the Darwin community is a reduced bacterial count on the beaches. Using a range of bacterial genetic markers, CDU has identified likely sources and hotspots that may result in immediate action. However, the data analysed in this study were collected at one Dry season sampling time. Bacterial communities are very likely to change during the Wet season when increased rainfall reduces salinity and increases run-off in the catchment. The bacterial communities may even change more often, for example, during high and low tides or during daily and monthly changes in tidal velocity, which is associated with changes in turbidity, temperature and sunlight. During the Wet season, bacteria associated with the sediments may also become important if they are resuspended during storms. It is therefore recommended that the sampling is replicated to cover changes throughout the year,
especially during the Wet season. CDU also recommend using a suite of pathogen and faecal markers, alongside the *Enterococcus* community profiles.

Table 3. Sites sampled in Darwin Harbour area and likely sources of bacteria

<table>
<thead>
<tr>
<th>Beach</th>
<th>Likely Dry season sources of bacteria</th>
<th>Type of bacteria present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid Creek Beach</td>
<td>Localised source/s between McMillans Road Bridge and the mouth of Rapid Creek.</td>
<td>Bacteria present from faeces and likely from human faeces at some sites in Rapid Creek.</td>
</tr>
<tr>
<td>Mindil Beach</td>
<td>Sources likely to be Little Mindil Creek, Vestey’s Creek and Botanic Garden Drain. Sources may include boats, but this requires further investigation.</td>
<td>Bacteria present from faeces and likely from human faeces in Vestey’s Creek and Botanic Garden Drain.</td>
</tr>
<tr>
<td>Lameroo Beach and Doctor’s Gully</td>
<td>Larrakeyah discharge.</td>
<td>Bacteria from faeces and likely from human faeces.</td>
</tr>
<tr>
<td>Ludmilla Creek</td>
<td>Possibly influenced by Ludmilla discharge.</td>
<td>Bacteria present from faeces and likely from human faeces.</td>
</tr>
<tr>
<td>East Point/Fannie Bay Beach (near toilets and near boat clubs)</td>
<td>Sources may include the Fannie Bay Beach toilet block and boats – requires further investigation.</td>
<td>Bacteria present from faeces and likely from human faeces.</td>
</tr>
<tr>
<td>Cullen Bay</td>
<td>Source within Cullen Bay.</td>
<td>Bacteria present from faeces and likely from human faeces.</td>
</tr>
<tr>
<td>Casuarina Beach</td>
<td>Source likely to be Rapid Creek but requires further investigation.</td>
<td>Bacteria present from faeces.</td>
</tr>
<tr>
<td>Lake Alexander and intake</td>
<td>No faecal bacteria present.</td>
<td>No faecal bacteria present.</td>
</tr>
<tr>
<td>Wagait Beach</td>
<td>No faecal bacteria present.</td>
<td>No faecal bacteria present.</td>
</tr>
</tbody>
</table>

**Tracking of bacteria sources at hot-spots**

As part of the ongoing investigations into high bacteria levels reported on Darwin beaches, PWC and City of Darwin conducted dry weather sampling at selected storm water outfalls and drains around hot spots identified by the sanitary inspection surveys. Chapman Road, Rapid Creek and Little Mindil were all selected as areas of concern. The majority of Darwin’s stormwater drainage network is an asset owned and maintained by City of Darwin, with some owned by the NT Government. A sampling program was coordinated and completed by officers of both PWC and City of Darwin.

**Methodology**

For the program to serve its purpose, stormwater sampling must be conducted under dry weather conditions. Dry weather has been defined as no rain in the previous 24 hours. Multiple inspections of stormwater pipes are necessary.

Raw sewage will typically have ammonia concentrations of 20-40 mg/L (Galloway, 2009). Where stormwater flow is identified at an inspection point, a colorimetric ammonia field test is undertaken. If ammonia is detected above 1 mg/L and flow is sufficient, collection of a bacteriological sample is taken and forwarded to the laboratories for analysis (Galloway, 2009). If a leak is suspected, a catchment investigation undertaken by representatives from the local government and sewer utility is performed. This involves a catchment walk, sampling from stormwater assets at junctions and access chambers and utilising
colorimetric ammonia testing and bacteriological samples to pinpoint sewer leaks. Once a sewer leak location is suspected, various techniques such as CCTV of sewers, fluorescein dye injection, smoke testing or sewer manhole entry are used to pinpoint and rectify the faults (Galloway, 2009).

In late 2011, members of the Taskforce identified areas of high bacteria readings (hot-spots) to investigate the potential sources of bacteria in the catchment. This involved a detailed review of existing monitoring data to identify potential hot-spots for investigation, a review of the relevant sanitary surveys conducted by DoH to determine potential sources of bacteria, tracking these potential sources and identifying measures to mitigate sources wherever possible.

Results and discussion

On 28 October 2011, stormwater flow inspections were conducted at 26 stormwater drains and pipes located in and around the Little Mindil, Rapid Creek and Chapman Road areas. All sampling was undertaken under dry weather conditions (no rainfall in 24 hours). Ammonia was tested at 14 stormwater pipes where stormwater was detected and ammonia readings at the threshold level (1 mg/L) were recorded at four locations. Bacteriological samples were not taken because the ammonia levels were minimal and the very low stormwater flow meant that it was impractical to collect an adequate sample.

A second round of sampling was undertaken, on 24 November 2011, at stormwater sites around Little Mindil and Rapid Creek. One stormwater pipe at Little Mindil returned a positive ammonia reading. Stormwater flow exiting the pipe was sufficient for a sample to be taken and was sent to the laboratory to be tested for *E. coli* and enterococci. The bacteriological results were; *E. coli* and enterococci were 1,119 and 776 CFU/100ml respectively, consistent with results of the earlier DoH investigation from April 2011 (Rogers *et al.*, 2011).

The ammonia readings detected through the stormwater sampling program were generally less than the threshold of 1 mg/L, indicating low level background sources rather than a concentrated point source such as raw sewage.

The stormwater flows were very low and in most cases collection of a viable sample was not possible. Where stormwater flows were present they would not have provided any significant dilution factor, again suggesting that the source of the ammonia is low level background sources rather than sewage.

Sampling was not practical after 24 November 2011 due to the onset of Wet season rains and further monitoring of hot spots is recommended for the 2012 Dry season.
Sanitary inspections

According to the National Health and Medical Research Council (2008) *Guidelines for Managing Risks in Recreational Water*, sanitary inspections should be undertaken to determine the susceptibility of beaches to faecal contamination and the consequent potential risk to human health of bathers.

Sanitary inspections involve identifying all sources of faecal contamination which may affect the water such as stormwater drains, native animals, sewage outfalls, septic tanks, and boating activities; calculating the likelihood of these impacts and then assessing the overall human health risk.

As part of this assessment, the following information is collected:
- Type of water body, and the level of mixing that occurs;
- Surrounding land cover including agricultural runoff;
- Number of bathers and type of recreational activities performed;
- Toilet facilities in the area, including sewered and non-sewered facilities;
- Sewage outfalls and pump stations;
- Stormwater discharges;
- Septic tank systems;
- Waste water reuse schemes;
- Stormwater runoff after rainfall events;
- Riverine discharges within 1 km, and stormwater/ sewage discharges to riverine system;
- Boats in the Harbour and whether pump out facilities are provided;
- Campers and itinerants living in close proximity to the beach or nearby waterways;
- Wildlife i.e. aquatic bird density;
- Domestic animals and their density on beaches, such as dogs being exercised and evidence of any defecating on beaches;
- Agricultural animals.

In 2010, sanitary inspections were undertaken for Darwin Harbour beaches by DoH environmental health officers and comprehensive reports produced. These reports have been used to identify potential sources of bacteria on Darwin Harbour beaches and to identify suitable actions for addressing these sources.

Further ground-truthing of these sanitary inspection surveys has been scheduled by DoH in collaboration with NRETAS officers, during the 2012 Dry season.
**Beach classifications**

The National Health and Medical Research Council (2008) Guidelines allow water bodies to be assessed after a sanitary inspection category has been derived from field or desk top analysis of the environment surrounding the water body to assess the potential for faecal contamination, and sufficient water quality data has been collected to allow for a microbial water quality assessment.

Water quality data collected for a microbial assessment should only be analysed for the Swimming Season. For this reason the microbial assessment category (MAC) for Darwin beaches has been determined using water samples collected between 1 June and 30 September, whereas all available data has been used to determine the MAC for the Darwin Waterfront Lagoon as this water body is available for swimming all year round.

Using enterococci analysis from Australian recreational waters it has been shown that for sample sizes greater than 100 water analysis tests, the difference in a 95th percentile calculated by different statistical methods is minimal (NHMRC, 2008). For sample sizes of less than 20 water analysis tests, the difference in 95th percentiles calculated by different statistical packages can be large.

For this reason, it is recommended that a minimum of 20 water analysis tests from Darwin beaches over the Swimming Season are collected before a 95th percentile is calculated, in order for the results from monitoring program to be statistically sound.

Darwin Harbour beaches have been classified according to the Beach Classification Matrix, which indicates suitability for swimming, taking into account the Sanitary Inspection Category and the Microbial Assessment, as shown in Table 4.

Beach grades range from Good to Very Poor, defined in accordance with Abbott *et al.* (2011). Beach classifications have been determined for Darwin Harbour beaches, based on microbiological testing undertaken during 2011 and sanitary inspections and are shown in Table 5.

Microbial Assessment Categories, Sanitary Inspections and Beach Water Classifications should be updated at the end of the Swimming Season to reflect any improvements in infrastructure, increased densification and urbanisation, and behavioural changes.
## Table 4. Beach Classification Matrix

<table>
<thead>
<tr>
<th>Sanitary Inspection Category</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low</td>
<td>Very Good</td>
<td>Very Good</td>
<td>Follow Up</td>
<td>Follow Up</td>
</tr>
<tr>
<td>Low</td>
<td>Very Good</td>
<td>Good</td>
<td>Follow Up</td>
<td>Follow Up</td>
</tr>
<tr>
<td>Moderate</td>
<td>Good</td>
<td>Good</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>High</td>
<td>Good</td>
<td>Fair</td>
<td>Poor</td>
<td>Very Poor</td>
</tr>
<tr>
<td>Very High</td>
<td>Follow Up</td>
<td>Fair</td>
<td>Poor</td>
<td>Very Poor</td>
</tr>
</tbody>
</table>

## Table 5. Darwin Harbour beach classifications 2011

<table>
<thead>
<tr>
<th>Site</th>
<th>Public Health Consequence</th>
<th>Sanitary Inspection Category (SIC)</th>
<th>Microbiological Assessment Category (MAC)</th>
<th>Risk Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casuarina Beach</td>
<td>Minor</td>
<td>Low</td>
<td>B</td>
<td>Good</td>
</tr>
<tr>
<td>Waterfront Lagoon</td>
<td>Moderate</td>
<td>Moderate</td>
<td>A</td>
<td>Good</td>
</tr>
<tr>
<td>Cullen Bay</td>
<td>Minor</td>
<td>Moderate</td>
<td>A</td>
<td>Good</td>
</tr>
<tr>
<td>East Point Beach</td>
<td>Minor</td>
<td>Moderate</td>
<td>B</td>
<td>Good</td>
</tr>
<tr>
<td>Lameroo Beach</td>
<td>Minor</td>
<td>Moderate</td>
<td>B</td>
<td>Good</td>
</tr>
<tr>
<td>Lee Point Beach</td>
<td>Minor</td>
<td>Moderate</td>
<td>B</td>
<td>Good</td>
</tr>
<tr>
<td>Mandorah/Wagait Beach</td>
<td>Minor</td>
<td>Low</td>
<td>A</td>
<td>Very Good</td>
</tr>
<tr>
<td>Little Mindil Beach</td>
<td>Moderate</td>
<td>Moderate</td>
<td>A</td>
<td>Good</td>
</tr>
<tr>
<td>Mindil Beach</td>
<td>Moderate</td>
<td>Moderate</td>
<td>B</td>
<td>Good</td>
</tr>
<tr>
<td>Nightcliff Beach</td>
<td>Minor</td>
<td>Moderate</td>
<td>C</td>
<td>Poor</td>
</tr>
<tr>
<td>Rapid Creek Beach</td>
<td>Minor</td>
<td>High</td>
<td>D</td>
<td>Very Poor</td>
</tr>
<tr>
<td>Vestey’s Beach</td>
<td>Minor</td>
<td>High</td>
<td>B</td>
<td>Fair</td>
</tr>
</tbody>
</table>

**Beach grading – Based on Abbott et al., 2011**

**Very Good:** Water is considered safe for swimming at all times. Consistently very good water quality tests and very few potential contamination sources indicate that water at this location should be of a high standard.

**Good:** Conditions are safe for swimming most of the time. Water quality tests are generally good on nearly all occasions and there are few potential faecal pollution sources identified.

**Fair:** Conditions are generally acceptable for swimming, although water quality tests may show times of elevated bacteria mostly due to animal pollutant sources and rainfall.

**Poor:** Conditions are generally not acceptable for swimming, as indicated by historical sampling results.

**Very Poor:** Avoid swimming at these locations, as there are direct discharges of faecal material.
Summaries for each of the beaches are provided below, with respect to the factors that contributed towards their beach classification.

**Casuarina Beach**

Figure 5. Casuarina Beach  
Casuarina Beach consists of a 6km long beach backing onto the Casuarina Coastal Reserve. The Reserve protects approximately 1500 ha of coastal habitats. The presence of the Reserve behind Casuarina Beach itself means that Casuarina Beach is minimally impacted by urban stormwater. The CDU study did not identify likely human faecal bacteria at Casuarina Beach, but did identify faecal bacteria.

The sanitary inspection category assigned to Casuarina Beach by DoH was low risk. The microbial water quality was assessed as a B, and these two categories combine to give a beach water classification of ‘good’.

**Waterfront Recreation Lagoon**

The Waterfront Recreation Lagoon is a man-made structure adjacent to the Wave Pool. Water is pumped in from the surrounding ocean and screened to protect bathers from jellyfish. The average water turnover in the Lagoon is 23,000m³ per day, which is sufficient to ensure the entire Lagoon is flushed weekly. The Darwin Waterfront Corporation actively manage and maintain the area surrounding the Lagoon because of its position as a gateway to Darwin for tourists arriving by Cruise ship and its popularity with tourists.

The sanitary inspection category assigned to the Waterfront area was moderate risk. The microbial water quality was assessed as an A, and these two categories combine to give a recreational water classification of ‘good’.

**Cullen Bay**

Cullen Bay is situated at the north-western end of Darwin City beginning at Myilly Point. The 25m long beach was constructed in the 1990s as part of the redevelopment of Cullen Bay. The local area is comprised of apartment buildings surrounding a marina lined with commercial shopping and eating areas near the foreshore. The main feature of this area is the Cullen Bay Marina where in excess of 250 vessels are moored. The Marina provides extensive modern facilities for local and visiting crafts including yacht maintenance services, an internal slipway, an external fuelling station and 24 hour staffing.
The sanitary inspection category assigned to Cullen Bay was moderate risk. During the survey only four stormwater drains were located in this area, though it expected that there are many more drains that discharge to the Cullen Bay Marina. Rubbish and food waste from restaurants were also observed in the Marina, and there is an exchange of water between the beach area and the Marina when boats use the lock. Of note, likely human faecal bacteria were detected in the Bay by the CDU study, suggesting that pump out facilities for boats should be installed at Cullen Bay as a priority.

The sanitary inspection category assigned for Cullen Bay was moderate risk and the microbial water quality was assessed as an A, and these two categories combine to give a beach water classification of ‘good’.

East Point Beach

The 1.5km long East Pont Beach is adjacent to the East Point Reserve, a popular family recreation area. The sparse residential and commercial development and minimal road infrastructure in the Reserve means that there are few municipal stormwater discharge points in the area. There are however a number of unsewered toilet blocks in the area, and it is a popular mooring for boats in the Dry season.

For these reasons the sanitary inspection category assigned to East Point Beach was moderate risk. The microbial water quality was assessed as a B, and these two categories combine to give a beach water classification of ‘good’.

Lameroo Beach

Lameroo Beach is an unpatrolled beach in the Darwin Central Business District. It is located at the base of densely vegetated 15m high bluffs at the centre of Bicentennial Park. A walkway leads down through tropical rainforest to the 100m long sand and gravel beach. Lameroo Beach is a popular fishing spot and was the location of the once popular all-season swimming baths.
During the Dry season, Lameroo Beach is utilised as an illegal camping area and it is occasionally used as a swimming area during high tide. The CDU study identified likely human faecal bacteria at Lameroo Beach and concluded that the beach is likely to be impacted by the Larrakeyah Sewage Outfall. The beach also experiences occasionally high levels of bacteria following rain in the Wet season.

For these reasons, the sanitary inspection category assigned to Lameroo Beach was moderate risk. The microbial water quality was assessed as a B, and these two categories combine to give a beach water classification of ‘good’.

**Lee Point Beach**

Lee Point is located at the northern fringes of the Darwin urban area, approximately 14km from the Darwin Central Business District. The area is bounded by Casuarina Coastal Reserve – Buffalo Creek (north); Shoal Bay Waste Disposal Site (south); Shoal Bay mangroves and salt flats (east); and Lee Point Road (west).

The coastal area near Buffalo Creek is within the Casuarina Coastal Reserve managed by NRETAS Parks and Wildlife. Although the sandy beach near Buffalo Creek is readily accessed from the Coastal Reserve car park, it is not a popular swimming area. Buffalo Creek is primarily used as an access point for boats via the Buffalo Creek boat ramp. Buffalo Creek is also the sewage discharge point for the Leanyer Sanderson Wastewater Treatment Plant.

For these reasons, the sanitary inspection category assigned to Lee Point Beach was moderate risk. The microbial water quality was assessed as a B, and these two categories combine to give a beach water classification of ‘good’.

**Mandorah and Wagait Beaches**

Mandorah Beach and Wagait Beach are located on the Cox Peninsula which is on the western side of the Darwin Harbour, approximately 6km from Cullen Bay. This area is accessible by the Cox Peninsula Road and by sea via a Ferry Service between Cullen Bay and the Mandorah Jetty.
Recreational fishing is popular within the area. A public boat ramp is located next to the Jetty and land based fishing also commonly occurs from the Jetty and nearby beaches. Bird life around the wetlands, coastal savannah and foreshore is prolific and a wide range of native and feral animals inhabit the surrounding bush land. There is a restricted land use area along Wagait Beach.

The sanitary inspection category assigned to Mandorah and Wagait Beaches was low risk. The microbial water quality was assessed as an A, and these two categories combine to give a beach water classification of ‘very good’.

Little Mindil Beach

The southern end of Mindil Beach adjacent to the tidal Little Mindil Creek is called Little Mindil Beach. It is directly opposite and popular with residents of the SkyCity Casino Hotel. The creek is not typically used for primary contact recreational purposes (swimming), however fishing has been observed on high tides.

The sanitary inspection category assigned to Little Mindil Beach was moderate risk. The microbial water quality was assessed as an A, and these two categories combine to give a recreational water classification of ‘good’.

Mindil Beach

Mindil Beach is Darwin’s most famous and popular beach, site of the Mindil Beach Sunset Market, and backed by the large Mindil Beach reserve. The 500m long beach faces west and is bordered by 15m high Myilly and Bullocky points. It consists of a moderately steep 100m wide high tide beach, fronted by 200m wide low tide sand flats. It is patrolled by the Mindil Beach Surf Life Saving Club during the Dry season.

Bacteria on Mindil Beach are thought to arise from Little Mindil Creek, Vestey’s Creek and the Botanic Garden Drain, and potentially from sewage discharge from boats.
The sanitary inspection category assigned to Mindil Beach was moderate risk. The microbial water quality was assessed as a B, and these two categories combine to give a recreational water classification of ‘good’.

Nightcliff Beach

Nightcliff Beach is backed by eroding bluffs that are protected by a rubble seawall, with claystone rock platforms at either end of the 300m long beach. A road runs along the top of the bluffs with two walkways down to the beach, which is patrolled by Darwin Surf Life Saving Club between June and August. The beach is moderately steep and narrow at high tide, while sand and some rock flats are exposed at low tide. It is separated from its neighbouring beach to the east by a high headland, with a public swimming pool and park located on the headland.

The sanitary inspection category assigned to Nightcliff Beach was moderate risk. The microbial water quality was assessed as a C, and these two categories combine to give a recreational water classification of ‘poor’. Nightcliff Beach is influenced by backwash water from the public swimming pool and some large municipal stormwater outlets. The microbial assessment category for Nightcliff Beach should improve in 2012 following improvements made by City of Darwin to the Nightcliff swimming pool backwash infrastructure.

The Taskforce recommends installing signage at Nightcliff Beach, advising that conditions may not always be suitable for swimming.
Rapid Creek Beach

Rapid Creek Beach is located on the eastern side of the headland. It is 300m long and consists of a veneer of high tide sand over protruding rocks, with a mixture of sand and rock flats exposed at low tide. It is backed by steep eroding red bluffs which restrict access to the far eastern end of the beach. A narrow foreshore reserve, road and then apartment buildings are located behind the bluffs. Rapid Creek lies to the southern end of the beach and is the largest freshwater system within the Darwin urban area. A large portion of the catchment has been cleared, although a stream corridor stretching nearly 7km from the Darwin Airport to the mouth of creek is relatively intact. Enterococci levels within the creek consistently exceed recreational water quality guidelines and contribute to the poor water quality experienced at Rapid Creek Beach. The CDU study identified likely human faecal bacteria within Rapid Creek itself. Rapid Creek Beach was closed twice to swimming during the 2011 Dry season, and experienced elevated levels of bacteria during the Wet season.

Figure 16. Rapid Creek Beach

The sanitary inspection category assigned to Rapid Creek Beach was high risk. The microbial water quality was assessed as a D. These two categories combine to give a recreational water classification of ‘very poor’.

The Taskforce recommends installing signage at Rapid Creek Beach and in Rapid Creek itself, advising beach users that high levels of bacteria are sometimes recorded at this beach. Figure 17 provides a suggestion for the beach sign advisory that could be coupled with both rainfall advisory signage (Figure 4), as well as signage warning of Box Jellyfish between October and May.
Beach Advisory

High levels of Bacteria are sometimes recorded at this beach throughout the year. These high levels usually only last for a short period of time. Although most swimmers are not expected to become ill, the risk of illness increases with higher levels of bacteria.

To further reduce the risk of illness, it is recommended that beach users take the following precautions:

1. Avoid swallowing the water
2. Avoid putting your head under water
3. Wash your hands before handling food
4. Avoid swimming with open cuts or wounds, or if you are feeling unwell.

Do not swim at this beach for at least 3 days after rainfall as bacteria levels could be high and pose a risk to swimmers.

Latest beach water quality results are available at:

Figure 17. DRAFT Beach Advisory for Rapid Creek Beach
Vestey’s Beach

Vestey’s Beach is a gentle curving 2.2km long beach around 100m wide. It has a steep high tide section, 400m of tidal flats and is backed by moderately high cliffs. The beach follows on from Mindil Beach and concludes at East Point Reserve. This area is well used by the boating community with four boat ramps. Boat cleaning, waste discharge and maintenance are carried out on the beach, in the water and in the local area, especially adjacent to the Darwin Sailing Club. The Darwin Trailer Boat Club and Darwin Sailing Club have large hard-stand areas for the storage and maintenance of boats.

There are many stormwater discharge points along the Vestey’s coastline. They are fed by the road networks in the surrounding residential, recreational and commercial/industrial areas. The stormwater outlets are well hidden in the rocky outcrops of the coastline and some are only accessible by following the drains from the road out to the beach.

Vestey’s Lake, situated along Atkins Drive in Fannie Bay is a natural wetland, which has been modified to act as a stormwater catchment area. The area in and around the lake is regularly used for illegal camping. It also provides a habitat for birds and aquatic life.

The sanitary inspection category assigned to Vestey’s Beach was high risk. The microbial water quality was assessed as a B, and these two categories combine to give a recreational water classification of ‘fair’.

The Taskforce recommends installing signage at Vestey’s Beach, advising that conditions may not always be suitable for swimming.

Figure 18. Vestey’s Beach
Dangers posed by Box Jellyfish and other marine stingers

During the Wet season, DoH do not recommend swimming due to the increased risk of encountering Box Jellyfish in Darwin Harbour. Furthermore every year, approximately 200 crocodiles are removed from traps in Darwin Harbour. During the course of the beach monitoring program, DoH has replaced faded or out of date warning signs relating to dangerous aquatic organisms such as Box Jellyfish on boat ramps and at popular swimming beaches.

While no conclusive gastro-intestinal cases can be identified in Top End hospitals related to bacteria levels at Darwin Harbour beaches, hospitals have however recorded an average of 14 presentations for Box Jellyfish injuries per year. There are likely to be many more incidents which are treated locally by General Practitioners and are not considered serious enough to attend hospital. Hospital presentations relating to Box Jellyfish injuries occur in every month of the year, with October and November being the most common time for Box Jellyfish injuries over the past two years.

An analysis of rainfall and microbial water quality data has also indicated a correlation between rainfall and bacteria levels in Darwin Harbour. However, the Taskforce considers that the risk to recreational users of coastal waters from crocodiles and Box Jellyfish is far greater than the risk posed by the microbial quality of the water, particularly during the Wet season.

![Box Jellyfish Safety Sign](image192x123to434x435)

Figure 19. Box Jellyfish sign recommended to be erected at beaches
Summary of findings and recommended actions to address sources of bacteria

Since the detection of elevated levels of bacteria on Darwin Harbour beaches in June 2010, several monitoring and research programs have been conducted in Darwin Harbour, seeking to determine whether beaches are safe for swimming and to identify the sources of bacteria on Darwin Harbour beaches. Many of these are outlined in the initial report of the Taskforce, with updates on monitoring and research also provided in the previous chapter.

Weekly monitoring of Darwin Harbour beaches and Lake Alexander during the Swimming Season and monitoring of tidal creeks identified varying levels of bacteria over space and time.

Investigations suggest that there is no single ‘smoking gun’ cause of bacterial pollution on Darwin Harbour beaches, and hence no single simple solution. Investigations into sources of bacteria on Darwin Harbour beaches, such as the CDU genetic fingerprinting study, sanitary inspections and hot spot investigations, suggest that there are multiple sources of bacteria on Darwin Harbour beaches, including bacteria arising from stormwater and run-off from the catchment; sewage discharged from boats; bacteria replicating in sediments and from native animals such as magpie geese; dog and horse faeces on beaches; itinerants and campers and from sewage systems. There are multiple causes of bacterial pollution on Darwin Harbour beaches and in major waterways, and the relative contribution of different sources of pollution varies in different parts of the Harbour and its catchment.

Consequently, a range of measures are suggested that target stormwater management, discharge from ships and boats, sewage system upgrades, and management of dispersed sources of faecal pollution from dogs and illegal campers. These measures are discussed in the following chapter. An important conclusion of this study is the need for a comprehensive community education campaign to help the wider Darwin community and visitors to understand the factors that affect water quality in a tropical, monsoonal, macro-tidal harbour with high water temperatures — in particular in relation to rainfall events — and to encourage and assist people to adopt measures that would reduce the risks of bacterial contamination of waterways and beaches.

A summary of the key findings of the Taskforce with respect to the potential sources of bacteria on Darwin Harbour beaches and key waterways and the recommended actions to address these sources is provided in Table 6. The recommended actions to address sources of bacteria are further detailed in the following chapter.
<table>
<thead>
<tr>
<th>Location</th>
<th># closures 2010</th>
<th># closures 2011</th>
<th>Beach classification</th>
<th>Potential sources of Dry season bacteria</th>
<th>Type of bacteria present</th>
<th>Recommended actions to address sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casuarina Beach</td>
<td>1</td>
<td>1</td>
<td>Good</td>
<td>Rapid Creek, domestic and native animals, catchment/stormwater, septic systems, illegal campers, caravans</td>
<td>Bacteria found in animal faeces</td>
<td>Ensure Healthy Harbour education campaign targets stormwater management and domestic animal faeces Install bins in foreshore areas for disposal of dog faeces Ongoing management of sites with septic systems within 100m of waterways Maintain vigilance in management of illegal campers Review appropriateness of dump points for caravan and motor homes</td>
</tr>
<tr>
<td>Cullen Bay Beach</td>
<td>0</td>
<td>0</td>
<td>Good</td>
<td>Sewage discharge from boats, catchment/stormwater, septic systems</td>
<td>Bacteria found in animal faeces and likely to be from human faeces</td>
<td>Enact Part Five of the Marine Pollution Act Install sewage pump out facilities at Cullen Bay and other locations in Darwin Harbour Finalise and implement Stormwater Management Strategy Continue investigating reports of pollution, encouraging compliance and enforcing legislation Ongoing management of sites with septic systems within 100m of waterways</td>
</tr>
<tr>
<td>East Point Beach</td>
<td>1</td>
<td>0</td>
<td>Good</td>
<td>Toilet blocks / septic systems, sewage discharge from boats, domestic and native animals, illegal campers</td>
<td>Bacteria found in animal faeces and likely to be from human faeces</td>
<td>Ensure Healthy Harbour education campaign targets domestic animal faeces Install bins in foreshore areas for disposal of dog faeces Ongoing management of sites with septic systems within 100m of waterways Enact Part Five of the Marine Pollution Act Install sewage pump out facilities at Cullen Bay and other locations in Darwin Harbour Maintain vigilance in management of illegal campers</td>
</tr>
<tr>
<td>Lameroo Beach</td>
<td>0</td>
<td>0</td>
<td>Good</td>
<td>Larrakeyah discharge, illegal campers</td>
<td>Bacteria found in animal faeces and likely to be from human faeces</td>
<td>Implement improvements to the Ludmilla sewage treatment plant and close the Larrakeyah discharge Maintain vigilance in management of illegal campers</td>
</tr>
<tr>
<td>Lee Point Beach</td>
<td>0</td>
<td>1</td>
<td>Good</td>
<td>Domestic and native animals, caravans/motor homes</td>
<td>NA</td>
<td>Ensure Healthy Harbour education campaign targets domestic animal faeces Install bins in foreshore areas for disposal of dog faeces Review appropriateness of dump points for caravan and motor homes</td>
</tr>
<tr>
<td>Mindil Beach</td>
<td>2</td>
<td>0</td>
<td>Good</td>
<td>Little Mindil Creek, Vestey's Creek and Botanic Garden Drain,</td>
<td>Bacteria found in animal faeces</td>
<td>Ensure Healthy Harbour education campaign targets stormwater management and domestic animal faeces Finalise and implement Stormwater Management Strategy</td>
</tr>
</tbody>
</table>

2. Beaches classified according to suitability for swimming, taking into account Sanitary Inspection Category and Microbial Assessment, defined in accordance with Abbott et al. (2011).
3. Note that these data reflect samples taken on a single date (20/6/11) by Neave and Gibb (2011) and information collected through the sanitary surveys (Rogers et al., 2011).
4. These actions are discussed more fully in the following chapter.
<table>
<thead>
<tr>
<th>Beach Location</th>
<th>Rating</th>
<th>Scores</th>
<th>Status</th>
<th>Recommendations</th>
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</thead>
<tbody>
<tr>
<td>Little Mindil Beach</td>
<td>Good</td>
<td>1-0</td>
<td>NA</td>
<td>Install bins in foreshore areas for disposal of dog faeces</td>
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<td>Enact Part Five of the <em>Marine Pollution Act</em></td>
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<td>Install sewage pump out facilities at Cullen Bay and other locations in Darwin</td>
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<td>Harbour</td>
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<td>Ongoing management of sites with septic systems within 100m of waterways</td>
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<td>Continue investigating reports of pollution, encouraging compliance and enforcing</td>
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<td>legislation</td>
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<td></td>
<td></td>
<td>Maintain vigilance in management of illegal campers</td>
</tr>
<tr>
<td>Mandorah Beach</td>
<td>Very Good</td>
<td>0-0</td>
<td>NA</td>
<td>Ensure Healthy Harbour education campaign targets stormwater management</td>
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<tr>
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<td>and domestic animal faeces</td>
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<td>Finalise and implement Stormwater Management Strategy</td>
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<td>Install bins in foreshore areas for disposal of dog faeces</td>
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<td>Continue investigating reports of pollution, encouraging compliance and enforcing</td>
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<td>Continue investigating bacteria hot spots</td>
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<td></td>
<td></td>
<td>Maintain vigilance in management of illegal campers</td>
</tr>
<tr>
<td>Nightcliff Beach</td>
<td>Poor</td>
<td>3-0</td>
<td>NA</td>
<td>Ensure Healthy Harbour education campaign targets stormwater management</td>
</tr>
<tr>
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<td>and domestic animal faeces</td>
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<td>Finalise and implement Stormwater Management Strategy</td>
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<td>Continue investigating bacteria hot spots</td>
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<td></td>
<td>Maintain vigilance in management of illegal campers</td>
</tr>
<tr>
<td>Rapid Creek Beach</td>
<td>Very Poor</td>
<td>4-2</td>
<td>NA</td>
<td>Ensure Healthy Harbour education campaign targets stormwater management</td>
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<td>and domestic animal faeces</td>
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<td>Finalise and implement Stormwater Management Strategy</td>
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<td>Install bins in foreshore areas for disposal of dog faeces</td>
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<td>Continue investigating reports of pollution, encouraging compliance and enforcing</td>
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<td>Continue investigating bacteria hot spots</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>Maintain vigilance in management of illegal campers</td>
</tr>
<tr>
<td>Vestey's Beach</td>
<td>Fair</td>
<td>2-0</td>
<td>NA</td>
<td>Ensure Healthy Harbour education campaign targets stormwater management</td>
</tr>
<tr>
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<td>and domestic animal faeces</td>
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<td>Finalise and implement Stormwater Management Strategy</td>
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<td>Enact Part Five of the <em>Marine Pollution Act</em></td>
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<td></td>
<td>Install sewage pump out facilities at Cullen Bay and other locations in Darwin</td>
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<td></td>
<td>Harbour</td>
</tr>
</tbody>
</table>

Locations:
- Little Mindil Creek, sewage discharge from boats, septic systems, stormwater/catchment
- Mandorah Beach: Domestic and native animals
- Nightcliff Beach: Stormwater/catchment, domestic and native animals, illegal campers
- Rapid Creek Beach: Localised sources in Rapid Creek, catchment/stormwater, domestic and native animals, illegal campers
- Vestey’s Creek, stormwater/catchment sources, illegal campers, caravans/ motor homes, domestic and native animals, sewage discharge from boats
### Tidal creeks & other swimming locations

| Location       | Results of sampling                                                                 | Potential sources of Dry season bacteria | Type of bacteria present | Recommended actions to address sources
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Wagait Beach</td>
<td></td>
<td>Domestic and native animals</td>
<td>No faecal bacteria found</td>
<td>Ensure Healthy Harbour education campaign targets domestic animal faeces</td>
</tr>
<tr>
<td>Rapid Creek</td>
<td>High levels of bacteria recorded during tidal creek sampling</td>
<td>Catchment/stormwater, illegal camping, native and domestic animals, septic systems</td>
<td>Bacteria likely to be from found at some sites, bacteria found in animal faeces</td>
<td>Ensure Healthy Harbour education campaign targets stormwater management and domestic animal faeces, Finalise and implement Stormwater Management Strategy, Continue investigating reports of pollution, encouraging compliance and enforcing legislation, Continue investigating bacteria hot spots, Maintain vigilance in management of illegal campers, Ongoing management of sites with septic systems within 100m of waterways, Continue PWC program of inspecting the sewer collection network</td>
</tr>
<tr>
<td>Ludmilla Creek</td>
<td>Monitoring undertaken by NRETAS for the Darwin Harbour Region Report Cards and by PWC suggests high bacteria loads</td>
<td>Ludmilla sewage discharge</td>
<td>Bacteria found in human faeces, bacteria found in animal faeces</td>
<td>Implement improvements to the Ludmilla sewage treatment plant</td>
</tr>
<tr>
<td>Waterfront Lagoon</td>
<td>Infrequent closures due to bacteria levels</td>
<td>Catchment/stormwater</td>
<td>NA</td>
<td>Ensure Healthy Harbour education campaign targets stormwater management</td>
</tr>
<tr>
<td>Lake Alexander</td>
<td>Occasionally elevated levels of bacteria, leading to closures</td>
<td>Catchment, domestic and native animals, septic systems</td>
<td>No faecal bacteria found</td>
<td>Ensure Healthy Harbour education campaign targets stormwater management and domestic animal faeces, Install bins in foreshore areas for disposal of dog faeces, Finalise and implement Stormwater Management Strategy, Ongoing management of sites with septic systems within 100m of waterways</td>
</tr>
<tr>
<td>Botanic Garden drain</td>
<td>High levels of bacteria recorded through CDU study (Neave and Gibb, 2011)</td>
<td>Catchment/stormwater, illegal campers</td>
<td>Bacteria found in animal faeces and human faces</td>
<td>Ensure Healthy Harbour education campaign targets stormwater management and domestic animal faeces, Finalise and implement Stormwater Management Strategy, Maintain vigilance in management of illegal campers</td>
</tr>
<tr>
<td>Vestey's Creek</td>
<td>High levels of bacteria recorded during tidal creek sampling</td>
<td>Catchment/stormwater, illegal campers</td>
<td>Bacteria found in animal faeces and human faces</td>
<td>Ensure Healthy Harbour education campaign targets stormwater management and domestic animal faeces, Finalise and implement Stormwater Management Strategy, Maintain vigilance in management of illegal campers</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th><strong>Little Mindil Creek</strong></th>
<th>High levels of bacteria recorded during tidal creek sampling</th>
<th>Catchment/stormwater, septic systems</th>
<th>Bacteria found in animal faeces and human faces</th>
<th>Ensure Healthy Harbour education campaign targets stormwater management Finalise and implement Stormwater Management Strategy Ongoing management of sites with septic systems within 100m of waterways Continue investigating reports of pollution, encouraging compliance and enforcing legislation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Buffalo Creek</strong></td>
<td>Monitoring undertaken through NRETAS for the Darwin Harbour Region Report Cards and by PWC suggests high bacteria loads</td>
<td>Leanyer/Sanderson sewage discharge</td>
<td>Bacteria found in animal faeces</td>
<td>Implement improvements to the Leanyer/Sanderson sewage treatment plant</td>
</tr>
</tbody>
</table>
**Recommended actions to address sources of bacteria**

This chapter outlines a series of actions aimed at addressing the sources of bacteria on beaches. Some of these actions are relatively straightforward, while others are complex. Some can be implemented by residents of the Darwin Harbour region, while others require investment from Governments over the long term.

**Bacteria arising from stormwater**

1. **Implement a stormwater management strategy for Darwin Harbour and its catchment**

   The initial report of the Taskforce recommended that the 2006 Draft Stormwater Management Strategy for the Darwin Harbour catchment be reviewed and a stormwater management strategy for Darwin Harbour and its catchment be finalised. The Taskforce understands that this work is still in progress.

   The Taskforce recommends that once this strategy is finalised, that it be endorsed and implemented by Governments as a matter of priority. In particular, the Taskforce would suggest that the following actions be addressed through implementation of the strategy:

   - Developing an agreed process to ensure that stormwater components of new developments are appropriately designed and managed;
   - Promoting use of best environmental practice guidance material, with respect to stormwater management;
   - Developing codes of practice for source pollution control;
   - Implementing a comprehensive stormwater management education program, including development of educational materials; media; a website; community monitoring and drain stencilling.

   ![Example of drain stencilling](image)

   **Figure 20. Example of drain stencilling to raise awareness of stormwater impact on Chesapeake Bay, on the east coast of the USA**
2. **Ensure the Healthy Harbour education campaign targets stormwater management**

The initial report of the Taskforce recommended that a multi-faceted and comprehensive ‘Healthy Harbour education campaign’ be developed, targeting beach users, Darwin residents and school children, to encourage improved management of stormwater and pollution. It is understood that the education campaign is planned for 2012.

The Taskforce recommends that the Healthy Harbour education campaign includes advertisements and messaging around stormwater management, as well as making publicly available a web-based map of stormwater catchments and outlets.

![Figure 21. Examples of raising awareness of stormwater management](image)

3. **Continue investigating reports of pollution, encouraging compliance and enforcing legislation**

The Northern Territory Government has an ongoing role in investigating reports of pollution, encouraging compliance and enforcing various pieces of legislation, including the *Waste Management and Pollution Control Act* and the *Public and Environmental Health Act*. This includes ensuring businesses are undertaking appropriate stormwater management and pollution controls.

The Taskforce recommends that NRETAS and DOH continue to work together to investigate reports of pollution, to encourage compliance and to enforce legislation.

Priorities for investigation include buildings and infrastructure adjacent to tidal creeks and major waterways, landfills and new major developments, including sub-divisions.
4. **Continue investigation of bacteria hotspots**

In its initial report, the Taskforce recommended that further investigations be undertaken into identified areas of high bacteria readings (hot spots) to investigate the potential sources of bacteria in the catchment. This will involve a more detailed review of existing monitoring data to identify potential hot spots for investigation, tracking these potential sources and identifying measures to mitigate sources wherever possible. This program has commenced and the Taskforce recommends that it continues, with hotspots for inter-agency investigation including buildings and infrastructure adjacent to Darwin Harbour beaches, particularly those along the Rapid Creek area.

**Bacteria arising from the sewer system**

5. **Implement improvements to the Ludmilla sewage treatment plant and Leanyer-Sanderson sewage treatment plant**

PWC has recently closed the Larrakeyah sewage outfall. Diversion of sewage flows from the Larrakeyah and Darwin Central Business District catchments commenced in November 2011 and progressively increased over the subsequent five months. The Larrakeyah sewage outfall ceased operation by 31 May 2012, when the current Waste Discharge Licences expired.

To support the closure of the Larrakeyah outfall, the Ludmilla Wastewater Treatment Plant is being upgraded and a duplicate treated effluent rising main from the treatment plant to East Point will be constructed during 2012.

The East Point outfall will also be extended into deeper water where effluent dispersion can be optimised. The East Point outfall extension is subject to environmental approval and a Public Environmental Report will be prepared in 2012. The current outfall is located adjacent to the East Point Coastal Reserve, and is unacceptably close to the shoreline. To ensure adequate effluent dispersion, the East Point Outfall must be extended as soon as practicable.

PWC is also in the planning phase of upgrading treatment processes at the Leanyer Sanderson Wastewater Treatment Plant.

PWC has increased environmental monitoring in Buffalo Creek and Shoal Bay and is working with NRETAS to develop site-specific trigger values (water quality targets) for Buffalo Creek over the next two years. The treatment concept and design will be progressed following confirmation of the site-specific trigger values to be applied for Buffalo Creek and a separate Public Environmental Report approval process.

The Taskforce recommends that Government commits to completing the works associated with the extension of the East Point outfall and the implementation of improved treatment at the Leanyer Sanderson Wastewater Treatment Plant.
6. **Ongoing management and monitoring of sites with septic systems within 100m of waterways and encourage connection to sewer**

The Taskforce recommends reviewing all sites in the Darwin Harbour catchment that are using septic systems within 100m of waterways and gradually transitioning these sites to be connected to the sewer system, as resources permit. Many of these sites were identified during the sanitary inspection surveys undertaken by DoH officers in 2010 and corrective action taken.

Departmental officers from NRETAS Environment and Heritage Branch and DoH Environmental Health Branch are continuing to progress this work. Sites have been prioritised according to their public health risk.

7. **Continue PWC program of inspecting the sewage collection network**

As noted in the initial report of the Taskforce, PWC undertakes regular inspections of the sewage collection network and routinely invests around $2 million annually in Darwin on sewer pipeline relining and rehabilitation programs. The Taskforce believes this program is a very important risk mitigation measure and recommends that it should continue.

**Bacteria arising from boats**

8. **Install sewage pump out facilities at Cullen Bay and other locations in Darwin Harbour**

In its initial report, the Taskforce recommended enacting Part 5 of the *Marine Pollution Act* and declaring parts of Darwin Harbour sensitivity zones to prohibit the discharge of sewage from boats. The report recognised that a sewage pump-out facility is to be installed at Cullen Bay during 2012.

The Taskforce recommends a communication plan to ensure Darwin boat owners are aware of the presence of the new facilities, and signage at mooring points to ensure visiting boat owners are aware of, and can locate the new facilities. The installation in due course of an additional sewage pump-out facility for boats in Darwin Harbour is also recommended, to provide back-up for the facility at Cullen Bay and to service boats in other parts of the Harbour.

**Bacteria arising from itinerants and campers**

9. **Review appropriateness of sewage dump points for caravans and motor homes**

Effluent dump points have been installed in a number of camping and recreation areas throughout the Northern Territory. The major public effluent dump point for caravans and motor homes in Darwin is at the Darwin Showground. In addition, grey waste disposal facilities are available at a number of commercial caravan parks for guests, with a fee-for-service arrangement for non-guests (NT Tourism Commission).

The Taskforce recommends that relevant government agencies review the arrangements in place for caravans and motor homes in the Darwin Region, particularly where overnight camping is not encouraged.
10. **Maintain vigilance in management of illegal campers**

City of Darwin is proactive in discouraging illegal activities such as camping or sleeping in any public places within the Darwin municipality. This includes sleeping in a motor vehicle, campervans, caravans and tents. City of Darwin Rangers regularly monitor public places including foreshore areas and issue infringement notices.

The Taskforce recommends continuing vigilance with respect to illegal campers.

**Bacteria arising from dogs, horses**

11. **Ensure the Healthy Harbour education campaign targets pollution and domestic animal faeces**

The Taskforce recommends that as part of the Healthy Harbour education campaign, that pet owners, particularly of dogs and horses, be made more aware of their responsibilities to collect their pet’s faeces through public messaging, provision of biodegradable plastic bags through local government depots and through the erection of appropriate foreshore signage.

![Image of people walking dogs on beach with signs indicating no littering and no dogs]

*Figure 22. Raising pet owner’s awareness of responsibility for their pets’ waste on beaches*

12. **Install additional bins in foreshore areas for disposal of dog faeces**

The Taskforce also recommends that additional bins be installed in foreshore areas to facilitate disposal of dog faeces.

**Bacteria arising from native animals and replicating in sediments**

The CDU genetic fingerprinting study (Neave and Gibb, 2011) found animal faecal bacteria present at several sites draining into Darwin Harbour. This suggests that bacteria present on Darwin Harbour beaches are likely to be sourced at least in part from native animals and through replication in the sediments.

The Taskforce does not make any recommendations with respect to addressing these sources of bacteria.
Recommendations with respect to beach monitoring and management

The National Health and Medical Research Council (2008) Guidelines for Managing Risks in Recreational Waters provide a framework for protecting the health of people from threats posed by the recreational use of coastal, estuarine and fresh waters. The microbial quality of recreational water is only one of a number of hazards that have been identified in our coastal waters.

Based on the microbial sampling and investigations conducted in Darwin Harbour over the past two years, and the beach classifications outlined previously, the following program of beach monitoring and management is recommended by the Taskforce:

- Signage should be erected at beaches classified as ‘very poor’, ‘poor’ or ‘fair’ (Rapid Creek, Nightcliff and Vestey’s Beaches) advising that conditions may not always be suitable for swimming. This signage should be modified or removed as appropriate after a periodic review of beach classifications in accordance with National Health and Medical Research Council (2008) Guidelines for Managing Risks in Recreational Water.

- Following periods of rainfall in the Swimming Season and at the beginning of each Wet season, precautionary advice should be issued, advising that swimming is not recommended for at least 72 hours following rainfall due to the potential for elevated levels of bacteria. Signage should also be erected at the Darwin Harbour beaches providing this precautionary advice, which could be coupled with Box Jellyfish warning signs.

- Members of the public who wish to access recreational waters during the Wet season should take note of any advisory notices in place or signs erected, particularly in relation to the presence of Box Jellyfish or crocodiles, and determine the frequency and duration of recent rainfall before making a decision to enter the water for the purpose of swimming or other water sports. Vinegar should always be carried by groups intending to enter the water.

- Weekly monitoring should occur at all beaches during the 2012 Swimming Season, to provide data for a review of beach classifications. Beach classifications should be reviewed at the end of the 2012 Swimming Season, after the collection of at least twenty separate water analysis samples for each beach location.

- After 2012, the beach monitoring program should be reviewed and aligned with beach classifications detailed in the above guidelines and monitored by the Darwin Harbour Integrated Monitoring and Research Program.

- All data collected through the beach monitoring program will also be used by the Darwin Harbour Integrated Monitoring and Research Program to assist in determining the ecological health of Darwin Harbour.
Key messages for the Healthy Harbour education campaign

Action by community members and stakeholders will be critical to addressing the sources of bacteria on Darwin Harbour beaches. This chapter outlines the importance of an ongoing community education campaign and the key messages that should be communicated through this campaign.

Healthy Harbour education campaign

In its initial report, the Taskforce recommended that a multi-faceted and comprehensive Healthy Harbour education campaign be developed. This campaign is planned for 2012.

The campaign will focus initially on increasing community awareness about the health of the Harbour and the importance of stormwater and pollution management to maintaining the health of the Harbour. The audiences for the first phase of the campaign will be residents / parents (through a website, signage in foreshore areas, general media/advertisements and promotional material) and school children (through development of curriculum materials, presentations).

Following completion of a Stormwater Management Strategy for the Darwin Harbour catchment, the education campaign will focus its efforts on implementing more targeted education, such as developing web-based information, fact sheets and guidance materials for light industrial and commercial stakeholders regarding stormwater management and pollution.

A Healthy Harbour website will provide users with real time information about the status of beaches, as well as access to broader information about the health of the Harbour, and access to all promotional material, factsheets etc. The website will have sections aimed at different users of the Harbour and its catchment, including children and families, teachers, business and industry.

The Healthy Harbour education campaign will be developed by NRETAS, DoH, City of Darwin and in collaboration with City of Palmerston and a range of key stakeholders from industry and special interest groups.
Key messages

Key messages for the campaign are as follows:

- Dangerous aquatic animals (especially Box Jellyfish and crocodiles) pose a greater risk to human health on Darwin Harbour beaches than bacterial loads.
- It is common in Australia and overseas for authorities to routinely advise against beach swimming in urban areas in the days immediately after heavy rain.

- Play it safe when swimming, by:
  - Avoiding swimming after heavy rainfall;
  - Avoiding swimming next to stormwater drains or sewage outfalls;
  - Avoiding swallowing water or putting your head under water if you are unsure about its quality.

We all have a part to play in protecting our Harbour from pollution. You can help by:

- Putting rubbish in the bin;
- Washing the car on the lawn, not in the driveway;
- Wrapping up dog faeces and putting it in the bin;
- Putting vegetable scraps and garden clippings in the compost, rather than washing them down the sink or hosing them into the stormwater;
- Installing sewage containment devices on your boat, caravan or motor home and ensuring facilities are regularly pumped out;
- Getting involved in a local community group and helping to monitor and manage Darwin Harbour and its catchment.
Summary of recommendations

Actions to address sources of bacteria

The Taskforce recommends the following actions to address sources of bacteria on Darwin Harbour beaches:

- Enact Part Five of the *Marine Pollution Act* and prescribe Darwin Harbour as a Sensitivity Zone under the Act, to prohibit the discharge of sewage from ships;
- Implement a Stormwater Management Strategy for Darwin Harbour and its catchment;
- Ensure the Healthy Harbour Education Campaign targets stormwater management, pollution and domestic animal faeces;
- Continue investigating reports of pollution, encouraging compliance and enforcing legislation;
- Continue investigating bacteria hot spots;
- Implement improvements to the Ludmilla sewage treatment plant and Leanyer Sanderson sewage treatment plant;
- Ongoing management and monitoring of sites with septic systems within 100m of waterways and encourage connection to sewer;
- Continue Power and Water Corporation program of inspecting the sewer collection network;
- Install sewage pump-out facilities at Cullen Bay and other locations in Darwin Harbour;
- Review appropriateness of sewage dump points for caravans and motor homes;
- Maintain vigilance in management of illegal campers;
- Install bins in foreshore areas for disposal of dog faeces.

Beach monitoring and management program

The Taskforce recommends the following, with respect to the beach monitoring and management program:

- Weekly microbiological monitoring (enterococci) should continue over the 2012 Swimming Season (start of June – end of September) at the most popular swimming beaches in the Darwin Harbour region;
- Results of 2012 Dry season beach water quality results should be reviewed and beaches classified according to National Health and Medical Research Council (2008) *Guidelines for Managing Risks in Recreational Water* and signposted accordingly at all beaches. Beach water quality sampling frequency in 2013 and in ensuing Swimming Seasons should be undertaken in accordance with the guidelines and monitored under the Darwin Harbour Integrated Monitoring and Research Program.
- Signage should be erected at all beaches advising people to avoid swimming at Darwin beaches for at least 3 days after rainfall events, as conditions are unlikely to be suitable for swimming. Additional precautionary advice should be added to signage erected at Nightcliff, Vesteyes and Rapid Creek beaches advising of fluctuating water quality conditions.
Key messages

The Taskforce recommends the following key messages underpin the Healthy Harbour education campaign.

- Dangerous aquatic animals (especially Box Jellyfish and other marine stingers, as well as crocodiles) pose a greater risk to human health on Darwin Harbour beaches than bacterial loads;
- It is common in Australia and overseas for authorities to routinely advise against beach swimming in urban areas in the days immediately after heavy rain;
- Play it safe when swimming, by:
  - Avoiding swimming after heavy rainfall;
  - Avoiding swimming next to stormwater drains or sewage outfalls;
  - Avoiding swallowing water or putting your head under water if you are unsure about its quality.
- We all have a part to play in protecting our Harbour from pollution. You can help by:
  - Putting rubbish in the bin;
  - Washing the car on the lawn, not in the driveway;
  - Wrapping up dog faeces and putting it in the bin;
  - Putting vegetable scraps and garden clippings in the compost, rather than washing them down the sink or hosing them into the stormwater system;
  - Installing sewage containment devices on your boat, caravan or motor home and ensuring facilities are regularly pumped out;
  - Getting involved in a local community group and helping to monitor and manage Darwin Harbour and its catchment.
References


APPENDIX A. Taskforce membership and Terms of Reference

Membership

Professor Andrew Campbell — Chair
Charles Darwin University (CDU)

Dr Samantha Fox
Department of Natural Resources, Environment, the Arts and Sport (NRETAS)

Mr Xavier Schobben
Department of Health (DoH)

Mr Steve McKenzie
Power Water Corporation (PWC)

Mr Mark Blackburn
City of Darwin (CoD)

Alderman Sue McKinnon
City of Palmerston (CoP)

Terms of Reference

Overall objective

To ensure that water quality in Darwin’s beaches and waterways is of high quality and to minimise the risk of future beach closures.

Strategy

Establish a Taskforce of senior officials from relevant agencies, under independent oversight, to identify the most probable sources and pathways of contaminants implicated in recent beach closures, and to recommend measures necessary to reduce future contamination and minimise the risk of future beach closures.

Establishment of the Taskforce

1. The Taskforce will be convened comprising senior officers of DOH, NRETAS and PWC.
2. CoD and CoP will be invited to join the Taskforce.
Independent oversight and reporting

3. Professor Andrew Campbell of CDU will be engaged by the DCM to chair the Taskforce. Professor Campbell is a research leader of national standing who is highly experienced in the design and implementation of research and monitoring programs, and in facilitation of community consultation and engagement initiatives.

4. Professor Campbell will provide independent oversight of the design and implementation of an investigation program to determine the most probable causes of elevated faecal indicator results on Darwin beaches.

5. Professor Campbell will report directly to the Minister for Health and the Minister for Natural Resources, Environment and Heritage.

6. An initial report will be prepared by Professor Campbell and the Taskforce and will be provided within one month of agreement to these Terms of Reference. That report will:
   - outline the existing state of knowledge about likely contaminant sources and pathways;
   - identify gaps in the knowledge base and existing monitoring programs that need to be filled in order to increase certainty to the community about real risks to public health around contaminant sources and pathways;
   - identify an investigation program to fill critical gaps in the knowledge base to determine the most probable sources of faecal contamination, elevated bacteria levels and the actual nature and level of public health risks;
   - recommend complementary measures such as public education activities that could be initiated in parallel with the systematic investigation; and
   - outline likely resource requirements and probable timelines.

7. Professor Campbell will then provide independent oversight of the subsequent investigation program to be managed by the Taskforce, which will:
   - identify key contributors in space and time to bacterial readings in Darwin Harbour, especially those related to beach closures;
   - identify actions that will reduce or mitigate the effects of the inputs that lead to high bacterial loads; and
   - establish the requirements in terms of the types of data, the sampling methods and frequency and the distribution of sampling points or sensors, for a long-term, on-going monitoring system capable of identifying emerging issues as early as feasible, in order to maintain water quality at satisfactory levels.

8. A final report, to be prepared by Professor Campbell and the Taskforce, will:
   - make recommendations on the range of measures to mitigate contamination risks, and the consequent risk to public health and associated beach closures;
   - include a succinct summary of key messages for the wider community; and
   - outline a recommended long-term monitoring system that would underpin community confidence in the water quality of Darwin Harbour beaches, and provide an early warning system for any future risks to public health from bacterial pollution.

Recommendations provided by Professor Campbell and the Taskforce will be jointly assessed by both levels of government and the broader community.
Governments’ support

9. All Northern Territory Government agencies, CoD and CoP will provide unfettered support for the Taskforce and Professor Campbell, including making relevant staff available to serve on the Taskforce, provision of access to existing monitoring programs and results, and any other data and information relevant to possible causes of Harbour pollution, as soon as possible on request from Professor Campbell.

10. NRETAS will provide Secretariat support for Professor Campbell.

Community input and communication

11. DHAC and the RCCAC will be invited to act as community reference groups.

12. The Secretariat will assist with the engagement of DHAC and RCCAC.

13. Communications will be coordinated by DOH and NRETAS with support from DCM.

14. A public communications strategy will be developed jointly by DCM, DOH, NRETAS, COD and CoP.

15. Communications measures will include a dedicated website for open and transparent reporting to the local, Northern Territory, Australian and international communities of progress on investigations and to provide regular updates on water quality at Darwin beaches.
Advisory Mechanisms

As outlined in the Terms of Reference, the key stakeholder advisory mechanisms for the Task Force are the Darwin Harbour Advisory Committee (DHAC) and the Rapid Creek Catchment Advisory Committee (RCCAC).

Darwin Harbour Advisory Committee

DHAC is a multi-stakeholder Ministerial Advisory Committee that provides the Minister for Natural Resources, Environment and Heritage with advice on land use, planning, development and the use of natural resources within the Darwin Harbour region. The Committee’s focus is on sustainable development and the long-term protection of the Darwin Harbour.


Rapid Creek Catchment Advisory Committee

In 1994, COD and Greening Australia developed the Rapid Creek Management Plan. The plan proposed a range of strategies to stimulate greater awareness of the presence and importance of the Rapid Creek area; promote increased protection and appropriate management of the Rapid Creek system; and to encourage government agencies and the community to co-operate in the development of protection and rehabilitation measures for the Rapid Creek system. One of the key recommendations of the Plan was to set up a management structure to coordinate implementation of the Plan.

RCCAC was formally established under the Water Act in 1996. Committee members are committed to improving the cooperative management of the catchment and advise the Minister on policy for management of the natural resources of the catchment.

RCCAC includes representatives from the Department of Defence, Darwin International Airport, COD, Larrakia Nation Aboriginal Corporation, CDU, Greening Australia, Rapid Creek Landcare Group, Department of Lands and Planning and NRETAS.