



**MIGRATORY SHOREBIRDS IN  
DARWIN HARBOUR,  
NORTHERN TERRITORY**

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**FIRST REPORT**

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**REPORT TO THE NORTHERN TERRITORY GOVERNMENT  
31 OCTOBER 2013**

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31 October 2013

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## SUMMARY

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This project assesses the importance of Darwin Harbour for migratory shorebirds protected under the Environmental Protection and Biodiversity Conservation Act 1999. This first report identifies the hardware to be purchased, provides a complete record of all shorebirds recorded roosting at East Arm Wharf and identifies the known and potential roost sites that will be investigated during the duration of the project. It provides a baseline for the remainder of the project.

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## BACKGROUND

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This project examines migratory shorebird ecology in Darwin Harbour. The research has practical implications for the long-term planning of development in Darwin Harbour. The distribution and abundance of shorebirds in Darwin Harbour is unknown, as is the importance of the mudflats in the harbour to maintaining these migratory shorebird populations, which are protected under the Environmental Protection and Biodiversity Conservation Act 1999. Development of Darwin Port is expected to increase and most projects will need to anticipate their impact on shorebirds if they are to get permits under the EPBC Act. A study of the shorebirds in Darwin Harbour will place any local developments in context and ensure the approval process is linked to empirical data. The research will also fulfil the shorebird monitoring required as part of the Northern Territory's environmental management of East Arm Wharf.

In order to meet the aims of this project, migratory shorebirds will be trapped and tagged to track movements within Darwin Harbour. To do this an array of tracking equipment (listed in Table 1) will be attached to shorebirds. At the time of this report these items are yet to be purchased.

Table 1. List of items to be purchased to undertake migratory shorebird project in Darwin Harbour.

| Description                       | Per item cost | Number of items |
|-----------------------------------|---------------|-----------------|
| Geolocators                       | 204.50        | 20              |
| GPS tags                          | 80.75         | 10              |
| VHF transmitters glue-on          | 213.00        | 50              |
| VHF transmitters lite             | 158.00        | 70              |
| Telemetry software                | 2000.00       | 1               |
| Automatic receivers               | 8000.00       | 2               |
| Yagi Aerials and housing          | 1485.00       | 4               |
| VHF receiver                      | 2200.00       | 4               |
| Automatic receivers               | 8000.00       | 2               |
| Fuel costs: 5000 kms @ \$0.50 c/l | 0.50          | 5000            |

Selected individual shorebirds will have tracking devices applied to them. Tracking of shorebirds is widely used in biological and ecological surveys, mostly to understand movement at a local-scale and migration at a global-scale. In the first season (January to April 2014) shorebirds will be applied with VHF tracking devices. These birds will then be tracked for local-scale movement in the Harbour using hand-held radio tracking receivers and antennae. Tracking of shorebirds will be complemented with intensive observational work to resighting individually-marked shorebirds. Additionally, in the second fieldwork season GPS bird tags will be applied to selected individual birds. These devices can be used to track shorebirds at a global scale; they are also advanced enough to track small-scale movements, such as those within a harbour. Moreover, geolocators will be attached the leg of the shorebird and can be used for one to five years, depending on the battery size. Geolocators measure the ambient light level with reference to time, so the location of the bird can be known.

The fieldwork component of the study will include intense observational surveys, in addition to the tracking using telemetry devices. Surveys performed at high tide roost-sites have been performed at East Arm Wharf since late-2009. These surveys will continue throughout the duration of the project.

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## **SURVEY METHODS**

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### **SHOREBIRD SURVEYS**

Migratory shorebirds were surveyed weekly at Pond D at East Arm Wharf from 2009 to 2013. All 36 listed migratory shorebirds were surveyed for during counts at Pond D. Surveys were conducted two hours either side of the high tide, within daylight hours. All birds were identified and counted using binoculars and a spotting scope.

### **HABITAT MAPPING**

Potential roost sites for shorebirds were mapped using Google Earth. Roost habitat was selected for optimum conditions of a site, including large, open area, distance to nearest tall vegetation, distance to coastal water, connectedness and distance to other known roosting and feeding sites. The distance from East Arm Wharf to other known roost sites has been calculated.

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## **SURVEY RESULTS**

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### **SHOREBIRD SURVEYS**

Results from regular shorebird surveys at Pond D are shown in Table 2. Maximum counts and threshold values for migratory shorebirds at East Arm Wharf are shown in Table 3.

Table 2. Migratory shorebird count data from November 2009 to October 2013, continued from page 6 - 15.

| Date                                  | 30/11/2009 | 9/01/2010 | 6/02/2010 | 27/03/2010 | 17/04/2010 | 10/07/2010 | 28/10/2010 | 12/11/2010 | 16/11/2010 | 18/11/2010 | 22/11/2010 | 24/11/2010 |
|---------------------------------------|------------|-----------|-----------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| <b>Time of count</b>                  | 14:00:00   | 10:50:00  | 10:50:00  | 15:00:00   | 8:00:00    | 15:00:00   | 9:00:00    | 7:35:00    | 15:02:00   | 10:35:00   | 18:30:00   | 9:32:00    |
| <b>Time of nearest high tide</b>      | 17:39:00   | 12:59:00  | 11:07:00  | 16:34:00   | 8:04:00    | 9:11:00    | 8:06:00    | 8:57:00    | 14:52:00   | 16:38:00   | 19:03:00   | 18:47:00   |
| <b>Hight tide (m)</b>                 | 7          | 5.3       | 5.9       | 6.4        | 7.4        | 6.7        | 6.2        | 5.06       | 4.9        | 5.9        | 7.3        | 6.5        |
| <b>Count site</b>                     | Pond D     | Pond D    | Pond D    | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     |
| <b>Time difference with high tide</b> | 3:39:00    | 2:09:00   | 0:17:00   | 1:34:00    | 0:04:00    | 5:49:00    | 0:54:00    | 1:22:00    | 0:10:00    | 6:03:00    | 0:33:00    | 9:15:00    |
| Latham's snipe                        |            |           |           |            |            |            |            |            |            |            |            |            |
| Pin-tailed snipe                      |            |           |           |            |            |            |            |            |            |            |            |            |
| Swinhoe's snipe                       |            |           |           |            |            |            |            |            |            |            |            |            |
| Black-tailed godwit                   |            |           |           |            | 7          |            |            |            |            |            |            |            |
| Bar-tailed godwit                     |            |           |           |            |            |            |            |            |            |            |            |            |
| Little curlew                         |            |           |           |            |            |            |            |            |            |            |            |            |
| Whimbrel                              |            |           |           |            |            |            |            | 2          | 2          |            |            |            |
| Eastern curlew                        |            | 1         | 5         | 101        | 1          |            |            | 1          | 95         |            | 27         |            |
| Common redshank                       |            |           |           |            |            |            |            |            |            |            |            |            |
| Marsh sandpiper                       |            | 1         | 1         |            |            |            |            |            |            |            | 250        | 63         |
| Common greenshank                     |            | 6         | 8         | 11         | 3          |            |            | 20         | 15         |            | 10         | 2          |
| Wood sandpiper                        |            |           |           |            |            |            |            |            |            |            |            |            |
| Terek sandpiper                       |            |           |           |            |            |            |            |            |            |            |            |            |
| Common sandpiper                      |            |           |           |            | 1          |            |            |            |            |            |            |            |
| Grey-tailed tattler                   |            |           |           |            |            |            |            |            |            |            |            |            |
| Wandering tattler                     |            |           |           |            |            |            |            |            |            |            |            |            |
| Ruddy turnstone                       |            |           |           |            |            |            |            |            |            |            |            |            |
| Asian dowitcher                       |            |           |           |            |            |            |            |            |            |            |            |            |
| Great knot                            |            |           |           |            |            |            |            |            | 20         |            |            |            |
| Red knot                              |            | 1         |           |            | 150        |            |            |            |            |            |            |            |
| Sanderling                            |            |           | 1         |            |            |            |            |            |            |            |            |            |
| Red-necked stint                      |            | 6         |           | 4          | 4          |            |            | 30         | 25         |            |            | 55         |
| Long-toed stint                       |            |           |           |            |            |            |            |            |            |            |            |            |
| Pectoral sandpiper                    |            |           |           |            |            |            |            |            |            |            |            |            |

| Date                                  | 30/11/2009 | 9/01/2010 | 6/02/2010 | 27/03/2010 | 17/04/2010 | 10/07/2010 | 28/10/2010 | 12/11/2010 | 16/11/2010 | 18/11/2010 | 22/11/2010 | 24/11/2010 |
|---------------------------------------|------------|-----------|-----------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| <b>Time of count</b>                  | 14:00:00   | 10:50:00  | 10:50:00  | 15:00:00   | 8:00:00    | 15:00:00   | 9:00:00    | 7:35:00    | 15:02:00   | 10:35:00   | 18:30:00   | 9:32:00    |
| <b>Time of nearest high tide</b>      | 17:39:00   | 12:59:00  | 11:07:00  | 16:34:00   | 8:04:00    | 9:11:00    | 8:06:00    | 8:57:00    | 14:52:00   | 16:38:00   | 19:03:00   | 18:47:00   |
| <b>Hight tide (m)</b>                 | 7          | 5.3       | 5.9       | 6.4        | 7.4        | 6.7        | 6.2        | 5.06       | 4.9        | 5.9        | 7.3        | 6.5        |
| <b>Count site</b>                     | Pond D     | Pond D    | Pond D    | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     |
| <b>Time difference with high tide</b> | 3:39:00    | 2:09:00   | 0:17:00   | 1:34:00    | 0:04:00    | 5:49:00    | 0:54:00    | 1:22:00    | 0:10:00    | 6:03:00    | 0:33:00    | 9:15:00    |
| Sharp-tailed sandpiper                |            |           | 9         | 1          | 5          |            |            | 10         |            |            | 200        | 32         |
| Curlew sandpiper                      |            |           |           |            |            |            |            | 14         | 2          |            | 12         | 18         |
| Broad-billed sandpiper                |            |           |           |            |            |            |            |            |            |            |            |            |
| Ruff                                  |            |           |           |            |            |            |            |            |            |            |            |            |
| Red-necked phalarope                  |            |           |           |            |            |            |            |            |            |            |            |            |
| Golden plover                         |            |           |           |            |            |            |            |            |            |            |            |            |
| Grey plover                           |            |           |           |            |            |            | 1          |            |            |            |            | 6          |
| Double-banded plover                  |            |           |           |            |            |            |            |            |            |            |            |            |
| Lesser sand plover                    |            |           |           |            |            |            |            |            |            |            | 300        | 20         |
| Greater sand plover                   |            |           | 1         |            |            |            |            |            | 45         |            | 210        | 21         |
| Oriental plover                       |            |           |           |            |            |            |            |            |            |            |            |            |
| Oriental pratincole                   |            |           |           |            |            |            |            |            |            |            |            |            |
| Unidentified                          |            |           |           |            |            |            |            |            |            |            |            |            |
| <b>TOTAL</b>                          | 0          | 15        | 25        | 117        | 171        | 0          | 1          | 77         | 204        | 0          | 1009       | 217        |

| Date                           | 29/11/2010 | 11/12/2010 | 10/01/2011 | 16/01/2011 | 23/03/2011 | 11/04/2011 | 20/06/2011 | 14/07/2011 | 18/08/2011 | 16/09/2011 | 15/10/2011 | 28/11/2011 |
|--------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| Time of count                  | 9:25:00    | 8:35:00    | 9:20:00    | 16:45:00   | 9:30:00    | 11:30:00   | 10:00:00   | 8:30:00    | 10:00:00   | 9:00:00    | 10:00:00   | 8:20:00    |
| Time of nearest high tide      | 10:59:00   | 8:50:00    | 9:18:00    | 16:26:00   | 8:39:00    | 10:56:00   | 9:17:00    | 5:50:00    | 8:28:00    | 7:47:00    | 7:11:00    | 7:11:00    |
| Hight tide (m)                 | 5.03       | 5.9        | 6.06       | 5.67       | 7.77       | 5.95       | 6.93       | 6.59       | 6.86       | 6.83       | 6.68       | 6.8        |
| Count site                     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     |
| Time difference with high tide | 1:34:00    | 0:15:00    | 0:02:00    | 0:19:00    | 0:51:00    | 0:34:00    | 0:43:00    | 2:40:00    | 1:32:00    | 1:13:00    | 2:49:00    | 1:09:00    |
| Latham's snipe                 |            |            |            |            |            |            |            |            |            |            |            |            |
| Pin-tailed snipe               |            |            |            |            |            |            |            |            |            |            |            |            |
| Swinhoe's snipe                |            |            |            |            |            |            |            |            |            |            |            |            |
| Black-tailed godwit            |            |            |            |            |            |            |            |            |            |            |            |            |
| Bar-tailed godwit              |            |            |            |            |            |            |            |            |            |            |            |            |
| Little curlew                  |            |            |            |            |            |            |            |            |            |            |            |            |
| Whimbrel                       | 8          |            | 1          |            | 15         |            |            |            |            |            |            |            |
| Eastern curlew                 | 9          |            |            |            | 72         |            |            |            |            |            |            |            |
| Common redshank                |            |            |            |            |            |            |            |            |            |            |            |            |
| Marsh sandpiper                |            |            |            | 2          | 1          | 2          | 2          |            |            |            |            | 3          |
| Common greenshank              | 2          | 15         |            | 4          | 8          |            |            |            | 12         |            | 16         | 28         |
| Wood sandpiper                 |            |            |            |            |            |            |            |            |            |            |            |            |
| Terek sandpiper                |            |            |            |            |            |            | 12         | 20         |            |            |            |            |
| Common sandpiper               |            |            | 2          | 1          | 2          |            |            |            | 1          |            |            |            |
| Grey-tailed tattler            | 2          |            |            |            |            |            | 3          | 1          |            |            |            |            |
| Wandering tattler              |            |            |            |            |            |            |            |            |            |            |            |            |
| Ruddy turnstone                |            |            |            |            |            |            |            |            |            |            |            |            |
| Asian dowitcher                |            |            |            |            |            |            |            |            |            |            |            |            |
| Great knot                     |            |            |            |            |            |            | 50         | 20         |            |            |            |            |
| Red knot                       |            |            |            |            |            |            |            |            |            | 53         |            |            |
| Sanderling                     |            |            |            |            |            |            |            |            |            |            |            |            |
| Red-necked stint               |            |            |            | 2          |            |            | 12         | 20         | 12         | 6          |            |            |
| Long-toed stint                |            |            |            |            |            |            |            |            |            |            |            |            |
| Pectoral sandpiper             |            |            |            |            |            |            |            |            |            |            |            |            |



| Date                           | 29/11/2010 | 11/12/2010 | 10/01/2011 | 16/01/2011 | 23/03/2011 | 11/04/2011 | 20/06/2011 | 14/07/2011 | 18/08/2011 | 16/09/2011 | 15/10/2011 | 28/11/2011 |
|--------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| Time of count                  | 9:25:00    | 8:35:00    | 9:20:00    | 16:45:00   | 9:30:00    | 11:30:00   | 10:00:00   | 8:30:00    | 10:00:00   | 9:00:00    | 10:00:00   | 8:20:00    |
| Time of nearest high tide      | 10:59:00   | 8:50:00    | 9:18:00    | 16:26:00   | 8:39:00    | 10:56:00   | 9:17:00    | 5:50:00    | 8:28:00    | 7:47:00    | 7:11:00    | 7:11:00    |
| Hight tide (m)                 | 5.03       | 5.9        | 6.06       | 5.67       | 7.77       | 5.95       | 6.93       | 6.59       | 6.86       | 6.83       | 6.68       | 6.8        |
| Count site                     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     |
| Time difference with high tide | 1:34:00    | 0:15:00    | 0:02:00    | 0:19:00    | 0:51:00    | 0:34:00    | 0:43:00    | 2:40:00    | 1:32:00    | 1:13:00    | 2:49:00    | 1:09:00    |
| Sharp-tailed sandpiper         | 10         |            | 3          | 7          | 6          |            | 4          |            |            | 6          | 2          |            |
| Curlew sandpiper               |            |            |            |            |            |            |            |            |            | 6          | 1          | 6          |
| Broad-billed sandpiper         |            |            |            |            |            |            |            |            |            |            |            |            |
| Ruff                           |            |            |            |            |            |            |            |            |            |            |            |            |
| Red-necked phalarope           |            |            |            |            |            |            |            |            |            |            |            |            |
| Golden plover                  |            |            |            |            | 16         |            |            |            |            |            |            |            |
| Grey plover                    | 2          |            |            |            |            |            |            | 3          |            |            |            |            |
| Double-banded plover           |            |            |            |            |            |            |            |            |            |            |            |            |
| Lesser sand plover             | 3          | 20         |            |            |            |            |            |            |            |            |            |            |
| Greater sand plover            | 50         | 50         |            |            |            |            |            |            |            |            |            |            |
| Oriental plover                |            |            |            |            |            |            |            |            |            |            |            |            |
| Oriental pratincole            |            |            |            |            |            |            |            |            |            |            |            |            |
| Unidentified                   |            |            |            |            |            |            |            |            |            |            |            |            |
| <b>TOTAL</b>                   | 86         | 85         | 6          | 16         | 120        | 2          | 83         | 64         | 25         | 71         | 19         | 37         |

| Date                           | 15/12/2011 | 12/01/2012 | 21/02/2012 | 23/03/2012 | 23/04/2012 | 20/07/2012 | 17/08/2012 | 14/09/2012 | 15/11/2102 | 15/11/2012 | 12/02/2013 | 13/02/2013 |
|--------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| Time of count                  | 9:45:00    | 7:30:00    | 9:27:00    | 8:35:00    | 8:40:00    | 8:30:00    | 8:32:00    | 9:00:00    | 7:22:00    | 6:30:00    | 7:17:00    | 7:25:00    |
| Time of nearest high tide      | 8:16:00    | 7:35:00    | 5:46:00    | 6:56:00    | 7:39:00    | 7:21:00    | 6:19:00    | 5:06:00    | 6:05:00    | 6:05:00    | 7:23:00    | 8:04:00    |
| Hight tide (m)                 | 6.26       | 6.71       | 6.36       | 7.09       | 7.18       | 6.96       | 6.76       | 6.3 m      | 7.1        | 7.1        | 7.26       | 7.3        |
| Count site                     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     |
| Time difference with high tide | 1:29:00    | 0:05:00    | 3:41:00    | 1:39:00    | 1:01:00    | 1:09:00    | 2:13:00    | 3:54:00    | 1:17:00    | 0:25:00    | 0:06:00    | 0:39:00    |
| Latham's snipe                 |            |            |            |            |            |            |            |            |            |            |            |            |
| Pin-tailed snipe               |            |            |            |            |            |            |            |            |            |            |            |            |
| Swinhoe's snipe                |            |            |            |            |            |            |            |            |            |            |            |            |
| Black-tailed godwit            |            |            |            |            |            |            |            |            |            |            |            |            |
| Bar-tailed godwit              |            |            |            |            |            |            |            |            |            | 36         |            |            |
| Little curlew                  |            |            |            |            |            |            |            |            |            |            |            |            |
| Whimbrel                       |            |            |            |            |            | 37         |            |            |            | 2          |            |            |
| Eastern curlew                 |            |            |            |            |            |            |            |            | 1          | 1          | 1          |            |
| Common redshank                |            |            |            |            |            |            |            |            |            |            |            |            |
| Marsh sandpiper                | 18         |            | 1          |            |            |            |            |            | 1          | 4          | 1          | 2          |
| Common greenshank              |            | 6          | 9          | 24         | 3          | 47         |            | 5          | 54         | 32         | 30         | 22         |
| Wood sandpiper                 |            |            |            |            |            |            |            |            |            |            |            |            |
| Terek sandpiper                |            |            |            |            |            |            |            |            |            |            |            | 5          |
| Common sandpiper               | 1          |            |            | 2          |            |            |            |            |            |            |            | 3          |
| Grey-tailed tattler            |            |            |            |            |            |            |            |            |            |            |            |            |
| Wandering tattler              |            |            |            |            |            |            |            |            |            |            |            |            |
| Ruddy turnstone                |            |            |            |            |            |            |            |            |            |            |            |            |
| Asian dowitcher                |            |            |            |            |            |            |            |            |            |            |            |            |
| Great knot                     |            |            |            |            | 20         |            |            |            |            | 1          | 100        | 21         |
| Red knot                       |            |            |            |            |            |            |            |            |            |            |            |            |
| Sanderling                     |            |            |            |            |            |            |            |            | 1          |            |            |            |
| Red-necked stint               | 35         |            |            |            |            |            |            | 4          | 3          | 57         | 23         | 17         |
| Long-toed stint                |            |            |            |            |            |            |            |            |            |            |            |            |
| Pectoral sandpiper             |            |            |            |            |            |            |            |            |            |            |            |            |

| Date                           | 15/12/2011 | 12/01/2012 | 21/02/2012 | 23/03/2012 | 23/04/2012 | 20/07/2012 | 17/08/2012 | 14/09/2012 | 15/11/2102 | 15/11/2012 | 12/02/2013 | 13/02/2013 |
|--------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| Time of count                  | 9:45:00    | 7:30:00    | 9:27:00    | 8:35:00    | 8:40:00    | 8:30:00    | 8:32:00    | 9:00:00    | 7:22:00    | 6:30:00    | 7:17:00    | 7:25:00    |
| Time of nearest high tide      | 8:16:00    | 7:35:00    | 5:46:00    | 6:56:00    | 7:39:00    | 7:21:00    | 6:19:00    | 5:06:00    | 6:05:00    | 6:05:00    | 7:23:00    | 8:04:00    |
| Hight tide (m)                 | 6.26       | 6.71       | 6.36       | 7.09       | 7.18       | 6.96       | 6.76       | 6.3 m      | 7.1        | 7.1        | 7.26       | 7.3        |
| Count site                     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     |
| Time difference with high tide | 1:29:00    | 0:05:00    | 3:41:00    | 1:39:00    | 1:01:00    | 1:09:00    | 2:13:00    | 3:54:00    | 1:17:00    | 0:25:00    | 0:06:00    | 0:39:00    |
| Sharp-tailed sandpiper         | 14         |            |            |            |            |            |            |            | 8          | 30         | 13         | 5          |
| Curlew sandpiper               | 1          |            |            |            |            |            |            |            | 14         | 5          |            |            |
| Broad-billed sandpiper         |            |            |            |            |            |            |            |            |            |            |            | 3          |
| Ruff                           |            |            |            |            |            |            |            |            |            |            |            |            |
| Red-necked phalarope           |            |            |            |            |            |            |            |            |            |            |            |            |
| Golden plover                  |            |            |            |            |            |            |            |            |            |            |            |            |
| Grey plover                    |            |            |            |            |            |            |            |            |            |            |            |            |
| Double-banded plover           |            |            |            |            |            |            |            |            |            |            |            |            |
| Lesser sand plover             |            |            |            |            |            |            |            |            |            | 5          |            |            |
| Greater sand plover            |            |            |            |            |            |            |            |            |            | 4          |            |            |
| Oriental plover                |            |            |            |            |            |            |            |            |            |            |            |            |
| Oriental pratincole            |            |            |            |            |            |            |            |            |            |            |            |            |
| Unidentified                   |            |            |            |            |            |            |            |            |            |            |            |            |
| <b>TOTAL</b>                   | 69         | 6          | 10         | 26         | 23         | 84         | 0          | 9          | 82         | 177        | 168        | 78         |

| Date                           | 14/02/2013 | 18/04/2013 | 3/05/2013 | 16/05/2013 | 22/05/2013 | 29/05/2013 | 21/06/2013 | 27/06/2013 | 5/07/2013 | 11/07/2013 | 16/07/2013 | 25/07/2013 |
|--------------------------------|------------|------------|-----------|------------|------------|------------|------------|------------|-----------|------------|------------|------------|
| Time of count                  | 7:45:00    | 10:00:00   | 11:12:00  | 8:55:00    | 15:20:00   | 8:15:00    | 14:43:00   | 8:03:00    | 14:50:00  | 8:21:00    | 11:00:00   | 8:24:00    |
| Time of nearest high tide      | 8:42:00    | 10:56:00   | 11:58:00  | 9:52:00    | 15:33:00   | 9:15:00    | 15:43:00   | 9:03:00    | 16:04:00  | 8:15:00    | 10:36:00   | 8:07:00    |
| Hight tide (m)                 | 7.16       | 5.79       | 6         | 6.38       | 5.92       | 7.36       | 5.84       | 7.47       | 5.22      | 6.9        | 6.1        | 7.7        |
| Count site                     | Pond D     | Pond D     | Pond D    | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D    | Pond D     | Pond D     | Pond D     |
| Time difference with high tide | 0:57:00    | 0:56:00    | 0:46:00   | 0:57:00    | 0:13:00    | 1:00:00    | 1:00:00    | 1:00:00    | 1:14:00   | 0:06:00    | 0:24:00    | 0:17:00    |
| Latham's snipe                 |            |            |           |            |            |            |            |            |           |            |            |            |
| Pin-tailed snipe               |            |            |           |            |            |            |            |            |           |            |            |            |
| Swinhoe's snipe                |            |            |           |            |            |            |            |            |           |            |            |            |
| Black-tailed godwit            |            |            |           |            |            |            |            |            |           |            |            |            |
| Bar-tailed godwit              |            |            | 9         |            |            |            |            |            |           |            |            |            |
| Little curlew                  |            |            |           |            |            |            |            |            |           |            |            |            |
| Whimbrel                       |            | 10         | 8         | 2          | 11         | 7          | 6          | 8          |           |            |            | 4          |
| Eastern curlew                 |            |            | 48        | 11         |            |            |            |            |           |            |            | 2          |
| Common redshank                |            |            |           |            |            | 35         |            |            |           |            |            |            |
| Marsh sandpiper                | 10         | 1          | 1         |            |            |            |            |            |           |            |            |            |
| Common greenshank              | 27         | 18         | 25        | 9          |            |            | 19         | 34         | 14        | 43         | 9          | 73         |
| Wood sandpiper                 | 2          |            |           |            |            |            |            |            |           |            |            |            |
| Terek sandpiper                |            | 5          |           |            |            |            |            |            |           |            |            | 1          |
| Common sandpiper               | 1          |            |           |            |            |            |            |            |           |            |            |            |
| Grey-tailed tattler            |            |            |           |            |            |            |            |            |           |            |            |            |
| Wandering tattler              |            |            |           |            |            |            |            |            |           |            |            |            |
| Ruddy turnstone                |            |            |           |            |            |            |            |            |           |            |            |            |
| Asian dowitcher                |            |            |           |            |            |            |            |            |           |            |            |            |
| Great knot                     | 66         | 21         | 34        | 8          | 16         |            |            |            |           |            |            |            |
| Red knot                       |            |            |           |            |            |            |            |            |           |            |            |            |
| Sanderling                     |            |            |           |            |            |            |            |            |           |            |            |            |
| Red-necked stint               | 20         | 3          | 10        | 5          | 7          | 4          | 8          | 11         | 11        | 23         |            |            |
| Long-toed stint                |            |            |           |            |            |            |            |            |           |            |            |            |
| Pectoral sandpiper             |            |            |           |            |            |            |            |            |           |            |            |            |

| Date                           | 14/02/2013 | 18/04/2013 | 3/05/2013 | 16/05/2013 | 22/05/2013 | 29/05/2013 | 21/06/2013 | 27/06/2013 | 5/07/2013 | 11/07/2013 | 16/07/2013 | 25/07/2013 |
|--------------------------------|------------|------------|-----------|------------|------------|------------|------------|------------|-----------|------------|------------|------------|
| Time of count                  | 7:45:00    | 10:00:00   | 11:12:00  | 8:55:00    | 15:20:00   | 8:15:00    | 14:43:00   | 8:03:00    | 14:50:00  | 8:21:00    | 11:00:00   | 8:24:00    |
| Time of nearest high tide      | 8:42:00    | 10:56:00   | 11:58:00  | 9:52:00    | 15:33:00   | 9:15:00    | 15:43:00   | 9:03:00    | 16:04:00  | 8:15:00    | 10:36:00   | 8:07:00    |
| Hight tide (m)                 | 7.16       | 5.79       | 6         | 6.38       | 5.92       | 7.36       | 5.84       | 7.47       | 5.22      | 6.9        | 6.1        | 7.7        |
| Count site                     | Pond D     | Pond D     | Pond D    | Pond D     | Pond D     | Pond D     | Pond D     | Pond D     | Pond D    | Pond D     | Pond D     | Pond D     |
| Time difference with high tide | 0:57:00    | 0:56:00    | 0:46:00   | 0:57:00    | 0:13:00    | 1:00:00    | 1:00:00    | 1:00:00    | 1:14:00   | 0:06:00    | 0:24:00    | 0:17:00    |
| Sharp-tailed sandpiper         |            |            |           |            |            |            |            |            |           |            |            |            |
| Curlew sandpiper               |            | 2          |           |            |            |            |            |            |           |            |            |            |
| Broad-billed sandpiper         |            |            |           |            |            |            |            |            |           |            |            |            |
| Ruff                           |            |            |           |            |            |            |            |            |           |            |            |            |
| Red-necked phalarope           |            |            |           |            |            |            |            |            |           |            |            |            |
| Golden plover                  |            |            |           |            |            | 5          | 2          |            |           |            |            |            |
| Grey plover                    |            | 2          |           | 4          |            |            |            |            |           |            |            |            |
| Double-banded plover           |            |            |           |            |            |            |            |            |           |            |            |            |
| Lesser sand plover             |            |            | 5         |            |            | 3          |            |            |           |            |            |            |
| Greater sand plover            | 9          | 4          |           |            |            | 2          |            |            |           |            |            |            |
| Oriental plover                |            |            |           |            |            |            |            |            |           |            |            |            |
| Oriental pratincole            |            |            |           |            |            |            |            |            |           |            |            |            |
| Unidentified                   |            |            |           |            |            |            |            |            |           |            |            |            |
| <b>TOTAL</b>                   | 135        | 66         | 140       | 39         | 34         | 56         | 35         | 53         | 25        | 66         | 9          | 80         |

| Date                           | 1/08/2013 | 8/08/2013 | 12/08/2013 | 23/08/2013 | 27/08/2013 | 6/09/2013 | 11/09/2013 | 20/09/2013 | 23/09/2013 | 2/10/2013 | 8/10/2013 | 17/10/2013 | 21/10/2013 |
|--------------------------------|-----------|-----------|------------|------------|------------|-----------|------------|------------|------------|-----------|-----------|------------|------------|
| Time of count                  | 12:25:00  | 8:36:00   | 8:47:00    | 8:47:00    | 9:34:00    | 8:15:00   | 6:56:00    | 7:35:00    | 6:30:00    | 15:20:00  | 6:20:00   | 16:28:00   | 6:25:00    |
| Time of nearest high tide      | 12:21:00  | 7:23:00   | 9:00:00    | 7:39:00    | 9:22:00    | 6:48:00   | 8:56:00    | 6:31:00    | 7:54:00    | 16:53:00  | 7:30:00   | 17:16:00   | 6:50:00    |
| High tide (m)                  | 4.8       | 7         | 6.84       | 7.61       | 6.39       | 7.04      | 6.62       | 7.33       | 7.08       | 5.76      | 7.15      | 6.71       | 6.95       |
| Count site                     | Pond D    | Pond D    | Pond D     | Pond D     | Pond D     | Pond D    | Pond D     | Pond D     | Pond D     | Pond D    | Pond D    | Pond D     | Pond D     |
| Time difference with high tide | 0:04:00   | 1:13:00   | 0:13:00    | 1:08:00    | 0:12:00    | 1:27:00   | 2:00:00    | 1:04:00    | 1:24:00    | 1:33:00   | 1:10:00   | 0:48:00    | 0:25:00    |
| Latham's snipe                 |           |           |            |            |            |           |            |            |            |           |           |            |            |
| Pin-tailed snipe               |           |           |            |            |            |           |            |            |            |           |           |            |            |
| Swinhoe's snipe                |           |           |            |            |            |           |            |            |            |           |           |            |            |
| Black-tailed godwit            |           |           |            |            |            |           | 1          | 2          | 3          |           | 1         |            |            |
| Bar-tailed godwit              |           | 1         |            |            |            |           | 18         | 53         | 55         | 34        | 48        | 40         | 41         |
| Little curlew                  |           |           |            |            |            |           |            |            |            |           |           |            |            |
| Whimbrel                       |           | 22        |            |            |            | 8         | 1          |            | 1          | 69        | 1         | 58         |            |
| Eastern curlew                 |           | 1         |            |            |            | 1         |            |            |            |           |           | 83         |            |
| Common redshank                |           |           |            |            |            |           |            |            |            |           |           |            |            |
| Marsh sandpiper                |           |           |            |            |            |           |            | 2          |            | 1         | 6         |            | 4          |
| Common greenshank              | 20        | 38        |            | 58         | 71         | 97        | 104        | 112        |            | 111       | 86        | 30         | 76         |
| Wood sandpiper                 |           |           |            |            |            |           |            |            |            |           |           |            |            |
| Terek sandpiper                |           |           |            |            |            |           |            | 1          | 1          |           |           |            |            |
| Common sandpiper               |           |           |            |            |            |           |            |            | 1          | 1         |           |            |            |
| Grey-tailed tattler            |           |           |            |            |            | 3         | 2          | 10         | 9          |           |           |            |            |
| Wandering tattler              |           |           |            |            |            |           |            |            |            |           |           |            |            |
| Ruddy turnstone                |           |           |            |            |            |           |            |            |            |           |           |            |            |
| Asian dowitcher                |           |           |            |            |            |           | 2          | 3          | 3          | 3         | 3         | 2          | 1          |
| Great knot                     |           | 1         |            |            |            |           | 3          | 4          | 5          | 13        | 58        | 8          | 10         |
| Red knot                       |           |           |            |            |            | 6         |            |            | 2          |           | 2         |            |            |
| Sanderling                     |           |           |            |            |            |           |            |            |            |           |           |            |            |
| Red-necked stint               |           | 11        |            |            |            | 6         | 25         | 3          | 13         |           | 66        |            | 68         |
| Long-toed stint                |           |           |            |            |            |           |            |            |            |           |           |            |            |
| Pectoral sandpiper             |           |           |            |            |            |           |            |            |            |           |           |            |            |

| Date                           | 1/08/2013 | 8/08/2013 | 12/08/2013 | 23/08/2013 | 27/08/2013 | 6/09/2013 | 11/09/2013 | 20/09/2013 | 23/09/2013 | 2/10/2013 | 8/10/2013 | 17/10/2013 | 21/10/2013 |
|--------------------------------|-----------|-----------|------------|------------|------------|-----------|------------|------------|------------|-----------|-----------|------------|------------|
| Time of count                  | 12:25:00  | 8:36:00   | 8:47:00    | 8:47:00    | 9:34:00    | 8:15:00   | 6:56:00    | 7:35:00    | 6:30:00    | 15:20:00  | 6:20:00   | 16:28:00   | 6:25:00    |
| Time of nearest high tide      | 12:21:00  | 7:23:00   | 9:00:00    | 7:39:00    | 9:22:00    | 6:48:00   | 8:56:00    | 6:31:00    | 7:54:00    | 16:53:00  | 7:30:00   | 17:16:00   | 6:50:00    |
| High tide (m)                  | 4.8       | 7         | 6.84       | 7.61       | 6.39       | 7.04      | 6.62       | 7.33       | 7.08       | 5.76      | 7.15      | 6.71       | 6.95       |
| Count site                     | Pond D    | Pond D    | Pond D     | Pond D     | Pond D     | Pond D    | Pond D     | Pond D     | Pond D     | Pond D    | Pond D    | Pond D     | Pond D     |
| Time difference with high tide | 0:04:00   | 1:13:00   | 0:13:00    | 1:08:00    | 0:12:00    | 1:27:00   | 2:00:00    | 1:04:00    | 1:24:00    | 1:33:00   | 1:10:00   | 0:48:00    | 0:25:00    |
| Sharp-tailed sandpiper         |           |           |            |            |            | 16        | 19         | 20         | 4          | 50        | 24        | 37         | 2          |
| Curlew sandpiper               |           |           |            |            |            | 2         | 4          | 1          | 5          | 4         | 8         | 6          | 5          |
| Broad-billed sandpiper         |           |           |            |            |            |           | 6          | 2          | 4          | 1         | 4         |            | 3          |
| Ruff                           |           |           |            |            |            |           |            |            |            |           |           |            |            |
| Red-necked phalarope           |           |           |            |            |            |           |            |            |            |           |           |            |            |
| Golden plover                  |           |           |            |            |            |           |            |            |            | 32        |           |            |            |
| Grey plover                    |           |           |            |            |            |           |            | 2          | 1          |           |           | 8          |            |
| Double-banded plover           |           |           |            |            |            |           |            |            |            |           |           |            |            |
| Lesser sand plover             |           |           |            |            |            |           |            | 1          |            |           | 1         |            |            |
| Greater sand plover            |           |           |            |            |            |           | 1          |            |            |           | 1         |            |            |
| Oriental plover                |           |           |            |            |            |           |            |            |            |           |           |            |            |
| Oriental pratincole            |           |           |            |            |            |           |            |            |            |           |           |            |            |
| Unidentified                   |           |           |            |            |            |           |            |            |            |           |           |            |            |
| <b>TOTAL</b>                   | 20        | 74        | 0          | 58         | 71         | 139       | 186        | 216        | 107        | 319       | 309       | 272        | 210        |

Table 3. The 36 migratory shorebirds surveyed at East Arm Wharf, Darwin. Shorebird abundances are represented as present in the counts, as a per cent, maximum numbers counted, and times the counts exceeded the threshold for national significance, as outlined by Department of the Environment Water Heritage and the Arts (2009).

| Shorebird              | Counts | % present in counts | Maximum count | No. counts > EPBC threshold | Threshold (DEHWA 2009) |
|------------------------|--------|---------------------|---------------|-----------------------------|------------------------|
| Latham's snipe         | 0      | 0                   | 0             | 0                           | 34                     |
| Pin-tailed snipe       | 0      | 0                   | 0             | 0                           | 25 -1000               |
| Swinhoe's snipe        | 0      | 0                   | 0             | 0                           | 25 - 100               |
| Black-tailed godwit    | 5      | 9                   | 7             | 0                           | 160                    |
| Bar-tailed godwit      | 10     | 18                  | 55            | 0                           | 325                    |
| Little curlew          | 0      | 0                   | 0             | 0                           | 180                    |
| Whimbrel               | 22     | 39                  | 69            | 2                           | 55                     |
| Eastern curlew         | 18     | 32                  | 101           | 5                           | 38                     |
| Common redshank        | 1      | 2                   | 35            | 0                           | 75                     |
| Marsh sandpiper        | 22     | 39                  | 250           | 0                           | 1000                   |
| Common greenshank      | 46     | 82                  | 112           | 3                           | 100                    |
| Wood sandpiper         | 1      | 2                   | 2             | 0                           | 100                    |
| Terek sandpiper        | 7      | 13                  | 20            | 0                           | 50                     |
| Common sandpiper       | 11     | 20                  | 3             | 0                           | 50                     |
| Grey-tailed tattler    | 7      | 13                  | 10            | 0                           | 40                     |
| Wandering tattler      | 0      | 0                   | 0             | 0                           | n/a                    |
| Ruddy turnstone        | 0      | 0                   | 0             | 0                           | 35                     |
| Asian dowitcher        | 7      | 13                  | 3             | 0                           | 24                     |
| Great knot             | 20     | 36                  | 100           | 0                           | 380                    |
| Red knot               | 6      | 11                  | 150           | 0                           | 220                    |
| Sanderling             | 2      | 4                   | 1             | 0                           | 320                    |
| Red-necked stint       | 34     | 61                  | 68            | 0                           | 160                    |
| Long-toed stint        | 0      | 0                   | 0             | 0                           | 25                     |
| Pectoral sandpiper     | 0      | 0                   | 0             | 0                           | n/a                    |
| Sharp-tailed sandpiper | 26     | 46                  | 200           | 1                           | 180                    |
| Curlew sandpiper       | 19     | 34                  | 18            | 0                           | 180                    |
| Broad-billed sandpiper | 7      | 13                  | 6             | 0                           | 25                     |
| Ruff                   | 0      | 0                   | 0             | 0                           | n/a                    |
| Red-necked phalarope   | 0      | 0                   | 0             | 0                           | 100 - 1000             |
| Golden plover          | 4      | 7                   | 32            | 0                           | 100                    |
| Grey plover            | 9      | 16                  | 8             | 0                           | 125                    |
| Double-banded plover   | 0      | 0                   | 0             | 0                           | 50                     |
| Lesser sand plover     | 9      | 16                  | 300           | 1                           | 40                     |
| Greater sand plover    | 12     | 21                  | 210           | 1                           | 100                    |
| Oriental plover        | 0      | 0                   | 0             | 0                           | 700                    |
| Oriental pratincole    | 0      | 0                   | 0             | 0                           | 2880                   |
| Unidentified           | 0      | 0                   | 0             | 0                           | -                      |



## HABITAT MAPPING

There are several known habitat sites used by migratory shorebirds in the Darwin Harbour region (Figure 1). In addition, satellite image were used to investigate potential habitat areas. The minimum distances from the East Arm Wharf roost site to other known roost sites are shown in Table 3. Using satellite imagery, additional potential roost sites for migratory shorebirds have been identified based on habitat environmental attributes that have been correlated with shorebird presence, abundance and species composition (Figure 3). Most of these sites will be investigated for ground-truthing of habitat characteristics and surveyed during the Austral summer season for roosting shorebird presence.



Figure 1. Known roost sites in the Darwin Harbour region. Image credit: Google Inc (2013)

Table 3. Minimum distances for travelling migratory shorebirds from the East Arm Wharf roost site to other known roost sites in the Darwin Harbour region.

| From East Arm Wharf to: | Distance (km) |
|-------------------------|---------------|
| Wickham Point           | 3.15          |
| Channel Island          | 7.14          |
| Spot on Marine          | 10.22         |
| East Point              | 11.69         |
| Nightcliff              | 13.16         |
| Sandy Creek             | 15.26         |
| Lee Point               | 17.79         |
| Tree Point              | 24.27         |

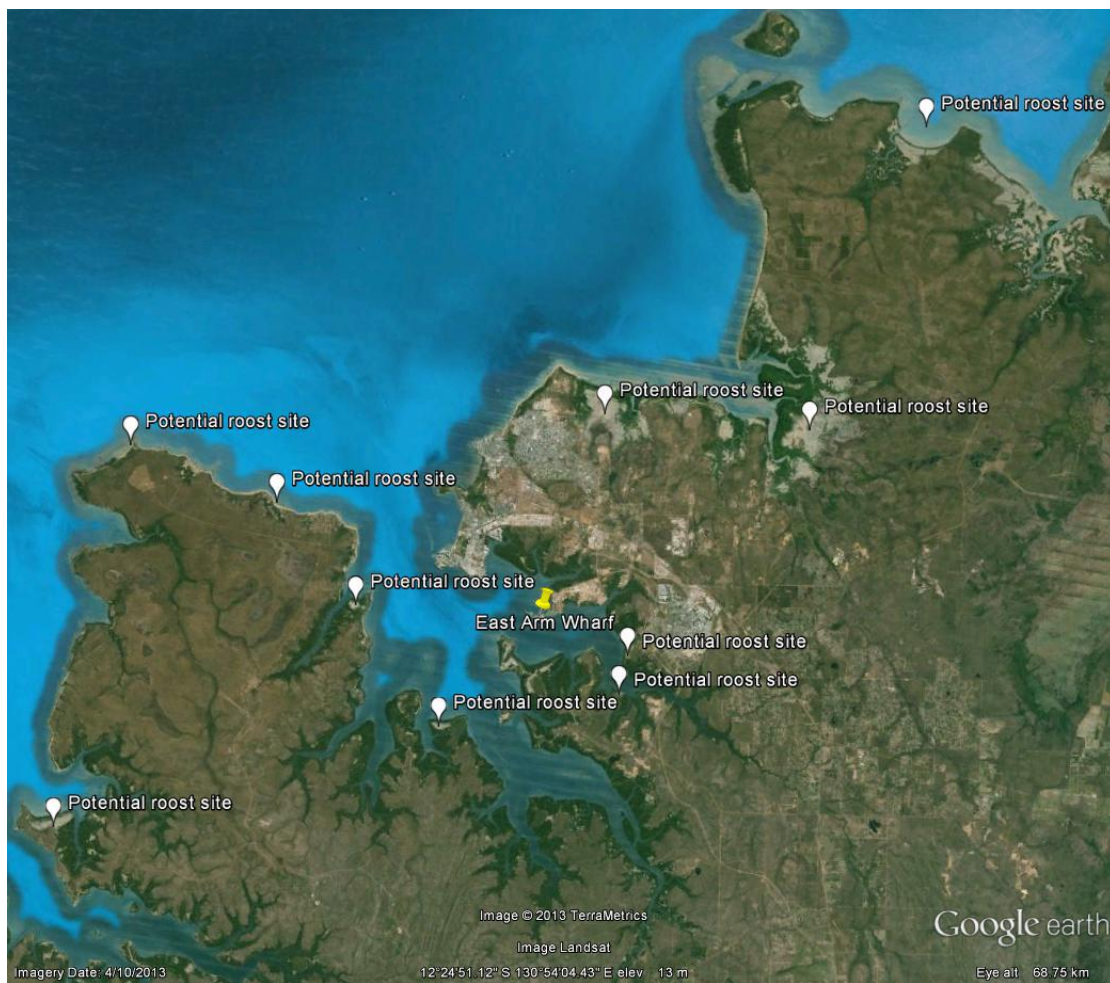


Figure 2. Potential roost sites for migratory shorebirds in the Darwin Harbour region based on habitat characteristics. Image credit: Google Inc (2013).

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## REFERENCES

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Department of the Environment Water Heritage and the Arts (2009) Significant impact guidelines for 36 migratory shorebird species. Background paper to EPBC Act policy statement 3.21.

Google Inc (2013) Google Earth.