ASSESSMENT OF THE HEALTH, VIABILITY AND SUSTAINABILITY OF MANGROVE COMMUNITIES AT FISHERMAN ISLANDS

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Synopsis:

This report presents the findings of a study of the health and sustainability of the mangrove community on Fisherman Islands at the mouth of the Brisbane River. The study focuses upon the current status of the mangrove community in terms of community structure, health (relative to a number of defined criteria) and distribution. Historical assessments of the mangrove community are also made. The report presents details of the methodology employed in developing the data, results of these works and a discussions as to the implications of the findings, including a preliminary assessment of management options.

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EXECUTIVE SUMMARY

The Port of Brisbane Corporation is responsible for the management of the Port of Brisbane, a ship loading and cargo facility located at the mouth of the Brisbane River. Part of the management responsibilities of the Corporation is to ensure that the activities of the port do not unduly impact on the adjacent wetland areas at the Fisherman Islands.

These wetlands have contained areas of dead mangroves for some time. In the absence of adequate baseline and/or monitoring data, the PBC has insufficient information to determine the causes for the mangrove death and/or identify opportunities for management practices to address this issue.

WBM Oceanics was commissioned to undertake a survey of the mangroves of the Fisherman Islands area and map the distribution of mangrove communities and current health status. The objectives of the study were to determine the current status of the resource and identify the potential impacting processes leading to mangrove death.

Surveys of the study area were conducted in November 1999 to January 2000. This involved the traversal of the site and recording detailed information such as mangrove species, canopy height, community structure, mangrove health, macroalgae and macrofauna abundance (relative to a number of criteria).

Detailed review of low level aerial photography of the Port area from 1972 to 1999 was also undertaken to map changes in both land use and mangrove distribution.

The results of the study indicate that a large proportion of the mangroves within the Fisherman Islands area were of poor health and that recovery/regrowth in these areas was limited. It should be noted that adjacent areas (such as Whyte Island and Luggage Point) are also suffering similar mangroves losses, and the degradation process appears to be occurring on regional basis. The author understands that the QDPI are currently undertaking investigations to determine the distribution of effected mangroves within western Moreton Bay.

The reasons for mangrove decline in the study area are not clear, however three impacting processes are suspected. These are:

- land reclamation practices undertaken in the 1980's as part of the expansion of the Port facility. These practices, which differ from current reclamation techniques, have resulted in the direct loss of mangroves and large scale changes to drainage patterns. This has resulted in the ponding of waters around mangroves which prevents the re-establishment of mangroves and provides an on-going impacting process in adjoining areas.
- excessive algal growth, possibly related to elevated nutrients in adjacent waters, including the lower reaches of the Brisbane River, from sewerage discharges (Wynnum and to a lesser extent Luggage Point treatment plants) and inputs from the Brisbane River catchment. The macroalgae may directly effect mangroves by smothering mangrove roots systems, reducing their efficiency, or reducing the recruitment of seedlings. Furthermore,

the growths of the macroalgae may from small "bunds", leading to ponding waters and resulting in mangrove stress/death. Ponded waters also provide areas of open water which are suitable for the continual growth of macroalgae.

- development of sand bunds related to increased wave energy at some sections of frontal mangroves. Dredging activities have removed seaward shallow areas which previously dissipated wave energy. Some areas now contain sand bunds at the crest of the seaward fringe that has the effect of either directly smothering mangroves and/or blocking flow paths and ponding waters within mangrove areas. This process is most evident along the Boat Passage, but is also occurring within the Brisbane River south of the Bulk Coal Facility.

It is likely that the above processes interact to provide the current range of impacts. For example sand bunds cause the ponding of waters, resulting in the loss of mangroves and the development of open water, which then leads to the growth of macroalgae. These processes may further blocks flow paths and elevates the ponded water levels, increasing the area of impact.

Whilst some management options are available to address the impacting processes within the study area, most of the impacting processes are at a much larger scale than the study area. A, broadscale approach from a variety of organisations responsible for management of waterways, and nutrient inputs from the Brisbane River catchment, may be required to adequately address the issue.

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1 INTRODUCTION

1.1 Background

The Port of Brisbane Corporation (PBC) is responsible for the operation and management of the Port of Brisbane facility at Fisherman Islands, located at the mouth of the Brisbane River (Figure 1.1). The PBC has a number of responsibilities as defined in the Corporation's Environmental Policy and under the *Environmental Protection Act 1994* with respect to the impact of the port's activities upon the surrounding environment.

As part of these responsibilities, the PBC has a duty of care to ensure that the operation of the Port facility and associated activities does not adversely impact adjacent wetland areas. At present, the wetland areas surrounding the Port area include some areas of dead and dying mangroves. The specific cause(s) for the mangrove death is uncertain, and in the absence of both baseline and monitoring data, the Corporation has a limited understanding of the on-going potential impacting processes, either attributable to the development/operation of the Port and/or other factors.

The information from this study provides an assessment of potential impacting processes within the area and a baseline data set for future comparisons.

1.2 Need for the Study

Mangrove communities have high conservation value as they provide food resources and shelter for a range of invertebrates, birds and fish (Chapman and Underwood 1995). Many of the fish species inhabiting mangrove areas are of direct recreational and commercial fisheries value (Morton 1990). Mangroves are also highly productive (Davie 1984), and are important in the stabilisation of bed and banks (Carlton 1974). In recognition of this high ecological value, all marine plants, including mangroves, are protected species under the *Fisheries Act 1994*.

As such, the degradation of the mangroves within the Fisherman Islands may have a range of associated ecological impacts, and the reasons for the decline must be determined before effective management can be implemented.

1.3 Study Aims

To address the issue of mangrove health, the PBC has commissioned WBM Oceanics Australia to investigate the health, viability and sustainability of the mangrove communities on Fisherman Islands (Study Area Figure 1.1). The aims of this study are :

- to determine and accurately map the current condition of the mangrove communities within the study area
- to determine the extent and nature of any historical and on-going environmental impacts acting upon the mangrove community within the study area; and
- to provide a preliminary assessment of the potential for remediation works as required.

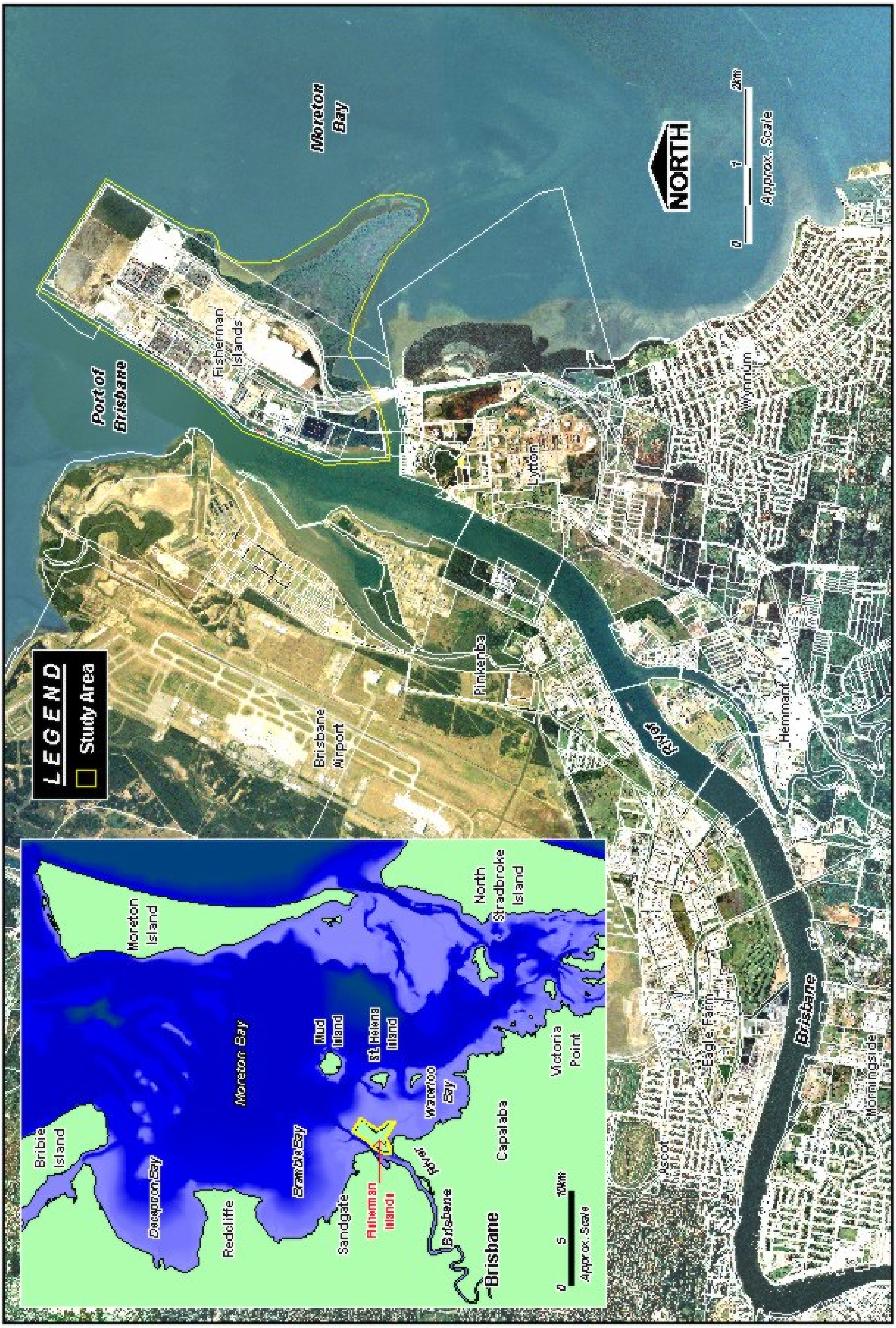

Figure 1.1 Locality Map

2 METHODOLOGY

The study area for this report includes the mangrove communities within the Fisherman Islands area located at the mouth of the Brisbane River (Figure 1.1). These mangrove communities are either within, or immediately adjacent to, PBC controlled lands, and as such have the potential to be directly effected by the development and/or activities of the Port.

This study was completed in two complementary stages; Stage 1, Mapping Historical Changes and Stage 2, Field Assessments.

2.1 Mapping Historical Changes

To develop an understanding of the historical distribution patterns of the nominated habitats (including mangrove, saltmarsh and bare areas) within the study area, and the changes associated with the development and subsequent expansion of the port facility, low level aerial photography was obtained for a number of years. This included periods prior to the major development of the Port of Brisbane facility (1972), during initial, stage 1 development (1978, 1983 and 1987), during further stage 2 expansion of the facility (1991, 1993 and 1995) and during current operations(1999).

The photos were scanned at a high resolution (300 dpi) and imported into a mapping software package (MapInfo Professional Ver 5.5). Using a number of recognisable features (minimum six per image), the photos were then geo-corrected and the accuracy of the final image compared to both data supplied by the PBC and ground control points to ensure a horizontal accuracy of at least 5m.

The photos were then reviewed and mapped in three broad land use types. These were :

- *Mangroves* : areas with visible mangroves.
- *Saltpan/Bare*: areas not being directly used/disturbed by the activities of the port with no visible mangroves
- *Port Operations*: areas being directly used and/or disturbed by the operation of the port at the time of the photo.

The classification of areas may change in subsequent years as usage changes. For example, the areas to which dredge spoil is deposited in the 1978 aerial was classified as Port Operational Area, whilst in subsequent years, proportions of this area was colonised by mangroves and/or appeared as bare/saltpan areas.

The areas were then overlayed with current cadastre data supplied by the PBC to provide a reference to present the port operations area.

The aerial photography was also used to provide a guide to impacting process which may have resulted in the current distribution of mangroves. A digital map layer was developed of the current (1999) area of mangroves as mapped during field works (see Section 2.2). This layer was then overlayed on each of the years of aerial photography and any features which may be related to the mangrove distribution noted. When features were noted which may be associated with mangrove degradation, comparison of the areas on subsequent photos was also made, thus providing a indication of the trends of mangrove distribution.

2.2 Field Assessments

The field assessments undertaken as part of this study were designed to address three main aims. These were to :

- gain an understanding of the physical and chemical environment of the mangroves within the study area;
- map the mangrove community in terms of species composition and community structure; and
- map the health of the mangroves, including stressed mangroves, using visual analysis of foliage characteristics.

2.2.1 Survey Technique

A survey of the study area was undertaken during the period November 1999 to early January 2000, over a total of 15 field days. The study area was traversed on foot along predetermined survey transects which ranged in length from 0.1 to 6.0 km depending on the areas. Measurements were recorded at approximately 50m intervals, with more frequent observations made in dense areas and/or those containing changes in community structure. Additionally, observations were recorded more frequently in and about the features of interest, such as areas of dead and/or dying mangroves.

Plate 2.1 Operator with GPS and Survey Staff

The location of the measurements was recorded using a differentially corrected GPS, providing a horizontal accuracy of ± 1m. The GPS was also used to navigate to the transect starting position and, in conjunction with a compass, used to navigate along the transect route.

Deviations were made from the predetermined route in response to field conditions (such as especially soft sediments) and/or the presence of features of interest. The boundaries of vegetation communities along the transects were also recorded to ground truth the present day vegetation maps (Section 2.1). The location of measurement stations are shown in Appendix A.

2.2.2 Physical and Chemical Measurements

Following the guidelines outlined by ASEAN (English *et al* 1994) a variety of *in-situ* measurements were recorded at each station along the survey transects. Due to a lack of baseline data regarding the various chemical properties of the sediments within the study area, samples were also collected for laboratory analysis of sediment chemical characteristics.

Redox Potential

The reduction-oxidation potential is a quantitative measure of the reducing power which provides a diagnostic index of the degree of anoxia of a soil sample. The redox potential of the sediments at each of the sampling stations along the transects was measured *in-situ* using a hand held Eh meter. Measurements were made by pressing the probe into the upper 0.10m of the sediment profile. The accuracy of the probe was checked with calibration standards prior to, and at the end of, each day's field work.

Plate 2.2 Redox and pH Probes in Sediment.

Acidity/Alkalinity

Soil pH is an important limiting factor of plant growth as it controls the chemical transformation of nutrients as an available source to plants. The acidity/alkalinity of the sediments at each of the sampling stations was recorded *in-situ* with a portable pH meter. As with the measurement of Eh, pH was recorded in the upper 0.10m of the soil profile with the accuracy of the meter determined prior and subsequent to field measurements.

Chemical Analysis of Sediments

Samples of sediments were collected from a number of locations from within the study area and analysed for a range of parameters including:

- heavy metal concentrations;
- organochlorine *a* contamination;
- BTEX/TPH; and
- nutrient concentration.

The samples were collected from the upper 0.10m of the sediment profile and retained in approved sampling containers before delivery to an NATA registered laboratory within 24 hours of sampling. The location of the sampling sites for the respective analytes is shown in Figure 2.1.

2.2.3 Species Composition, Community Structure and Health of Mangroves

During field surveys, observations were made at each station along the survey transects of a number of parameters. At each station, the following observations were recorded.

- *Species Composition* - the species composition was recorded including an estimate of the proportion of the community represented by various species (eg 100% *Avicennia marina*; 75% *A.marina*, 25% *Rhizophora stylosa*).
- *Community Structure* - at each station along the survey transects, an assessment was made of the community structure which included:

  ⇒ Projective cover of the tree and shrub layers. Projective cover estimates the horizontal coverage of a site by standing plant material. Cover estimates were made in 5 categories, 0-10%, 11-30%, 31-50%,51-75% and 76-100% cover on the basis of pre-printed sheets providing an example of each cover category.

  ⇒ Average height of the canopy. Height is a prime indicator of the quality of site conditions for plant growth. Together with basal area (see below) it provides an estimate of standing biomass. The height of the tallest strata of the community was recorded at each location using a surveyors staff as a guide for height estimations.

  ⇒ Density of trees, shrubs and seedlings. The density of plants (number of individuals per unit area) in the various layers gives an indication of the serial stage of a plant community and the degree of disturbance or change experienced over time. At each sampling station three random points were selected and the distance from the point to the nearest tree, selected using the T-square method as described by Krebes (1989), measured. The distance from this tree to its nearest neighbour was then also measured. The analysis of the resultant data set was then used to provide an indication of plant density.

  ⇒ Girth of tall shrubs and trees. Girth can be used to calculate diameters and basal areas. The number of individuals of various diameter size classes are indicative of population structure, whereas basal area can be used to estimate standing biomass. The tree selected in the above process (T-square method) were also measured for girth at breast height
- *Mangrove Health* - at each site along the survey transect, a visual assessment of the health of the mangroves was made based on criteria developed in conjunction with the PBC. The criteria are shown in table 2.1 with an example of each category shown in Plates 2.3 to 2.7 respectively.

Table 2.1 Mangrove Health Criteria

Category	Condition	Description
1	Good	Leaves green. No abnormal leaf loss evident. No epicormic growth. No leaf curling.
2	Fair	Leaves green. Some yellowing of leaves and/or curling, but <20% of canopy affected. Some epicormic growth apparent.
3	Poor	Many leaves yellow, brown and/or curled. Substantial reduction in canopy. Abundant leaf curling and/or epicormic growth apparent.
4	Dead	Leaves brown or absent. Little or no canopy remaining.
5	Regrowth	Canopy reduced but regrowth evident in the form of new trees. Disturbance event generally evident (ie. constructed bund).

Plate 2.3 Mangrove Health Category "Good"

Plate 2.4 Plate Mangrove Health Category "Fair"

Plate 2.5 Mangrove Health Category "Poor"

Plate 2.6 Mangrove Health Category "Dead"

Plate 2.7 Mangrove Health category "Regrowth"

2.2.4 Macroalgae

At each of the sampling stations along the survey transect, a visual estimation of the coverage of macroalgae was recorded. This estimation was based on four categories as shown in Table 2.2 with examples of each of the categories are shown in Plates 2.8 to 2.11.

Table 2.2 Macroalgae Coverage Categories

Category	Condition	Description
1	Very Abundant	>75% coverage of pneumatophores and/or sediments, heavy coating/carpet
2	Abundant	50-75% coverage, most surfaces coated, easily visible
3	Common	10-50% coverage some macroalgae visible
4	Rare	<10% coverage, no macroalgae

Plate 2.8 Macroalgae Category "Rare"

Plate 2.9 Macroalgae Category "Common"

Plate 2.11 Macroalgae Category "Abundant"

Plate 2.10 Macroalgae Category "Very Abundant"

2.2.5 Macrofauna

At each of the sampling stations, an estimation of the abundance of visible macrofauna was recorded, based on four categories as shown in Table 2.3. Macrofauna observations were made in conjunction with Eh and pH readings (See Section 2.2.2) as the operator remained quiet and still while the meter readings stabilised.

Macrofauna included crabs and epi-fauna such as snails. The measurement was made to provide a semi-qualitative indication of the biological utilisation of the subject area, and develop correlations between macrofauna apparent and mangrove health. It should be noted that no differentiation between abundances of different functional groups was made (eg abundant crabs recorded same as abundant snails or combinations of each group).

Table 2.3: Macrofauna Observation Categories

Category	Condition	Description
1	Very Abundant	Macrofauna very evident, >50 individuals sighted
2	Abundant	Macrofauna moderately evident 20-50 individuals sighted
3	Common	Some Macrofauna evident <20 individuals
4	Rare	No Macrofauna evident

2.2.6 Other Observations

The presence of other salient features at each of the sampling locations or encountered during field works was also recorded as required. Other features included to presence of litter, bank erosion, development of ponding ridges and depositional areas. The location of the features was recorded using the GPS described above.

2.3 Photographic Monitoring

At a number of locations throughout the study area (Figure 2.1), permeant photo monitoring stations were established. Sites were selected that were representative of the locality, and 1.8m plastic star picket was driven 0.8m into the sediment. The picket was tagged with stainless steel tags recording the site number and owner (PBC) and the location recorded using the differential GPS system described above.

A camera (Minolta WeatherMatic 35DL) with a 35mm lenses was placed on top of the picket and a photographic taken on each of the major compass points (ie magnetic north east south and west). A survey staff was placed in each of the photographs approximately 5m from the camera to provide a relative scale and record (via a system of coloured ribbons) the site and direction of the photo.

The results of these works have been provided to the Port of Brisbane Corporation under a separate cover and are not further discussed within this document.

Figure 2.1 Location of Sediment sampling sites for analysis of Heavy Metal, Organochlorine, BTEX/TPH and Nutrient concentrations.

3 RESULTS

3.1 Historical Changes

The Fisherman Islands' area has undergone significant changes as a result of the development of the Port of Brisbane facility. These changes were included both the loss and creation of mangrove areas. Generally, the majority of changes/disturbances to mangroves on Fisherman Islands have occurred within, or immediately adjacent to, the Port development area. However, changes to the canopy density, and possibly plant cover in areas relatively remote to the Corporation's activities (eg the eastern tip of the Islands) are evident in later photography. The trends presented by the photography are discussed below, with a discussion of potential impacting processes provided in Section 4.1.

During the period 1972 (Figure 3.2) to 1978 (Figure 3.3), the development of the Port facility included the reclamation of the western area of Fisherman Islands. This was undertaken using material gained from dredging of the Brisbane River and Moreton Bay. Material was unloaded as slurry from the dredger in the Brisbane River and deposited, via a pipeline, at the required area. This deposition was unconfined, with material flowing east (Figure 3.2), forming an area which has been subsequently colonised by mangroves. The 1978 aerial photography shows the development of the bridge joining Fisherman and Whyte islands and the filling of an area immediately west of the largest part of Fisherman Islands, with the subsequent removal of mangroves in this area (Figure 3.4 and 3.5). Additionally dredging activities are apparent within the Boat Passage, south of Fisherman Islands.

The 1983 aerial photography (Figure 3.5) shows the continuation of reclamation activities and the development of the Port and bulk coal loading facility. An area immediately south of the coal facility was also reclaimed prior to this photography. The colonisation of mangroves of the area between the two islands, and re-establishment of the area disturbed west of the central saltpan on the larger portion of the Islands is also apparent.

The 1987 aerial photography (Figure 3.4) shows the unconfined deposition of material within the central saltpan area east of the main rail line. The fluvial movement of this material onto the central saltpan area is clearly visible as is the resultant mangrove death to the north west of the reclamation area. The further reclamation and filling of lands for the development of additional loading facilities on the west of the Islands is also evident. The development of the rail loop at the northern end of the Fisherman Islands is visible.

The development of the southern portions of the reclamation project for the second stage of the Port of Brisbane development are visible in the 1991 aerial photography (Figure 3.6). This stage included the bunding and reclamation of approximately 90ha, including approximately 15ha of recently established mangroves in the area between the two Islands. The discolouration of the ponded waters remaining in the central saltpan area, possibly indicating anoxic conditions, is also evident.

The use of the dredging equipment to stockpile material immediately east of the access road on the southern end of the island should also be noted. Detailed inspection of the photography indicates that this deposition was also unconfined, and the loss of significant areas of mangroves east and north of this area resulted.

Review of the 1993 aerial photography (Figure 3.7) indicates that a bund had been developed and a large proportion of the mangroves had re-established in the adjacent area. This figure also shows the development of the second stage of the Port facility (commonly referred to as the Superbund), which included the reclamation of approximately 170ha, including approximately 11ha of mangroves and 117 ha of subtidal lands (with Bishop Island providing the balance).

Detailed review of this figure indicates that the mangroves on the larger portion of the remaining Fisherman Islands had undergone a significant thinning and possible canopy reduction relative to previous years. Prior to the 1993 figure, the mangrove communities in this area appeared to be relatively stable. It should be noted that this decline is also evident, albeit to a lessor degree, on the eastern tip of the Islands, an area relatively remote from the Ports activities. The possible reasons for this broadscale decline are discussed in Section 4.

The continuation of the development the second stage of the Port is evident in the 1995 aerial photography (Figure 3.8). The increase in bare areas, within both the central and eastern portions of Fisherman Islands is also evident. Additional dredging works within the Boat Passage in relative close proximity to the southern shoreline of the Islands is evident.

The resultant chronological changes in areas of the three mapped categories (Port Operations, Mangrove and Bare/Saltpan) for the period of review for the purposes of this report (1972 - 1999) is shown in Figure 3.1.

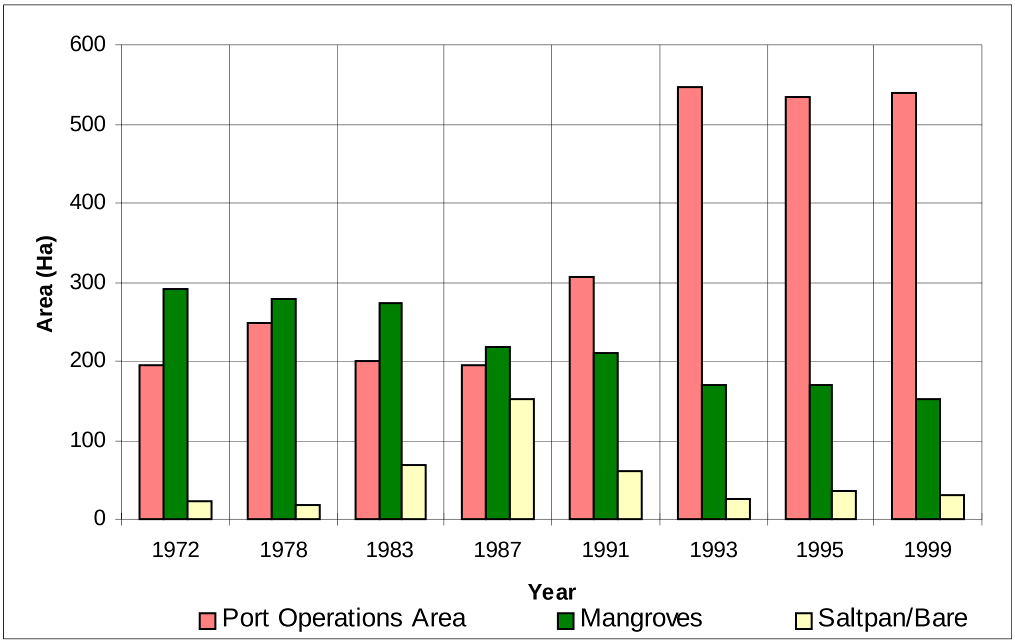

Figure 3.1 Land Use Areas of Fisherman Islands, 1972 to 1999

Over the period of analysis (1972-1999) there has been a substantial increase in the area of Port Operations, from approximately 200 ha to 540 ha. Most of this increase resulted from the Stage 2 port expansion (Superbund reclamation). The area of mangroves has been reduced from approximately 300 ha in 1972 to 150 ha in 1999. Saltpan/bare areas have been variable (as a result of sediment deposition and mangrove regrowth), but are now similar in extent to the 1972 situation.

3.2 Physical and Chemical Measurements

3.2.1 Physical Characteristics

Sediments throughout the Fisherman Islands area were generally grey to dark grey fine silts. In a few areas, the exposure to high wave energies had produced low berms of medium to course sands (see Section 2.2.6) whilst the exposed saltpan/bare areas contained cracking clays.

Whilst the vegetation had consolidated the material in the majority of areas, the material due east of the PBC office is very soft. This material has been deposited as the result of unconfined deposition of dredge material visible in the 1972 and 1974 aerial photography (Figure 3.2 and Figure 3.3 respectively).

Whilst no measurements were made of moisture content of sediments throughout the study area as part of this study, these were calculated for the chemical analysis presented in Section 3.3.2.

As a general observation, those central areas containing dead mangroves which **did not** have visible ponded waters were often waterlogged, with ground water level very close to the surface. Often footprints made whilst traversing the site rapidly filled from ground waters. This was not as evident in areas of healthy mangroves.

3.2.2 In-Situ Measurements and Chemical Analysis

In general, the sediments returned a positive reduction/oxidation potential (mean = 86.0, SD = 126) which suggests that the upper 0.1m layer of sediments were aerobic, with a range of -217 to 292. Results were highly variable however.

The results of the pH measurements tended towards slight acidity with a range of 4.5 to 8.2 (mean = 6.5 S.D = 0.6) which is consistent with those reported for sub-tropical mangrove sediments (Hutchings and Saenger 1987, Ericsson 1990)

The results of the chemical analysis of samples is provided in Table 3.1 to Table 3.4. These indicated that the sediments generally had negligible or low contamination relative to ANZECC Sea Dumping Guidelines, and were similar to other relatively unpolluted areas of Moreton Bay (ie. Wellington and Victoria Point, Deception Bay).

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Figure 3.2 1972 Aerial Photography and Land Use, Fisherman Islands

Figure 3.3 1978 Aerial Photography and Land Use, Fisherman Islands

Figure 3.4 1983 Aerial Photography and Land Use, Fisherman Islands

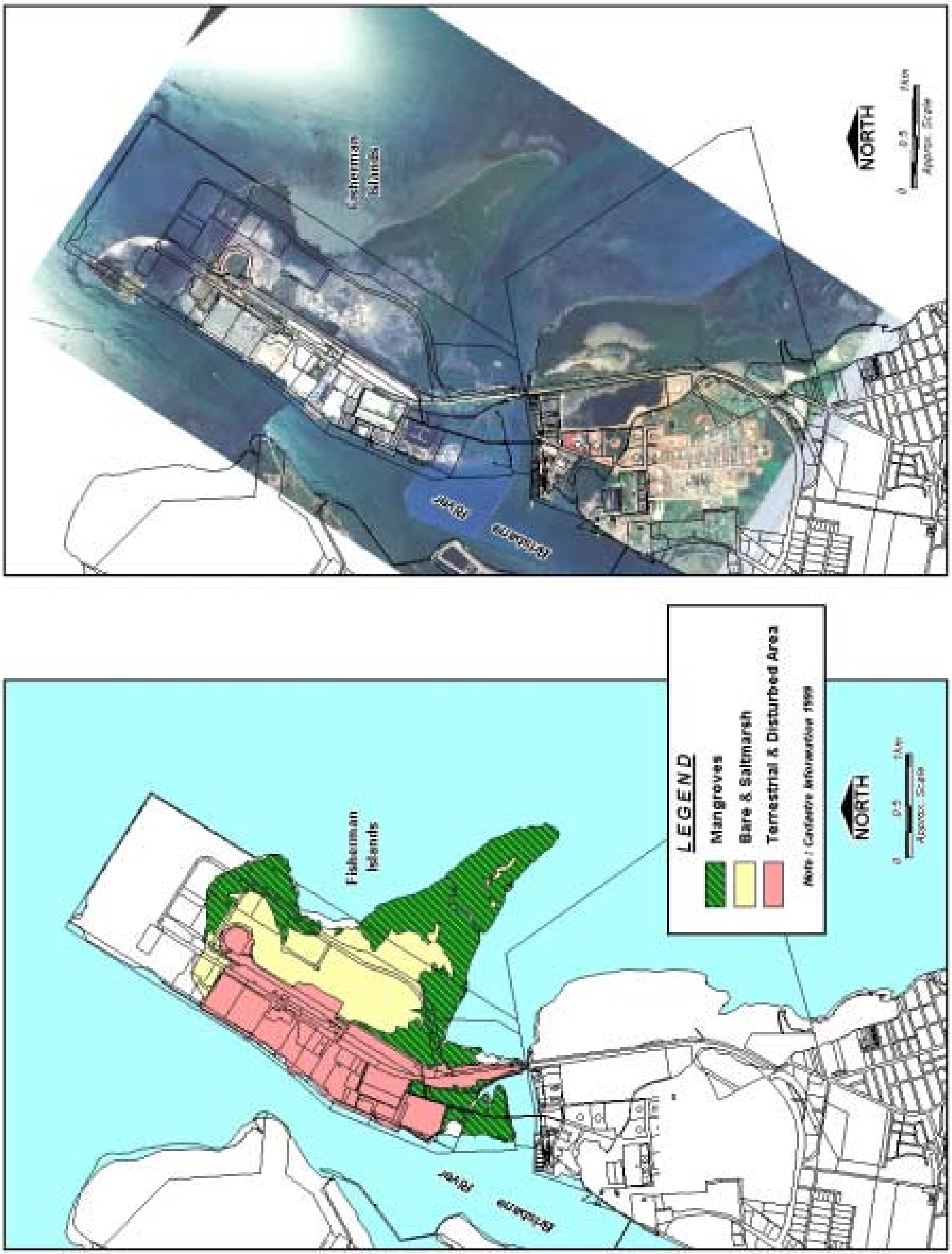

Figure 3.5 1987 Aerial Photography and Land Use, Fisherman Islands

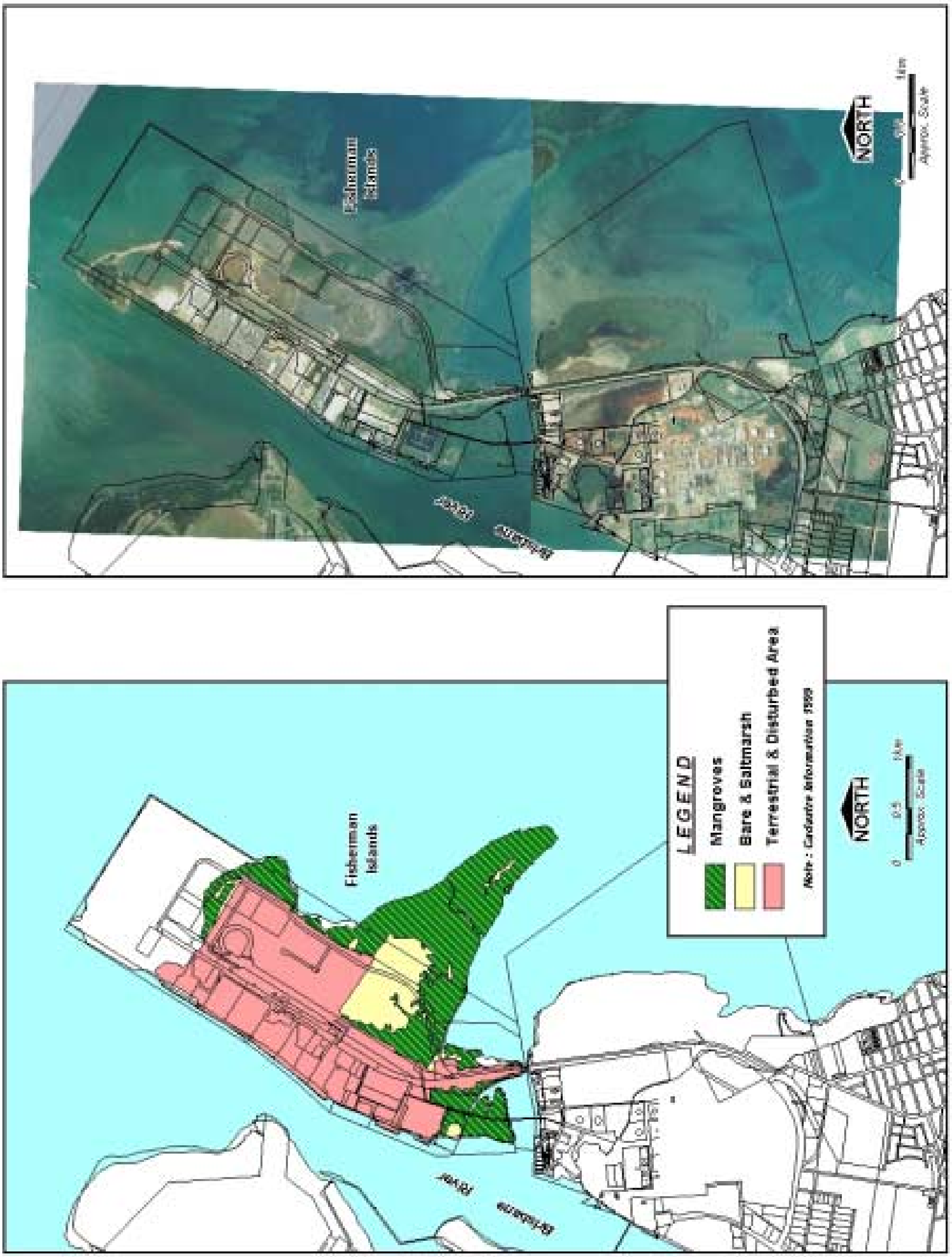

Figure 3.6 1991 Aerial Photography and Land Use, Fisherman Islands

Figure 3.7 1993 Aerial Photography and Land Use, Fisherman Islands

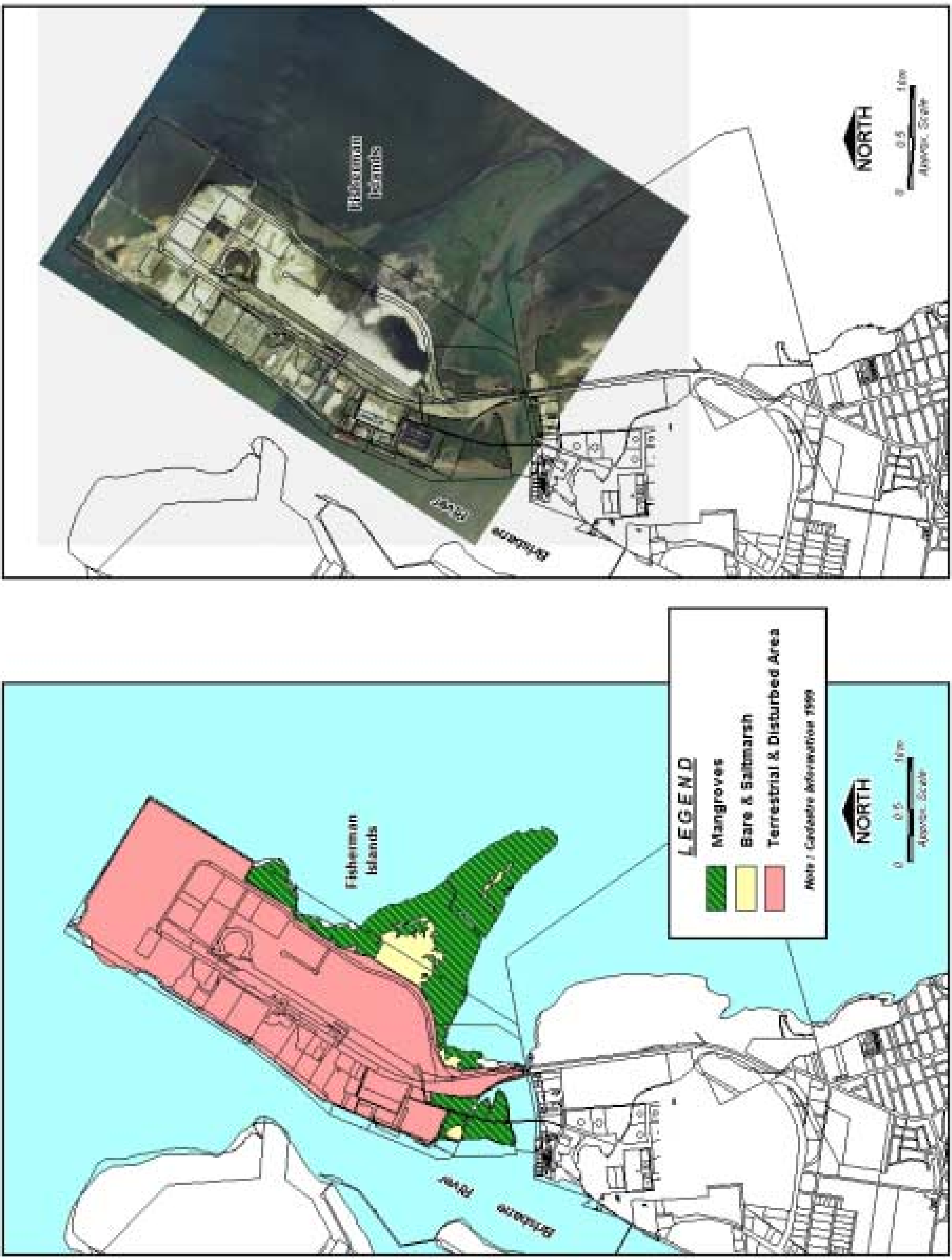

Figure 3.8 1995 Aerial Photography and Land Use, Fisherman Islands

Table 3.1 Results of Chemical Analysis of Sediments for Heavy Metal Contamination. **See Figure 2.2 for sampling Locations**

			Sample Site Number											
Analyte	**Units**	**Detection Limit**	**1**	**3**	**6**	**9**	**11**	**13**	**15**	**17**	**18**	**19**	**23**	**ANZECC[1] Screening Limit**
Arsenic	mg/kg	0.05	6.8	8.95	3.1	2.8	8.35	9.7	7.65	7.05	6	5.1	4.35	20
Cadmium	mg/kg	0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	0.1	0.05	0.05	<0.05	0.1	1.5
Chromium	mg/kg	0.05	57.7	59.8	93.1	86	56.4	44.6	39.4	77	57.9	40.7	43.8	80
Copper	mg/kg	0.05	13.7	24.7	5.65	8.2	13.8	19.6	13.6	13.2	9.65	17.6	20.5	65
Mercury	mg/kg	0.05	0.1	0.15	<0.05	<0.05	0.05	<0.05	0.1	0.05	0.05	<0.05	0.1	0.15
Nickel	mg/kg	0.05	12.4	16.6	9.65	7	13.6	18.6	17.4	15.4	12.8	23.1	19.9	21
Lead	mg/kg	0.05	11.5	24.2	4.05	5.05	12.3	16.3	11	10.4	8.15	11.7	18.9	50
Zinc	mg/kg	0.05	48.3	68.4	23.8	30.2	48.3	65.3	53.8	52.3	43.3	63.3	58	200
Moisture Content	%	0.1	36	63	24.8	40.3	46	50.3	38	57.5	52.2	40.9	78.6	N/A

[1] ANZECC (1998) Guidelines for Ocean Disposal

Table 3.2 Results of Chemical Analysis of Sediments for Nutrient Content.

	Units	Detection Limit	1	3	6	9	11	13	15	17	18	19	23	Luggage Point [1]	Wellington Point[1]	Victoria Point[1]	Deception Bay[1]
Nitrite and Nitrate as N	mg/kg	0.05	0.15	0.5	0.15	<0.05	0.2	1.2	<0.05	0.1	0.3	0.35	0.15	NA	NA	NA	NA
Total Kjeldahl Nitrogen as N	mg/kg	10	600	1800	260	430	1890	1570	540	1110	1580	740	2540	NA	NA	NA	NA
Total Nitrogen as N	mg/kg	10	600	1800	260	430	1900	1570	540	1110	1580	740	2540	8606	2566	3000	1043
Phosphorus as P - Total	mg/kg	10	410	460	170	150	430	360	400	290	380	500	230	1367	656	526	250

[1] Average of 3 values obtained from WBM (1999)

See Figure 2.2 for sampling locations

Table 3.3 Results of Chemical Analysis of Sediment for Ogranochlorine Concentration

Analyte	Units	Detection Limit	Sample Site Number 9	19	23
ORGANOCHLORINE PESTICIDES					
alpha-BHC	mg/kg	0.05	<0.05	<0.05	<0.10
HCB	mg/kg	0.05	<0.05	<0.05	<0.10
beta-BHC & gamma-BHC	mg/kg	0.1	<0.1	<0.1	<0.3
delta-BHC	mg/kg	0.05	<0.05	<0.05	<0.10
Heptachlor	mg/kg	0.05	<0.05	<0.05	<0.10
Aldrin	mg/kg	0.05	<0.05	<0.05	<0.10
Heptachlor epoxide	mg/kg	0.05	<0.05	<0.05	<0.10
Chlordane – trans	mg/kg	0.05	<0.05	<0.05	<0.10
Endosulfan 1	mg/kg	0.05	<0.05	<0.05	<0.10
Chlordane – cis	mg/kg	0.05	<0.05	<0.05	<0.10
Dieldrin	mg/kg	0.05	<0.05	<0.05	<0.10
DDE	mg/kg	0.05	<0.05	<0.05	<0.10
Endrin	mg/kg	0.05	<0.05	<0.05	<0.10
Endosulfan 2	mg/kg	0.05	<0.05	<0.05	<0.10
DDD	mg/kg	0.05	<0.05	<0.05	<0.10
Endrin aldehyde	mg/kg	0.05	<0.05	<0.05	<0.10
Endosulfan sulfate	mg/kg	0.05	<0.05	<0.05	<0.10
DDT	mg/kg	0.2	<0.2	<0.2	<0.5
Endrin ketone	mg/kg	0.05	<0.05	<0.05	<0.10
Methoxychlor	mg/kg	0.2	<0.2	<0.2	<0.5
ORGANOCHLORINE PESTICIDE SURROGATE					
Dibromo-DDE	%	1	58	75	95

See Figure 2.2 for sampling locations

Table 3.4 Results of Chemical Analysis of Sediments for Total Petroleum Hydrocarbons and BTEX Contamination

			Sample Site Number														
Analyte	Units	Detection Limit	**1**	**2**	**3**	**4**	**6**	**7**	**9**	**11**	**13**	**15**	**17**	**18**	**19**	**22**	**23**
TOTAL PETROLEUM HYDROCARBONS																	
C6 - C9 Fraction	mg/kg	2	<2	<5	<5	<5	<2	<2	<2	<2	<5	<2	<5	<5	<2	<5	<5
C10 - C14 Fraction	mg/kg	50	<50	<125	<125	<125	<50	<50	<50	<50	<125	<50	<125	<125	<50	<125	<125
C15 - C28 Fraction	mg/kg	100	<100	<250	<250	<250	<100	<100	<100	<100	<250	<100	<250	<250	<100	<250	435
C29 - C36 Fraction	mg/kg	100	<100	<250	<250	<250	<100	<100	<100	<100	<250	<100	<250	<250	<100	<250	565
BTEX																	
Benzene	mg/kg	0.2	<0.2	<0.5	<0.5	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.5	<0.5	<0.2	<0.5	<0.5
Toluene	mg/kg	0.2	<0.2	<0.5	<0.5	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.5	<0.5	<0.2	<0.5	<0.5
Chlorobenzene	mg/kg	0.2	<0.2	<0.5	<0.5	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.5	<0.5	<0.2	<0.5	<0.5
Ethylbenzene	mg/kg	0.2	<0.2	<0.5	<0.5	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.5	<0.5	<0.2	<0.5	<0.5
meta- & para-Xylene	mg/kg	0.2	<0.2	<0.5	<0.5	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.5	<0.5	<0.2	<0.5	<0.5
ortho-Xylene	mg/kg	0.2	<0.2	<0.5	<0.5	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.5	<0.5	<0.2	<0.5	<0.5
VOLATILE TPH/BTEX COMPOUND SURROGATES																	
1.2-Dichloroethane-D4	%	1	78	65	73	64	88	88	70	66	64	78	51	63	81	56	31
Toluene-D8	%	1	87	64	71	64	81	84	76	77	72	78	60	65	74	52	27
4-Bromofluorobenzene	%	1	81	61	68	63	80	79	82	77	81	78	63	68	82	55	32

See Figure 2.2 for sampling locations

3.3 Vegetation Community Types

The survey recorded five of the seven species of mangrove known to occur within Moreton Bay (Dowling 1979), including Grey Mangroves (*Avicennia marina* var. *australasica*), Yellow Mangroves (*Ceropis australis*), Red Mangrove (*Rhizophora stylosa*), Orange Mangroves (*Bruguieia gymnorhiza*) and River Mangrove (*Aegiceras corniculatum*) (see Figure 3.12). Within the study area, a total of 167.7 ha of mangroves was mapped from the 1999 aerial photography, which is approximately 4.2% of the resource reported in northern Moreton Bay (Empire Point to Caboolture River) by Hyland and Butler (1987).

All mangrove species found within the study area are common and widespread within Moreton Bay (Hyland and Butler 1987). The zonation and community structure patterns observed were also typical of mangrove systems within the region (eg. Lovelock 1993). The occurrence of stands of the River Mangrove within the study area (Figure 3.12) was unexpected as this species is generally replaced by Grey Mangroves in areas of typically oceanic salinities (Hutchings and Saenger 1987, Abal *et. al.* 1998). However a similar pattern has been recorded at Bulwer Island (Mackey and Monosour 1994), where the communities were dominated by Grey Mangroves, with a well developed understorey of River Mangroves.

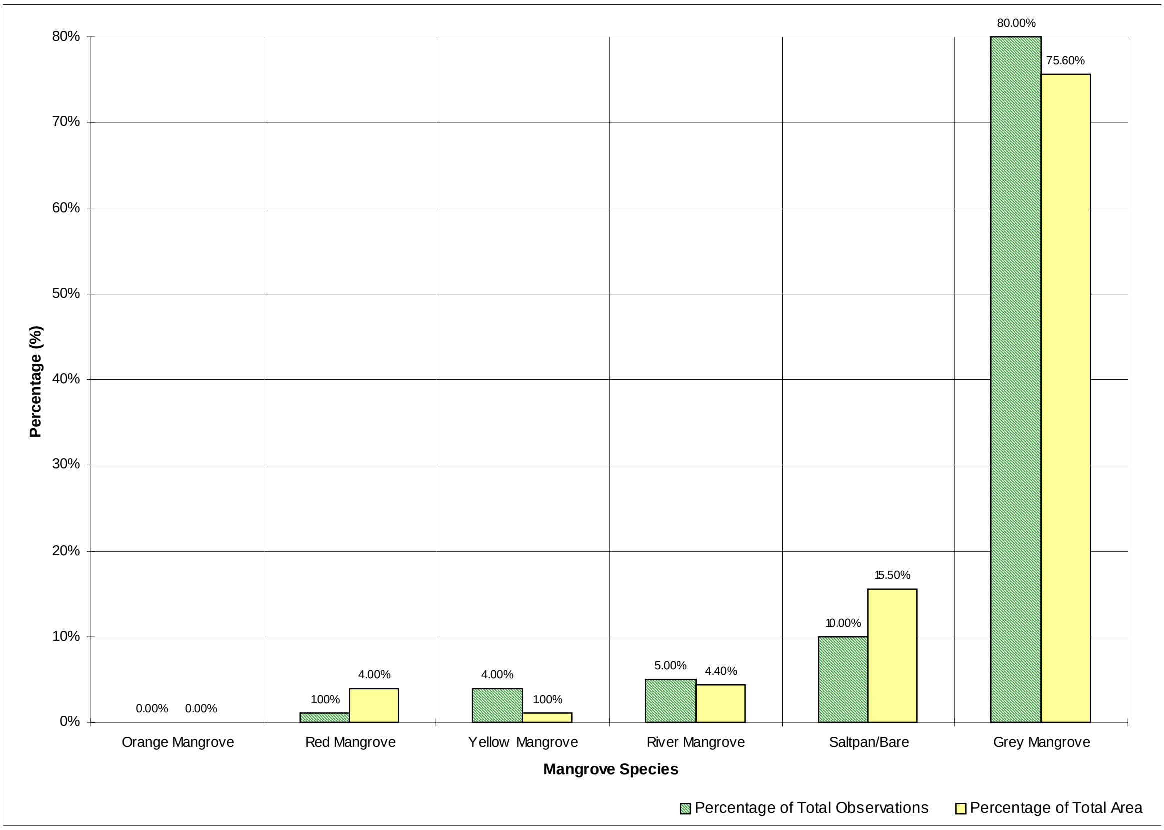

Figure 3.9 Percentage of Mangrove Species by Field Observations and Total Area for the Fisherman Islands, 1999.

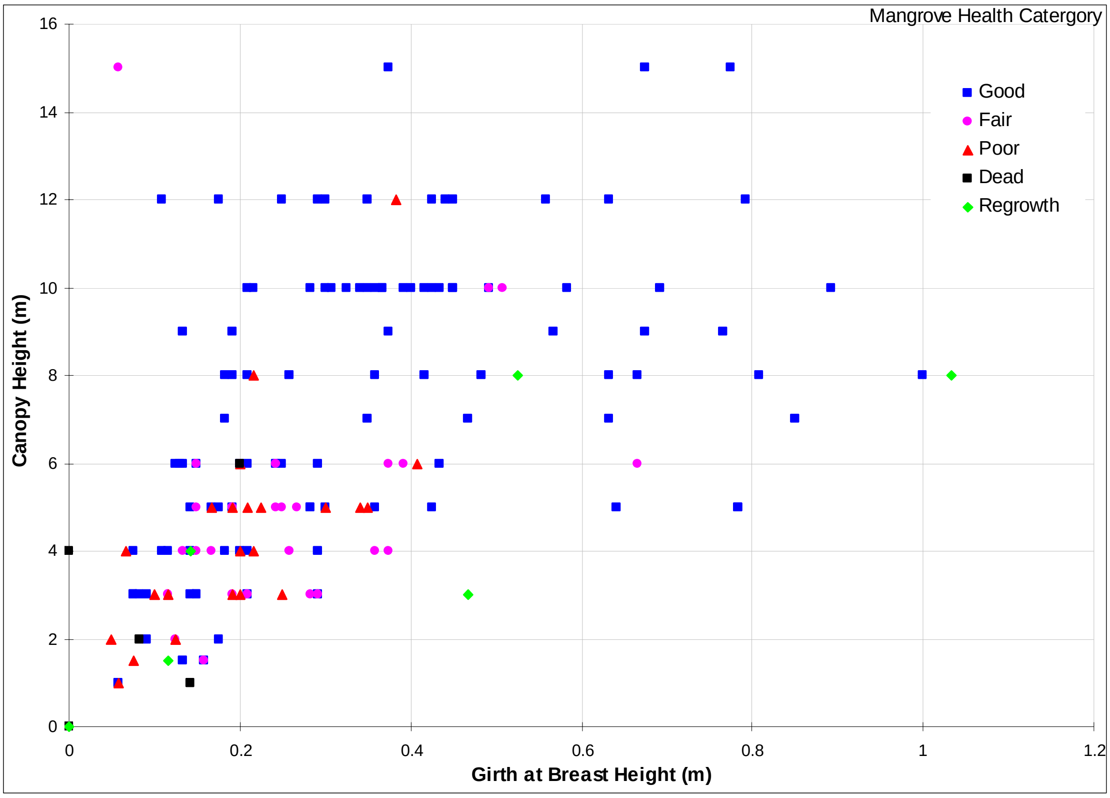

Figure 3.10 Average Girth at Breast Height and Canopy Height for Mangrove Health Categories

The results of field surveys indicate that the Fisherman Islands area was dominated by Grey Mangroves, which comprised approximately 80% of individuals recorded across sites and covered 75.6% of the survey area (excluding Port Operations Area, see Section 2.1). The Orange Mangrove was the least abundant mangrove throughout the study area, and only occurred as isolated individual plants rather than monospecific or dominated stands, as was recorded of other species. As such species did not record observation or area totals (Figure 3.9) and was only recorded as a species record from the study area.

The distribution of the mangrove species is shown in Figure 3.12. It should be noted that due to the transitional nature of mangrove communities, the location of the boundaries shown within the map is somewhat arbitrary on a fine scale. The actual percentages of each of the mangrove species recorded at each site are presented in Appendix A.

Figure 3.10 shows the relationship between Girth at Breast Height (GBH) and canopy height at each site. This is consistent with trends reported for mangrove communities at Bulwer Island (Mackey and Monsour 1994). Canopy height increased with increasing girth approximately linearly with girth up to a GBH of approximately 0.6m, after which the curve asymptotes.

The relative abundance of mangrove seedlings was qualitatively estimated at each site. Seedlings were almost exclusively Grey Mangroves whereas other species were rare/absent.

Mackey and Monsour (1994) noted a similar pattern at Bulwer Island, and suggested that the lack of recruitment may lead to localisation of some species.

3.4 Mangrove Densities

Average mangrove stem densities and standard errors were calculated for each of the mangrove health classes for the data collected using the T-square method described above. The results indicate that there were only slight differences in density between “good” and “dead” areas. This is expected as the health categories span a number of different communities (eg mature frontal mangroves and small mangroves at the edge of a saltpan) may both fall into the “good” mangrove health category. The “regrowth” category contained a much higher stem density (3.33 per m^2). The high mangrove densities in the regrowth reflected the high densities of small Grey Mangroves in these areas.

The stem densities recorded during this study are similar to that report for both the Fisherman Islands and Bulwer Island area (Mackey and Monsour 1994).

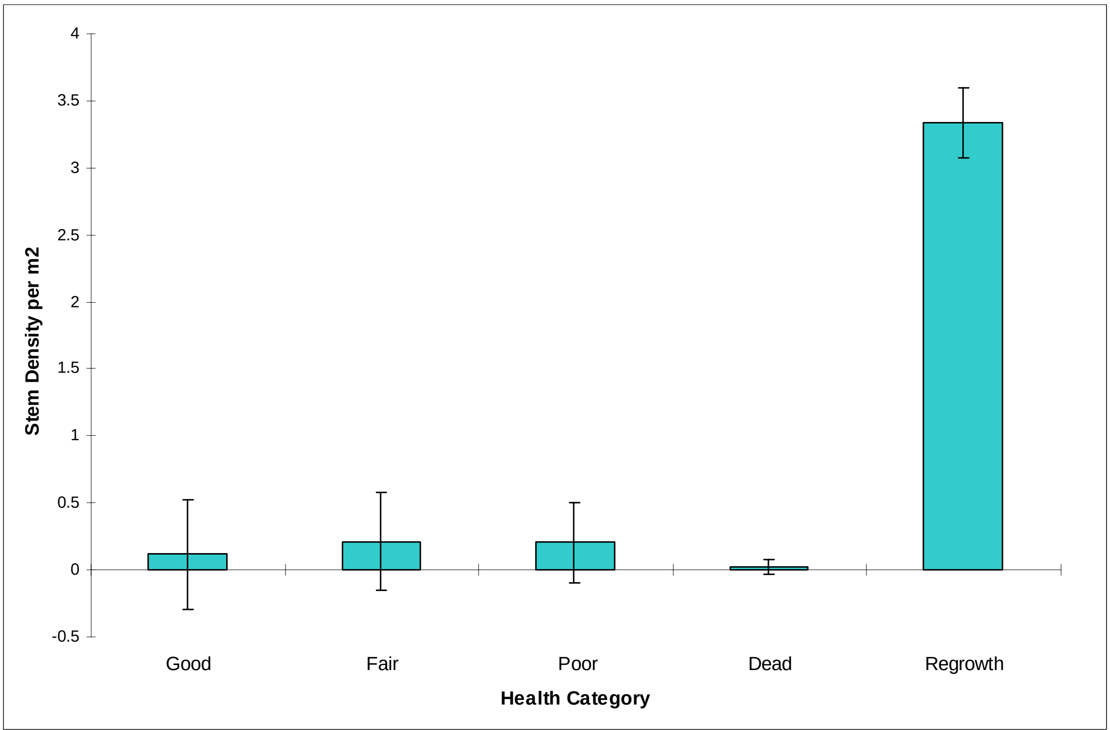

Figure 3.11 Average Mangrove Stem Density with Standard Errors by Health Categories, Fisherman Islands 1999.

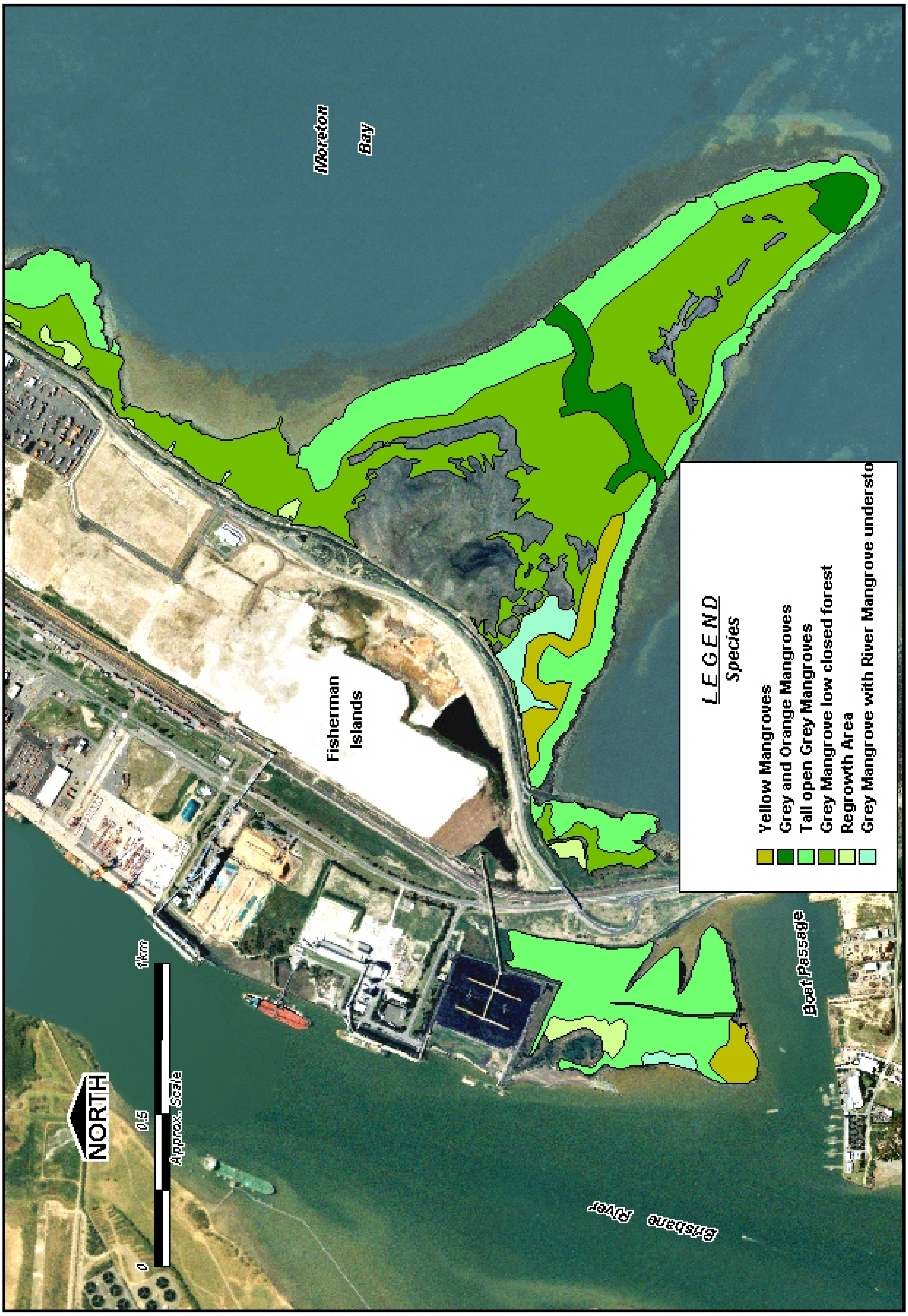

Figure 3.12 Distribution of Mangrove Species, Fisherman Islands, 1999.

3.5 Macroalgae Coverage

The survey results indicate that macroalgae was highly abundant within the study area, with approximately 62.6% of observation sites recording either very abundant (>75% coverage) or abundant (50-75% coverage; Table 2.2) macroalgae coverage. The remaining two categories (common and rare) recorded only 24% and 14% of the total observations respectively.

Whilst species of macroalgae was not recorded, a general trend was noted that the brown macroalgae (*Bostrychia-Calogssa* assemblages) were generally associated with mangroves towards the fringe of the mangrove stands, with the highest abundance (often 100% coverage, see Plate 4.5 in Section 4.1.3) at the seaward edge. Mangroves in these areas were generally healthy with minimal signs of stress.

The green macroalgae was associated with ponded water areas (See Plate 4.6 in Section 4.1.3) and dead mangrove stands where water had ponded. Here it appeared as a white flaking material (see background of Plate 2.2 and 2.6).

Due to the extremely variable nature of the distribution of macroalgae observed during field works it is not possible to map the distribution without presenting large scale generalisations of the data. As such, no mapping has been undertaken, with the above generalisation being presented. The raw data set, including macroalgae abundance criteria and data point locations is presented in Appendix A. A discussion as to trends observed and the implications of same is presented in Section 4.1.3.

3.6 Macrofauna Abundance

Macrofauna was generally abundant within the study area with 35% of observations recorded as very abundant, whilst the remaining three categories recorded 30%, 23.5% and 12% respectively. Observations generally indicated that fauna was more abundant towards the seaward fringe of the mangrove, relative to more isolated areas inland. Additionally, higher macrofanua abundances were noted in open areas relatively to closed, densely vegetated areas.

3.7 Mangrove Health

3.7.1 Field Data

The survey results indicate that approximately 50% (by observations or total area) of the mangroves within the study area were classified as being in "Good" health (see Section 2.2.3 for Criteria). Of the remaining mangroves, approximately 40% exhibited signs of stress and/or where dead at the time of the survey (late 1999; Figure 3.13). Most mangroves showing signs of stress were located in the central claypan areas and the central portion of the eastern tip of Fisherman Islands, whilst mangroves at the fringes of the Islands were generally good health (Figure 3.14). This distribution has important implications for the postulated reasons for mangrove death within the Fisherman Islands area, as discussed in Section 3.5.2.

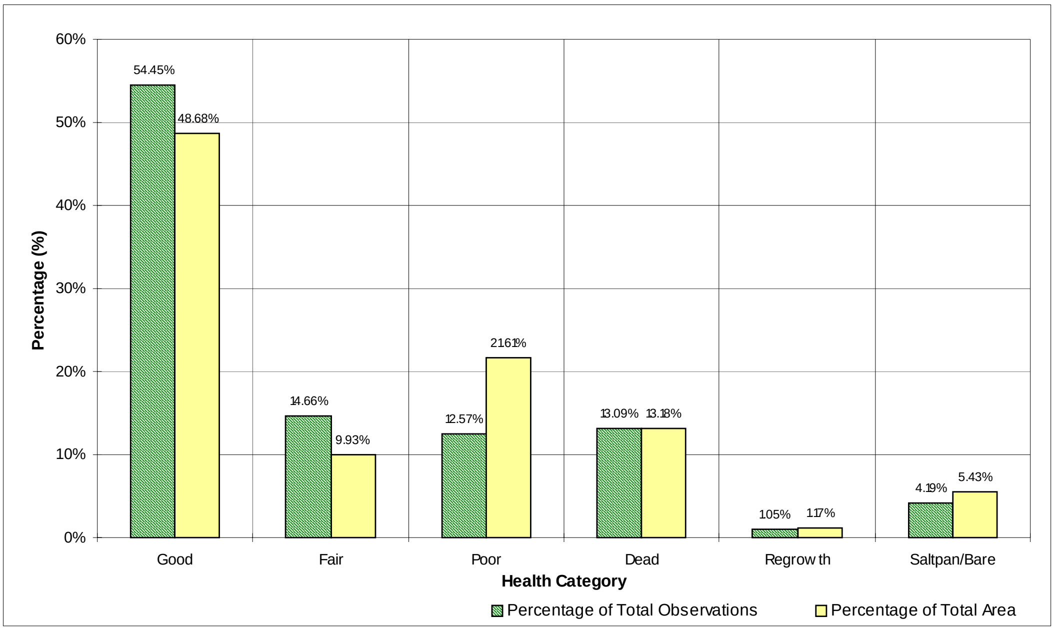

Figure 3.13 Percentage of Mangroves within Various Health Categories by Field Observations and Total Area

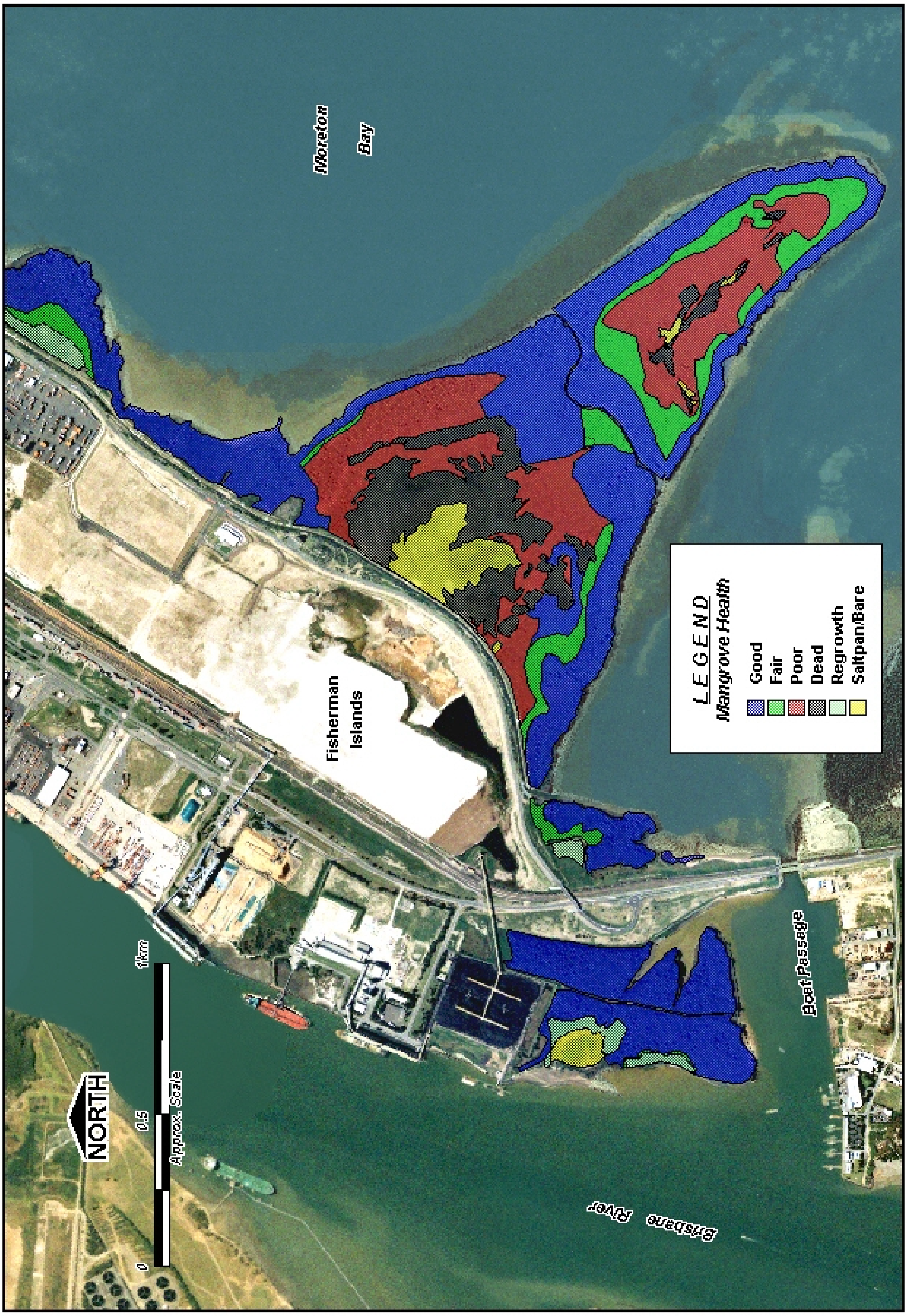

Figure 3.14 Distribution of Mangroves within Various Health Classifications, Fisherman Islands, 1999.

3.7.2 Correlation of Data

To investigate the potential interactions between the collected data, statistical analysis of the data set was undertaken. As the data was not normally distributed, the non-parametric Spearman's rho rank correlation coefficients were calculated. The test provides both an indication as to significant correlations between data and an indication of the direction of the correlation. Positive R_s coefficients indicate a positive correlation and vice versa.

Table 3.5 Spearman's Rho Ranked Correlation Coefficients for Sediment pH and Redox Potential, Mangrove Health[1], Macroalgae Abundance[2] and Macrofauna Abundance[3].

	pH	Mangrove Health	Macroalgae Abundance	Macrofauna Abundance
Redox	0.245**	-0.268**	-0.018^{ns}	0.217**
pH		-0.235**	0.081^{ns}	0.163*
Mangrove Health			-0.274**	-0.508**
Macroalgae Abundance				0.287**

[1]Mangrove Health ranked from Good (1) to Dead (4)

[2]Macroalgae Abundance ranked from Rare (1) to Very Abundant (4)

[3]Macrofauna ranked from Rare (1) to Very Abundant (4)

*p<0.01, **p<0.001 ^{ns} not significant

The above correlations suggest that mangrove health was significantly correlated with both pH and redox potential, showing a decrease in mangrove health with decreasing redox potential (ie anaerobic conditions) and pH (acidic conditions). It is likely that the degradation of mangroves results in an increase in the litter fall, which would produce both humic acids and increase biological oxygen demand, possibility resulting in decreased redox potential.

The data also suggests that macrofauna abundance was highest in areas of healthy mangroves and where macroalgae abundance was highest. This presents an apparent contradiction in the data trends as increased macroalgae abundance was correlated with a decrease in mangrove health. However as stated in Section 3.5, the observation of macroalgae did not differentiate between brown macroalgae (often associated with seaward healthy mangroves) and green macroalgae, which was more often recorded from internal areas of ponded waters, where mangroves were generally of poor health.

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3.8 General Observations

During the course of field surveys, four other potentially impacting processes/products were recorded:

- sand ridges/areas of recent erosion;
- areas containing large amounts of litter;
- areas of dead seagrass; and
- signs of foxes.

3.8.1 Sand Ridges

Relatively large (0.5 - 1.0 m) ridges of clean course sand material and dead seagrass were noted in several areas (Figure 3.15). These ridges covered the base of well established mangroves, indicating that they had formed relatively recently.

The ridges were located at the leading edge of the mangrove fringe, generally at the crest of the beach slope. The ridges formed a generally continuous line on the northern shore of the Boat Passage, with intermittent breaks at drainage lines. Mangroves covered by the ridges in some locations had died, whilst ponded water on the landward side of the ridges was also noted.

Plate 3.1 Sand Ridge in Mangroves Adjacent Brisbane River, Fisherman Islands.

Plate 3.2 Sand Ridge in Mangroves adjacent Boat Passage, Fisherman Islands

3.8.2 Bank Erosion

Erosion of the seaward fringe areas was noted in association with the development of the sand ridges. This was particularly evident in the western areas of the northern Boat Passage shoreline, with a severe erosion scarp formed in some areas. The central and eastern areas of this shoreline were not as severely eroded, although sheet erosion was evident in some areas (Plate 3.3).

Plate 3.3 Sheet Erosion Evident in Northern Boat Passage Shoreline. Note the exposed lateral roots.

3.8.3 Litter

Excessive litter was recorded in many areas (Figure 3.15). This material was likely to have floated into the study area from wider Moreton Bay and Brisbane River, as no material which would be directly attributable to the operation of the Port and/or dumped directly on-site was recorded. Litter consisted mainly of plastic material, such as drink containers, which do not readily degrade.

Figure 3.15 Location of Sand Ridges and Litter noted during Field Works

The areas in which litter was most abundant was about structures which would act as collection devices, such as the bund wall east of the main drain (Plate 3.4). Material would float in with the tide, be concentrated by the prevailing winds and stranded by the receding waters. Litter appeared to be most abundant west of the central saltpan/bare area, possibly as it was more visually obvious in open areas compared to vegetated areas.

Plate 3.4 Litter Immediately East of the Bund associated with the Main Drain, Fisherman Islands

Plate 3.5 Seagrass mats within mangroves. Note complete coverage of pneumatophores.

3.8.4 Seagrass

Seagrass leaf material occurred as piles (up to 1m deep and 20m long) where structures stopped the movement of floating seagrass mats. The material had a strong anaerobic smell when disturbed. Large (up to $50m^2$) shallow pools containing strongly anaerobic sediments, and which were devoid of mangrove seedlings and/or pneumatophores, were also observed. The sand ridges discussed above (Section 3.6.1) also contained layers of seagrass.

In foreshore areas, especially along the north eastern shoreline, seagrass mats had smothered all mangrove seedlings. The ability of seedlings to recover from smothering is unknown, however very few trees representing the previous year class were observed.

3.8.5 Foxes

Abundant fox tracks were noted at numerous locations on the extensive saltpan/bare area on the western end of Fisherman Islands (Plate 3.6). The saltpan/bare area is a major bird roosting area, and the foxes were presumably hunting the roosting birds at night. Several areas where birds had been killed were observed.

It is possible that the abundance of feral predators, including foxes, in association with this and other roosts within the region may be a contributing factor to the declining numbers of waders utilising these areas, although this link has not been conclusively established.

Plate 3.6 Fox Tracks on Saltpan/Bare Area, Fisherman Islands

4 DISCUSSION

The results of the field and desktop assessments indicate that a large proportion (approximately 40%) of the mangroves on Fisherman Islands are showing significant signs of stress and do not appear to be recovering (ie no regrowth and/or seedlings).

This trend is not confined to the Fisherman Islands area as mangroves to the south (Whyte Island, pers. obs. author) and west (Luggage Point, WBM 1999) of the study site contain significant areas of very stressed/dead mangroves. It is the understanding of the author that the Queensland Department of Primary industries, Fisheries is currently (April 2000) undertaking investigations to determine both the distribution and status of degraded mangroves within Moreton Bay, but especially western portions of the Bay.

Nevertheless, the mangrove resources within the Fisherman Islands study area constitute a significant proportion of the mangroves within western Moreton Bay; hence the ecological ramifications of the decline and possible eventual loss of these mangroves would be significant on a regional scale.

The reasons behind the decline of these mangroves is not clear, however three main impacting process have been identified:

- disruption to normal drainage patterns;
- increase in wave energy at the seaward edge of mangroves; and
- increase in macroalgae abundance and associated water logging.

4.1 Impacting Processes

4.1.1 Disruption to Drainage Patterns

The results of the mangrove health survey indicate that with the exception of two isolated areas on the south west and north east of the study area (Figure 3.14), degraded mangrove stands were located on the margins of the saltpan/bare area on the west and eastern ends of the Fisherman Islands. The areas of degraded mangroves were generally well defined, with rapid transitional zones from degraded areas to apparently healthy areas. This indicates that the factors causing mangrove degradation are area specific rather than an overall deterioration in health as might be expected with widespread fungal and/or insect infestations.

Review of aerial photography indicates that mangrove extent in the western saltpan/bare area was relatively stable until 1987, coinciding with land reclamation works associated with stage two of port expansion works. Inspection of the 1987 photography (Figure 3.5 and Plate 4.1) indicates that the relocation of material to the natural saltpan/bare area was not confined by bund walls and/or sedimentation ponds, as is current practice. The material from the relocation works spread across the existing saltpan areas, with fluvial patterns clearly visible.

The relocated material is likely to have caused significant disruption to the natural drainage patterns and/or the nature of the sediments within the immediate vicinity of relocation works. The changes to local topography are likely to have resulted in a reduction in the drainage efficiency, with resultant increases in sediment moisture content and ponding of surface waters.

Plate 4.1 1987 Aerial Photography of Material Relocation Activities on Natural Saltpan/Bare Area of Western Fisherman Islands.

Ponding of water can lead to asphyxia of mangroves and ponded waters about the roots of mangroves reduces the ability of the aerial components of the roots (pneumatophores in Grey mangroves) to take up oxygen. Plant stress due to asphyxiation is generally very rapid (ie evident within several days, pers. comm.. D.Mayer QDPI Fisheries and P. Coleman, Delta Environmental Consulting), and may lead to death occurring within 6 weeks (Hutchings and Saenger 1987). Additionally, the ponded waters provide a suitable environment for the growth of algae which compounds mangrove stress (see below).

Reduction in soil aeration as a result of increased moisture content, impeded drainage and/or reduced water movement can also lead to the exhaustion of major plant nutrients in interstitial water surrounding the plant roots. Furthermore, the development of anaerobic conditions in the immediate vicinity of the roots can lead to pH changes, which can alter the bio-availability of nutrients (Hutchings and Saenger 1987).

These processes lead to plant stress and if the effects are not directly lethal, the plant may become susceptible to infection by fungal pathogens such as *Phytophora*. *Phytphora* is thought to be a major contributing factor in mangrove dieback. Research into a degraded community in Gladstone indicated that a community which normally has a high level of resistance to a fungal pathogen was devastated in times of environmental stress (Pegg and Foresberg 1981).

4.1.2 Sand Ridges

The mobile sand ridges within the study area may be the product of changes to near shore bathymerty by dredging. As can be seen in 1978 and 1991 aerial photography (Figure 3.3 and (Figure 3.6; Plate 4.2 and Plate 4.3), the Boat Passage area has been subject to dredging for both navigation and to obtain fill for the development of the Port area.

Plate 4.2 1978 Aerial Photography showing Dredging Activity in Boat Passage.

Prior to dredging, the shallow near shore areas would have dissipated much of the wave energy prior to waves reaching the mangrove fringe. Dredging would have reduced the extent of shallow flats, which is likely to have increased wave energy at the mangrove fringe. As a result, deposits of coarse sands have accumulated at the crest of the beach profile, forming a series of bunds. The seagrass mats (see Section 2.2.6) may also aid in the formation of the ridges by increasing the bulk of the formation.

Plate 4.3 1991 Aerial Photography showing Dredging Activity in Boat Passage. Note reclamation area adjacent road and associated dead mangroves.

The large abundance of dead seagrass within the mangrove areas was surprising. Although there are extensive beds of *Zostera capricornii* adjacent to the study area, the experience of the authors in similar areas (eg. Goodwins Beach, northern Moreton Bay) is that the amount of seagrass drifting into the mangrove areas at Fisherman Island was particularly high. It is possible that the large amount of unattached seagrass relates to the high number of commercial (and illegal recreational) bait worm collectors operating in adjacent areas.

During bait worm collection, the seagrass is dug out in sods and retained. Operators are required to replace the seagrass at the conclusion of operations, however discussions with a commercial operator indicate that illegal operators are unlikely to do this (pers. com. Mr B Johnson, Commercial Bait Worm Collector). This may result in the death of seagrass, which is subsequently dispersed into mangrove areas by prevailing currents and winds.

The sand bunds have two main impacts. Firstly, the direct effect has been the loss of some areas of mangrove directly smothered by the sand ridge, especially adjacent the Brisbane River where approximately 0.75 ha of mangroves have been lost. The sand directly smothers either the mangroves or the pneumatophores, causing plant death. In some areas the sand ridges have been colonised and stabilised by a range of saltmarsh and terrestrial plant species.

The second, and possibly more critical, impact of the sand ridges has been the disruption to drainage patterns. In many areas the sand ridges have ponded large areas of water resulting in the deterioration of mangrove health (see above). Where the ridges are continuous for some distance, they have concentrated flows from uniform sheet flow to small creeks. The potential exists for relatively minor events (such as storms) to close these systems and pond significant areas, with the rapid deterioration in mangrove health. Ponding caused by the formation of ridges was noted in some areas (Plate 4.4), and is likely to be the primary cause of the deterioration in mangrove health at the eastern tip of the Fisherman Islands (Figure 3.14).

Plate 4.4 Water Ponded on Landward Edge of Sand Ridge, Northern Shore of Boat Passage, Fisherman Islands.

4.1.3 *Algal Growth*

Abundant macroalgae growth was recorded in association with mangroves in most areas. In general, brown macroalgae (*Bostrychia-Calogssa* assemblages) was associated with live mangrove stands, whilst green macroalgae (Chlorophyta) was abundant in dead mangrove areas, especially in ponded waters.

Plate 4.5 Abundant Brown Macroalgae Associated with Mangrove Fringe, Fisherman Islands.

Plate 4.6 Green Filamentous Macroalgae in association with Ponded Waters, Fisherman Islands

Whilst macroalgae is naturally found on most hard structures in the marine environment (Cribb 1978, King 1981), including the portion of mangroves below approximately mean high water spring (Phillips 1998), the amount of macroalgae within the mangroves of the study area was often excessive. In many areas, 100% coverage of mangrove trunks and pneumatophores occurred (Plate 4.5).

The results of the Brisbane River and Moreton Bay Waste Water Study have demonstrated that nutrient enriched waters from the Wynnum and Luggage Point sewerage treatment works enter the study area. Nutrient enrichment would promote the growth of algal species. It has been noted that there is often a shift in plant biomass to algal biomass in nutrient enriched systems (Morand and Briand 1996, Sturis and Murray 1997, Dennison 1999).

The direct effects of elevated macroalgal loads are not well known. It is possible that macroalgae attached to root structures (as opposed to green filamentous algae which is reported to directly affect mangrove seedlings, see below) may reduce transpiration efficiency of the plants and/or provide more suitable environment for secondary infestation by fungal pathogens (such as *Phytophora*). Some of the plants which had heavy algal growth on the pneumatophores exhibited signs of water stress, such as epicormic growth and/or aerial roots (Plate 4.7). It has been suggested that the development of such structures is an attempt by the plant to partially restore root aerial/gas exchange function. Extensive development of epicormic shoots may be a strategy to enhance transpirational water loss (Snedaker *et. al.* 1981) and possibly an indicator of stress.

In many places the green filamentous algae formed large thick (up to 5 cm) algal mats in the ponded areas where sufficient light was available. Some of this macroalgae (or particularly mats of macroalgae) is then transported from the bare areas by tidal currents and/or wind action and into the seaward edge of mangrove stands where it becomes “trapped” by the mangrove pneumatophores.

This algae may smother the pneumatophores, leading to pneumatophore decay (Snedaker *et. al.* 1981) and possibly mangrove death (Edyvane 1991). Widespread mortality of mangroves has been linked to the continual covering of pneumatophores, particularly where soil aeration is already poor (Breen and Hill 1969, Hergerl 1975).

Plate 4.7 Aerial Root Structures on Grey Mangrove, Fisherman Islands .

The transported macroalgal mats that enter mangrove areas may also effect the potential for seedlings to colonise areas. Edyvane (1991) noted that *Ulva* mats smothered young *Avicennia marina* by bending the stems and shading/covering leaves, thus reducing the plants photosynthetic ability, and consequently condition. *Ulva* was also noted to dislodge mangrove seedlings physically. This process may be occurring at Fisherman Islands with algae as well as seagrass mats, which were noted to be affecting seedlings (Section 2.2.6).

Macroalgae mats may become lodged, and perhaps block major drainage channels, leading to the ponding of waters and mangrove stress. As the pneumatophores (and ultimately the trees) die and decay, they, in conjunction with the macroalgae, tend to form a "bund" within the landward mangrove areas. These "bunds" retain waters that would normally drain off the mangrove area, further compounding the ponding. Many of the areas containing degraded mangroves at Fisherman Islands have ponded water up to 30cm deep, which is atypical for saltpan habitats.

The ponds formed by these blockages provide ideal conditions for macroalgae growth. As mangroves within the ponds die and decay, they would release nutrients, further exacerbating the situation. As more macroalgae grows, the blockages may significantly increase water levels, thereby providing additional areas for macroalgae growth and impacting on larger areas of mangroves. The system may become cyclic, with the area impacted increasing at an exponential rate. This process is suspected to have caused the loss of large areas of mangroves at Luggage Point (WBM 1999).

4.2 Summary of Impacts

In summary the following processes are likely to have resulted in the degradation of mangroves at Fisherman Islands:

- The unconfined material relocation within the natural Saltpan/Bare area on the western area of Fisherman Islands during the 1980's. Aerial photography indicates that the extent of mangroves adjacent to the saltpan significantly declined following this event. This effect, compounded by the development of macroalgae, is likely to be the major process in the deterioration of mangroves in this area. This is supported by the recovery of mangroves affected by material relocation in areas of good flushing (eg western end of northern shoreline, Boat Passage. See Plate 4.3).

- Dredging of the Boat Passage appears to have resulted in the development of sand ridges. Dredging within the Brisbane River adjacent to the sand ridges on the south western part of the Islands, although unconfirmed, is also likely to have been undertaken. The development of these ridges, coupled with excessive macroalgae growth, is likely to be the main cause of mangrove death on the eastern tip of the Islands.

- Modelling of the fate of nutrient rich waters discharged from the Wynnum and Luggage Point sewerage treatment plants indicates that the study area is likely to be impacted, thus providing a mechanism for the development of excessive macroalgae. General observations indicate that the macroalgae abundance increases with proximity to the Wynnum plant discharge, which may have caused the deterioration of a large area of mangroves within Whyte Island, south of the study area (pers. obs. author). Nutrient enrichment may lead to the direct loss/deterioration of mangroves in the study area, and/or inhibit the recovery of mangroves degraded by this and other processes.

4.3 Further Research

This study has identified a number of impacting processes that may have caused the degradation of mangroves at Fisherman Islands. However, the actual magnitude of impacts attributable to these and other processes cannot be determined at this stage. It would therefore be prudent to undertake further investigations to refine the causes of mangrove decline prior to undertaking management programs (Section 5).

As discussed above, not all areas which contain dead mangrove have ponded waters. To determine if water logging of the areas is contributing to mangrove death, it is recommended that a survey of the moisture content of a range of areas (degraded and apparently healthy) be undertaken to determine soil moisture/mangrove health relationships.

Additionally it would be useful to determine whether mangroves are being affected by the fungal pathogen, *Phytophora* and determining the abundance of the fungus within both healthy and degraded areas. Selected sediment samples collected in the above investigation could be submitted to determine the occurrence of the fungus, with data correlated to present, and future, mangrove health.

Advice received at the conclusion of field works indicates that the occurrence of advanced *Phytophora* infestation is evident as a purple discoloration under the bark at the base of the affected plant (Pers. com. Dr Jim Davie, Senior Lecturer in Tropical Forestry, The University of Queensland). Selected trees could be examined in degraded areas to determine if this is a cause or symptom of degradation and in healthy areas to determine the spread of the impact.

This data would be useful to determine if secondary infections brought about by stresses to mangroves are the primary reason for mangrove loss, or if the fungal infection is the primary reason for mangrove decline. For example, results indicating that *Phytophora* abundance in sediments are similar in dead and healthy mangrove areas (similar to that reported by Pegg and Foresberg 1981) would suggest that a primary stress is required, such as the processes described above, for *Phytophora* to have significant effects on mangrove health.

If the converse was indicated (ie *Phytophora* abundances much higher in degraded mangrove area relative to health areas), any management option suggested would have to take the fungal pathogen as a primary agent in mangrove decline into consideration.

5 MANAGEMENT OPTIONS

The following is offered as a preliminary assessment of options available for the future management of the mangroves at Fisherman Islands.

5.1 Option 1 : No Action

This option involves no active management by either the PBC or statutory authorities. The direct impact from the unconfined material deposition associated with reclamation works is likely to have stabilised given the intervening time since deposition (some 13 years). However the ongoing algal production in the ponded waters will increase the depth of waters in the saltpan/bare areas. This will impact additional areas, leading to the provision of additional nutrients and an increase in available area for the macroalgae to colonise.

Whilst the areas directly flushed by oceanic waters (ie those in close proximity to the edges and/or creeks) may experience little direct effects (as little opportunity to pond waters in these areas exists), the degradation of the mangroves within the "central" areas is likely to continue. Given the deteriorated health of mangroves, the ongoing nature of the impacting processes and the lack of current recovery in affected areas, it is likely that most mangroves within the "poor" and "fair" category, will die. This may pose a range of environmental issues, such as sediment remobilisation, loss of habitat, nutrient inputs and loss of primary production for both the adjacent areas and wider Moreton Bay.

The ponded waters within the Fisherman Islands currently provide suitable habitat for breeding mosquitos. These are currently controlled by the Brisbane City Council with aerial spraying of the control agent BTI. The expansion of these areas may increase the need for mosquito control in these areas.

Advantages : No cost and/or management requirements.

Disadvantages : Continual degradation and likely loss of large areas of mangrove resources within Fisherman Islands, with possible associated secondary effects to adjacent areas. Continual, and possible increase, in need for mosquito management.

Cost : nil

5.2 Option 2 : Monitoring of Sand Bunds

This option involves the monitoring, and if required, active management of the sand bunds which have developed in several areas in Fisherman Islands. The sand bunds may pond large areas of water by closing existing drainage patterns. This has the potential to impact on large areas of mangroves in a relatively short space of time.

The management of these bunds would initially involve the inspection and mapping of existing sand bunds (during low tide). Some survey work may be required to determine the extent of waters ponded by existing bunds. Where areas ponded by bunds are identified, breaks would be made in appropriate areas to reinstate drainage. Dye could be placed in waters to track the flow paths in areas where slopes are small and flow direction is not evident.

Monitoring of the sand bunds would then involve regular inspections of the sand bunds to ensure mapped drainage paths did not become blocked. Blocked drains would then be cleared by hand and/or equipment as required. Access to most areas would be possible on foot although a small boat would be required to access areas east of the creek on the tip of Fisherman Islands.

Advantages: Cease degradation due to ponding from bunds, and restore mangrove health in areas directly effected by this process. Monitoring would involve relatively low cost and time requirements (eg 1 person day/month monitoring, 1 person day/month drain clearance). Monitoring would also provide an opportunity to inspect mangrove areas on a regular basis and record relevant changes.

Disadvantages: This process will not assist mangroves directly smothered by the sand bunds (which are likely to be lost in time) and/or manage the process responsible for the formation of bunds and associated erosion issues. Additionally, where multiple effects are causing mangrove deterioration (such as macroalgae build-up) or other processes are solely responsible (eg. material relocation), the success achieved by monitoring and management of the sand bunds may be reduced. This process will not assist mosquito control in areas not ponded by bund formation.

Permits from a variety of Government Authorities would be required for any works undertaken, and experience has shown that this may seriously delay the process and significantly increase the management time and capital requirements.

Costs: The costs associated with direct monitoring and management are likely to be relatively small (<$10,000/annum), however initial costs associated with achieving necessary permits (eg Section 51 Marine Plants Disturbance approval, Section 86 Works on Tidal Lands approval, Marine Parks approval, Development of Integrated Environmental Management System documentation) may be significant (> $25,000).

5.3 Option 3: Drainage and Tidal Flushing Reinstatement.

This option involves the construction of a network of shallow channels to reinstate natural drainage to areas which are currently ponded. It is likely that the natural drainage lines have been disturbed to such an extent that they are no longer visible, and a new network would have to be developed.

This would require detailed survey work to identify the appropriate areas and slopes for the constructed channels. The constructed channels would be shallow and follow the Queensland Department of Primary Industries (Fisheries) Guidelines for the development of runnels (eg. 1:3 depth width ratio, maximum depth 0.3m).

It would be advisable to target a small, relatively accessible area for initial works and monitor the success, or otherwise, of these works before progressing to larger areas. WBM Oceanics

Australia is currently involved in a similar project at Luggage Point for the Brisbane City Council where preliminary stages of the rehabilitation works are well advanced. It may be prudent to monitor the success and/or issues encountered at Luggage Point prior to any works at Fisherman Islands.

Advantages: Reinstatement of tidal flushing to degraded areas is likley to bring about a rapid increase in mangrove health. The area contains an abundant supply of parent stock material and adequate recruitment is likely. By draining the ponded areas, the areas of suitable mosquito breeding habitat would also be reduced.

Disadvantages : The construction of the channels is likely to disturb other areas of mangroves during the construction process. Some care will need to be taken to ensure that existing drainage lines are not disrupted by channel construction. Additionally, the issue of exposure of potential acid sulphate soils by either draining areas or reducing local water tables will need to be addressed. Some maintenance of the channels may be required to ensure they do not become blocked.

Due to the relatively small scale level changes in topography across the Fisherman Islands area, and the wide scale disturbance resulting from material relocation, considerable planning and survey work may be required to design and implement a successful drainage network.

Costs: The costs for the development of a full scale network are likely to be considerable (>$100,000). Additionally, a number of permits will be required from a variety of Government Agencies.

5.4 Option 4: Bird Roost Development

This option involves the development of a bird roost site on the existing saltpan/bare area of the western Fisherman Islands. This area has been subject to significant disturbance and currently contains a variety of severely degraded habitats. As discussed above, there is limited potential for the rehabilitation of this area due to the distances and complexity involved in reinstating drainage. The development of the roost would provide a beneficial ecological use of this area.

Driscoll (1996) indicated that that the Fisherman Islands area constitutes one of the major areas of importance for migratory waders known to winter in east Australia and New Zealand. The saltpan/bare area was recognised as an important high tide roost and feeding area for a variety of wader species including Eastern Curlew, Whimbrel, Grey-tailed Tattler, Bar-tailed Godwit, Sharp-tailed Sandpiper, Greenshanks, Black winged Stilt and Curlew Sandpiper, with 18 species regularly sighted in the area.

Several of these species are listed on the Japan Australia Migratory Bird Agreement and the China Australia Migratory Bird Agreement, international agreements providing protection for habitats critical for migratory waders (Kikkawa 1996).

The development of a bird roost in this area would include a mosaic of different of roost types, such as elevated shingle covered hills, sloping unvegetated margins and treed roost sites. The area is currently tidally inundated on large spring tides, and contains significant areas of ponded waters. The designed roost would seek to minimise the area of ponded waters to control mosquito breeding.

Advantages: The redevelopment of the area as a roost site would remove some of the ponded waters currently providing mosquito breeding habitat. Additionally this would increase the utilisation of the area for migratory waders, and increase the visual amenity of the area.

Disadvantages: Development of the bird roost would not address mangrove degradation in other areas. The development of the roost would require permits from a number of Government agencies and additional studies to provide details of the potential construction and operation impacts. The Port currently has planned for the development of a bird roost within the current Port expansion proposal which will include an intertidal area. This feature would make that roost preferable to a greater range of species, and therefore of higher priority. The site would need to be fenced to prevent feral animals, especially foxes, entering the site.

Costs : The cost of the construction of the Bird Roost is likely to be considerable (>$100,000). The site would also need on-going maintenance for the fence and to control weed species (approx $10,000/annum).

6 CONCLUSION

A significant proportion of the mangroves in the Fisherman Islands area are degraded. The processes causing this deterioration are not clear, but are likely to include past material relocation, excessive algal growth related to elevated nutrients from adjacent sewerage treatment plants and the development of sand bunds by waves in foreshore areas. These processes would interact to provide the current distribution of degraded mangroves.

The processes (implicated in the deterioration are on-going, with the exception of material deposition associated with land reclamation, and there appears to be little or no natural recovery in most degraded areas. In the absence of management intervention, the future viability of a large proportion of the mangroves within the study area is considered to be limited. The Fisherman Islands area contains a significant proportion of the mangrove resources within western Moreton Bay, and their continual decline is a matter of concern for the wider area. It should be noted however that the Fisherman Islands mangroves are not isolated in decline, but part of a wider area from Wynnum/Whyte Island to Hayes Inlet and Redcliffe which exhibits severe stress and significant mangrove loss.

Due to the complexity of the impacting processes, there is no single management option to address the issue. Additionally, some of the impacting processes are located outside Port boundaries, such as the elevated nutrients of adjacent waters due to sewerage inputs. Without addressing these issues in a broad scale multi-disciplinary approach, any on-site management is likely to be hampered.

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APPENDIX A: SURVEY DATA

Table A.1 Survey Data, Species, Cover, Canopy Height and Mangrove Health

						Species Composition							
Waypoint	Easting	Northing	Redox	pH	A.marina (Av)	A.corniculatum (Ae)	R.stylosa (Rh)	B.gymnorrhiza	C.australis (Ce)	Cover	Canopy Height	Mangrove Health	Comment
t10a	517020.923	6970050.215	187.00	6.25	0	0	0	0	0	0	0	4	Saltmarsh Sp
t10b	517065.433	6969999.406	229.00	6.53	0	0	0	0	0	0	0	4	Saltmarsh Sp
t10c	517086.238	6969966.781	-17.00	6.31	0	0	0	0	0	0	0	4	Saltmarsh Sp
t10d	517134.815	6969882.08	110.00	6.30	100	0	0	0	0	2	2	3	Regrowth Abundant Saltmarsh Sp
T10E	517218.13	6969762.372	-37.00	8.20	0	0	0	0	0	1	0	0	Ponded Water with Algae (Pic)
t10f	517334.29	6969747.787	103.00	7.50	100	0	0	0	0	1	5	3	Transition dead mang to live mang. Epicormic growth abundant.
t10g	517509.168	6969673.195	115.00	6.81	90	10	0	0	0	3	5	2	Gen healthy. VA seedlings Some Epi
t10h	517509.168	6969673.195	220.00	6.83	50	25	25	0	0	2	4	1	Mixed community assoc with creek. Erosion evident
T10I	517607.28	6969574.67	190.00	6.92	100	0	0	0	0	3	6	2	Very Abundant (VA) Seedlings
T10J	517624.98	6969551.12	91.00	6.81	90	0	10	0	0	3	7	1	Abundant Seedlings and Rh near Creek
t11a	517477.924	6969479.723	-6.00	6.19	100	0	0	0	0	3	8	1	Very Abundant Seedlings
t11b	517446.565	6969546.267	-67.00	6.22	25	75	0	0	0	3	4	1	Abundant Av and Ae seedlings
t11c	517420.205	6969588.081	-41.00	5.76	25	75	0	0	0	2	4	1	No seedlings
t11d	517401.763	6969626.385	169.00	5.62	50	50	0	0	0	3	6	1	Abundant Av Seedlings
t11e	517349.2	6969677.09	170.00	5.71	100	0	0	0	0	2	5	3	Much fallen timber. Abundant seedlings
t11f	517307.97	6969713.969	-194.00	6.64	100	0	0	0	0	0	0	4	100% algal cover t11f wpt edge of live mang
t11g	517240.586	6969741.919	-132.00	6.62	100	0	0	0	0	1	2	1	small sparse Av
t11h	517160.845	6969784.105	109.00	6.71	0	0	0	0	0	0	0	0	Bare area, some Saltmarsh sp
t11i	517071.464	6969806.753	-10.00	6.13	100	0	0	0	0	4	2	1	
t11j	517032.312	6969840.524	185.00	6.26	90	10	0	0	0	3	3	1	Large Av with small Ae understorey
t11k	516997.931	6969912.909	215.00	6.18	100	0	0	0	0	3	3	2	Large Av
T11L	516983.978	6969948.349	181.00	6.62	0	0	0	0	0	0	0	4	Dead mang with Saltmarsh sp
t12a	516844.801	6969762.758	-69.00	7.10	100	0	0	0	0	2	4	1	
t12b	516810.855	6969784.073	57.00	7.03	0	0	0	0	100	2	1.5	1	Low open Ae
t12c	516761.913	6969819.616	145.00	6.68	10	0	0	0	90	2	4	1	Av with Ae understorey. Av fringe
t12d	516692.443	6969850.937	220.00	6.03	0	0	0	0	100	2	1	1	

Waypoint	Easting	Northing	Redox	pH	A.marina (Av)	Species Composition A.corniculatum (Ae)	R.stylosa (Rh)	B.gymnorrhiza	C.australis (Ce)	Cover	Canopy Height	Mangrove Health	Comment
t12e	516633.384	6969872.625	192.00	5.95	0	0	0	0	100	2	1	1	Av with Ae understorey. Av fringe
t13A	516548.064	6969879.511	-57.00	6.85	0	100	0	0	0	5	4	1	Crab humps
T13b	516577.261	6969818.108	-29.00	6.93	50	0	0	0	50	3	6	1	Mod Av with Ae understorey
t13c	516625.43	6969786.88	-189.00	6.85	95	0	5	0	0	2	6	2	Seagrass mats abundant
t13d	516743.59	6969729.69	-156.00	6.15	100	0	0	0	0	2	10	1	Abundant seagrass mats. Lrg open Av 40m from seaward fringe
T14A	516384.382	6969866.561	220.00	6.28	100	0	0	0	0	3	6	2	Seagrasss mats present.
T14B	516400.958	6969834.903	215.00	6.59	100	0	0	0	0	2	3	1	
T14C	516396.507	6969804.78	189.00	6.89	100	0	0	0	0	2	10	1	Tall open Av. No seedlings
T14D	516398.21	6969742.1	174.00	6.51	100	0	0	0	0	2	10	1	Tall open Av. No seedlings
T14E	516388.329	6969662.265	189.00	6.53	100	0	0	0	0	2	8	1	Tall open Av. No seedlings
T14F	516351.17	6969581.4	195.00	6.89	100	0	0	0	0	3	12	1	Tall open Av. No seedlings
T14G	516334.62	6969453.992	187.00	6.59	100	0	0	0	0	3	7	1	Tall open Av. Few seedlings. Thin frontal sand beach ridge
T15A	516256.127	6969427.955	220.00	6.12	100	0	0	0	0	4	6	1	exp to SE. Sand ridge. Abundant seagrass
T15B	516260.086	6969477.586	189.00	6.75	90	10	0	0	0	3	6	1	
T15C	516256.92	6969529.65	-48.00	6.89	100	0	0	0	0	4	12	1	
T15D	516259.24	6969602.28	146.00	6.65	100	0	0	0	0	2	15	1	Tall mat Av with abundant seed
T15E	516259.24	6969661.77	217.00	6.89	100	0	0	0	0	3	12	1	
t16a	515932.48	6969619.32	210.00	6.32	100	0	0	0	0	4	8	1	Abundant Av seedlings/juv
t16b	515876.86	6969645.59	103.00	6.10	100	0	0	0	0	4	10	1	Tall Av forest
t16c	515825.563	6969654.118	154.00	6.02	100	0	0	0	0	4	10	1	Site 3 photo
T1A	518044.03	6971646.542	220.00	7.27	100	0	0	0	0	0	0	4	Dead Av with regrowth apparent
T1B	518076.89	6971624.72	159.00	6.70	100	0	0	0	0	3	9	1	Sparse Av no seedlings
T1C	518120.14	6971596.9	148.00	6.29	100	0	0	0	0	3	8	1	Sparse Av no seedlings
T1D	518170.35	6971574.49	209.00	5.95	95	0	5	0	0	3	8	1	Sparse Av no seedlings
T1E	518193.6	6971548.899	148.00	6.72	95	0	5	0	0	3	9	1	Sparse Av no seedlings
T1F	518193.52	6971469.41	225.00	6.73	95	0	5	0	0	4	12	1	Sparse Av no seedlings
T1G	518179.066	6971390.37	126.00	6.79	100	0	0	0	0	2	10	1	Large sparse Av with iso R.stylosa
t20a	515515.002	6969181.189	189.00	6.04	75	0	0	0	25	3	8	1	Nth edge of Ceropis fringe
t20b	515529.79	6969160.04	292.00	6.32	5	0	0	0	95	3	6	1	Site 1 Photo Beach Ridge Boat Passage side
t20c	515551.064	6969189.483	215.00	6.40	75	0	0	0	25	4	6	1	Crab humps

						Species Composition							
Waypoint	Easting	Northing	Redox	pH	A.marina (Av)	A.corniculatum (Ae)	R.stylosa (Rh)	B.gymnorrhiza	C.australis (Ce)	Cover	Canopy Height	Mangrove Health	Comment
t20d	515511.674	6969217.185	244.00	6.64	50	25	0	0	25	3	5	1	Very abundant macroalgae near sml Ck. Well def patch
t20e	515588.432	6969365.558	210.00	6.48	10	90	0	0	0	3	15	2	Beach ridge west with dead mang. Erosion on foreshore
t20f	515635.505	6969482.745	130.00	5.40	100	0	0	0	0	3	15	1	Lrg mat Av with abt seedlings
t20g	515604.744	6969660.712	107.00	8.20	0	0	0	0	0	0	0	0	Terr veg lantana and Rhodes Grass
t20h	515660.097	6969627.126	241.00	6.30	100	0	0	0	0	3	3	1	Av regrowth edge
t20i	515684.228	6969590.914	213.00	6.67	100	0	0	0	0	4	4	1	Av regrowth edge
t20j	515709.403	6969568.886	220.00	6.20	100	0	0	0	0	4	15	1	Edge Regrowth in mat stand
t20k	515977.28	6969280.13	195.00	6.70	100	0	0	0	0	4	12	1	Mat Av seedlings understorey. Breach ridge on boat passage Site 4 photo
t23a	517795.591	6970382.691	-90.00	5.40	100	0	0	0	0	3	10	1	
t23b	517726.712	6970341.584	-160.00	5.79	95	0	5	0	0	3	6	2	0.2-0.3 sparse Av with iso 1.0m dia
t23c	517676.229	6970303.642	-183.00	6.23	100	0	0	0	0	2	8	6	Plants stressed. Abt seedlings
t23d	517616.867	6970268.314	109.00	5.93	0	0	0	0	0	0	0	4	Dead. Av?
t23e	517529.522	6970241.212	106.00	6.00	100	0	0	0	0	2	3	3	Sml patch live on edge of dead area
t23f	517430.44	6970151.997	-177.00	6.63	0	0	0	0	0	0	0	4	saltmarsh sp
t23g	517423.708	6970129.296	-171.00	7.02	0	0	0	0	0	0	0	4	Filamentous algae
t23h	517348.185	6969917.78	115.00	7.47	0	0	0	0	0	0	0	4	Dead. Av?
t23i	517277.858	6969782.941	-43.00	6.82	100	0	0	0	0	3	3	1	100% Av regrowth
t23j	517234.555	6969730.424	180.00	5.88	100	0	0	0	0	2	3	2	Saltmarsh in Mang
t23k	517189.726	6969650.079	223.00	6.44	90	10	0	0	0	3	4	1	
t23l	517149.491	6969602.634	-24.00	5.89	90	5	5	0	0	2	12	1	
t24a	517,608.72	6,969,409.50	-118.00	6.59	100	0	0	0	0	3	6	2	
t24b	517,707.59	6,969,526.92	145.00	7.03	95	0	5	0	0	3	8	1	Av
t24c	517,837.36	6,969,782.36	130.00	6.89	50	10	40	0	0	3	7	1	
t24d	517,890.91	6,969,858.58	18.00	6.71	100	0	0	0	0	3	4	2	Small Av with some watershoots evident
t24e	517,940.35	6,969,930.67	117.00	7.23	90	0	10	0	0	2	10	1	Large Av with iso Rh
t25a	518142.38	6969030.92	23.00	5.46	100	0	0	0	0	2	6	3	sml area stressed Av
t25b	518161.09	6969100.37	-150.00	4.32	100	0	0	0	0	3	4	3	Abt watershoots
t25c	518169.37	6969134.35	212.00	5.61	100	0	0	0	0	3	4	3	Ponded water
t25d	518183.57	6969165.99	105.00	5.43	0	0	0	0	0	0	0	4	Saltmarsh sp with ponded water
t25e	518202.19	6969236.17	16.00	5.87	100	0	0	0	0	3	1.5	2	Saltmarsh sp in mang

Waypoint	Easting	Northing	Redox	pH	A.marina (Av)	Species Composition A.corniculatum (Ae)	R.stylosa (Rh)	B.gymnorrhiza	C.australis (Ce)	Cover	Canopy Height	Mangrove Health	Comment
t25f	518228.95	6969308.97	-115.00	5.43	100	0	0	0	0	2	3	3	some large Av dead. Abt watershoots
t25g	518273.69	6969345.8	-33.00	6.29	100	0	0	0	0	3	5	1	Abundant seedlings and ponded water
t25h	518325.79	6969361.03	-104.00	5.92	100	0	0	0	0	3	10	1	
t27a	518459.29	6969139.99	-31.00	5.90	95	0	5	0	0	3	10	1	Av with iso Rh Understorey
t27b	518,357.39	6,969,062.17	18.00	6.20	100	0	0	0	0	2	2	3	Av stressed
t27c	518,316.82	6,969,087.88	-152.00	5.91	100	0	0	0	0	3	3	3	Av stressed
t27d	518,350.27	6,969,145.99	-67.00	6.03	100	0	0	0	0	3	3	3	Av stressed
T2A	518115.962	6971305.75	158.00	6.54	100	0	0	0	0	2	9	1	Large sparse Av No seedlings
T2B	518089.971	6971349.024	169.00	7.15	100	0	0	0	0	2	9	1	Brahmaney Kite Nest
T2C	518048.585	6971371.598	218.00	6.22	95	0	5	0	0	3	10	1	Large Av with Dense seedlings, many covered with floating seagrass mats
T2D	517997.235	6971378.82	209.00	5.92	95	0	5	0	0	3	10	2	Large Av with Dense seedlings, many covered with floating seagrass mats
T2E	517977.244	6971397.618	210.00	6.20	100	0	0	0	0	2	12	3	Water shoots abundant. Poor condition
T2F	517965.076	6971426.489	220.00	6.57	90	10	0	0	0	2	8	3	Some low Ag. Lrg Av dying
T2G	517954.396	6971461.77	159.00	6.60	95	5	0	0	0	1	2	4	Regrowth Av to 2m, Ag less than 2m
T2H	517931.478	6971492.467	174.00	6.70	100	0	0	0	0	2	6	4	Regrowth Av to 3m
T3A	517863.245	6971363.917	59.00	6.57	100	0	0	0	0	1	1	4	Regrowth
T3B	517883.76	6971333.47	89.00	6.65	100	0	0	0	0	3	6	1	Thin Av Mod to Dense
T3C	517888.4	6971293.29	70.00	6.72	100	0	0	0	0	3	6	1	Some Large Av dead evident
T3D	517882.99	6971262.39	115.00	6.72	100	0	0	0	0	3	5	1	No seedlings no understorey
T3E	517861.5	6971234.5	165.00	6.75	100	0	0	0	0	2	5	1	Large sparse Av Seaward fringe
t4a	517782.342	6971236.298	225.00	6.52	100	0	0	0	0	3	5	1	Seaward fringe. Lge av. Thick macroalgae
t4b	517776.39	6971253.91	212.00	6.59	100	0	0	0	0	3	5	1	Mod Dense closed Av. No Seedlings
t4c	517,772.35	6,971,269.09	186.00	7.03	100	0	0	0	0	3	4	5	Regrowth Av after construction related disturbance?
t5a	517533.39	6970984.75	14.00	7.00	100	0	0	0	0	3	5	1	Tall thin Av. Very soft seds
t5b	517,556.98	6,970,967.27	58.00	6.83	100	0	0	0	0	3	5	1	Tall thin Av. Very soft seds
t6a	517,433.97	6,970,809.77	115.00	6.82	100	0	0	0	0	2	4	2	Tall thin Av. Very soft seds
t6b	517,453.96	6,970,774.10	202.00	6.59	100	0	0	0	0	2	4	2	Tall thin Av. Very soft seds
t6c	517,498.97	6,970,745.78	187.00	6.71	100	0	0	0	0	2	5	1	Some mat Av
t6d	517,546.35	6,970,701.48	113.00	6.83	100	0	0	0	0	2	7	1	Mat Av near seaward edge
t7a	517,350.10	6,970,596.84	189.00	6.79	100	0	0	0	0	4	4	2	Tall thin Av

Waypoint	Easting	Northing	Redox	pH	A.marina (Av)	Species Composition A.corniculatum (Ae)	R.stylosa (Rh)	B.gymnorrhiza	C.australis (Ce)	Cover	Canopy Height	Mangrove Health	Comment
t7b	517,397.60	6,970,536.17	112.00	6.83	100	0	0	0	0	3	5	3	Tall Thin Av
t7c	517,392.41	6,970,512.76	156.00	6.53	100	0	0	0	0	4	6	1	
t7d	517,457.77	6,970,421.59	-103.00	6.21	100	0	0	0	0	1	0	4	Dead area. Bare
t7e	517,526.69	6,970,353.68	-98.00	6.03	100	0	0	0	0	1	0	4	Dead area. Bare
t7f	517587.98	6970348.09	111.00	6.45	100	0	0	0	0	2	3	6	Av very stressed
t7g	517711.449	6970287.659	-46.00	6.45	100	0	0	0	0	2	8	6	V Lge Av. Many stunted seedlings
t7h	517810.38	6970220.71	-65.00	5.51	100	0	0	0	0	4	10	2	A abt seagrass mats
t7i	517823.708	6970314.942	-217.00	4.37	100	0	0	0	0	3	9	1	Lrg Av. Seaward Fringe
t8a	518282.15	6969385.65	36.00	5.77	90	0	10	0	0	2	10	1	
t8b	518230.72	6969418.96	30.00	6.03	100	0	0	0	0	3	8	1	
t8c	518156.57	6969449.88	-151.00	6.45	100	0	0	0	0	2	5	3	
t8d	518075.2	6969494.17	-170.00	6.35	100	0	0	0	0	2	3	2	
t8e	517965.31	6969511.08	33.00	6.00	100	0	0	0	0	2	3	2	
t8f	517934.43	6969504.62	-340.00	6.70	100	0	0	0	0	2	3	3	Dead Mang with regrowth apt
t8g	517886.45	6969548.49	-113.00	5.87	100	0	0	0	0	3	3	2	few epi. Abt seedlings
t8h	517846.66	6969605.47	30.00	6.35	100	0	0	0	0	3	5	1	
t8i	517863.33	6969673.01	45.00	7.00	100	0	0	0	0	3	8	1	Near Ck with some lge Av 1.5m dia
t9a	517794.04	6969664.17	16.00	7.50	95	0	5	0	0	3	7	1	Adt Seedlings and Rh near Creek
t9aw	517737.47	6969724.07	-13.00	6.45	95	0	5	0	0	3	10	1	
t9b	517832.82	6969541.52	78.00	7.00	100	0	0	0	0	3	6	1	Sparse Thin Av. Abt Seedlings
t9bw	517663.45	6969728.96	-15.00	6.70	100	0	0	0	0	3	6	2	
t9c	517848.33	6969484.11	94.00	7.20	100	0	0	0	0	3	4	2	Sparse Tthin Av. Some epi
t9cw	517606.59	6969761.02	130.00	6.00	100	0	0	0	0	3	5	3	Abt epi
T9D	517856.94	6969413.94	160.00	7.25	0	0	0	0	0	1	0	4	Thin strip dead mang
t9de	517545.25	6969785.26	-153.00	5.50	100	0	0	0	0	0	0	4	Dead mang near old rear lead mark
t9e	517459.02	6969785.45	182.00	7.90	100	0	0	0	0	2	4	3	Highly Stressed
t9ee	517880.59	6969350.51	114.00	5.70	100	0	0	0	0	3	5	2	Some epi
t9fe	517914.29	6969284.88	120.00	6.20	100	0	0	0	0	3	5	1	
t9fw	517393.18	6969781.88	59.00	6.20	100	0	0	0	0	1	4	4	Av near dead
t9ge	517971.18	6969245.94	-13.00	5.70	100	0	0	0	0	2	6	3	Abt epi
t9gw	517344.68	6969806.86	123.00	6.60	100	0	0	0	0	0	0	4	Edge dead mang

Waypoint	Easting	Northing	Redox	pH	A.marina (Av)	Species Composition A.corniculatum (Ae)	R.stylosa (Rh)	B.gymnorrhiza	C.australis (Ce)	Cover	Canopy Height	Mangrove Health	Comment
t9he	518037.07	6969176.82	32.00	6.80	100	0	0	0	0	2	5	3	Abt epi
t9hw	517281.5	6969837.94	159.00	6.54	100	0	0	0	0	4	1.5	3	sml patch live mang
t9ie	518121.41	6969156.21	-45.00	7.20	100	0	0	0	0	3	3	1	Just inside small mang area
t9Iw	517223.69	6969845.29	159.00	6.95	100	0	0	0	0	3	1.5	5	sml patch live mang
t9je	518208.69	6969042.85	-37.00	5.70	100	0	0	0	0	3	5	2	epi
t9jw	517105.13	6969866.78	-74.00	6.32	0	0	0	0	0	0	0	4	Dead Mang (Av?)
t9ke	518282.06	6968975.57	-75.00	5.40	100	0	0	0	0	3	5	2	Canopy loss
t9kw	517039.88	6969897.37	89.00	6.89	100	0	0	0	0	1	2	3	Abt epi SM sp and ponded water
t9le	518378.13	6968905.11	-15.00	6.20	100	0	0	0	0	2	5	3	Abt epi and seedlinds
t9lw	517009.08	6969880.04	-53.00	6.12	25	75	0	0	0	2	4	2	Ag understorey with mat Av
t9me	518430.34	6968781.44	-203.00	5.70	0	0	0	0	0	3	5	2	Many Rh dead, Wpt nth cnr of patch
t9mw	516956.98	6969871.45	-110.00	7.03	5	95	0	0	0	3	3	1	Ag understorey with mat Av
t9ne	518440.84	6968720.86	54.00	6.80	100	0	0	0	0	2	5	1	End FI east
t9nw	516920.79	6969857.86	87.00	6.52	0	100	0	0	0	2	1	3	30-50% Ae dead
t9o	516843.95	6969852.65	114.00	6.73	75	25				3	3	2	Ae with Av upper
t9ow	517147.45	6970197.95	274.00	6.62	10	90	0	0	0	2	1.5	1	isolated av only
t9pw	517233.26	6970159.48	-17.00	6.86	100	0	0	0	0	0	0	4	tip of some regrowth
t9qw	517310.85	6970112.7	-104.00	5.82	0	0	0	0	0	0	0	6	Sm sp bare
t9rw	517336.76	6970046.38	14.00	6.15	0	0	0	0	0	0	0	6	Sm sp bare
t8j	517,272.50	6,970,337.11	186.00	6.83	0	0	0	0	0	0	0	4	
t8k	517,374.73	6,970,265.36	47.00	6.49	0	0	0	0	0	0	0	4	Bare Sm Ponded Water
t8l	517,573.79	6,970,089.55	133.00	6.31	100	0	0	0	0	2	2	2	Sml Av regrowth
t8m	517,683.18	6,969,999.86	-196.00	5.82	0	0	0	0	0	0	0	4	Dead Av
t8n	517,787.20	6,969,897.61	217.00	6.73	100	0	0	0	0	3	3	1	Sml Av
t8o	517,989.84	6,969,766.65	220.00	7.21	90	0	10	0	0	4	8	1	Av and Rh
t8p	518,049.02	6,969,707.45	230.00	7.15	90	0	10	0	0	4	10	1	
t8q	518,190.70	6,969,594.44	191.00	6.87	95	0	5	0	0	4	12	1	
t16d	515,781.81	6,969,714.64	103.00	6.87	95	0	5	0	0	4	10	1	Tall Mat Av with iso Rh
t16e	515,727.32	6,969,748.28	141.00	7.03	100	0	0	0	0	4	3	1	Av regrowth edge
t16f	515,680.93	6,969,774.97	179.00	7.21	100	0	0	0	0	4	3	1	Av regrowth
t17a	515,805.01	6,969,592.86	100.00	6.85	100	0	0	0	0	3	12	1	Tall mat Av

						Species Composition							
Waypoint	Easting	Northing	Redox	pH	A.marina (Av)	A.corniculatum (Ae)	R.stylosa (Rh)	B.gymnorrhiza	C.australis (Ce)	Cover	Canopy Height	Mangrove Health	Comment
t17b	515,865.30	6,969,551.11	218.00	6.79	100	0	0	0	0	4	10	1	
t17c	515,930.24	6,969,515.15	209.00	6.93	100	0	0	0	0	3	12	1	
t18a	515,875.74	6,969,410.78	-116.00	5.93	100	0	0	0	0	4	10	1	
t18b	515,799.21	6,969,442.09	243.00	8.01	90	0	10	0	0	4	9	1	
t18c	515,712.24	6,969,479.21	216.00	6.81	90	0	10	0	0	3	10	1	
t18d	515,634.55	6,969,515.18	189.00	7.02	100	0	0	0	0	4	10	1	
t18e	515,562.65	6,969,546.50	201.00	6.87	90	0	10	0	0	3	12	1	erosion scarp on river side
t19a	515,926.76	6,969,271.60	173.00	6.81	100	0	0	0	0	4	10	1	
t19b	515,821.24	6,969,271.61	190.00	7.30	100	0	0	0	0	3	12	1	
t19c	515,745.87	6,969,311.05	203.00	6.15	90	0	10	0	0	3	8	1	Rh assoc with creek
t19d	515,660.06	6,969,352.81	118.00	6.93	100	0	0	0	0	4	10	1	Av with Cp west
t19e	515,563.82	6,969,264.69	107.00	6.99	25	0	0	0	95	3	10	1	Cp U/S with Av
t19f	515,663.53	6,969,209.00	216.00	7.03	50	0	0	0	50	3	12	1	

Table A.2 Survey Data, Macroalgae, Macrofauna, Girth at Breast Height and Distance

				1st Tree			2nd Tree			1st Tree			2nd Tree			1st Tree			2nd Tree	
Waypoint	Macro Algae	Fauna	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith
t10a	Abundant	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t10b	Abundant	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t10c	Abundant	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t10d			1.00	Av	0.05	1.20	Av	0.15	0.40	Av	0.15	1.70	Av	0.10	1.20	Av	0.20	0.40	Av	0.10
T10E	Very Abundant	Rare	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00
t10f	Rare	Rare	1.30	Av	0.35	1.10	Av	0.40	1.20	Av	0.25	2.10	Av	0.50	1.10	Av	0.40	0.60	Av	0.20
t10g	Rare	Rare	2.30	Av	0.40	2.60	Av	0.20	1.90	Av	0.25	1.40	Av	0.20	3.60	Av	0.15	1.30	Av	0.40
t10h	Common	Very Abundant	1.20	Av	0.25	1.60	Av	0.20	1.40	Av	0.30	0.90	Av	0.30	2.40	Rh	0.40	1.90	Ag	0.30
T10I	Very Abundant	Common	0.70	Av	0.25	2.10	Av	0.25	0.90	Av	0.60	1.40	Av	0.35	1.30	Av	0.45	1.70	Av	0.45
T10J	Very Abundant	Common	0.70	Av	0.25	2.10	Av	0.25	0.90	Av	0.60	1.40	Av	0.35	1.30	Av	0.45	1.70	Av	0.20
t11a	Very Abundant	Abundant	3.10	Av	0.60	2.30	Av	0.50	2.70	Av	0.80	1.90	Av	1.00	3.80	Av	1.20	2.70	Av	1.90
t11b	Abundant	Abundant	0.80	Ae	0.05	0.75	Av	0.60	0.40	Ae	0.10	0.50	Ae	0.15	0.70	Ae	0.15	0.30	Ae	0.15
t11c	Abundant	Abundant	0.50	Ae	0.15	0.40	Ae	0.15	0.30	Ae	0.15	0.70	Ae	0.10	0.60	Ae	0.20	0.20	Ae	0.10
t11d	Abundant	Abundant	1.20	Av	0.65	0.40	Ae	0.10	0.50	Ae	0.10	0.30	Ae	0.10	0.70	Av	0.40	0.70	Ae	0.15
t11e	Rare	Rare	0.60	Av	0.35	1.10	Av	0.30	3.10	Av	0.40	2.60	Av	0.20	2.60	Av	0.40	3.10	Av	0.40
t11f	Very Abundant	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t11g	Rare	Common	2.30	Av	0.20	2.00	Av	0.15	2.10	Av	0.20	2.30	Av	0.20	1.00	Av	0.15	1.40	Av	0.15
t11h	Rare	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t11i	Rare	Rare	0.40	Av	0.10	1.00	Av	0.15	0.60	Av	0.05	0.30	Av	0.05	1.00	Av	0.10	0.50	Av	0.10
t11j	Rare	Common	1.60	Av	0.25	1.00	Av	0.10	1.00	Av	0.30	0.80	Av	0.40	2.10	Av	0.40	1.70	Av	0.30
t11k	Rare	Common	2.10	Av	0.30	1.70	Av	0.30	1.60	Av	0.15	2.30	Av	0.05	1.70	Av	0.45	1.20	Av	0.45
T11L	Abundant	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t12a	Rare	Abundant	1.00	Ae	0.20	1.10	Ae	0.25	1.30	Ae	0.15	0.90	Ae	0.15	1.10	Ae	0.15	1.50	Ae	0.20
t12b	Rare	Abundant	0.90	Ae	0.10	0.30	ae	0.15	0.70	ae	0.20	0.60	Ae	0.15	1.30	Ae	0.05	1.00	Ae	0.15
t12c	Rare	Abundant	0.60	Ae	0.05	0.30	Ae	0.10	0.90	Ae	0.10	0.70	Ae	0.10	0.30	Ae	0.05	0.50	Av	0.30
t12d	Rare	Abundant	0.30	Ae	0.05	0.80	Ae	0.05	0.70	Ae	0.05	0.70	Ae	0.10	0.40	Ae	0.05	0.70	Ae	0.05
t12e	Rare	Abundant	0.30	Ae	0.05	0.80	Ae	0.05	0.70	Ae	0.05	0.70	Ae	0.10	0.40	Ae	0.05	0.70	Ae	0.05
t13A	Rare	Very Abundant	0.30	Ae	0.10	1.20	Ae	0.15	0.50	Ae	0.10	0.60	Ae	0.10	1.30	Ae	0.10	1.30	Ae	0.10
T13b	Rare	Abundant	1.20	Rh	0.10	1.00	Av	0.15	1.30	Av	0.20	0.70	Av	0.20	1.00	Ae	0.05	1.90	Ae	0.05
t13c	Very Abundant	Common	1.20	Av	0.20	1.70	Av	0.55	1.00	Av	0.30	0.70	Av	0.15	2.10	Rh	0.05	2.10	Av	0.20

				1st Tree			2nd Tree			1st Tree			2nd Tree			1st Tree			2nd Tree	
Waypoint	Macro Algae	Fauna	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith
t13d	Abundant	Common	2.10	Av	0.45	3.10	Av	0.40	2.30	Av	0.25	2.40	Av	0.65	3.40	Av	0.20	2.60	Av	0.25
T14A	Rare	Rare	0.30	Av	0.15	1.20	Av	0.20	0.70	Av	0.05	1.10	Av	0.15	1.20	Av	0.20	0.30	Av	0.15
T14B	Rare	Very Abundant	1.10	Av	0.05	1.20	Av	0.05	3.10	Av	0.10	1.10	Av	0.10	2.40	Av	0.05	1.60	Av	0.10
T14C	Rare	Very Abundant	2.10	Av	0.35	1.40	Av	0.30	3.20	Av	0.40	3.20	Av	0.45	1.80	Av	0.40	1.90	Av	0.25
T14D	Common	Very Abundant	2.60	Av	0.25	1.60	Av	0.20	1.50	Av	0.30	3.20	Av	0.25	3.10	Av	0.25	2.10	Av	0.05
T14E	Abundant	Very Abundant	3.10	Av	0.65	2.80	Av	0.45	2.80	Av	0.85	1.60	Av	0.30	3.60	Av	1.10	2.90	Av	0.65
T14F	Common	Abundant	5.20	Av	1.10	2.60	Av	0.65	6.70	Av	1.30	4.30	Av	0.80	4.80	Av	0.40	4.60	Av	0.50
T14G	Rare	Common	0.70	Av	0.10	0.90	Av	0.30	0.30	Av	0.20	0.40	Av	0.15	0.60	Av	0.15	0.70	Av	0.20
T15A	Rare	Common	0.90	Av	0.10	0.60	Av	0.10	1.40	Av	0.05	1.30	Av	0.20	1.60	Av	0.20	1.30	Av	0.15
T15B	Common	Common	1.20	Ag	0.05	1.80	Av	0.35	1.70	Av	0.10	2.60	Av	0.20	0.90	Av	0.10	1.00	Av	0.10
T15C	Rare	Common	1.20	Av	0.05	0.70	Av	0.10	1.30	Av	0.10	1.40	Av	0.30	0.90	Av	0.05	0.40	Av	0.05
T15D	Abundant	Common	1.30	Av	0.55	1.70	Av	0.20	1.50	Av	0.15	0.60	Av	0.50	2.00	Av	0.60	1.30	Av	0.25
T15E	Very Abundant	Common	0.90	Av	0.20	1.50	Av	0.25	1.10	Av	0.05	0.40	Av	0.20	2.40	Av	0.15	0.80	Av	0.20
t16a	Abundant	Common	1.20	Av	0.15	1.00	Av	0.10	1.00	Av	0.20	1.70	Av	0.30	0.40	Av	0.10	1.20	Av	0.25
t16b	Abundant	Abundant	3.20	Av	0.45	1.20	Av	0.15	2.30	Av	0.25	3.00	Av	0.30	1.60	Av	0.30	2.10	Av	0.25
t16c	Abundant	Abundant	1.20	Av	0.45	3.10	Av	0.35	2.10	Av	0.15	1.20	Av	0.60	3.10	Av	0.60	2.60	Av	0.40
T1A	Rare	Common	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
T1B	Common	Common	2.70	Av	0.05	2.80	Av	0.25	1.60	Av	0.25	1.60	Av	0.20	2.40	Av	0.30	0.90	Av	0.10
T1C	Common	Rare	2.20	Av	0.15	1.50	Av	0.60	1.80	Av	0.35	1.40	Av	0.35	1.80	Av	0.50	0.90	Av	0.20
T1D	Common	Rare	1.90	Av	0.75	0.90	Av	1.25	3.20	Av	1.20	2.10	Av	0.60	2.10	Av	0.80	1.50	Av	0.25
T1E	Common	Rare	0.90	Av	0.05	2.20	Av	1.10	1.30	Av	0.35	2.10	Av	1.20	3.20	Av	1.00	2.60	Av	0.35
T1F	Rare	Common	0.70	Av	0.05	0.60	Av	0.05	1.30	Av	0.20	1.60	Av	0.10	3.20	Av	0.85	1.90	Av	0.25
T1G	Abundant	Common	9.70	Av	0.90	3.20	Av	1.80	4.20	Av	0.85	1.30	Av	0.25	6.40	Av	1.25	3.30	Av	0.30
t20a	Rare	Very Abundant	1.00	Av	0.30	2.00	Av	0.15	0.80	Ce	0.15	1.60	Av	0.20	1.20	Av	0.15	0.90	Av	0.20
t20b	Rare	Very Abundant	1.20	Ce	0.20	1.10	Av	0.25	0.30	Ce	0.20	0.30	Ce	0.15	1.70	Av	0.45	1.30	Ce	0.20
t20c	Common	Very Abundant	1.30	Av	0.15	1.20	Av	0.20	1.90	Av	0.20	0.60	Ce	0.15	0.60	Av	0.45	2.10	Av	0.05
t20d	Very Abundant	Rare	2.10	Ae	0.15	0.80	Av	0.45	0.40	Av	0.45	2.60	Av	0.80	1.70	Ce	0.25	1.30	Ae	0.05
t20e	Rare	Common	1.20	Ae	0.05	1.00	Ae	0.10	1.30	Ae	0.05	0.60	Ae	0.05	0.90	Ae	0.05	0.50	Ae	0.05
t20f	Rare	Abundant	4.10	Av	1.20	5.20	Av	1.00	6.00	Av	0.20	7.00	Av	0.75	4.30	Av	0.90	3.60	Av	0.60
t20g	Rare	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t20h	Rare	Rare	0.30	Av	0.05	1.00	Av	0.05	0.70	Av	0.10	0.70	Av	0.10	0.50	Av	0.10	0.20	Av	0.05
t20i	Rare	Common	0.30	Av	0.05	1.00	Av	0.05	0.70	Av	0.10	0.70	Av	0.10	0.50	Av	0.10	0.20	Av	0.05

				1st Tree			2nd Tree			1st Tree			2nd Tree			1st Tree			2nd Tree	
Waypoint	Macro Algae	Fauna	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith
t20j	Abundant	Common	4.20	Av	1.20	3.60	Av	0.40	3.90	Av	1.00	1.10	Av	0.15	1.60	Av	0.70	4.10	Av	0.60
t20k	Abundant	Abundant	3.10	Av	0.50	1.00	Av	0.25	3.10	Av	0.25	1.00	Av	0.50	2.70	Av	1.00	2.30	Av	0.15
t23a	Very Abundant	Common	1.10	Av	0.40	1.20	Av	0.60	2.40	Av	0.95	1.30	Av	1.00	0.90	Av	0.30	1.00	Av	0.90
t23b	Very Abundant	Common	0.70	Av	0.10	0.60	Av	1.10	1.00	Av	0.25	1.20	Av	0.20	0.30	Av	0.15	3.20	Av	2.20
t23c	Rare	Very Abundant	3.10	Av	0.45	1.20	Av	0.60	1.10	Av	0.70	3.20	Av	0.50	1.00	Av	0.40	2.60	Av	0.50
t23d	Rare	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t23e	Rare	Rare	1.20	Av	0.15	1.00	Av	0.45	1.40	Av	0.45	0.85	Av	0.20	0.30	Av	0.10	0.30	Av	0.15
t23f	Rare	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t23g	Rare	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t23h	Rare	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t23i	Rare	Rare	1.10	Av	0.25	1.10	Av	0.15	0.70	Av	0.15	0.30	Av	0.10	0.40	Av	0.40	0.50	Av	0.20
t23j	Rare	Common	2.10	Av	0.20	2.30	Av	0.35	1.60	Av	0.25	0.90	Av	0.15	2.30	Av	0.40	2.40	Av	0.40
t23k	Rare	Abundant	0.30	Ae	0.15	1.50	Ae	0.10	0.70	Ae	0.30	2.10	Ae	0.15	1.10	Ae	0.35	1.40	Ae	0.20
t23l	Abundant	Very Abundant	3.12	Av	0.15	1.50	Av	0.85	2.70	Av	0.05	3.40	Rh	0.05	1.30	Av	2.60	1.90	Av	0.10
t24a	Abundant	Abundant	0.80	Av	0.35	2.60	Av	0.40	0.80	Av	0.35	2.60	Av	0.40	0.80	Av	0.35	2.60	Av	0.40
t24b	Abundant	Abundant	2.70	Av	0.70	1.50	Av	0.90	1.80	Av	0.25	1.90	Av	0.20	0.70	Av	0.10	0.60	Av	0.15
t24c	Rare	Abundant	2.00	Ag	0.20	3.90	Ag	0.15	1.10	Av	0.65	2.10	Av	0.05	0.30	Ag	0.15	1.50	Av	0.10
t24d	Abundant	Rare	1.30	Av	0.05	0.50	Av	0.10	0.20	Av	0.05	0.90	Av	0.15	0.75	Av	0.05	1.50	Av	0.10
t24e	Very Abundant	Abundant	2.10	Av	1.10	3.20	Av	0.30	3.20	Av	0.60	4.80	Av	0.25	1.00	Av	0.25	2.20	Rh	0.20
t25a	Very Abundant	Abundant	0.60	Av	0.45	1.20	Av	0.40	1.20	Av	0.40	0.70	Av	0.25	1.90	Av	0.35	1.40	Av	0.60
t25b	Common	Rare	1.00	Av	0.15	1.30	Av	0.20	0.30	Av	0.30	2.10	Av	0.15	1.20	Av	0.20	0.40	Av	0.30
t25c	Rare	Rare	0.40	Av	0.05	0.60	Av	0.05	0.20	Av	0.10	0.25	Av	0.05	0.70	Av	0.05	0.40	Av	0.10
t25d	Rare	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t25e	Rare	Rare	1.00	Av	0.15	1.20	Av	0.15	0.60	Av	0.20	0.70	Av	0.15	0.50	Av	0.10	0.50	Av	0.20
t25f	Rare	Rare	1.30	Av	0.20	2.10	Av	0.20	2.10	Av	0.25	1.80	Av	0.15	1.60	Av	0.15	2.30	Av	0.25
t25g	Abundant	Common	1.20	Av	0.45	1.20	Av	0.25	2.30	Av	0.20	2.60	Av	0.30	3.10	Av	0.35	1.90	Av	0.15
t25h	Abundant	Common	1.20	Av	0.50	2.10	Av	0.20	2.10	Av	0.15	3.60	Av	0.20	1.30	Av	0.45	1.40	Av	0.30
t27a	Very Abundant	Abundant	1.00	Av	0.60	1.00	Rh	0.05	1.40	Av	0.35	2.20	Av	0.35	2.60	Av	1.10	3.20	Av	0.50
t27b	Abundant	Common	1.20	Av	0.05	1.10	Av	0.05	0.60	Av	0.05	0.50	Av	0.05	0.80	Av	0.05	1.30	Av	0.05
t27c	Abundant	Rare	0.30	Av	0.10	1.50	Av	0.05	1.20	Av	0.10	1.00	Av	0.15	1.30	Av	0.10	0.45	Av	0.10
t27d	Abundant	Rare	0.45	Av	0.05	0.60	Av	0.10	0.10	Av	0.05	0.60	Av	0.10	1.40	Av	0.25	0.60	Av	0.15
T2A	Abundant	Rare	6.00	Av	1.30	4.90	Av	1.10	4.50	Av	0.80	5.30	Av	0.65	0.45	Av	0.45	1.90	Av	0.30

				1st Tree			2nd Tree			1st Tree			2nd Tree			1st Tree			2nd Tree	
Waypoint	Macro Algae	Fauna	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith
T2B	Abundant	Rare	1.20	Av	0.15	2.70	Av	0.05	0.80	Av	0.15	1.60	Av	0.20	0.30	Av	0.10	1.30	Av	0.15
T2C	Abundant	Rare	3.60	Av	0.60	2.20	Rh	0.20	1.20	Av	0.95	2.60	Av	0.45	0.75	Rh	0.30	3.80	Av	1.00
T2D	Common	Rare	1.50	Av	0.70	2.00	Av	0.25	0.90	Av	1.20	3.20	Av	0.40	1.70	Rh	0.35	2.80	Av	0.05
T2E	Rare	Rare	2.70	Av	0.70	1.50	Av	0.90	1.80	Av	0.25	1.90	Av	0.20	0.70	Av	0.10	0.60	Av	0.15
T2F	Rare	Common	2.00	Ag	0.20	3.90	Ag	0.15	1.10	Av	0.65	2.10	Av	0.05	0.30	Ag	0.15	1.50	Av	0.10
T2G	Rare	Rare	1.30	Av	0.05	0.50	Av	0.10	0.20	Av	0.05	0.90	Av	0.15	0.75	Av	0.05	1.50	Av	0.10
T2H	Rare	Rare	1.20	Av	0.50	2.30	Av	0.10	0.80	Av	0.20	1.00	Av	0.20	1.30	Av	0.15	0.40	Av	0.05
T3A	Rare	Abundant	1.70	Av	0.20	1.50	Av	0.05	1.60	Av	0.20	0.60	Av	0.15	1.80	Av	0.05	1.60	Av	0.20
T3B	Common	Common	1.50	Av	0.15	0.50	Av	0.03	0.80	Av	0.10	1.40	Av	0.20	0.40	Av	0.05	1.30	Av	0.25
T3C	Common	Common	0.80	Av	0.15	1.20	Av	0.20	0.40	Av	0.20	0.75	Av	0.10	2.10	Av	0.20	1.50	Av	0.40
T3D	Abundant	Common	0.90	Av	0.35	1.10	Av	0.25	1.20	Av	0.20	2.00	Av	0.35	0.25	Av	0.30	2.40	Av	0.25
T3E	Abundant	Very Abundant	3.20	Av	0.65	2.70	Av	0.90	1.80	Av	0.65	3.40	Av	0.40	2.90	Av	0.70	4.70	Av	1.40
t4a	Very Abundant	Abundant	2.10	Av	0.30	2.40	Av	0.40	1.80	Av	0.60	2.80	Av	0.45	2.00	Av	0.30	1.60	Av	0.50
t4b	Common	Common	1.50	Av	0.30	0.40	Av	0.35	0.80	Av	0.40	1.20	Av	0.25	1.50	Av	0.20	1.50	Av	0.30
t4c	Common	Abundant	0.60	Av	0.05	0.85	Av	0.30	1.00	Av	0.05	1.20	Av	0.10	2.10	Av	0.15	1.30	Av	0.20
t5a	Common	Abundant	1.50	Av	0.20	1.60	Av	0.30	1.50	Av	0.25	2.60	Av	0.15	1.50	Av	0.15	2.10	Av	0.10
t5b	Common	Common	1.30	Av	0.15	2.70	Av	0.20	2.40	Av	0.15	1.90	Av	0.20	2.30	Av	0.10	1.80	Av	0.20
t6a	Common	Common	1.40	Av	0.15	2.60	Av	0.20	2.60	Av	0.20	3.30	Av	0.60	1.20	Av	0.25	1.20	Av	0.15
t6b	Common	Common	0.80	Av	0.25	1.80	Av	0.15	1.50	Av	0.15	1.60	Av	1.20	2.60	Av	0.15	1.50	Av	0.25
t6c	Common	Abundant	1.10	Av	0.25	2.30	Av	0.10	1.30	Av	0.05	1.70	Av	0.20	0.30	Av	0.05	2.90	Av	0.20
t6d	Common	Abundant	0.30	Av	0.05	3.10	Av	0.45	1.00	Av	0.35	2.30	Av	1.30	0.90	Av	0.20	0.65	Av	0.45
t7a	Common	Common	1.30	Av	0.30	1.60	Av	0.05	1.60	Av	0.25	1.70	Av	0.05	1.20	Av	0.20	1.70	Av	0.15
t7b	Common	Common	0.80	Av	0.30	2.10	Av	0.20	2.10	Av	0.15	2.10	Av	0.20	2.10	Av	0.25	1.80	Av	0.15
t7c	Common	Rare	0.90	Av	0.45	3.10	Av	0.35	0.60	Av	0.35	3.50	Av	0.60	0.30	Av	0.50	2.50	Av	0.35
t7d	Rare	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t7e	Rare	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t7f	Common	Abundant	3.20	Av	0.35	0.80	Av	0.75	1.60	Av	0.40	2.30	Av	0.40	2.00	Av	0.60	1.80	Av	0.30
t7g	Abundant	Common	1.20	Av	1.10	6.10	Av	0.90	3.10	Av	0.95	1.30	Av	1.40	1.60	Av	1.65	2.30	Av	0.20
t7h	Very Abundant	Common	0.30	Av	0.30	0.15	Av	0.15	1.20	Av	0.35	0.80	Av	0.10	0.40	Av	0.75	0.65	Av	1.40
t7i	Very Abundant	Common	1.90	Av	0.80	1.30	Av	0.40	2.00	Av	0.65	0.90	Av	0.90	3.00	Av	0.40	1.00	Av	0.25
t8a	Abundant	Abundant	0.20	Av	0.40	2.00	Av	0.30	2.10	Av	0.50	2.10	Av	0.50	1.60	Rh	0.15	0.60	Av	0.25
t8b	Abundant	Abundant	0.30	Av	0.45	0.30	Av	0.45	0.90	Av	0.65	1.80	Av	1.00	2.10	Av	0.15	3.00	Av	0.20

				1st Tree			2nd Tree			1st Tree			2nd Tree			1st Tree			2nd Tree	
Waypoint	Macro Algae	Fauna	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith
t8c	Rare	Common	0.60	Av	0.25	2.60	Av	0.40	3.10	Av	0.35	1.00	Av	0.15	2.40	Av	0.40	2.00	Av	0.25
t8d	Common	Common	1.00	Av	0.15	1.00	Av	0.05	1.20	Av	0.10	1.00	Av	0.10	0.30	Av	0.15	0.70	Av	0.15
t8e	Common	Common	1.00	Av	0.15	1.00	Av	0.05	1.20	Av	0.10	1.00	Av	0.10	0.30	Av	0.15	0.70	Av	0.15
t8f	Rare	Rare	0.60	Av	0.25	1.20	Av	0.15	1.20	Av	0.20	2.00	Av	0.15	1.30	Av	0.15	2.40	Av	0.25
t8g	Rare	Rare	0.60	Av	0.25	1.20	Av	0.15	1.20	Av	0.20	2.00	Av	0.15	1.30	Av	0.15	2.40	Av	0.25
t8h	Common	Common	1.20	Av	0.65	1.00	Av	0.20	3.60	Av	1.10	2.60	Av	0.45	2.90	Av	0.45	3.20	Av	1.00
t8i	Common	Common	1.20	Av	0.25	1.00	Av	0.20	2.10	Av	0.10	2.10	Av	0.15	1.60	Av	0.15	0.50	Av	0.40
t9a	Very Abundant	Very Abundant	3.60	Av	1.40	2.20	Av	0.35	2.70	Av	1.80	2.60	Av	0.40	2.90	Av	0.30	4.00	Av	0.85
t9aw	Abundant	Common	1.20	Av	0.25	1.00	Av	0.20	2.10	Av	0.10	2.10	Av	0.15	1.60	Av	0.15	0.50	Av	0.40
t9b	Common	Common	1.70	Av	0.30	2.10	Av	0.45	1.30	Av	0.25	0.30	Av	0.30	1.10	Av	0.30	1.40	Av	0.15
t9bw	Common	Common	1.10	Av	0.25	1.10	Av	0.35	0.40	Av	0.15	0.40	Av	0.20	0.90	Av	0.15	1.00	Av	0.10
t9c	Common	Common	0.90	Av	0.25	1.40	Av	0.15	1.10	Av	0.20	1.00	Av	0.05	0.40	Av	0.05	2.10	Av	0.20
t9cw	Common	Common	0.50	Av	0.20	1.10	Av	0.15	1.30	Av	0.10	2.40	1	0.25	1.10	Av	0.25	0.35	Av	0.20
T9D	Common	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t9de	Rare	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t9e	Rare	Rare	1.30	Av	0.20	2.10	Av	0.15	1.00	Av	0.15	1.50	Av	0.20	0.90	Av	0.20	2.10	Av	0.30
t9ee	Rare	Rare	0.70	Av	0.25	2.70	Av	0.20	0.40	Av	0.20	2.00	Av	0.15	1.30	Av	0.15	1.10	Av	0.20
t9fe	Abundant	Abundant	1.10	Av	0.25	1.10	Av	0.15	1.20	Av	0.10	0.30	Av	0.20	0.90	Av	0.15	0.90	Av	0.20
t9fw	Rare	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t9ge	Rare	Common	1.20	Av	0.15	1.60	Av	0.20	2.10	Av	0.20	2.10	Av	0.35	1.30	Av	0.15	1.80	Av	0.15
t9gw	Common	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t9he	Rare	Rare	1.00	Av	0.25	1.40	Av	0.15	1.30	Av	0.15	1.00	Av	0.40	2.10	Av	0.20	2.10	Av	0.20
t9hw	Rare	Rare	0.70	Av	0.05	0.70	Av	0.05	0.40	Av	0.05	1.00	Av	0.10	0.50	Av	0.10	0.60	Av	0.10
t9ie	Rare	Rare	0.70	Av	0.05	1.00	Av	0.10	1.00	Av	0.10	0.90	Av	0.10	1.00	Av	0.10	0.30	Av	0.05
t9Iw	Rare	Rare	1.20	Av	0.15	1.70	Av	0.05	0.70	Av	0.15	1.20	Av	0.10	1.00	Av	0.10	1.40	Av	0.15
t9je	Rare	Common	1.60	Av	0.30	0.70	Av	0.30	2.10	Av	0.25	1.40	Av	0.30	2.40	Av	0.15	2.10	Av	0.20
t9jw	Common	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t9ke	Rare	Common	0.70	Av	0.10	0.50	Av	0.20	1.10	Av	0.15	1.00	Av	0.20	0.50	Av	0.15	1.30	Av	0.10
t9kw	Common	Rare	1.20	Av	0.10	0.90	Av	0.10	1.60	Av	0.10	1.60	Av	0.15	1.00	Av	0.15	1.30	Av	0.15
t9le	Rare	Rare	1.50	Av	0.05	2.10	Av	0.20	1.70	Av	0.15	1.60	Av	0.15	2.60	Av	0.25	2.80	Av	0.20
t9lw	Rare	Rare	0.75	Av	0.15	1.00	Av	0.25	1.00	Ae	0.05	1.10	Av	0.20	1.30	Ae	0.05	1.10	Ae	0.10
t9me	Abundant	Abundant	2.10	Rh	0.20	1.20	Av	0.45	1.40	Rh	0.15	1.00	Rh	0.20	0.30	Rh	0.20	2.00	Rh	0.25

				1st Tree			2nd Tree			1st Tree			2nd Tree			1st Tree			2nd Tree	
Waypoint	Macro Algae	Fauna	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith
t9mw	Common	Rare	0.70	Ae	0.10	1.00	Ae	0.05	1.40	Ae	0.05	0.90	Ae	0.10	0.90	Ae	0.05	0.40	Ae	0.20
t9ne	Abundant	Abundant	4.20	Av	1.40	4.40	Av	1.20	3.60	Av	0.30	3.00	Av	0.30	2.80	Av	0.60	1.90	Av	0.90
t9nw	Rare	Abundant	0.70	Ae	0.10	1.10	Ae	0.05	1.20	Ae	0.05	1.40	Ae	0.05	1.40	Ae	0.05	0.40	Ae	0.05
t9o	Common	Abundant	1.20	Ae	0.10	1.50	Av	0.35	0.65	Ae	0.05	0.45	Ae	0.10	0.80	Av	0.25	1.50	Av	0.40
t9ow	Rare	Abundant	1.10	Ae	0.15	2.10	Ae	0.05	1.10	Ae	0.15	1.40	Ae	0.15	0.30	Av	0.30	1.10	Ae	0.15
t9pw	Very Abundant	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t9qw	Rare	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t9rw	Rare	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t8j	Rare	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t8k	Common	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t8l	Rare	Rare	0.60	Av	0.05	1.20	Av	0.15	1.20	Av	0.10	0.40	Av	0.15	0.80	Av	0.15	1.00	Av	0.15
t8m	Very Abundant	Rare	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00	0.00	Av	0.00
t8n	Abundant	Common	1.00	Av	0.25	1.10	Av	0.15	0.60	Av	0.15	0.90	Av	0.05	1.20	Av	0.15	1.30	Av	0.15
t8o	Very Abundant	Very Abundant	1.40	Av	0.35	2.30	Av	0.25	0.90	Rh	0.35	1.80	Av	0.65	2.10	Av	0.60	2.70	Av	0.30
t8p	Very Abundant	Very Abundant	1.30	Rh	0.30	2.60	Av	0.45	0.70	Av	0.45	4.20	Av	0.50	1.80	Av	0.75	1.40	Av	0.15
t8q	Very Abundant	Very Abundant	2.60	Av	0.80	2.40	Rh	0.30	1.40	Av	0.65	3.20	Rh	0.25	0.90	Av	0.25	1.60	Av	1.10
t16d	Common	Abundant	2.60	Av	0.35	3.10	Av	0.60	4.10	Av	0.60	2.60	Av	0.25	1.60	Av	0.25	1.80	Rh	0.30
t16e	Common	Very Abundant	0.30	Av	0.10	1.00	Av	0.15	1.20	Av	0.15	1.10	Av	0.15	0.60	Av	0.20	0.40	Av	0.10
t16f	Abundant	Very Abundant	0.10	Av	0.25	1.00	Av	0.05	0.30	Av	0.15	0.90	Av	0.15	1.00	Av	0.15	1.10	Av	0.15
t17a	Very Abundant	Abundant	1.70	Av	0.25	3.10	Av	0.40	2.10	Av	0.30	2.60	Av	0.40	3.20	Av	0.30	1.10	Av	0.10
t17b	Very Abundant	Abundant	1.60	Av	0.45	2.40	Av	0.35	2.80	Av	0.50	3.10	Av	0.65	1.00	Av	0.50	4.75	Av	0.25
t17c	Very Abundant	Abundant	2.10	Av	0.20	1.80	Av	0.20	0.90	Av	0.80	2.60	Av	0.80	3.10	Av	0.65	1.90	Av	0.05
t18a	Abundant	Very Abundant	2.10	Av	0.60	1.60	Av	0.45	1.30	Av	0.25	3.40	Av	0.60	2.30	Av	0.35	1.80	Av	0.25
t18b	Abundant	Very Abundant	1.60	Av	0.25	2.60	Av	0.45	2.40	Av	0.45	3.10	Av	0.50	3.10	Rh	0.40	1.00	Av	0.20
t18c	Common	Common	1.10	Av	0.20	3.10	Av	0.25	1.30	Av	0.45	2.00	Av	0.45	2.40	Rh	0.25	3.40	Av	0.60
t18d	Abundant	Very Abundant	1.30	Av	0.45	1.20	Av	0.15	2.20	Av	0.20	3.10	Av	0.40	1.60	Av	0.15	0.90	Av	0.60
t18e	Very Abundant	Very Abundant	1.70	Av	0.25	1.30	Av	1.10	2.00	Av	0.15	2.10	Av	0.45	1.50	Rh	0.35	1.60	Av	0.25
t19a	Common	Abundant	0.60	Av	0.25	3.10	Av	0.05	1.30	Av	0.45	2.30	Av	0.20	0.90	Av	0.60	1.70	Av	0.50
t19b	Common	Abundant	0.90	Av	0.35	1.40	Av	0.15	1.60	Av	0.05	3.20	Av	0.60	2.10	Av	0.40	2.10	Av	0.25
t19c	Abundant	Abundant	1.30	Av	0.25	3.20	Av	0.40	0.90	Av	0.40	1.80	Av	0.25	2.10	Rh	0.20	4.60	Rh	0.05
t19d	Rare	Common	1.30	Av	0.45	1.20	Av	0.40	2.10	Av	0.25	3.10	Av	0.30	0.60	Av	0.50	1.60	Av	0.50
t19e	Abundant	Common	0.60	Cp	0.35	1.20	Av	0.45	1.20	Cp	0.25	3.10	Cp	0.25	3.10	Cp	0.25	3.20	Cp	0.30

				1st Tree			2nd Tree			1st Tree			2nd Tree			1st Tree			2nd Tree	
Waypoint	Macro Algae	Fauna	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith	Dist	Sp	Grith
t19f	Very Abundant	Abundant	2.10	Cp	0.25	2.20	Cp	0.20	1.60	Av	0.45	3.10	Cp	0.25	2.10	Av	0.45	1.20	Av	0.50

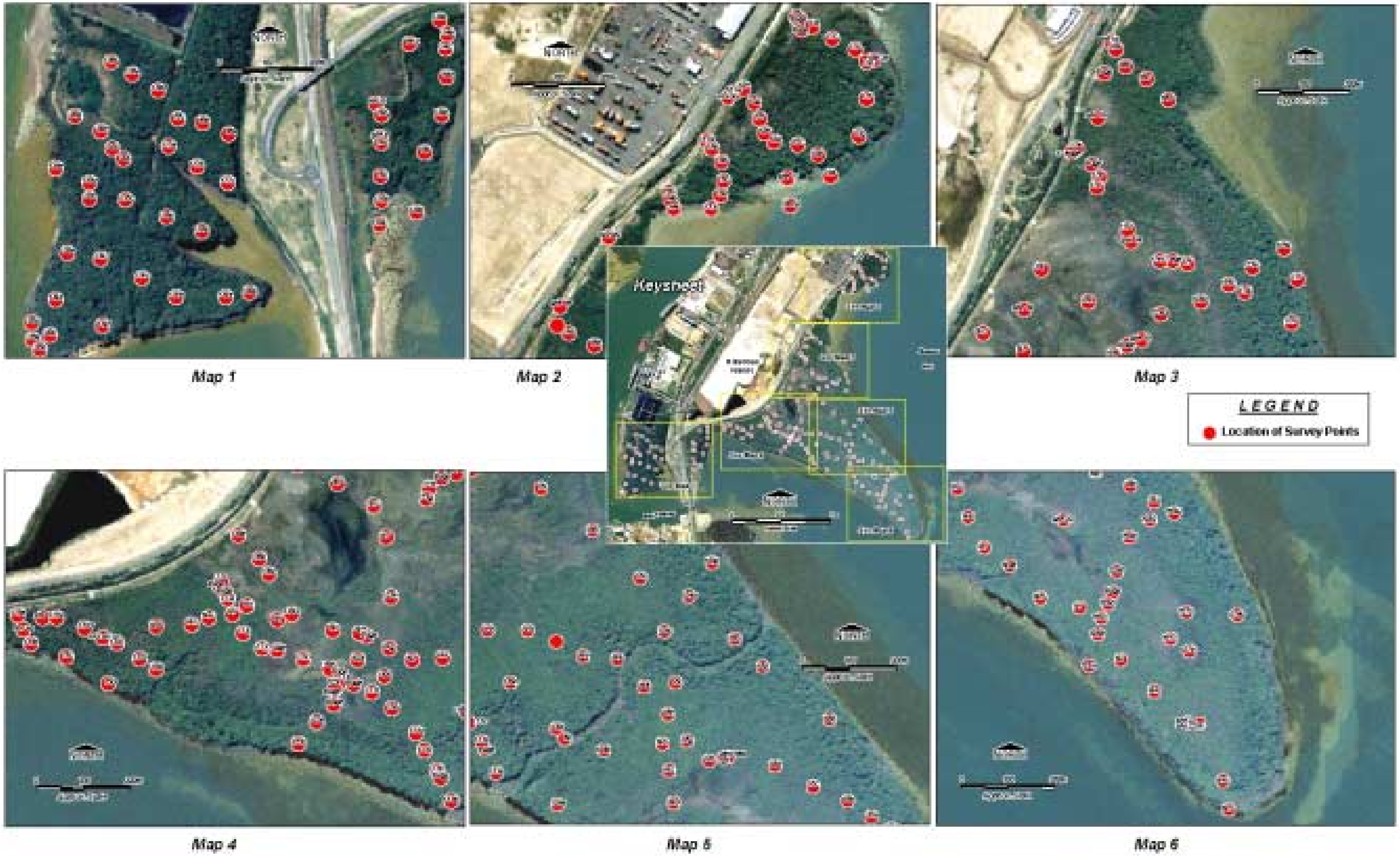

Figure A.1 Location of Survey Points