Submission for the
1995 Earth Awards
EAST ARM PORT DEVELOPMENT
This submission has been documented as a joint entry. The following Northern Territory Government Agencies, Consultants and Contractors contributed to the submission:

- Department of Transport & Works
- Department of Lands, Planning & Environment
- Northern Territory University
- Henry Walker Contracting Pty Ltd
- GHD
- acer/VAUGHAN Consulting Engineers
- Harlley Caissell and Associates Pty. Ltd.
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APPENDICES

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Appendix J: Darwin Port Expansion - East Arm Environmental Assessment Report and recommendations (Assessment Report 19) Conservation Commission of the NT Environmental Protection Unit

Appendix K: East Arm Port - Stage 1 Water Quality Monitoring Program Report on Setup Phase and Baseline Data Collection Marine Ecology Technical Report 95/1 - April 1995
The Northern Territory Government announced in August 1992 that additional port facilities would be built at East Arm in Darwin harbour. The Conservation Commission of the Northern Territory recommended environmental impact assessment at the Environmental Impact Statement (EIS) level.

A draft EIS was submitted in November 1993 for assessment and public review. The assessment was completed in February 1994 with the outcome that the project could proceed subject to the implementation of a number of environmental safeguards. The recommended safeguards were accepted and incorporated in the project development by the proponent.

The Department of Transport and Works is managing the East Arm Port development on behalf of the Darwin Port Authority, the Department of Lands, Planning and Environment and the Federal Better Cities Programme.

As an outcome of the environmental impact assessment the NT Government established a Project Environmental Control (PEC) group and specialist Technical Advisory Groups (TAGs) to consider and advise on all environmental matters relating to the project.

A comprehensive water quality monitoring programme has been undertaken which included corals and pearl oysters as biological indicators. The baseline component of this study commenced in October 1994 and ran for 7 months. The construction phase of the project has been monitored weekly since dredging commenced in May 1995.

Of the $2 m spent to date on environmental studies and the assessment process approximately $500,000 have been spent on environmental monitoring.

Stage 1 work for the new port which has included excavation of fill from Quarantine Island, construction of embankments in the harbour and dredging is substantially complete with over 1.7 million cubic metres of fill and 225,000 cubic metres of rock armour being placed and 380,000 cubic metres of marine sediments dredged.

Coral colonies adjacent to North Shell Island were relocated to Weed Reef to ensure their survival. Monitoring has shown that they are thriving at the new location.

Results of the monitoring programme have shown that there has been no detectible environmental impact on the marine flora and fauna adjacent to the work site. The development has met the aims of the construction brief and environmental management programme.
1. PROJECT TITLE:

- East Arm Port Development - Access road, earthworks, dredging and wharf embankment. Environmental monitoring and management during the construction phase.

This submission relates to the construction and associated environmental management of Stage I of the East Arm Port Development project.

Although Stage I will not be completed when this submission is judged the components of the work requiring extensive environmental monitoring such as:

- Excavation of fill from Quarantine Island;
- Construction of embankments within Darwin Harbour;
- Filling of hardstand areas; and
- Dredging

will be substantially complete. The remaining components consisting of pile driving and concrete wharf deck construction would not require the extensive environmental monitoring programme put in place for the other components.

2. CATEGORY:

- Category 3 ie > $10 million.

3. NAMES AND ROLES OF PRINCIPALS, CONSULTANTS AND CONTRACTORS:

All NT government agencies, consultants and contractors have operated on a partnership basis on this project, consequently this submission has been documented as a joint entry and details of all agencies and companies are provided together as follows:

3.1 NT Government Agencies

1. Darwin Port Authority

Client - Darwin Port Authority
Mr. Paul Tyrrell - CEO
Mr. John Butler - Port Manager

The Darwin Port Authority is responsible for the control, development and management of all waters and land within the Port of Darwin and to facilitate the operation of marine related activities and industries. The Darwin Port Authority Act was amended in 1993 to align the functions and powers of the Authority with its increasing responsibility for the management and development of recreational, tourist and commercial activities within the port environs.
2. Department of Transport and Works

The Northern Territory Department of Transport and Works is managing the project on behalf of the Darwin Port Authority, the Northern Territory Department of Lands, Planning and Environment and the Federal Better Cities Programme.

Project Manager - Department of Transport and Works
Mr Ken Hornsby - Assistant Secretary, Transport Infrastructure

- Total project management
- Project development and design
- Masterplanning

Project Manager (Construction) - Department of Transport and Works
Mr Dick Norris - Construction Agency

- Construction management including on site supervision;

Project Environmental Co-ordinator - Department of Transport and Works
Mr Phill Piper - Construction Agency

- Responsible to the Project Manager (Construction) for implementation of environmental safeguards (in conjunction with DLPE);
- Responsible for specific project briefs such as the water quality monitoring programmes required for the dredging phases of the port construction. Selection of consultants and supervision of environmental monitoring contracts;
- Co-ordinate rapid response group if monitoring detects any adverse environmental effects at the port site which might be related to construction activities;
- Circulate information from various sources on environmental management to all relevant NT Government Departments and contractors. Prepare Environmental Bulletins.

3. Department of Lands, Planning and Environment (DLPE)

Environment Protection Division (formerly the Environmental Protection Unit of the Conservation Commission of the Northern Territory)

Ms Barbara Singer and Mr Helge Pedersen - Environmental Protection Division

- Environmental impact assessment;
- In conjunction with the Department of Transport and Works oversee the implementation of environmental safeguards and general environmental management.

4. Museum and Art Gallery of the Northern Territory - Marine Ecology Unit (MEU)

Dr J Russell Hanley and Ms Gabi Caswell

- To provide technical and scientific advice and skills concerning the design, implementation, management and analyses of environmental monitoring program;
To develop biological indicators and provide interpretation of ecological data to the Northern Territory Department of Transport and Works;

To provide weekly status reports on corals and pearl oysters at the five monitoring sites between April and September 1995;

To provide an integrated report including the data and results of all coral, pearl oyster and water quality environmental monitoring.

5. Environmental Chemistry Department - Northern Territory University

Dr Dave Parry

To provide physico-chemical baseline data collection and dredge return water monitoring;

To determine acid leachate parameters;

To provide weekly water quality monitoring reports.

3.2 Consultants

1. Hanley, Caswell and Associates Pty. Ltd.

Dr J Russell Hanley & Ms Gabi Caswell

Implementation and analyses of environmental monitoring, environmental monitoring co-ordination and data analyses;

To provide weekly status reports on corals and pearl oysters between October and December 1995;

To provide reports containing data and analyses of all coral, pearl oyster and water quality environmental monitoring.

2. Gutteridge Haskins and Davey

Manager - Mr John Gersekowski

Masterplanning;

Detailed design and documentation;

Technical advice during design and construction phases of the project.

3. Ace Vaughan

Manager - Mr Keven Bascombe

Preparation of environmental impact statement including analysis of life cycle effects of the port construction and reporting on feedback from government, local interest groups and the community;

Geotechnical investigation of the port site and interpretive reporting of the findings including assessment of foundations, slope stability, dredgeability, potential for re-use of materials in reclamation and acid leachate potential of sediments.
3.3  **Contractors**

1. **Henry Walker Contracting**

   Site Project Manager - Mr Robert Wallwork

To provide construction services to the Northern Territory Department of Transport and Works for the first contracts of Stage 1 of the East Arm port project.

4. **PROJECT DESCRIPTION:**

4.1 **Brief description of Darwin Harbour and the existing port**

Port Darwin is an active port servicing general cargo, visiting cruise passengers ships, naval vessels, live cattle and mineral exports and fuel ships. It is the only container port on Australia’s northern coast and is five days sailing from Singapore.

Port Darwin is located within Darwin Harbour, a large estuarine system with a shoreline predominantly lined with mudflats and mangroves, with an estimated area of 500 km². The mangrove forest is currently estimated to cover 20,000 ha of the Harbour’s edge, making it one of the most significant stands of mangroves in Australia.

Darwin residents and tourists utilise the Harbour waters for many recreational activities including fishing, diving and boating. Commercial imports through Port Darwin include vehicles, petroleum, and bulk products such as sulphur, clinker and building materials. Exports include mineral ore concentrates, livestock and frozen meat.

The major developments on the shore of the Harbour representing the main population centre of the Northern Territory are the City of Darwin (with a population of approximately 70,000), the town of Palmerston (population 13,000) and adjoining rural areas (population 14,000).

The Northern Territory Government has begun to design a city for the 21st century in order to maintain a pleasant living environment. To achieve this aim the current commercial and industrial developments need to be relocated in an area devoted to these types of activities. This will ensure that commercial activities are separated from residential housing zones.

4.2 **East Arm Port Development**

East Arm Port - Stage 1 is one of the major steps in this plan to move industrial activities away from the City of Darwin. When operational in December 1997 stage 1 will provide:

- 300 metres of general purpose wharf;
- 80 metres of multi-user platform capable of berthing bulk liquid ships;
- 4 ha land backing;
- 18 ha of industrial hardstand on Quarantine Island.

The port will initially cater for bulk cargo activity such as sulphur and clinker, live cattle exports, petroleum and rig tender servicing and general cargo. The bulk liquids berthing facility is an integral part of the relocation of the industry tank farm from the CBD to East Arm.

The existing port will continue to provide for increased volumes of visiting passenger cruise ships, port precinct visitors and naval vessels on rest and recreation leave.
Completion of Stage 1 will be the first step in developing the new port and will see the eventual construction of major container handling facilities and the terminal for the Darwin to Adelaide railway. The future container facilities will be required as container traffic outgrows existing port facilities.

Facilities for the Navy, including ship maintenance yards and a dedicated offshore supply base, may also be established at East Arm as required. Considerable preliminary contact has been undertaken with the Commonwealth Department of Defence in regard to the various options for establishing increased home porting facilities for an expanded naval presence in Darwin.

4.3 Design Features: East Arm Port - Stage 1

East Arm Port - Stage 1 features the construction of the following components:

- Causeway
- Bund walls
- Realignment of the existing road on Quarantine Island and the provision of a new access road to the end of the bunded section.
- Wharf access embankment
- Wharf structures
- Dredging

This submission relates to all of the components of Stage 1 except the wharf structures. The environmental monitoring addressed the phases of construction which could cause the most environmental concern i.e. excavation of fill material from Quarantine Island, construction of embankments in the harbour and dredging required for the project. Table one contains design details of this work.

Table one: Details of Stage 1

1. Access road, earthworks and bund walls

- 4.8 km of earth formation including 3.3 km off shore, 36 metres wide at the crest at levels as low as -12.0 m AHD resulting in formations up to 17.5 metres in height.

- 3.6 km of 8.3 metre wide access road.

2. Earth fill

- Total volume of fill placed in all areas - 1.7 million cubic metres.

3. Armour rock

- 210,000 cubic metres has been imported from Mt. Bundy with an additional 15,000 cubic metres being supplied from the CSR quarry in Thorngate Road.

4. Dredging

- 380,000 cubic metres of mud has been dredged. Disposal areas used were on Quarantine Island and the impounded area adjacent to North Shell Island.

Table two contains wharf design data for the new port at East Arm.
Table two: Vessels to be accommodated and dredging depths at East Arm Port

<table>
<thead>
<tr>
<th>Stage One</th>
<th>Vessel Data</th>
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<tr>
<td>° Rig Tenders</td>
<td>60 m LOA x 4 m laden draft</td>
</tr>
<tr>
<td>° Livestock Ships</td>
<td>80 m LOA x 5 m laden draft</td>
</tr>
<tr>
<td>° Bulk Carriers</td>
<td>200 m LOA x 11 m laden draft (40,000 dwt) on the general purpose wharf</td>
</tr>
<tr>
<td>° Oil Tankers</td>
<td>240 m LOA x 13 m laden draft (80,000 dwt) at the multi-user platform</td>
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<table>
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<th>Future stages</th>
<th>Vessel Data</th>
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<tr>
<td>° Container Vessels</td>
<td>275 - 300 m LOA, 60,000 dwt (capable of carrying 4-5,000 TEU’s)</td>
</tr>
<tr>
<td>° Oil Tankers and Bulk Carriers</td>
<td>100,000 dwt bulk carriers</td>
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The multi-user platform will be incorporated into the container terminal in Stage 2 and the general purpose wharf will act as a back up berth for the container vessels.

Dredging

° Approach channel and turning basin -12m chart datum. (initially)
° Berth pocket (multi user platform) -14 m chart datum.
° Berth pocket (general purpose wharf) -13 m chart datum.

The overall cost of Stage 1 of the port development at East Arm is estimated to be $75 million, with the Darwin Port Authority supplying $60 million, the Federal Government’s Better Cities program providing $7.5 million and the Department of Lands, Planning and Environment an additional $7.5 million. The earthworks element of the development (including the access road, bunds and wharf access embankment) have been constructed by Henry Walker Contracting for an estimated cost of $25.4 million.

5. IMPACT ON COMMUNITY

Construction of the first stage of the port had little or no direct impact on the communities of Darwin and Palmerston. The location of the development at East Arm has utilised the natural features of Darwin Harbour placing the development within one of the Harbour’s arms, adjacent to the existing live cattle exporting facilities at Wishart Road and convenient to the Trade Development Zone (TDZ).

During construction activities, the Northern Territory Department of Transport and Works has ensured that access to the East Arm public boat ramp has remained available to the general public. Under direction from the Department of Transport and Works, Henry Walker Contracting provided road wardens to direct traffic safely through the construction site to the boat ramp. To this date there has been little restriction to the boat ramp and no accidents involving construction and recreational boating vehicles.

Perhaps the most emotive issue dealt with under the environmental assessment process was the loss of mangroves, given their importance to the life cycle of fish and other marine biota.
As previously mentioned Darwin Harbour supports a mangrove population of some 20,000 ha. The port development will directly result in the loss of approximately 8 ha or about 0.04 per cent of the total population.

It was recognised that the environmental value of mangroves could not be quantified solely on an area basis without reference to the structure and productivity of mangroves and associated fauna.

As about 30 percent of the 8 ha to be lost to development consisted of low productivity zones such as salt flats and cyclone disturbed mud zones, it was concluded that this would have no detectible effect on the overall diversity or productivity of mangroves in Darwin Harbour.

An exclusion zone around the work site was established by placing buoys offshore prior to any work commencing to ensure public safety. A Notice to Mariners was also posted.

Local businesses at East Arm such as the Northern Cement plant and Paspaley have been able to continue operations during the construction phase as they were kept fully briefed on timing and scope of works of all roadworks, blasting and earthworks. Blasting times were notified well in advance and were monitored for sound and vibration levels.

The Department of Transport and Works has adopted a policy of keeping the public informed on all aspects of the project. This has been achieved by:

- Constructing a public viewing platform to ensure that members of the public could see the developing port easily and safely;
- Providing a comprehensive information display at the Transport and Works site office showing progress and details of future works. The display is periodically upgraded to keep pace with development;
- Provision of regular press and media briefings and the circulation of monthly Environmental Bulletins;
- Conducting an open day on 22 October. Approximately 2000 members of the public took part in guided tours of the facility;
- Encouraging various groups to visit the port for both educational purposes (High school and NT University students) and business groups. To date approximately 20 groups have visited the site for briefings and conducted tours.

The Palmerston residential area is located closer to the new port development than the City of Darwin. Although construction activities continued day and night over the contract period, (with the exception of a rostered day off each fortnight), the natural features surrounding the development, in particular the mangrove forest, provided a natural barrier to the carriage of sound and dust from the construction site to any urban residential housing.

Training walls were built within the bunded spoil disposal area on Quarantine Island to maximise the distance the waste water had to travel to the outfall weir thereby ensuing maximum deposition of solid materials prior to discharge.

Waste oil from all equipment on site was collected and stored for recycling.
Armour rock transported to the site has been carted via major highways and through the industrial sector of Berrimah. This has meant that no residential housing estates have been disturbed by the road trains transporting armour to the site.

Direct impact on community lifestyle has been negligible during the development of the port.

6. ENVIRONMENTAL SOLUTIONS

6.1 Environmental Assessment

The residents of Darwin and Palmerston have a strong association with the natural environment of Darwin Harbour, both recreationally and commercially. The Northern Territory Government has been keen to ensure that, during the progressive development of the facilities required to maintain growth in trades and services, the natural ecology of Darwin Harbour is maintained.

The port project was subject to environmental assessment under the NT Environmental Assessment Act and consultants were employed to prepare a Draft Environmental Impact Statement (DEIS) which was open for public review and comment. Interested persons and groups were invited to make written submissions to the NT Government on the proposal.

The Conservation Commission of the Northern Territory, being the agency responsible at the time for environmental assessments, prepared a report taking into consideration all information provided in the submissions. The outcome was that the project could proceed subject to implementation of a number of recommendations and environmental safeguards.

6.2 Reporting

Following the assessment and adoption of the recommendations by the NT Government a Project Environmental Control (PEC) group was established with representatives from all relevant NT government agencies. The group is chaired by the Department of Lands, Planning and Environment (previously CCNT). It considers all environmental matters relating to the port construction making appropriate recommendations to the Department of Transport and Works.

The PEC group established three specialist Technical Advisory Groups (TAGs) on water quality, flora and fauna and on waste management. The Department of Transport and Works nominated an environmental co-ordinator who liaises continually with the environmental monitoring groups, the PEC group and the TAGs, providing a direct line of communication.

The Water Quality (WQ) TAG designed a comprehensive water quality monitoring programme based on a similar programme implemented by the Townsville Port Authority for a major dredging project in 1993. This program had demonstrated its effectiveness as a mechanism for environmental management during the Townsville dredging program.

Threshold criteria for the biological indicators were established on the basis of scientific data gathered by the marine biologists and environmental chemists during the baseline study. If any of the thresholds were exceeded or indications were that they were about to be exceeded during the various dredging and construction phases then the WQ TAG was to make recommendations on actions to be taken to overcome any adverse or potentially adverse effects.
6.3 Consideration of Options

In May 1992 GHD were commissioned to investigate concepts for the new East Arm Port. They outlined two options:

A: A maximum dredge, maximum reclaim option which brought deep water in closer to land, with substantial land backing;

B: A minimum dredge, minimum reclaim option which located the wharf out in naturally deep water but which initially had minimal land backing.

Initially the Northern Territory Government selected option A as the preferred development option. Subsequent geological investigations by Acer Vaughan indicated an extensive requirement for hard rock excavation for the dredged channel, berthing pockets and swing basin.

The construction of the port using option A would have caused significant environmental disturbance to the local marine environment and considerable cost penalties. These considerations saw the Northern Territory Government investigate option B, utilising the natural geographical features of the site, as the preferred option.

The site of the new port was relocated further west to utilise naturally deeper waters. This decision proved to be a more cost effective and environmental friendly solution.

Though some amendments have been made to the layout of the East Arm Port development since the EIS was submitted, the revised layout still fitted within the original footprint and the Conservation Commission indicated that no further environmental impact submissions were required. In addition the revised layout is estimated to have significantly less impact on the local marine environment as hard rock excavation has been minimised.

The method of excavation and disposal of marine sediments were both seen as potential major environmental impacts. Dredging was selected as the method of excavation of the unsuitable foundation materials on the seabed because it produced the least turbidity of all excavation methods. Transport of the material to the spoil sites was done via pipelines ensuring a clean operation.

Previous experience with dredge spoil or disturbed marine sediments in Darwin Harbour had shown that mangrove muds had a high acid leachate potential. Release of this material back into the marine environment, through disposal into tidal channels, was considered undesirable primarily because very little information exists on natural sediment deposition regimes in the Harbour.

Disposal of dredge spoil on land was therefore the preferred option and the material was incorporated into the hardstand areas. Certain mangrove muds can have a high acid leachate potential and to maintain environmental integrity, capping of these materials is being progressively undertaken. Ongoing monitoring of the disposal area will continue for some time to ensure that the acid soils remain stable.

6.4 Development of Biological Indicators

The development of an environmental monitoring program for the port project required the identification of potential biological indicators, followed by the refinement of a monitoring program capable of detecting environmental impact.
The WQ TAG in conjunction with the Department of Transport and Works designed the Water Quality Monitoring Program whose specific aims included:

**Biological Indicators:** To develop the use of corals and pearl oysters as indicator organisms which could provide early detection of any potentially damaging effects created by dredging or other construction activities on marine life in Darwin Harbour.

**Water Quality:** To measure turbidity, suspended sediment concentration, sedimentation rates, heavy metals, percentage sediment cover on coral surfaces and light attenuation to provide indication of the relationship between these characteristics and any biological effects and whether such effects are related to the dredging and construction activities.

**Acid Leachate:** To measure pH, acidity, heavy metals and sediment concentration of the dredge return water to determine if acid leachate is produced as a result of the dredging activities.

To facilitate the gathering of meaningful data, and recognising the dramatic wet season impact on the Harbour (particularly with regards to water quality), the Department of Transport and Works engaged the MEU and NTU to commence the physico-chemical and biological monitoring well before the start of construction activities. This allowed scientists to gather a large volume of baseline data which could be used for environmental monitoring and provide much needed information on the ecology of Darwin Harbour.

The baseline component of the water quality monitoring programme spanned from October 1994 to April 1995.

The outcome of the baseline data collection is presented in the technical report prepared by the MEU, (Appendices K and L), and several research papers are now in development and will be submitted to the following journals: Corals Reefs (international journal), Reef Research and Australian Coral Reefs Society Newsletter.

### 6.5 Additional Projects

Apart from the monitoring programs outlined in the Draft Environmental Impact Statement three additional environmental programmes were conducted:

- The physical relocation of a coral outcrop from an area which was to be dredged;
- The release of several fish species which had become trapped within the bund walls;
- Surveys of bird populations within Darwin Harbour with particular emphasis on breeding areas adjacent to the East Arm Port site.

#### 6.5.1 Relocation of the corals from North Shell Island

During monitoring of corals in the construction phase, marine biologists noticed that the corals of Darwin Harbour lived in an environment where they were continually disturbed (upturned and moved by tidal currents). During the collection of baseline data they conducted additional experiments in an effort to estimate the amount of disturbance different species of corals would tolerate before they began to indicate signs of stress.
As a trial, a number of species were moved to different areas around the Harbour. Subsequent monitoring of the relocated coral colonies showed that they were not affected by the move. At one site (Weed Reef) some of the relocated corals (i.e. Herpolitha limax) doubled their size in a period of four months after the relocation.

The marine biologists then comprehensively surveyed the waters surrounding North Shell Island to locate any areas of coral growth. Once the corals had been located and estimates of numbers of the different species completed, a suggestion was made to the Department of Transport and Works that it would be worthwhile to relocate the population prior to dredging operations commencing to ensure their survival.

Advertisements were placed in the Northern Territory News and a team of 40 volunteer recreational divers was assembled. The divers were tutored by the marine biologists on how to handle and bring the corals to the surface safely and “replant” them at new locations.

On 25 and 26 March 1995, a flotilla of boats left the Cullen Bay Marina and headed for North Shell Island. Divers entered the water in pairs and filled laundry baskets with corals, returning to the boat to unload. A large boat with a floodable deck was hired to hold the corals during transportation. Once the dive time had been exhausted, the corals and divers were transported to a location on Weed Reef, where the colonies were replanted.

Over the weekend the entire coral population was relocated, with some 660 colonies representing 35 species of coral, moved. Subsequent monitoring of the corals at their new home, on the fringes of Weed Reef, have shown that they have thrived at their new location.

6.5.2 Relocation of land locked fish

As construction proceeded, several species of fish became trapped within the bunded areas adjacent to North Shell Island. The Department of Transport and Works was advised by the Darwin Aquaculture Centre - Fisheries Division of the Department of Primary Industries and Fisheries, that the fish would eventually suffer from overheating, overcrowding and oxygen depletion in the ponds and approval was granted to retrieve the fish for breeding purposes.

When the Darwin Aquaculture Centre netted the bunded areas very few fish suitable for breeding were caught. A few hundred assorted fish comprising mainly of Salmon, Mullet and others were released back into the Harbour. This exercise saved the fish from certain death and would be regarded as an unusual activity to be conducted during port construction activities.

6.5.3 Bird survey

The need for a comprehensive bird survey was flagged during the environmental assessment process to determine if construction activities at the new port would adversely affect bird life within the East Arm area.

The flora and fauna TAG designed and supervised the surveys completed by a Conservation Commission wildlife officer as part of his regular bird surveys within Darwin Harbour and along the adjacent NT coastline. The findings of the surveys indicated that the East Arm area was not a significant bird habitat and that the impact of port construction would not be noticeable. A single pair of beach thick knees had been found to inhabit the East Arm area. This pair had successfully bred between the first and second surveys while port construction works were underway.
6.5.4 Site Drainage and Revegetation

Material quarried from Quarantine Island provided the bulk of the fill for the bund construction. Operation of the quarries was designed to ensure that stormwater drainage runoff from disturbed areas was controlled and directed through silt traps prior to discharge into the harbour.

Most of the construction batters on the edge of the quarried areas have been topsoiled and revegetated to prevent erosion during the oncoming wet season. Selected areas within the quarries will also be stabilised prior to the arrival of the monsoon.

6.5.5 Quarantine Island Heritage Area

Quarantine Island has had many uses over the years. It was used as a base for insurgent raids into Japanese held areas in Asia as well as a Catalina flying boat base during WWII and a holding area for Vietnamese “boat people” during the 1970’s. An area of the Island containing the most significant heritage sites has been put aside and fenced and a development plan is being prepared for the management of the area to ensure the history of the Island is not lost.

7. CONCLUSION

The Department of Transport and Works is managing the East Arm port development on behalf of the Darwin Port Authority, the Department of Lands, Planning and Environment and the Federal Better Cities Programme.

Due to the size of the development and the possible ecological impacts on Darwin Harbour the Department of Transport and Works has taken a variety of measures to ensure that the construction phase of the project is cost effective and completed with minimum impact to the environment.

To achieve these goals environmental monitoring procedures have been extensive and funded for long periods of time which have allowed scientists to gather a large amount of ecological data on the harbour for use in this project and other future developments.

A reporting system has been implemented to ensure an immediate review of construction activities causing any impacts on the marine environment. Recommendations to rectify any potential problems would be formulated as part of the review.

Regular press and media briefings have maintained a flow of information to the public. A viewing platform has been constructed on site and a dedicated information display has been provided to show progress and details of future works. Environmental Bulletins have been circulated monthly and a recent open day attracted 2000 local people.

The PEC group and the special TAGs, established with representatives from all relevant NT Government agencies, have proven to be an efficient and effective environmental management tool.

In addition to the water quality monitoring program the Department of Transport and Works also supported the relocation of a coral population away from the dredge path, thereby saving 660 individual coral colonies from certain death.

Fish that had become land locked when the bund walls were completed were released back into the harbour after netting by the Darwin Aquaculture Centre.
Surveys in the East Arm area revealed that the port site was not a significant bird breeding area.

Throughout the construction phase of the new port there has been no detectable environmental impact on the marine flora and fauna adjacent to the work site. The development has met the aims of the construction brief and environmental management program.

8. SUMMARY

Costing Data

- Cost of East Arm Port - Stage 1: $75m
- Cost of work to date:
  - Preliminary studies, environmental impact statement, environmental monitoring of corals, pearl oysters and water quality: $2.0m
  - Masterplanning, design and documentation, technical advice during design and construction phases: $2.0m
  - Contract 1 - East Arm Access road upgrading: $0.4m
  - Contract 2 - Access road, earthworks and bund walls: $16.6m
  - Contract 3 - Wharf access embankment: $8.8m

Total cost of work to date: $29.8m

Environmental Solutions

- Development of interdepartmental water quality technical advisory group and reporting procedures;
- Redesign of development to complement the geographical features of the site;
- Effective management of dredge spoil and acid leachate potential;
- Long baseline study allowing ecological research during wet season (1994/95);
- Development of bio-indicator organisms;
- Development of Water quality data collection regime;
- Development of acid leachate regime;
- Relocation of coral reef outcrops to stop damage by dredging procedures;
- Rescue of land locked fish inside the bund wall.
- Surveys of bird populations in the proposed port area.
REFERENCES

Acer Vaughan (1993)


Acer Vaughan (1993)


Environment Protection Unit (1994)


Coastal management issues in the Northern Territory. Marine Pollution Bulletin 25:134-142


APPENDIX A

CLIENT STATEMENT
STATEMENT OF CLIENT REQUIREMENTS

The Northern Territory Government believes that, given appropriate infrastructure, Darwin will develop into a regional transport hub serving our neighbouring Asian countries and will, increasingly, become Australia's Gateway to Asia.

A primary infrastructural component needed to achieve this objective is the provision of a modern, cost-effective port, capable of expansion as freight demand escalates.

Darwin's existing port is well capable of handling the current freight task although road access is becoming less efficient as the city's residential areas encroach on the port's immediate hinterland. For the same reason, the re-establishment of a rail link to the port has become less feasible and would entail unacceptable constraints in the future.

Consultants recommended East Arm as the site for a new port as early as 1967. The site provides:

- good access to deep water;
- good access for a future rail link with the southern States;
- ample room for the development and expansion of a major port and its associated industries;
- good access to existing industrial areas including the Trade Development Zone Authority;
- ample separation from sensitive land uses;
- unrestricted road access.

A further factor considered by the Government when committing to a decision to build a new port was the value of the land upon which the existing port is situated. The port is adjacent to the Central Business District and offers exceptional potential for the development of recreational and tourist related facilities. Some land has already been released for these purposes and the facilities provided are proving to be extremely popular.

The "greenfields" site at East Arm has permitted a port design which meets all the essential criteria identified by Government to accommodate Darwin's marine transport needs in the foreseeable future. The completed port will provide:

- 900 metres of berth space for container vessels to a deadweight of 70,000 tonnes;
- craneage and associated land transfer equipment commensurate with working post-Panamax vessels;
- a full automated container transfer system from ship to rail and vice versa;
- container storage facilities with a capacity for a through-put of 500,000 TEUs per annum;
- the northern terminal of the Darwin to Adelaide railway;
- three berths for livestock carriers;
- bulk liquids berths, including oil tanker berths, for vessels to 100,000 tonnes deadweight;
- berths for bulk cargo carriers to 100,000 tonnes deadweight, including bulk cargo loading and unloading units and associated conveyor systems;
- undercover storage and stockpile areas for bulk cargoes;
- berths for rig service vessels with adjacent land areas for the establishment of logistic bases;
- ample undeveloped land adjacent to the port for the establishment of marine-related service industries.

Ample space also exists for the construction of berths for fishing and naval vessels, together with land for their associated support services. Similarly, an area has been identified for the establishment of ship building, ship repair and maintenance facilities.
The Government's program calls for the completion of Stage 1 of the new port by December 1997. Initial construction stages are well advanced and potential tenderers for the final construction stage indicate that completion of Stage 1 is likely to be achieved some months before the Government's target date.

Stage 1 will provide 300 metres of general purpose wharf and an 80 metre long multi-user platform capable of berthing bulk liquid vessels to 240 metres in length. Four hectares of hardstand will back the wharf faces with a further 18 hectares of industrial hardstand available on Quarantine Island.

The transfer of cargo handling from the existing port to the new port will take place progressively as each Stage of the new port is completed. The immediate transfer of imported bulk cargoes (such as sulphur, clinker and lime), livestock exports, rig service vessel activity and general cargo handling will take place when Stage 1 is opened.

The transfer of container handling, bulk cargo exports and bulk liquid cargoes will take place as demand dictates.

Not only is the construction of Stage 1 expected to be completed ahead of schedule but there is every expectation that the project will be completed within budget.

This Authority commends all agencies and contractors involved in the design, construction and monitoring processes of the project. Cooperation, combined with professionalism, has been displayed by all parties throughout and we are confident that Darwin will be provided with a high quality asset on which the future of the Northern Territory's shipping requirements may be firmly based.

JOHN BUTLER
Port Manager
Two statements have been included.

The first statement is an overall project statement describing the physical elements of the Stage 1 Development of the Port of Darwin. It also contains aspects of the environmental monitoring during construction of the Port.

The second statement describes in more detail, the elements of the environmental monitoring including the structures set up to manage the process. It also describes some of the results of the monitoring.
The Northern Territory Government announced in August 1992 that additional port facilities would be built at East Arm in Darwin harbour.

The port has been designed to make provision for the long planned Darwin to Alice Springs railway line and represents a major step in the Government's strategy to ensure that Darwin plays an increasingly important role in Australia's trade with nations in the rapidly expanding Asia Pacific region.

East Arm Port is being built on a greenfield site with ample land available for expansion. Over 1700 hectares will be available for development for port related and waterfront industries, light, medium and heavy industries, transport services and naval services.

Stage I of the new port is estimated to cost $75 million and will provide 300 metres of general purpose wharf and an 80 metre long multi user platform capable of berthing bulk liquid ships with 4 ha of land backing plus an extra 18 ha of industrial hardstand on Quarantine Island.

The Darwin Port Authority is funding $60 million with the Department of Lands, Planning and Environment and Federal Better Cities providing $15 million for the multi user platform.

The port will initially cater for bulk cargo activity such as sulphur and clinker, live cattle exports, petroleum products and rig tender servicing and general cargo. The bulk liquids berthing facility is an integral part of the relocation of the petroleum industry tank farm from the CBD to East Arm.

The existing port will continue to provide for general cargo and containers in the short term. It will also continue to provide for increased volumes of visiting passenger cruise ships, port precinct visitors and naval vessels.

The Department of Transport and Works is managing the project on behalf of Darwin Port Authority and the Department of Lands Planning and Environment. A project control group has been established to represent interests of Government, the clients, end users and Transport and Works as project managers.

Major consultants involved in the project are Gutteridge Haskins and Davey (planning and design), Acer Vaughan (geotechnical and DEIS) and the Museum and Art Gallery of the NT, Hanley Caswell & Associates and the Northern Territory University (Environmental monitoring).

Construction work on site to date has been undertaken by Henry Walker Contracting. The first contract costing approximately $16 m consisting of earthworks and rock armouring has been completed and a second contract consisting of a 450 metre long wharf access embankment valued at $8.8 m was awarded in September. This contract will be completed in time for wharf construction and dredging to commence early in the new year and be complete by the end of 1997.

A draft Environmental Impact Statement (DEIS) and assessment were undertaken in 1993 and endorsed by the former Conservation Commission of the Northern Territory (now the Department of Lands, Planning and Environment - DLPE).

The recommendations of the DEIS are being adhered to with more than $500,000 being allocated for a comprehensive environmental
management programme. This has been favourably received by interested community and environmental groups.

Environmental issues have been thoroughly researched throughout the planning, design and construction phases of the project and many proactive environmental actions have been taken.

A project Environmental control group chaired by DLPE and made up of experts from various NT Government departments provides advice on environmental aspects.

To date, the main thrust has been on obtaining baseline studies and extensive monitoring of the effect of construction (including dredging) on the marine environment within the harbour.

The Marine Ecology Unit of the NT Museum and Art Gallery and the Environmental Chemistry Department of the Northern Territory University are undertaking a coral monitoring and water quality program.

The program is based on the successful monitoring program undertaken in Townsville in 1993 by James Cook University on behalf of the Townsville Port Authority.

A spinoff will be the acquisition of baseline environmental data on the harbour which was previously unavailable to the scientific community. This data will enhance the knowledge and understanding of the unique Darwin harbour environment thus enabling informed development decisions to be taken in the future.

The monitoring programme is designed to provide a warning system in case construction and dredging operations have an unacceptably adverse effect on marine life in the harbour so that immediate corrective action can be taken if necessary to reduce the effects.

The constant monitoring in the area adjacent to the construction activities and outer control areas have found that there are no measurable impacts on the environment.

Successful media campaigns including provision of bulletins to the media and other interested bodies on progress and testing results and the coral relocating exercise in March this year all enhance the public’s knowledge and confidence.

The problem of acid sulphate sediments was highlighted early in the project planning phase by geotechnical investigations. Care was taken not to expose these materials to the air during earthwork excavation and dredging operations because this would cause the sulphides in the materials to oxidise and form reactive sulphuric acid.

It is planned to provide an area in the East Arm area for public usage and interpretation signage to acknowledge the significant history of the area including WWII catalina bases, the Q station (multi national intelligence gathering operations and for the training of foreign allied insurgents), aboriginal sacred sites, the leprosarium and immigration issues.

Comprehensive bird surveys have been undertaken as baseline data and during construction. Data collected to date indicates that port construction activities have not affected bird habitats within the harbour.

This major development, combining the best in creative design and innovative technology, will have a positive flow on effect to all aspects of life in Darwin.

The value of the benefits of the expanded port to local businesses, local development and local people cannot be underestimated.
In November 1993 the NT Government released a draft Environmental Impact Statement (EIS) for a proposed expansion of the Port of Darwin. The site for the new port is located in East Arm, about 5 km east of the existing port and further upstream in Darwin Harbour.

The environmental impact assessment of the proposal was completed in February 1994 with the outcome that it could proceed subject to a number of environmental safeguards being implemented. One of the main concerns was the possible impacts construction and dredging activities could have on marine life and water quality in the Harbour. A comprehensive water quality monitoring program was developed, based on a similar program implemented in Townsville in 1992 in conjunction with a major dredging project.

The Townsville program used corals as indicator species and, after careful consideration, it was decided to do the same for the East Arm Port development. The corals used in Darwin Harbour are: Mycedium elephantotus, Herpolitha limax, Turbinaria spp. and Goniopora spp.

It was also decided to monitor pearl oysters because two pearling companies in Darwin lease areas in the Harbour and have established pearl oyster beds in these areas. One of the areas used for this purpose is fairly close to the port site and there were concerns that construction and dredging activities would adversely affect the oysters.

Four sites in the Harbour were chosen for the coral and pearl oyster monitoring: a primary impact site adjacent to the port; a secondary impact site across the channel from the port; and two control sites some considerable distance from the port. An additional pearl oyster monitoring site was chosen at the pearling company’s lease area. Twenty colonies of each coral species were tagged at the four monitoring sites and photographed to provide a record of their health.

During the monitoring, which is still in progress, the tagged corals are being checked for bleaching and mortality once a week. The monitoring program includes measuring water quality parameters such as temperature, dissolved oxygen, salinity, turbidity and heavy metals. Water quality is measured at the five sites described above and at another three sites near the port.

A rapid response group has been established to consider and make recommendations on any necessary action in case the monitoring shows any indication of deterioration in water quality. The group will consider options to change or vary the activities to overcome any adverse effects on the corals, pearl oysters or water quality.

Baseline data collection for the corals and pearl oysters commenced in November 1994, 26 weeks before dredging activities started in May 1995. This period of baseline data collection has provided a good base for the reactive monitoring phase that commenced with the dredging activities.

During the baseline collection, two events occurred that severely affected the health of the corals. Soon after the monitoring commenced in November 1994, coral bleaching was very high at the primary impact site. Mortality was also greater at this site than the other sites. As construction activities had not commenced this event could not be attributed to the port construction. At this time of year Darwin Harbour has very low tides during the middle of the day. It is assumed that the corals were exposed to the sun and this, it is thought, caused the high bleaching and mortality.
Corals at the other monitoring sites were not as stressed as corals at the primary impact site. The lower stress was attributed to the transects being about half a metre deeper at these sites. A new transect was established half a metre deeper at the primary impact site. A check has been kept on the health of the remaining live colonies at the old transect. It is hoped monitoring during November 1995 will confirm that the cause of the high coral stress at the primary impact site was their exposure during the low tides, in particular if coral stress is lower this year than last year.

The other event that occurred was the onset of the wet season with heavy rainfalls in January 1995 which produced a great influx of sediment into the Harbour. The health of all the corals deteriorated at the onset but picked up and recovered as the wet season progressed and the silt load lessened.

The results from the monitoring to date indicate that dredging and construction activities have had little effect on the corals, pearl oysters and water quality in the Harbour. Coral and pearl oyster monitoring continues on a weekly basis whilst the water quality parameters are now checked once a month. The present monitoring continues and will continue for a short period after the present earth works, including dredging, is completed, probably in June 1996.

A major impact identified during the assessment of the port development was the loss of coral reefs at the port site. During the baseline monitoring it had been observed that many coral colonies were loose and were moved around by the strong tidal currents in the Harbour. It was therefore decided to relocate the corals from the reef at the port site to a reef elsewhere in the Harbour in an attempt to save them. These corals have been monitored as part of the monitoring program and it appears that the relocation was successful. The corals are alive and healthy six months after the relocation.
APPENDIX C

STAGE 1
APPENDIX D

MASTERPLAN
EAST ARM PORT DEVELOPMENT
MASTER PLAN

LEGEND

- BULK ORE/COAL FREIGHT
- CONTAINER FREIGHT
- ALTERNATE BULK DRY
- CONTAINER BERTHS (700m)
- GENERAL PURPOSE
- BOAT DUMP
- GUNN ISLANDS
- NORTHERN CEMENT PLANT
- STOCKPILES AND BULK LOOPS
- MARSHALLING YARD
- SHORT TERM RAILWAY
- LONG TERM RAILWAY
APPENDIX E

ENVIRONMENTAL BULLETINS
The Marine Ecology Unit of the NT Museum and Arts Gallery has been busy setting up the water quality monitoring program as the first stage of the Government's commitment to ensure that stringent environmental standards are followed to protect Darwin Harbour during construction of the new East Arm port.

The water quality monitoring program has been designed following consultation with relevant NT authorities and internationally recognised experts through the James Cook University in Townsville.

The monitoring program is designed to provide a warning system in case construction and dredging activities have an unacceptably adverse affect on marine life in the harbour, so that corrective action can be taken, if necessary, to reduce the effects.

Biological indicators at two impact sites close to the proposed works and two control sites outside the area of potential impact are being monitored.

The four sites selected have corals growing despite the muddy conditions. These are at the impact sites of South Shell Island and near Wickham Point and also at the control sites of Channel Island and Weed Reef. Divers have surveyed the sites and selected four species of coral which are common at all four sites.

Diving will be undertaken on Monday and Tuesday every week during the monitoring period. Completing the monitoring tasks under water is difficult because of the fast currents and low visibility. The best visibility would be around 3 to 4 metres and the worst can be less than 30 centimetres.

Within these sites a total of 320 colonies of coral have now been identified and marked in a way that does not damage them but will allow divers to find them quickly each week during the monitoring period. (Each colony can be equated to a single animal).

During the next two weeks the next step of the establishment process will take place. This involves photographing each colony underwater to provide a baseline estimate of each coral's health.

As part of the monitoring program panels of pearl oysters are being installed at each monitoring site. The oysters will be distributed to their respective sites this week.

Further aspects of the Environmental Monitoring Programs will be reported in future bulletins.

For further information contact:

Phill Piper
Environmental Co-ordinator,
Department of Transport and Works.
Telephone: 89 4628
Facsimile: 89 4633

The East Arm Port Development Environmental Bulletin will be issued fortnightly. If you would like to be included on the mailing list please contact:

Trish Roberts
Public Relations Officer,
Department of Transport and Works
Telephone: 82 7116
Facsimile: 82 7200
Since the release of Bulletin No. 1, significant progress has been made in setting up the phase 1 of the water quality monitoring program.

Tagging of all coral colonies has been completed by the Marine Ecology Unit of the Museum and Arts Gallery. Rope transects have been attached to the harbour bottom to enable individual colonies to be easily located each week with a minimum of diving time.

Photography of the coral colonies is being carried out at neap tides as underwater visibility improves.

Racks of pearl oysters have been located at five sites in the harbour (South Shell Island, Channel Island, Wickham Point, Weed Reef and the Paspaley pearling beds).

The method used to deploy the oysters was developed locally and consists of a rigid triangular metal frame supported by a single buoy at each corner with a rack hanging from each buoy. Two frames have been installed at all of the above sites.

The next phase of the monitoring is to commence within the next two weeks and will entail the weekly collection of data on the relative health of the organisms selected for monitoring.

It is important that baseline monitoring occurs prior to construction work so that realistic comparisons can be made between health of the corals and pearl oysters both before and during the construction phase.

Weekly visits by the divers will enable subtle changes of the health of the corals or oysters to be identified quickly. If health problems occur speedy corrective action can be taken to address the situation during the construction phase.

During monitoring the diving team has noticed that some locals are tying their boats up to the buoys. The public are asked to keep clear of these buoys and the other single buoys nearby which mark the beginning of the rope transects on the bottom of the harbour. Although well anchored to the bottom, the buoys are not suitable for moorings and anyone interfering with them could seriously affect the results of the monitoring program.

For further information contact:

Phill Piper
Environmental Co-ordinator,
Department of Transport and Works.
Telephone: 89 4628
Facsimile: 89 4633

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Trish Roberts
Public Relations Officer,
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Telephone: 82 7116
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In Environmental Bulletin No. 2 a request was made on behalf of the diving team conducting the water quality monitoring program that local boat owners and divers keep clear of the buoys marking the monitoring sites.

Unfortunately, a dive on the 28 November revealed that over the weekend the ropes marking approximately 20 coral colonies being studied at the Wickham Point site, were severed. This damage seems to have been caused by anchors snagging the ropes. A frame containing pearl oyster shells, an integral part of the monitoring program, is also missing and appears to have been stolen.

There is very little to prevent the public entering the test sites within the harbour, apart from appealing to boat owners and divers to leave the experimental areas alone.

In early November it was observed that all the corals at South Shell Island and many of the corals at the other sites were bleached. The cause of the bleaching may well be due to the recent very low tides during daylight hours. Corals at South Shell Island are in slightly shallower water than at the other sites and were affected to a greater degree.

Darwin harbour is not a particularly good habitat for corals and the coral species that do occur in the harbour have to deal with the problems of very turbid waters, which tend to force them to grow in very shallow water, and the problem of exposure on big spring tides at the hottest time of the year. Most of the very low tides occur right in the middle of the day when potential damage from sunlight is at its maximum.

Corals are subject to higher temperatures and greater amounts of sunlight in the shallow water at low tides and they may respond to this stress by expelling their symbiotic algae (zooxanthellae) resulting in bleaching. During the monitoring in mid November it was observed that approximately 80% of all the affected corals had recovered.

A bird survey has just been completed as part of the extensive monitoring program associated with the port development. Observations of local sea birds and waders likely to be found in the harbour were carried out both by aerial observations and ground verification of target areas within the harbour.

The survey was conducted during November to coincide with the expected breeding season of the Beach Thick-Knee, as it was considered important to know how many of these birds reside in the harbour and whether the harbour is one of their main breeding areas. The preliminary indications are that the incorporation of North Shell Island into the general port area at East Arm, is unlikely to have any significant adverse effect on the breeding of the Beach Thick-Knee, or other birds within the harbour.

It is expected that the report of this survey will be released by the end of December 1994 and the findings of the study will be summarised in a following Bulletin.

Environmental Chemists from the Northern Territory University, as part of the monitoring team, will commence 4 weeks of intensive water quality baseline testing and data collection today. Water temperature, dissolved oxygen, suspended solids, pH, turbidity levels and concentrations of heavy metals are some of the water quality characteristics being measured.

For further information contact:
Phill Piper
Environmental Co-ordinator,
Department of Transport and Works.
Telephone: 89 4628
Facsimile: 89 4633

The East Arm Port Development Environmental Bulletin will be issued fortnightly. If you would like to be included on the mailing list please contact:
Trish Roberts
Public Relations Officer,
Department of Transport and Works
Telephone: 82 7116
Facsimile: 82 7200
Construction of the first stage of the new port at East Arm has been awarded to Henry & Walker at a cost of $15 m. The work consists of the construction of an access road, a 1800 metre long X 30 metre wide causeway and bund walls which will enclose an area of 12 Ha for future reclamation.

The perimeter bund walls are to be constructed in tidal conditions using material won from Quarantine Island. The bunds will be protected by armour material imported from local quarries. Roadworks will consist of a new access road and extension within the bunded area. All roadworks will be constructed whilst maintaining property and boat ramp access to the general public.

A notice was placed in the local press today advising the general public that construction had commenced and that heavy plant and equipment would be working in the East Arm area from that date onwards and warning the public to exercise caution on Berrimah road and within the vicinity of the works. Notice was also given that blasting on Quarantine Island would commence from today.

Monitoring has recommenced after a short break over Christmas. Baseline monitoring has been completed and the teams have moved into the construction monitoring phase.

An interesting development which occurred during recent monitoring was the identification of a potentially serious pest amongst the fauna living on the outside of the oyster shells that are being used in the monitoring programme.

The boring sponge, Cliona margaritiferae, commonly called the "cancer sponge" bores its way through the shell of the oyster near the hinge, attacking the adductor muscle and eventually killing the animal.

The species is native to Sri Lanka, and may have been transported to other areas through pearl oyster trade. It was first recorded in Australia in 1911 in Western Australia and therefore may be native to our waters also.

Although the sponge has been responsible for major losses in Sri Lanka and the Persian Gulf, it is found in relatively low concentrations in Australia and there have been no major outbreaks. Paspaley Pearls have reported that the sponge occurs in 5 - 10 % of all oysters collected for cultivation. These individuals are returned to the sea, while cleaning probably keeps the remaining oysters free from colonisation.

Other factors which may influence sponge abundance include availability of habitat, age and health of the oysters, position on the racks, water quality and handling procedures. Regular cleaning of the oyster shells during monitoring will be carried out to avoid colonisation by the sponge.
Earthworks have commenced on the access road and the bund wall for the spoil disposal area and site compounds have been established to provide offices and other facilities to on-site workers. Progress on site has been quite slow because of the recent heavy rains.

The blasting contractor has completed the first blast on Quarantine Island. Prominent signs are erected well in advance of each blast advising when the blasts will occur. Henry & Walker placed a public notice in the NT News advising that heavy transports would be using Berrimah Road and that blasting would occur periodically on site and caution should be exercised by all visitors.

The collection of baseline data on corals by the Marine Ecology Unit of the NT Museums and Arts Gallery is progressing well. The results to date show very clearly the importance of baseline data collection and control sites located well away from the construction site area.

In the Darwin region, the largest tides of the year occur through the period October to April. Very large areas of the seabed that are usually under water at other times of the year can be exposed during these extremely low tides. These low tides always occur in the middle of the day when the sun is directly overhead and the potential for damage to delicate marine organisms is at its highest.

The monitoring programme has now recorded the effects of two sets of low tides in November and December last year which badly affected the corals being studied. Many of the corals at the monitoring sites have been affected, particularly those in the shallowest part of the depth range for corals in the harbour. For two of the species the damage has been severe with the bleaching and death of some of the colonies, but not all species have been affected in the same way.

The capacity of these corals to recover from such extreme events appears remarkable, but at two of the sites there is evidence that some coral species are continuing to be stressed by the severe decline in water quality which began with the arrival of the monsoon in January.

The water in the harbour is now very dirty with dive teams reporting visibility of less than 10 cm and having to use torches to examine corals in shallow water in the middle of the day. The amount of silt settling out has covered the monitoring sites in 2 to 3 cms of mud and sand.

It is very important to understand that the observed damage to the coral colonies occurred before any construction and dredging activities commenced and that the natural cycle of the seasons can have a dramatic effect upon flora and fauna in the harbour.

The results of the baseline data collection will now be analysed to determine the appropriate strategy of detection and response to be adopted during the monitoring phase of the programme during dredging (expected to commence end of March 1995).
Frequent rain during January and February has hampered work on site. The Bureau of Meteorology advised that Darwin’s January rainfall of 940.4 mm eclipsed the previous January record of 922.2 recorded in 1991 and was the second highest total recorded at Darwin for any month (the highest total recorded for any month was 1013.6 which occurred in March 1977).

Blasting on Quarantine Island has been underway since the last bulletin. Fifteen blasts have been completed and approximately 100,000 cubic metres of material have been removed from the various quarry areas.

The quarries have been worked in such a way that a barrier has been retained which prevents any material being washed into the mangrove area on the eastern side of the Island.

The material won from the quarries has been used to construct two sides of the spoil disposal area which is located adjacent to the main access road. It is expected that the gap in the last side of the impounded area will be closed to the sea on Monday 27 February 1995.

The quarried material has also been used to construct the main access road into the new port (some of which forms the third side of the triangular spoil area mentioned above). The quarry material is mostly a good quality sandstone rockfill.

Construction of the stage 1 bund has been completed up to the shoreline and the contractor is about to commence the section that protrudes out into the harbour and leads to the wharf face. Removal of mud from beneath a short section of the bund adjacent to the site compounds has been completed.

Armour for protection of the stage 1 bund is being collected from both Quarantine Island (sandstone) and a quarry at Mt Bundy (granite). Approximately 900 tonnes of primary armour has been transported from the Mt Bundy quarry - this material has been placed directly on the seaward side of the bund. The armour rock from Quarantine Island is likely to be suitable as secondary armour (under the primary armour) at more exposed sections of the bund.

Dredging of unsuitable foundation material is expected to commence during April and approximately 70,000 cubic metres of mud will be removed to allow the outer extremity of the stage 1 bund to be constructed on a firm foundation.

The water quality monitoring is now into week 18 and is gearing up for a more intense period during the minor dredging. Besides monitoring health of corals and pearl oysters during and after the dredging phase, heavy metals and acid leachate (both of bulk mangrove mud placed in the disposal area and leachate from this area) will be monitored weekly to ensure that decant water from the spoil disposal area is of acceptable quality for discharge into the harbour. Decant water not meeting acceptable water quality criteria will be treated prior to release.
The Northern Territory Government has begun construction of new port facilities in the East Arm area. The Port Authority has undertaken to monitor corals as bio-indicators for the Darwin Harbour region, to determine the impact (if any) of dredging on marine life during port construction.

Darwin Harbour does not support many species of corals, and these tend to be restricted to small patches on shallow water rocky reefs. Marine Biologists have recorded 111 species of corals from the Harbour, compared with the 250-330 species recorded from true coral reefs elsewhere in tropical Australia.

Much of the Harbour is very shallow, and it is only the strong tidal currents generated by large volumes of water moving into and out of the Harbour every six hours which maintain the deeper channels in the Harbour.

The combination of muddy shorelines and strong tidal movements produce turbid waters which are naturally high in suspended solids. These factors are further exacerbated during the wet season when large volumes of freshwater and sediment are flushed into the harbour.

The corals which are relatively common on the suitable substrates in the Harbour are those which can cope with the stresses imposed by the deterioration of water quality every wet season; stresses which are present to some extent for most of the year.

Coral species are known to exhibit signs of stress relatively quickly and a major clue to stress is bleaching - a loss of typical colouration which occurs when corals eject their symbiotic zooxanthellae.

During the baseline data collection the MEU conducted several other experiments, including relocation of corals from one site to another. Some species of corals, such as the mushroom and slipper corals are quite adaptable to relocation, and after six months have shown no signs of stress, injury or bleaching. Other species such as Turbinaria sp. and Mycedium elephantopus have also shown no ill effects.

As North Shell Island will become part of the supporting structure of the East Arm Port Facility, the corals in the shallow waters around the island are being relocated. The Northern Territory Government has provided funds for volunteer divers to relocate the corals to suitable sites on Weed Reef.

The weekend of 25 and 26 of March 1995 has been chosen for the relocation due to the neap tides at that time. Volunteer divers will assist marine biologists from the MEU to relocate the corals.

The Northern Territory Government is confident of the success of this operation which is the first of its kind for the Northern Territory.
Construction of the new port is progressing smoothly. The embankment reached North Shell Island on 16 May 1995 and is now circumnavigating the island and will rejoin the main embankment at a point approximately half way along its length.

Before this loop can be constructed the soft unstable material along the alignment of the embankment must be removed by dredging and disposed of within the impounded area on Quarantine Island. Dredging operations commenced during the first week of May but breakdowns and other difficulties resulted in a number of shutdowns. It is expected that operations will be stabilised within the next week and significant progress in embankment construction achieved.

It is anticipated that 120,000 cubic metres of mud will be removed to the impounded area. This mud (and a significant volume of seawater) enter the bund at the southern corner of the impounded area and the flow is directed around a series of internal training walls which significantly increase the distance the decant water has to travel before it discharges over the outlet weir at the north western corner of the area. This increase in length ensures that as much material as possible is settled out before the water is released back into the harbour.

The regular monitoring programme conducted by the NT Museums and the NTU has passed from the baseline phase into the operational phase. Results to date have indicated that none of the coral colonies have been affected by the dredging operations.

In addition to the monitoring programme Construction Agency supervisors are taking daily pH measurements both inside and outside the impounded area. These measurements will allow early detection of any potential problems with the dredge decant water being released back into the harbour. Any necessary action to rectify the problem can then be quickly determined and implemented.

The corals which were relocated from North Shell Island on the 25 and 26 March have been continuously monitored along with the regular coral colonies and it has been reported that they are enjoying their new habitat.

Some statistics on the project to date are:

- A total of 600,000 cubic metres of material have been extracted from Quarantine Island and used as fill in the embankment. This has resulted in a lowering of the surface level of the island in the vicinity of the quarries by some 15 metres.
- Total length of embankment constructed to date is 3300 metres.
- Approximately 63,000 tonnes of rock armour have been imported from Mt. Bundy. This is equivalent to 900 road train loads. Most of this has been placed on the sides of the embankment as storm protection.
- Volume of mud dredged is 26,000 cubic metres. An additional 28,000 cubic metres was removed by excavator and truck.

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Construction of the bund wall around North Shell Island is 50% complete. Approximately 40,000 cubic metres of mud have been dredged from under the embankment alignment and placed in the impounded area. A second dredge commissioned to increase output is expected to be operational within two weeks.

Monitoring of seawater inside and outside the bunded area (as described in Bulletin No. 8) has revealed lower than normal pH readings within the bunded area. This means that seawater inside the bund (pH 7.3) is more acidic than the seawater of the harbour (pH 8.2).

Tests of the small amount of water leaking through the bunds have also shown lower pH values although subsequent sampling over the area out to 100 metres seaward of the bund shows no evidence of lower pH persisting for more than a few metres from where the water is escaping from the bund ie pH values quickly return to that of normal seawater just a few metres from the base of the bund.

Some decant water discharged over the weir on Monday 5 June. This water had a pH similar to seawater, and its content of dissolved heavy metals was not dissimilar to that of normal seawater in the harbour.

In this respect the impoundment and decanting process has been successful. However, the decant water was carrying higher than normal amounts of suspended sediment out of the impoundment, and this material contained heavy metal concentrations, higher than those normally recorded in the seawater of the harbour.

While the recorded concentrations were well below the National water quality levels recommended by ANZECC (Australian & New Zealand Environmental Conservation Council), immediate action was taken to close the weir and make modifications to the impounded area to ensure that the decant water characteristics were close to normal harbour background levels prior to release. To achieve this aim the internal training wall layout was amended, the weir location changed and the level of the weir raised to increase water retention time.

The bunds enclosing the impounded area are being progressively sealed by the dredged mud. To speed up this process the dredge outlet pipe has been relocated and is gradually being extended along the inside edge of the western bund.

Continued monitoring of the impounded area will indicate if any further remedial action is required during the current dredging contract.

During the last few weeks the NTCA supervision staff have reported that the public are fishing off the rock protection that has been placed along sections of the embankment.

A notice will be placed in the NT News advising the public that while access to the public boat ramp is being maintained they are not to enter the construction site.

Henry Walker Contracting recommence blasting on Quarantine Island on 17 June.

Construction of a groyne (an extension to the present embankment) is to be the next stage undertaken at the port. This work will be tendered in July and it is expected that a contract will be awarded in August 1995.
The Marine Ecology Unit of the Museum and Art Gallery of the Northern Territory and the Environmental Chemistry Department of the Northern Territory University have now been monitoring water quality, corals and pearl oysters in Darwin harbour for thirty seven weeks.

During the twenty six weeks of baseline data collection, (before the dredging began), the monitoring team recorded substantial natural fluctuations in water quality and coral health.

It is not known if the death of corals is an annual event during the low spring tides of October, November and December. Monitoring is expected to continue through to December this year which will provide an opportunity to confirm whether the high mortality is an annual cyclic event or the result of special conditions in November 1994.

Divers surveying the corals every week began to notice the presence of new colonies of some species in February and March of 1995. This suggested that the corals spawned in November (the same time as the corals on the Great Barrier Reef). Until this observation it was assumed that corals in the harbour might spawn in March as they do on the Western Australian coast. Since noticing the arrival of these new corals the divers report that the growth of some of the species is extremely rapid. Discussions with coral experts on the east coast suggest that these growth rates might be the highest recorded in Australian waters.

Since the end of the wet, water quality in the harbour has steadily improved, and this has resulted in healthier corals. The dredging programme has had no impact upon this rate of improvement and at present there is virtually no bleaching of corals apparent at any of the monitoring sites. Therefore the harbour appears to have returned to typical dry season conditions.

Pearl oysters have also been monitored throughout the thirty seven weeks and apart from a low level of mortality (10 out of 180) all oysters have not only shown no signs of stress but have continued to thrive and grow especially during the middle of the wet season. This demonstrates how a deterioration in water quality may be quite stressful to some organisms (corals) while it may represent an improvement in conditions ideal for growth in another species.

Construction operations at the new port have continued at a rapid rate. The embankments have engulfed North Shell Island and are now within 300 metres of completion. Armour rock is being placed progressively on the completed formations.

To date 870,000 cubic metres of fill (mostly excavated from quarries on Quarantine Island) have been placed with 110,000 tonnes of armour rock being imported from remote quarries at Mt Bundy and Yarrawonga. The quarrying on Quarantine Island is being carried out in an area identified for this purpose in the port EIS. The historic area on the Island containing the most important WWII sites has been fenced off. No quarrying will be undertaken in this area.

Over the last 11 weeks 70,000 cubic metres of material has been dredged from bund alignments adjacent to North Shell Island. This material has been placed mainly in the disposal area on Quarantine Island but during the last two weeks some has been pumped into the enclosed area on the eastern side of North Shell Island. A total quantity of 15,000 cubic metres will be dredged into this area and allowed to settle.

Work is continuing on the main road into the port and the formation is almost up to final surface level. This road will be sealed all the way to North Shell Island once pavement construction is completed.
The current bund and access road contract (contract No. 2 of stage 1) is nearing completion. Some interesting statistics on the project to date are as follows:

- Volume of fill placed in all areas - 1,150,000 cubic metres.
- Volume of material blasted on Quarantine Island - 825,000 cubic metres.
- Volume of mud dredged - 86,000 cubic metres. An additional 28,000 cubic metres of mud were removed by excavator and truck from the main access embankment alignment on Quarantine Island.
- Armour rock imported from Mt. Bundy - 185,000 tonnes with an additional 10,000 tonnes transported from the CSR quarry in Thorngate Road.

Contract No. 3, which consists of a 450 metre extension of the wharf access embankment towards the CBD, was recently awarded to Henry Walker Contracting at a cost of $8.8 M. This contract is due for completion by February 1996.

About 450,000 cubic metres of terrestrial fill will be placed to form this extension following the dredging of 280,000 cubic metres of unstable material from the embankment alignment. This material will be placed in the North Shell Island impounded area.

The wharf structure will be constructed adjacent to this embankment providing the first 300 metres of general cargo wharf and an 80 metre long bulk berth. Terrestrial fill will be used to create a four hectare hardstand area for port operations at the end of the existing embankment.

Expressions of interest for wharf construction and dredging (contract No. 4) were called during August 1995 from a list of preselected local firms. Four of these firms will be invited to submit design/construct tenders. Work is expected to commence in December and be completed by November 1997.

The current contract for monitoring corals, pearl oysters and water quality concludes at the end of September. A new three month contract will be signed with the monitoring team to cover the next phase of dredging and construction.

Since the previous bulletin, monitoring results have shown that the recent low tides have not harmed the coral colonies at the impact and control sites. The diving team will continue to monitor the colonies closely as we move into the latter part of the year as high coral mortality occurred during the corresponding period in 1994.

As reported in February, the large number of coral deaths in November 1994 was assumed to be linked to the very low tides during the middle of the day which exposed the corals. It is hoped that the continued monitoring will provide more conclusive evidence of the cause of these deaths.

A bird survey completed in mid November 1994 indicated that incorporating North Shell island into the port development was unlikely to have any significant adverse effect on the breeding of any local birds within Darwin harbour. Follow up surveys have confirmed these results.
Members of the public will have the opportunity to visit the new port development at East Arm at an Open Day this Sunday (22 October).

Visitors will see a short video and static displays showing details of current and future works, climb the observation tower for a birds-eye view of the embankments, then take a guided tour out to the proposed wharf site at the end of the recently constructed bunds.

Parking areas for the Open Day will be clearly signposted and access to the port will be controlled. Visitors will travel by bus from the parking areas to a shaded area adjacent to the site office. The main display will be located in the site office yard. Service clubs stalls will be set up nearby to sell refreshments.

Buses will take visitors on a conducted tour of the port works and staff from the Department of Transport and Works and Henry Walker Contracting will be on hand to provide information on the project and to answer any queries.

While the public boat ramp on Quarantine Island will remain open during the Open Day, parking for vehicles using the ramp will need to be located at a separately marked parking area.

Visitors to the site on Sunday will be able to view work completed to date which has comprised earthworks, reclamation and rock armouring, totalling approximately $16 million, as well as inspect layout plans showing future works.

When operational in December 1997, Stage 1 of the port, costing approximately $75 million, will comprise 300 metres of general purpose wharf and an 80 metre long multi user platform capable of berthing tankers transporting bulk liquids. The facility will initially cater for bulk cargo activity such as sulphur, clinker, live cattle exports, rig tender servicing and general cargo. The bulk liquids berthing facility is an integral part of the relocation of the petroleum industry tank farm from the CBD to East Arm.

Depths of water available at the new berths will range from 14 metres at low tide to approximately 22 metres at high tide. Ships able to use the new facilities will range from 60 metre long rig tenders (requiring a 4 metre draft) to 240 metre long oil tankers requiring a draft of 13 metres.

The existing port will continue to provide for general cargo and containers in the short term. It will also continue to provide for increased volumes of visiting passenger cruise ships, port precinct visitors and naval vessels. Ultimate development of the port as shown on the masterplan will include the eventual construction of major container handling facilities and the terminal of the Darwin to Alice Springs railway.

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APPENDIX F

PROJECT PHOTOGRAPHS
Construction of Stage 1 began in December 1994. Picture shows the progress made by January 1995
Progress on Stage 1 as at April 1995 showing dredge disposal area
A large amount of fill for the project has been obtained from quarries at nearby Quarantine Island.
Construction as at October 1995
View looking towards Quarantine Island, October 1995.
Dredge disposal area, shown in full operation.
Darwin CBD, with the existing Port of Darwin in the foreground.
General view of the project, showing the project's proximity to the CBD and existing port.
Relocation of coral colonies from North Shell Island to Weed Reef in March 1995.
One of the 35 species of coral successfully relocated.