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CYPLUS
CAPE YORK PENINSULA
LAND USE STRATEGY

LAND USE PROGRAM

OTHER PRIMARY INDUSTRIES (NON-PASTORAL, NON-FORESTRY) OF CAPE YORK PENINSULA

D. Hanlon and S. Sloss
RCS Hassall Pty Ltd, Spring Hill 1995

A.J.W. Biggs and S.R. Philip
Department of Primary Industries, Mareeba 1995

S. Golden
Department of Primary Industries, Northern Fisheries Centre, Cairns 1995

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DPI
QUEENSLAND
DEPARTMENT OF PRIMARY INDUSTRIES
NORTH REGION

CYPLUS is a joint initiative of the Queensland and Commonwealth Governments

CAPE YORK PENINSULA LAND USE STRATEGY
(CYPLUS)

Land Use Program

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PART A
OTHER PRIMARY INDUSTRIES

D. Hanlon and S. Sloss
RCS Hassall Pty Ltd, Spring Hill 1995

PART B
AGRICULTURAL LAND SUITABILITY

A.J.W. Biggs and S.R. Philip
Department of Primary Industries, Mareeba 1995

PART C
GENERAL SUITABILITY OF AQUACULTURE AND MARICULTURE DEVELOPMENTS

S. Golden
Department of Primary Industries, Northern Fisheries Centre, Cairns 1995

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Biggs, A.J.W. and Philip, S.R. (1995). 'Other Primary Industries (Non-Pastoral, Non-Forestry) of Cape York Peninsula. **Part B:** 'Agricultural Land Suitability'. (Cape York Peninsula Land Use Strategy, Office of the Co-ordinator General of Queensland, Brisbane, Department of the Environment, Sport and Territories, Canberra and Department of Primary Industries, Mareeba).

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Note:

Due to the timing of publication, reports on other CYPLUS projects may not be fully cited in the BIBLIOGRAPHY section. However, they should be able to be located by author, agency or subject.

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CAPE YORK PENINSULA LAND USE STRATEGY
STAGE I

PREFACE TO PROJECT REPORTS

Cape York Peninsula Land Use Strategy (CYPLUS) is an initiative to provide a basis for public participation in planning for the ecologically sustainable development of Cape York Peninsula. It is jointly funded by the Queensland and Commonwealth Governments and is being carried out in three stages:

Stage I - information gathering;
Stage II - development of principles, policies and processes; and
Stage III - implementation and review.

The project dealt with in this report is a part of Stage I of CYPLUS. The main components of Stage I of CYPLUS consist of two data collection programs, the development of a Geographic Information System (GIS) and the establishment of processes for public participation.

The data collection and collation work was conducted within two broad programs, the Natural Resources Analysis Program (NRAP) and the Land Use Program (LUP). The project reported on here forms part of one of these programs.

The objectives of NRAP were to collect and interpret base data on the natural resources of Cape York Peninsula to provide input to:

evaluation of the potential of those resources for a range of activities related to the use and management of land in line with economic, environmental and social values; and
formulation of the land use policies, principles and processes of CYPLUS.

Projects examining both physical and biological resources were included in NRAP together with Geographic Information System (GIS) projects. NRAP projects are listed in the following Table.

Physical Resource/GIS Projects	Biological Resource Projects
Bedrock geological data - digitising and integration (NR05)	Vegetation mapping (NR01)
Airborne geophysical survey (NR15)	Marine plant (seagrass/mangrove) distribution (NR06)
Coastal environment geoscience survey (NR14)	Insect fauna survey (NR17)
Mineral resource inventory (NR04)	Fish fauna survey (NR10)
Water resource investigation (groundwater) (NR16)	Terrestrial vertebrate fauna survey (NR03)
Regolith terrain mapping (NR12)	Wetland fauna survey (NR09)

Physical Resource/GIS Projects	Biological Resource Projects
Land resource inventory (NR02)	Flora data and modelling (NR18)
Environmental region analysis (NR11)	Fauna distribution modelling (NR19)
CYPLUS data into NRIC database FINDAR (NR20)	Golden-shouldered parrot conservation management (NR21)
Queensland GIS development and maintenance (NR08)*	
GIS creation/maintenance (NR07)*	

* These projects are accumulating and storing all Stage I data that is submitted in GIS compatible formats.

Research priorities for the LUP were set through the public participation process with the objectives of:

collecting information on a wide range of social, cultural, economic and environmental issues relevant to Cape York Peninsula; and

highlighting interactions between people, land (resource use) and nature sectors.

Projects were undertaken within these sector areas and are listed in the following Table.

People Projects	Land Projects	Nature Projects
Population	Current land use	Surface water resources
Transport services and infrastructure	Land tenure	Fire
Values, needs and aspirations	Indigenous management of land and sea	Feral and pest animals
Services and infrastructure	Pastoral industry	Weeds
Economic assessment	Primary industries (non-pastoral, non-forestry)	Land degradation and soil erosion
Secondary and tertiary industries	Forest resources	Conservation and natural heritage assessment
Traditional activities	Commercial and non commercial fisheries	Conservation and National Park management
Current administrative structures	Mineral resource potential and mining industry	
	Tourism industry	

As a part of the public participation process, community and other groups associated with CYPLUS were invited to review all draft reports. These reviews were designed to correct any errors of fact (which were then modified in the final report) and to provide an opportunity for people to express their views of the information presented. The comments submitted to the CYPLUS process by various community groups and other interested persons in regards to this project report are situated within a final attachment to this report.

PART A

OTHER PRIMARY INDUSTRIES OF CAPE YORK PENINSULA

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SUMMARY

Regional stakeholders and industry representatives have expressed differing opinions as to the development potential of other agricultural industries in the Cape York Peninsula Land Use Strategy (CYPLUS) study area. The major limitations to any development is the cost associated with initiating a new agricultural venture, production competitiveness with other agricultural areas and the market competitiveness of commodities produced.

At present most occupants in Cape York Peninsula are not in a position to outlay capital on medium to large scale development projects. New activities are comparatively expensive to develop when considered against other regions. The time period between initial capital outlay and anticipated time for return or profit on that capital invested can be greater than other regions. This can be largely attributed to the dormant winter period where rainfall is seasonally very low, hence growth rates and productivity decreases.

There are possibilities for development of subsistence horticultural operations by some of the Peninsula's Aboriginal communities.

Soil types and generally low fertility inhibit development throughout the CYPLUS study area. Phosphorous and nitrogen are inherently low. Some of the better soils have an adequate soil nutrient status for cropping, however, over the longer term a fertiliser application schedule would need to be developed to maintain production levels.

Most areas that have the potential for development do require clearing of native trees. The problems associated with clearing are two fold, initially a clearing permit must be acquired on grazing lease holdings, requiring a property plan to be undertaken and secondly, costs associated with clearing are high.

Marketing of commodities was identified by stakeholders as one of the major economic constraints facing development in the region. Transport costs, lack of post harvest handling infrastructure facilities, relatively small volumes of production and distance to markets add to the marketing dilemma.

Little Government policy is specifically directed at developing horticulture, broadacre cropping, improved pasture or aquaculture in the region. Cape York Peninsula is utilised as a buffer zone between Papua New Guinea and Australia's established horticultural areas. Current government policy is to maintain Cape York Peninsula's buffering capabilities. Therefore horticultural development is not a priority for the region.

1.0 INTRODUCTION

1.1 Background to this report

This report has been prepared to provide planners and others associated with the Cape York Peninsula Land Use Strategy (CYPLUS) a synopsis of the key issues associated with non-pastoral, non-forest agricultural land use. As such, this report addresses issues raised by stakeholders and expressed in more primary reports. The major reports used include Existing and Potential Erosion Hazard of Cape York Peninsula, Agricultural Land Suitability of Cape York, Animal and Weed Pests, Salinity Hazard - Cape York Peninsula, Current Land Use and General Suitability of Aquaculture and Mariculture Developments.

Due to the limited resources allocated to the project, no field work was undertaken in the region, however, telephone discussions were undertaken with stakeholders or their representatives.

1.2 Data availability

The information in this document should be regarded as indicative rather than fully accurate. It is the first pass at gathering all the statistics and other necessary material on the improved pasture, broadacre cropping, horticulture and aquaculture industries.

Production and area statistics are drawn from the Australian Bureau of Statistics. The data utilised was derived from the Australian Census conducted at 31 March 1992 for the 1991-92 season. Having spoken to some industry representatives it is apparent that these figures should be treated as an industry ball park estimate. They do, however, illustrate the relative situation of the four previously mentioned industries within the CYPLUS study area.

The ABS excludes from the census those establishments which make only a small contribution to agricultural production. From 1991-92 the scope of the census is establishments undertaking agricultural activity having an estimated value of agricultural activity (EVAO) of $22,500 or more.

The reliability of the production and area statistics varies between industries. Industry representatives are of the opinion that the statistics given for broadacre cropping are reasonably accurate and valid.. We are aware that production and area statistics for horticulture have not included developments undertaken on some of the mining sites in the study area. Therefore, the horticulture figures in this report will be lower than the actual but it is difficult to establish how much lower.

The "prices received" statistics were sourced from the "Australian Bureau of Statistics prices received for Queensland Commodities 1991/92" publication. It is considered the prices received statistics are quite reliable and representative across all industries canvassed in this report.

2.0 THE REGION

2.1 Population

In 1994 the resident population of Cape York Peninsula was estimated to be between 17,605 and 18,024 (CYPLUS - Population Project, David King). Of these, approximately 3,000 are residents of Thursday and Horn Islands. Between 60% and 65% of the population are Aboriginal or Torres Strait Islander people living in communities of 200 people or more. Most of these communities are located on or near the coast or are island communities. Weipa has a population of 2,500, Napranum 1,000, Cooktown 1,600 and Kowanyama 1,000.[1] These are the four most established townships on the Peninsula.

2.2 Production (current situation)

Production statistics from the area are summarised in Table 2.1. The total value of agricultural production from broadacre cropping, horticulture, pasture seed and hay was approximately $3.1 million. The region also supports pearl oyster operations in the vicinity of the Torres Strait Islands and the top of Cape York Peninsula. The pearl industry within the study area is estimated to generate $10 million per annum.

Agricultural operations other than beef production on native and natural pastures and forestry occupy approximately 0.2% of the land in the study area. Of the 32,585 ha involved in agricultural production, other than beef production on native pasture and forestry, approximately 30,833 ha are improved pasture for grazing. Horticulture (74 ha), pasture for seed production (306 ha) and broadacre cropping (1,372 ha) utilise only 1,752 ha. (Refer to Table 2.2)

2.3 Infrastructure

Further development around the Lakeland region can be serviced by the amenities available from Cooktown and the Atherton Tablelands. The current cropping operations in place in the Lakeland area successfully utilise the industry infrastructure of these communities. The Atherton Tablelands and Cooktown areas are able to supply all farm production inputs, have storage and marketing facilities for peanuts and maize as well as experienced consultants able to advise broadacre farmers.

Lack of infrastructure and support services could hinder the development of broadacre cropping activities in other areas. Supply routes do exist, but other areas of the Peninsula lack industry storage and marketing facilities. Roads and transport facilities would have to undergo further development or be improved. Farm input supply chains would have to be established and availability of professional advice would be useful for new enterprises or developments.

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[1] Figures are current estimates from local councils.

Table 2.1

PRODUCTION - TONNES PRODUCED AND CROP VALUES						
Item	Cook	Carpen-taria	Torres	Total	Unit Value	Total Value
Crop & Pasture for Hay	140	9		149	107.65	16,040
Pasture Seed	23			23	938.13	21,577
Maize for Grain	1,452			1,452	213.90	310,583
Navy Beans	12			12	1,200.0	14,400
Lab Lab - Seed	106			106	1,750.0	185,500
Peanuts	2,149			2,149	1,022.0	2,196,278
Cucumber	1			1	950.04	950
Mangoes	3			3	1,675.9	5,028
Bananas	173			173	1430.82	247,532
Papaws	1			1	705.25	705
Pineapples	1			1	293.62	294
Water Melon			30	30	375.64	11,269
Coffee	34			34	2,500.0	85000
Pearl Oysters						10,000,000
TOTAL	4,095	9	30	4,134		13,095,156

Source: Australian Bureau of Statistics farm surveys 1991/92, Australian Bureau of Statistics prices received for Queensland Commodities 1991/92.

Table 2.2

AREA OCCUPIED IN HECTARES - ABS farm surveys 1991/92.					
ITEM	Aurukun	Cook	Carpentaria	Torres	Total
IMPROVED PASTURE					
Sown Grasses		3,311			3,311
Pasture Legumes excluding pure lucerne		14,542			14,542
Sown Grass and Legume Mix	300	12,135			12,435
Lab Lab		123			123
Pastures cut for hay			53	5	58
Other improved pasture		359	5		364
TOTAL IMPROVED PASTURE	300	30,470	58	5	30,833
PASTURE SEED PRODUCTION					
Pasture seed - Stylo		245			245
Pasture seed - Panics		10			10
Pasture seed - Rhodes		36			36
Pasture seed - Nec		15			15
TOTAL AREA FOR PASTURE SEED	0	306	0	0	306
BROADACRE CROPPING					
Maize for Grain		305			305
Navy Beans		8			8
Forage Sorghum		10			10
Peanuts		981			981
Crops for Hay		53	5		58
Crops fed off or cut for green feed		10			10
TOTAL AREA OF BROADACRE CROPPING	0	1,367	5	0	1,372

AREA OCCUPIED IN HECTARES - ABS farm surveys 1991/92.					
ITEM	Aurukun	Cook	Carpentaria	Torres	Total
HORTICULTURE					
Cucumbers		1			1
Mixed vegetables		1		2	3
Orchard trees		1			1
Bananas		8			8
Pawpaw		1			1
Pineapples		2			2
Berries and Small Tropical Fruit			10		10
Coffee		48			48
TOTAL AREA OF HORTICULTURE	0	62	10	2	74
TOTAL AREA OF AGRICULTURE EXCLUDING NATIVE PASTURE	300	32,205	73	7	32,585
OTHER PASTURES NATIVE AND NATURAL	299,690	856,022	1,354,044	0	2,509,756
TOTAL AREA FOR AGRICULTURAL USE	299,990	888,227	1,354,117	7	2,542,341
Other	450,010	6,825,131	5,397,443	993	12,673,577
TOTAL AREA	750,000	7,713,358	6,751,560	1,000	15,215,918

Note: The Total Area is larger than the area of the CYPLUS region (13,670,000 ha) due to the inclusion of the total area of the Carpentaria Shire.

3.0 IMPROVED PASTURE

3.1 Current status

Australian Bureau of Statistics farm surveys from 1991/92 indicate that approximately 30,833 ha of pasture had been improved within the CYPLUS study area. Improved pasture includes sown grasses (3,311 ha), sown grass legume mix (12,435 ha), pasture legumes excluding lucerne (14,542 ha), other improved pasture (364 ha), Lab Lab (123 ha) and pastures cut for hay (58 ha).

The majority of this pasture improvement has been undertaken in the Cook Shire. Aurukun contributes 300 ha of sown grass and legume mix. Carpentaria has 58 ha of improved pasture which is dominated by pasture excluding pure lucerne cut for hay, 53 ha and 5 ha of other improved pasture.

Pasture seed has been harvested from some of the improved areas on Cape York Peninsula. This activity produced roughly 150 tonnes of pasture seed in 1991/92. Of this, 106 tonnes was Lab Lab seed, 21 tonnes was stylo and 1 tonne was rhodes panic and other pasture seed. The Cook Shire is well suited to tropical pasture seed production. Quality is enhanced by the frost free climate and availability of irrigation water in the Cooktown region.

3.2 Issues

Establishment of improved pasture in the region requires a considerable financial outlay. Seasonal conditions result in a lay period between time of development and time of utilisation. The extreme summer dominance of rainfall further slows the development process in comparison to other regions.

Geographical Information Systems (GIS) Land Capability maps indicate that over 3,000,000 ha would be agronomically suitable for development of improved pasture. Soil types under this category are diverse and some of the soils with a depleted nutrient status would be economically not viable as costs of fertiliser would be difficult to recoup.

Issue	Discussion
Constraints	**Capital** - Investment in improved pasture is a function of industry profitability. The live export trade is providing impetus for better turnoff. The majority of beef producers in the region do not have the necessary capital available at present for improved pasture development. In the opinion of the Queensland Department of Primary Industries (QDPI), minimum input pasture improvement can, in some circumstances, increase productivity.

	Clearing - Development of improved pasture on some areas identified as having potential would initially have to be cleared. The costs of clearing and difficulty in attaining clearing permits on Grazing Leaseholds alone make development of improved pasture an economically marginal activity. The QDPI has found that, in some circumstances, minimum input improved pastures do not require clearing. **Time from establishment to utilisation** - The dry growing conditions throughout the winter months would increase the time from sowing to effective utilisation. Some of the soils identified as having potential to be developed to improved pasture have marginal nutrient status and fertiliser would have to be incorporated in any development plan. This will increase the costs of development on areas characterised by these soil types.
Potential	**Soil fertility** - Specific areas of red basaltic soil have adequate soil chemical and physical attributes to allow improved pasture development without the use of fertiliser. This is, in many cases, also the land that has been identified as having the greatest potential for crop development. Some members of the beef community are of the opinion that potential exists to develop or improve considerable pastoral areas of Cape York Peninsula. Cost of development is the primary limiting factor. Within the areas identified as being suitable for pasture development some will be more favourable than others. The continued development of the pasture seed industry will aid the development of improved pasture on the Peninsula. Ultimately, if improved pasture can be developed to a stage where it has the capacity to naturally regenerate and increase its area, it will increase the economic viability of the activity.

Industry & Community Aspirations	Most producers can see the long term benefit of improved pastures to the beef industry. They are also aware of the areas that have the greatest development potential. The immediate barrier to development is that producers do not, at present, have the capital to commence or further advance improved pasture. The beef industry stands to benefit from development of an improved pasture industry as it needs to produce a large number of higher quality bulls that are adapted to the Cape's climatic conditions. This is presently being limited by low calving percentages and poor conception rates. Improved pasture will assist in the improvement of calving rates.
Environmental & Cultural Impacts	Any development in the quality and availability of pasture to the Cape York Peninsula beef industry will have a positive community impact due to more stabilized productivity. The challenge is still to develop improved pasture in the most cost effective way. From an environmental perspective, development of improved pasture is a positive managerial step. Environmentally damaging consequences resulting from pasture improvement will result if these pastures are overgrazed to the extent an erosion risk develops. Areas suitable for pasture development have been categorised according to potential level of development eg. high, medium and low input pasture. If improved pasture is developed in accordance with adequate guidelines environmental risks are minimised.
Current Government Policy Initiatives	There is minimal government policy specific to Cape York Peninsula to facilitate the further development of the region's improved pasture production. QDPI officers do provide assistance and advice to pastoral operators through the implementation of several programs and models such as "Grass-check".

4.0 BROADACRE CROPPING

4.1 Current status

For the purposes of this study, broadacre cropping can be defined as production of annual crops where the commodity produced is harvested or utilised in the year of production and where the production requires management of medium to low intensity. Crops included in this section include: peanuts, maize, forage sorghum and navy beans. Sugar cane, even though a perennial crop, has also been considered within the broadacre cropping section.

Cropping is, at present, restricted to the red basaltic soils and the better drained metamorphic soils of the Lakeland Downs region. Other areas in the Peninsula have been identified as having the potential to be cropped (Agricultural Land Suitability of Cape York Peninsula, Briggs 1990). In the past, high freight costs and low prices received for produce have impaired attempts to further develop the cropping industry.

In total 1,372 ha were used for broadacre cropping in 1991/92 within the CYPLUS study area. Crops for hay accounted for 58 ha.

Broadacre cropping in Cape York Peninsula is dominated by peanut production. In 1991/92 peanuts occupied 981 ha or 71.5% of the broadacre cropping land. Peanut production is almost exclusive to the Lakeland district. This area of peanuts produced 2,149 tonnes of peanuts in shell and would have had a commercial value of approximately $2 million dollars.

Maize grown for grain occupied 305 ha, 22.2% of the broadacre cropping area and yielded 1,452 tonnes, this crop was also produced nearly exclusively in the Lakeland region. Total area of forage sorghum was 10 ha. Crops fed off or cut for green feed occupied the same area. Navy Bean production occupied 8 ha and yielded 12 tonnes of beans.

The bulk of grain produced is from rain grown summer plantings. Small areas have also been grown in the winter months with the assistance of irrigation. Reasonable yields have been obtained from winter irrigated maize but sorghum has not been as successful. Production of sorghum through the winter months has assisted in the build up of insect pests like sorghum midge.

Nitrogen and phosphatic fertilisers are necessary to maintain crop yields. Where management practices have adopted rotations with legumes such as lab lab, cowpeas or a pasture legume the requirement for nitrogenous fertiliser application is not as great.

4.2 Issues

Approximately 240,000 ha have been identified within the CYPLUS study area of having the potential to be developed for growing peanuts, sorghum, maize, high, medium and low intensity pasture. Of this land identified, 65 to 70% is located at the 14^0 latitude and 60 to 110 km off the west coast of the Peninsula.

At present this area is not being utilised for broadacre cropping, but has the greatest potential, largely because of its size. Issues specific to the development of this region would include labour availability, source of inputs and transport of inputs and outputs. Aurukun and Weipa are the closest established townships, however, Aurukun does not maintain the infrastructure to facilitate such a development and Weipa is 170 km from the area.

Approximately 50 km east of the Weipa township, patches of country have been identified as suitable for peanut, maize and sorghum production. Agricultural land suitability maps indicate 37,000 ha of land in this region are suitable for cropping. A major limitation of this area is that the cropping land is dispersed amongst land of low fertility. The patches of potential land in this region represent 15% of land identified as being suitable for peanut, maize and sorghum production.

This region has the advantage of its relative proximity to the township of Weipa. Proposed development of a live export facility at Weipa may allow access for inputs required to support a broadacre cropping industry, however, inputs may be at a price disadvantage due to excess freight costs. This is an issue which may need investigation in Stage 2 of CYPLUS.

The Lakeland region has the potential to expand its cropping area suitable for peanuts, maize and sorghum to 4,000 ha. A further 5,000 ha could be cropped to sorghum and maize, but are not suitable for peanut production.

Directly south of Aurukun there are approximately 110,000 ha of land suitable for maize and sorghum production. This region is not suitable for peanuts. Within the CYPLUS study area 130,100 ha have been designated in this class of land suitability. The maize and sorghum area south of Aurukun represents 84% of this class of land in the Cape York Peninsula. Development of this area is severely constrained by distance and availability of farm inputs, labour, and delivery of commodities produced to markets.

Other areas designated as being suitable for cropping exist in relative small holdings and costs to develop a small parcel of land would not be economically feasible considering the input costs, distance and availability of inputs and infrastructure.

Development of a sugar cane industry in the region would be confronted with those inhibitions facing peanut production as well as additional processing and transport problems. Traditional production areas are all within 50 km of the east coast.

Most Australian cane farms are less than 50 km from a sugar mill. The closest established mill to the CYPLUS area is at Mossman. This is 200 km south of the CYPLUS study area. Other support infrastructure, particularly rail and storage services, are heavily utilised in established cane regions.

Warm sunny weather, freedom from frosts, well drained soils and at least 1,500 mm of rain per year represent ideal conditions for sugar production. Potential sugar production within the CYPLUS area is, therefore, restricted on the basis of climate and land suitability to the

Lakeland region and an area of about 6,500 ha, 40 km north-east of Cooktown. Sugar cane land suitability was not separately identified on CYPLUS GIS maps, although land suitable for broadacre cropping of sorghum and maize could also be considered suitable for cane production.

Most mills in operation today crush over 800,000 tonnes of cane per year. If 6,000 ha were developed to cane in the region 40 km north of Cairns and 1,500 ha in the Lakeland district, production of 600,000 tonnes per year could be expected. This approximation is based on average industry production of 80 tonnes per ha.

Development of high tech mills with small to medium size crushing capacities are feasible and one is currently under construction in the Ord region. This mill is to crush 120 tonnes per hour and cost approximately $30 million. It is important that sugar cane be crushed within 16 hours of harvest. Efficient transport links would have to be established between growing areas and the mill. The most central location to establish a mill would be at Cooktown. The new sugar developments in the Ord region have found effective road transport more suitable than development of tram lines for regions with small to medium size production capacities.

Raw sugar storage capacity at ports would have to be available. At present there is available storage capacity at the Cairns port, however, proposed development on the Atherton Tablelands could account for all of this.

Issue	Discussion
Constraints	**Marketing** - This was identified by industry stakeholders as the most inhibiting constraint to industry development. Even if all agronomic and economic barriers are overcome, marketing of broadacre commodities from the region could propose difficulties. Marketing difficulties were seen to arise through the relatively small volumes of commodities initially produced, a lack of infrastructure eg. storage facilities, therefore decreasing marketing flexibility and finally having to compete with well established regions who can utilize past history to demonstrate continuity of supply.

	Peanuts and maize produced from the Lakeland area do have effective market avenues through PMB Australian and the Maize Marketing Board's Atherton Tableland facilities. **Costs** - The established Lakeland region does have good transport facilities and as a result the costs of production are reasonable. Development of other potential areas that have been identified would be limited by the increase in cost of inputs brought about largely by additional freight expenses. **Transport** - Transport systems from Atherton to Lakeland are considered to be reliable and adequate. Further development of this area will not be hindered considerably by transport difficulties even though it is 220 km from Atherton. Development of some of the other potential areas identified, eg. the 150,000 ha of good soil 60 km south-east of Aurukun would experience considerable transport difficulties. The road routes from Cooktown to Weipa and Atherton to Weipa bypasses this area, therefore specialist trips would have to be made to service any developments. Presently, Weipa does not have the necessary supply capabilities to service the area. Cropping supplies would have to be sourced from the Atherton tablelands. Freight capabilities would have to be improved to cater for sugar cane production. The short time period allowable between cutting and time to crushing being the reason.

	Infrastructure - Development of a new 100 ha peanut operation would require an initial capital outlay of between $180,000 and $245,000 (this does not include the purchase price of the undeveloped land). This is largely due to the specialised harvesting, thrashing and drying equipment required to ensure quality standards are met.[2] Sorghum and maize operations would require considerably less capital outlay. The area south west of Aurukun that has been identified as a potential peanut producing area, a major infrastructural constraint is the absence of industry facilities, eg. storage and technical support services in the vicinity of the area. Sugar cane development would have to coincide with development of post farm facilities including an improved transport network, construction of a mill and adequate storage facilities. On farm production would require a reliable water supply. In most other established areas this has usually included the development of irrigation facilities. This would include on and off farm development, ie. a storage dam for the industry and facilities to undertake flood or drip irrigation on farm. **Land tenure** - The Lakeland district is largely freehold. Any new development on freehold land will not be significantly inhibited by tenure restrictions. Some land use planning controls do exist. The region south-west of Aurukun that has been identified as having the potential to produce peanuts, sorghum and maize is located on pastoral leasehold. Pastoral leasehold does permit the land to be cultivated for primary industry purposes. If clearing is required, the owners must gain a permit. Application for such a permit must be accompanied by a management plan. If the development of new cropping areas involves increased risk of land degradation, the application can be refused.

[2] Comment from PMB Australia.

	There are approximately 100,000 ha 60 km south of Aurukun that are potentially arable. This area is suitable for sorghum and maize production only, peanuts are not an agronomic option on these soils. The tenure of this area is made up of Aboriginal Leases and Aboriginal Deed of Grant in Trust Land etc. Any development would have to coincide with the wishes of the resident Aboriginal community and in accordance with any tenure regulations.
Potential	Further development of the peanut industry in the Lakeland region is seen to be a favourable and practical development by PMB Australia. The Lakeland district, which usually produces between 3000 and 4000 tonnes of peanuts a year, has the potential to double this output through development of new cropping areas. Both irrigated and dryland production activities are carried out in the Lakeland district, irrigated yields have been as high as 4.2 t/ha while dryland production realises about 1.8 t/ha. Some of the ravines in the peanut growing areas have the potential to be dammed which would allow a greater area to be irrigated. Industry storage facilities on the Atherton Tablelands are only being utilised to half capacity. Therefore, further developments in peanut production can be facilitated by PMB Australia. Maize and sorghum have been identified as the two major broadacre crops other than peanuts. Profits from these crops are not as rewarding compared to peanut production, but in the interest of sustainable production, peanuts should not be grown as a monoculture in this region. Maize and sorghum are heavily utilised as part of a rotation in peanut production. As a result, increased development of the peanut industry will generate additional potential for maize and sorghum production.

Industry & Community Aspirations	The cattle industry has expressed interest in utilising grains and hay produced from the region. At present much of the grain produced in the Lakeland region is sold as cattle feed to northern producers, indicating the willingness of the beef industry to use these commodities when available. At present, costs involved with transporting grain from traditional production areas like Central Queensland, make it economically impractical for most beef producers to use grain as a supplementary feed through the winter months.
Environmental & Cultural Impacts	The Pastoral Holding tenure that presides over most of the land that has the potential to be developed will act as a safety net and decrease the likelihood of any adverse environmental impacts. Development of cultivation areas on Grazing Leases in most cases will require a clearing permit. The region will be evaluated and, if there is a chance of degradation, the permit will not be granted.
Current Government Policy Initiatives	No government initiatives are currently in place to encourage the development of broadacre cropping in the CYPLUS study area.

5.0 HORTICULTURE

5.1 Current status

Only small areas within Cape York Peninsula are utilised for horticultural activities. For 1991/92 the Australian Bureau of Statistics recognised 74 ha of land as being used for horticultural commodity production. On an area basis, coffee was the largest crop occupying 48 ha, berries and small tropical fruit occupied 10 ha, followed by 8 ha of bananas, 3 ha of mixed vegetables, 2 ha of pineapples and 1 ha each for cucumbers, orchard trees and papaws.

This small area of horticultural production generated 243 tonnes of produce with a total value of over $350,778. The largest contributor to this amount was by the 173 tonnes of bananas with a value of $247,532 followed by 34 tonnes of coffee which had an approximate value of $85,000.

Cashew production is being undertaken on Comalco regeneration sites at Weipa and Aurukun. Each plantation has 300 trees on 3 ha. Production of the Comalco site is normally between 20 to 30 kg of cashews per tree. Cyclone Mark slowed development of the Comalco site in 1991 when it damaged 80% of the trees.

Comalco is planning to develop up to 800 ha of land for horticultural production. The Comalco mine regeneration site at Weipa is approximately 17,000 ha, the remaining area will be returned to native flora or improved pasture. Trials of many tropical horticultural crops have also been undertaken. Cashews and neem have been given the most attention and are the crops likely to undergo further development.

5.2 Issues

Areas suitable for horticultural production have not been individually identified. Attributes that led to land being classified as suitable for broadacre cropping would, in many cases, result in the land also being suitable for horticultural production. This was the opinion of Queensland Department of Primary (QDPI) officers responsible for preparation of the CYPLUS Land Suitability Map.

Land suitable for broadacre cropping was divided into three categories. The first was land suitable for peanuts, sorghum, maize and improved pasture, the second was suitable for sorghum, maize and improved pasture, and the third category land was considered suitable for sorghum and maize but not improved pasture on the grounds of poor soil fertility.

A wide variety of tropical horticultural crops have been trialled on these soil types. Crops that have been agronomically successful have normally shown limited promise in regards to economic viability. The main factors impacting on economic viability have been marketability of produce and additional costs associated with freight.

A food processing plant for Cape York Peninsula has been suggested as strategic development designed at overcoming many of the marketing barriers restricting further horticultural development in the Peninsula. The idea of a multi-purpose food processing plant was developed by the Cook Shire Council in 1991.

Issue	Discussion
Constraints	**Marketing** - Horticultural crops that have been, or potentially could be grown successfully, still have to overcome marketing constraints to be economically viable. Lack of post-harvest and storage infrastructure, the perishable nature of many horticultural commodities and having to compete with established horticultural regions were identified as aspects that contribute to marketing difficulties. **Costs** - production input costs exceed that of traditional horticultural areas mainly as a result of extra transport costs. **Transport** - Three issues are to be considered when evaluating the suitability of transport. Initially, there are the additional costs of transport of inputs and produce from Cape York Peninsula. Secondly, the regularity or availability of transport has to be adequate and, thirdly, the quality or applicability of the transport type available must be consistent with the needs of the horticulture industry. **Post harvest handling facilities** - Many of the horticultural crops suitable have a limited shelf life. To ensure produce quality is able to meet market expectations post harvest handling facilities would have to be incorporated into any industry development. This would include packing facilities, refrigeration facilities and storage facilities.

	Infrastructure and capital outlay required for establishment- Development and establishment of a horticultural operations in Cape York Peninsula would have to be compatible with current or planned infrastructure, eg. packaging and storage facilities, adequate roads for transport of inputs and commodities. Where necessary infrastructure is not already in place, the price of development of such necessities must be calculated into development costs. **Land tenure** - Pastoral holding or grazing homestead perpetual leases occupy approximately 57% of the CYPLUS area, Aboriginal tenures account for approximately 15% and national parks encompass approximately 10%. Freehold land occupies 4%. The remaining 14% consists of state forest, Crown reserves, timber reserves, vacant Crown land, mining leases and small amounts of other types of tenure. The majority of the land, identified as having the capability to be developed to broadacre cropping or horticultural production, is held under pastoral lease tenure, the remainder falls under various Aboriginal and Torres Strait Islander tenures. The nature of pastoral leases and Aboriginal and Torres Strait Islander tenures will have to be considered before any proposed horticultural development.
Potential	**Export potential** - Large marketing and economic barriers must initially be overcome before any expansion of horticultural commodity production for export can be undertaken. **Domestic potential** - For horticultural produce from Cape York Peninsula to compete successfully on the domestic market through traditional markets such as Brisbane, Sydney and Melbourne. A substantial price, volume or quality advantage must be forthcoming to offset the increased costs of transport associated with both inputs and produce. **Multi-purpose food processing plant** - such a venture could bring an increased level of sustainability to horticultural activities in the region, because it would overcome many of the marketing constraints outlined above.

	Feasibility studies would have to be undertaken to determine if current or potential volumes of produce are of sufficient size to ensure such a venture is economically realistic. It is proposed that such a plant may be able to competitively supply traditionally imported products to the domestic market. Consideration has been given to the processing of limes, mangoes, passionfruit, banana, pineapple, ginger, chillies, vanilla, pawpaw, tamarind, soursop, jackfruit, custard apples, lychees and five corners. The Cook Shire undertook preliminary investigations into the development of such a facility in 1991. Results of the investigation are not available for publication in this report. **Subsistence Production** - Increased small scale production on Aboriginal communities utilizing resources such as the Community Development Employment Program (CDEP) funds has the potential to increase the production of a whole range of fruits and vegetables. **Suitable Soil** - Although the Agricultural Land Suitability map did not indicate areas suitable for horticultural production the Queensland Department of Primary Industries is of the opinion that soil suitable for sorghum and maize production would, in many circumstances, be suitable for horticultural crops. This indicates that a large area could potentially be suitable for horticulture activities. Further investigation of land suitability would be required to determine specific areas. **High Rainfall** - The median annual rainfall for approximately half of the study area is between 800 and 1,200mm. For the remainder of the study area the median annual rainfall is in excess of 1,200mm. Rainfall in the study area is considered to have moderate to low variability.[3] Stakeholders have indicated that there is a potential for increased water storage based on these rainfall characteristics.

[3] Atlas of Australian Resources

Industry & Community Aspirations	**Regional usage** - Over 50% of the people living on Cape York Peninsula are Aboriginal or Torres Strait Islander people living in communities with populations between 100 and 1200 people. The opportunity exists for some of these communities to develop subsistence horticultural operations for the community and possible communities around them. At Weipa, Comalco has conducted investigations with several horticultural crops regarding potential development as part of regeneration programs on mining sites. Experiments with cashews and neem trees are showing favourable results. Production in these areas requires large quantities of fertiliser. This would render many commercial operations unviable on economic grounds. Comalco plans to continue to develop and trial horticultural activities on some of their mine rehabilitation sites. The work being undertaken by these companies should be monitored as it will assist in identification of many of the problems a fledgling horticultural industry is likely to encounter. Marketing of commodities was an equally large constraint. Access to inputs is an issue and control of pests has presented problems. Transport links between Mareeba, Atherton and Cairns to Weipa are adequate and sixteen articulated vehicle supply trucks travel to Weipa each week. Roads between Weipa and southern supply centres are usually passable for seven[4] months of the year.
Environmental & Cultural Impacts	Some industry representatives consider development of horticultural activities in the CYPLUS study area could pose a threat to other established horticultural areas. Banana plantation development could act as a corridor of host plants allowing the spread of tropical diseases to established banana growing regions further south.

[4]Cape York Peninsula Pastoral Advisory Group

Current Government Policy Initiatives	No government policies have been generated for horticultural development in the region. Policies are in place relating to monitoring of renegade horticultural plants that could harbour tropical diseases that may spread to established horticultural areas. Horticultural policies in Cape York Peninsula relate to prevention of disease spread and not regional development. Development of horticultural activities in the region is not a priority. It is considered preferable that the Peninsula is not developed and allowed to continue to act as a buffer zone between Papua New Guinea and Queensland's established horticultural areas.

6.0 AQUACULTURE

6.1 Current status

Aquaculture is a relatively small industry in Australia. Some industry and government representatives feel the industry will undergo gradual growth for some years based on the increased demand for fish products as a result of continual world populations increases and increased awareness of the health benefits of fish. Secondly, the depletion of natural fish numbers from traditional fisheries will place increased pressure on the aquaculture industry to meet increased demands.

The production value of the pearl oyster industry within the Torres Strait and down the east-coast as far as Cairns is estimated to be approximately $10 million per annum. The total area used for pearl production in the Peninsula's surrounding waters is 1,766 ha. Table 6.1 shows sizes of operations within the study area (the area for pearling was not included in Table 2.2 because these operations take place offshore). Production statistics were not available for other aquaculture and mariculture industries in the study area.

Table 6.1

AREA OCCUPIED IN HECTARES BY PEARL OYSTER OPERATIONS

Location	Area(ha)
Albany Passage	234.70
Owen Channel	25.00
Friday Passage	400.00
Turtle Head Island	423.00
Escape River	305.40
Trochus Island	28.40
Trochus Island	38.90
Walker Bay	60.00
Roko Island	111.00
Packe Island	49.90
Friday Passage	90.00
TOTAL	1,766.30

6.2 Issues

The Department of Primary Industries report, "General Suitability of Aquaculture and Mariculture Developments", identifies several issues limiting the development of these industries. A number of economic and environmental factors will infringe upon the development of any aquaculture operation.

Market demand, prices received and production costs were identified as crucial economic considerations in the development of any aquaculture venture. The economies of developing aquaculture operations, eg. infrastructure costs, also have to be considered. Return on capital expenditure, number of years until profit is generated and other risks must be factored into any proposed development.

Environmental factors that require consideration in any proposed development include water quality, soil characteristics, topography and climate. These conditions will also have a bearing on the species chosen for the aquaculture operation.

Several positive development characteristics for the region were identified. Year round high temperatures, good water quality, availability of wild stock sources from local habitats and large landmasses are characteristics that favour aquaculture developments in the region. Infrastructural inadequacies such as roads, power, towns (labour), post harvest facilities, etc. would have to be overcome to allow development.

Other problems applicable to Cape York Peninsula that face the Australian aquaculture industry in general include complex regulatory framework, low awareness of overseas market forces and a relatively in-experienced aquaculture workforce.

Issue	Discussion
Constraints	The Department of Primary Industries has identified areas suitable for aquaculture development on the basis of water suitability, land suitability and environmental sensitivity. **Economics** - Factors that will determine the economic practicality of any development must also be considered. This would include attributes such as power availability, infrastructure, transport logistics, capital input required, economic competitiveness with other regions and labour availability.

	Markets - Worldwide aquaculture production is currently worth US $30 billion per year and is predicted to contribute over 24% of world fisheries production in 2010. In Queensland, aquaculture production has increased from $ 7 million in 1989/1990 to approximately $ 13 million in 1991/92. This is a positive sign for the aquaculture industry, however, if costly development of an aquaculture industry was to be undertaken in the Cape York region it should not be done in the absence of an extensive market analysis. **Water** - Aquaculture requires reliable water availability. An abundant and regular supply of water to commercial ponds and hatcheries is essential. Poor water quality will reduce survival and growth rates of cultured species. Dissolved oxygen, ammonia, salinity, pH and temperature were factors identified as being important water quality characteristics. **Land** - Flooding potential, soil type and topography were factors identified as having an impact on suitability of many potential sites. The soil of any proposed pond system must have adequate holding capabilities and it is important to build away from areas where ground water levels are high. **Climate** - High wind velocities have an adverse effect on aquaculture operations and would have to be given consideration, particularly for some of the possible mariculture ventures. The distinct wet and dry season climatic regime on the Peninsula results in many potential areas having extended periods of no flow through the dry season.The seasonal nature of rainfall is an important factor. Rain events must be able to address the availability and quality needs of any pond operation.

Potential	Several development sites, suitable for aquaculture development, have been located in the Cape York Peninsula region. Characteristics such as year round high temperatures, good water quality and suitable habitats for wild stock all favour aquaculture development. Land suitable for aquaculture development was identified in the CYPLUS report "Suitability of Aquaculture and Mariculture Developments." The forecast increase in demand for fish products is predicted to greatly increase opportunities for commercial aquaculture and mariculture. Several primary sites have been identified as suitable for aquaculture on agronomic grounds. The relative immaturity of commercial aquaculture in Australia makes it difficult to predict the industry's growth potential in the region. Statistics available indicate the pearl industry is a significant generator of revenue for the region. Further research is needed to show if the industry is saturated or if there is room for growth. Queensland Department of Primary Industries agricultural biologists at the Walkamin Research Station are predicting strong growth in redclaw crayfish production. Their market research indicates a large demand for the product in Europe and Asia. Queensland currently produces 70 tonnes of redclaw per year, however, the QDPI, predicts the Queensland industry could increase production to over 1,000 tonnes per year. Redclaw production was investigated in the CYPLUS report on General Sustainability of Aquaculture and Mariculture Development. The region may be in a position to accompany any expansion in production of redclaw crayfish.

Industry & Community Aspirations	Interest has been expressed to the QDPI by Aboriginal communities in the Peninsula regarding aquaculture development. Interest appears to be in the areas of pearl and barramundi production. At this stage, no formal steps have been taken to further develop any of these proposals.
Environmental & Cultural Impacts	Disturbances of important areas such as National Parks, Marine Parks, mangroves and Fisheries Habitats and Wetland Reserves are important to consider, as waste discharge from the operation can have the potential to adversely effect ecologically sensitive areas (Gillespie & Taylor-Moore, 1994). **Disease and Genetics** - Contamination of wild stock by farmed animals escaping during incidents of flooding has been identified as a potential risk. It has also been suggested that escaped stock may cause genetic problems if they breed with wild fish stock, as the genetic composition of the farmed stock may differ from the wild species.
Current Government Policy Initiatives	Government policy relating to aquaculture development in the CYPLUS study area is in preliminary stages. State planning policies are being initiated to ensure that sites favourable for aquaculture are zoned appropriately by local authorities. Some processes being undertaken relate to the identification of fishery reserves. These reserves, once identified, may then be declared as significant habitat areas.

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APPENDIX

TERMS OF REFERENCE

Other Primary Industry (non-pastoral, non-forestry)

1. Based on information collected by QDPI on the nature and location of current and potential non-pastoral, non-timber primary industries, the QDPI assessment of areas of general suitability for primary industry and other information available from the consultant's own sources:

   - prepare a draft overview report identifying, describing and analysing issues related to primary industries for consideration in Stage 2 of CYPLUS. These issues are to include but are not limited to;

     - constraints and potential;
     - industry and community aspirations;
     - environmental and cultural impacts;
     - current government policy initiatives.

   Output: Draft overview report on Primary Industry issues to be considered in CYPLUS Stage 2.

2. Prepare final overview report following review by CYPLUS Land Working Group.

   Output: Final Report.

PART B

AGRICULTURAL LAND SUITABILITY OF CAPE YORK PENINSULA

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SUMMARY

The agricultural land suitability in Cape York Peninsula has been assessed for the following uses:

- Low input pastures (sown legume, native grass, fertiliser and possible phosphorous supplementation)
- Medium input pastures (sown legume, native grass, fertiliser application)
- High input pastures (timber clearing, cultivation, fertiliser application, sown pasture)
- Sorghum/maize cropping
- Peanut cropping
- Horticulture

This assessment is based on a 1: 900 000 scale soil and land suitability field survey which mapped and described parcels of land according to soil, topographic, vegetation and climatic properties. This involved field description of soil profiles at 905 sites and chemical analysis of 31 profiles. Use was also made of 740 field sites from previous surveys. Some 96 soil types and 17 variants have been named and described. Each map unit comprises one, or up to four soil types with associated topographic, vegetation and climatic features.

In a survey of this scale, not all map units can be field checked, hence with a knowledge of geological types and using stereo air photo interpretation of landform and vegetation patterns, mapping in ground truthed areas is extrapolated to areas that were not ground truthed.

All mapping boundaries were initially marked on aerial photos and then cartographically transcribed and recorded digitally in a geographic information system (GIS). There is therefore a database linked to each mapping unit which contains all descriptive and interpreted information gathered during the survey.

To determine agricultural land suitability, particular soil, vegetation and climatic properties have been selected and assessed as the determinants of profitable and sustainable agricultural land use. These are referred to as land use **limitations**, for example, soil nutrient status, moisture holding capacity, drainage, rockiness etc.

The suitability of each **soil type** for the respective land uses was determined by matching the expression of each limitation in that soil type against the requirements of each land use. This is expressed as a five class suitability rating. The suitability of each **map unit** for each of the land uses is determined according to the dominant soil type.

An important difference applies in the way cropping uses and improved pasture uses were assessed. Pasture use assessment is based on current cost/price structures in the existing beef industry on Cape York. In the absense of any substantial cropping industries over most of the study area, the assessment of cropping uses is based on the assumption that all the necessary infrastructure and support facilities are in place in reasonable proximity to the land being assessed.

The land indicated as suitable for native pasture grazing has not been directly assessed as have the other uses. It was determined as land that is not suitable for any of the developed uses but not in the category of -agricultural land. For example, land that is extremely steep or too wet for any form of grazing. It should also be noted that beef production based only on native pastures is not considered to be a viable land use in the long term on Cape York.

Horticultural land suitability was also indirectly determined by delineating land that has assured ground or surface water supplies and is suitable for any of the other cropping uses. It is therefore an indicative assessment only and applies to a broad range of horticultural crops and not to one specific crop.

The areas of land assessed as suitable for various land use combinations are as follows:

Land use	**Area (ha)**
Land suitable for peanuts, sorghum and maize	239 000
Land suitable for sorghum and maize	2 050 800
Land suitable for high input pasture	3 444 050
Land suitable for low and medium input pastures	4 448 150
Land suitable for low intensity grazing of native pastures	6 148 100
Land suitable for nominated land uses	966 120

Land indicated as suitable for peanuts is largely restricted to stone free, red, clay loam soils in the central and north-west of the Peninsula. The majority of land assessed as suitable for sorghum/maize is also in the north-west of the Peninsula, generally on clay loam and clay soils on low slopes. A large proportion of the sandy earth soils in the central-west and central-south of the Peninsula are suitable for high, medium and low input pastures, but not for peanuts or sorgum/maize, due to factors such as moisture holding capacity. Land with excessive slope, rockiness or other limiting factors (e.g rockiness), in the far northern portion of the Peninsula, the east, and the south is only suitable for low intensity grazing of native pastures. Land assessed as unsuitable for any of the specified land uses is mostly restricted by slope (mountainous areas) or salinity/flooding (coastal areas - mangroves, saltpans)

1.0 AGRICULTURAL LAND SUITABILITY ASSESSMENT

1.1 General

The suitability of the soils of Cape York Peninsula for a number of land uses has been assessed using the methods described by Land Resources Branch Staff (1990). The land uses directly[1] assessed were:

- Low input pastures (sown legume, native grass and possible phosphorous supplementation)
- Medium input pastures (sown legume, native grass, fertiliser application)
- High input pastures (timber clearing, cultivation, fertiliser application, sown pasture)
- Sorghum/maize cropping
- Peanut cropping
- Horticulture

These land uses were chosen because they are currently practiced on the Peninsula. The pastures' categories were derived after discussion with staff of the QDPI Pastures Management Unit, and Beef Cattle Husbandry Group.

The land suitability assessment for cropping uses has been made on a different basis to that for the improved pasture categories. The latter is based on prevailing economic and marketing conditions in the beef industry on the Peninsula. The suitability assessment for cropping uses assumes that there are no infrastructural restrictions in relation to product handling and marketing.

[1] Two other categories are displayed on the maps associated with this report. The generation of these categories is discussed in 1.4.

1.2 Methodology

1.2.1 Soil mapping base

Land suitability assessment is based on soil mapping undertaken as part of another CYPLUS poject titled "Soil survey and agricultural land suitability of Cape York Peninsula" (NR02), at a scale of 1:900 000, and a published map scale of 1:500 000. At this scale, individual map units (or UMA's[2]) usually comprise more than one, and up to four soil types. There is commonly a dominant soil in each UMA, i.e one soil comprising 60% or more of the UMA, but in many cases there are two or more sub-dominant soils.

In all cases, the percentage of each soil is recorded in the UMA DATA FILE - a file of information entered into a database for each UMA mapped in the study. There are over 6000 UMA's in the NR02 UMA data file.

As explained in 1.2.2, the suitability of each of the soils within each UMA is assessed for each land use. However, it is difficult to thematically portray the complex results generated in such a process. Hence the map associated with this section of the report is compiled using the suitability of the dominant soil only, within each UMA.

1.2.2 Suitability assessment process

Land suitability assessment for selected agricultural uses is based on the evaluation of particular land properties which determine plant growth, machinery usage and the management of land degradation. It follows that these properties are the environmental factors which determine the profitability of selected land uses in average cost/price structure circumstances.

The NR02 land suitability assessment has evaluated 12 land properties which encompass climatic, soil and topographic attributes. These are referred to as land use limitations, shortened to the term **limitations**. They are:

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[2] A unique map area (UMA) is a mappable area of land with a defined soil and topographic composition.

- Climate (C)
- Moisture Supply (M)
- Fertility (F)
- Wetness (W)
- Flooding (F)
- Rockiness (R)
- Topography (T)
- Physical Condition (P)
- Vegetation (V)
- Water Erosion (E)
- Landscape Complexity (X)
- Salinity (S)

The first step in the process is therefore to determine the limitation levels that apply to each soil/land type in each UMA. Table 1 shows the limitation levels that apply to a *Picanniny* soil in UMA 1683 This information is recorded in the UMA data file so that for each soil in each UMA, a value or code is recorded for each of the above limitations (Figure 1, part 2). This code or value expresses the level of restriction in the UMA. Each code is identified by its prefix e.g N5 indicates 3-8 ppm P and greater than 4 ppm SO_4 Sulphur.

The second stage in the process is to determine the effect of each limitation on each land use. This is the interpretive phase of land suitability assessment. It requires knowledge gained from farming and extension experience, as well as that from agricultural research. In the case of the present study, the suitability criteria have been developed in consultation with DPI staff who have worked on Cape York Peninsula in the fields of cropping, pasture management and beef cattle husbandry.

The level of expression of each limitation determines how suitable the UMA is for various land uses. However, the effect of the limitation will vary for different land uses. For example, in a rocky soil, the level of rock will have a more adverse effect on cropping uses than it will on improved pasture production. Five classes of suitability have been used to portray the degree of effect of each limitation level on respective land uses: Classes one to five imply a negligible, minor, moderate, severe and extreme effect on the land use respectively.

Table 1 **Example of the relationship between limitations and suitability classes for a UMA**

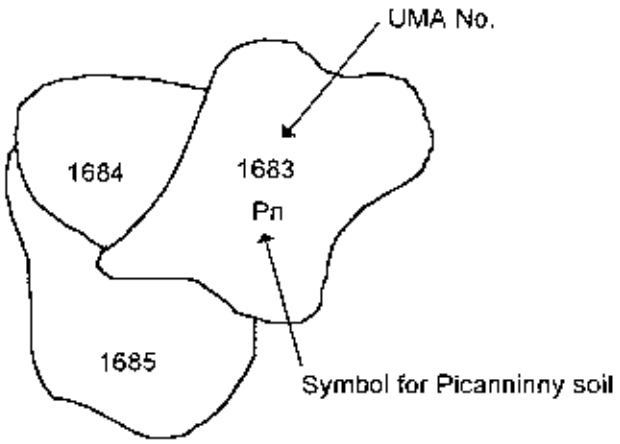
Simplified description of UMA No. 1683	**Limitation levels**[1]	**Limitation classes**[2]				
		Low input pasture	Medium input pasture	High input pasture	Sorghum /maize	Peanuts
Picanninny (Pn) Deep cracking grey clay soil on level plains. Climatic zone 1	**N5** (3-8 ppm P, > 4 ppm S04-S)	0[3]	0	0	2	2
	W4v (Imperfectly drained, very slowly permeable)	1	1	0	4	5
	T2 (Microrelief 0.1- 0.3 m)	1	1	2	2	3
	P7 (Strongly adhesive soils, narrow moisture range, moderately hardsetting)	2	2	2	3	4
	E2u (1-3%, slowly drained clays and unstable soils)	1	1	3	3	4
	So (Discharge zone)	1	1	0	0	0
Land Suitability Class		**2**	**2**	**3**	**4**	**5**

[1] These are inherent properties of the soil/land type

[2] These are interpreted values based on the inherent properties

[3] This value indicates that more investigation is required.

1. Part of soil map



2. Part of the data file for UMA 1683

Limitation level codes

UMA 1683	Pn	70%	C1	M2l	N5	W4v	F0	R0	T2	P7	Vc1e1	E2u	X1	So

translates to

Limitation classes and final suitability class

for low input pastures — for peanuts

1	1	1	2	1	1	1	2	1	1	1	1	2	1	2	2	5	1	1	3	4	1	4	5	0	5

Limitation class for respective limitations

Final suitability of the UMA for respective land uses

Figure 1 Example of soil map and UMA data file

The implication of the above is that if a UMA is given for example, an Rf4 code for rockiness (i.e 20-50% of 2-6 mm size stone present in the profile), this will translate to class 2 for maize and class 5 for peanuts.

Taking the case of UMA 1683, with *Picanninny* the dominant soil type, Table 1 shows how each limitation level is expressed as a limitation class for each land use. The limitation classes for each land use are also recorded in the UMA data file, as shown in Figure 1, part 2.

The final suitability class of the UMA for a particular land use is determined by the limitation with the greatest expression, that is with the highest suitability class (Table 1). In some cases, when several limitations are present at say a class 2 level, the final suitability class may be set at class 3 if there is a significant interactive effect. The suitability class is recorded in the UMA data file. The final suitability classes given to the land uses are defined as follows:

Class 1	suitable land with negligible limitations
Class 2	suitable land with minor limitations
Class 3	suitable land with moderate limitations
Class 4	marginal land which is presently considered unsuitable due to severe limitations
Class 5	unsuitable land with extreme limitations

1.2.3 Explanation of individual limitations

Appendix 1 provides an explanation of each of the limitations used in the study. For each limitation, there is a page of explanation of how it was assessed. This is followed by a table which shows how increasing levels of expression of the limitation affect each land use i.e the relationship between limitation level and limitation class.

1.3 Summary of findings

The results of the suitability assessment process are summarised in Table 2 and displayed on the maps in this report. The assessment was such that overlap between land uses exists, hence the figures in Table 2 do not sum to the total area of the Peninsula. Comparison of the maps illustrates the overlap between pastoral, cropping and horticultural land uses.

Table 2 Summary of agricultural land suitability assessment results

Land use	Area (ha)
Land suitable for peanuts, sorghum and maize	239 000
Land suitable for sorghum and maize	2 050 800
Land suitable for high input pastures	3 444 050
Land suitable for low and medium input pastures	4 448 150
Land suitable for low intensity grazing of native pastures	6 148 100
Land not suitable for nominated land uses	966 120

1.4 Discussion

As indicated in **1.1**, the suitability of each UMA for five land uses was **directly** assessed. Land assessed as unsuitable for any of the five land uses consists of those areas allocated a final suitability class of 4 or 5. Class 5 land includes mangroves, saltpans, urban areas and slopes >32%. It is designated as "**Land not suitable for the nominated land uses**". Class 4 land is mostly country with a very low fertility status and/or land vegetated with heaths. It is native pasture grazing land, which in many cases is associated with areas suitable for one or more pastoral development categories, and hence is a useful component of the total grazing system. (refer to **1.5** for further explanation). In many cases, it is not geographically or economically practical to exclude the Class 4 land from use. Bearing these factors in mind, land assessed as Class 4 for low input pastures has been labelled as "**Land suitable for low intensity grazing of native pastures**".

1.4.1 Context of suitability assessment

There is an important difference in the way land for improved pastures has been assessed compared to the assessment for cropping uses. The pasture assessment is based on average cost/price and marketing conditions that have prevailed in the Cape in the recent past. In contrast, because there is very little established cropping in the Cape, the suitability assessment for cropping assumes that all necessary infrastructural and marketing requirements are available within reasonable proximity of the land being assessed. In other words, the assessment for cropping uses is based dominantly on physical constraints of the land within a prescribed economic setting.

1.4.2 Improved pastures

Poor pasture nutrition, related to low soil fertility, in particular low phosphorous levels, is a major restriction to beef cattle production based on the grazing of native pastures and the establishment of legumes for the grazing of improved pastures (McKeague, 1992). Hence this study has assessed land for three forms of grazing use based on pasture improvement, defined as follows:

- *Low input* - native grass, sown legume and possible P supplemention
- *Medium input* - native grass, sown legume and fertiliser application
- *High input* - timber clearing, cultivation, fertiliser application and pasture sowing.

Following advice from DPI extension and research staff, land that has indicated fertility levels below 3ppm phosphorous is not considered suitable for any form of pasture improvement (see soil nutrition limitation), because pasture and animal responses will not be sufficient to provide a return on the cost of improvements. It should be noted however, that the chemical testing of soils was not comprehensive in this study, and hence individual land holders should have on site testing carried out before deciding on pasture improvement strategies.

Low input pastures

Low input pastures are generally regarded as the minimum form of development for long term profitable and sustainable beef cattle production. Wet season phosphorous supplementation of cattle is recognised as an important part of increasing weight gain and herd viability (Boorman, 1990), and is an integral part of the low input system.

Medium input pastures

This form of development is the next step in pasture improvement, and may be conducted in areas where soil phosphorous levels are low, but the potential for greater pasture production is high, if soil phosphorous levels are raised. The cost of transport and application of fertiliser will have a significant bearing on the economic viability of this form of development. Fertiliser application may or may not occur in conjunction with phosphorous supplementation.

Land assessed as suitable for low or medium input pasture development **only** is generally unsuitable for other land uses because of slope, rockiness, or moisture supply. Vegetation type may also have an effect, as illustrated in Appendix 1. Closed-forests are generally regarded as unsuitable for land uses that do not involve clearing.

While some UMA's may be class 1 for one of the uses and class 2 or 3 for the other use, there are no UMA's where the land is suitable for one use and not suitable (class 4) for the other. Hence the two land uses are portrayed together on Map 1.

High input pastures

The requirements for this type of development are more similar to those for the cropping land uses than for the other pasture land uses, given that tree clearing is involved. Both existing vegetation and regrowth can cause problems, but landholders on the Peninsula appear to be developing methods to counter these problems. Factors such as rockiness and wetness are not as restricting as for cropping because cultivation is only required for the establishment of a pasture, and at infrequent intervals.

CYPLUS

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LAND USE STRATEGY

DPI DEPARTMENT OF PRIMARY INDUSTRIES
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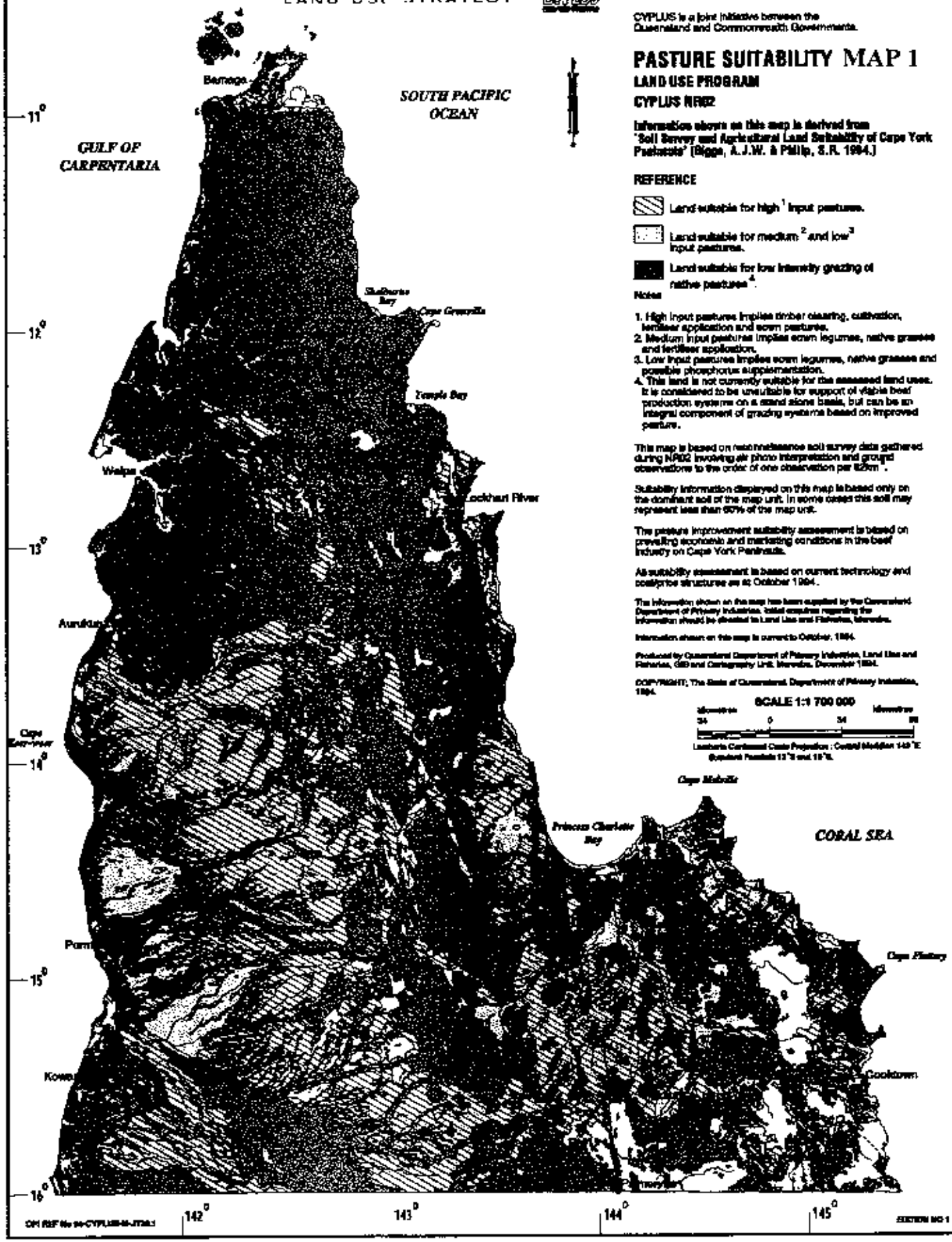
PASTURE SUITABILITY MAP 1

LAND USE PROGRAM

CYPLUS NR02

Information shown on this map is derived from 'Soil Survey and Agricultural Land Suitability of Cape York Peninsula' (Biggs, A.J.W. & Philip, S.R. 1994.)



REFERENCE

- Land suitable for high[1] input pastures.
- Land suitable for medium[2] and low[3] input pastures.
- Land suitable for low intensity grazing of native pastures[4].

Notes

1. High input pastures implies timber clearing, cultivation, fertiliser application and sown pastures.
2. Medium input pastures implies sown legumes, native grasses and fertiliser application.
3. Low input pastures implies sown legumes, native grasses and possible phosphorus supplementation.
4. This land is not currently suitable for the assessed land uses. It is considered to be unsuitable for support of viable beef production systems on a stand alone basis, but can be an integral component of grazing systems based on improved pasture.

This map is based on reconnaissance soil survey data gathered during NR02 involving air photo interpretation and ground observations to the order of one observation per 625m².

Suitability information displayed on this map is based only on the dominant soil of the map unit. In some cases this soil may represent less than 60% of the map unit.

The pasture improvement suitability assessment is based on prevailing economic and marketing conditions in the beef industry on Cape York Peninsula.

Suitability assessment is based on current technology and costs/price structures as at October 1994.

The information shown on the map has been supplied by the Queensland Department of Primary Industries. Initial enquiries regarding the information should be directed to Land Use and Fisheries, Mareeba.

Information shown on this map is current to October, 1994.

Produced by Queensland Department of Primary Industries, Land Use and Fisheries, GIS and Cartography Unit, Mareeba. December 1994.

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SCALE 1:1 700 000

Kilometres 34 0 34 68 Kilometres

Lambert Conformal Conic Projection : Central Meridian 143°E Standard Parallels 13°S and 19°S.

DPI REF No 94-CYPLUS-M-JT08.1

EDITION NO 1

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CROPPING SUITABILITY MAP 2

LAND USE PROGRAM

CYPLUS NR02

Information shown on this map is derived from 'Soil Survey and Agricultural Land Suitability of Cape York Peninsula' (Biggs, A.J.W. & Philip, S.R. 1994.)

REFERENCE

Land suitable for peanuts, sorghum and maize.

Land suitable for sorghum and maize.

This map is based on reconnaissance soil survey data gathered during NR02 involving air photo interpretation and ground observations to the order of one observation per 52km².

Suitability information displayed on this map is based only on the dominant soil of the map unit. In some cases this soil may represent less than 50% of the map unit.

The suitability assessment for cropping assumes a hypothetical situation of having no infrastructural restrictions in relation to product handling and marketing. Recommended fertiliser applications are assumed.

All suitability assessment is based on current technology and cost/price structures as at October 1994.

The information shown on the map has been supplied by the Queensland Department of Primary Industries. Initial enquiries regarding the information should be directed to Land Use and Fisheries, Marrabe.

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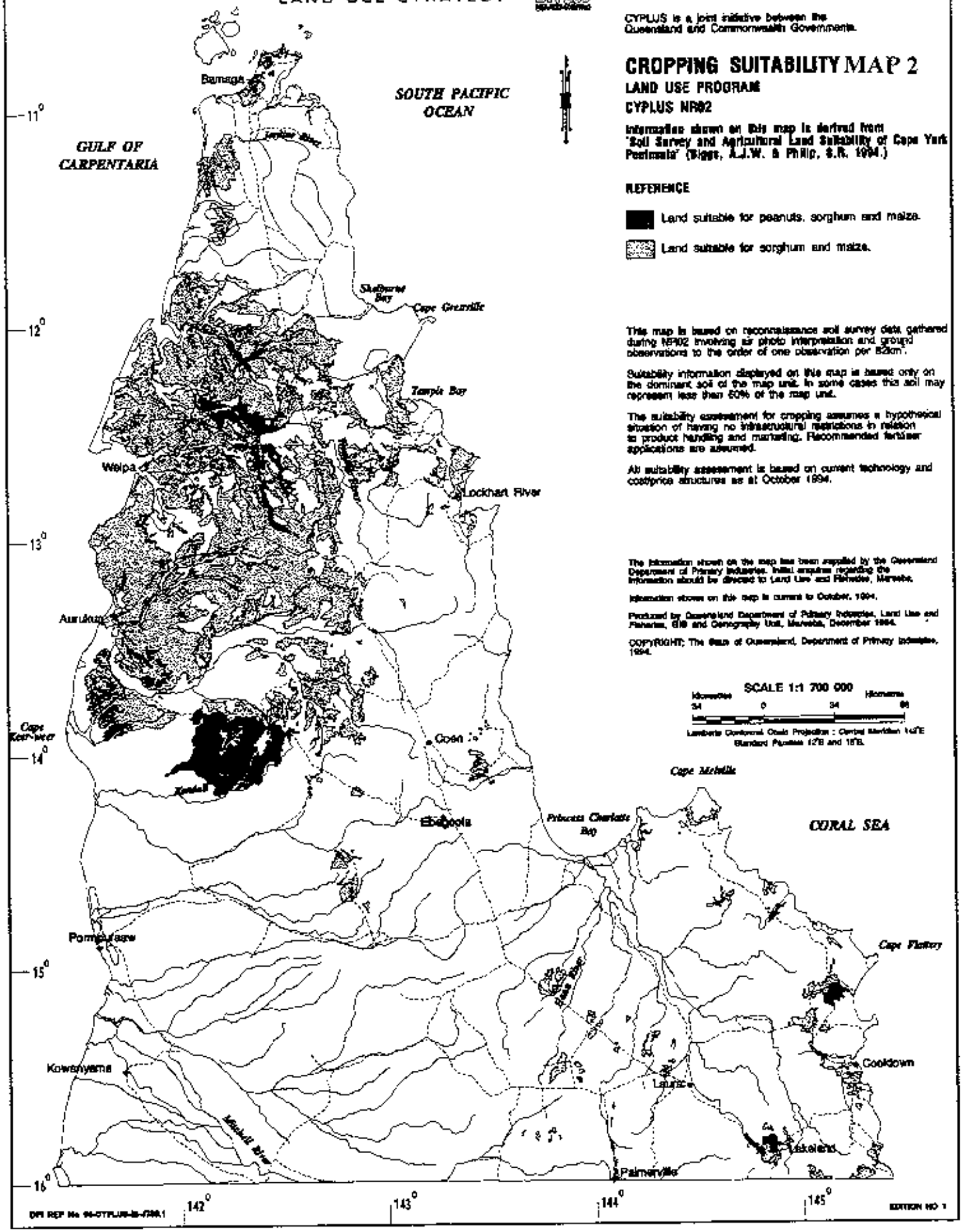
SCALE 1:1 700 000

Kilometres 34 0 34 68 Kilometres

Lambert Conformal Conic Projection : Central Meridian 142°E
Standard Parallels 12°S and 18°S.



DPI REF No 94-CYPLUS-S-/NR1

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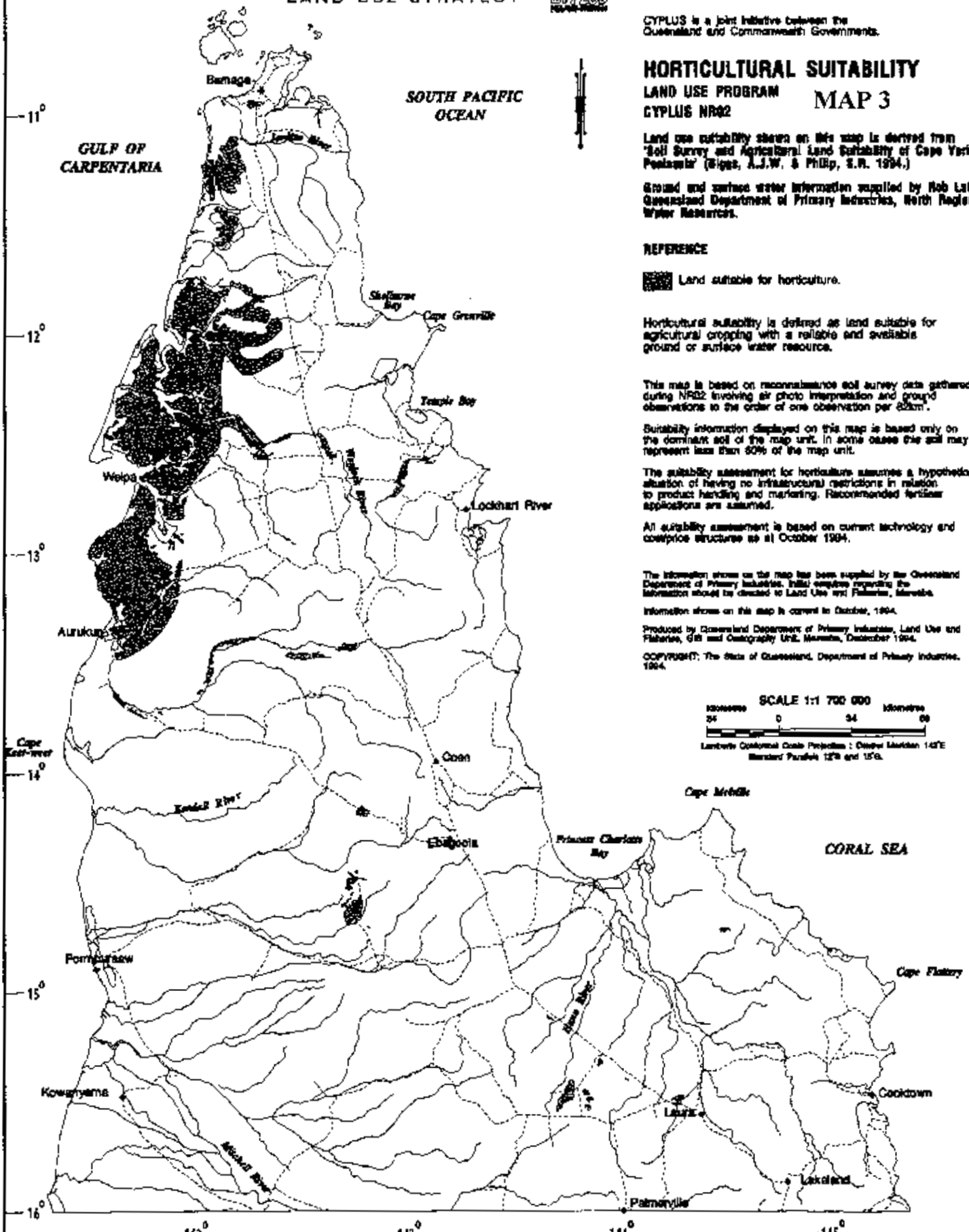
HORTICULTURAL SUITABILITY
LAND USE PROGRAM
CYPLUS NR02

MAP 3

Land use suitability shown on this map is derived from 'Soil Survey and Agricultural Land Suitability of Cape York Peninsula' (Biggs, A.J.W. & Philip, S.R. 1994.)

Ground and surface water information supplied by Rob Lait Queensland Department of Primary Industries, North Region Water Resources.



REFERENCE

Land suitable for horticulture.

Horticultural suitability is defined as land suitable for agricultural cropping with a reliable and available ground or surface water resource.

This map is based on reconnaissance soil survey data gathered during NR02 involving air photo interpretation and ground observations to the order of one observation per 80km².

Suitability information displayed on this map is based only on the dominant soil of the map unit. In some cases the soil may represent less than 60% of the map unit.

The suitability assessment for horticulture assumes a hypothetical situation of having no infrastructural restrictions in relation to product handling and marketing. Recommended fertiliser applications are assumed.

All suitability assessment is based on current technology and cost/price structures as at October 1994.

The information shown on the map has been supplied by the Queensland Department of Primary Industries. Initial enquiries regarding the information should be directed to Land Use and Fisheries, Mareeba.

Information shown on this map is current to October, 1994.

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SCALE 1:1 700 000
Kilometres 34 0 34 68 Kilometres

Lambert Conformal Conic Projection : Central Meridian 143°E
Standard Parallels 12°S and 15°S.

DPI REF No 94-CYPLUS-NR-FT0001

EDITION NO 1

Sorghum/maize and peanuts

All land assessed as suitable for peanuts is also assessed as suitable for sorghum/maize cropping, but the opposite does not apply due to the greater effects that rockiness and soil physical characteristics can have on peanuts. Land indicated as suitable for cropping of sorghum/maize is dominantly in the north on the Aurukun Surface where the presence of nodules in the surface horizon is not a major restriction. High temperatures are a restriction to sorghum/maize cropping in the south-west. Areas assessed as suitable for peanuts are located in the Lakelands area in the south and areas of sandstone derived soils in the north. Refer Map 2.

It is important to note that not all land suitable for cropping is suitable for pasture development. Fertility and existing vegetation are not major restrictions to cropping, but can restrict pasture development.

Horticultural suitability

An assessment of land suitable for horticultural purposes was generated using suitability assessment and available water resources data. Land suitable for horticulture is defined as land suitable for cropping that also possesses a reliable ground or surface water resource. Refer Map 3.

1.5 Suitability assessment and Peninsula grazing systems

The nature of the environment on Cape York Peninsula is such that grazing systems often require a range of soil/land types to cater for seasonal variations.

An example is the Batavia Landscape. The clay soils (*Picanninny, Myall and Batavia*) are indicated as suitable for a number of uses, in particular high input pasture grazing. The ironstone ridge soils (*Bertie, Scorpion*) are only assessed as being suitable for low input pasture grazing, due to a number of limitations e.g rockiness, fertility. The clay soils are often poorly drained and during the wet season, cattle move to the drier ironstone ridges. Any property or grazing system design must therefore include these ridge soils, which on a stand alone basis are considered unsuitable for intensive pasture

development, but when considered in the context of the whole system, play a valuable role.

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- The staff of Resource Assessment and Planning (Mareeba and Indooroopilly) for technical support and advice

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APPENDIX 1

RELATIONSHIP BETWEEN LAND USE LIMITATION LEVELS AND LIMITATION CLASSES FOR SIX LAND USES

This appendix provides an explanation of each of the limitations used in the study. For each limitation, there is a page of explanation of how it was assessed. This is followed by a table which shows how increasing levels of expression of the limitation affect each land use i.e the relationship between limitation level and limitation class.

CLIMATE (C)

Effect

High temperature can affect crop production. Poor pollination occurs in maize and sorghum when temperatures exceed 38°C. Rainfall influences plant growth by supplying the soils store of plant available moisture. This effect is dealt with under the moisture supply limitation (M).

Three climatic zones have been defined on the basis of rainfall and temperature differences, which have significant effects on plant performance.

Assessment

Crop tolerance information and local experience have been matched with climatic data to determine limitation classes.

Land Attributes

Mean monthly maximum temperature and mean annual rainfall .

Climatic zones

C1 mean monthly maximum temperatures less than 35°C, mean annual rainfall less than 1500 mm.
C2 mean monthly maximum temperatures less that 35°C, mean annual rainfall greater than 1500 mm.
C3 mean monthly maximum temperatures greater than 35°C, mean annual rainfall less than 1500 mm.

Land Attribute level		Limitation classes for selected land uses				
Temperature, Rainfall		**Low input pastures[1]**	**Medium input pastures[2]**	**High input pastures[3]**	**Maize, Sorghum**	**Peanuts**
C1	< 35°,< 1500 mm	1	1	1	1	1
C2	< 35°,> 1500 mm	1	1	1	1	1
C3	> 35°,< 1500 mm	1	1	1	3	1

1 *Low input pastures* implies sown legume, native grass, and possible P supplementation.
2 *Medium input pastures* implies sown legume, native grass, fertiliser application.
3 *High input pastures* implies timber clearing, cultivation, fertiliser application, sown pasture.

MOISTURE SUPPLY (M)

Effect

Plant yield will be decreased by periods of water stress particularly during critical growth periods. The supply of moisture to the plant seasonally or over a crop cycle depends on rainfall and stored soil moisture.

Assessment

Soil moisture storage has been determined by assessing plant available water capacity (PAWC) to the effective rooting depth[1]. PAWC is based on predicted values using Shaw and Yule (1978) and laboratory determinations of PAWC in similar soils in north Queensland.

Each soil is thereby allocated to one of six groups defined by a PAWC range[2].

Water balance modelling using PERFECT has then been used to determine, for each climatic zone, the relationship between PAWC and productivity of selected pasture and crop types. A minimum acceptable production level is selected and the equivalent PAWC value used to set the limitation class 3/4 boundary.

Land Attributes

PAWC to effective rooting depth within climatic zones.

---

1 Effective rooting depth is assumed to be 1m or to the depth of shallower impermeable layers, rock or high salt concentrations.

2 For soils that occur in landscape positions affected by water tables, there is an increase in moisture supply to the root zone because of a capillary rise effect. This results in an extension of the period of adequate moisture supply following rainfall. The estimated PAWC of these soils has been increased accordingly.

Land Attribute level			Limitation classes for selected land uses				
	Annual Rainfall	**Soil PAWC**	**Low input pastures**	**Medium input pastures**	**High input pastures**	**Maize, Sorghum**	**Peanuts**
M1l	< 1500 mm	> 140 mm	1	1	1	1	1
	(Climatic zones C1, C3)						
M2l		100-140 mm	1	1	1	2	2
M3l		80-100 mm	1	1	1	3	3
M4l		60-100 mm	1	1	1	4	4
M5l		40-60 mm	1	1	3	4	4
M6l		< 40 mm	3	3	4	4	4
M1h	> 1500 mm	> 140 mm	1	1	1	1	1
	(Climatic zone C2)						
M2h		100-140 mm	1	1	1	1	1
M3h		80-100 mm	1	1	1	1	1
M4h		60-80 mm	1	1	1	2	2
M5h		40-60 mm	1	1	1	3	3
M6h		< 40 mm	2	2	3	4	4

SOIL NUTRITION (N)

Effect

Plants require adequate levels of nutrients for optimal growth.

Assessment

For crop production, all soils require fertiliser treatment. Soils with poorer natural fertility have been downgraded because they require more than standard application rates. For the various forms of pasture improvement, soils with high natural fertility do not require fertiliser, but poorer soils require some fertiliser treatment. Soils with very low natural fertility have not been recommended for pasture development.

Soil phosphorus and sulphur levels from a representative selection of soils have been used to determine fertility status.

Nutritional requirements of crop and pasture species, and local knowledge of cropping and pasture management practices, have been used to determine fertiliser requirements and set limitation class limits.

Land Attributes

Acid extractable P for acid soils and bicarbonate extractable P for neutral to alkaline soils are both reported in units of *ppm*. Extractable sulphur (sulphate sulphur), using a technique similar to Barrow (1967) is reported as mg S kg^{-1} soil.

Land Attribute level		Limitation classes for selected land uses				
		Low input pastures	Medium input pastures	High input pastures	Maize, Sorghum	Peanuts
N1	> 20 ppm P, > 4ppm SO4-S	1	1	1	1	1
N2	> 20 ppm P, < 4ppm SO4-S	1	2	2	1	1
N3	8-20 ppm P, > 4ppm SO4-S	1	1	1	2	2
N4	8-20 ppm P, < 4ppm SO4-S	2	2	2	2	2
N5	3-8 ppm P, > 4ppm SO4-S	2	2	2	2	2
N6	3-8 ppm P, < 4ppm SO4-S	2	2	2	2	2
N7	< 3 ppm P, > 4ppm SO4-S	4	4	4	2	2
N8	< 3 ppm P, < 4ppm SO4-S	4	5	5	2	2

WETNESS (W)

Effect

Waterlogged soils will reduce plant growth and hamper effective machinery operation.

Assessment

Internal and external drainage are assessed by examining soil morphology (such as texture, grade and type of structure, colour, mottles, segregations and impermeable layers) and position in the landscape. Vegetation is often an indicator of soil wetness. Limitation classes are determined by relating drainage class and soil permeability (McDonald *et al.*, 1990)[1], to crop tolerance information, local experience and the effect on machinery operations.

Land Attributes

Drainage class and soil permeability.
Landscape position.

---

[1] The codes from McDonald *et al.* (1990), have been modified as follows.

Limitation Class Code	McDonald *et al.*, (1990) Drainage Class	
W1	6	Rapidly drained
W2	5	Well drained
W3	4	Moderately well drained
W4	3	Imperfectly drained
W5	2	Poorly drained
W6	1	Very poorly drained

Permeability codes
h - highly permeable
m - moderately permeable
s - slowly permeable
v - very slowly permeable

Land Attribute level		Limitation classes for selected land uses				
		Low input pastures	Medium input pastures	High input pastures	Maize, Sorghum	Peanuts
W1h	Rapidly drained, highly permeable	1	1	1	1	1
W2h	Well drained, highly permeable	1	1	1	1	1
W2m	Well drained, moderately permeable	1	1	1	1	1
W3h	Moderately well drained, highly permeable	1	1	1	1	2
W3m	Moderately well drained, moderately permeable	1	1	1	2	3
W3s	Moderately well drained, slowly permeable	1	1	1	3	4
W4h	Imperfectly drained, highly permeable	1	1	1	3	3
W4m	Imperfectly drained, moderately permeable	1	1	1	3	4
W4s	Imperfectly drained, slowly permeable	1	1	2	4	4
W4v	Imperfectly drained, very slowly permeable	1	1	2	4	5
W5h	Poorly drained, highly permeable	3	3	3	4	4
W5m	Poorly drained, moderately permeable	3	3	3	4	5
W5s	Poorly drained, slowly permeable	3	3	3	5	5
W5v	Poorly drained, very slowly permeable	3	3	3	5	5
W6h	Very poorly drained, highly permeable	4	4	3	5	5
W6m	Very poorly drained, moderately permeable	4	4	4	5	5
W6s	Very poorly drained, slowly permeable	4	4	4	5	5
W6v	Very poorly drained, very slowly permeable	4	4	4	5	5

FLOODING (F)

Effect

Yield reduction or plant death can be caused by high water temperatures and/or silt deposition during inundation, and physical removal or significant damage of plants can be caused by flowing water.

Assessment

Flooding frequency has been used to distinguish between suitable and unsuitable land only in extreme frequency situations or for intolerant crops. Where flood frequency is significant but not extreme the "0" symbol has been used to indicate the occurrence of flooding, but due to insufficient knowledge, it is not used to downgrade the suitability class.

Assessing the effects of flooding on an individual UMA is difficult. Flooding records, local experience, landscape position and flood debris have been used to distinguish affected areas.

Land Attributes

Flooding frequency.
Landscape position.

Land Attribute level		Limitation classes for selected land uses				
		Low input pastures	**Medium input pastures**	**High input pastures**	**Maize, Sorghum**	**Peanuts**
F0, F1	No Flooding or less than 1 in 10 years	1	1	1	1	1
F2	Flooding frequency of approximately 1 in 2-10 years	1	1	1	0	0
F3	Flooding frequency annually	1	1	3	4	5

ROCKINESS (R)

Effect

Coarse fragments[1] and rock in the plough zone will interfere with the efficient use of agricultural machinery. Surface rock in particular interferes with peanut harvester machinery.

Assessment

Visual assessment of the size, abundance (McDonald *et al.*, 1990) and distribution of coarse fragments and rocks in the plough layer. Limitation classes are determined by machinery tolerance as well as a knowledge of farmer tolerance to size and amount of coarse fragments and rock.

Local Attributes

Size and amount of coarse fragments and rock in the plough layer.

---

[1] Coarse fragments are particles greater than 2 mm not continuous with underlying bedrock (McDonald *et al.*, 1990) and includes rock fragments and segregations. Rock is defined as being continuous with bedrock.

Land Attribute level			Limitation classes for various land uses				
			Low input pastures	Medium input pastures	High input pastures	Maize, Sorghum	Peanuts
Rf4	2-6 mm	20-50%	1	1	1	2	5
Rf5		> 50%	1	1	1	3	5
Rm3	6-20 mm	10-20%	1	1	1	2	5
Rm4		20-50%	1	1	1	3	5
Rm5		> 50%	1	1	2	4	5
Rg1	20-60 mm	< 2%	1	1	1	1	3
Rg2		2-10%	1	1	1	2	4
Rg3		10-20%	1	1	1	3	5
Rg4		20-50%	1	1	2	4	5
Rg5		> 50%	1	1	3	5	5
Rc1	60-200 mm	< 2%	1	1	1	2	4
Rc2		2-10%	1	1	1	3	5
Rc3		10-20%	1	1	2	4	5
Rc4		20-50%	1	1	3	5	5
Rc5		> 50%	1	1	4	5	5
Rs1	200-600 mm	< 2%	1	1	1	3	5
Rs2		2-10%	1	1	2	4	5
Rs3		10-20%	1	1	3	5	5
Rs4		20-50%	1	1	4	5	5
Rs5		> 50%	1	1	5	5	5
Ro1 or R1	> 600 mm or rock outcrop	< 2%	1	1	2	4	5
Ro2 or R2		2-10%	1	1	3	5	5
Ro3 or R3		10-20%	1	1	4	5	5
Ro4 or R4		20-50%	1	1	5	5	5
Ro5 or R5		> 50%	1	1	5	5	5

TOPOGRAPHY (T)

Effect

Microrelief can cause uneven and reduced plant productivity due to uneven water distribution, for example, waterponding in depressions, and can inhibit efficient machinery operations.

Assessment

The vertical interval of gilgai, channels and other microrelief dictates the amount of leveling required for efficient surface drainage or the efficient use of machinery. Limitation classes are determined by local experience and consultation.

Land Attributes

Vertical interval of microrelief.

Land Attribute level		Limitation classes for selected land uses				
	Vertical interval	Low input pastures	Medium input pastures	High input pastures	Maize, Sorghum	Peanuts
T0	No microrelief	1	1	1	1	1
T1	< 0.1 m	1	1	1	1	1
T2	0.1 to 0.3 m	1	1	2	2	3
T3	0.3 to 0.6 m	1	1	3	3	4

SOIL PHYSICAL CONDITION (P)

Effect

Germination and seedling development problems are associated with adverse conditions of the surface soil such as hardsetting, large aggregates and clays with strong consistency.

A narrow moisture range for cultivation can create difficulties in achieving a favourable seed bed condition (tilth).

Soil adhesiveness can cause harvest difficulties and affect the quality of subsurface harvest material, such as peanuts.

Assessment

The degree of hardsetting, coarse aggregation and soil consistency are assessed in relation to their effect on germination and seedling development for a range of seed sizes.

Hardsetting friable and heavy clays are associated with a narrow moisture range for cultivation.

Land Attributes

Texture, structure, consistence.

Land Attribute level		Limitation classes for selected land uses				
		Low input pastures	Medium input pastures	High input pastures	Maize, Sorghum	Peanuts
P0	No Restriction	1	1	1	1	1
P1	Slightly to moderately adhesive soils, moderate moisture range moderately hardsetting	1	1	1	1	2
P2	Slightly to moderately adhesive soils, moderate moisture range, strongly hardsetting and or large aggregates	2	2	2	2	3
P3	Slightly to moderately adhesive soils narrow moisture range, moderately hardsetting	2	2	2	3	3
P4	Slightly to moderately adhesive soils, narrow moisture range, strongly hardsetting and/or large aggregates	2	2	2	3	3
P5	Strongly adhesive soils, moderate moisture range, moderately hardsetting	2	2	2	1	2
P6	Strongly adhesive soils, moderate moisture range, strongly hardsetting and/or large aggregates	2	2	2	2	4
P7	Strongly adhesive soils, narrow moisture range, moderately hardsetting	2	2	2	3	4
P8	Strongly adhesive soils narrow moisture range, strongly hardsetting and/or large aggregates	3	3	3	3	4

VEGETATION (V)

Effect

Regrowth after clearing certain vegetation communities for improved pasture establishment may require cultivation or other methods of regrowth control and involve significant or prohibitive costs. Similarly, introduction of pasture species into certain vegetation communities may create regrowth problems due to modified management, for example, reduced or cool burning.

Very dense vegetation may be too costly to clear, or may restrict the benefits of introducing pasture species into native vegetation communities due to plant competition and stock handling problems. Clearing and regrowth are not considered problems for uses requiring regular cultivation.

Assessment

Vegetation types have been identified by Neldner and Clarkson (personal communication). Determination of limitation classes for each land use has been based on local experience and management inputs required for initial timber clearing and subsequent control of regrowth, and the vegetation types which may be subject to severe regrowth under changing fire management.

Land Attributes

Vegetation type, density and height.

Land Attribute level		Limitation classes for selected land uses				
		Low input pastures	Medium input pastures	High input pastures	Maize, Sorghum	Peanuts
Vc1c1	Regrowth no problem to control, existing vegetation no problem	1	1	1	1	1
Vc1c2	Regrowth no problem to control, existing vegetation a problem (rainforests, vine scrubs)	5	5	1	1	1
Vc2c1	Regrowth poses a problem, existing vegetation no problem (*E. tetrodonta* woodlands, *Melaleuca* low open woodlands)	3	3	2	1	1
Vc2c2	Regrowth poses a problem, existing vegetation a problem (*E. tetrodonta* tall woodlands, *Melaleuca* low woodlands, heath)	3	3	2	1	1
Vc3	Existing vegetation precludes development (cycads)	4	4	1	1	1

EROSION (E)

Effect

On and off-site land degradation and long term productivity decline will occur on unprotected cultivated land and overgrazed pasture land due to excess soil erosion.

Assessment

Soil loss will depend on soil erodibility and land slope for a particular land use and surface management system. For each soil there is a maximum slope above which soil loss cannot be reduced to acceptable levels by erosion control measures or surface management practices.

Slope limits are determined in consultation with soil conservation personnel, agronomists and local experience. The implication of the classes are:

Cropping land

Class 1	surveyed row direction required.
Class 2	conservational parallel structures required, or some surface management practices[1].
Class 3	class 2 measures and increased surface management practices.
Class 4 & 5	non-cultivated land.

Pasture land

Class 1.	Yet to be determined
Class 2	
Class 3.	
Class 4 & 5.	

Land Attributes

Soil type
Slope

[1] Surface management practices are a range of options aimed at minimising soil disturbance, combined with the retention of harvest residue material as a surface cover.

Land Attribute level		Limitation classes for selected land uses				
	Slope %	Low input pastures	Medium input pastures	High input pastures	Maize, Sorghum	Peanuts
	Well drained and stable soils					
E1s	< 1	1	1	1	1	1
E2s	1-3	1	1	1	2	3
E3s	3-10	1	1	3	3	4
E4s	10-32	3	3	5	5	5
E5s	32-56	5	5	5	5	5
E6s	> 56	5	5	5	5	5
	Slowly drained clays, and unstable sodic soils (A horizon > 0.3 m)					
E1u	< 1	1	1	1	2	3
E2u	1-3	1	1	3	3	4
E3u	3-10	2	2	4	5	5
E4u	10-32	3	3	5	5	5
E5u	32-56	5	5	5	5	5
E6u	> 56	5	5	5	5	5
	Very unstable sodic soils (A horizons < 0.3 m)					
E1v	< 1	1	1	2	3	4
E2v	1-3	2	2	3	4	5
E3v	3-10	3	3	5	5	5
E4v	10-32	4	4	5	5	5
E5v	32-56	5	5	5	5	5
E6v	> 56	5	5	5	5	5

LANDSCAPE COMPLEXITY (X)

Effect

An area of suitable land may be too small or too isolated to justify its development as an isolated production area for a particular land use. Additionally, small areas of suitable land surrounded by unsuitable lands occur in some map units due to dissected topography or soil complexity.

Assessment

Areas of suitable land that are too isolated to justify development have been flagged but not downgraded. Map units that have complex soil patterns or dissected topography have been downgraded if the contiguous area of suitable land is smaller than an acceptable minimum production area for the land use in question. This production area has been determined in consultation with local extension staff.

The "0" symbol indicates that information on the classes for other limitations, the size of units, distance and practicality of access need to be considered before development is undertaken.

Land Attributes

Suitability class.
Access distance and difficulty.
Area of contiguous suitable land.

Land Attribute level		Limitation classes for selected land uses				
	Production area (ha)	Low input pastures	Medium input pastures	High input pastures	Maize, Sorghum	Peanuts
X0	> 100	1	1	1	1	1
Xi	Isolated areas 20 - 100	1	1	0	4	4
X1	< 20	1	1	5	5	5

SALINITY (S)

Effect

Deep drainage from permeable soils, usually higher in the landscape **(intake zones)**, may cause secondary salinisation downslope in **outflow zones.** Clearing of native vegetation can increase deep drainage.

Assessment

In areas associated with geological types that are possible sources of salinity, soil permeability, drainage class (McDonald *et al.*, 1990) and position in the landscape are used to determine intake zones that are linked to downslope outflow zones. High watertables may occur above areas where slowly permeable soils exist.

Any map unit with existing salinity is class 5 for any form of development. The suitability of intake, transmission and outflow zones is not downgraded. A value of 0 has been used to indicate that certain land management options are conditional on any development for a particular land use[1].

Land Attributes

Soil permeability and drainage class.

Landscape position.

Field and laboratory electrical conductivity measurements of selected soils.

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[1] Soil hydraulic conductivity, groundwater level and salinity measurements should be conducted prior to developing those soils indicated as having potential for secondary salinisation.

Land Attribute level		Limitation classes for selected land uses				
		Low input pastures	Medium input pastures	High input pastures	Maize, Sorghum	Peanuts
Si1	Intake zone - well drained, moderately to highly permeable soils in elevated landscape positions. Low risk geological unit	1	1	0	0	0
St1	Transmission zone - imperfectly drained, moderately to highly permeable soils in midslope positions. Low risk geological unit	1	1	0	0	0
So1	Discharge zone - imperfectly to poorly drained, slowly permeable soils in lower landscape positions. Low risk geological unit	1	1	0	0	0
Si2	Intake zone - well drained, moderately to highly permeable soils in elevated landscape positions. Moderate risk geological unit	1	1	0	0	0
St2	Transmission zone - imperfectly drained, moderately to highly permeable soils in midslope positions. Moderate risk geological unit	1	1	0	0	0
So2	Discharge zone - imperfectly to poorly drained, slowly permeable soils in lower landscape positions. Moderate risk geological unit	1	1	0	0	0
Si3	Intake zone - well drained, moderately to highly permeable soils in elevated landscape positions. High risk geological unit.	1	1	0	0	0
St3	Transmission zone - imperfectly drained, moderately to highly permeable soils in midslope positions. High risk geological unit.	1	1	0	0	0
So3	Discharge zone - imperfectly to poorly drained, slowly permeable soils in lower landscape positions. High risk geological unit	1	1	0	0	0
Su	Non-saline areas	1	1	1	1	1
Ss	Naturally saline soils	5	5	5	5	5

APPENDIX 2
TERMS OF REFERENCE
Relevant for Part B & Part C of Report

Other Primary Industry (non-pastoral, non-forestry)

1. Provide details of current aquaculture and mariculture activities to the Department of land current Land Use project.

2. Review the Department of Lands draft Current Land Use project report on the nature and location of current non-pastoral and non-timber primary industries in Cape York Peninsula.

   Provide advice to the DoL on the nature and location of current use not described in the draft report.

3. Prepare a draft report on a regional assessment of areas of general suitability for primary industry, and create a GIS layer which depicts suitability for pasture improvement categories, maize, sorghum and peanuts.
   Output:
   Draft report, maps and GIS layer of potential areas for primary industry for the use of the consultant undertaking the 'industry issues' task of this project and for review by the Land Working Group.

4. Prepare a draft report on a regional assessment of areas of general suitability for aquaculture and mariculture.
   Output:
   daft report, maps and GIS layer of potential areas for aquaculture and mariculture for the use of the consultant undertaking the 'industry issues' task of this project and for review by the Land Working Group.

5. Prepare draft final report and present to the Land Working Group.

6. Prepare a final project report.

PART C

GENERAL SUITABILITY OF AQUACULTURE AND MARICULTURE DEVELOPMENTS OF CAPE YORK PENINSULA

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EXECUTIVE SUMMARY

The aim of this project was to assess the regional areas of general suitability for aquaculture and mariculture operations in the CYPLUS region. Aquaculture is the farming of aquatic plants and animals under controlled or semi-controlled conditions. Aquaculture includes the breeding, hatching, rearing and cultivation of aquatic organisms for sale. The term aquaculture encompasses mariculture which is the sea based farming of salt water aquatic organisms.

The successful development of any aquaculture operation depends on a number of economic and environmental factors. Market demand, product prices and cost of production are important economic factors when developing an aquaculture operation.

When selecting potential sites for aquaculture and mariculture operations it is important to locate areas with specific combinations of attributes that accommodate the requirements of both the animal and farm.

There are several basic environmental factors to consider when developing an aquaculture operation. These attributes can be divided into the following classifications: water, land, climate and environment (Lobegeiger, 1994).

Year round high temperatures, good water quality, habitats for wild stock sources (ie. estuaries, bays and rivers) and a large landmass are characteristics that favour aquaculture developments on the Peninsula. However, the lack of infrastructure and facilities, such as power and road access, may cause some limitation on aquaculture development in the region.

The environmental criteria in this study was developed for culture species found in tropical areas of Australia and species that have been cultured with a degree of success and/or that have had research into their culture opportunities in northern Australia. The species used for assessment in this study include: *Lates calcarifer* (barramundi); *Tridacna gigas* (giant clam); *Penaeus monodon* (black tiger prawn); *Saccostrea spp.* (edible oysters); *Pinctada maxima* (pearl oyster); *Cherax quadricarinatus* (red claw crayfish) and *Crocodylus porosus* (saltwater crocodile).

The criteria was based on information regarding the relationship between the cultured species and its environment. The criteria included: soil type, flooding frequency, flow periods, chemical composition of surface water, coastline characteristics and proximity to sensitive areas.

The criteria were then used to format maps and tables outlining information on areas suitable for aquaculture. Attributes vital to the farm location such as power availability, infrastructure (towns) and farm access were not used in the direct assessment of suitable culture sites as the GIS map produced display characteristics at a regional scale. Power, infrastructure and transportation are vital to the success of the operation and should be assessed on site once a regional area for operation has been defined.

It is important to note that criteria used for this study are appropriate at a regional scale and do not suit assessment at the site level. Further examination at the site level, such as testing of water and soil composition, is needed when developing any aquaculture operation.

The CYPLUS region has several potential areas suitable for aquaculture operations. Many of these areas are suitable for a variety of species and size of developments. There is also a great opportunity for several Aboriginal Communities on the Peninsula to develop aquaculture operations.

The tip of Cape York Peninsula is void of any suitable land areas for aquaculture except for a small area surrounding Bamaga. This area has suitable soil characteristics, a gently undulating landform (3-10% slope) and has infrequent flooding of 1 in 10 years.

A large area of suitable land exists in central Cape York Peninsula from 12 to 14 degrees latitude and 142 to 143 degrees longitude. This area has suitable soil characteristics with varying degrees of flooding and landforms. Most flooding occurs 1 in 10 years with seven small pockets (dark green areas on map Appendix B) flooding 1 in 2 - 10 years. A small stretch of land along the Watson River has annual flooding and may be less suitable than other areas which flood less frequently. Landform in this area varies between flat to gently undulating.

Several suitable land areas exist along the western and eastern coastlines within the CYPLUS region. On the western coast, land areas north of Weipa and surrounding Aurukun have suitable soil characteristics, although they flood annually.

Sites in the eastern coast are more positive for aquaculture developments. There are several sites with varying landform and flooding frequencies. Cape Weymouth has suitable land areas that flood 1 in 10 years and gently undulating landform of 3-10%. Inland from Cape Weymouth, approximately 40 km, is a stretch of suitable soil that runs for 30 km. This area floods once in 2-10 years and has a gently undulating slope. Bordering this area in the south is an area with flatter land form and flooding 1 in 10 years. Suitable land area runs approximately 70 km along the Lockhart river.

South of 14 degrees latitude, the western coast has numerous suitable soil areas that extend eastward some 150 km along major rivers such as, the Kendall, Holroyd, Edward and Mitchell.

A stretch of land running 90 km southwards along the Normanby River has annual flooding. Two areas bordering Princess Charlotte Bay have suitable soil characteristics, flat landform and flood 1 in 10 years.

Coastal areas from Cape Melville to Archer Point are dotted with suitable soil characteristics, landform and infrequent flooding.

The Peninsula's surface water characteristics such as flow periods and salinity will impact the size and number of aquaculture development. Surface water on Cape York Peninsula is extremely fresh (free of dissolved solids) and future aquaculture operations on suitable land would need to introduce sea water or nutrients to raise conductivity/salinity of pond water.

No flow periods greater than eight weeks occur in 7 river basins on land defined as suitable for aquaculture. The Embley, Watson, Ducie, Archer, Coleman and Jeannie River basins all have gauging stations with unsuitable no flow periods. The Olive-Pascoe, Stewart, Normanby, Jeannie, Endeavour, Mitchell at Koolatum, Holroyd at Strathgordon, Archer, Wenlock and Ducie are river basins with suitable water flow on land suitable for aquaculture.

Prawn and Crayfish operations will vary in size and location due to the differing water volume of river basins on aquaculture land.

20 stations with suitable water flow periods have an average annual volume of water flow appropriate to supply barramundi operations with 1 to 50 ponds 1 hectare in size or nursery operations.

The CYPLUS region has approximately 1,600 kilometres of coastline and has great potential for the development of sea based aquaculture operations. The coastal areas on the eastern coast of the CYPLUS region are managed by the Great Barrier Reef Marine Park Authority and is designated as Marine National Park. This coast has several islands, bays and estuaries that may be suitable for sea based operations, however, development of sea based operations on the eastern coast will be restricted due to zones within the Marine Park.

The Torres Strait and tip of Cape York are proven areas for pearl oyster operations.

Development of sea based aquaculture operations on the western coast of the Peninsula will be limited to inland estuary areas such as those found in Weipa and Aurukun. The remaining coastline has limited protection such as islands and bays from weather conditions and would not be suitable for sea based operations. In addition, the south-east coast is adjacent to land which floods annually and fresh water run-off may enter mariculture operations neighbouring these land areas.

LIST OF ABBREVIATIONS

ACIAR	Australian Centre for International Agriculture Research
C.I.T.E.S.	Convention on International Trade in Endangered Species of Wild Fauna & Flora
CYPLUS	Cape York Peninsula Land Use Strategy
DEH	Department of Environment and Heritage
DPI	Department of Primary Industries
GBR	Great Barrier Reef
GBRMPA	Great Barrier Reef Marine Park Authority
GBRMP	Great Barrier Reef Marine Park
GIS	Geographical Information System
NRAP	Natural Resource Analysis Program
QFMA	Queensland Fish Management Authority
QNPWS	Queensland National Parks and Wildlife Service

1.0 INTRODUCTION

The Cape York Peninsula Land Use Strategy (CYPLUS) is a project established by the Commonwealth and Queensland Governments with the aim of providing information to assist in making informed decisions on the future use of the Cape York Region.

The Land Use Program is a component of CYPLUS which has been established to collect information about economic, environmental, social and cultural issues in the sustainable development of Cape York Peninsula.

The CYPLUS region encompasses approximately 140,000 km^2 of land in far north Queensland and over 1,600 kilometres of coastline. The boundaries of the CYPLUS region follow the eastern coast of Queensland from approximately 16 degrees south to the tip of Cape York and includes the southern islands of Torres Strait. The boundary then extends down along the western coast of Queensland and inland along the Nassau, Mitchell, McLeod and Bloomfield Rivers to Wujal Wujal south of Cooktown (Figure 1).

The project outlined in this paper is a Land Use Program (Other Primary Industries) commissioned by the CYPLUS Taskforce to assess the regional areas of general suitability for aquaculture and mariculture. Appendix D outlines the Terms of Reference for this project.

LANDS

CYPLUS

CAPE YORK PENINSULA LAND USE STRATEGY

CYPLUS is a joint initiative between the Queensland and Commonwealth Governments.

LOCALITY MAP

CYPLUS Study Area

The information shown on the map has been supplied by the Queensland Department of Lands. Initial inquiries regarding the information should be directed to Cartographic Unit, Cairns.

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Produced by the Queensland Department of Lands, Cairns July 1995.

Note: The CYPLUS boundary includes off shore water up to the three mile limit.

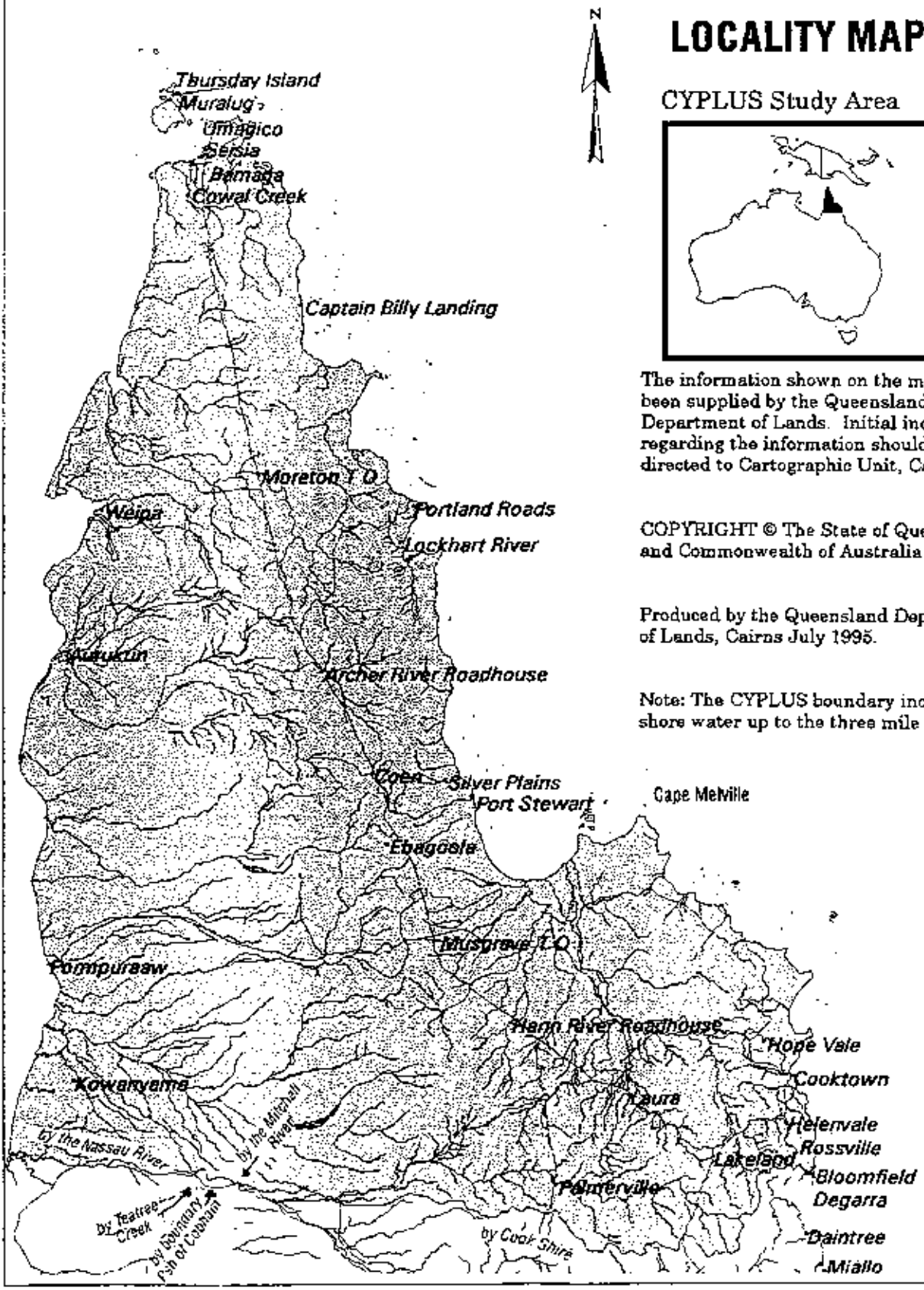


Figure 1

2.0 DEVELOPMENT OF AQUACULTURE AND MARICULTURE

Aquaculture is the farming of aquatic plants and animals under controlled or semi-controlled conditions. Aquaculture includes the breeding, hatching, rearing and cultivation of aquatic organisms for sale (Baker, 1994). Mariculture is a term used to describe sea based farming of salt water aquatic organisms. Aquaculture involves land or sea based farming of fresh or salt water aquatic species. Throughout this report the term **aquaculture** will refer to mariculture as well as land based freshwater culture.

Worldwide aquaculture production has greatly increased over the past twenty years and is now worth approximately US $30 billion per year. This is likely to double by the turn of the century (Baker, 1994). It is predicted that by 2010, global aquaculture production will contribute over 24 percent of total fisheries production (Rowland, 1991).

The successful development of any aquaculture operation depends on a number of economic and environmental factors. Market demand, product prices and cost of production are important economic factors when developing an aquaculture operation. Site selection is a key success factor in aquaculture operations. Environmental factors such as water quality, soil characteristics, topography and climate will be a major influence in the choice of species, cost and location of the aquaculture operation.

Cape York Peninsula has several development opportunities for future aquaculture operations. Year round high temperatures, good water quality, habitats for wild stock sources (ie. estuaries, bays and rivers) and a large landmass are characteristics that favour aquaculture developments. However, the lack of infrastructure and facilities, such as power and road access, may cause some limitation on aquaculture development in the CYPLUS region.

3.0 AQUACULTURE OPERATIONS

Aquaculture is an industry with varying operations and techniques. There are two distinct phases of farming aquatic organisms; a hatchery/nursery phase and a growout phase. A culture operation can include both phases of operation or just one. It is important to note that each phase may require different environmental conditions which will affect site location.

Aquaculture can be classified into extensive or intensive levels of operation. Extensive culture is one in which adult and juveniles are stocked at relatively low densities in ponds and feeding is based primarily on the natural food available in the pond (Rowland, 1986). Intensive culture consists of high densities and growth of the species is increased by supplementary feeding. This system requires regular flushing of the holding facilities to maintain balanced water quality (Rowland, 1986). Environmental factors will influence the level of operation used. Intensive culture should not be chosen in areas where an annual supply of water is not guaranteed.

Culture of aquatic animals involves several types of rearing facilities. Ponds, tanks, dams, enclosures, pens, cages and longlines are all methods used in aquaculture operations.

4.0 SITE SELECTION

When selecting potential sites for aquaculture and mariculture operations it is important to locate areas with specific combinations of attributes that accommodate the requirements of both the animal and farm.

There are several basic environmental factors to consider when developing an aquaculture operation. These attributes can be divided into the following classifications: water, land, climate and environment (Lobegeiger, 1994).

4.1 Water

Water availability is an important development factor for operations in the CYPLUS region as there is a distinct dry season in which many water sources may have periods of no flow. The success of a culture operation is dependent on the consistent availability and quality of a water source. Water sources for culture operations can include rivers, creeks, estuaries, small dams, lakes, irrigation canals, sea water and ground water. An abundant and regular supply of water to ponds and hatcheries is essential for the maintenance and growth of healthy cultured animals.

Good quality water is also vital for culture operations. Poor water quality will reduce survival and growth rates of cultured species. Ph, dissolved oxygen, ammonia, salinity and temperature are important characteristics of water quality in culture operations.

4.2 Land

Land attributes important for culture operations include soil type, surrounding topography and the potential for flooding.

In pond aquaculture it is vital to select a site with suitable soil characteristics. The soil must have good holding qualities so the water does not seep out of the pond. It is also important to build the ponds away from areas with high ground water as the ponds need to be completely drained and dried after harvest. The chemical composition of the soil is also an important consideration. Ponds constructed on or near mangrove areas may have difficulties with acid sulphate soils and low soil Ph levels (McCormack, 1989).

Land areas that are subject to floods should be avoided as culture stock could escape and ponds be destroyed during floods. Escaped stock may be a cause of genetic problems for species in the areas surrounding the farm (ie. water ways) as the genetic composition of the farmed animals may differ from the wild species. Wild stocks may also come into contact with diseases associated with intensive culture. It is important for farm operations to reduce the possibility of farmed species being introduced into the wild.

Flooding is an important factor for sea based aquaculture operations as developments adjacent to the mouths of rivers may be subject to high levels of sediment run-off. Floods may also increase freshwater flow to sites adjacent to rivers and islands. Freshwater will impact species that are not tolerant of salinity fluctuations (Lucas, 1986).

The physical features of the land surrounding aquaculture operations is important to consider when selecting a potential site of operation. The land surrounding most pond aquaculture operations should be relatively flat and free from vegetation. Leaves falling into the pond can change the chemical composition of the water and thus affect the water quality of the pond. Flat to gently undulating land surrounding the pond is important as surface run-off can enter the pond and affect the water quality (McCormack, 1989 & Rowland, 1986). These two factors are especially relevant to small scale operations as the larger intensive operations neutralise these factors.

4.3 Climate

Climatic factors such as rainfall, wind and air temperatures should be considered when selecting potential sites for aquaculture operations. Rainfall and its seasonal nature will impact the availability of water to the operation and also the water quality of individual ponds. Air temperature is also an important factor to consider as it will affect the growth, reproduction and general behaviour of the cultured animal.

Wind velocity is especially important for mariculture operations. Potential sites should be protected from strong winds and waves so holding facilities, such as cages, are not destroyed (Beveridge, 1987). Winds along the east coast from March to September generally follow a south-east to easterly direction and reach speeds of between 15-20 knots. During these months, winds north of Princess Charlotte Bay may reach greater than 20 knots. Between September and December winds come from the south-east with some north-easterlies. Winds reach approximately 10 knots. Between January and March the monsoonal trough moves across the Cape and winds come from the west. The Gulf Coast between March and September encounters light winds coming from the west. Between January and March the Gulf Coast has westerly and north-westerly winds of up to 20 knots. Information on wind velocity was gained though personal interviews with the Bureau of Meteorology, Cairns.

4.4 Environment

Areas surrounding or that will be disturbed due to potential aquaculture operations need to be considered before developing an operation. Disturbance of sensitive areas such as National Parks, Marine Parks, mangroves and Fisheries Habitat and Wetland Reserves are important to consider, as waste discharge from the operation can have the potential to adversely affect ecologically sensitive areas (Gillespie & Taylor-Moore, 1994).

Proposed aquaculture operations greater than 200 m^2 need to be assessed by a range of government departments. DPI, GBRMPA, QFMA and DEH are Government agencies that grant permission to develop an aquaculture operation. Obtaining approval to develop a site for aquaculture may involve the following:

- land use approval from a Local Authority under the *Local Government (Planning and Environment) Act 1991*
- technical and impact assessment of the proposal from DPI under the *Fishing Industry Organisation and Marketing Act 1990*

- permit for the removal or disturbance of mangroves from DPI under the *Fisheries Act 1989*
- permit for disturbance of Wetland or Fish Habitat Reserves from DPI under the *Fisheries Act 1989*
- licence for waste discharge and approval for construction of water intake and outlet structures on tidal lands from DEH under the *Clean Waters Act 1990*
- licence to take freshwater is required from DPI under the *Water Resources Act 1989* Section 35A(2)
- permit application complete with all necessary approvals and submitted to the QFMA
- processing of aquaculture product requires licences for the buildings from QFMA and the local council and for processing and selling from the QFMA (Gillespie & Taylor-Moore, 1994).

All commercial mariculture operations in the GBRMP require a Marine Park Permit (Gillespie & Taylor-Moore, 1994). GBRMPA is responsible for ensuring that mariculture operations below mean low water mark do not cause significant environmental damage on the Marine Park and its users (Gillespie & Taylor-Moore, 1994). Operations in certain areas of the Marine Park such as Marine National Park zones, Scientific Research or Preservation zones will not be granted approval (GBRMPA, 1994). DEH advises the GBRMPA on local factors and administers the Queensland Marine Parks adjacent to the GBR and has responsibility for the inter-tidal zone (Gillespie & Taylor-Moore, 1994).

Knowledge of the location and permit requirements and potential impacts of aquaculture developments near or within sensitive areas is important when assessing potential sites as it can assist in eliminating areas that might otherwise be suitable and reduce unnecessary costs and effort for the operator.

The selection of suitable sites for aquaculture or mariculture operations should also be based upon knowledge of the geography, geology, hydrology, environment and climate of the area. Information on the relationship between the species chosen for culture and its environment is important. A species can be assessed for its suitability for culture under a specific set of circumstances. It is important to locate areas with a specific combination of attributes that match favourably with the cultured species' natural habitat and with the needs of the farm operation (Rowland, 1986). Culture operations should be planned carefully and a vital key to success is getting the location right.

5.0 CULTURED SPECIES

The environmental criteria in this study were developed for culture species found in tropical areas of Australia and species that have been cultured with a degree of success and/or that have had research into their culture opportunities in northern Australia. The species used for assessment in this study include: *Lates calcarifer* (barramundi); *Tridacna gigas* (giant clam); *Penaeus monodon* (black tiger prawn); *Saccostrea spp.* (edible oysters); *Pinctada maxima* (pearl oyster); *Cherax quadricarinatus* (red claw crayfish) and *Crocodylus porosus* (saltwater crocodile).

5.1 Barramundi

The barramundi has a national and international reputation as a good sporting fish and is sought for its excellent eating qualities. Barramundi live in rivers and estuaries in tropical and subtropical areas of the Indo-Pacific region (Evans et al, 1989). These fish prefer slow moving or still muddy waters in rivers, creeks, swamps and estuaries. However, barramundi can also be found in saltwater near shore islands and reefs (Evans et al, 1989). This makes the barramundi a suitable species for both land and sea based aquaculture operations.

5.2 Giant clam

Giant clams inhabit shallow clear waters of coral reefs around countries in the Indo-Pacific region. *T. gigas* is the largest and fastest growing of the giant clam species and occurs naturally on fringing reefs in the GBR region (ACIAR, 1992). Giant clams are a food source for many island and coastal people of the Indo-Pacific region and natural stocks have been greatly reduced in many areas due to over-harvesting (ACIAR, 1992). The culture of giant clams provides food to coastal people, such as Torres Strait Islanders and a means for restocking areas depleted of clams (ACIAR, 1992). Extensive research into clam culture has been undertaken off islands in the GBR region.

5.3 Black tiger prawn

Marine prawns have been a preferred candidate for aquaculture in Australia for several decades. One of the first land based aquaculture operations in Queensland in the early seventies was a pilot prawn farm in Karumba (Baker, 1994). The black tiger prawn has an excellent growth rate and is able to handle varying levels of water factors, such as dissolved oxygen and salinity (McCormack, 1989). This species is ideal for areas with high rainfall such as tropical regions that experience long wet seasons (Evan et al, 1989).

5.4 Edible oysters

Two types of edible oysters; *S. enhinata* or black lip oyster and *S. amasa* or milky oyster, may be suitable for culture operation in the Cape York Region. Black lip oyster are found in central Queensland, the Northern Territory, north Western Australia and countries to the north of Australia (McCormack, 1989). Farming trials of the black lip oyster have met with some success on Magnetic and Palm Islands near Townsville, Queensland (Witney et al, 1988). Milky oysters grow in northern Australia on coral reefs and in tropical inlets and are found in the Indo-west Pacific region (McCormack, 1989).

Farming of edible oysters involves several different rearing facilities such as stick cultivation, trays, ground banks, floating cylinders and deep water during the maturation stage (Witney et al, 1988). Deep water facilities involve methods of holding the oysters below buoyant rafts which are anchored against ingoing and outgoing tides. Stacks of trays or longlines are the two preferred holding facilities for deep water culture (Witney et al, 1988).

5.5 Pearl oysters

Cultivation of pearl oysters first began in Queensland in the 1890's in Torres Strait (Ward, 1993). At present there are 21 pearl farms in Queensland. Approximately half of the farms are located in Torres Strait and near the tip of Cape York with the remainder scattered along the eastern coast of Queensland between Cooktown and Townsville (Coles, 1994). *Pinctada maxima*, the largest species of pearl oyster, is the major species of oyster used to cultivate pearls. It is estimated that Australia produces half of the world's south sea pearls (Ward, 1993).

5.6 Red claw crayfish

Red claw crayfish is a species of freshwater crayfish native to tropical Queensland and the Northern Territory. They are found throughout northern Australia in the Gulf river systems of Queensland and the Northern Territory (Evans et al, 1989). Red claw crayfish is considered to be a good candidate for aquaculture in Queensland as it is well suited to tropical climatic conditions. Crayfish culture normally involves the growout and hatchery/nursery phase of the operation. Breeding and growout ponds are kept separate. Once mating has taken place, the eggs are nurtured by the female for approximately 4-6 weeks with the eggs hatching between 6-8 weeks (Jones, 1990). It takes approximately 60 days for the hatchlings to reach suitable stocking size of 0.5 - 1.0 grams (Jones, 1990). The Juveniles are then placed into growout ponds and can reach commercial size in 12 months (Jones, 1990).

5.7 Estuarine (saltwater) crocodiles

All crocodiles are listed on the C.I.T.E.S as species threatened by trade. Queensland is one of three Australian crocodile range States, thus it is important to ensure that both Estuarine and Freshwater crocodiles maintain viable wild populations. The QNPWS attempts this by listing crocodiles as Protected Fauna in Queensland and not accepting new farming proposals based on Freshwater crocodiles(QNPWS, 1992).

Crocodile farming in Queensland began in 1969. The first farm, the Edward River Crocodile Farm, was located on the western Cape York Peninsula and collected the saltwater crocodile species (*Crocodylus porosus*) for breeding (Lobegeiger et al, 1994).

Crocodile farming in Queensland is estimated to hold 60-70 percent of the total of farmed crocodiles in Australia. In 1992, there were approximately 12,000 saltwater crocodiles held on farms in Queensland (Lobegeiger et al, 1994). The culture of crocodiles is predominantly for the sale of skins and the industry received a boost when the export of crocodile skins became legal in 1986. Some farms, such as Hartley's Creek just north

of Cairns, are set up as tourist attractions with daily feeding shows. Crocodile farming is still developing in Queensland and tourism will continue to be an important source of income for new farms.

Crocodile farming ventures must meet the current C.I.T.E.S. requirements of being self-sustaining, closed cycled farming operations, which are capable of reliably breeding crocodiles to the second generation, without augmentation from the wild (QNPWS, 1992). Farm operations must obtain a Fauna Dealer's Licence, a Certificate of Registration of Fauna Dealer Premises-Class A and a Permit to Keep and Deal in Fauna before commencing farming operations. If the farm intends to open the operation to the public for display or educational purposes, a permit to keep endorsed for exhibition (under Section 53) must be issued (QNPWS, 1992). These licences can be obtained from the Department of Environment and Heritage.

Acquisition of crocodiles must be from either a licensed crocodile farmer or from a licensed zoo (Class G Fauna Dealer). A farmer is not permitted to acquire crocodiles directly from a non-dealer or from the wild (QNPWS, 1992). Ranching (wild harvesting) of eggs, or live animals is not permitted within Queensland.

The stocking rate for all sizes of estuarine crocodile is dependent on the amount of cover, available water and feeding space. The animals are likely to become stressed if any of these factors are limited.

To protect the crocodile skin from damage caused by infections from fungus growth, the animals are kept in concrete ponds.

Year round high temperatures, available land and wild stocks are factors favouring the development of crocodile operations on the Peninsula. A limiting factor for farming, especially during the growout phase of a crocodile operation, would be the lack of a guaranteed food supply. Juveniles, less than one year, are fed between 5-7 times a week and maturing animals, 1-3 years, are fed approximately 3 times a week.

The industry in Queensland is constrained by the number of crocodiles that can be harvested from the small supply of wild stocks, however, purchasing breeding stock from existing farms will allow some expansion.

Farm manager, Mr Freeman, of Hartley's Creek Farm in Cairns, suggested the future of crocodile farming lies in the increasing demand for skins and the available wild stocks (animal and eggs) on the Peninsula. There is an opportunity to develop a tanning factory in Queensland and to process the skins locally.

5.8 Phase of operation

The development criteria compiled for this study were based upon the growout and hatchery phase of culture operations. It was important to separate the two phases as they require different development criteria.

6.0 METHODOLOGY

The aim of this project was to assess the regional areas of general suitability for aquaculture. Key environmental attributes important to the development of cultured tropical species were collated to develop criteria for potential culture operations. The criteria were based on information on the relationship between the cultured species and its environment. The development criteria were then used to format maps and tables outlining information on areas suitable for aquaculture. Attributes vital to the farm location such as power availability, infrastructure (towns) and farm access were not used in the direct assessment of suitable culture sites, as the GIS map produced displays characteristics at a regional scale. Power, infrastructure and transportation are vital to the success of the operation and should be assessed on site once a regional area for operation has been defined.

Environmental attributes chosen to assess the regional areas of general suitability for aquaculture on Cape York Peninsula were based upon available and accessible data from the NRAP and Land Use Program of CYPLUS and other government departments (GBRMPA, DPI).

6.1 Development criteria

The development criteria consisted of several water, land and environmental parameters mentioned in section 4.0. These parameters are listed in Table 1. Information gathered for the development criteria in Table 1 was obtained from literature and interviews with individuals experienced in aquaculture and mariculture operations.

Tables 5-7 in Appendix A list the specific factors used in the analysis of suitable sites for aquaculture. The development factors were grouped by cultured species and phase of operation since environmental criteria may vary between cultured species and/or phase of operation.

It is important to note that criteria used for this study are appropriate at a regional scale and do not suit assessment at the site level. Further examination at the site level, such as testing of water and soil composition, is needed when developing any aquaculture operation.

6.2 Geographical information system

Once information for the development criteria had been gathered; GIS, table and map outputs were developed. Information from NRAP/ Soils Survey and Agriculture Suitability of Cape York Peninsula (NR02), and Land Use Project/Surface Water Resources Report were used to compile GIS maps and tables showing suitable areas for aquaculture developments. Further information from GBRMPA was used to ascertain suitable locations for sea based operations.

A comprehensive range of development criteria for mariculture operations was difficult to compile into GIS format due to the lack of available data on coastline and sea

characteristics. Instead, coastline maps from GBRMPA were used in the assessment of suitable sites for mariculture developments. Environmental attributes used to assess potential sites for mariculture were limited to accessible data and maps within these agencies. This displays the need for detailed information on land and water factors of coastal areas if the potential for mariculture operations is going to be assessed in detail.

Table 1: Development criteria for aquaculture & mariculture operations

PARAMETERS	FACTORS	CRITERIA
WATER	Salinity	Min-max range
	Temperature	Min-max range
	Flow period	No flow periods
	Exchange flow rates per year	Daily exchange for 1 ha of pond or (1) 12 500 litre tank
	Ph of water	Min-Max range
	Ground water	Minimum depth
LAND	Soil type	% of clay
	Flooding	Frequency of floods
	Landform	Slope & coastline characteristics
	Ph of soil	Min-max range
ENVIRONMENTAL	Sensitive areas: National Parks, Parks, Marine Parks, State Forest	Proximity to suitable land areas

7.0 LAND SUITABILITY FOR AQUACULTURE DEVELOPMENTS

Appendix B contains a map coverage, Land Suitability for Pond Aquaculture, which shows a GIS output of land suitability for aquaculture developments on Cape York Peninsula. The criteria used for land suitability include: soil characteristics (soil type, soil Ph and depth to ground water), degree of flooding and topographic features, refer to Table 5, Appendix A. The map displays five possible groups, shown in colour, of suitable land areas for aquaculture. The white areas lack any suitable land characteristics for aquaculture operations.

The tip of Cape York Peninsula is void of any suitable land areas for aquaculture except for a small area surrounding Bamaga. This area has suitable soil characteristics, gently undulating landform (3-10% slope) and has infrequent flooding of 1 in 10 years.

A large area of suitable land exists in central Cape York Peninsula from 12 to 14 degrees latitude and 142 to 143 degrees longitude. This area has suitable soil characteristics with varying degrees of flooding and landforms. Most flooding occurs 1 in 10 years with seven small pockets (dark green areas on map Appendix B) flooding 1 in 2 - 10 years. A small stretch of land along the Watson River has annual flooding and may be less suitable than other areas which flood less frequently. Landform in this area varies between flat to gently undulating.

Several suitable land areas exist along the western and eastern coastlines within the CYPLUS region. On the western coast, land areas north of Weipa and surrounding Aurukun have suitable soil characteristics, although they flood annually. On the ground analysis into pond development should be undertaken to ensure culture stock will not wash away during flooding. Sites in the eastern coast are more positive for aquaculture developments. There are several sites with varying landform and flooding frequencies. Cape Weymouth has suitable land areas that flood 1 in 10 years and gently undulating landform of 3-10%. Inland from Cape Weymouth, approximately 40 km, is a stretch of suitable soil (grey colour) that runs for 30 km. This area floods 1 in 2-10 years and has a gently undulating slope. Bordering this area in the south, is an area with flatter land form and flooding 1 in 10 years. A suitable land area runs approximately 70 km along the Lockhart river (dark green colour). This area may be especially suitable for aquaculture operations that include both nursery and growout stages as it is adjacent to a constant supply of seawater. Higher salinity levels are needed for nursery phase of operations.

South of 14 degrees latitude, the western coast has numerous suitable soil areas that extend eastward some 150 km along major rivers such as the Kendall, Holroyd, Edward and Mitchell. However, the landform along these rivers is flat with a slope of less than 3% and is subject to annual flooding. In the south-west corner of CYPLUS, a large area of suitable soils with flat landform and flooding of 1 in 10 years and 1 in 2-10 years exists.

The eastern coast south of 14 degrees latitude floods less frequently in regions with suitable soils. A stretch of land running 90 km southwards along the Normanby River has annual flooding. Two areas bordering Princess Charlotte Bay have suitable soil characteristics, flat landform and flood 1 in 10 years.

Coastal areas from Cape Melville to Archer Point are dotted with suitable soil characteristics, landform and infrequent flooding.

Inland near Laura, there is a relatively large area with suitable land characteristics. This area has flat to gently undulating landform with flooding occurring 1 in 10 and 1 in 2-10 years. Land surrounding the town of Lakeland has suitable soil characteristics for aquaculture operations and landforms suitable for pond developments.

A noteworthy point about land areas suitable for aquaculture on the Peninsula is, many do not have towns in the vicinity. Only towns such as Bamaga, Aurukun, Pormpuraaw, Lakeland and Cooktown have land suitable for aquaculture close by.

8.0 WATER SUITABILITY FOR AQUACULTURE DEVELOPMENTS

Information on surface water resources on the Cape York Peninsula was collated from the Land Use Program: The Surface Water Resources of Cape York Peninsula, which investigated the nature of the surface water resources. A key feature of the analysis was the use of the hydrographic gauging station records compiled by DPI. Within CYPLUS there are 47 gauging stations located on key rivers and creeks. These stations gather information for water resource management (DPI, 1994).

This study focuses on gauging stations located among areas containing suitable aquaculture land characteristics as shown on the map in Appendix B. Thirty gauging stations were found among areas suitable for aquaculture. Figure 2 outlines these gauging stations. Table 2 lists the river basins in which the 30 gauging stations occur.

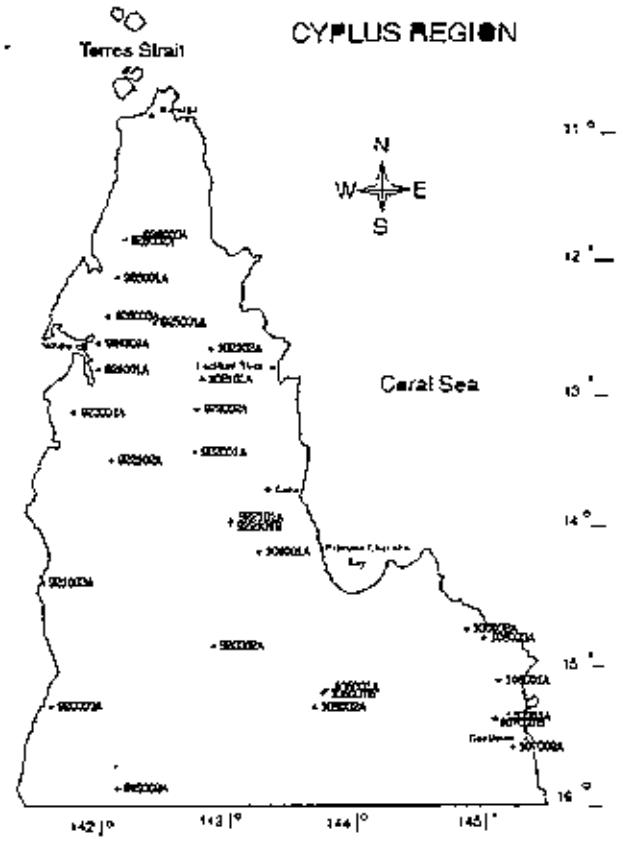


Figure 2 Gauging stations on land suitable for aquaculture land in Cape York Peninsula

Data on the physical and water quality characteristics at each gauging station found in suitable aquaculture land areas was gathered from the Land Use Program Surface Water Resources project. Further information on Cape York water characteristics such as quality and chemistry can be found in the Surface Water Report and the NRAP project report (NR10/Fish Fauna Survey). The Fish Fauna Survey gathered data on water chemistry for major river systems of Cape York Peninsula, not previously well surveyed.

Table 2: River basins important for aquaculture development on Cape York Peninsula

River Basin	Basin number	Basin Area (km^2)
Olive-Pascoe River	102	4,350
Stewart River	104	1,162
Normanby River	105	24,605
Jeannie River	106	3,755
Endeavour River	107	2,200
Mitchell River at Koolatum	919	71,795
Coleman River	920	13,080
Holroyd River at Strathgordon	921	10,425
Archer River	922	13,595
Watson River	923	4,715
Embley River	924	4,715
Wenlock River	925	7,575
Ducie River	926	6,655

Tables 3 and 4 outline physical and chemical water characteristics important for aquaculture operations. The data collated in these tables is based on water factors needed for tropical cultured species as shown in Table 6, Appendix A. The chemical data contained within the Land Use Program was taken from the latest sample collected only and there is a limit to its representativeness (DPI, 1994). The seasonal nature of the Peninsula (ie. evaporation and floods) will greatly affect water chemistry and detailed chemical analysis of the water source for the operation is recommended during the wet and dry seasons.

Table 3: Physical characteristics of surface water on aquaculture land

Gauging station	Location	Years of Record	Length of record (years)	Cumulative Length of No Flow Periods	% of No Flow Periods	Annual weeks of no flow periods	Annual flow volume megalitres
102101A	Pascoe River at Falls Creek Crossing	1967-93	26	0.81 years	3.1	1.6	603099
102102A	Pascoe River at Garraway Creek Junction	970-93	3			0	490066
104001A	Stewart River at Telegraph Road	1970-93	23	5.3 years	23	11.98	249740
105001A	Hann River at Kalinga Homestead	1958-71	13	0	0	0	128133
105001B	Hann River at Sandy Creek	1968-91	23	0	0	0	183167
105002A	Jungle Creek at Kalinga Street	1970-88	18	20 days	0.3	.15	59147
106001A	McIvor River at Elderslie	1969-88	19	30 days	0.4	.22	119214
106002A	Jeannie River at Wakooka Road	1970-88	18	7.6 year	42.2	21.95	150844
106003A	Starke River at Causeway	1970-88	18	4.3 years	23.9	12.4	138976
107001A	Endeavour River at Flaggy	1958-90	32	1.7 years	5.3	2.76	154101
107001B	Endeavour River at Flaggy	1967-91	24	2 years	8.3	4.3	159270
107002A	Annan River at Mt. Simon	1969-91	22	0	0	0	432994
919009A	Mitchell River at Koolatah	1972-93	21	27 days	0.4	.18	13013901
920002A	Coleman River at King Junction	1970-91	21	10.3 years	49.0	25.0	701714

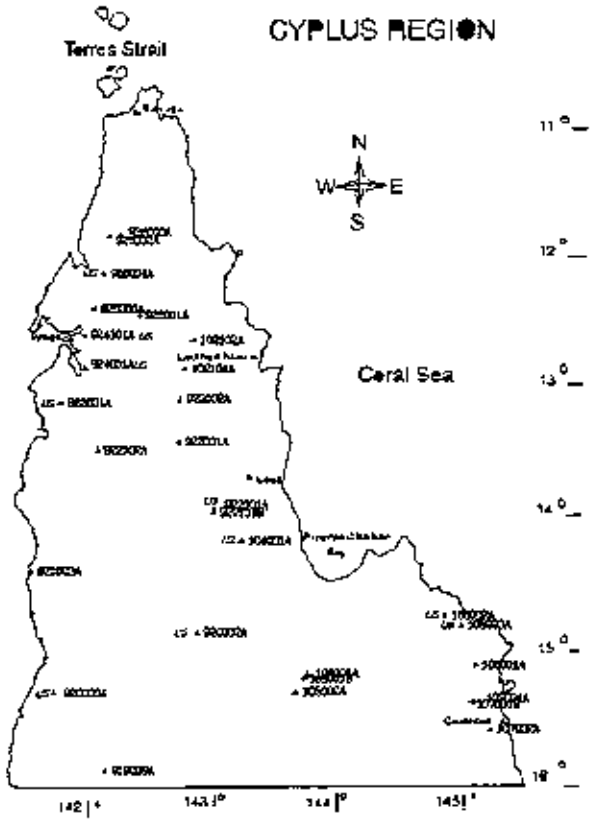
Table 3: Physical characteristics of surface water on aquaculture land (cont)

Gauging station	Location	Years of Record	Length of record (years)	Cumulative Length of No Flow Periods	Percentage of No Flow Periods	Annual weeks of no flow periods	Annual flow volume in megalitres
920003A	Coleman River at Bass Yards	1975-89	14	6.2	44.3	23.0	519786
921003A	Holroyd River at Delta	1974-89	15				
922001A	Archer River at Telegraph Crossing	1968-93	25	3.4 years	13.6	7.07	1706773
922101A	Coen River at Coen	1957-67	10	2.1 years	21	10.92	55307
922101B	Coen River at Racecourse	1957-92	25	3.3 years	13.2	6.86	105486
922102A	Coen River at Fish Hole	1974-89	15				
922002A	Archer River Ring Yards	1971-89	18				
923001A	Watson River at Above Jackin Creek	1972-91	19	5.4 years	28.4	14.72	590576
924001A	Embley River at Kurracoo Creek	1971-86	15	6.1 years	40.7	21.14	271945
924101A	Mission River at York Downs	1972-91	16	6.9 years	43.1	22.42	297941
925001A	Wenlock River at Moreton Telegraph	1958–90	32	0	0	0	1408830
925002A	Wenlock River at Wenlock	1969-91	22	2.8 years	12.7	6.61	468679
925003A	Wenlock River at Jacks Camp	1971-88	17	0	0	0	3197539
926001A	Ducie River at Bertichaugh	1968-88	20	6.6 years	33.0	12.16	412069
926002A	Dulhuntly River at Dougs Pad	1970-92	22	0	0	0	247862
926003A	Bertie Creek at Swordgrass Swamp	1972-90	18	0	0	0	107610

8.1 Physical Characteristics Of Surface Water On Aquaculture Land

There is limited use of surface water throughout Cape York Peninsula. Available supplies are not extensively used due to the region's small population, seasonal nature of water supply (lack of guaranteed supply between September and December) and limited industry (DPI, 1994).

Eight of the 30 gauging stations have continuously flowed during the period of record. A further four sites have no flow periods of less than 1% and three sites have no flow period between 1-10%. Refer to Table 3. The greatest percentage of no flow period is found along the Coleman River at King Junction, station 920002A. This site recorded a 49% no flow period from 1970-1989. A lack of water supply greater than 8 weeks per year to any culture operation is unsuitable. Ten of the 30 gauging stations listed in Table 3 have no flow periods of greater than 8 weeks. The basin area of Coleman River has the greatest period of no flow with 2 stations (920002A & 920003A) having 25 and 23 average weeks of no flow. Aquaculture operations developed in areas with a lack of annual guaranteed water supply are not recommended. Figure 3 shows the gauging stations with unsuitable water flow characteristics (ie. > 8 weeks).



* US = unsuitable no flow periods

Figure 3 Gauging stations with no flow periods greater than eight weeks

The Embley, Watson, Ducie, Archer, Coleman and Jeannie River basins all have gauging stations with unsuitable no flow periods and aquaculture operations within these regions are not recommended without further investigation into river flows.

In addition to water flow, the volume of water is an important criteria to aquaculture operations. This report used 1 hectare as the standard size for pond operations. However, landbased aquaculture ponds vary in size and number depending on the individual operator and operation, and the phase of operation (ie. growout or nursery), and the size and age of the stock. Once stock reaches a certain size or weight, it will be transferred to a different pond. This reduces competition for space and food with the smaller species in the pond. Table 6, Appendix A outlines the water exchange rate needed for a 1 hectare pond or a single 12 500 litre tank for prawn, crayfish and barramundi.

All 20 stations with suitable water flow periods have an average annual volume of water flow appropriate to supply barramundi operations with 1 to 50 ponds one hectare in size or nursery operations.

Prawn and crayfish culture operations on potential aquaculture land on the Peninsula will vary in location and size due to the changing water volume of river basins. Sites 102101A and 105002A have suitable water volume for prawn or crayfish operations with 1 to 10 ponds, one hectare in size. Sites 922101B and 926003A have suitable water volume for 1 to 20 ponds, one hectare in size. Sites 105001A and 106001A have suitable water volume for operations with 1 to 30 ponds, one hectare in size. Sites 107001A, 107002B and 105001B have suitable water volume for operations with 1 to 40 ponds, one hectare in size. The remaining 8 sites have suitable water characteristics for prawn or crayfish operations with greater than 50 ponds, one hectare in size.

In regions of suitable aquaculture land there are several river sites/ basins with suitable physical water characteristics (ie. water flow and volume) that would be appropriate for a range of farm sizes and culture species.

8.2 Chemical Characteristics Of Surface Water On Aquaculture Land

The chemical composition of water at the 20 sites with suitable water flow is also an important factor to consider when developing a culture operation. Three water chemical characteristics (temperature, Ph and salinity) were chosen as criteria for the assessment of aquaculture operations on the Peninsula, refer to Table 4.

Ph levels at the date of testing ranged from 6.2-7.98. Ph levels below 7.0 are unsuitable for crayfish operations and a Ph below 6.5 is not recommended for cultured prawns or barramundi. Nine sites have a Ph level below 7.0 with four of the nine sites having a Ph level below 6.5. Figure 4 shows the gauging stations with low Ph levels. The basins of the Normanby (105) and Ducie (926) rivers have Ph levels below 6.5. Operations developed in these areas would need to adjust Ph levels.

Available data for water temperature shown in Table 4 indicate that one gauging station, 925002A, falls below the recommended minimum temperature criterion. In May 1992, a temperature of 22 degrees Celsius was recorded.

Perhaps the most limiting factor for aquaculture development on the Peninsula will be the "freshness" of the surface water. Tropical cultured species require a certain level of salinity in pond water. A salinity range of 0-40 parts per thousand(ppt) is the suggested criteria listed in Table 6, Appendix A.

Salinity is not directly tested at the gauging stations, instead the water is tested for conductivity and/or dissolved solids. Table 4 gives the conductivity and salinity levels at each site. Conductivity was converted to salinity ppt by the following calculation: Conductivity × .64 ÷ 1000 (Dehayr, 1995).

Each site has a recorded salinity level below 1ppt, falling well below the minimum criteria for P. monodon and crayfish during the nursery and growout phase of operation. Cultured barramundi can grow in freshwater (0 salinity) and/or water high in salinity (40 ppt). Gauging stations on potentially suitable aquaculture land have very low salinity levels that would be appropriate for freshwater barramundi operations. Other tropical species would need to have a large input of salt/sea water in order to raise salinity levels.

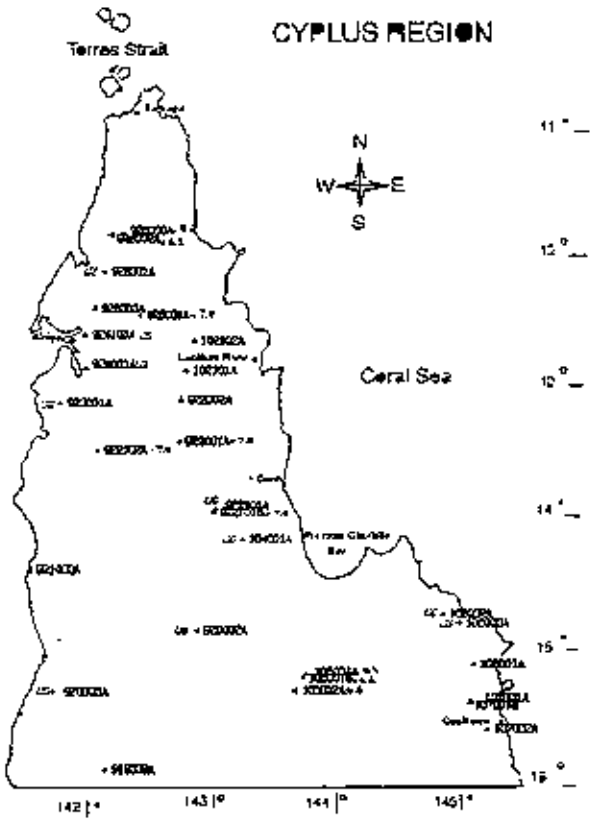


Figure 4 Gauging stations with Ph levels below 7.0

Table 4: Water quality of surface water in areas of suitable aquaculture land

Gauging Station	Location	Date of sample	Recorded Temp (Celsius)	Ph	Conductivity (μScm^{-1}) /Salinity ppt
102101A	Pascoe River at Falls Creek Crossing	Sept 93	24	7.08	117.0 / .075
102102A	Pascoe River at Garraway Creek Junction	Sept 93	24	7.05	90.0 / .058
104001A	Stewart River at Telegraph Road	Sept 93	24	7.39	146.0 / .093
105001A	Hann River at Kalinga Homestead	July 91	23	6.20	44.90 / .029
105001B	Hann River at Sandy Creek	August 93	24	6.56	41.20 / .026
105002A	Jungle Creek at Kalinga Street	Nov 88	-	6.20	45.0 / .029
106001A	McIvor River at Elderslie	Nov 88	-	7.4	195.0 / .125
106002A	Jeannie River at Wakooka Road	March 88	-	6.5	65.0 / .042
106003A	Starke River at Causeway	May 88	-	7.5	110.0 / .07
107001A	Endeavour River at Flaggy	-	-	-	-
107001B	Endeavour River at Flaggy	Sept 93	24	7.21	116.0 / .074
107002A	Annan River at Mt. Simon	August 91	23	6.5	73.4 / .047
919009A	Mitchell River at Koolatah	May 93	23	7.98	113.70 / .073
920002A	Coleman River at King Junction	May 90	-	6.90	55.0 / .035
920003A	Coleman River at Bass Yards	March 88	-	6.70	40.0 / .026

Table 4: Water quality of surface water in areas of suitable aquaculture land (cont)

Gauging station	Location	Date of sample	Recorded Temp (Celsius)	Ph	Conductivity (μScm^{-1}) / Salinity ppt
921003A	Holroyd River at Delta	March 87	-	7.50	43.0 / .028
922001A	Archer River at Telegraph Crossing	August 93	24	7.2	139.0 / .089
922101A	Coen River at Coen	-	-	-	-
922101B	Coen River at Racecourse	August 93	24	6.82	97.70 / .063
922102A	Coen River at Fish Hole	August 89	-	6.5	79.0 / .051
922002A	Archer River Ring Yards	Feb 90	-	6.9	63.0 / .04
923001A	Watson River at Above Jackin Creek	August 93	24	7.33	174.0 / .111
924001A	Embley River at Kurracoo Creek	May 85	-	7.70	235.0 / .150
924101A	Mission River at York Downs	May 88	-	7.5	66.0 / .042
925001A	Wenlock River at Moreton Telegraph	August 93	24	6.77	74.90 / .048
925002A	Wenlock River at Wenlock	May 92	22	7.08	109.0 / .07
925003A	Wenlock River at Jacks Camp	May 88	-	7.50	60.0 / .038
926001A	Ducie River at Bertiehaugh	August 87	-	7.10	80.0 / .051
926002A	Dulhuntly River at Dougs Pad	August 93	24	6.29	38.60 / .025
926003A	Bertie Creek at Swordgrass Swamp	Nov 91	24	6.44	39.00 / .025

9.0 ENVIRONMENTALLY SENSITIVE AREAS ON AQUACULTURE LAND

Cape York Peninsula has several National Parks which are located in regions of suitable aquaculture land. Potential aquaculture developments within protected areas may be inhibited by regulations or legislation enacted by Commonwealth or State Governments mentioned in section 4.4. Appropriate Government Departments should be contacted before developing any aquaculture operation.

The following National Parks fall in areas near or directly on sites assessed as suitable aquaculture land on the Peninsula: Iron Range National Park, north of Lockhart River; Archer Bend and Rokeby National Parks in central Cape York; Lakefield National Park, south of Princess Charlotte Bay; Cape Melville National Park and Mitchell and Alice National Park.

10.0 COASTAL SUITABILITY FOR SEA BASED AQUACULTURE OPERATIONS

The CYPLUS region has approximately 1,600 kilometres of coastline and has great potential for the development of sea based aquaculture operations. Table 7, Appendix A outlines several coastline characteristics needed to develop sea based operations. Protection from wind and wave action is an important criterion for sea based operations.

The coastal areas on the eastern coast of the CYPLUS region are managed by the GBRMPA and are designated as Marine National Park. This coast has several islands, bays and estuaries that may be suitable for sea based operations. However, only areas within General Use A & B zones may be developed. Appendix C contains three maps outlining the coastline characteristics and zones for the eastern coastline.

There are several bays and headlands that are protected from wind and wave action and zoned for approved development by GBRMPA. The coast of Cape Bedford and Flattery may be suitable for sea based operations as they fall outside the Marine Park and are protected from harsh weather conditions. Bathurst and Princess Charlotte Bays have a long strip of coastline that also may be suitable for sea based operations. However, land adjacent to the bay floods annually, refer to map, Appendix B, and current flows of the bay should be assessed so outputs of freshwater do not inundate sea based culture operations.

Further north at Lloyd Bay, off Lockhart River, is a coastal area suitable for mariculture development. In addition, Cape Grenville and southern Temple Bay may be suitable for sea based operations.

Sea based operations may also be developed on the western side (lee) of islands or cays protected from easterly winds. Most islands on the eastern coast are protected from development through Marine Park zoning. Those islands located in blue areas on the maps in Appendix C may be suitable for sea based operations.

Torres Strait has great potential for sea based operations as there are several islands on which operations could be developed. At present there are 6 pearl oyster culture farms operating around the islands of Torres Strait and 5 operating off islands and the Escape River on the tip of Cape York (Coles, 1994). Figures 5 and 6 shows the location of the pearl farms in the CYPLUS region.

Development of sea based aquaculture operations on the western coast of the Cape will be limited to inland estuary areas such as those found in Weipa and Aurukun. The remaining coastline has limited protection, such as islands and bays from weather conditions and would not be suitable for sea based operations. In addition, the south-east coast is adjacent to land which floods annually and fresh water run-off may enter mariculture operations.

Coastal areas which may be suitable for sea based culture operations should be assessed on site to determine factors such as current flow, water temperature, salinity and depth of water.

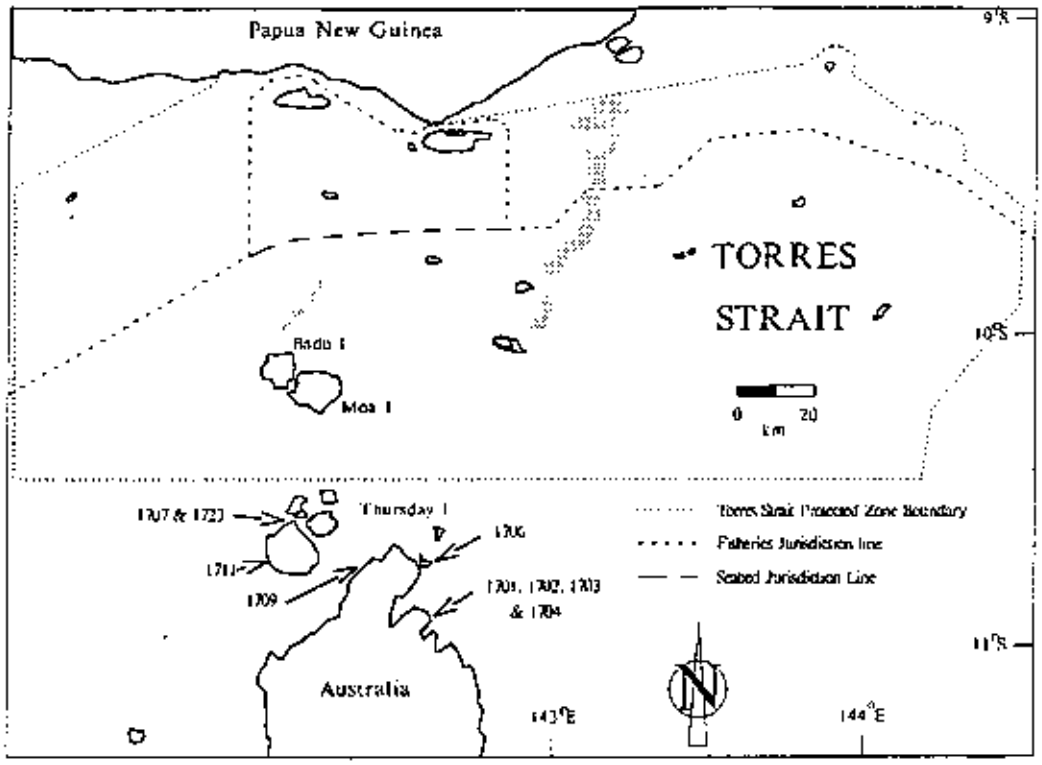


Figure 5: Pearl farms at the tip of Cape York Peninsula

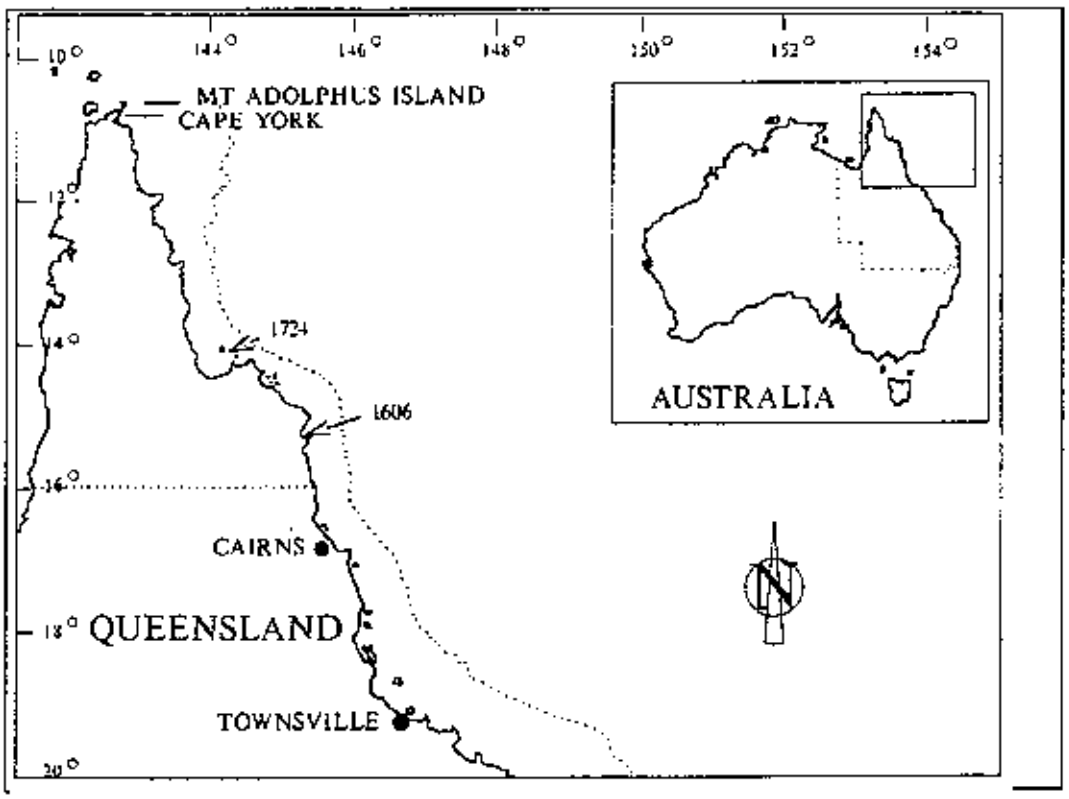


Figure 6: Pearl Farms on the east coast of the CYPLUS Region

11.0 CONCLUSIONS

This paper assessed the regional areas of general suitability for land and sea based aquaculture operations within the CYPLUS Region. Several land, water and environmental attributes important to the culture of tropical aquatic species were used in the assessment.

Below is a summary of the findings in this paper.

- The CYPLUS region has large land areas suitable for aquaculture
- Several of these locations are on or near sensitive areas such as National Parks
- Surface water characteristics on the Peninsula will reduce the extent of aquaculture development eg. no flow periods greater than eight weeks occur in 7 river basins on potentially suitable aquaculture land
- Olive-Pascoe, Stewart, Normanby, Jeannie, Endeavour, Mitchell at Koolatum, Holroyd at Strathgordon, Archer, Wenlock and Ducie are river basins with suitable water flow on aquaculture land
- All river basins on potentially suitable aquaculture land have water volumes suitable for 1-50 hectare pond or nursery Barramundi operation
- Prawn and Crayfish operations will vary in size and location due to the differing water volume of river basins on potentially suitable aquaculture land
- Normanby and upper Ducie river basins have unsuitably low Ph levels for all tropical species
- All areas within the Archer River basin except one, at Ring Yards, have unsuitable Ph levels for crayfish operations
- Wenlock River at Moreton Telegraph also has unsuitable Ph levels for crayfish operations
- Surface water on Cape York Peninsula is extremely fresh (free of dissolved solids)
- Aquaculture operations on potentially suitable land would need to introduce sea water or nutrients to raise conductivity/salinity of pond water
- Aquaculture land with suitable water characteristics such as those near Cooktown, Lockhart River and Kulinchin are located on Aboriginal Land
- Potential exists for the Hopevale and Lockhart River Aboriginal Communities to develop aquaculture operations
- The eastern coastline has potential for all types of cultured sea based operations
- Development of sea based operations will be restricted to approved zones within the Marine Park
- The Torres Strait and tip of Cape York are proven areas for pearl oyster operations
- Estuaries near Weipa, Aurukun, Escape River and Mapoon Aboriginal Community offer good protection for mariculture operations from high winds and currents

The CYPLUS region has several potential areas suitable for aquaculture operations. The majority of these areas are suitable for a variety of species and sizes of development. There is also an opportunity for several Aboriginal Communities on the Peninsula to develop aquaculture operations.
It is important that further assessment at the site level be undertaken on aquaculture land before development begins.

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APPENDICES

APPENDIX A

Land, Water And Coastal Criteria For Aquaculture Operations

Appendix A contains Tables 5-7 which list the criteria chosen to assess the regional areas of suitability for aquaculture. The criteria consisted of several land, water and environmental attributes mentioned in section 4.0.

Table 5: Suggested land characteristics for aquaculture developments

Species	Operation	% of clay	Flooding frequency	Landform	Soil Ph	Min depth ground water
P. monodon/ Giant Tiger	pond growout	30-100%	1 in 10 years 1 in 2-10 years annual flooding	flat slope < 3 % undulating slope 3-10 %	6.5 - 8.5	5-8 metres
C. quadricarinatus/ Red Claw Crayfish	pond growout/ breeding	30-100%	1 in 10 years 1 in 2-10 years annual flooding	flat slope < 3 % undulating slope 3-10 %	6.5 - 8.5	5-8 metres
L. calcarifer/ Barramundi	pond growout	30-100%	1 in 10 years 1 in 2-10 years annual flooding	flat slope < 3 % undulating slope 3-10 %	6.5 - 8.5	5-8 metres

Table 6: Suggested surface water characteristics for aquaculture developments

Species	Operation stage	Salinity	Ph	Temp C°	No flow period	exchange flow rates mL/yr for 1 Ha of pond & 12500 l tank
P. monodon/ Giant Tiger	growout	10-25ppt	6.5-8.5	27-33	>8 weeks Unsuitable	10 mL per day or 3650 mL per year
P. monodon/ Giant Tiger	hatchery	30-34ppt	6.5-7.5	28-29	>8 weeks Unsuitable	1.35 mL per year
C. quadricarinatus/ Red Claw Crayfish	growout & breeding ponds	<12 ppt	7 - 8.5	23-30	>8 weeks Unsuitable	10 mL per day or 3650 mL per year
L. calcarifer/ Barramundi	growout	0-40 ppt	6.5-8.5	23-33	>8 weeks Unsuitable	5 mL per week or 260 mL per year
L. calcarifer/ Barramundi	nursery	28-32 ppt	6.5-8.5	28-36	>8 weeks Unsuitable	.3 mL/day or 109 mL/year

Table 7: Suggested criteria for sea based aquaculture operations

Species	Operation stage	Coastline characteristics	Current/wave action	Wind
S. enhinata/ Black Lip Oyster *S. amasa*/ Milky Oyster	Growout (deep water & banks)	Bays Estuaries Foreshore flats	Protection needed	Protection needed
S. enhinata/ Black Lip Oyster *S. amasa*/ Milky Oyster	Hatchery	Islands Mainland		
P. maxima/ Pearl Oyster	Growout deep water	Bays Estuaries Lee of Island	Protection needed	Protection needed
P. maxima/ Pearl Oyster	Hatchery	Islands Mainland		
T. gigas/ Giant Clam	Growout	Reef flat Mouth of rivers US Sandy bottom	Protection needed	Protection needed
T. gigas/ Giant Clam	Hatchery	Reef flat Mouth of rivers US Sandy bottom	Protection needed	Protection needed

APPENDIX B

Land Suitability For Pond Aquaculture

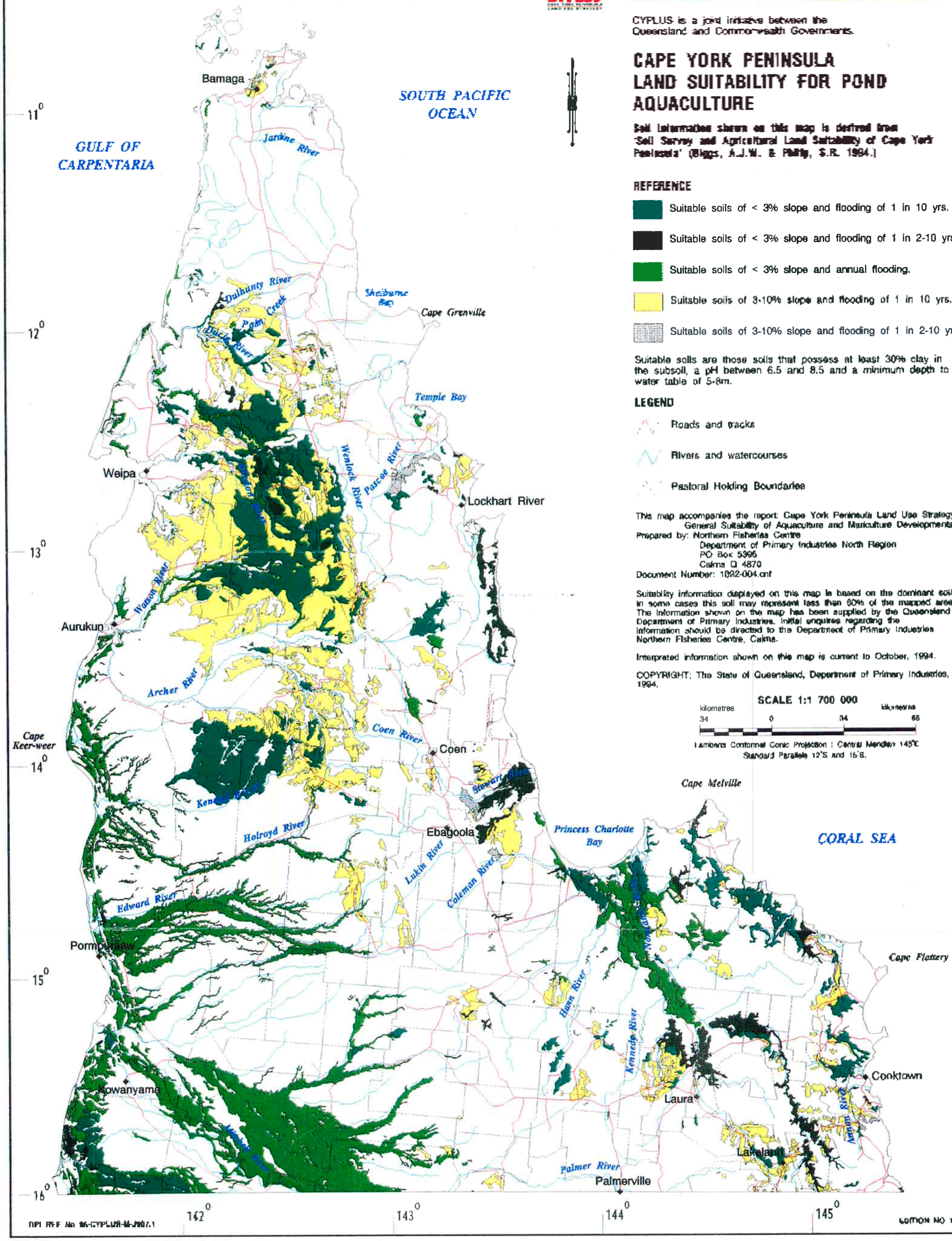
CYPLUS
CAPE YORK PENINSULA
LAND USE STRATEGY

DPI DEPARTMENT OF PRIMARY INDUSTRIES
QUEENSLAND NORTH REGION

CYPLUS is a joint initiative between the Queensland and Commonwealth Governments.

CAPE YORK PENINSULA LAND SUITABILITY FOR POND AQUACULTURE

Soil information shown on this map is derived from 'Soil Survey and Agricultural Land Suitability of Cape York Peninsula' (Biggs, A.J.W. & Philip, S.R. 1994.)



REFERENCE

- Suitable soils of < 3% slope and flooding of 1 in 10 yrs.
- Suitable soils of < 3% slope and flooding of 1 in 2-10 yrs.
- Suitable soils of < 3% slope and annual flooding.
- Suitable soils of 3-10% slope and flooding of 1 in 10 yrs.
- Suitable soils of 3-10% slope and flooding of 1 in 2-10 yrs.

Suitable soils are those soils that possess at least 30% clay in the subsoil, a pH between 6.5 and 8.5 and a minimum depth to water table of 5-8m.

LEGEND

- Roads and tracks
- Rivers and watercourses
- Pastoral Holding Boundaries

This map accompanies the report: Cape York Peninsula Land Use Strategy General Suitability of Aquaculture and Mariculture Developments
Prepared by: Northern Fisheries Centre
Department of Primary Industries North Region
PO Box 5396
Cairns Q 4870
Document Number: 1092-004.cnf

Suitability information displayed on this map is based on the dominant soil. In some cases this soil may represent less than 60% of the mapped area. The information shown on the map has been supplied by the Queensland Department of Primary Industries. Initial enquiries regarding the information should be directed to the Department of Primary Industries Northern Fisheries Centre, Cairns.

Interpreted information shown on the map is current to October, 1994.

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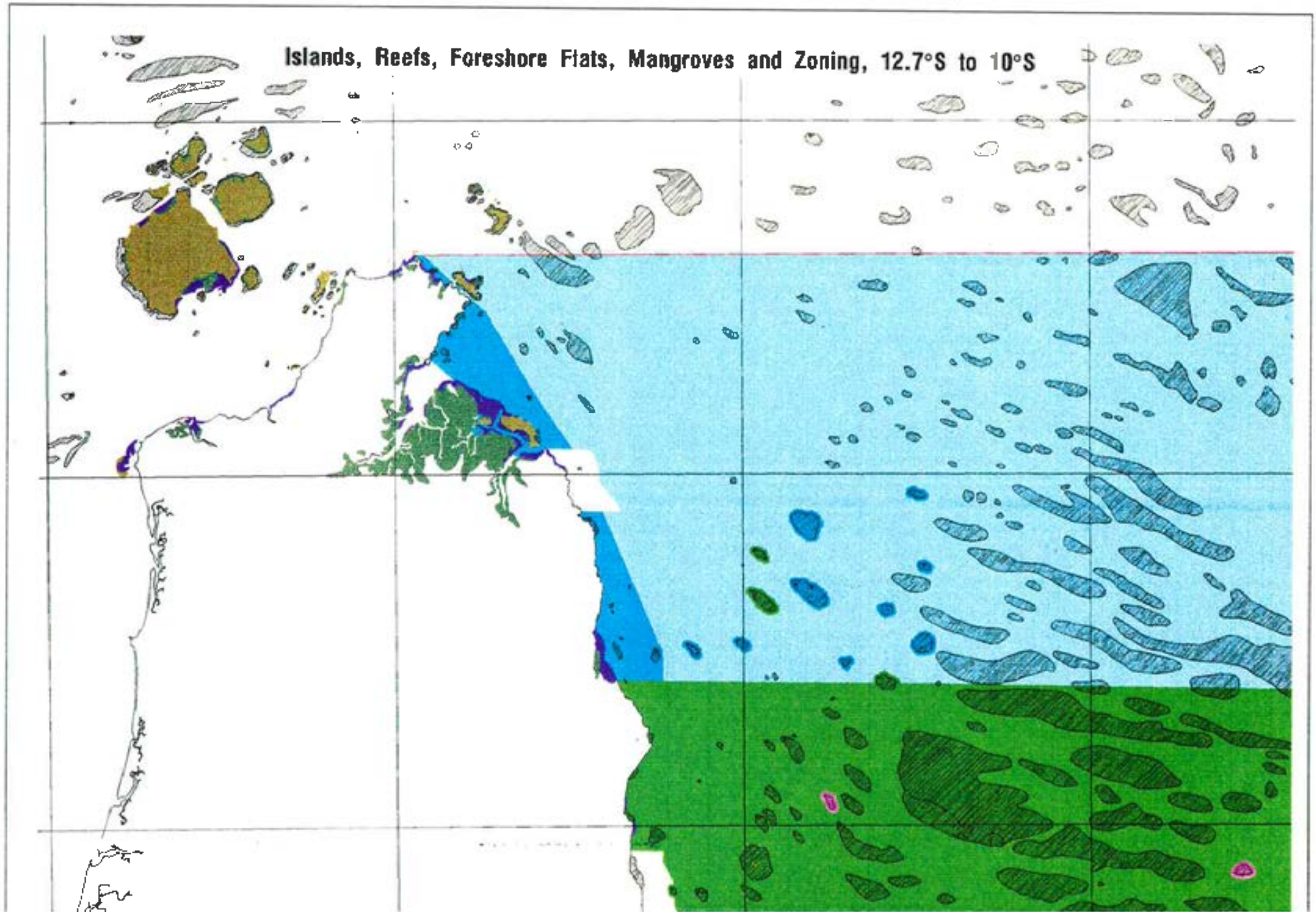
Lambert Conformal Conic Projection : Central Meridian 143°E
Standard Parallels 12°S and 16°S.

DPI FILE No 96-CYPLUS-M-J0001

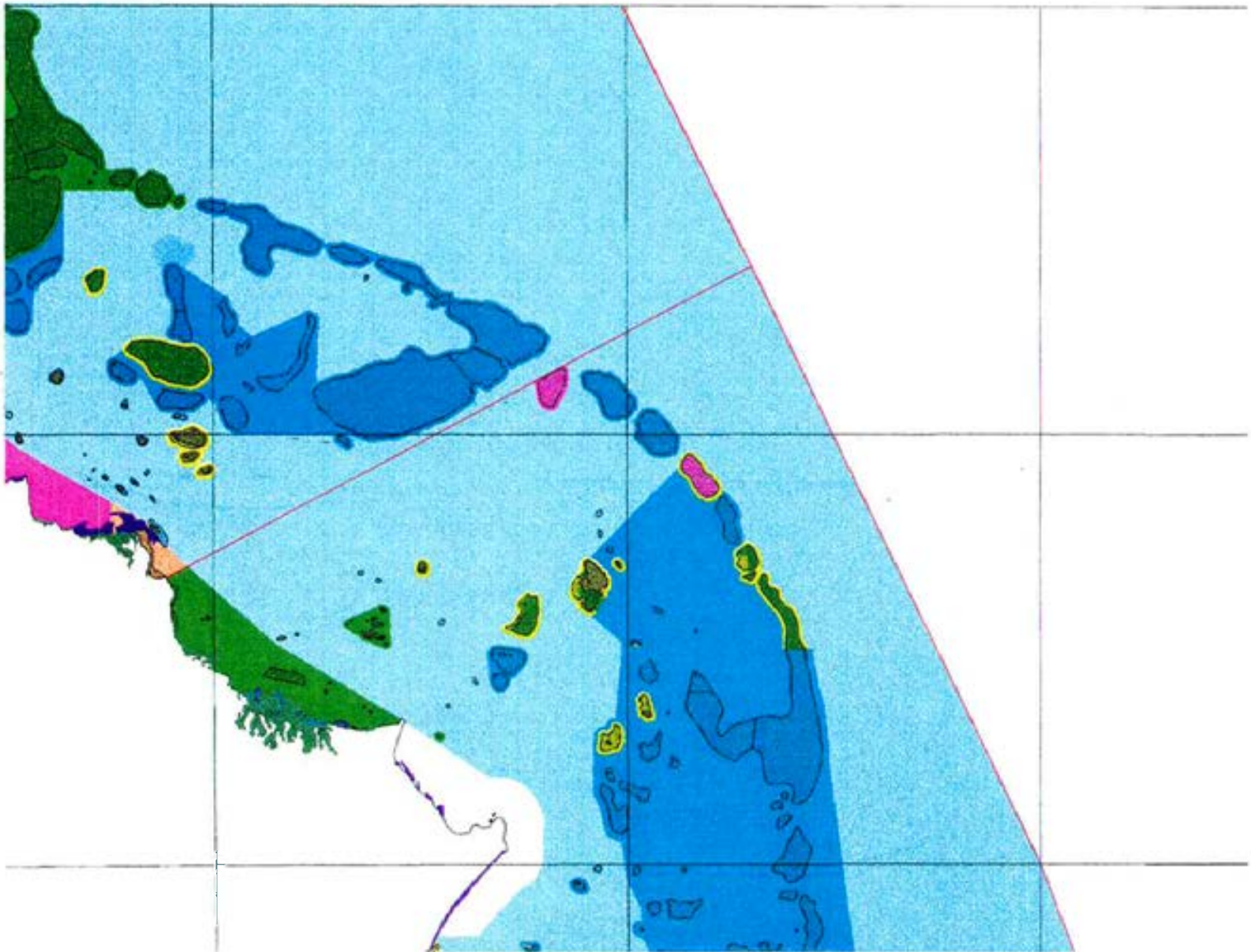
EDITION NO 1

APPENDIX C

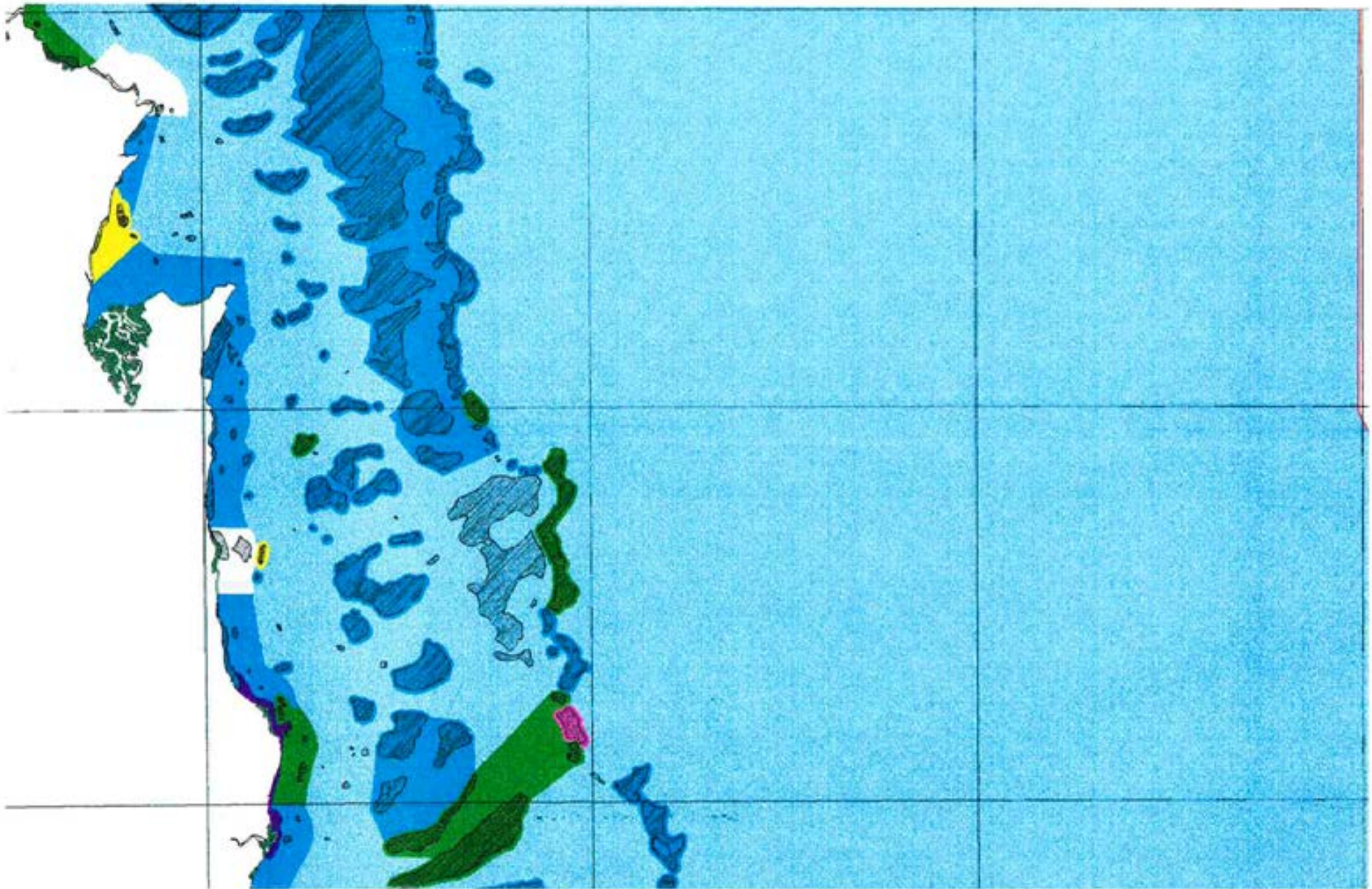
Queensland's Eastern Coastline


Islands, Reefs, Foreshore Flats, Mangroves and Zoning, 12.7°S to 10°S

Islands, Reefs, Foreshore Flats, Mangroves and Zoning, 16.2°S to 14°S



Islands, Reefs, Foreshore Flats, Mangroves and Zoning, 14.7°S to 12.5°S



APPENDIX D

Terms of Reference

Terms of reference for Other Primary Industry (non pastoral, non-forestry)

1. Provide details of current aquaculture and mariculture activities to the Department of Lands Current Land Use Project.

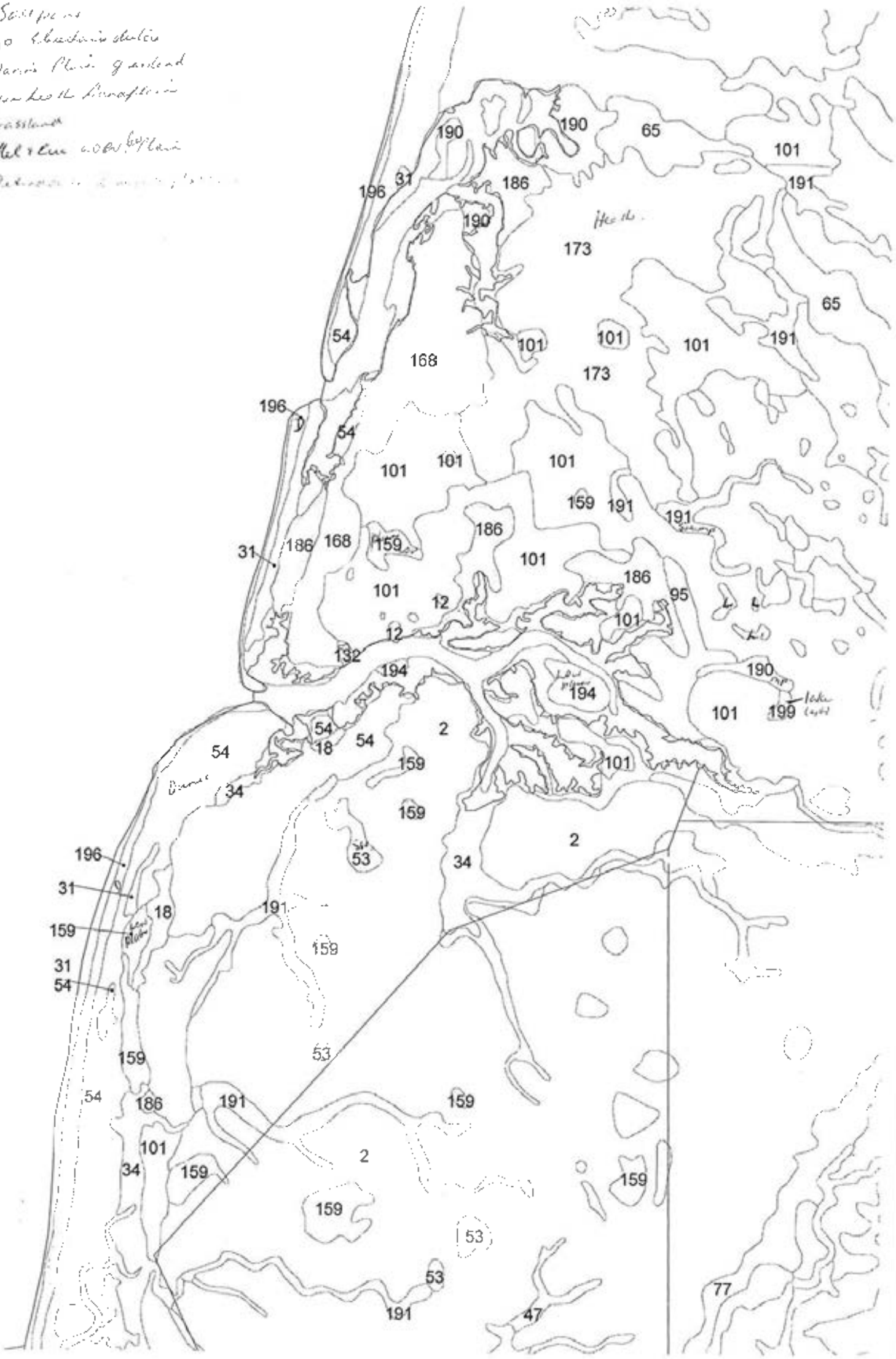
2. Review the Department of Lands draft Current Land Use Project report on the nature and location of current non-pastoral and non-timber primary industries in Cape York Peninsula

3. Prepare a draft report on a regional assessment of areas of general suitability for primary industry, and create a GIS layer which depicts suitability for pasture improvement categories, maize, sorghum and peanuts.
   Output:
   Draft report, maps and GIS layer of potential areas for primary industry for the use of the consultant undertaking the 'industry issues' task of this project and for review by the Land Working Group.

4. Prepare a draft report on a regional assessment of areas for aquaculture and mariculture for the use of the consultant undertaking the 'industry issues' task of this project and for review by the Land Working Group.

5. Prepare draft final report and present to the Land Working Group.

6. Prepare final project report.


194 Scirpus
140 Schoenus nigricans
186 Marsh Plain grassland
168 Open heath Bracken
14 grassland
159 Melaleuca woodland
2 Tea tree
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