4. CONDITION OF CATCHMENTS ADJACENT TO DUGONG PROTECTION AREAS

The condition of the river catchments adjacent to each DPA, their hydrology and present catchment activities, effectively determine the water and habitat quality that exists in the adjacent DPAs. The condition of the catchments adjacent to each DPA is discussed below. Specific information regarding each of the DPA catchments is provided in Appendix 1, namely:

- Land use and terrestrial runoff statistics (Table A1);
- Fertiliser and pesticide application rates (Table A2);
- Sediment and nutrient export (Table A3);
- Catchment fertiliser use in the past 100 years (Figures A1 to A6).

4.1 Hinchinbrook and Taylors Beach DPAs

The most northern DPAs, Hinchinbrook and Taylors Beach DPAs, are adjacent to each other (Figure 6). They are located around and to the south of Hinchinbrook Island, approximately half way between Cairns and Townsville. The islands included in the Hinchinbrook Region DPA, i.e. Hinchinbrook, Goold and Brook Islands, are predominantly undeveloped except for a small resort at the northern end of Hinchinbrook Island. Small urban centres close to the DPAs include Ingham, Cardwell, Taylors Beach and Lucinda. An integrated residential and resort complex is currently under construction on the adjacent mainland at Oyster Point, south of Cardwell, and a 200 berth marina has been completed. A 50 berth marina is proposed at Dungeoness in the Enterprise Channel which flows into the southern end of the Hinchinbrook Channel, and Lucinda has a major port facility for the export of raw sugar.

The Herbert River catchment drains the hinterland of the Hinchinbrook and Taylors Beach DPAs. The Herbert River flows from the Atherton Tablelands into the floodplains of the lower Herbert River catchment, past Ingham, and then enters the sea at the border of the two DPAs, just north of Lucinda. The Herbert River has both wet and dry catchment areas, which result in a high year-to-year variability in rainfall and associated river discharge (Mitchell & Furnas 1997). Cattle Creek, which drains the floodplain adjacent to the coast of the Taylors Beach DPA and enters the sea just south of it, is an important local watercourse. The coastal area in which the two DPAs are located is also influenced by the Burdekin River (Figure 6), which enters the sea approximately 150 km further south. Cyclonic flood plumes from the Burdekin River are reported to extend as far north as Innisfail, which is north of the Hinchinbrook DPA (Wolanski & Jones 1981; Devlin et al. 2001).

The principal land uses in the Herbert River catchment are cattle grazing, sugar cane cultivation and other cropping in the coastal plains (Table A1), as well as some alluvial tin mining in the upper catchment (DPI 1993a). Moller (1996) notes several areas of serious habitat degradation in the Herbert River catchment and emphasises in particular the degradation of riparian vegetation, erosion problems and the intrusion of exotic weeds. Figure 7 shows the there has been a significant increase in the area of land utilised for sugarcane cultivation in the lower Herbert River catchment over the past 140 years, and the natural vegetation cover has decreased correspondingly. Although less than 7% of the Herbert River catchment area is used for crop farming (mainly sugarcane), the fertiliser used, per hectare of catchment area, is one of the highest of the Queensland coast. For example, a total of 9800 tonnes of nitrogen and

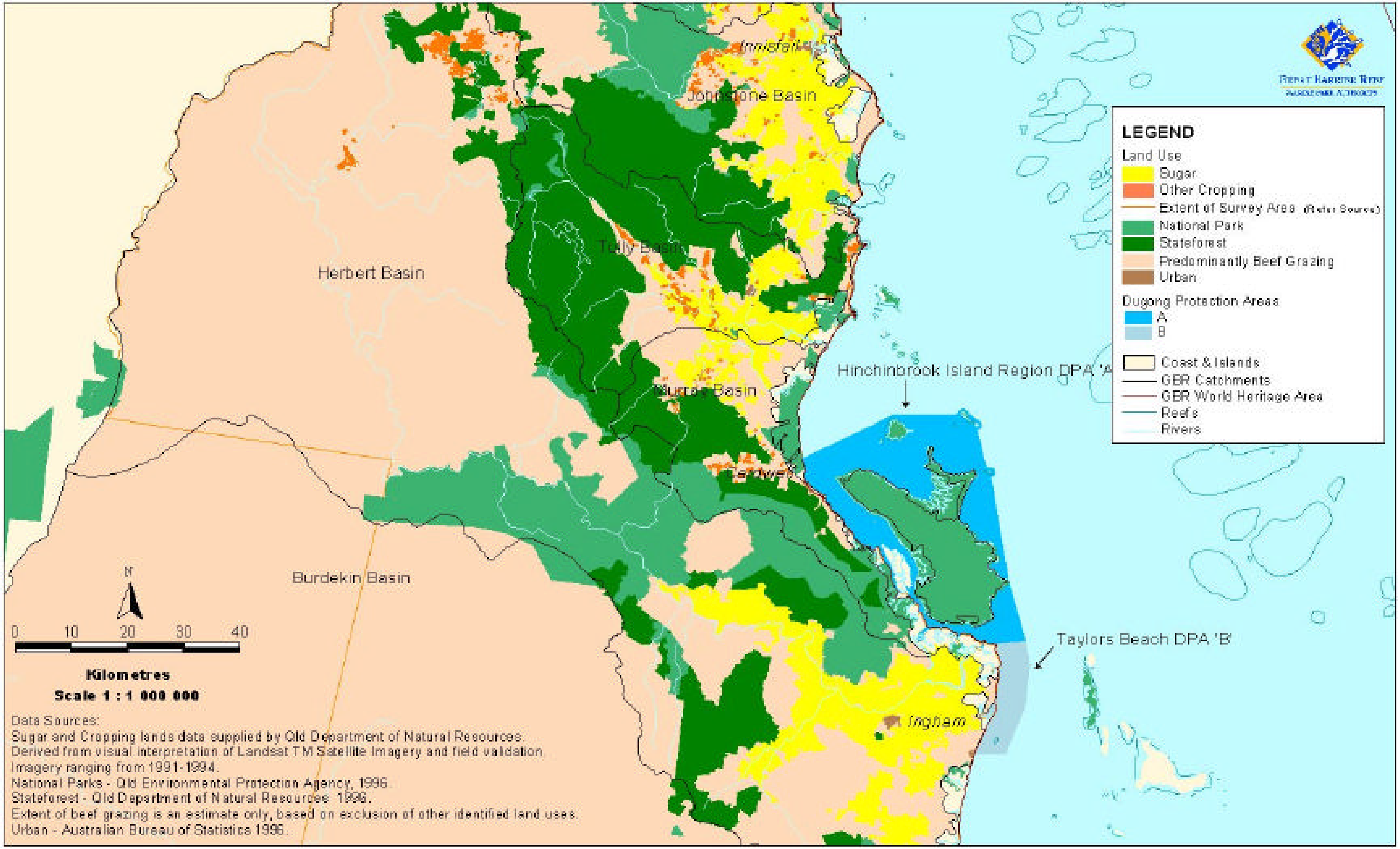

Figure 6. Land use in river catchments adjacent to the Hinchinbrook Island Region and Taylors Beach Dugong Protection Area

1330 tonnes of phosphorus were applied in 1990 (Table A2). In the Herbert-Burdekin area a 65% expansion of the area harvested for sugarcane has occurred during 1990-99, predominantly in the Herbert catchment (Australian Sugar Year Book 2001). This expansion has likely to have led to an increase in fertiliser and pesticide use in this catchment.

The concentrations of nutrients in the Herbert River water are much higher during flood conditions, with the highest concentrations measured during the first flow of the season (Table 1), when most of the suspended sediment is also discharged (Mitchell et al. 1997). The model estimates of riverine sediment and nutrient export data (Table A3) are currently being verified by *in situ* measurements of suspended solids and nutrient concentrations in flooding rivers (Mitchell & Furnas, 1997). First estimates of the exports during the flood of cyclone Sadie in 1994 are presented by Mitchell et al. (1997).

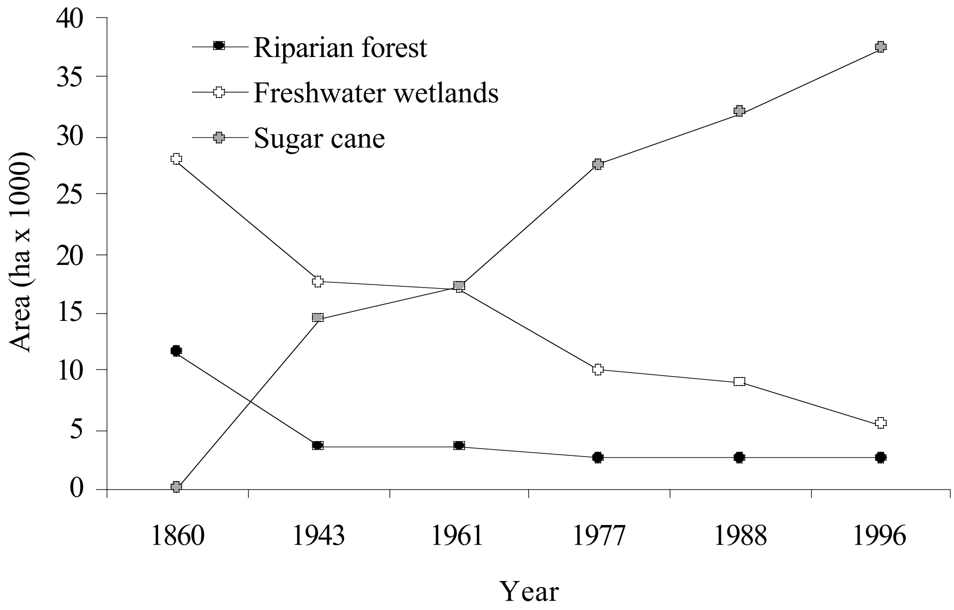

Figure 7. Change of land use in the lower Herbert River catchment over the past 140 years *(data from Johnson et al. 1998).*

Table 1. Summary of dissolved inorganic nitrogen (DIN) and phosphate (µM)in the water column of the Herbert River (lower catchment) and the Hinchinbrook Channel. Data are overall arithmetic means and/or ranges of means from different sites and/or seasons.

	Herbert River water, non-flood conditions[1]	Herbert River water, flood conditions[2]	Hinchinbrook Channel[3]
DIN	7.8 (2.7–12.8)	14.5 (3–26.5)	0.7–8.9
Phosphate	0.06 (0.04–0.09)	0.5 (0.1–0.7)	0.01–0.19

(Sources: [1]Furnas et al. 1995, [2]Mitchell et al. 1997, [3]A. Mitchell, AIMS pers. comm.)

Water column nutrient concentrations in the inshore areas of the Herbert River region are slightly higher compared to data from further offshore (Table 1; Furnas et al. 1995, 1997), which indicates the retention of terrestrial runoff in the coastal waters.

Point sources of nutrients into the DPAs from the Herbert River include sewage effluent from the Ingham sewage treatment plant, sugar mill effluent and runoff from active and closed tin mines. There are also a number of aquaculture operations in the Hinchinbrook Channel (prawn and barramundi farms), which discharge nutrient and particle-enriched water. Recently, the Hinchinbrook Channel has been focus of a number of collaborative research projects, examining sedimentary processes, carbon and nutrient fluxes, and contaminant loadings (Ayukai 1998).

Marine surface sediments in the Hinchinbrook region have elevated concentrations of mercury, which is suggested to indicate the past and present use of herbicides and fungicides containing mercury in the area (Walker & Brunskill 1997a, b). Also, low levels of DDT (3 ng/g) were detected in one surface sediment sample collected in Hinchinbrook Channel (G. Brunskill, AIMS, pers. comm.). Cavanagh et al. (1999), however, did not detect pesticide residues in coastal sediments around Hinchinbrook Island or in Rockingham Bay.

4.2 Cleveland Bay, Cape Bowling Green Bay and Upstart Bay DPAs

The Cleveland Bay DPA is located adjacent to the city of Townsville; a major residential, industrial, tourist and defence centre in north Queensland. Townsville has significant heavy industries including nickel, copper, and zinc refineries. Townsville Port is a major facility for the import and export of ore and export of refined metal products and the city is also a major private and commercial boating centre in this area of the Queensland coast. The Bowling Green Bay and Upstart Bay DPAs are located adjacent to a relatively undeveloped section of the coastline, except for the residential areas around Ayr and Home Hill.

The Ross River and Black River (including the Bohle River) catchments drain the hinterland of the Cleveland Bay DPA. An important local watercourse is Barratta Creek. The water quality in Cleveland Bay is also influenced by the northward flowing water of the Burdekin River during major flood events (Wolanski & Jones 1981).

The Haughton and Burdekin Rivers drain into the Bowling Green Bay and Upstart Bay DPAs respectively. These rivers drain the second largest catchment in north-east Queensland, and it is estimated that the Burdekin River is the second largest contributor of sediments to the GBRWHA (Table A3). The Elliot River is an important local watercourse in the Upstart Bay DPA.

The principal agricultural land use in the Ross and Black River catchments is cattle grazing, although grazing occupies only 30% of the catchment land (Figure 8, Table A1). The fertiliser usage in the two catchments is negligible (Table A2). Both the Ross and Black Rivers enter the sea in the Cleveland Bay DPA. The pressures on these catchments are mainly due to urban and industrial development that may lead to the loss of wetlands, introduction of contaminants, stream bed disturbance by sand and gravel extraction, and competition for groundwater resources (DPI 1993a).

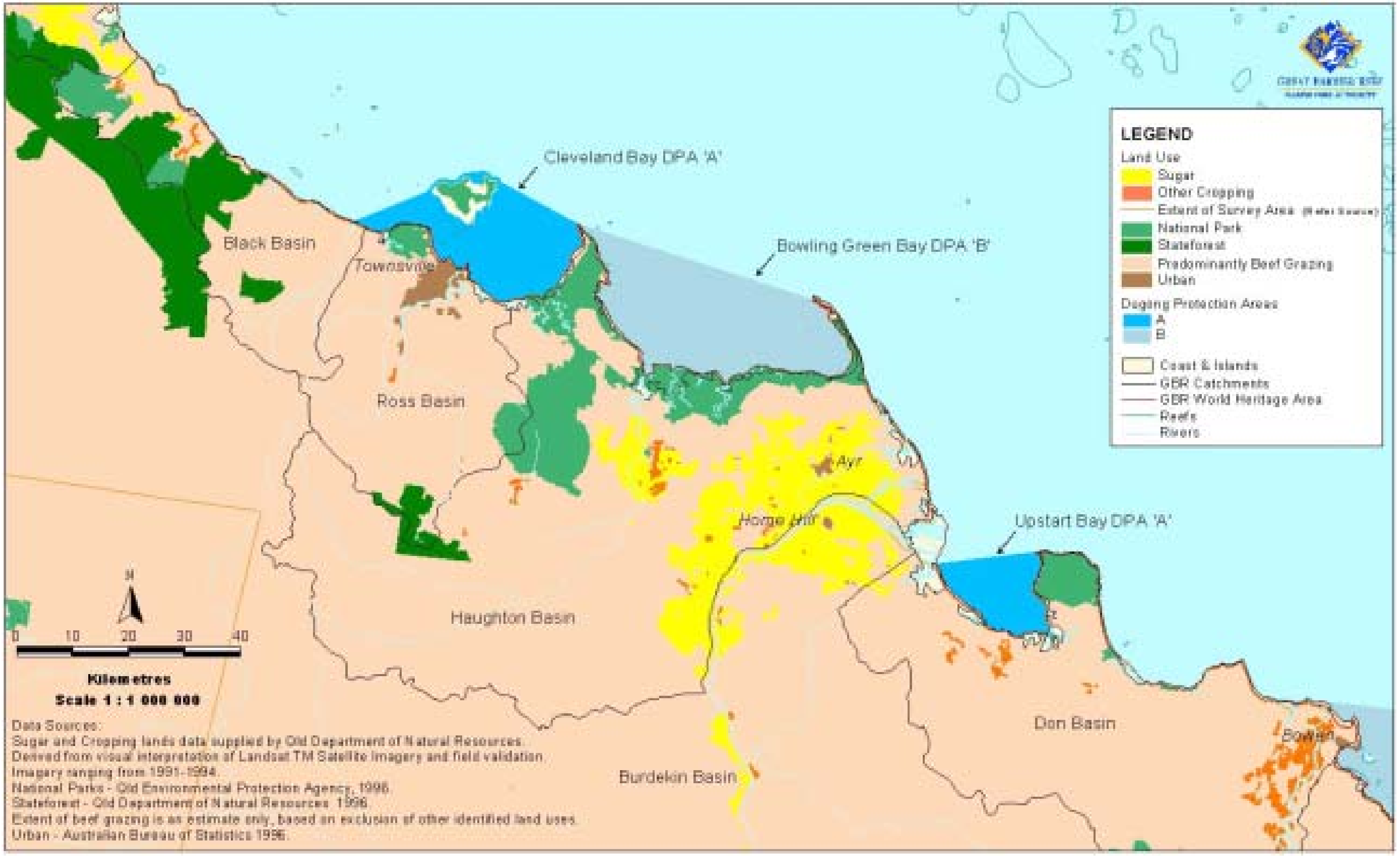

Figure 8. Land use in river catchments adjacent to the Cleveland Bay, Bowling Green Bay and Upstart Bay Dugong Protection Areas

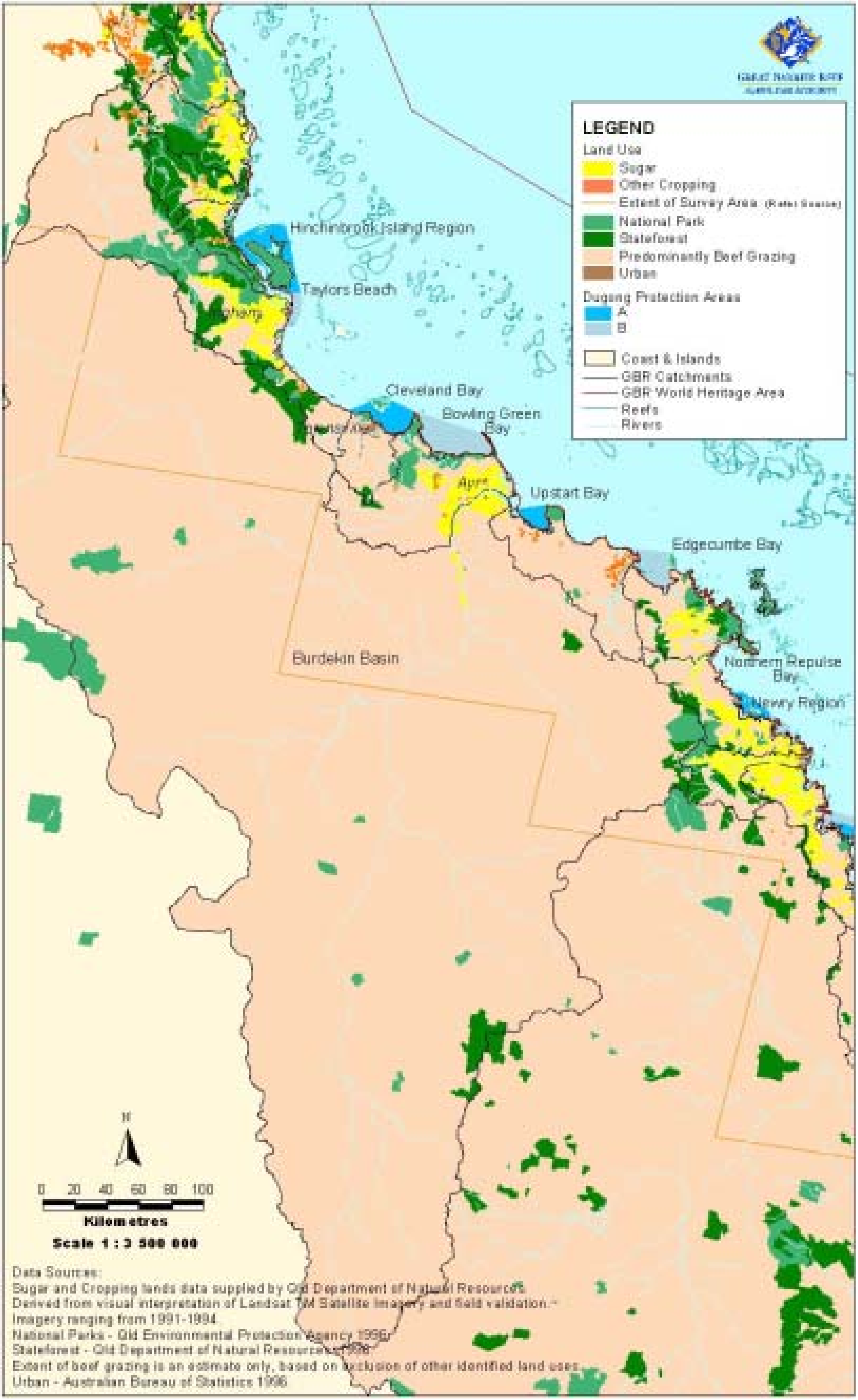

Figure 9. Land use in the Burdekin River Catchment Area

The Bowling Green Bay and Upstart Bay DPAs include the river mouths of the Haughton and Burdekin Rivers, respectively (Figure 8). The Haughton and Burdekin Rivers drain a dry tropical catchment with grazing as the major land use (Figures 8 and 9, Table A1). However, the sugarcane and other crop cultivation areas in the Haughton basin lead to the third highest fertiliser application rates of all GBR catchments (Table A2). There are also significant coal and gold mining activities in this catchment area, that produce waste which may contain silt and contaminants, such as heavy metals and cyanide.

The pressures on the Burdekin and Haughton River catchments include widespread erosion caused by overgrazing, introduction of exotic weeds, wetland degradation due to flow alteration caused by the Burdekin Dam, and salinity problems in irrigated areas.

Water column nutrient concentrations in Cleveland Bay and Bowling Green Bay have been measured for several years and at different sampling points (Walker & O'Donell 1981; Revelante & Gilmartin 1982; Ullman & Sandstrom 1987; Blake 1994). The values are variable and range from 0.1 to 1.2 μM for dissolved inorganic nitrogen, from 0.2 to 0.3 μM for phosphate and from 3 to 5 mg/l for suspended solids. These data are relatively high compared to average data for the GBRWHA (Furnas et al. 1997). All water quality parameters are strongly influenced by seasonal flood events (discussed above). The concentrations of suspended solids in the Bays are largely controlled by wind-driven resuspension of sediments and levels of up to 200 mg/l have been measured (Larcombe et al. 1995).

The runoff from the Burdekin catchment can vary by two orders of magnitude between wet and dry years (Table A1). The data for sediment export to the coast are derived from mathematical models (Table A3), however, research currently underway provides first estimates of directly measured nutrient concentrations in the Burdekin River (Table 2), and hence improved estimates of nutrient export (Furnas et al. 1996; Mitchell & Furnas 1997). These authors also emphasise the importance of the impact of the first discharge of a flood event (first flush), which transports the bulk of suspended sediments and high concentrations of dissolved nutrients. During cyclonic conditions the high sediment and nutrient loads are transported as flood plumes into waters further offshore.

Point source discharges from the Townsville and Thuringowa sewage treatment plants and industrial inputs are significant contributors of nutrients and contaminants into Cleveland Bay (Moss et al. 1992). The major point sources of pollution in the Burdekin and Haughton River catchments are inputs from the Ayr and Home Hill sewage treatment plants although these plants are relatively small.

Table 2. Nutrient concentrations in Burdekin River water (μM). Data are mean values for the period 1987–95.

Dissolved Nitrogen	9.3–28.9
Particulate Nitrogen	6.3–75.1
Phosphate	0.2–0.8
Particulate Phosphorus	0.4–2.7

(Source: Furnas et al. 1996)

The concentration of heavy metals in samples collected from nearshore waters between 1976–77 in Cleveland and Bowling Green Bays and between Townsville and Cardwell in 1979 were within the range of mean world data reported at that time (Burdon-Jones et al. 1982; Klumpp & Burdon-Jones 1982). Background concentrations of metals have been assessed in nine species of bivalves in the greater Townsville region in 1979 (Klumpp & Burdon-Jones 1982). High levels of manganese and zinc were detected in seagrasses of the region (Denton et al. 1980). Elevated mercury levels

have been detected in the upper layers of a sediment core from Upstart Bay, and are suggested to originate from the use of herbicides and fungicides containing mercury in the Burdekin River catchment, or are a result of using mercury to extract gold at Charters Towers in the 1870–1890s (Walker & Brunskill 1997a, b).

Polyaromatic hydrocarbons (PAHs) have also been detected in sediments from Townsville Port and are probably caused by fuel discharges and motor exhaust emissions to the water (Smith et al. 1985). Concentrations of chlorinated organics and pesticides (PCBs, DDTs, HCHs, aldrin, dieldrin and chlordanes) in fish tissue were low in the Townsville region compared to the Brisbane region and other urbanised areas (Kannan et al. 1995). Lindane was detected in Burdekin River sediment (Dyall & Johns 1985) and lindane and heptachlor in groundwater of the Burdekin region (Brodie et al. 1984). The levels were below the Australian drinking water standard of 30 ng/l and 10 ng/l for lindane and heptachlor, respectively, but in some cases exceeded the water quality guidelines for the protection of the aquatic environment (1 ng/l for lindane, 0.3 ng/l for heptachlor) (Nicholson 1984).

Denton et al. (1980) reported high concentrations of several metals in the tissues of 48 dugongs collected from Torres Strait to Townsville between 1974 and 1978, compared to other marine mammals. It was considered unlikely that these high concentrations were a reflection of anthropogenic impacts, given the remoteness of the sampling sites (Denton et al. 1980). However the long life span and large spatial range of these animals may complicate the understanding of any causal relationships. Recent studies show migratory activity for dugong over significant distances (Preen 2001). Low levels of lindane, dieldrin and PCB have been found in the small sample number of dugongs collected in the Townsville region (Heinsohn & Marsh 1978; Smillie & Waid 1985).

Molongle Creek boat ramp and access channel extends into the Upstart Bay DPA. This channel extends beyond the mean low water mark and has been dredged regularly in the past to maintain all tide boat access.

4.3 Edgecumbe Bay, Repulse Bay, Newry Region and Sand Bay DPAs

These DPAs are located in a relatively undeveloped section of coastline between Bowen and Mackay (Figure 10). The urban area of Bowen is immediately adjacent to the Edgecumbe Bay DPA and the mouth of the Don River enters the sea close to the northern border of this DPA. The mouths of the Proserpine and O'Connell Rivers are just south of the Repulse Bay DPA, and the city of Mackay and the mouth of the Pioneer River are just south of the Newry Region and Sand Bay DPAs.

In northerly winds, the Edgecumbe Bay DPA is influenced by terrestrial runoff from the Don River catchment, where grazing is the primary land use (Figure 10, Table A1). The Repulse Bay DPA is mainly affected by the Proserpine and O'Connell Rivers (Figure 10). The Newry Region and Sand Bay DPAs are largely influenced by the Pioneer River, which enters the sea just south of these two adjacent DPAs, at Mackay. The Newry Region and Sand Bay DPAs are also possibly influenced by the Fitzroy River, which enters the sea approximately 300 km south. The Fitzroy River has the largest river catchment in north-east Queensland and, under certain wind conditions, river plumes after severe cyclonic floods may affect coastal areas far to the north. Further details on this river are included in section 4.4. Important local watercourses are the Gregory River draining into Edgecumbe Bay DPA and the St Helens River draining into the Newry Region DPA.

The city of Bowen is located at the coast of the Edgecumbe Bay DPA, which may result in some impact from urban runoff, a sewage outfall and of the Bowen Port activities, however, no data are available. The catchment issues in the adjacent Don River catchment are related to pasture degradation and erosion (DPI 1993a).

The Proserpine River drains a catchment with grazing as the main land use and large cropping areas (mainly sugarcane) in the coastal plains (Figure 10, Table A1). Fertiliser application rates are relatively high (Table A2). Impacts from urban inputs from the town of Proserpine can also be expected. The Peter Faust Dam upstream of Proserpine largely altered the flow pattern of the Proserpine River, and the downstream impacts of this are still unknown. The O'Connell River catchment has large grazing and some sugarcane cropping areas (Figure 10, Table A1), which lead to the sixth highest fertiliser application rates of all GBR catchments (Table A2). However, about 20% of the combined Pioneer-O'Connell River catchment area is forested (Figure 10, Table A1).

The predominant land-use in the Pioneer River catchment is grazing (Figure 10, Table A1). Sugarcane cultivation areas occupy almost 14% of the combined Pioneer and O'Connell River catchment (Figure 10, Table A1), and this area has the highest fertiliser application of all GBR catchments (Table A2). The main issues in the catchment are erosion and soil degradation (DPI 1993a). The flow of the Pioneer River has been largely modified by aggradation, and by several weirs (DPI 1993a).

The Bowen sewage outfall is the major point source discharge that is likely to impact on the Edgecumbe Bay DPA. There are no other major discharges in this region that are likely to influence the DPAs.

There is very little water quality data available in this region. Water quality data from Pioneer Bay, which is located south of the Edgecumbe Bay DPA, and from Repulse Bay indicate high nutrient and suspended solids values (DIN 1.1 μM, phosphate 0.2 μM, suspended solids 6 mg/l) in the inshore waters compared to waters further offshore (Blake 1994). This may indicate the influence of terrestrial runoff on coastal water quality.

Some adverse effect of urban runoff from Mackay on the DPAs may be expected, however, there are no coastal water quality data available to quantify this possibility. The surface waters of the Pioneer and O'Connell Rivers have been rated as being in a good to moderate condition, regarding dissolved N and P concentrations and other water quality characteristics (Queensland Department of Environment and Heritage 1999).

No data was available on pollutant concentrations in this region.

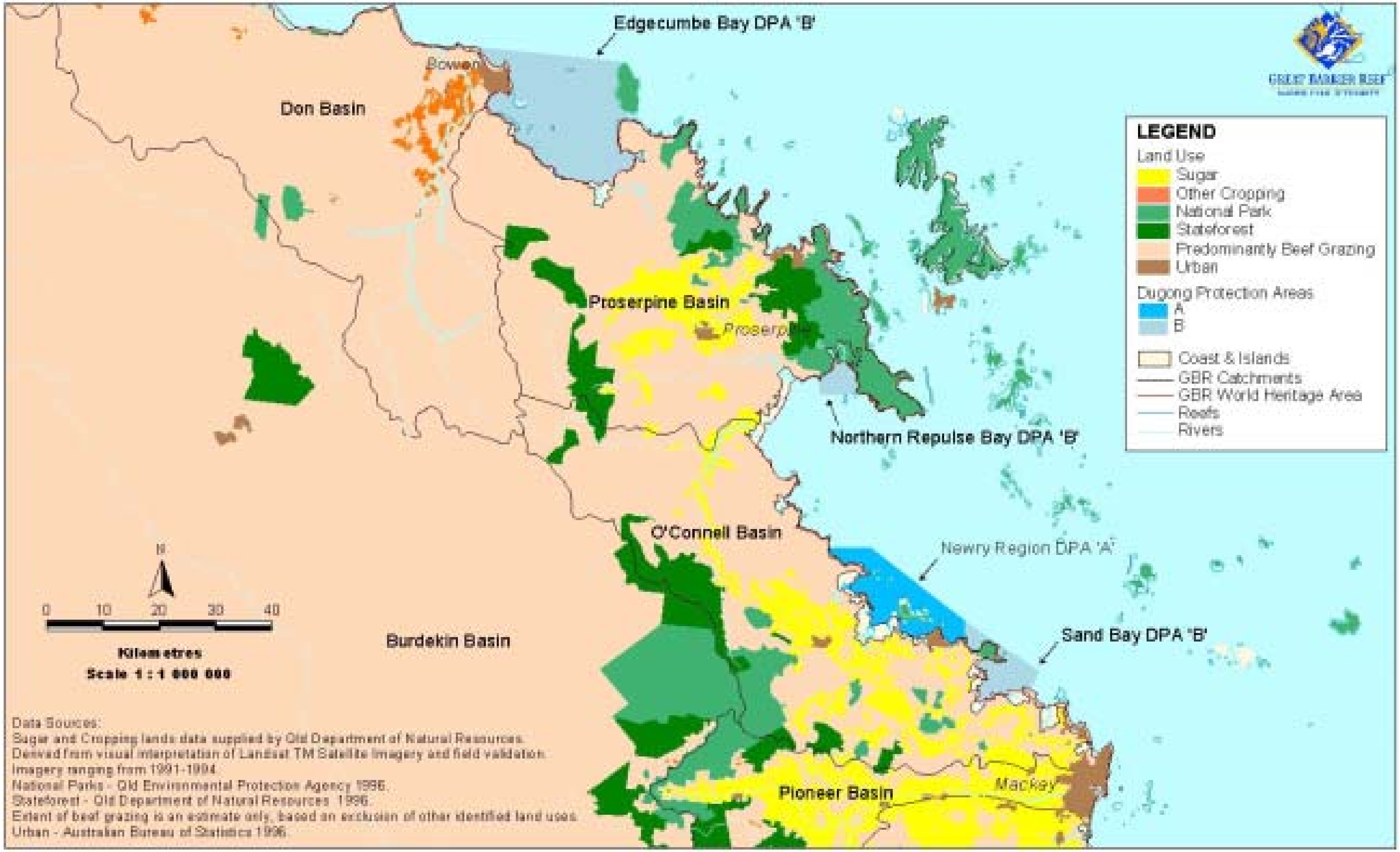

Figure 10. Land use in river catchments adjacent to the Edgecumbe Bay, Repulse Bay, Newry Region and Sand Bay Dugong Protection Areas

4.4 Llewellyn Bay, Ince bay, Clairview Region, Shoalwater Bay and Port Clinton DPAs

The Llewellyn Bay and Ince Bay DPAs are located just south of Sarina, and the Clairview region, Shoalwater Bay and Port Clinton DPAs are a further 50 to 100 km south (Figure 11).
The Llewellyn Bay and Ince Bay DPAs may be influenced by Plane Creek, in the Plane Creek catchment, which enters the sea at the Sarina Inlet just north of Llewellyn Bay. All DPAs in this region are influenced by the Styx River, which enters the sea south of Clairview. The Clairview Region, Shoalwater Bay and Port Clinton DPAs are also influenced by the Shoalwater catchment. The two latter DPAs may also be affected by activities in the Waterpark River catchment. Shoalwater Bay is considered to be the most important dugong habitat in the GBRWHA, south of Cooktown (Marsh & Corkeron 1997). All five DPAs are influenced by the Fitzroy River, which enters the sea near Rockhampton, about 100 km south of Shoalwater Bay. An important local watercourse is Carmila Creek draining into the Clairview Region DPA.

There is no major urban development along the mainland coast that adjoins this group of DPAs, although Port Clinton has been identified as a potential port site.

The Plane Creek catchment has a sugarcane cultivation area of more than 20% (Figure 11) and has the third highest rate of fertiliser application of all GBR catchments (Table A2).

Most of the mainland coastline adjoining the Shoalwater Bay and Port Clinton DPAs is located within the Shoalwater Bay Military Training Area. Approximately 22% of the area of the adjacent Shoalwater Bay–Plane Creek catchment is forested (Figure 11, Table A1). The adjacent Shoalwater catchment is also of importance for the Clairview DPA. Both the Styx River and Plane Creek catchments have some cleared, grazing areas at low stocking rates (Figure 11, Table A1) and fertiliser application is negligible (Table A2).

The Waterpark River catchment is relatively small and is used for extensive grazing and some pineapple cultivation (Figure 11), however, fertiliser application rates are low (Table A2).

The Fitzroy River drains the largest catchment in Queensland and has the second highest flow rates, after the Burdekin River (Table A3). The Fitzroy catchment is predominantly used for grazing with some significant areas of grain, legume, and cotton cultivation (Figure 12, Table A1). The increase in crop cultivation has lead to an increase in fertiliser application rates over the last 20 years (Figure A4). Land clearing for grazing and cultivation in this catchment resulted in the loss of 3 million hectares of Brigalow woodland from 1960 to 1975 (a decrease from 30% cover to only 1% cover of the total catchment area). Increased soil erosion on the resulting grazing lands, exacerbated by droughts and seasonal overgrazing, has led to large increases in sediment and nutrient delivery to the inner lagoon. Model estimates for sediment and nutrient runoff are given in Table A3. There are also significant coal mining activities in the Fitzroy River catchment (Gilbert et al. in press), which have the potential to release contaminated or acidic runoff. Additional pressure on the coastal areas caused by urban runoff from the city of Rockhampton can be assumed. The Fitzroy barrage, just upstream of the Rockhampton township, prevents flushing of the Fitzroy estuary during low flow events and has resulted in the increase of nutrient concentrations downstream. These increases may be attributed to urban sewage and abattoir outfalls (Connell et al. 1981). These nutrients may be flushed out during major floods and transported northward towards the DPAs.

An ongoing research program monitors the water quality in the Fitzroy River (M. Furnas, AIMS, pers. comm.) and the data from the period 1992–95 are presented in Table 3. The

estimates of annual inputs of nutrients have to be regarded with caution, because during the study period no major flood event occurred.

Table 3. Nutrient concentrations (μM) in the Fitzroy River. Data are mean values for the period 1992–95.

Dissolved Nitrogen	15.8–29.4
Particulate Nitrogen	4.6–74.9
Phosphate	0.1–1.8
Particulate Phosphorus	0.4–2.5

(Source: Furnas et al. 1996)

In 1991 cyclone Joy caused major flooding of the Fitzroy River, with an estimated discharge of 19 million ML of water, containing average concentrations of nitrogen and phosphorus of 43 μM and 5 μM, respectively (calculated after Brodie & Mitchell 1992). This flood resulted in the mortality of 90% of the hard corals on the fringing reefs in the adjacent Keppel Bay (Byron & O'Neill 1992). Chapman (1992) estimated a flood-related loss of 1300 t of soil per hectare from some paddocks, which was presumably deposited in adjacent areas.

A multidisciplinary project from 1993 to 1996 addressed the health of the streams in the Fitzroy River catchment and indicated some areas of concern (Noble et al. 1997). The levels of suspended solids and nutrients in river water were very high, especially under high flow conditions. In the Fitzroy River suspended solids concentrations ranged from 82 to 693 mg/l and the median concentrations of total nitrogen and total phosphorus were 107 μM and 13 μM, respectively (calculated after Noble et al. 1997). Pesticide residues were detected in a number of samples, and some atrazine and endosulfan levels exceeded the Australian Drinking Water Guidelines and the water quality guidelines for the protection of aquatic ecosystems. Also noted was the poor state of the riparian vegetation in the Fitzroy River catchment and the appearance of cyanobacterial blooms in the upper catchment (Noble et al. 1997; Fabbro & Duivenvoorden 1996).

Metal concentrations have been assessed in a number of seagrass species from Shoalwater Bay in 1975 (Denton et al. 1980). No other information on pollutant levels in these four DPAs is available.

4.5 Rodds Bay and Hervey Bay–Great Sandy Strait DPAs

The Rodds Bay DPA is located south of Curtis Island along the coast adjacent to the city of Gladstone (Figure 13). The Calliope and Boyne River enter the sea inside the DPA, and the mouth of the Baffle River is approximately 70 km further south. The Hervey Bay–Great Sandy Strait DPA is located south of Bundaberg between Fraser Island and the mainland (Figure 14). The urban areas of this region include the coastal settlements of

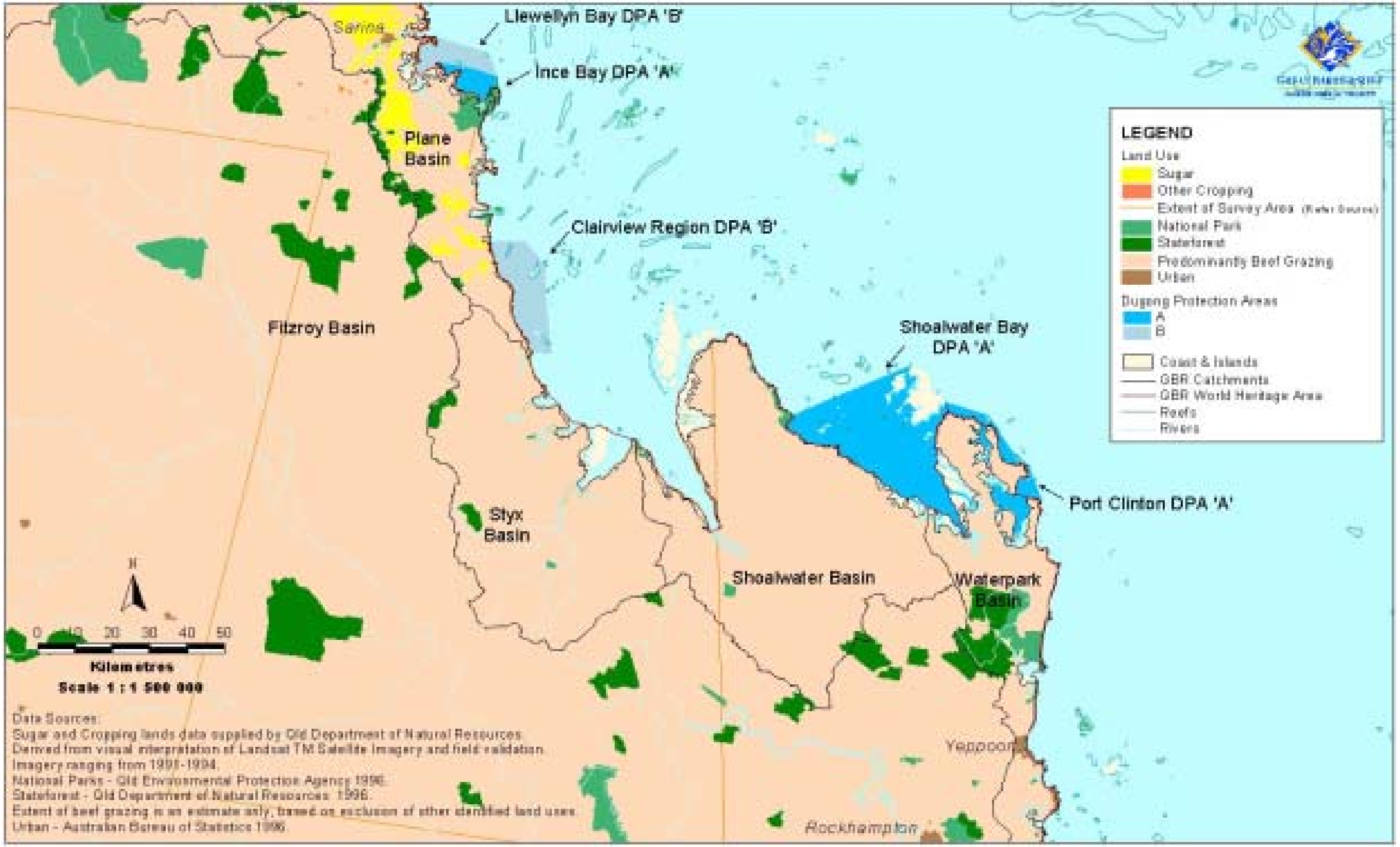

Figure 11. Land use in river catchments adjacent to the Llewellyn Bay, Ince Bay, Clairview Region, Shoalwater Bay and Port Clinton Dugong Protection Areas

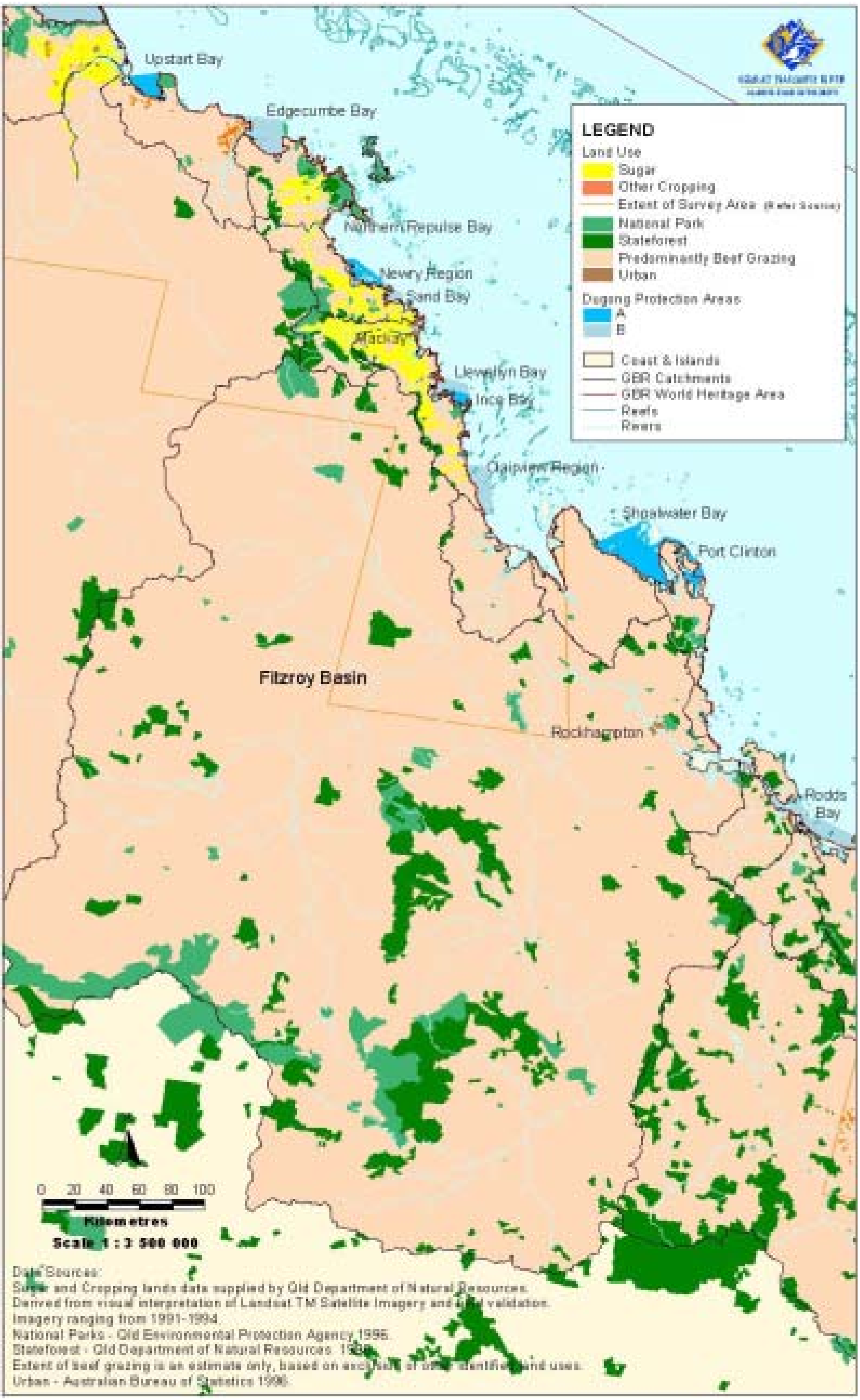

Figure 12. Land use in the Fitzroy River Catchment Area

Hervey Bay, Tin Can Bay and Maryborough. The Mary River drains into this DPA. An important local watercourse is Auckland Creek draining into the Rodds Bay DPA.

The principal land use in the Curtis Coast catchment area, which includes the catchments of the Calliope, Boyne, and Baffle Rivers, is grazing (Figure 13, Table A1). Some areas in the Baffle River catchment have sugarcane cultivation that involves low rates of fertiliser application (Table A2). The Curtis coast catchment has been extensively cleared, which results in severe erosion problems (DPI 1993a). Also of concern is the effect of the heavy industrial development around Gladstone. Adjacent to the Rodds Bay DPA, a pilot plant for the open-pit mining of shale oil is operational and expansion of the development is expected however the environmental consequences of such mining activities are uncertain.

The Burnett-Kolan River catchment area is located between the Rodds Bay and Hervey Bay–Sandy Strait DPAs and may affect the water quality in both DPAs. The Kolan and Burnett Rivers enter the sea close to Bundaberg. The main land use in this catchment area is grazing (Figure 14, Table A1). In the Bundaberg irrigation area a large number of different crops (sugarcane, maize, peanuts, citrus fruit) are grown (Figure 14), which result in moderate fertiliser application rates in the Kolan and Burrum River catchments (Table A2). Problems caused by urban runoff from Bundaberg can be expected, however no data on contaminants are available. The irrigation infrastructure may lead to flushing problems due to flow alterations and salinity problems in irrigated areas (DPI 1993a).

The Mary River catchment has been extensively cleared for agriculture and the lower catchment is under significant pressure from grazing and agriculture (DPI 1993a). The main land use is cattle grazing with some area of sugarcane cultivation in the lower catchment areas (Figure 14, Table A1). The fertiliser use is relatively low (Table A2). The State of the Rivers Report rates most of the streams in the Mary River catchment as being in a moderate to poor overall condition, specifically in relation to erosion problems and the poor status of riparian vegetation (Johnson 1997). An input of contaminants from the Maryborough urban area can be expected, although there are no data available.

Land clearing and subsequent increases in erosion and sediment transport to the inner lagoon were implicated as causes of massive losses of seagrass meadows from Hervey Bay following a flood event (ex-cyclone Fran) in 1992 (Preen et al. 1995). The catastrophic decline of seagrass meadows was followed by a mass migration of dugongs from Hervey Bay as well as mortality of a large number of dugong as a result of starvation (Preen & Marsh 1995).

Herbicide and insecticide concentrations present in the Mary River and in Hervey Bay sediments were measured between 1993 and 1996 (Queensland Department of Environment 1996). Sediment and river water pollutant concentrations were below detection limits for most compounds however the herbicides 2,4-D and Triclopyr were detected at trace concentrations ($<0.2\ \mu g/l$).

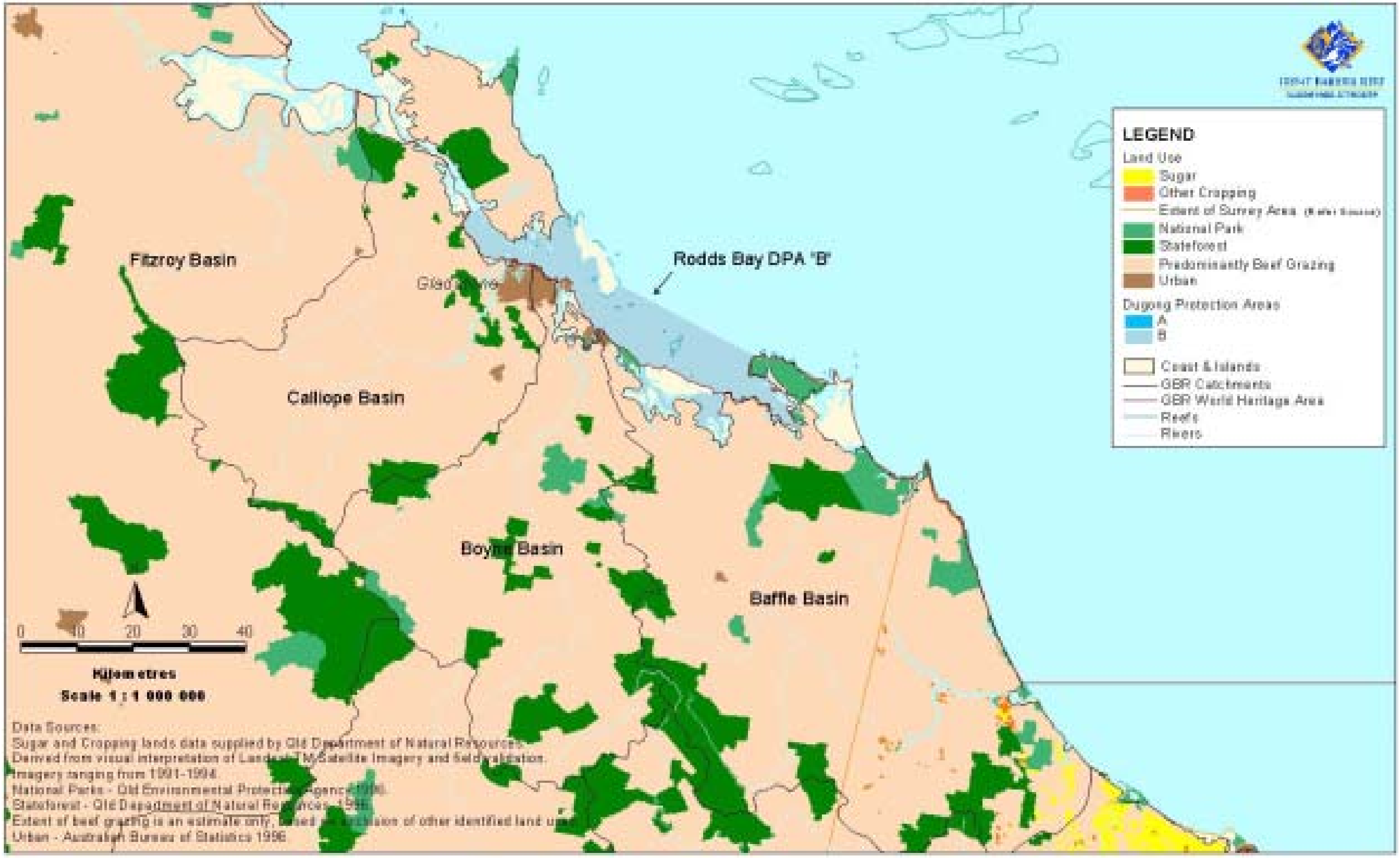

Figure 13. Land use in river catchments adjacent to the Rodds Bay Dugong Protection Area

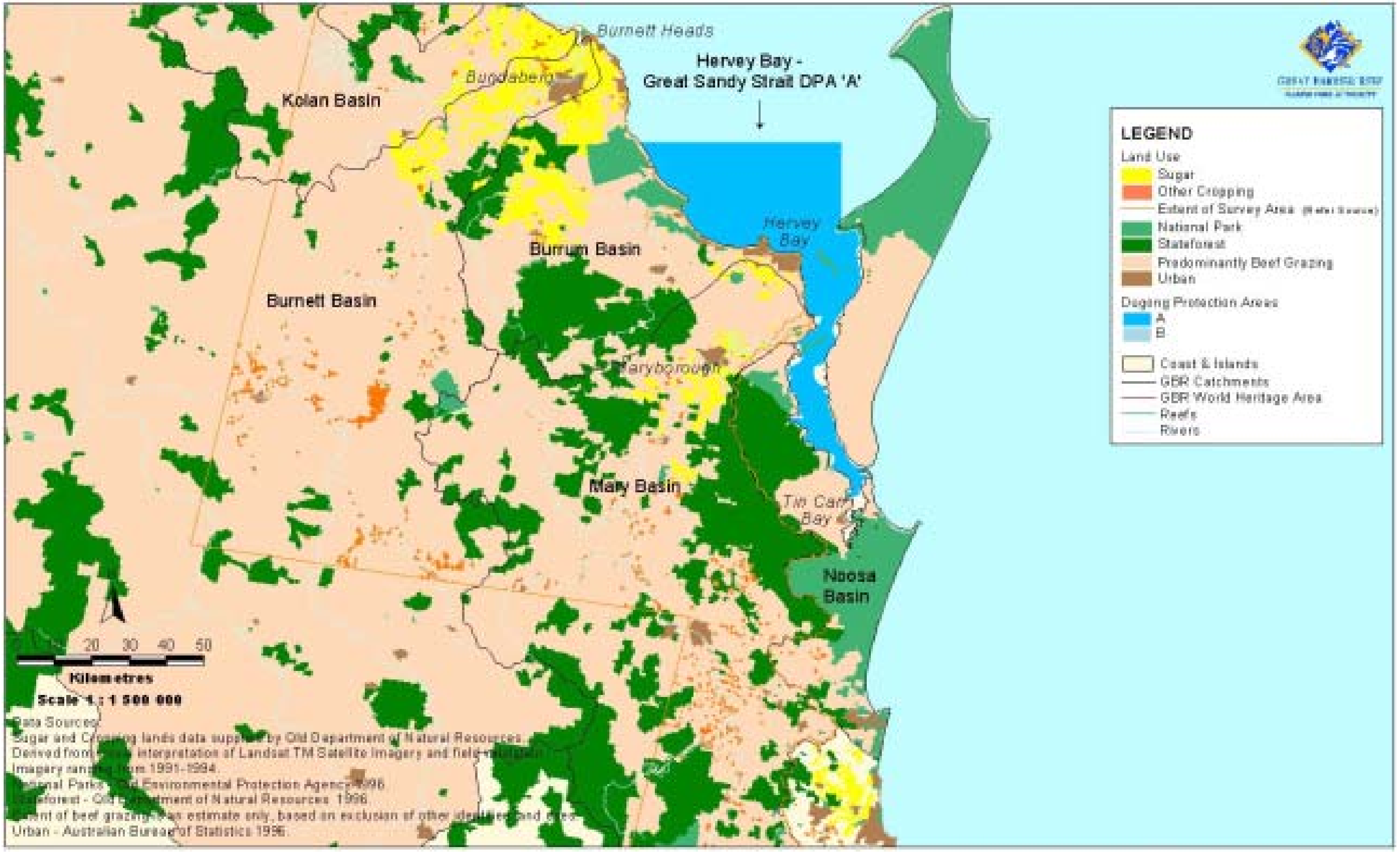

Figure 14. Land use in river catchments adjacent to the Hervey Bay – Great Sandy Strait Dugong Protection Area