Coastal Resource Atlas for Oil Spills in Port Jackson

EPA NSW

COASTAL RESOURCE ATLAS FOR OIL SPILLS IN PORT JACKSON

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Coastal Resource Atlas for Oil Spills in Port Jackson

Prepared at the request of the
coordinating authority for oil spill response,
the New South Wales State Committee of Advice to the
National Plan to Combat Pollution of the Sea by Oil,
for use as an advisory document.

AMSA
Australian Maritime
Safety Authority

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Other titles in the series:

- Coastal Resource Atlas for Oil Spills in Trial Bay (1986)
- Coastal Resource Atlas for Oil Spills in Botany Bay (1989)
- Coastal Resource Atlas for Oil Spills in Jervis Bay (1989)
- Coastal Resource Atlas for Oil Spills in and Around the Port of Newcastle (1989)
- Coastal Resource Atlas for Oil Spills in and Around Port Kembla (1989)
- Coastal Resource Atlas for Oil Spills in and Around Twofold Bay (1990)
- Coastal Resource Atlas for Oil Spills from Cape Dromedary to Cape Howe (1991)
- Coastal Resource Atlas for Oil Spills in Broken Bay, Pittwater and the Hawkesbury River (1992)
- Coastal Resource Atlas for Oil Spills from Point Danger to Clarence River (1992)
- Coastal Resource Atlas for Oil Spills from Clarence River to Smoky Cape (1992)
- Coastal Resource Atlas for Oil Spills from Barrenjoey Head to Bellambi Point (in press)
- Coastal Resource Atlas for Oil Spills in Brisbane Water (in press)

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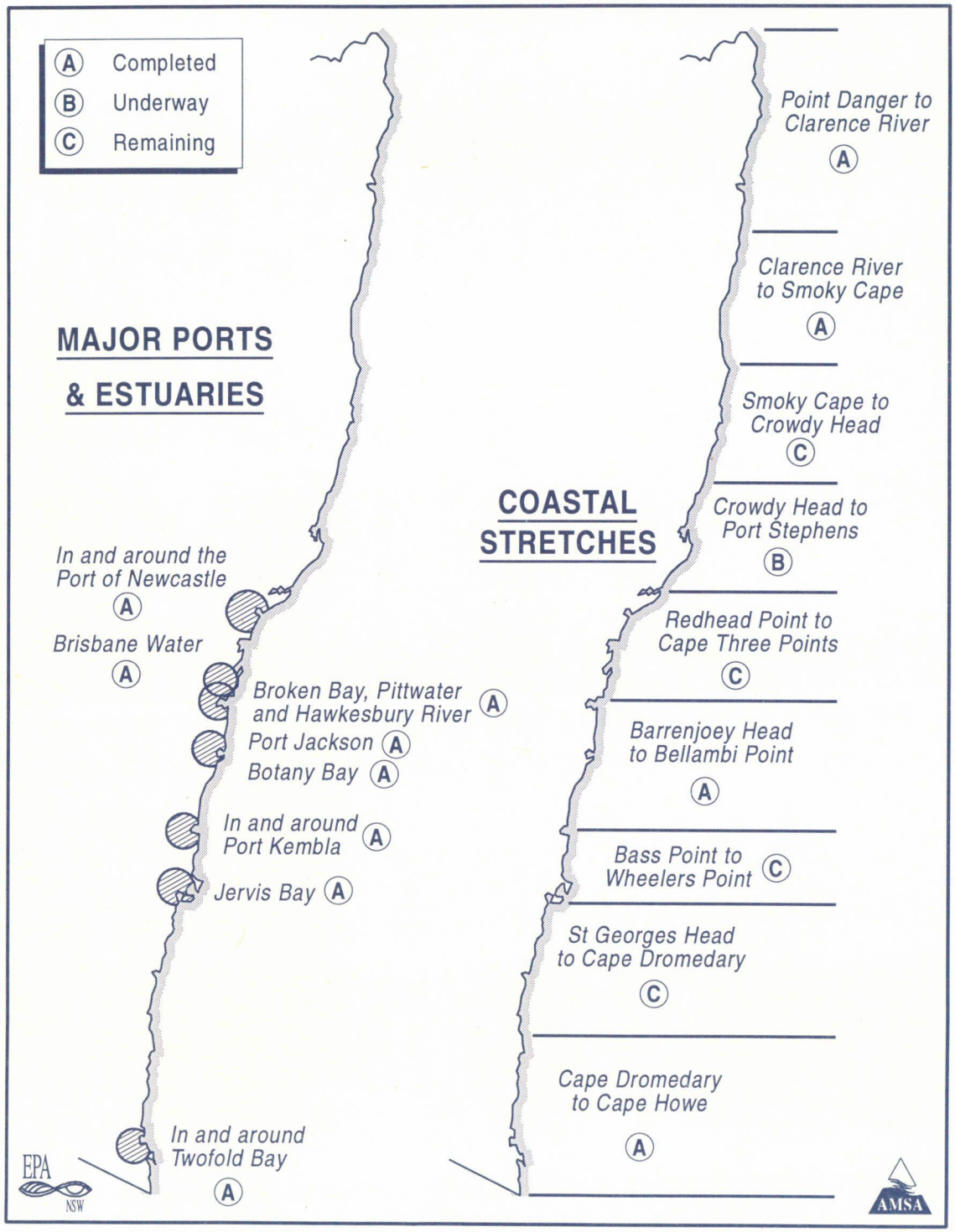

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Summary and recommendations

This atlas details environmentally sensitive areas of Port Jackson. The atlas is designed to complement existing plans/manuals for dealing with oil spills in general and contains recommendations to minimise the impact of a spill in this region.

The coastal resources in the region are divided into four categories of sensitivity: extreme, high, moderate and low. If there is an oil spill, the first priority is to protect the extreme and high sensitivity areas (Figure 1). The extreme sensitivity areas include mangroves, saltmarshes, intertidal seagrass beds, and the feeding and roosting sites of birds protected under international agreements or listed in Schedule 12 of the NSW National Parks and Wildlife Act 1974. Areas of high sensitivity include sites inhabited by birds that are not protected under treaties or listed in Schedule 12, oyster leases, marine mammals, subtidal seagrass beds and water intakes for public aquariums.

The intensive use of Port Jackson for recreational purposes means that particular effort must be made to keep oil away from areas that are subject to the heaviest pressure, especially the recreational beaches and boats and moorings. The value of tourism to the city also means that the area around the Harbour Bridge and Circular Quay needs to be protected from a spill.

There are many potential sources of oil spills in the region, including collisions between vessels at sea or within ports and harbours, vessels that run aground, vessels that discharge tank washings or oily bilge water, refuelling accidents, refinery accidents, road accidents and other land-based spills. A spill may come into contact with sensitive resources within hours of being released (Figure 11), so a rapid response is required to try to protect these resources.

When planning measures to counter oil spills, it is important to consider a region's environmentally sensitive areas, particularly when planning the deployment of booms or the use of dispersants. Less than optimal use of these measures may cause further damage.

The coastline in the region is generally composed of protected rocky shoreline (including constructed seawalls), interspersed with sandy beaches in the lower estuary, grading to protected rocky shores and mangroves in the upper reaches. The protection of resources is a high priority and the use of booms is probably the most effective response to a spill that is likely to affect these areas. Two obvious locations for the use of booms to keep oil out of sensitive areas are the entrances of Lane Cove River and Middle Harbour. Dispersant will only work on some types of oil

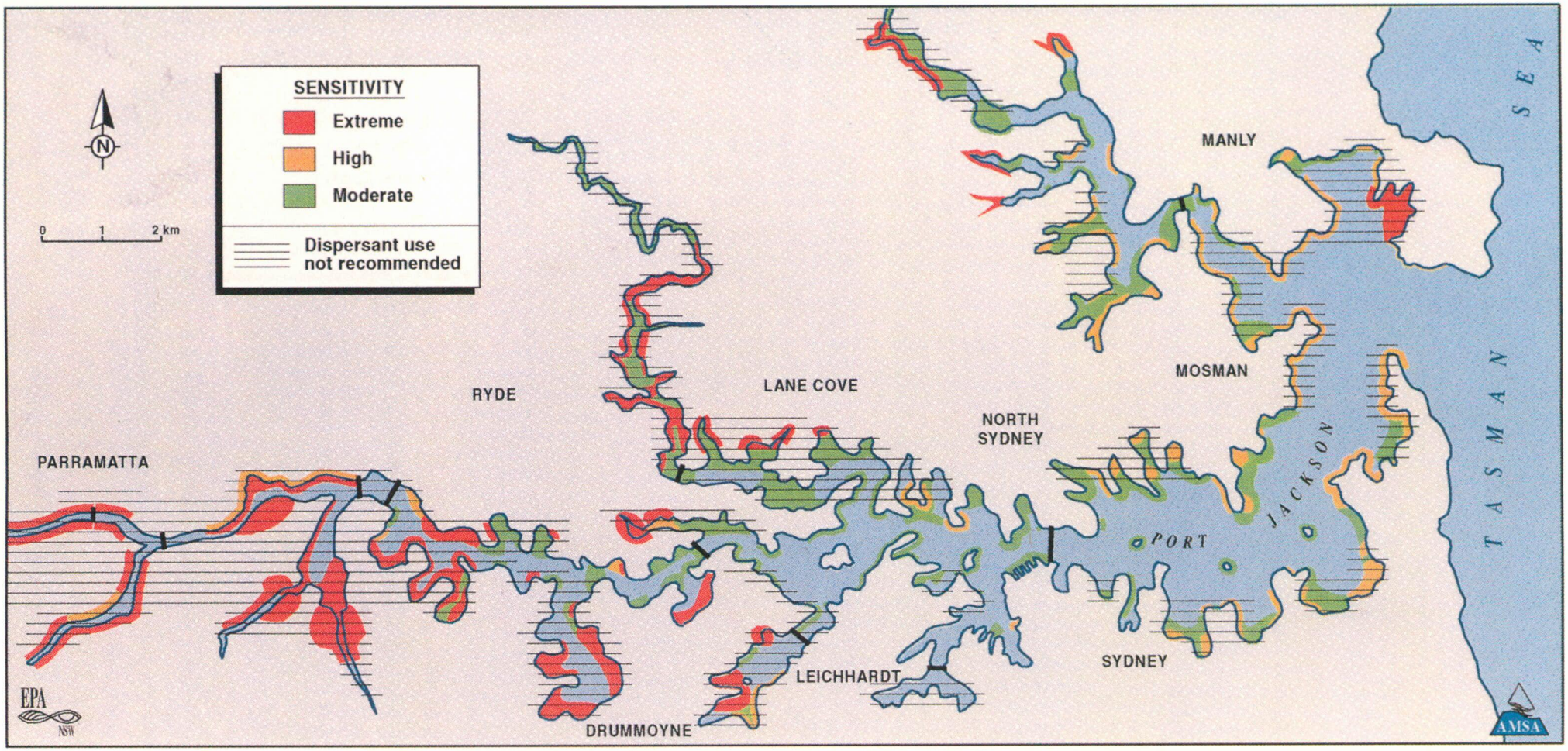
(*see* Table 1), and even in those cases it may cause damage to subtidal resources if it is used in water less than 5 metres deep or where there is little tidal flushing (Figure 1). Owing to the convoluted nature of Port Jackson and the proximity of sensitive resources to potential spill sites, booms and dispersants must be used as soon as possible after the initial spill. This quick response may be aided by the proximity of equipment stored in Port Jackson and Botany Bay.

In the case of a spill affecting the estuary, the main beaches can be accessed, which enables oiled sand to be removed by earthmoving equipment. However many of the smaller beaches are best approached from the water.

Defensive deployment of booms, spraying of dispersants and shoreline clean-up are all possible response options to an oil spill. Waste removal and disposal options need to be clearly defined. Authorities responsible for oil spill clean-up should develop expertise in all methods of response operations, including the protection of environmentally sensitive areas.

This summary and Figures 1 and 11 contain the essential points of the atlas. The remainder of the text contains detailed information on the coastal resources in the region and recommended protection measures.

Figure 1
Sensitivity of resources in Port Jackson
Figure also shows 'no dispersant use' areas.



1. INTRODUCTION

This atlas is one of a series designed to assist in the control of oil spills and the protection of coastal resources in New South Wales. The atlases complement planning and actions to reduce the frequency and mitigate the effects of oil spills. If there is a spill, the environment will be better protected if proper contingency plans (based on these atlases) have been prepared. The atlases provide information on environmentally sensitive areas within a region, with values derived from environmental assessment and identification of potential conflicts of interest that may arise between scientific, commercial and recreational uses. The atlases also define areas where the use of dispersants is not recommended, and sites where booms could be effectively deployed.

The atlas is divided into three parts:

1. an analysis of the resources at risk and their sensitivity
2. an assessment of the threat
3. a review of oil spill countermeasure resources.

The region covered by this atlas is Port Jackson (RAN 1974), from Parramatta at the uppermost end of the estuary, to a line drawn from Inner North Head to South Head at the entrance to the harbour. This area includes Duck River, Lane Cove River and Middle Harbour (Figure 2). Much of the information contained in this atlas was contained in Thompson and McEnally (1985).

2. ASSESSMENT OF RESOURCES AT RISK

The risk assessment of resources looks at three main groupings:

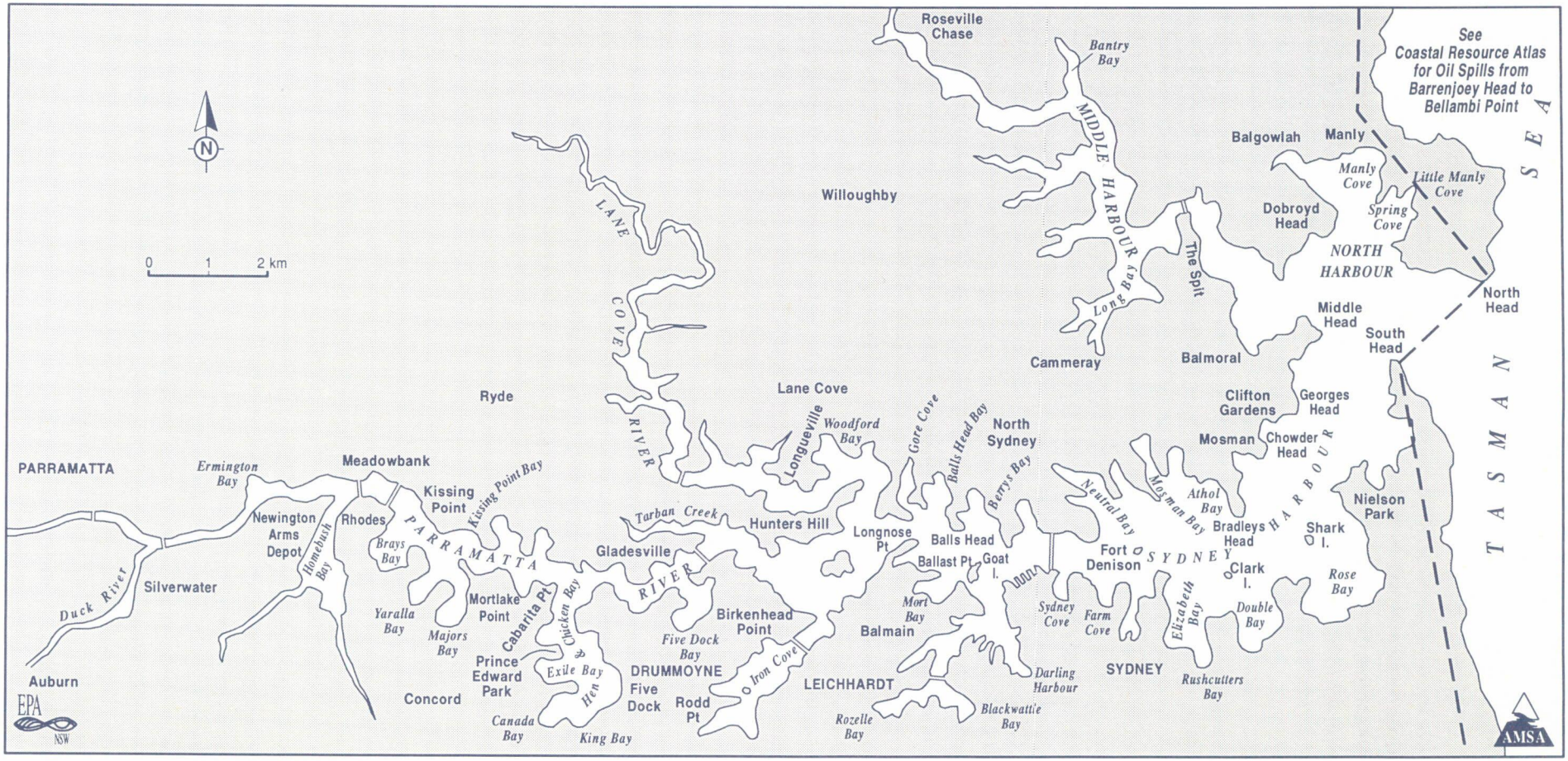
1. **Ecological resources**. These resources relate directly to the natural environment and there may also be some economic value attached to them. These resources include birds and their habitats, mangroves, saltmarshes, seagrass beds, rocky shores and fish nursery and spawning grounds.
2. **Socio-economic resources**. These are resources that can be assessed as having a monetary value to society, and include recreational beaches, boats and moorings, oyster leases, commercial and recreational fisheries and diving areas.
3. **Cultural resources**. These include archæological sites and historic or heritage sites.

Each resource is assigned to one of four categories relating to the sensitivity of that resource to an oil spill. These categories are:

- Extreme sensitivity
- High sensitivity
- Moderate sensitivity
- Low sensitivity.

The geomorphology of a region and the clean-up options available must be taken into account when determining a resource's final category. The geomorphology

Figure 2
Locations referred to in text



may relate to the area's potential to retain oil and its ability to recover from an oil spill, e.g. a rocky headland exposed to heavy seas would be less affected by an oil spill than a protected rocky headland, because the oil at the exposed headland would be rapidly broken down and removed by natural means (waves, sun, wind and weathering). In some cases, clean-up activities may cause more damage to the environment than the oil spill, e.g. using mechanical plant and equipment in saltmarsh areas.

Earlier Coastal Resource Atlases have set a precedent of not assigning National Parks and Nature Reserves to a particular category, but the resources found within these areas are discussed in the relevant sections.

2.1 Extreme sensitivity

Resources that are categorised as extremely sensitive to oil spills generally have one or more of the following characteristics:

- they have a high potential to retain oil, and may suffer severe or irreparable damage from an oil spill
- they are of international significance or are considered rare, vulnerable or threatened with extinction
- they cannot be restored or replaced after an oil spill
- they cannot be cleaned without compounding damage.

Extremely sensitive resources include mangroves, saltmarshes, intertidal seagrass beds, and birds that are protected under international treaties or listed in Schedule 12 of the National Parks and Wildlife Act 1974.

2.1.1 Birds protected under international treaties or listed under Schedule 12 of the National Parks and Wildlife Act 1974

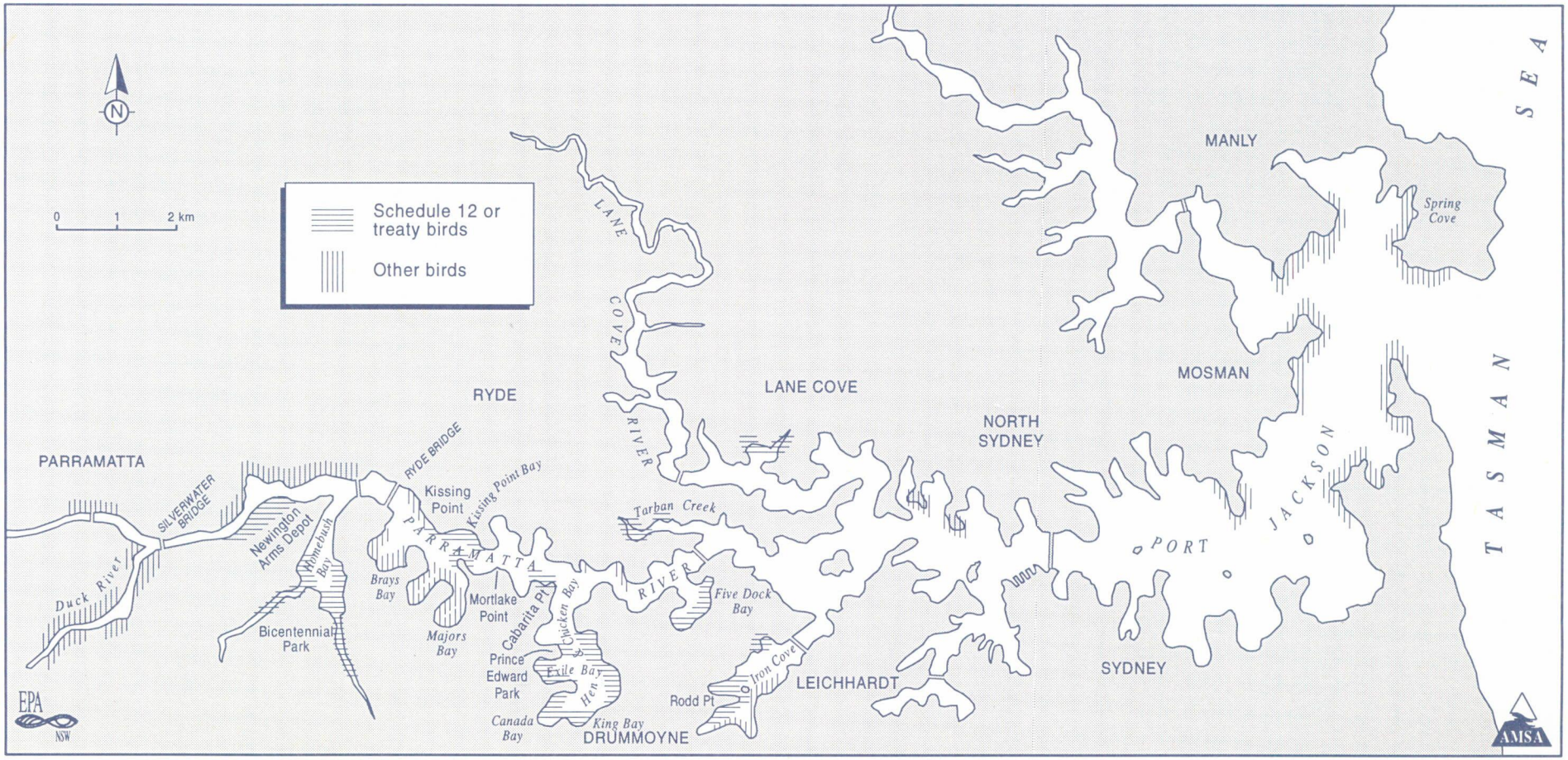
Most of the birds protected under international agreements are waders (*Charadriiformes*) and sea birds (*Procellariiformes*, *Pelecaniformes* and *Sphenisciformes*). The birds and their habitats are both extremely sensitive to oil spills. Australia is a signatory to several international agreements that protect migratory birds and their habitats: the Japanese-Australia Agreement for the Protection of Migratory Birds, Birds in Danger of Extinction and their Environment (JAMBA) and the Agreement between Australia and the People's Republic of China for the Protection of Migratory Birds and their Environment (CAMBA), the Bonn Convention on the Conservation of Migratory Species of Wild Animals (1979) and the Ramsar Convention on the Protection of Significant Wetlands (1975). Schedule 12 of the National Parks and Wildlife Act 1974 lists birds that may be threatened or endangered and therefore require protection (Appendix 1).

Tidal movements influence the feeding patterns of many species of birds. Most waders move into the intertidal areas at low tide to feed and roost in special sites during high tide. An oil spill that reaches the intertidal flats or the high-tide mark may bring the waders into direct contact with the oil, as well as damaging the intertidal food sources the birds rely on.

Wading birds feed and roost on many of the intertidal flats in inner Port Jackson

Figure 3

Feeding, resting and roosting sites for birds protected by international treaty or Schedule 12, and for other birds



(Figure 3). The Parramatta River, between Duck River and Lane Cove River, is considered the seventh most important estuary for waders in NSW (Smith 1992). Homebush Bay Bicentennial Park includes important wader habitats, as do the saltmarshes under the nearby radio towers and the wetlands in the Newington Arms Depot further west. Elsewhere on the river, the most important feeding sites are the eastern shore of Hen and Chicken Bay and King, Canada and Exile bays, and the most important roosting sites are at Prince Edward Park and Kissing Point (Morris et al 1990). In summer, migratory waders also use the wetlands around Iron Cove, Five Dock Bay and Kissing Point Bay. Waders are also found in numbers in Tarban Creek, Lane Cove River and Duck River, and the sheltered rocky shores at Prince Edward Park, western Hen and Chicken Bay, Kissing Point, Mortlake Point, Cabarita Point and Rodd Point are all feeding sites for grey-tailed tattlers, golden plover and red-necked stint (Morris et al 1990). Many of the birds protected by international treaty or Schedule 12 are found in fairly high numbers in the Parramatta River, including the bar-tailed godwit, lesser golden plover, sharp-tailed sandpiper, red-necked stint and curlew sandpiper (Smith 1992).

East of the Lane Cove River, Port Jackson is a poor wader habitat, due to the lack of intertidal flats and the high level of human disturbance. However, six birds that are listed under the treaties (common tern, arctic jaeger, wandering albatross, wedge-tailed and short-tailed shearwaters, white-breasted sea eagle) and one bird listed in Schedule 12 (osprey) are known to inhabit or utilise the Sydney Harbour National Park near the mouth of Port Jackson (Morris 1986). These are sea birds or raptors and are susceptible to oil spills from direct contact or from ingesting oiled prey.

2.1.2 Mangroves

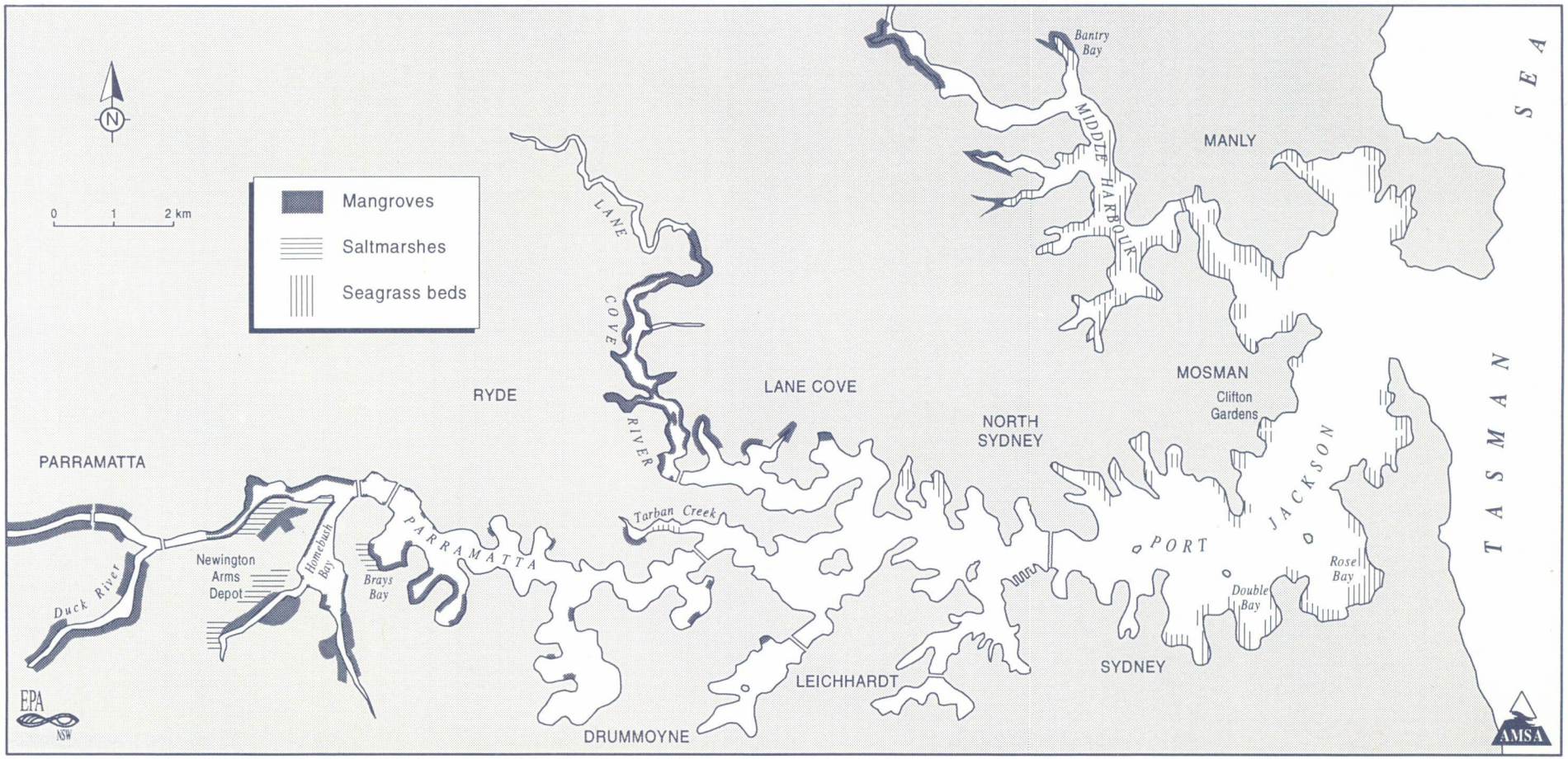
Mangroves are extremely sensitive to oil pollution. The destruction of seedlings and the oil-induced dieback of mature trees caused by repeated oiling is likely to destroy mangrove areas. Mangrove shorelines are very important to maintaining a high biological diversity of marine life in the estuaries they inhabit. They act as significant sediment traps and the consolidated sediments provide a habitat suitable for a wide variety of intertidal organisms. Mangroves also act as nursery areas for many fish and invertebrate species, and provide important nesting, feeding and roosting sites for a wide variety of birds and other animals. They are also important areas of primary production for the surrounding waters.

Two mangrove species, *Avicennia marina* and *Aegiceras corniculatum*, are found in Port Jackson and cover an area of 0.914 km^2 (West et al 1985). The major concentrations of mangroves are along the Lane Cove River, Parramatta River, Homebush Bay and Duck River, with other stands in Tarban Creek and the upper reaches of Middle Harbour (West et al 1985) (Figure 4).

2.1.3 Saltmarshes

Like mangroves, saltmarshes form an important habitat for waders and other birds and are extremely sensitive to oil pollution. Saltmarshes act in similar ways to mangroves in primary production and sediment accumulation. Saltmarshes also regulate nutrients in estuarine waters (Adam 1984). The small

Figure 4
Distribution of mangroves, saltmarsh and seagrass in Port Jackson
(modified from West et al 1985, MSB 1989)



area (58 km^2, West et al 1985) of saltmarsh habitat in NSW suggests that the protection of this habitat is vital. Saltmarsh often recovers from a single spill if left to recover naturally.

There are several small areas of saltmarsh surviving in Homebush Bay (0.0073 km^2) (West et al 1985), and smaller patches in Brays Bay and Lane Cove River. Upstream of Homebush Bay, within the Newington Armaments depot, there are some areas of mixed mangrove/saltmarsh communities (Figure 4).

2.1.4 Intertidal seagrass beds

Seagrass beds can occur in extremely shallow water and may be exposed at low tides. At such times, the beds may be entirely covered by oil and must be considered extremely sensitive. There are some *Zostera* beds in Port Jackson that are exposed at low spring tides, these are generally in the shallow bays in the outer harbour, e.g. Double Bay, Clifton Gardens, Bantry Bay and Rose Bay.

2.2 High sensitivity

Resources that are categorised as highly sensitive to oil spills generally have one or more of the following characteristics:

- they have high potential for retention of oil and can be seriously damaged by oil spills
- they are of national or regional significance
- they would require a difficult and protracted clean-up operation that may be only partially successful
- they would be difficult and/or expensive to replace or restore after an oil spill.

Highly sensitive resources include subtidal seagrass beds, oyster and mussel leases, and birds that are not protected under international treaties or listed in Schedule 12 of the National Parks and Wildlife Act.

2.2.1 Birds not protected under international treaty nor listed in Schedule 12

There is a great diversity of birdlife not protected by international treaty or Schedule 12 that may be affected by an oil spill. While all native birds are protected under the National Parks and Wildlife Act 1974, most are not considered threatened or rare and endangered. Although they are no less sensitive to oil spills, they are not protected by international agreements and, as such, are only classed as highly sensitive. This is a political rather than biological definition, which emphasises the status of internationally protected birds.

Birds of particular importance under this heading are the little penguin and the four main cormorant species, the pied, little pied, black and little black cormorant. All these birds feed along the coast, generally off rocky headlands, with the cormorant also feeding in bays and port areas. All species are at risk from ingestion of oiled food.

Because penguins spend most of their time in the water, they are at greatest risk. Diving birds (like the cormorants) are also vulnerable, as are other birds which feed by reaching below the surface. Oil quickly affects the plumage, reducing water-proofing on the feathers and thus causing waterlogging, which

leads to loss of buoyancy and insulation.

Although the survival of these birds is important, ensuring their protection would require the whole of the region's waters to be zoned as highly sensitive. The best protection these birds can be offered is quick response to a spill and diversion of oil before it can reach known feeding areas.

There is a small colony of little penguins surviving near Spring Cove at Manly. This is one of the two remaining mainland colonies of little penguin in NSW. It is recommended that the general area surrounding the colony be upgraded to extreme sensitivity.

The shoreline of Port Jackson, particularly Homebush Bay, also provides roosting and feeding sites for many birds not protected by treaties or Schedule 12. The most important of these birds are the crested tern, chestnut teal, pied stilt, grey teal, royal spoonbill, white-faced heron and hoary-headed grebe. The population of chestnut teal is one of the largest in NSW. The fringing mangroves in Majors Bay, Brays Bay and the northern side of the Parramatta River from Ryde Bridge to Silverwater Bridge, are important feeding sites for waterfowl, spoonbill, ibis, heron and egret. Pelican and cormorants feed in the deeper water in the middle of the bays (Morris et al 1990).

The most important bird habitats are outlined in Figure 3, however distribution patterns of individual species are too complex to map here. Generally, birds inhabit the wetland areas in the upper estuary, but feed and roost on the less sensitive rocky coasts around outer Port Jackson (Morris 1986).

2.2.2 Subtidal seagrass beds

Subtidal seagrass beds are classed as highly sensitive to oil pollution. They have several roles in maintaining the ecology of marine ecosystems. They provide an important habitat for fish and invertebrate species, both as a nursery area and as a lifelong habitat. The seagrasses act as sediment traps, resulting in substantial accretion of sediment. They are a major source of primary production in the estuarine system and support high levels of secondary production (Adam 1984). Seagrass beds are not exposed on most tides, so they are less susceptible to oil spills than mangroves.

Ruppia (sea tassel) is a submerged seagrass that produces surface flowers in summer and autumn and is most susceptible to oil spills at those times. *Ruppia* is generally found in lagoons with lowered salinities (Sainty & Jacobs 1986), where it is eaten by many species of water birds. The extent of *Ruppia* fluctuates from year to year, but in 1992–93 there were large areas reported in brackish drains and pools in the Homebush Bay/Newington area.

Beds of other seagrasses (*Zostera*, *Posidonia* and *Halophila*) generally occur in the lower reaches of the estuary and in the sandy bays of Middle Harbour (MSB 1989), and cover approximately 3.4 km^2 (West et al 1985) (Figure 4).

2.2.3 Marine mammals and other vertebrates

The dolphins, whales and seals which frequent the water of this region are highly sensitive to oil spills. Marine mammals are common visitors along the NSW coast, and dolphins are often present close to popular surfing beaches. All

marine mammals are listed under Schedule 12 of the National Parks and Wildlife Act 1974. In spring, humpback whales migrate south to feeding grounds in the Antarctic, then head north again in winter to breeding grounds off northern Australia. Southern right whales breed off the Central Coast of NSW during September/October, and rest with their young in some of the more sheltered bays (L. Gibson, Australian Museum, pers. comm.).

Dolphins and whales are less susceptible than seals to oil damage because they have smooth skin, but they are still at risk of ingesting oil from contaminated food sources. Seals are at greater risk because contact with oil can clog their fur and cause a loss of insulation, and they can also ingest oil, whether directly, or from grooming or eating contaminated food.

If there are reports of mammals in the area of an oil spill, all care should be taken to prevent them from coming into contact with the oil. Protection of the mammals' food sources is not feasible as it generally comprises free-swimming fish and invertebrates. Haul-out areas for seals should be protected where possible, but response personnel should try to have only minimal contact with the animals. Stress to mammals during clean-up operations may contribute to a high proportion of deaths.

Turtles are not common in the region, although green and loggerhead turtles have been reported, and sea snakes are occasional vagrants (Taronga Aquarium, unpublished data). These uncommon visitors require protection, but the irregularity of their visits makes it difficult to establish specific protection procedures.

2.2.4 Water intakes for public aquariums

There are three public aquariums that draw water from Port Jackson: Oceanworld in Manly Cove, Taronga Zoo in Athol Bay, and Sydney Aquarium in Darling Harbour (Figure 8). These aquarium intakes are particularly susceptible to dispersed oil as they are all located near the sea floor.

The Oceanworld intake is in water 3 metres deep and 1 metre above the sea floor, approximately 60 metres seaward of the building. The pumps can be safely shut down for 24 hours.

The Taronga Zoo intake is located on a wharf approximately 200 metres east of the Taronga Ferry Wharf. The intake is in about 6 metres of water and the foot valve is 2 metres off the seabed. The pumps at the zoo that supply the marine mammal pools can be shut down for a maximum of three days before possible animal health problems occur.

The Sydney Aquarium intake is situated in approximately 10 metres of water directly under the seal enclosure. The intake is 4 metres from the seabed and operates from 7 am to 5 pm daily. It can shut down for 24 hours without deterioration of animal health.

2.3 Moderate sensitivity

Resources that are categorised as moderately sensitive to oil spills generally have the following characteristics:

- they have a low potential for retaining oil and will recover rapidly if damaged by oil
- they can be cleaned reasonably effectively and economically
- they do not normally come into contact with floating oil, but may be damaged during the clean-up operation by land-based equipment.

Moderately sensitive resources include commercial and recreational fisheries, fish nursery and spawning grounds, sheltered rocky shores, heritage sites, recreational beaches, and boats and moorings.

2.3.1 Commercial fisheries

Commercial fisheries are moderately sensitive to oil spills, mainly because they are based on seabed resources that do not come into direct contact with floating oil. They may be damaged by the suspended droplets of dispersed oil and this must be considered when using dispersants in shallow water. Oil can affect a fishery directly (tainting) or indirectly (damage to larvæ, eggs or habitat, or damage to fishing gear).

Tainting of the flesh of commercial species can cause loss of income for commercial fishermen. Tainting is caused by contact *with* or ingestion *of* oil or fractions of oil or oil-affected food. The lighter fractions cause tainting at lower concentrations than the heavier fractions (e.g. petrol causes tainting at concentrations of 0.005 µg/L, kerosene at 0.1 µg/L, emulsifiable oil at >15.0 µg/L (ANZECC 1992)). Damage to eggs, larvæ or habitat may have long-term effects on future catches of adult fish.

Commercial fisheries in Port Jackson landed 126 tonnes of prawns, fish and crayfish during 1990–91 (NSW Fisheries 1991). Fishing methods for finfish are restricted to hauling and meshing, with some handlining. Hauling generally occurs within the estuary in bays that have a relatively flat, sandy bottom. Meshing is carried out in similar locations and also in areas adjacent to rocky shorelines that are unsuitable for hauling, particularly Middle Harbour (Figure 5). The taking of any finfish for commercial purposes upstream of Gladesville Bridge is prohibited for health reasons (J. Naughton, NSW Fisheries, pers. comm.).

Prawning occurs throughout the estuary between November and March, when prawns migrate from the upper reaches of the estuary. During this period, the trawlers fish throughout the estuary. Crayfish potting occurs around the rocky headlands in the outer extremities of the estuary (Figure 5).

There are several fishing closures in force in Port Jackson, these range from total closures to restrictions on equipment. The closures are outlined in Figure 5.

2.3.2 Recreational fishery

Recreational fisheries are widely distributed throughout the region and are moderately sensitive to oil pollution. The large population of the Sydney Basin utilises the area for all types of angling. Recreational fishing in NSW, mainly based on estuarine species or estuarine dependent species, is worth over $500 million per year (NSW Government 1992).

Throughout the estuary, recreational fishing occurs primarily from the shore

Figure 5
Commercial fishing areas and fishing closures in Port Jackson

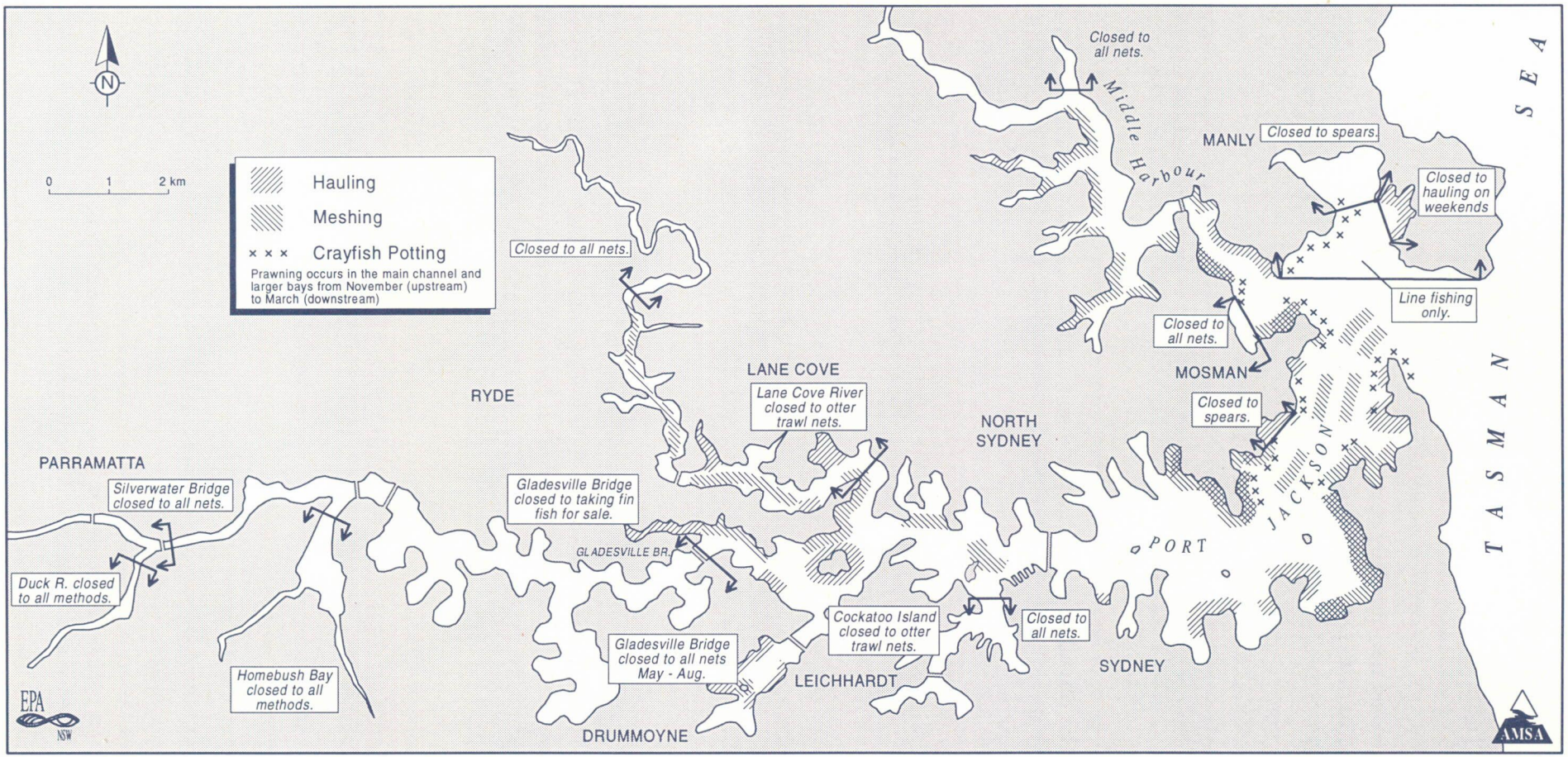
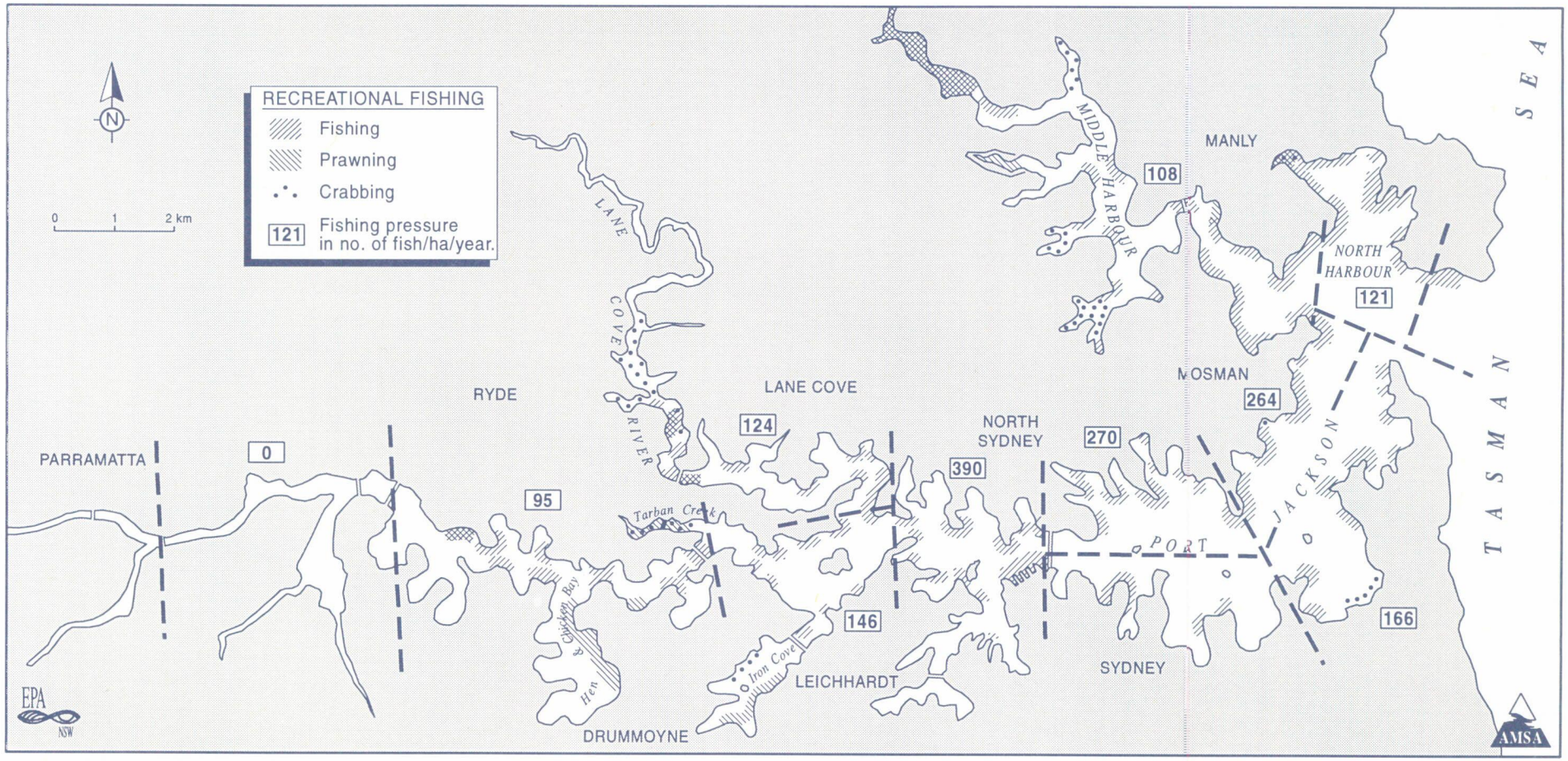


Figure 6
Recreational fishing areas and estimates of fishing pressure



(Figure 6). With the high population in the area and the accessibility of most of the headlands, many people fish as a principal form of relaxation (Henry 1984). Estimates of fishing pressure on sections of the estuary in the early 1980s (Henry 1984) show that the area upstream of the Harbour Bridge to Lane Cove River is the most heavily fished section of the river. The areas from the Harbour Bridge to the estuary mouth are the next most commonly fished areas (Figure 6). The estimates of pressure may have changed in the interim but the proportion between locations is unlikely to have varied greatly.

Recreational prawning occurs in the shallower bays during the season (November–March). These shallow bays generally have a flat, sandy or muddy bottom. Hen and Chicken Bay, Iron Cove, Tarban Creek, the upper reaches of Middle Harbour and western North Harbour are favoured sites (Figure 6) (Federal Publishing 1988).

Some recreational crabbing occurs in several sections of the estuary, the most popular areas being Lane Cove River, Tarban Creek, the upper reaches of the bays in Middle Harbour, western North Harbour and among the seagrass beds in some of the bays of the outer estuary. Target species differ from location to location, with mud crabs and blue swimmer crabs being targeted in the upper reaches of the estuary, and blue swimmers the main target in the lower reaches (Federal Publishing 1988; J. Naughton, NSW Fisheries, pers. comm.).

2.3.3 Nursery and spawning grounds

Although classed as moderately sensitive due to ease of recolonisation, fish nursery and spawning areas may be damaged by dispersants and dispersed oil droplets during oil spill response operations. Most seagrass beds and mangroves should be considered as spawning and nursery grounds for a variety of fish and crustaceans.

Port Jackson has juvenile snapper, tailor and yellowtail inhabiting the estuary all year round (Henry 1984). These are all important recreational species.

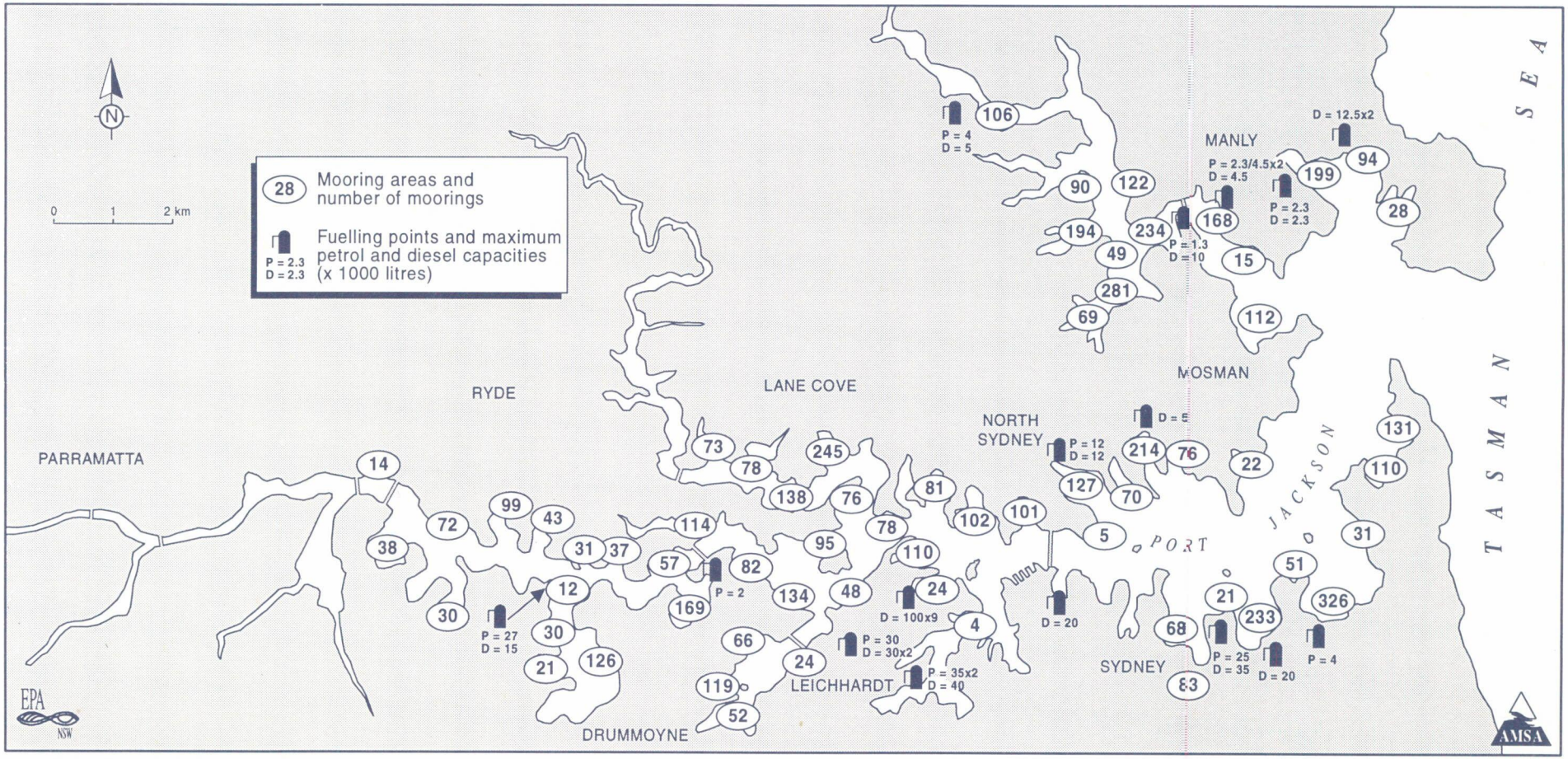
2.3.4 Boats and moorings

Boats and moorings are classed as moderately sensitive to oil pollution. Cleaning is expensive and time consuming but there is likely to be little lasting damage.

There are 4,500 recreational moorings and 1,503 commercial moorings in Port Jackson (Figure 7). The majority of the moorings are located west of the Harbour Bridge on the Parramatta River (2,578), with many others in Middle Harbour (1,440), Port Jackson east of the bridge (1,054), the Lane Cove River (610) and the coves near Manly (321). There are major concentrations of boats at The Spit Bridge (402) and Long Bay (281) in Middle Harbour, Rose Bay (326), Double Bay (233) and Mosman Bay (214) in eastern Port Jackson, Woodford Bay (245) in the Lane Cove River, and in Iron Cove (261) and Hen and Chicken Bay (189) on the Parramatta River.

There are 19 commercial waterside refuelling points in Port Jackson, with tank capacities ranging from 2,300 litres of diesel (Balgowlah) and 1,300 litres of petrol (The Spit) to 40,000 litres of diesel (MSB, Rozelle Bay) and 30,000 litres of petrol (Birkenhead Point).

Figure 7
Moorings and fueling points in Port Jackson



There are numerous licensed charter vessels operating on Port Jackson, most are sightseeing or cruising restaurants that cater to the tourist market. The five major companies, operating daily services, have 34 vessels in their fleets, with up to 60 other companies registered as licensed charter boat operators. These vessels carry up to 50,000 litres of fuel.

There is a large ferry fleet operated by the State Transit Authority, and several smaller companies that operate commuter services. The four largest ferries in these fleets can carry up to 200,000 litres of diesel fuel.

2.3.5 Recreational resources

Tourism is a very important resource in the Sydney region. During 1990–91, the contribution of tourism to Sydney was estimated at $1.2 billion dollars (S. Ryan, Tourism Information Bureau, pers. comm.).

Beaches. Recreational beaches are of moderate sensitivity. Although a spill may cause short term inconvenience to recreational users, it is possible to clean beaches without any serious long-term damage to their recreational value. Sandy beaches support substantial biological communities, some of which are highly sensitive to oil pollution (A. Jones, Australian Museum, pers. comm.).

Important recreational beaches are generally found east of the Harbour Bridge. The most popular beaches are Balmoral, Nielsen Park, Clifton Gardens and Manly (NPWS 1982) and east of The Spit Bridge (Figure 8).

Tidal Swimming Pools. There are 20 swimming enclosures in Port Jackson that may be affected by oil spills (Figure 8). Some are permanent fixtures (e.g. Little Manly) but others have nets that are removed during the winter months (e.g. Nielsen Park (NPWS 1982)).

2.3.6 Sheltered rocky shores

Natural and artificial sheltered rocky shores are moderately sensitive to oil spills. As wave action decreases, so does the natural degradation and dispersal of oil. The biota of these shores is at particular risk from inappropriate clean-up measures, and clean-up operations in such areas should follow the recommendations of the State Pollution Control Commission (1981).

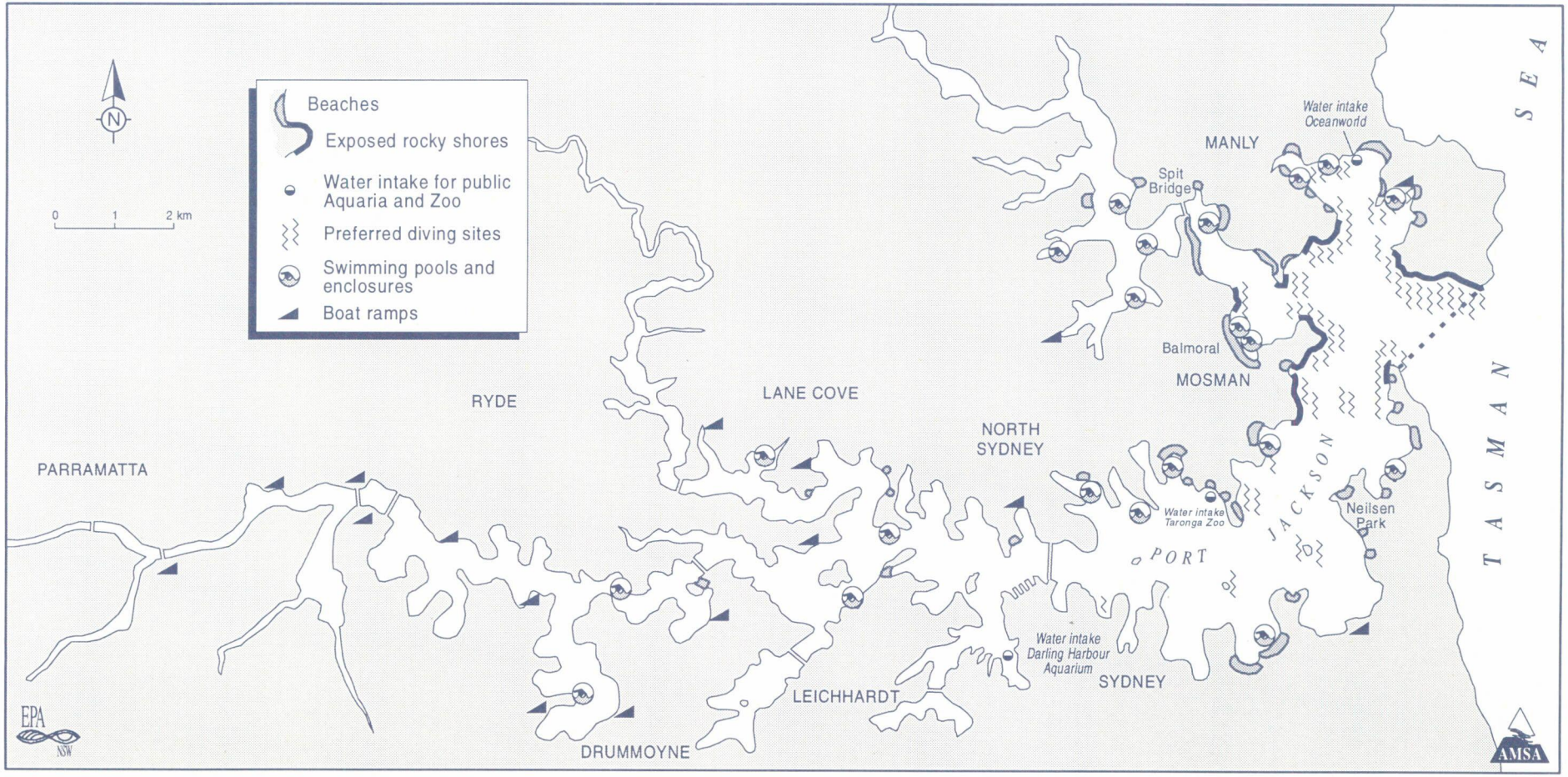
Much of the shoreline of the Port Jackson estuary is sheltered rocky shore. This includes extensive stretches of shoreline that have had rock walls constructed to enhance or extend the amenity of the backyards in many waterfront residences. Some of the areas considered as sheltered rocky shores are walls that have a small area of beach exposed at low tide, but the wall is the major contact zone during high tide.

2.3.7 Heritage sites

Heritage sites are classified as moderately sensitive areas because they are considered culturally and historically important to society in terms of Aboriginal, cultural, scientific or educational value. They are most likely to be put at risk by mechanical disturbance during clean-up operations, but Aboriginal shell middens on the water's edge may also come into contact with floating or storm-driven oil.

A 'Register of Aboriginal Sites' is kept by the National Parks and Wildlife

Figure 8
Recreational resources in Port Jackson



Service. There are currently more than 23,000 registered sites in NSW, and the great majority of these sites are on the coastal fringes (J. Duncan, pers. comm.). Aboriginal sites are protected under the National Parks and Wildlife Act 1974, and permission must be sought in writing before a site or relic is disturbed. Owing to time constraints, this will not be feasible in the event of a spill, but all steps must be taken to avoid contact with any possible sites. Unfortunately, many sites are not yet mapped, including buried middens, surface scatters of stone artefacts, burial sites, open camp sites and axe-grinding grooves. If there is a need to gain access to a beach or shoreline and there are no constructed roads, consult the National Parks and Wildlife Service. Do this by contacting the Duty Officer, Regional Incident Procedures, National Parks and Wildlife Service, Hurstville. The officer will be able to help the Scientific Support Coordinator to determine the best possible access.

Some Aboriginal sites, e.g. shell middens at the waters edge, may be highly sensitive to oil spills, as they would retain oil and be difficult to clean without irreparable damage. Many other sites are at risk from mechanical disturbance during clean-up operations. There are over 300 sites around Port Jackson and its tributaries, 178 in the Middle Harbour catchment, 95 in the Lane Cove catchment and 45 from Parramatta to the mouth of Sydney Harbour (Attenbrow 1991). If any of these sites is affected by oil, cleaning should not be attempted.

There are numerous sites listed as historic or environmental heritage sites in the Local Environment Plans of the local councils around the estuary. The majority of the sites are related to the maritime, military and transport history of the port and include wharves, boatsheds, fortifications and bridges (Figure 9). The majority of these sites comprise stonework or timber piles that may be coated by oil, but careful cleaning should not cause permanent damage.

2.4 Low sensitivity

Resources that are considered to be of low sensitivity to oil spills generally have the following characteristics:

- they have little or no potential to retain oil and will suffer relatively little damage from an oil spill
- they have little or no commercial or recreational value
- they have high potential for natural recovery or recolonisation
- they have high potential for natural degradation of contaminants but may be damaged by inappropriate clean-up measures.

These resources may include exposed rocky shores, boat ramps and diving areas.

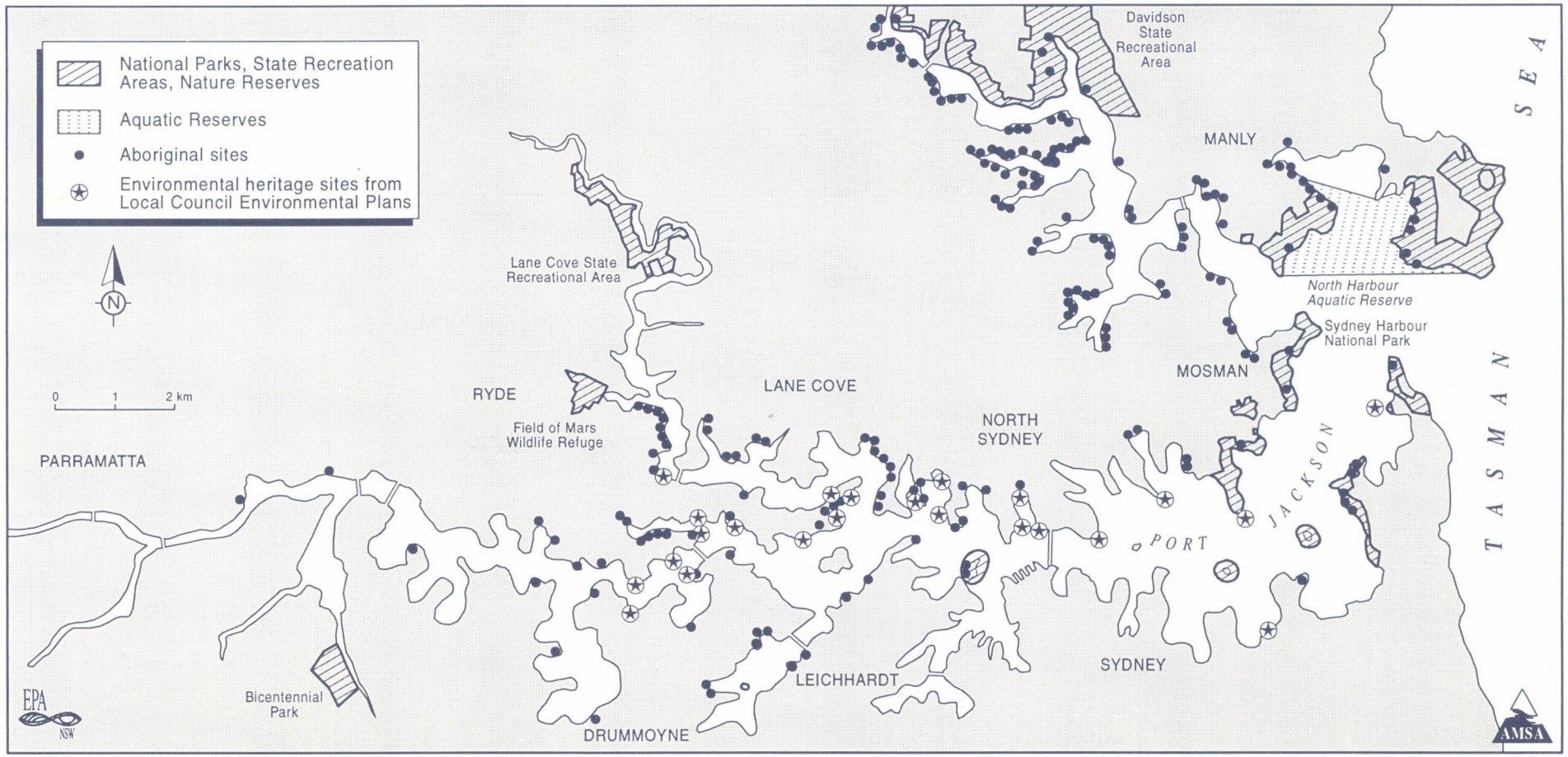
2.4.1 Exposed rocky shores

Natural and artificial exposed rocky shores are of low sensitivity to oil pollution. Strong wave action accelerates the natural breakdown of oil, reduces the potential of a site to retain oil, and associated current movements increase the chances of recruitment or recolonisation of a site.

Inappropriate clean-up procedures are again a major risk for these sites and the

Figure 9

Aboriginal and European heritage sites, National Parks, State Recreation Areas, nature reserves and aquatic reserves in Port Jackson



State Pollution Control Commission (1981) guidelines should be followed. Exposed rocky shores are generally restricted to outer Port Jackson (Figure 8). The headlands at North, South, Dobroyd and Middle Heads are all exposed to heavy seas and in some conditions the shores as far as Georges Head are affected (MSB 1989).

2.4.2 Boat ramps

Artificially constructed boat ramps are not very sensitive to oil spills, but the environment surrounding the boat ramp can still be a cause for concern. Boat ramps should be cleaned using the appropriate procedure (SPCC 1981) to avoid damaging these areas.

Most of the land along the foreshores of the estuary is either privately-owned or National Park, which, coupled with the high price of real estate, means that there are relatively few public boat ramps in Port Jackson (17, *see* Figure 8), and these are of variable condition. They range from an almost new four-lane concrete facility at Roseville Chase, to ex-vehicular ramps at Rhodes and Meadowbank, to single-lane ramps across a beach with no facilities at Longueville (Lucas 1989).

2.4.3 Boat ramps

SCUBA diving areas are of low sensitivity to oil spills because they are often located in deep water (deeper than 5 metres) or along rocky, exposed areas. However, many popular snorkelling areas are located in protected areas shallower than 5 metres. Generally these areas will not be affected by floating oil but the indiscriminate use of dispersants could cause damage. Care must be exercised when using dispersants in shallow waters.

The most popular diving areas are generally in the deeper water and rocky reefs near the entrance of Port Jackson (Figure 8), but some diving does occur further up the harbour in areas that are used for a particular purpose. Farm Cove, for example, is popular for divers who collect old bottles.

2.5 Other resources

2.5.1 National Parks and Nature Reserves

The coastal resources within the National Parks and Nature Reserves have been dealt with separately in the sensitivity outlines. However the locations of the areas operated by the National Parks and Wildlife Service (NPWS) must be distinguished, to allow the NPWS to implement its own contingency plans and procedures in the event of a spill.

The North Harbour Marine Reserve, administered by NSW Fisheries, was dedicated as a marine reserve as an extension of Sydney Harbour National Park.

2.6 Summary of resources at risk

The region surrounding Port Jackson contains many resources that may be adversely affected by an oil spill. It is important to identify priority areas for protection in order to avoid wastage of resources and effort.

First priority must go to extreme and high sensitivity resources, i.e. birds and

their habitat, mangroves, saltmarshes and seagrasses.

Some resources may be more sensitive to oil dispersants and dispersed oil droplets than they are to floating oil: particularly subtidal seagrass beds, seawater intakes for commercial aquariums, commercial and recreational fisheries, fish nurseries and spawning areas and diving areas. Because these resources are subtidal, they are relatively protected from floating oil. Dispersants should not be used where these resources are located in water less than 5 metres deep or on intertidal vegetation such as mangroves, saltmarshes and seagrasses which are extremely sensitive to both oil and dispersants.

Due to the high recreational and tourist value of Port Jackson, there will be considerable pressure to protect or clean the important recreational resources of the area: the recreational beaches, boats and moorings, and the areas around the major attractions that draw tourists to Sydney, including the Harbour Bridge, the Opera House and Darling Harbour.

3. ASSESSMENT OF THE THREAT

3.1 Potential sources of an oil spill

There is a great variety of vessels plying the waters of Port Jackson, carrying a range of oil fuels and cargo. The type of oil that may be spilt ranges from refined petroleum products to crude and heavy fuel oils. The density of ocean traffic is low compared to overseas shipping ports, therefore the likelihood of collision is also low. In 1991–92, there were 2,622 shipping movements in Port Jackson (39,577,772 gross tonnage). Each vessel carries up to 6,500 tonnes of bunker fuel. Between March 1992 and March 1993, 312 oil tankers entered Port Jackson. Sixty three of these vessels were over 200 metres long, carrying a maximum of 90,000 tonnes, and docked at the Gore Bay oil terminal (Appendix 3).

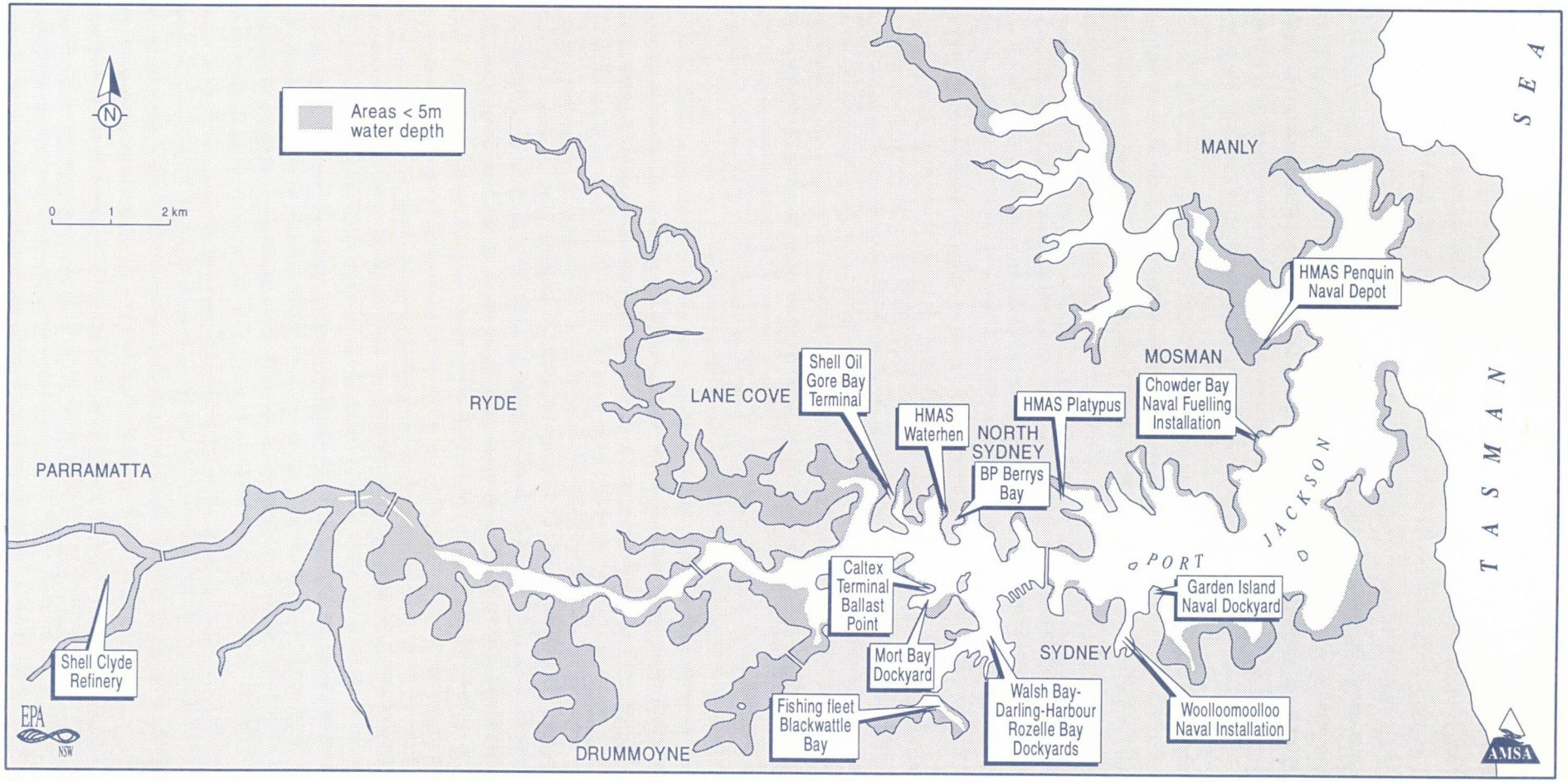
Within Port Jackson there are major storage facilities at the Chowder Bay naval refuelling depot, BP's Berrys Bay terminal, and Shell's Gore Bay oil terminal and Clyde refinery. The Caltex Ballast Point terminal is in the process of phasing out operations (Figure 10). Other refuelling depots are at Mort Bay Dockyard and at the 12 marinas that serve commercial and recreational boating in the Harbour (Figure 7).

There are also a large number of commuter and commercial tourist vessels plying Port Jackson, mostly in the lower harbour area although the RTA River Cat ferries now service Parramatta. These vessels carry varying quantities of diesel fuel and are a potential source of a spill in the event of a collision or accident.

3.2 Factors relating to oil movement

The behaviour of a particular type of oil depends on the physical and chemical characteristics of the oil and the prevailing environmental considerations. As not all factors can be considered in an atlas of this size and scope, a selection of environmental conditions is discussed, including wind direction and velocity, and tidal and current movements.

Figure 10
Areas less than 5m deep, major port installations and potential oil spill sources in Port Jackson



3.2.1 Wind

Oil on open water will move more rapidly than the water directly beneath it due to the difference in friction. This will result in the oil on the leeward side of the slick becoming thicker than oil on the windward. The slick will also rapidly elongate and form windrows parallel to the wind direction. Typically this oil will move downwind at 3% of the surface wind speed, so long as there are no strong surface currents (IMO 1988). Meteorological records for surface winds in Port Jackson indicate the following general patterns:

- in summer, predominantly southerly winds to 20 km/h in the morning, swinging to north-easterly in the afternoon with gusts up to 25 km/h
- in winter, the morning wind is from the north-west at 10 km/h, swinging to southerlies up to 20 km/h in the afternoon.

3.2.2 Tidal currents

The strength and direction of tides will influence the movement of the slick in the short term. In the absence of surface winds, oil moves at the same speed as the surface current. The movement of tides is cyclical, but tidal currents rarely cancel each other out completely, allowing a net movement of the slick (IMO 1988). Because of the variety of topography, tidal velocities in estuaries vary considerably, and this is clearly demonstrated in Port Jackson. In areas where the channel is narrowed, the tidal currents increase in velocity. This is particularly noticeable at Balls Head with an ebb tide of 2 knots and a flow tide of 1.5 knots, whereas tidal flow throughout the estuary averages about 0.5 knots in either direction (RAN 1974).

3.2.3 Predicting slick movement

With information on prevailing winds and current it is possible to estimate the movement of a slick on the surface. With the wind and current acting together, the movement of the slick can be determined by using vectors, with the following simplified formula (IMO 1988):

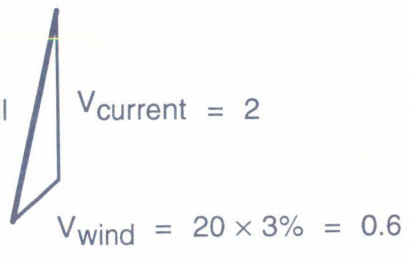
$$V_{oil} = V_{current} + (V_{wind} \times Q)$$

in which:

V_{oil} = velocity of the oil
$V_{current}$ = velocity of current
V_{wind} = velocity of wind
Q = empirically derived wind speed factor (usually 3%)

Example

$V_{current}$ = 2 km/h south
V_{wind} = 20 km/h north-east
Q = 3%



3.3 Hypothetical spills

Although it is important to understand the inter-relationship between the physical and chemical characteristics of different oils, it is impractical in the context of this atlas to predict the fate of a particular type of oil spill. In the following hypothetical spills (Figure 11) there is no attempt to differentiate between oil types and it is assumed that floating oil moves at 3% of the wind-speed and at the same speed as the surface current. Prevailing winds for specific seasonal periods have been based on 30 years of local meteorological data. The hypothetical spills are:

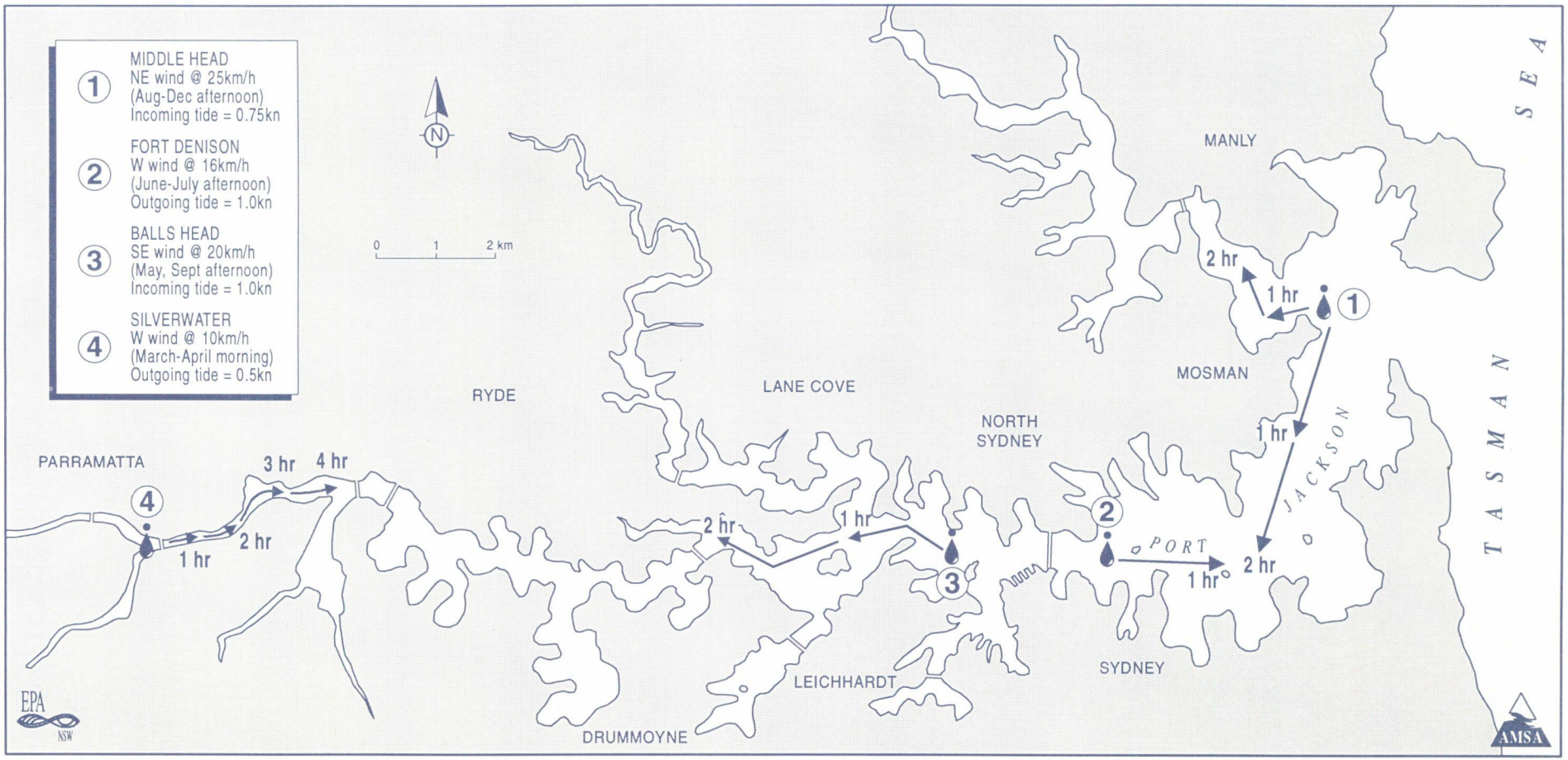
1. A tanker runs aground on Middle Head while entering Port Jackson on an afternoon between August and December. Tanks are ruptured and oil is released. The wind is blowing at 25 km/h from the north-east and there is an incoming tide of 0.75 knots (1.4 km/h). The oil is carried into Sydney Harbour and Middle Harbour. Within 2 hours, Middle Harbour as far as Clontarf Point will be covered with oil. This includes HMAS Penguin, moorings in Hunters Bay and Balmoral Beach. Within 2 hours, Sydney Harbour will be oiled as far as Bradleys Head and Point Piper. This includes nearly the whole area of the outer estuary.
2. A collision between a ferry and a large pleasure vessel occurs off Kirribilli Point on a winter afternoon. The wind is blowing from the west-south-west at 15 km/h and the tide is running out at 1 knot (1.85 km/h). A substantial amount of diesel fuel is released. Within 1–1½ hours, the majority of the headlands between Fort Denison and Bradleys Head will have been affected by oil.
3. A tanker approaching Balls Head runs aground and loses a portion of its cargo. It is an afternoon in May, September or October and there is a 20 km/h south-east wind blowing and an incoming tide of 1 knot (1.8 km/h). Within 1 hour, the oil will have reached Cockatoo Island and entered the Lane Cove River. Within 2 hours, the slick will have proceeded up the Lane Cove and Parramatta Rivers, approaching the Gladesville Bridge. Some oil will have started to move into Iron Cove.
4. On a morning in March or April, a storage tank at Silverwater ruptures and releases a substantial amount of oil into the Parramatta River. There is a 10 km/h westerly wind and an outgoing tide of 0.5 knots (1 km/h). Within 1 hour, oil will be in contact with mangroves on the northern shore of the river. Within 3 hours, the substantial areas of mangroves in Ermington Bay will be affected, and within 4 hours the oil will start to enter Homebush Bay.

4. REVIEW OF RESOURCES TO COUNTER OIL SPILLS

4.1 Introduction

As in previous atlases, no attempt is made here to duplicate existing manuals/plans to deal with an oil spill along this section of the coast. These manuals include the Operations and Procedures Manual of the National Plan,

Figure 11
Hypothetical spills in Port Jackson



the State Supplement to the National Plan, the Marine Oil Spill Action Plan (MOSAP) produced by the Australian Institute of Petroleum, and the Maritime Services Board's 'Oil Stop' Manual. This atlas seeks to complement those documents by providing information about environmentally sensitive areas and posing clear and unequivocal guidelines on countermeasures to protect resources.

4.2 Oil and its behaviour

Because of their different physical and chemical composition, different types of oil vary in behaviour and toxicity. As a result, different countermeasures are often required. The characteristics of the petroleum products commonly shipped in Australian waters are outlined in Table 1.

4.3 Countermeasures

Once a spill has occurred, five countermeasure options are normally available:

1. do nothing but monitor
2. contain and recover the oil close to its source
3. deploy booms defensively
4. use dispersants
5. undertake shoreline clean-up.

4.3.1 Do nothing but monitor

The first option, to do nothing but monitor, would only be resorted to if the oil is highly volatile, of no great volume, some distance from shore, or not expected to threaten sensitive resources. If a decision is made to allow the oil to degrade naturally, it is important to monitor the slick to ensure it does not change direction and move towards shore or sensitive resources.

Generally this option is not recommended in Port Jackson because of the proximity of resources to potential spill sites. However, saltmarsh, mangroves and Aboriginal heritage sites should be left alone to recover naturally after oiling, as clean-up operations may cause more damage than the oil itself.

In the case of spilt petrol, naphtha, kerosene and other volatile refined products, containment should never be attempted, as the risk of fire and explosion is far too great. These products should be allowed to disperse and evaporate naturally.

4.3.2 Contain and recover

Successful handling of spills of heavier oils requires initial containment by booms, followed by the use of skimmers and other collecting devices to remove it. Generally this is the preferred option for a spill in Port Jackson, as recovering oil means that it can be recycled and it also minimises the effect on vulnerable environments and the amount of oiled debris for disposal.

The success of a recovery operation at sea after a major spill will depend on sea conditions and currents, the speed at which response vessels can reach the spill site and the presence of aerial support. Because oil spreads rapidly after the initial release, the number of locations with high concentrations of oil decreases over time. Although booms are capable of containing oil under specific conditions, strong wave action will carry oil over the booms and strong currents or high

Table 1
Petroleum products commonly shipped in Australian waters
Characteristics and effective clean-up techniques

Characteristic	Minas Crude	Arab Crude	Bass St Crude	Barrow Is Crude	Kafji Crude	Saladin Crude	Bac Ho Crude	Kutubu Crude	LAR	Heating Oil	Fuel Oil	Diesel Oil	Jet Fuel	Kerosene
Hazardous (Vapours)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes
Evaporation 100%	No	No	No	No	No	No	No	No	No	Yes	No	Yes	Yes	Yes
Containment Boom	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Physical Removal	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No
Absorbent	No	Yes	Yes	Yes	—	Yes	No	—	Yes	No	Yes	Yes	No	No
Dispersant	No	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes[†]	Yes	No	No
Persistent	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No
Flash Point°C	<15	<15	<15	<15	N/A	N/A	15	N/A	>70	70	>70	70	39	40
Specific Gravity at 15°C	0.85	0.85	0.80	0.84	0.85–0.95	0.787	0.826	0.805	0.95	0.82	0.94	0.84	0.80	0.80
Viscosity cSt. at 15°C	—	10.5	—	3.1	25	1.9	22	2.5	—	2.9	0.65	5.0	1.6	1.6
Pour Point	36	–27	18	–33	12	–30	33	6	15	–18	15	–9	–18	< –18

[†] dispersant is effective on light fuel oils

Modified from McEnally & Thompson (1989), Department of Transport (1990) and MSB Sydney Ports Authority (1993).

towing speeds can lead to oil passing under the booms. It is difficult to deploy booms in strong tidal flows or in open water where there is a heavy ground swell. Nor can booms contain oil against water velocities much in excess of 1 knot acting at right angles to the boom (IMO 1988). However, they could be effective in Port Jackson, to contain oil or to divert it away from sensitive resources, so long as the booms are protected from heavy swell conditions.

Booms can also be used to contain oil against the shoreline if the spill has come ashore. This will stop the oil from moving to other areas, and concentrate the oil for collection.

The Sydney Ports Authority, in conjunction with the Australian Maritime Safety Authority and the petroleum industry have stockpiles of equipment in Port Jackson and Port Botany. The Sydney Ports Authority has 2,765 metres of containment boom available for immediate deployment, and an additional 2,700 metres can be relocated to Port Jackson at short notice. A combined mechanical recovery rated capacity of 115 cubic metres per hour is also available from this stockpile (C. Allsop, Sydney Ports Authority, pers. comm.). The Royal Australian Navy has 500 metres of boom, and stockpiles of absorbent booms and pads at Garden Island, where there is also a variety of combat equipment and trained personnel. No marinas or councils within the study area have booms or skimmers available.

4.3.3 Dispersant use

If containment and recovery are impractical, it may be appropriate to use dispersants on spills of lighter crude oil or light-to-medium fuel oil. Dispersants could be very effective in breaking up an offshore oil spill that is threatening the coast or the outer reaches of Port Jackson. However, dispersant would not work on most of the refinery feedstock imported to Sydney and the only option available would be to contain and recover (C. Allsop, Sydney Ports Authority, pers. comm.).

The spraying of dispersant must begin as soon as it is decided that mechanical containment is impractical. The best chance of success with dispersants will be before the oil has spread or weathered. The possibility of the early formation of viscous, undispersable water in oil emulsions (mousse) means that if dispersants are to be used they should be applied within 24 hours of the spill. Particular attention should be given to the aerial application of dispersant from helicopters, but care should be exercised when spraying in areas of abundant bird life (SPCC 1982).

Dispersants and spraying equipment are stored at Port Jackson and Botany Bay and two helicopter spray buckets are stored at Moores Wharf in Port Jackson. The nearest airport is at Mascot (Kingsford Smith Airport), which could be used for aerial surveillance of a spill, but a temporary helicopter base would have to be established nearer the spill due to restrictions on helicopters carrying underslung loads over residential areas.

Dispersants, however, do not actually remove oil from water, but break it into fine droplets which become suspended in the water column. These tiny droplets can reach greater depths than the undispersed oil and may pose a greater threat

to marine life. Consequently, dispersants should not be used in shallow waters. The State Pollution Control Commission (1981) recommends that dispersants should not be used in water less than 5 metres deep.

In Port Jackson, the 5 metre bathometric line is close to the shore in the outer estuary, while in the upper reaches there are extensive areas that are shallower than 5 metres (Figure 10). Extreme care should be exercised in these areas and dispersant should not be used. Accurate depths may be obtained from appropriate hydrographic charts. Dispersant use is also not recommended in the North Harbour Aquatic Reserve, as the reserve was established to protect seabed resources and the use of dispersant may bring these resources into contact with the dispersed oil.

4.3.4 Defensive boom deployment

As with the use of booms at sea, current speed and wave action make it difficult to deploy booms defensively (to deflect oil away from sensitive resources) in the exposed waters of the estuary. Defensive booming using angled booms in sheltered waters may overcome some of these problems. The main channels in Port Jackson are characterised by high tidal velocities, generally too strong for boom use. However, many of the bays and creeks in the upper estuary could be protected by booms (Figure 12).

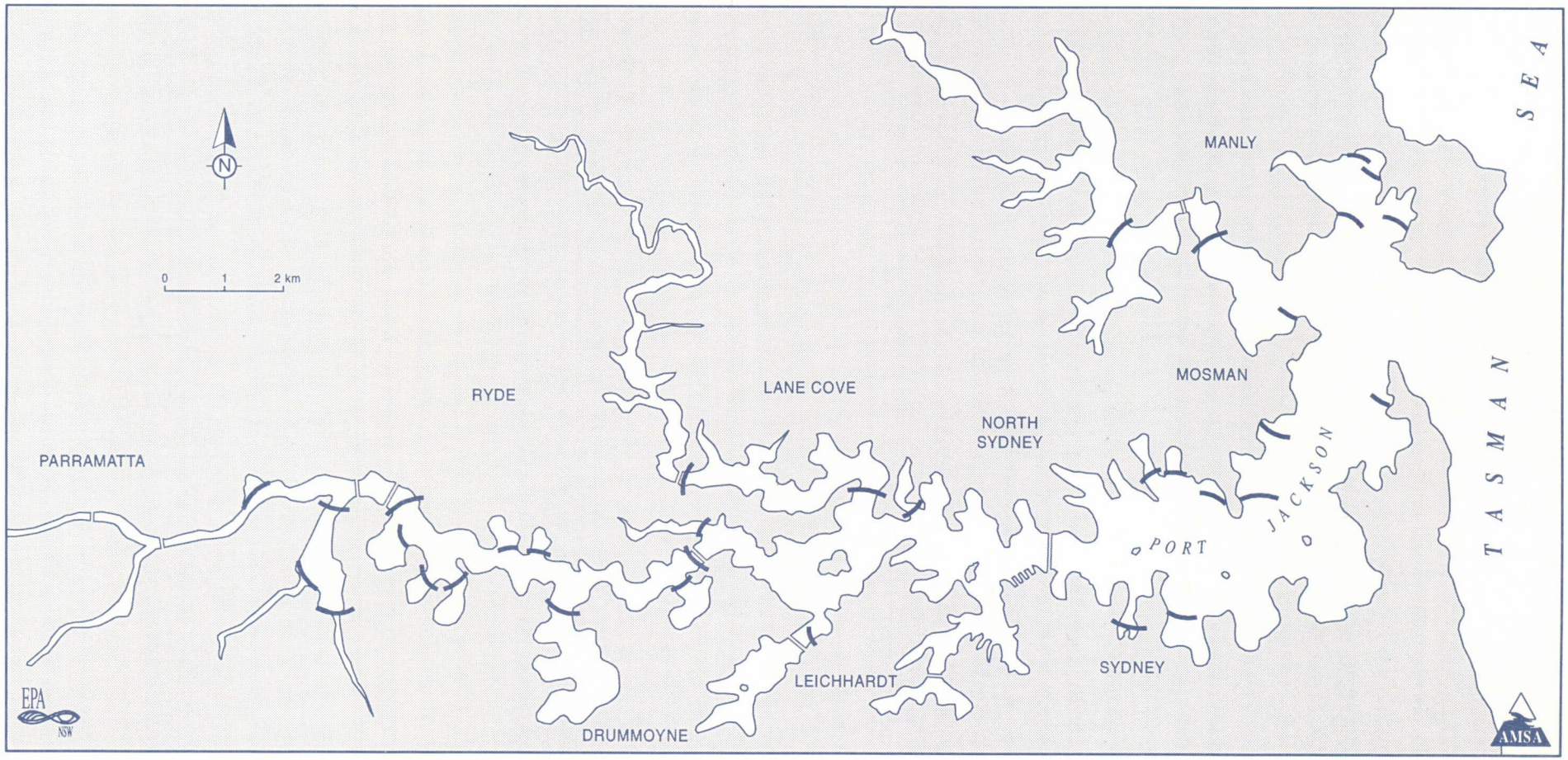
Detailed information on the placement and operation of booms is beyond the scope of this report, but a number of points are important to ensure their effectiveness in protecting environmentally sensitive resources:

- Booms must be deployed without delay. Oil may reach sensitive areas in a matter of hours after a spill. The booms must be in place before the oil arrives.
- Successful deployment requires careful planning, preselection of booming locations, and perhaps construction of permanent mooring points.
- Except in ideal conditions, some oil will escape past the booms, and in bad weather the booms may fail completely. Once oil passes the booms, absorbent material may be used to minimise impact on sensitive resources.
- Successful deployment will require suitable boats, communications and well-trained and experienced personnel.
- It is essential that equipment is provided to skim and pump the collected oil, and that the oil is subsequently stored, transported and disposed of in an environmentally approved manner.

4.3.5 Shoreline clean-up

Once an oil slick has been stranded on the shore, there is little need for urgent action, provided that tidal and meteorological conditions are unlikely to relocate oil to other areas. However, prompt clean-up action on sandy beaches can avoid the complication of oiled sand being buried by natural sand deposition. Shoreline clean-up procedures depend on the type of shoreline, the condition of the oil when it reaches the shore, and the quantity of oil. The On-Scene Coordinator, in consultation with the Scientific Support Coordinator if appropriate, should have ample time to consider the clean-up operations, using guidelines set down in the

Figure 12
Possible locations for defensive booms



MSB Sydney Ports Authority Port Jackson Oil Spill Contingency Plan (1993), the Operations and Procedures Manual of the National Plan to Combat Pollution of the Sea by Oil (AMSA 1992), the NSW State Supplement to the Manual (Department of Transport 1992), and by the State Pollution Control Commission (1981), the Australian Maritime Safety Authority and International Tanker Owners' Pollution Federation Ltd (1983).

The local councils have heavy earth-moving equipment available for oil spill clean-up strategically located throughout the region (Table 2). The use of heavy machinery in clean-up operations must be supervised to reduce or minimise damage to beach and dune habitats. Careless traffic movements may cause damage to dune vegetation, rare birds or heritage items. Particularly vulnerable areas include the beaches in the Sydney Harbour National Park.

Table 2
Locations of heavy earth-moving equipment

Council	Depot Location	Council	Depot Location
Manly	Balgowlah	Auburn	Auburn
Willoughby	Artarmon	Concord	Concord
Mosman	Mosman	Drummoyne	Five Dock
North Sydney	Cammeray	Leichhardt	Balmain
Lane Cove	Lane Cove	City of Sydney	*see* South Sydney†
Hunters Hill	Hunters Hill	South Sydney	Waterloo
Ryde	North Ryde	Woollahra	Double Bay
Parramatta	East Parramatta		

† City of Sydney and South Sydney Councils currently share facilities

4.4 Constraints

4.4.1 Operational constraints

There are several constraints facing a clean-up operation in this region.

Owing to the high population density throughout the region and the importance of the estuary for recreation, there will be considerable political and public pressure for a rapid and successful clean-up operation. This may tend to exert pressure to 'over-clean' a resource, and makes it hard to leave some areas to clean themselves. This problem will need to be addressed on an incident-by-incident basis.

Access to many areas in the estuary is restricted by private property and housing encroaching on the shoreline. Access to a spill that comes ashore in a National Park in the area may be limited to service trails. The presence of culturally and environmentally important resources throughout the parks means that the National Parks and Wildlife Service should be consulted to ensure that countermeasures comply with their Plans of Management for the parks and

reserves under their jurisdiction. Access to land controlled by the armed forces, particularly the Newington Arms Depot, will also require negotiation with relevant departments.

4.4.2 Oiled wildlife

In most spills there is a possibility that animals will come into contact with the floating or stranded oil. Most animals need treatment to remove the oil as they cannot clean themselves adequately or rapidly enough to ensure survival. Self-cleaning also contributes to ingestion of oil. In any case where oiled wildlife is found during a clean-up operation, the Scientific Support Coordinator should be advised and there are several organisations that can be called in to coordinate the cleaning and rehabilitation of oiled animals.

National Parks and Wildlife Service
Sydney District
Greycliffe House
Vaucluse 2250.

Wildlife Division
Taronga Zoo
Mosman 2088.

5. BIBLIOGRAPHY

Adam, P. 1984. *Towards a Wetlands Conservation Strategy*. Wetlands (Australia), 4;2. pp. 33–48.

Attenbrow, V. 1991. *Port Jackson Archæological Project: A Study of the Prehistory of the Port Jackson Catchment, New South Wales*. 'Stage 1—Site Recording and Site Assessment'. Australian Aboriginal Studies, No. 2, pp. 40–55.

AMSA (Australian Maritime Safety Authority) 1992. *National Plan to Combat Pollution of the Sea by Oil: Operations and Procedures Manual.*

ANZECC 1992. *Australian Water Quality Guidelines for Fresh and Marine Waters*. National Water Quality Management Strategy. Australian and New Zealand Environment and Conservation Council.

CAMBA 1988. Agreement Between the Government of Australia and the Government of The People's Republic of China for the Protection of Migratory Birds and their Environment. Treaty Series 1988 No. 22. Department of Foreign Affairs and Trade, Canberra.

Department of Transport 1992. *NSW State Supplement to the National Plan to Combat Pollution of the Sea by Oil*. NSW Department of Transport.

Federal Publishing 1988. *Sydney's Top Fishing Spots*. The Federal Publishing Company, Sydney.

Henry, G.W. 1984. 'Commercial and Recreational Fishing in a Sydney Estuary'. *Fisheries Bulletin 1*. NSW Department of Agriculture.

IMO (International Maritime Organisation) 1988. *Manual on Oil Pollution*, Section IV: 'Combating Oil Spills'. International Maritime Organisation, London.

International Tanker Owners' Pollution Federation Ltd 1983. *Shoreline Clean-Up*. Technical Information Paper No. 7.

JAMBA 1981. Agreement Between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment. Treaty Series 1981, No. 6. Department of Foreign Affairs, Canberra.

Lucas, A. 1989. *New South Wales Boat Launching Ramp Atlas*. Horwitz Grahame, Sydney.

McEnally, J.M. & G.B. Thompson 1989, 'Sensitivity Planning'. *Proceedings of the Australian National Oil Spill Conference*. Melbourne, 7–9 October 1987.

McIntyre, A.D. 1983. *Oil Pollution and Fisheries*. Phil. Trans R. Soc. Lond. B 297, pp. 401–411.

Morris, A.K. 1986. 'Birds of Sydney Harbour National Park'. *Australian Birds* 20: pp. 65–81.

Morris, A.K., V. Tyler, M. Tyler, H. Mannes & J. Dalby 1990. 'A Waterbird Survey of the Parramatta River Wetlands'. *Australian Birds* 23: pp. 44–64.

MSB (Maritime Services Board) 1989. *Foreshore Quality Assessment and Definition of Development Control Classes*. Maritime Services Board of NSW.

MSB Sydney Ports Authority 1993. *Port Jackson Oil Spill Contingency Plan* (Draft).

NPWS (National Parks and Wildlife Service) 1982. *Nielsen Park, Sydney Harbour National Park*. National Parks and Wildlife Service, Sydney.

NSW Fisheries 1991. *NSW Fisheries Annual Report, 1990–91*. NSW Government.

NSW Government 1992. *Estuary Management Manual* (Draft).

RAN (Royal Australian Navy) 1974. *Port Jackson, New South Wales*. Hydrographic Chart Aus. 200. Royal Australian Navy Hydrographic Service.

Sainty, G. & S. Jacobs 1986. *Wetland Plants*. Water Resources Commission.

Smith, P. 1992. *Biology and Management of Waders (Suborder* Charadrii*) in New South Wales*. Species Management Report No. 10, NSW National Parks and Wildlife Service.

SPCC 1981. *Guidelines for Controlling Oil Spills in Maritime Waters of New South Wales*. State Pollution Control Commission, Sydney.

SPCC 1982. *Aerial Application of Dispersants in Botany Bay*. State Pollution Control Commission, Sydney.

Strahan, R. (Ed.) 1983. *The Australian Museum Complete Book of Australian Mammals*. Angus and Robertson, Sydney.

Thompson, G.B. & J.M. McEnally 1985. *Coastal Resource Atlas for Oil Spills in Port Jackson*. State Pollution Control Commission, Sydney.

Walraven, E. 1992. *Rescue and Rehabilitation of Oiled Birds: Field Manual*. Zoological Parks Board of New South Wales, Australia.

West, R.J, C.A. Thorogood, T.R. Walford & R.J. Williams 1985. *An Estuarine Inventory for New South Wales, Australia*. Fisheries Bulletin 2. Department of Agriculture, New South Wales.

APPENDIXES

Appendix 1

NSW Birds protected by JAMBA, CAMBA and/or Schedule 12 of the National Parks and Wildlife Act 1974, and unprotected species discussed in text

Common Name	Species	Status
Little penguin	*Eudyptula minor*	—
Great egret	*Egretta alba*	J,C
Australian pelican	*Pelecanus conspicillatus*	—
Black cormorant	*Phalacrocorax carbo*	—
Little pied cormorant	*Phalacrocorax melanoleucos*	—
Little black cormorant	*Phalacrocorax sulcirostris*	—
Pied cormorant	*Phalacrocorax varius*	—
Pacific golden plover	*Pluvialis dominica*	J,C
Grey plover	*Pluvialis squatarola*	J,C
Mongolian plover	*Charadrius mongolus*	J,C,12B
Ruddy turnstone	*Arenaria interpres*	J,C
Whimbrel	*Numenius phæopus*	J,C
Eastern curlew	*Numenius madagascariensis*	J,C
Bar-tailed godwit	*Limosa lapponica*	J,C
Sharp-tailed sandpiper	*Calidris acuminata*	J
Sanderling	*Calidris alba*	J,C
Curlew sandpiper	*Calidris ferruginea*	J,C
Red-necked stint	*Calidris ruficollis*	J,C
Broad-billed sandpiper	*Limcola falcinellus*	J,C,12B
Pied oystercatcher	*Hæmatopus longirostris*	12B
Grey-tailed tattler	*Tringa brevipes*	J,C
Common sandpiper	*Tringa hypoleucos*	—
Bush stone curlew/ bush thick-knee	*Burhinus magnirostris*	12A

J = Birds protected under JAMBA
C = Birds protected under CAMBA
— = Birds not listed
12A = Threatened Fauna under Schedule 12
12B = Vulnerable and Rare Fauna under Schedule 12

Appendix 2

Scientific names of mammals, reptiles and fish referred to in text

Mammals	
Humpback Whales	*Megaptera novæanglaise*
Southern Right Whales	*Eubalæna glacialis*
Australian Fur Seal	*Arctocephalus pusillus*
Leopard Seal	*Hydrurga leptonyx*
Crabeater Seal	*Lobodon carcinophagus*
Dolphins	*Family Delphinidæ*
Reptiles	
Green Turtles	*Chelonia mydas*
Loggerhead Turtles	*Caretta caretta*
Fish	
Snapper	*Pagrus auratus*
Tailor	*Pomatomus saltator*
Yellowtail	*Trachurus novæzelandiæ*
Invertebrates	
Crayfish	*Jasus verrauxi* (main species)
Abalone	*Haliotis* species
Blue Swimmer Crab	*Portunus pelagicus*
Mudcrab	*Scylla serrata*

Appendix 3

Shipping movements in Port Jackson *(March 1992 – March 1993)*

Ship Type	Total	L.O.A. (metres)	Bunker Capacity (tonnes)	Cargo Capacity (tonnes)
Container	73	150–190	1,500–3,000	N/A
General Cargo	222	90–190	300–3000	N/A
Roll on-Roll off	157	140–260	500–650	N/A
Vehicle	103	140–190	1,200–2,000	N/A
Oil Tankers†	312	100–260	300–3,300	6,000–140,000
Chemical Tankers	33	100–160	300–2,800	6,000–31,000
Gas Tankers	1	100–150	300–1,500	6,000–13,000
Total	**901**			

† There are 63 oil tankers over 200m L.O.A. berthed in Port Jackson. Due to draft restrictions, the maximum capacity these vessels may carry is approximately 90,000 tonnes.

from MSB Sydney Ports Authority Records (unpublished)

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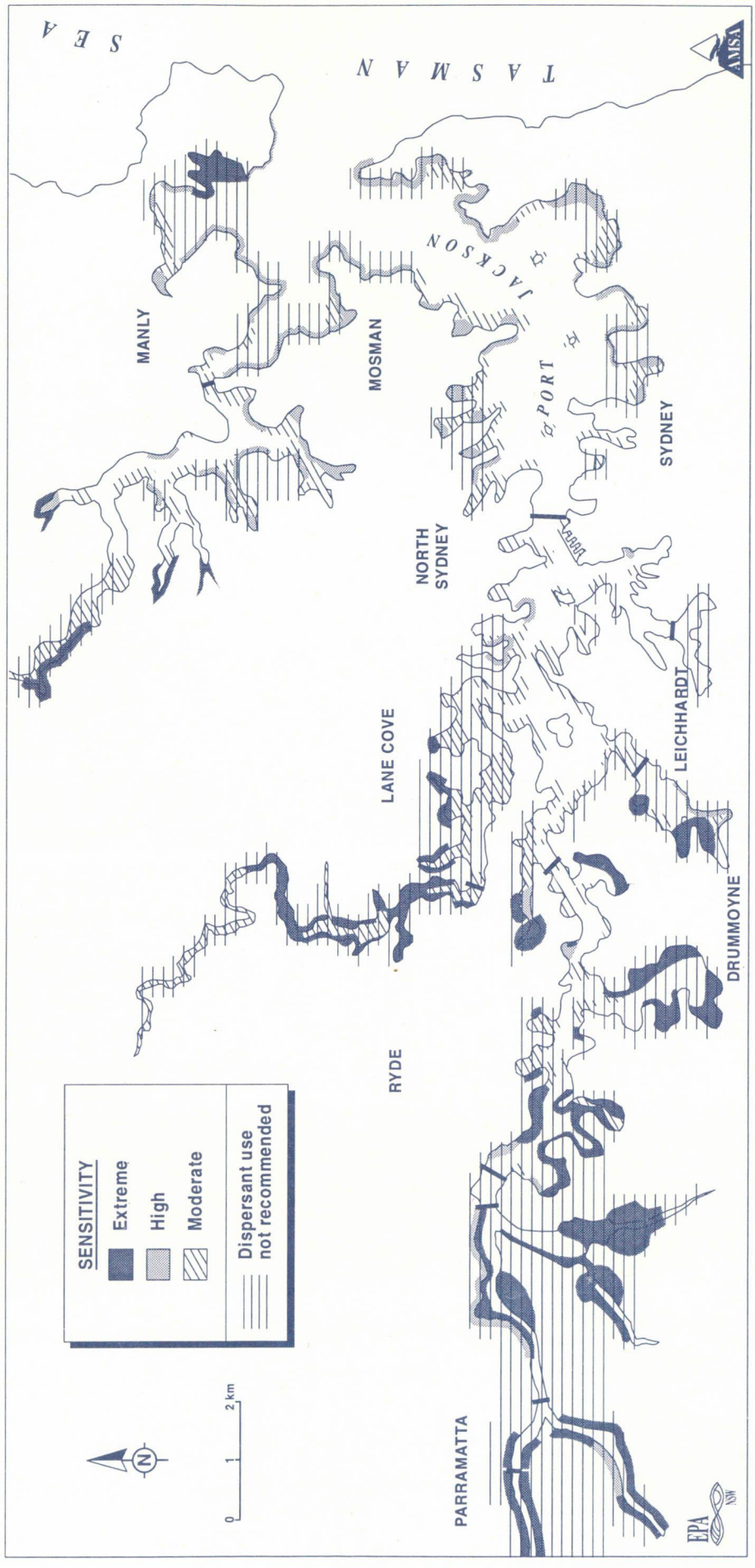

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