14.1 Background

Alcan Gove's operations interact with the marine environment principally through the discharge from the refinery outfall, rainfall runoff from the refinery, and through shipping activities that involve both import and export of materials. The latter have little known impact on the marine environment at Gove, but there is a risk to the marine environment through the potential for spills of oil and cargo.

14.2 Monitoring Programs

Alcan Gove has commissioned a number of marine habitat monitoring programs, in some cases incorporating repetitive surveys over a number of years, focussing on sites of identified or potential impact. More general surveys of marine habitats and biota have also been undertaken.

An overview of the major surveys undertaken is given below.

14.2.1 Refinery Outfall

A survey of the marine benthic invertebrates of Gove Harbour in the vicinity of the refinery outfall was undertaken in 1991 (Hanley, 1993) as part a survey of water, sediment and biota undertaken in conjunction with McConchie and Saenger (1993). This survey assessed the diversity and abundance of marine benthic invertebrates both in Gove Harbour and at a number of reference sites. The objective was to identify the marine habitats and benthic (bottom dwelling) biota adjacent to the refinery outfall. Follow-up surveys were undertaken in 2000 and 2002 (URS, 2001a and 2003b) to assess the extent of change to the benthic biota and the effects of the outfall discharge. The results of these surveys are summarised in Section 14.3.2.1.

14.2.2 Northern Beach

A survey of the marine and intertidal biota in and adjacent to the beach along the northern side of the refinery was undertaken in 1995 (LDM, 1995) to assess the effects of groundwater seepage in that area. A follow-up survey was undertaken in 2000 (URS, 2001c) approximately five years after the commencement of a groundwater recovery program, to assess the effectiveness of the recovery program. The survey report concluded that there was no significant impact to marine biota in the area.

14.2.3 Drimmie Arm

In April 1999, as a result of extremely heavy rainfall, the bund wall was breached to allow the controlled release of stored water from a water treatment storage pond at the Residue Disposal Area (RDA) into Drimmie Arm. Water sediment and biota surveys of the affected area were undertaken to monitor the affects on marine biota (LDM, 2000). A follow-up survey was undertaken by in 2000 (URS, 2001e). The survey found that there had been a recovery of the benthic organisms and that this recovery would continue.

14.2.4 Introduced Marine Species

The potential presence of introduced marine species at Gove was investigated in 2001 by a port species baseline survey conducted in accordance with the sampling protocols required by the Australian Quarantine Inspection Service (AQIS) Seaports Program. The study sampled a large number of marine fish and invertebrates occurring in

the vicinity of the port, adding significantly to the knowledge of native marine plants and animals occurring at Gove (CRC et al, 2003).

14.2.5 Habitat surveys

General marine habitat surveys were undertaken in 1999 (LDM, 1999) as part of the development of a marine oil spill risk assessment and management plan (GOVE PLAN).

Surveys of mangrove habitats were undertaken at Macassar Creek to assess areas that may have been affected by the existing RDA pond system (LDM, 2000b), and at No Name Bay to describe mangrove communities prior to the construction of Pond 7 and upgrade of Pond 6 (LDM, 2000c).

A more extensive survey of the intertidal and subtidal marine habitats of the Gove Peninsula was undertaken in 2002 as part of the program to acquiring background data for use in this EIS for areas that had not previously been surveyed (URS, 2003a). The results are summarised in Section 14.3.2.

14.3 Existing Environment

14.3.1 Regional Influences and Marine Biogeography

14.3.1.1 Biogeography

Melville Bay is situated in the northern Australia tropical zone and is part of the complex coastline within the Groote biogeographic region, which encompasses a myriad of bays, inlets, rivers and islands from Cape Wilberforce to Nyinpinti Point along the north-east Arnhem Land coast (Figure 14.3.1). The biogeographic region is composed of a cluster of interacting ecosystems that occur repeatedly along the coast. It represents a core faunal zone traversed by a large suite of tropical Indo-West Pacific fishes.

The climate of the region is described as monsoon tropical (Section 11.1). No major rivers discharge in the region. An internal clockwise current dominates ocean circulation in the Gulf of Carpentaria. Prolonged north-westerly monsoonal winds can reverse this current in the wet season. High turbidity in inshore waters is common due to the presence of fine sediments, strong winds and shallow waters. Tidal range is meso-tidal, with a 2-3 m variation.

14.3.1.2 Regional Habitats

The net effect of the patterns of marine biogeography is that species in the Gove area are generally distributed for thousands of kilometres along the northern Australian coastline, and into countries to the north such as Indonesia, Papua New Guinea and the Philippines (Wells, 1990). Some species occur widely across the entire Indo-West Pacific. Relatively few species have restricted ranges, and those that do are on the scale of tens or hundreds of kilometres.

Figure 14.3.1 shows the distribution of marine habitats in Melville Bay. The most biologically productive habitats are the mangroves and their associated biota, followed by the coral reefs and the shallow subtidal and low intertidal flats, which support seagrass beds and a rich community of burrowing animals. Compared to the northern part of Melville Bay, the southern part appears to contain a greater proportion of the more biologically productive and fish nursery habitats (i.e. mangrove forests and seagrass beds).

14.3.1.3 Regional Seabird Sites

A study of seabird breeding colonies in the Northern Territory recorded regionally important seabird breeding sites on Higginson Islet, a series of small rocky islets 8 km north-east of Bremer Island. It supports breeding colonies of many thousands of Bridled Tern, Crested Tern and Roseate Tern and several hundred Common Noddy. It is considered to be an extremely significant seabird colony and probably the most important in the Northern Territory (Chatto, 2001). This site lies approximately 30 km offshore from Gove and is not affected by the Alcan operations. Two other identified breeding sites, one site within Melville Bay (Granite Islands) and another just north of Melville Bay were not considered to be of regional significance (Chatto, 2001).

Important shorebird sites in the north-east Arnhem Land area have been identified in the Cadell Straits, Buckingham Bay, Arnhem Bay and Blue Mud Bay (Chatto 2003). The diversity and abundance of shorebirds (migratory and resident) observed during the November 2002 intertidal survey suggested that Gove Peninsula does not contain any sites that are of particular ecological significance to migratory shorebirds. This conclusion is supported by a study of the distribution and status of shorebirds of the Northern Territory coast (Chatto, 2003). That study did not identify Gove Peninsula or Melville Bay as important areas within the North-East Arnhem Land coastal block.

14.3.2 Southern Melville Bay

For descriptive purposes, the marine habitats present in southern Melville Bay in the vicinity of Gove Peninsula have been classified into subtidal and intertidal habitats.

A summary description of each of the habitats is described below, while the distribution of habitats is shown in Figures 14.3.2 – 14.3.6. Also discussed below are the threatened and migratory species within southern Melville Bay.

14.3.2.1 Subtidal Habitats

The subtidal marine habitats of the Melville Bay study area comprise basin silts, shallow sandy seafloor, seagrass meadows and coral reefs.

Soft Seafloor (Basin) Sediments

The deeper parts of the subtidal seafloor within Melville Bay largely comprise soft sediments (fine sands, silts and clays) that typically become coarser as the seafloor shallows before grading into the lower intertidal habitats. Rock stacks and small islets punctuate the seabed in a number of locations (e.g. Harbour Islet, Woody Islet and The Granites). South-east of Dundas Point, at the southern end of Melville Bay, the maximum depth is typically less than 10 m. North-west of Dundas Point the seafloor deepens to approximately 20 m.

The fauna of the soft sediments comprises predominantly polychaete worms, small holothurians (“sea cucumbers”) and ophiuroids (“brittle stars”). Bivalve molluscs, crabs and amphipods (small crustaceans) were present at some sites sampled around the peninsula.

Basin sediments, which comprise the largest habitat area in southern Melville Bay, are generally considered unaffected by human activity, with the exception of an area of approximately 120 ha in northern Gove Harbour centred around the refinery outfall discharge (Section 13.5.1), in the vicinity of the shipping berths, and at the small boat moorings in Inverell Bay.

Sandy seabeds

Sandy seabed typically occurs in the shallow water immediately below the low tide line, other than where it is replaced by outcropping rocky shore, such as occurs at Wargarpunda Point and Rocky Point. On exposed shorelines, such as occur at Northern Beach, the sediments are comprised of medium to coarse sands. In sheltered bays, the sediments are typically finer, with a higher proportion of fine sand and silt.

Along the majority of Northern Beach, rippled sands occur between the beach and most shoreward reef line. Typically 20-60 m wide, the sand sheet supports low, sparse and patchy cover of macroalgae, dominated by *Sargassum* with *Caulerpa*, *Colpomenia* and *Padina*, which are typically anchored to rock underlying the sand. Further offshore, between lines of reef, the sand sheet is mostly bare except for scattered algae, typically species of *Udotea*, *Caulerpa* and *Halimeda*, which are able to anchor in sand. Beyond the reef lines, the sediments typically become finer with increasing distance from shore, forming a generally flat, featureless sand sheet with patchy bioturbation. The sandier sediments have a higher abundance than do the finer sediments of benthic fauna, predominantly polychaete worms, bivalves, crustaceans and echinoderms. Similar sediment/fauna relationships are evident at sites at Wallaby Beach, East Woody Island, and off West Beach.

In northern Gove Harbour, the shallow seafloor on the western and northern side is generally comprised of medium to coarse sands that become finer and more highly bioturbated in the eastern portion (Wanaka Bay and Inverell Bay). A similar benthic fauna to that described above is present.

At the northern end of Drimmie Arm, sediments are predominantly mixed sands with a silty veneer where the dominant fauna are bivalve mussels. Polychaete worms, crustaceans, gastropod molluscs and echinoderms (ophiuroids and holothurians) are also common. Southwards, the sediments are finer and dominated by silt and clay, with the exception of the western side where fine to coarse mixed sands predominate or the silt/clay veneer is thinner. Benthic fauna abundances are variable and typically lower in silt/clay sediments than in the coarser sediments.

Sediment characteristics vary markedly within No Name Bay, reflecting the thickness of the silt/clay veneer over fine and medium sands. The abundance of benthic fauna is similar to that at Drimmie Arm. The veneer is generally thinner at the northerly sites and fauna abundances, predominantly bivalves and polychaetes, are higher. The south-eastern shoreline of No Name Bay has little silt or clay. Here the sediments are principally medium to coarse sands combined with dead shells and shell fragments, with polychaetes the dominant fauna.

Shallow sandy seafloor habitat and its associated flora and fauna is found fringing most of the mainland and island shorelines of Melville Bay and adjacent Arnhem Land coast. It is widespread and not under threat within the region.

Seagrass

Meadows of *Enhalus* seagrass, such as those in No Name Bay, are typically found in shallow estuarine areas of the wet tropics of northern Australia and the central Indo-West Pacific region. Other seagrass species found in southern Melville Bay are also common in many subtidal areas across tropical northern Australia.

The densest and most developed seagrass meadows known in south-eastern Melville Bay are those located in the northern part of No Name Bay. These are meadows of *Enhalus acoroides* that occur fringing the rim of the shallow basin and smaller clumps that occur within the basin itself. *Enhalus* beds typically occur just beneath the low spring water tide level, revealing their leaves during most low tides.

Less-dense but more extensive *Enhalus* beds occur around the southern rim of the Bay, in North Creek Bay and on the western side of the entrance channel to the Giddy River, while patchy clumps have also been found along the north-west side of Drimmie Arm.

Patchy meadows of *Halophila* species are present in several areas. *Halophila decipiens* has been recorded fringing the *Enhalus* meadows in No Name Bay, in small beds to south and west of Dundas Point, and in Gove Harbour where they are found to the north-east of Harbour Islet, on the north-eastern sides of Wanaka Bay, and in Inverell Bay. It is also found in parts of Drimmie Arm and off Knoll Island and Dolphin Rocks. Increased turbidity in Gove Harbour and southern Melville Bay appears to restrict *Halophila* to depths that are 0-3 m below the mean low water spring tide level.

The oval-leafed species *Halophila ovalis* and *H. ovata* are occasionally present in the Dundas Point meadows. Patchy but well developed *H. ovalis* has also been recorded on sandy substrates in 3-7 m depths in the channel east of West Woody Island and between Wagarpunda Point and Wallaby Beach.

A thin-leafed *Halodule* species (the narrow form of *H. uninervis* and/or *H. pininifolia*) is found in small patches to the north-east of the main harbour jetty. A small patchy meadow mixed with *Halophila decipiens* has also been found off the west side of Rocky Point.

No survey of seagrass distribution has been undertaken in Melville Bay to the north of the Gove Peninsula.

Seagrasses also provide food and habitat for a range of other species. The leaves of *Enhalus* are not readily digestible but due to their longevity and clumping form they provide sheltered nursery areas and food items for juvenile tiger prawns (*Panaeus semisulcatus*), swimming crabs (Portunidae) and small fish (Vance et al, 1994). The leaves and rhizomes of *Halophila* species provide important food resources for green turtles (*Chelonia mydas*) and dugongs (*Dugong dugon*) (Aragones & Marsh, 2000). A pair (cow and calf) of dugong that was sighted feeding on isolated patches off West Beach in approximately 5 m of water in July 2002 appeared to have been targeting the *Halophila* present in that area.

All of the species of seagrass present in southern Melville Bay occur widely, although patchily distributed, throughout northern Australian coastal waters, wherever suitable habitat is present. The seagrasses are recognised for their important contribution as food and habitat for other marine species, but are not considered to be under threat in the region.

Coral

About the Gove Peninsula, coral reefs and coral encrusted rock have been identified around West Woody Island and the rock outcrops to the south, around Wargarpunda Point, in the shallow and deeper waters offshore Northern Beach, fringing Wallaby Rocks and the rocky point to the north-east, around Harbour Islet and Rocky Point in Gove Harbour, and fringing The Granites.

Within Gove Harbour the main coral communities are those that fringe The Granites. These are predominantly comprised of branching and tabulate *Acropora* colonies, with *Porites*, faviids, *Turbinaria* and *Montipora* commonly occurring. In northern Gove Harbour corals are found around Harbour Islet and Rocky Point but abundance is limited by frequent high turbidity and the corals most commonly encountered are scattered small colonies on rock substrates. No true reef is developed.

The most diverse and extensive coral communities found around the Gove Peninsula are those occurring along the northern side of the peninsula. In the shallowest waters, coral cover is limited by wave action and exposure during low tides. Coral communities in exposed areas are dominated by faviids (*Goniastrea*, and *Favites*, etc.) and sheets of encrusted *Montipora*, but cover is limited to 10-20%. Where reef tops are sheltered from wave action, such as on the leeward side of islands, reef tops are extensively dominated by corymbose, low branching and tabulate colonies of *Acropora*, such as *A. cytherea* and *A. hyacinthus*, providing 90-100% live coral cover over large areas. Slightly deeper but more exposed areas commonly have 50% or more cover of sub-massive *Porites*, *Lobophyllia* and faviid colonies. These are typically found at locations more exposed to wave action, such as around West Woody Island,

Wargarpunda Point, Wallaby Rocks and the point between Wallaby Rocks and East Woody Island, where the more fragile *Acropora* species are unable to become established.

On the tops of deeper reef lines and boulders, coral cover is reduced (30 to 50% cover) due to greater exposure to wave action. *Acropora* species still dominate, while the deeper water allows them to take taller and more branching forms (eg. *A. nobilis*, *A. formosa*). *Acropora* tend to become less dominant on reef and boulder slopes at greater depths.

On the lower reef and boulder slopes, filter-feeding species that require less light and are more tolerant of high sediment loads are common. These include the sponges, soft corals (*Sarcophyton, Lobophyton, Sinularia, Nephthea Dendronephthya*) and gorgonians.

Coral "bommies" up to 2 m in diameter can occur in some locations off the reef edges, generally as singular-domed colonies of *Porites.* These often rise above the spring low tide level, where burrowing *Spirobranchus giganteus*, "christmas tree worm" have colonised.

The eastern end of the Northern Beach reef lines support dense thickets of branching "staghorn" *Acropora* (including *A. nobilis* and *A. formosa*) colonies covering several hundred metres, extending up to 500 m offshore.

The coral communities of northern Gove Peninsula (West Woody Island to Wallaby Rocks) are similar in structure to those found in other areas within the region with similarly turbid waters and it considered very unlikely that they would contain coral species not represented in the broader Arnhem Land region. Within Melville Bay, coral communities occur more extensively along the western shore, including Bonner Rocks, and the southern shore of Cape Wilberforce.

Benthic Macrofauna

A survey of benthic macrofauna was undertaken in Gove Harbour in July 2002. The results of the survey are shown in Figure 14.3.7.

The survey determined that approximately 120 ha of the seabed in northern Gove Harbour has been affected to some degree by discharges from the refinery. This includes an area of approximately 70 ha in which no macro-invertebrate fauna are found. Surrounding this is a transition area of approximately 50 ha wherein the macro-invertebrates are lower in number and have lower species diversity compared with similar marine areas. The approximate locations of these areas are shown on Figure 14.3.8. There are other physical and chemical indicators of impact on sediment quality, as discussed in Section 13.5.1.

The impact on marine biota is believed to result from a combination of physical stressors associated with the waste water discharge, including:

- Precipitation and sedimentation of suspended solids formed when the discharge mixes with seawater;
- Elevated temperature; and
- Nutrient concentrations above trigger values.

Metals present in the discharge are within trigger values over most of the affected area and are believed to have little if any effect on the benthic biota in the impact zone.

The effect of the wastewater discharge plume on mobile fish species is likely to be limited to avoidance behaviour, as such species are generally able to detect and avoid physically stressful environments.

The total affected area (ie. impact plus transition zone) is between 1% and 2% of the total area of such habitat present in southern Melville Bay (ie. south of Dundas Point).

14.3.2.2 Intertidal Habitats

The intertidal habitats comprise wave-dominated sandy shorelines, protected sandy and muddy bays, and extensive mangrove embayments with associated tidal creek systems.

Coastal Shoreline Mangroves

A narrow discontinuous fringe of mangroves occurs along the shoreline between Dundas Point and No Name Bay that is interspersed with sandy beaches and rocky shores. Within this setting two main habitats occur: the seaward fringe; and landward fringe. The former is a belt typically 20-50 m wide, which is dominated by 6-7 m tall *Rhizophora stylosa* forests, interspersed by *Sonneratia alba* and *Bruguiera gymnorrhiza*. Landward of this belt is a narrow (1-2 trees in width) though diverse belt abutting the terrestrial margin, typically comprising *Aegialitis annulata, Aegiceras corniculatum, Bruguiera exaristarta, B. gymnorrhiza, Scyphophora hydrophylacae, Ceriops tagal, Lumnitzera, racemosa, Osbornia octodonta, Avicennia marina* and *Pemphis acidula.*

More extensive distribution of coastal mangrove occurs along the south-western shoreline of Melville Bay, north of the mouth of the Giddy River and across northern Australia fringing sheltered coasts. All of the mangrove species present have also been widely recorded across northern Australia.

Tidal Creek Mangroves

Extensive mangrove systems occur within embayments that have been infilled with clays, silts and silty sands. Tidal creeks, extensive tidal flats, sand/shell cheniers and freshwater influence at the landward margin are features which support a wide range of mangrove habitats within this coastal setting. Around Gove Peninsula this setting is represented by the Crocodile Creek, Macassar Creek and No Name Bay/Creek systems.

In southern Melville Bay there are seven habitats identified in order of sequence from the seaward to landward margins.

- Tidal creek margins dominated by *Rhizophora stylosa* forest (6-12 m in height) interspersed by *Sonneratia Alba* and *Bruguiera gymnorrhiza*;
- The mid tidal flat immediately landward of the creek margin and dominated by *Bruguiera gymnorrhiza* forest (6-15 m);
- A mixed zone of closed scrub (3-5 m) occupies the mid-high tidal flat comprised of *Bruguiera exaristata, B. parviflora, Rhizophora stylosa* and *Ceriops tagal*;
- The high tidal flat comprises closed scrub (1-4 m) of largely monospecific *Ceriops tagal australis;*
- Salt flats occur as bare mudflats with some stunted halophytic shrubs and isolated stands of *Avicennia marina*;
- The landward mangrove fringe abuts terrestrial vegetation and can be of two community types depending on freshwater influences;
  - The landward section of the No Name Bay system receives freshwater from hinterland draining creeks or floodplains of creeks. The area supports the greatest diversity of mangrove species and habitats with tall forests and thickets (6-12 m) dominated by *Lumnitzera racemosa* and *Melalueca acaciaoides*; and
  - Where the habitat occurs adjacent to Eucalypt woodland there is less freshwater input and hence higher groundwater salinities. This produces shorter dense closed scrubs of *Scyphophora hydrophylacae* (3-4 m).
- Beach ridge/chenier fringes occur as a series of sand/shell deposits near the mouth of major tidal creek systems. While the crests of these sand deposits are colonised by coastal dune species, a narrow but diverse mangrove habitat has developed along their lower slopes and margins. These are typically closed scrubs (2-5 m) of mixed mangrove species.

Elsewhere, major mangrove embayments and tidal creek systems occur widely throughout Melville Bay and at the mouths of major drainage systems across northern Australia. The North Creek, Latram River and Giddy River mangroves are all extensive systems with connection to hinterland draining rivers (hence considerable freshwater input) and would be expected to support a rich and diverse mangrove system of similar, if not greater, extent than the No Name Creek system.

Mangrove Fauna

The mangroves support a diverse range of invertebrate fauna that can be classified into those species that are widespread on rocky and muddy shores, with ranges that extend into mangrove margins, and those species that solely occupy mangrove habitats. The latter is numerically dominant but less diverse. There is a wide range of molluscs (potamidids, ellobiids and *littoraria*) and crustacteans (*Uca* spp, *Scylla serrata* and sesarmids) that are characteristic of mangroves, and these are widespread in the Gove mangroves. Fauna diversity is greatest in areas such as the eastern end of Wanaka Bay where the habitat is most variable, comprising rocks, and a sand/mud mixture. This provides a greater range of niches for species to inhabit. Conversely, those mangals revealing less variability resulted in lower diversity, such as the extensive forests of Drimmie Arm and No Name Bay. These had a high diversity of tree species but the uniformity of the overall environment has lead to reduced invertebrate diversity.

The avifauna (bird species) of the mangroves is typical of Northern Territory tropical mangroves (Noske, 1996; Johnson, 1990). These are mainly nectivores (red-headed and brown honeyeaters and friarbirds), concentrated where either *Bruguiera* or *Rhizophora* trees are in flower, and insectivores (flycatchers, whistlers, Gerygone).

As with the habitat in which they are found, the fauna of the mangroves is comprised of widely distributed species which occur in similar habitat throughout tropical northern Australia.

Rocky Shores

Rocky shore habitats are generally restricted to small outcrops in the study area. Wave cut platforms of laterite/bauxite conglomerate (known locally as “bauxite shelf”) occur as small outcrops approximately 20-50 m along the shoreline at a few locations in Inverell Bay, Drimmie Arm and No Name Bay. Biota in this habitat is zoned according to position relevant to tidal influence/height.

The upper-most zone of the rocky shores experiences greater periods of exposure and consequently has fewer species. It is predominantly inhabited by limpets, littorinid snails and *Leptograpsus* crabs. A fringe of oysters is present at mean sea level along the northern coastline of Gove Peninsula. Invertebrate diversity is greatest in midtidal areas where exposure is reduced. Thaid snails are common, feeding on the oysters and other species. Large chitons (*Acanthopleura*) are also present with nerites, species of hermit crabs, and pulmonate slugs (*Onchidium* sp.). Reduced exposure in lower tidal areas tends to relate to greater diversity. Algae are present and diverse on the lower shore.

Exposed beach rock (limestone) is evident amongst sandy beaches at East Woody Island, Northern Beach and Dundas Point. These often have crevices and holes for invertebrates to inhabit, providing higher diversity than harder rocky habitats.

Granite outcrops occur as headlands or islands at East and West Woody Island, near the mouth of Crocodile Creek West, Wargarpunda Point, Rocky Point and Drimmie Head. The granite and bauxite shores tend to have smoother surfaces, which provide fewer crevices for invertebrates to colonise.

Crab species are occasionally found within shoreline pools. Birds have not been observed in great abundance and typically appear to utilise rocky shores as roosting sites during high tide.

In Melville Bay, rocky shore habitat is most extensively developed at Cape Wilberforce, Bromby Islet, Bremer Island and the shoreline between Cape Wirrawaywoi to Cape Arnhem. The outcrops occurring around the Gove Peninsula represent a very small percentage of the rocky shore habitat present in Melville Bay. They are also less varied in their setting and, as a result, likely to support a less diverse range of plant and animal species.

Sand Beaches

Extensive stretches of sandy beaches occur along the wave-exposed coastline from East Woody Island to Dundas Point. They are largely composed of medium to coarse-grained quartz and shelly sands. Where the coast is more protected, such as Gove Harbour, Drimmie Arm, and No Name Bay, small pockets of beach occur composed of medium to fine sands and silts.

The fauna pattern is zoned as on rocky shores, but is less obvious as the species remain buried beneath the sands on upper shores during low tide. These are typically crabs such as the ghost crab (genus *Ocypode*), and at high tide the swimming crab *Portunus* sp. A donacid bivalve is also locally common on the exposed northern beaches.

A diverse invertebrate fauna, particularly molluscs and crustaceans, occurs on the sand spit at the eastern end of Drimmie Arm. Along the shoreline is predominantly coarse sand which grades to finer sands and silts near the mangroves. Rocks occur providing niches for various species, and there is a muddy/sandy lagoon with protected water at low tide. A small number of shorebirds, waterbirds and terns have been observed along the beaches, which are used as roosting sites during high tide.

Sand beaches occur extensively along the west coast of Melville Bay as far north as Sandy Bay and would all be expected to have similar faunal communities.

As discussed in Section 12.1.1, a groundwater discharge occurs at Northern Beach. This discharge, which is naturally dark-coloured from the organic materials in the ground, has also been shown by the monitoring program to contain water with pH above background levels. Studies have been undertaken to investigate the likely environmental impact of this discharge. These investigations indicated that, apart from a temporary affect of the natural discolouration on water clarity over a small area, there was no measurable environmental impact occurring at Northern Beach as a result of the groundwater discharge (URS, 2001c).

Low Tidal Sand Flats

Natural reworking and deposition of sediment has formed broad sand sheets in the low tidal zone near the mouth of Crocodile Creek (East and West) and at some headlands such as Dundas Point. At the former these extend for approximately 300 m seaward of the beach. This habitat supports a diverse and abundant fauna community. Similar biota occur on the East and West Crocodile Creek sand flats, however the latter support greater invertebrate fauna diversity including sand, dollar and hermit crabs with occasional sea stars (*Astropectin*). Burrowing polychaete worms are common and sometimes form locally dominant masses of small tubeworms. In the lower intertidal sand beaches a variety of molluscs, both bivalves and gastropods, occur. Algae are uncommon as rocky surfaces providing suitable substrate for attachment are rare. The high invertebrate diversity and abundance provides productive feeding grounds for a range of migratory shorebirds, waterbirds and terns. The former is most diverse at the Crocodile Creek mouths.

Regionally, more extensive tidal sand flats have been identified in the Cadell Straits, Buckingham Bay, Arnhem Bay and Blue Mud Bay.

Low Tidal Mud Flats

Seaward of mangroves, mudflats are exposed during low tides in the most protected areas of Drimmie Arm and No Name Bay. Sediments are very fine and typically comprise shelly muds, silts and fine sands. They are reworked at

the mouths of major tidal creek systems, resulting in a complex mosaic of mud and sand sheets, small channels and sand bars.

The habitat is favourable to a diverse biota, including the dominant molluscs, crustaceans and polychaete worms. Hermit crabs and some snails are locally abundant and sea cucumbers occur in some areas. A small range of shorebirds and waterbirds have been recorded from low tidal mud flats.

The low diversity and abundance of shorebirds, both migratory and resident, observed during the November 2002 intertidal survey suggests that the Gove Peninsula area does not contain any sites that are of particular ecological significance to migratory shorebirds.

14.3.2.3 Threatened Marine Species

Turtles are the only marine species listed as 'threatened' that regularly utilise Melville Bay. However, the greatest occurrence of these species is outside of the area of localised impact associated with the refinery discharge into Gove Harbour. The nearest recognised turtle nesting sites in the region are:

- Hawksbill turtles: Bromby Islet and Truant Island (some 40 km and 60 km, respectively, to the north of Gove Harbour); and
- Green turtles: Bremer Island (20 km to the north-east of Gove Harbour).

Small numbers of Green turtles are also known to breed on the beaches along the northern side of the peninsula. Most of these are located on the open sandy beaches in the vicinity of Crocodile Creek (Figure 14.3.6). The beach immediately to the north of the refinery is less suited to turtle breeding because of the presence of the intertidal rocky ledge (Figure 14.3.3).

Olive Ridley and Flatback turtles have also been recorded as nesting on beaches in the Melville Bay region.

14.3.2.4 Migratory Species

Dugongs, crocodiles and certain dolphins are listed as 'migratory species' under the *Environment Protection and Biodiversity Conservation Act*. Extensive occurrences of key habitats for these species (eg. seagrass beds for dugongs, mangroves for crocodiles) do not occur within the discharge impact area. Whilst these species may occasionally enter the affected area, their mobility ensures that they are able to avoid environmental conditions that could be injurious to their health.

Dugongs and crocodiles are more frequently observed in Drimmie Arm and No Name Bay as a result of the presence of seagrass and mangrove habitats with which they are more frequently associated. No change to the habitats of either of these areas is predicted as a consequence of the proposed expansion.

The greatest occurrence of listed migratory species lies outside of the refinery's marine operational area and the area of localised impact associated with the refinery discharge. For example, there is more extensive suitable habitat for these species in and around the mouths of the Giddy and Latram Rivers and North Creek. Hence there will be no significant impact on these species from the refinery's expansion either at a local or regional level.

14.3.3 Fishing

14.3.3.1 Commercial Fishing

The deeper water areas of Melville Bay (5-30 m) are used as spawning areas by banana, tiger and endeavour prawns, with the local populations of these species capable of attracting up to twenty prawn trawlers or more from the Northern Trawl Fishery. The actual number of trawlers visiting Melville Bay each season varies according to prawn recruitment success and densities that vary between years according to seasonal rainfall and other factors. For example, five trawlers were fishing in the south-west sector of Melville Bay during May 1999.

Collection of reef fish, corals and other invertebrates for the aquarium trade is also undertaken at various locations within Melville Bay.

14.3.3.1 Recreational Fishing

Boat-based recreational hand-line fishing and sportfish angling are popular in the local estuaries, on the inshore reefs and further offshore in Melville Bay, with specific locations and fishing intensity varying with season, weather and tidal conditions. Targeted species include barramundi, mangrove jack and mudcrabs in the mangrove creeks and estuarine environment, coral trout and tropical snappers on the reefs, and Spanish mackerel, waahoo, shark, trevally, dolphin fish, and barracuda in open waters.

The generally small size of the sweetlips, snapper and cod species observed on the patch reefs in and close to Gove Harbour by diver surveys in 1999-2000 (most less than 25 cm) indicated a relatively high level of recreational fishing effort.

Shoreline fishing is undertaken during hight tides (eg. on the Drimmie Arm causeway). Setting traps for mud crab traps inside the mangrove areas within and south of Drimmie Arm is also undertaken.

14.3.3.2 Traditional Fishing

Aboriginal people in the Gove Area have a strong cultural attachment to the land, waters and biological resources in and around Melville Bay. Thus the waters and intertidal areas around the Gove Peninsula are regularly visited by members of the local indigenous community for collecting various species of seafood as well as for other cultural and recreational purposes. Discussions with traditional owners confirmed that, like other areas in Gove Harbour and southern Melville Bay, this area is also utilised for collecting a range of intertidal biota.

The local indigenous community prefers seafood collecting in the intertidal areas near the south end of Drimmie Arm and areas north of the Gove Peninsula. Species targeted by small groups of family and friends include sand clams, rock oysters, mud whelks and mud crabs. While the north end of Drimmie Arm is occasionally visited and fished, it has not been a regular or preferred source of seafood in Melville Bay. Line fishing is occasionally undertaken from dinghies in Macassar Creek. A few people set crab pots in the northern half of Drimmie Arm and some will visit its mangrove fringes from time to time.

14.4 Standards

Standards for marine water quality and sediments are described in Section 13.3.1. There are also a number of Acts and regulations that focus on protection of marine habitats and, where applicable, Alcan Gove complies with them. These include:

- The Commonwealth Sea Dumping Act, the function of which is to regulate the dumping of materials at sea, and particularly the dumping of materials that might adversely impact on marine ecosystems.
- Regulations governing the use of toxic compounds in antifouling paints. Since 1994, antifouling paints containing active ingredients (compounds toxic to animals) must be registered nationally by the National Registration Authority for Agricultural and Veterinary Chemicals.
- AQIS Voluntary Ballast Water Guidelines which are designed to reduce the potential for the introduction of exotic marine organisms that once established, may compete with and detrimentally affect local marine species.

14.5 Expanded Refinery Effects on Marine Habitats

14.5.1 Shipping

14.5.1.1 Shipping Movements

At present, approximately 113 ship visits are made annually to the Bulk Cargo Wharf and the General Cargo Wharf at Gove (Table 4.7.1). There is also a weekly barge and containerised freight service that operates a route from Darwin to Groote Eylandt via Gove. Gove Harbour does not provide a base for the northern prawn trawl, line or trap fisheries, but trawlers occasionally visit for emergency supplies or refuelling at Perkins wharf. These visits are highly seasonal.

As a result of the refinery expansion, the number of vessel movements at Gove will increase from 113 to 143 (gas fired) or 156 (oil fired).

14.5.1.2 Change in Spill Risk

Once gas is available, there will be a significant reduction in the number of heavy fuel oil import shipments from the current eight to only one per year. This will be a reduction from 480,000 t/y of fuel oil to only 34,000 t/y. This will significantly reduce the risk of oil spills in Gove Harbour. If gas is delayed, fuel shipments would increase from 8 to 14, with the total imports rising to 850,000 t/y. There would be a commensurate increase in the risk of a major spill associated with the increased number of shipments.

There will be an increase in the volume of other fuels used in the expanded operations resulting in the shipping movements increasing from two to four per year. The volume of shipped fuel will increase from 8,000 t to 16,000 t. While this will increase the risk of an oil spill, this risk will be more than outweighed by the reduced risk from the reduction in fuel oil shipments once gas is available.

There is also an increase in the importation of caustic soda as a result of the refinery expansion resulting in shipments increasing from 9 to 18 per year.

As discussed in Section 13.7.2.4, existing strategies are in place to manage the risk of spills to the marine environment and they will continue to be implemented in the expanded refinery.

14.5.1.3 Change of Risk of Introduction of Exotic Marine Species

The modified shipping regime as a result of the refinery expansion will alter the current risk of unwanted marine species being introduced at Gove. The main change to shipping is an increase in the number of hydrate and alumina

shipments per year and a decrease in bauxite shipments. Overall this will result in an increase of approximately 15% in the volume of ballast water discharged annually at Gove.

Non-native marine species, including species with known or suspected pest status, can be introduced to local port waters via the ballast water of merchant ships, and/or by attachment to the hulls of these or other vessels. The potential presence of introduced marine species at Gove was recently investigated by a port species baseline survey. This survey, which recorded over 990 separate marine taxa (CRC et al. 2003), found no species that was a known or suspected marine pest, as designated by the Australian Ballast Water Management Advisory Committee, the National Introduced Marine Pests Coordinating Group, or CSIRO (Hayes et al, 2002).

The risk of introducing exotic marine species into Gove Harbour as a result of the refinery expansion will not significantly increase as the increased additional volume of ballast water is relatively small (15%) and the ships will continue travel generally to and from the same ports as they do at present.

14.5.2 Benthic Macrofauna

Expansion of the refinery will result in changes to the chemical and physical characteristics and the volume of the refinery outfall discharge (Table 13.6.1). The results of the marine modelling described in Section 13.7.1.4 show that the effect of the changed discharge on the water quality of Gove Harbour is minimal. There will be no significant change to the mixing zones for temperature and suspended solids. Hence it is concluded that the area in Gove Harbour where benthic macrofauna are either absent or are in reduced numbers due to temperature and flocculant effects from the discharge will not increase above the current 1% to 2% of the total area of such habitat present in southern Melville Bay.

14.5.3 Turtles

As discussed in Section 14.3.2.3, there are no significant turtle habitats in the area surrounding the refinery. Furthermore, there will be no loss of habitat for turtle breeding as a result of the expansion. While there will be a small increase in light spill from the expanded refinery onto Northern Beach (Section 18.6), this area is not a preferred turtle breeding site because of the intertidal rocky ledge and hence any additional impact is likely to be low. Consequently, it is considered that the proposed development will not result in changes that will:

- Lead to a long-term decrease in the size of any important populations of turtles;
- Reduce the area of occupancy of any important populations of turtles;
- Fragment any existing important populations of turtles into two or more populations;
- Adversely affect habitat critical to the survival of turtles;
- Disrupt the breeding cycle of any important populations of turtles;
- Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that any species of turtles are likely to decline; or
- Result in the establishment, in turtle habitat, of invasive species that are harmful to turtles.

14.5.4 Migratory Species

As discussed in Section 14.3.2.4, there are no key habitats for migratory species within the area affected by the refinery operations. There will be no significant effects on migratory species because the expansion will not:

- Substantially modify, destroy or isolate any area of important migratory species habitat;
- Result in the establishment, in any habitats of importance to migratory species, of invasive species that are harmful to migratory species; or
- Disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of any populations of migratory species.

14.5.5 Other Marine Habitats

None of the other marine habitats in the area will be affected by the expansion. They are neither rare nor unique and they do not have significant conservation value. Hence the proposed expansion does not pose any risk to regional biodiversity.

14.6 Management

A strategic environmental management plan outlining strategies for the management and monitoring of marine habitats is presented in Section 25.

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KEY REGIONAL MARINE HABITATS

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File No.: R993F14-3-1.dgn

FIGURE 14.3.1

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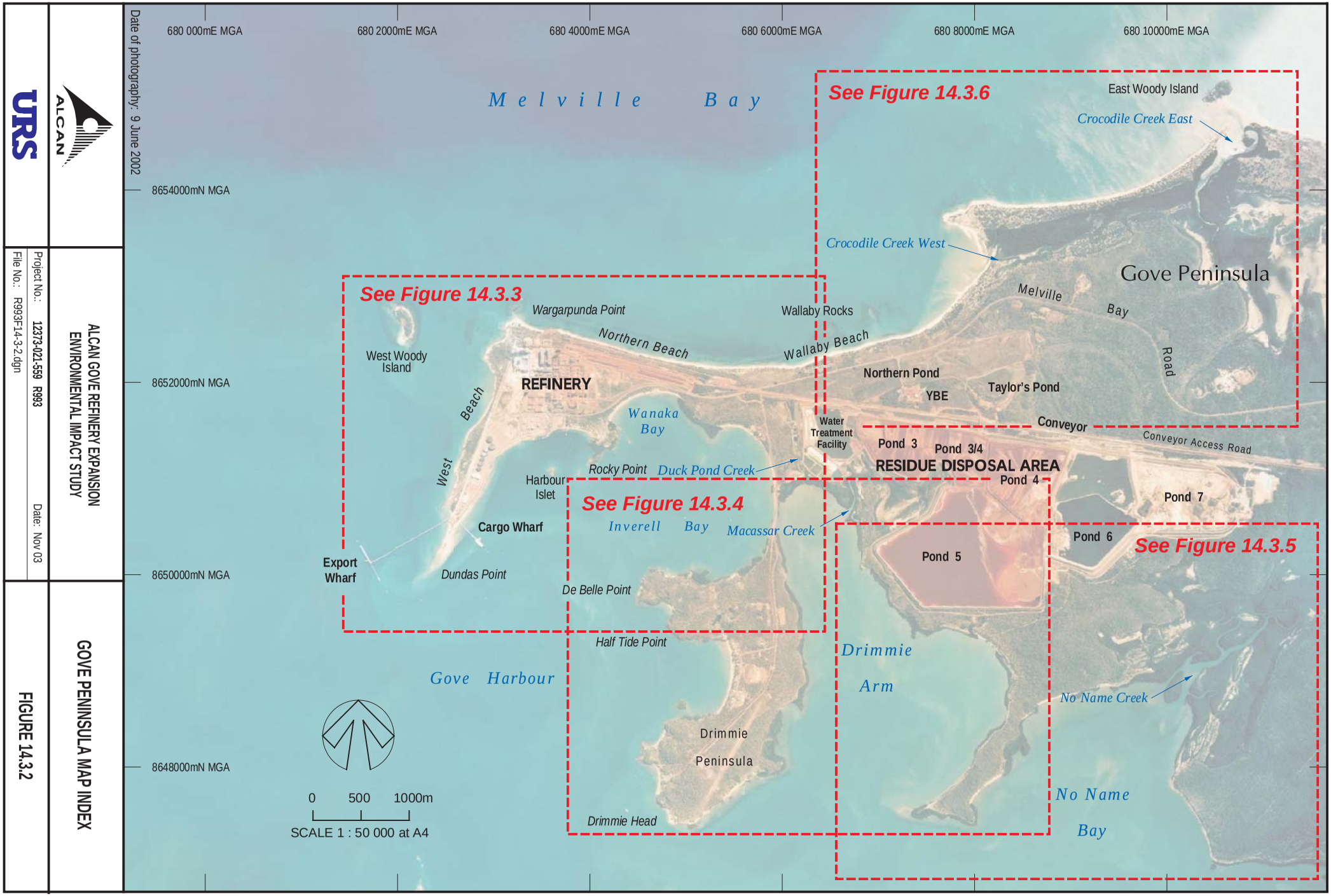

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GOVE PENINSULA MAP INDEX

FIGURE 14.3.2

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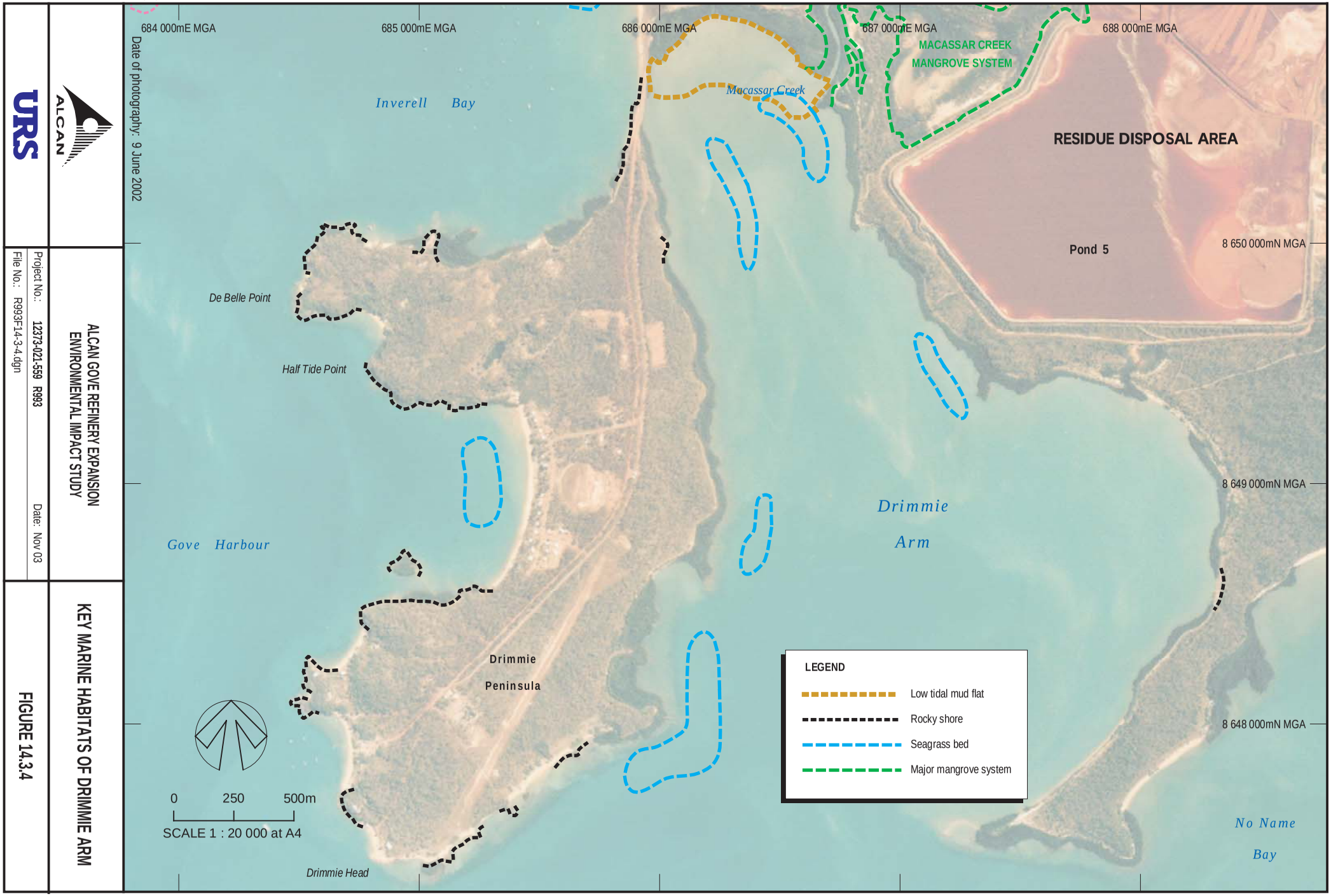
KEY MARINE HABITATS OF
WESTERN GOVE PENINSULA

FIGURE 14.3.3

ENVIRONMENTAL DRAFTING (08) 9278 8211



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KEY MARINE HABITATS OF DRIMMIE ARM

FIGURE 14.3.4

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KEY MARINE HABITATS OF NO NAME BAY

FIGURE 14.3.5

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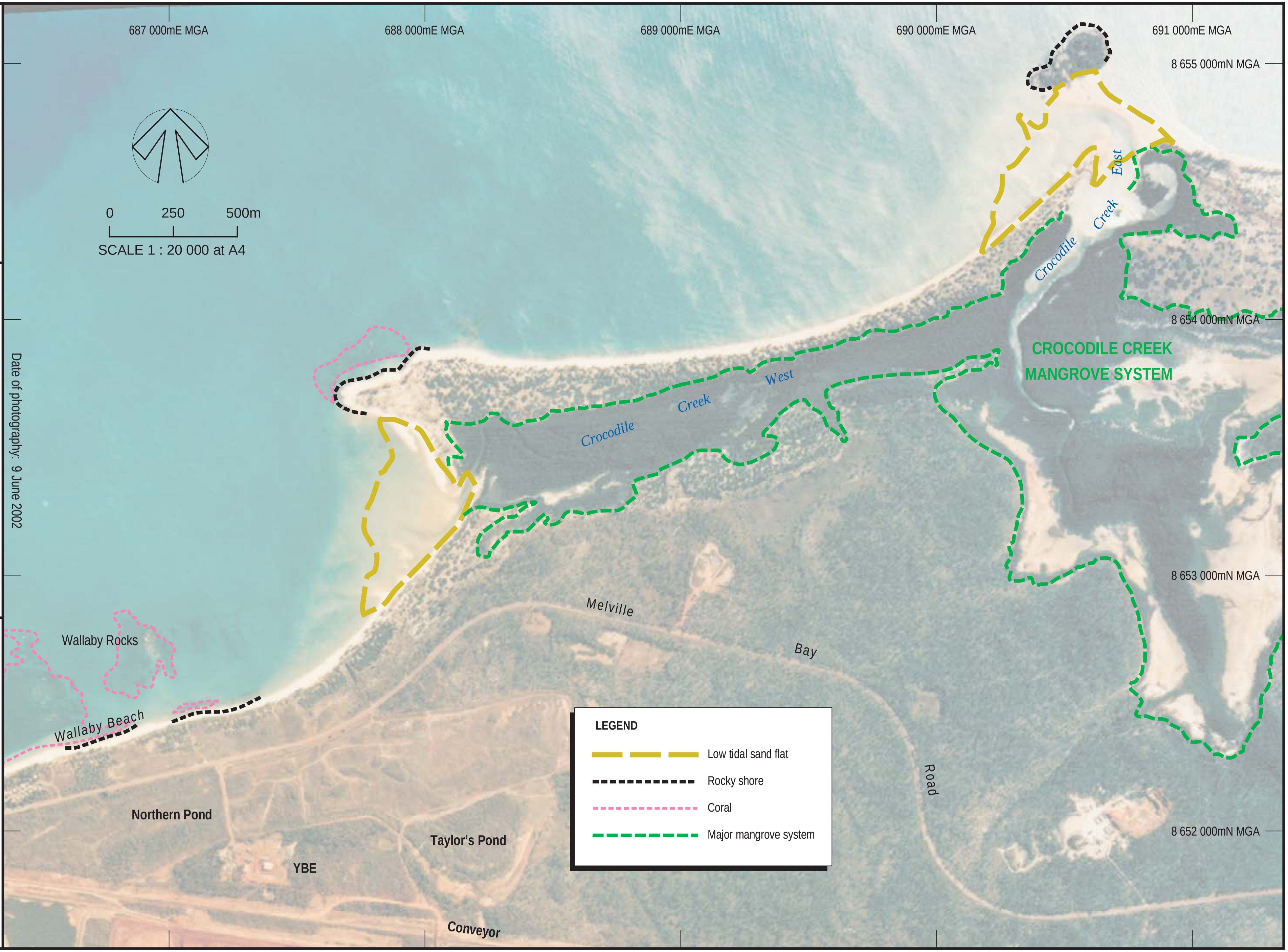

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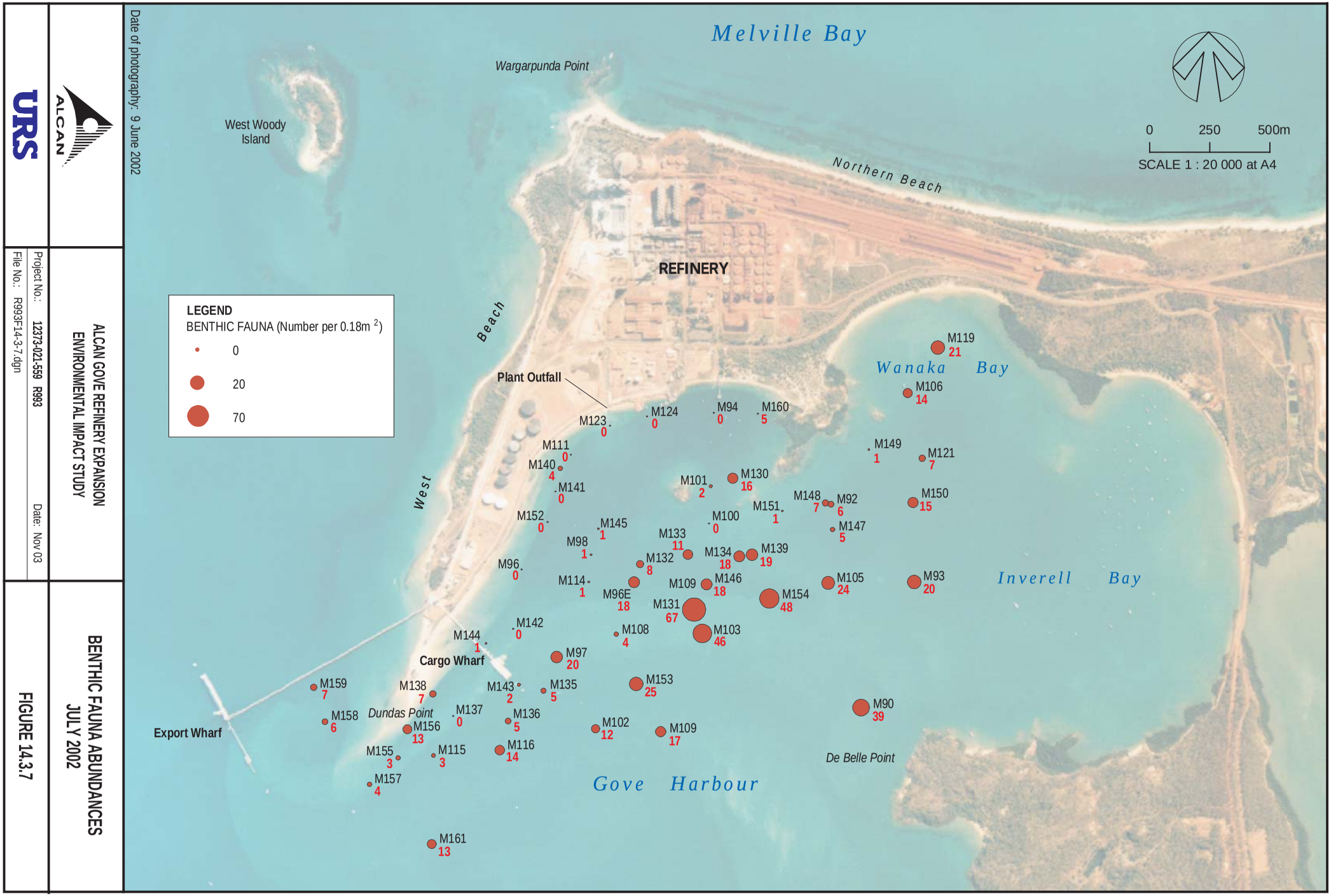
KEY MARINE HABITATS OF NORTHERN GOVE PENINSULA

FIGURE 14.3.6



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BENTHIC FAUNA ABUNDANCES
JULY 2002

FIGURE 14.3.7

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INTERPRETED SEABED IMPACT ZONE BOUNDARIES - JULY 2002

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File No.: R993F14-3-8.dgn

FIGURE 14.3.8

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