# CHAPTER 3: A REGIONAL REVIEW OF COASTAL HAZARDS

## 3.1 INTRODUCTION

The geomorphology and geology of the coastline varies from north to south within the study area. The change in geological landforms is significant, and enables the coastline to be classified into four distinct areas (Figure 3.1). Each area selected represents a coastal area dominated by a set of similar broad morphological and process characteristics, and therefore, also represents a number of hazards that may be unique to that particular landscape.

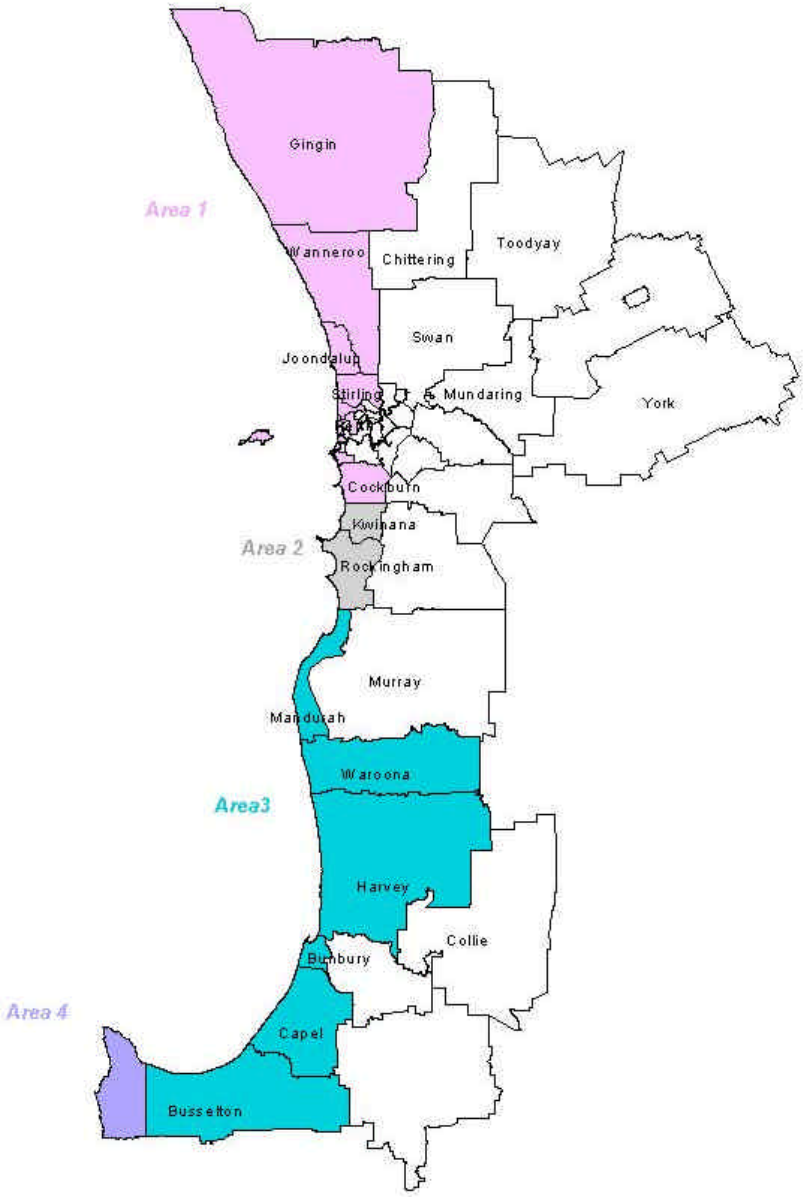


**Figure 3.1** Location map showing the Perth study area, LGAs and the four subdivisions of coastline based on geological and morphological differences.

## 3.2 GEOGRAPHY AND PHISOGRAPHY OF THE STUDY AREAS

### *3.2.1 Study area number 1*

Area no.1 encompasses the coastline from Naval Base (just north of Rockingham) to the northern most limit of the study area in the Shire of Gingin. The coastline within this area is almost linear with a constant north to northwest trend and has a typical absence of large bays and protruding headlands. Coastal geology within this area alternates between sandy beaches backed by Tamala Limestone cliffs (<6 m) with a rocky platform at their base and sandy dune systems (S2). Dunes vary in height along the coast and are usually between 5 and 50 m tall.

The length of coastline within this area is approximately 150 km and about 15 % of this is composed of Tamala Limestone. Although this area also contains extensive dune systems, it is the large area of coast backed by limestone cliffs (LS1) that distinguishes it from the rest of the study (Figure 3.2).

**Figure 3.2** Typical exposure of Tamala Limestone within study area no.1. The cliffs in this photo are 3-4 m tall and are located at site 4 (see Appendix A).

### *3.2.2 Study area number 2*

Area no. 2 extends south from area no.1 to Mandurah (~50km) and is characterised by large cuspate promontories composed of very low (< 1-2m) dunes (S13). These dunes are part of a prograding foredune plain that is influenced by the diffraction of waves around the offshore islands and reef. Tombolo development has occurred, and is still occurring, linking offshore islands to the mainland. There is only one occurrence of coastal limestone in the area, and that is on a former island captured by tombolo development.

### *3.2.3 Study area number 3*

The coastline between Dunsborough (just east of Cape Naturaliste) and Mandurah defines study area no. 3 and is approximately 75km in length. From Mandurah to Bunbury, the coastline is almost linear with a constant south to south east trend. From Bunbury to Dunsborough, the coastline sweeps around in a south westerly and then to a north westerly direction, forming a large north facing bay. The coastal landscape throughout this region is characterised by long narrow sandy beaches backed by vegetated dune systems (Figure 3.3) and back barrier swamps. In the area immediately south of Mandurah, the beaches are interspersed with minor limestone headlands. Dunes range in size from 2m - 60m with foredunes typically around 2m in height. There are no major cliffs in this area.

**Figure 3.3** Site 13 is a typical example of the sandy beach and low foredunes that characterise area no.3.

### *3.2.4 Study area number 4*

Area no. 4 occurs in the Naturaliste region, which is a belt of relatively rugged country between Capes Leeuwin and Naturaliste. The area extends from Cape Naturaliste to the southern edge of the Perth study area, about 10 km north of Gracetown. This area is significantly different to the others because it is floored by Archaen basement rock of granite-gneiss. It has a rocky coast with hard cliffs and small sandy beaches. Gneissic rock shore-platforms and headlands, along with limestone cliffs dominate the coastline. Limestone cliffs are significantly higher in this region, reaching heights above 10 m.

## 3.3 COASTAL HAZARDS

### *3.3.1 Field Investigations*

The regional variation in geology and geomorphology of the coastline was inspected over a period of 3 days. The aim of this investigation was to gain an appreciation for the different landforms in the area and their associated hazards. It was *not* our intention to undertake detailed geotechnical assessments. A total of 18 sites were visited (Figure 3.4) and a brief description and photo of these sites can be found in Appendix A.

### *3.3.2 Study area no.1*

Area number 1 contains both limestone backed beaches as well as dune backed beaches. The most noticeable hazards within this area are associated with the Tamala Limestone.

Visual examination of several outcrops revealed great variability in the limestone. While some cliffed areas appear quite fresh and consolidated, others exhibit extensive weathering, mainly due to dissolution and removal of calcium carbonate.

The most obvious feature pertaining to the cliff hazard, are the large limestone blocks that have separated from the parent body and fallen onto the beach (Figure 3.5). These limestone blocks can be up to $1m^3$ in dimension. The timing of collapse is not known, however in certain instances, variations in the colour of the exposed rock formations indicate recent fracture.


**Figure 3.4** Sites visited during a 3 day field investigation.

**Figure 3.5** Large limestone blocks (<1m$^3$) have separated from the cliff and fallen on to the beach (Site 5).

Overhangs or cantilevers along the leading edge of outcrops are common features. It is a certainty that these overhangs will eventually collapse, but the timing of these events is almost impossible to predict. Gordon (1997a) states that 'Geotechnical assessments cannot anticipate the magnitude of a major trigger such as cyclonic rain on a porous limestone cliff'. It can therefore be said that structures that may appear stable now, may not be stable after periods of intensive rainfall.

Other features seen within the limestone include cracks and fissures, along with solution piping. This piping was apparent at most sites, but was most noticeable at site 5 where the limestone was riddled with solution tubes up to 60 cm in diameter (Figure 3.6).

**Figure 3.6** Solution piping is a common feature within the Tamala limestone. At site 5, these solution tubes were up to 60cm in diameter.

### *3.3.3 Study area no. 2*

Area 2 stretching from Mandurah to Naval Base is dominated by a beach ridge plain and does not have any hazardous cliff lines. The area has a very low relief and has subsequently been used for residential developments. The major hazard associated with this area is the removal of vegetation in developed areas, and the subsequent loss of vegetation in surrounding areas due to increased recreational pressures and road development. While not necessarily threatening to life, this loss of vegetation destabilises the dune systems and can result in the development of blowouts, leading to frequent incursions of mobile sand into residential developments.

### *3.3.4 Study area no. 3*

Large vegetated dune systems dominate the coastline within this area. Field investigations revealed some potential hazards associated with these dunes. In some areas there has been significant loss of vegetation and blow out development. Of particular concern is the effect of public pressure on the dunes, primarily through trampling caused when accessing the beach.

Erosion as a result of wave action is also occurring, cutting into the foredunes and shaping the face into cliff-like structures (Figure 2.5). The increased angle of repose in these cliffs will significantly increase the risk of subsidence occurring.

Another concern for this area is related to public awareness. Digging or tunnelling at the base of a dune is particularly hazardous as it disturbs the natural stability of the dune, increases the rate of erosion, and makes the dunes highly susceptible to collapse.

### *3.3.5 Study area no. 4*

Gneissic rock shore-platforms and headlands, along with limestone cliffs dominate the coastline of this area. Field investigations did not extend into this region and there are no detailed site descriptions. However, the hazards in this area are mainly related to the Tamala Limestone, which forms cliffs that are significantly higher in this region. The weathering and erosion features of these cliffs are similar to those in study area no.1 and therefore pose similar hazards.