TECHNICAL REPORT

The Coast of the Shires of Coorow to Northampton, Mid West, Western Australia:

Geology, Geomorphology and Vulnerability

December 2012

GOVERNMENT OF WESTERN AUSTRALIA

Department of **Planning**

Department of **Transport**

The Department of Planning engaged Damara WA Pty Ltd to prepare this report as a background technical guidance document only. Damara conducted this project in conjunction with the Geological Survey of Western Australia.

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Cover Photograph
View northeast over the southern end of Port Gregory and across a 1 km wide barrier comprised nested parabolic dunes to the Hutt Lagoon, Beta carotene ponds, the delta of the Hutt River and Lytton Station. A tombolo and cuspate foreland are apparent at the shore. (Photograph: I. Eliot)

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EXECUTIVE SUMMARY

Approach

The Mid-West is a transitional region physically and climatologically. It spans the shallow reefs and inshore lagoons that are common south of Dongara and the deeper shoreface north of Glenfield. Additionally, streams and rivers are increasingly common to the north of the Study Area, with the Irwin River at Dongara, Chapman River at Geraldton, and several small streams between there and the Murchison River at Kalbarri. Despite the presence of the streams the northern sector of the Study Area is apparently sediment deficient. The largest unconsolidated sedimentary landforms – cuspate forelands and high barriers - are predominantly located along the southern shores. Conversely, extensive erosional forms, such as large cliffs and lagoons landward of exposed platforms are more prevalent in the northern sector.

Certain landforms and coastal features are more vulnerable to climate and sea level variation than others. Hence the immediate aim of this project was to determine the vulnerability of landforms on the Mid-West coast to changing weather and oceanographic conditions, including projected changes in climate. The determination involved assessment of aerial photography of coastal landforms between North Head and Nunginjay, site visits and a review of available meteorologic and oceanographic information. Interpretation of the information gathered was intended to identify vulnerable locations within the Study Area and assist decision-making regarding the location of any proposed coastal development and for coastal management purposes.

The structure and formation of landforms and coastal features between North Head and Nunginjay Springs Coast North is tied to rock outcrops along the shore as well as the presence and shape of the nearshore reef system. Coastal limestone forms much of the coast but merges with sandstone north of Bluff Point. This bedrock, geological control was used to identify discrete sediment cells where changes to landforms in one part of a cell were highly likely to affect the remainder of the cell but with potentially limited affect on adjoining cells. Sixty four cells were identified along approximately 160 km of coast. Potential relationships between sand dune ridges (barriers) and the underlying bedrock topography were determined where apparent; landform patterns comprising the dune barrier systems identified; and individual landforms described for each cell. The scales of description respectively correspond to scales used in the compilation of coastal management strategies and plans.

Landform vulnerability was estimated as a combination of the susceptibility of the geological structure supporting the landforms to environmental change and the current condition of the landforms as indicated by existing evidence of erosion. Together, a geological structure and the landforms it supports define a land system. The assessment involved consideration of the integrity of the geological or geomorphologic structures of land systems and the condition or stability of the landforms supported. Susceptibility rankings were determined from values assigned to marine topography near the shore; the shape of the shoreline; coastal orientation; and the prevailing type landforms present in the cell. Similarly, instability rankings were based on the proportion of rocky versus sandy seabed; beach type and/or beachface shape; whether the frontal dune complex has been eroded; and an overall estimate of vegetation cover on the sand barrier. The analysis was intended to be indicative rather than prescriptive and has application for strategic planning purposes as a first step to more detailed risk assessment procedures.

Land System Susceptibility

Sixty four cells were identified in the analysis. Three cells, between Connell Road and the Marina at Geraldton were not considered. They include Geraldton Port and engineered sections of coast. The overall results for all other coastal cells in the Mid-West revealed a substantial proportion, 39 of the 61 (64%) cells examined were moderately susceptible to environmental change. Seventeen cells (28%) had a landform assocation with a low susceptibility; and five cells (8%) were highly susceptible.

Tracts of land having low susceptibility to environmental change were most common south of Flat Rocks. They occurred between South Fisherman and South Bay, Webb Islet to Cliff Head, Leander Point to Seven Mile Beach, Bookara South and Headbutts and immediately north of the Bowes River. These were areas where the coast was protected by offshore reef, rock typically outcrops along the shore and the dune barrier was likely to be perched on a rock surface above High Water Level.

Sediment cells considered highly susceptible to environmental change due to unconsolidated landforms, lack of bedrock support and exposure to metocean forcing were not common in the Study Area. Exceptions occurred along the Geraldton coast between the Marina and St Georges (Cell 44) as well as from Sandalwood Bay to Yanganooka (Cell 57). A more extensive tract of coast that was highly susceptible to change in the natural structure was the mainly cliffed coast between Bluff Point and the Murchison River (Cells 61 to 63).

Landform Stability

Estimated levels of instability for each of the cells along the Mid-West coast revealed a high proportion, fifty three of the 61 (87%) cells examined, were moderately to highly unstable. Eight cells (13%) had a low instability ranking, twenty five cells (41%) were moderately unstable and twenty eight cells (46%) were of high instability.

Sediment cells with low instability were most common on the coast south of Cliff Head. They occurred between Sandy Cape and Fishermans Islands, unsurveyed point and Webb Islet, South Illawong and Cliff Head, Pages to Connell Road and from St Georges to the Chapman River. They were areas where there the shore was sheltered by inshore reefs and/or rocky pavement, the frontal dune complex was intact and the barrier dunes well vegetated.

Combinations of some of the following factors indicated current levels of landform instability: the inshore seabed was bare sand; beaches were commonly subject to high wave conditions or part of a barred river mouth; there was no foredune and the frontal dune was scarped; and vegetation cover was low and /or mobile sand sheets were present on the barrier. Cells having all or some of these criteria were considered to have high instability. They included tracts between Cliff Head and Leander Point, Nine Mile Beach and Headbutts, Duncans Pool to Cape Burney South and from the Bowes River to Red Bluff. Several isolated cells had landforms with a high level of instability. These included cells with southern boundaries at Separation Point, the Marina, Chapman River and the Murchison River.

Vulnerability

Vulnerability is a combination of landform association susceptibility to change due to metocean forcing and landform instability. A cell ranked at one level is highly likely to contain components of susceptibility and/or instability ranked at another. In particular, a cell ranked at a moderate level may have elements that are highly susceptible to change in the metocean regime and/or has landforms that are currently unstable. The qualification is particularly important at increasingly broader spatial scales in the land system hierarchy where a wider range of land systems and landforms is included at each compartmental scale.

Cells with a high vulnerability ranking were areas where the potential affect of metocean processes was considered a major constraint to rural-urban development due to low integrity of the natural structures, poor natural resilience and potentially require high ongoing management requirements. Development in a cell with high vulnerability is highly constrained.

An exception is where large-scale infrastructure may require coastal access (eg. for marine-based industries, major harbours or port facilities). Detailed geotechnical investigation (site assessment of elevation and coverage of underlying rock using drilling or other appropriate technique), sediment budget analysis (approximate volumetric rates of sediment transport including sources and sinks) and numerical modelling (such as wave, current and sediment transport modelling to provide further context for the volumetric rates of sediment transport) are recommended as the basis for establishment of such infrastructure.

The overall results for the Mid-West coast indicated four (6.5%) of the 61 cells examined had a low level of vulnerability; fourteen (23%) were of low-to-moderate vulnerability; seventeen (28%) were moderately vulnerable; twenty two (36%) were of moderate-to-high vulnerability and four (6.5%) had a high vulnerability.

At a broad, regional planning scale, distinct landform patternsweare apparent in each of the secondary compartments occurring in the Study Area, each characterising the structural compartment in which it occurred. The prevailing features of the secondary compartments were as follows:

1. The secondary compartment between South Illawong and Cliff Head with the lowest susceptibility to change. Its vulnerability and instability rankings were both low. Continuous offshore reef shelters much of the SW facing shore and much of the shoreface is shallow. Low-energy reflective beaches are inset between outcrops of rocky shore. Landward, the perched barrier is comprised of nested parabolic and blowout dunes. These are well vegetated away from the frontal dune ridge.

2. Coastal vulnerability rankings in two secondary compartments between North Head and South Illawong, and from Leander Point to Nine Mile Beach have an overall low to moderate ranking.

   Between North Head and South Illawong, the individual cell rankings range from low to moderate. Cells in the central part of the compartment, between South Bay and unsurveyed point, display moderate levels of susceptibility and instability, as does the coast between North Head and Sandy Cape. These are areas with a variety of landforms including cuspate forelands and tombolos as well as perched beaches and small embayments. In places, the frontal dune ridge is scarped along the shore and foredunes are either absent or discontinuous. The episodic transgressive dune barriers have small blowouts and some mobile sand sheets. There is evidence of disturbance related to vehicle access tracks.

   Sheltered beaches; most perched on rock platforms are found along the coast between Leander Point and Nine Mile Beach. The beaches front episodic transgressive barriers and foredune plains with high frontal dunes. The foredunes and frontal dunes have been locally scarped and cut by access tracks. The combination of a low susceptibility to change and a moderate level of instability gives the secondary compartment its overall susceptibility ranking.

3. Two adjoining secondary compartments have a moderate vulnerability ranking: Cape Burney South to Glenfield and Glenfield to the Bowes River. The former includes the shores of the Tarcoola Embayment and Champion Bay which are separated by the Point Moore Tombolo. Diversity of landform, in part underlain by coastal limestone and generally overlain by urban development in the Geraldton area has given rise to a wide range of instability rankings. High instability is notable between Separation Point and Point Moore as well as between the Chapman River and Glenfield. The coast between the Marina and St Georges is both highly susceptible to change due to its exposure and has a high instability ranking. It is a severely eroded shore.

   The character of the coast changes between Glenfield and the Bowes River. The inner continental shelf and shoreface are narrower than further south; much of the shore is stabilized by rock platforms and low bluff; the beaches are increasingly exposed with distance north; barrier forms included episodic transgressive dunes or narrow foredune plains abutting an older barrier complex; and there are numerous ORV

tracks in the area. The vulnerability ranking is derived from moderate levels of susceptibility and instability in the three cells comprising the compartment.

4. The remainder of the compartments subject to an overall moderate to high level of vulnerability to environmental change. This is apparent in three geographic areas.

   First, a wide transgressive barrier with nested parabolic dunes and mobile sand sheets is present between Cliff Head and Leander Point . It has formed landward a sandy inshore and has exposed beaches with bars and rips along a rhythmic shoreline. In many places, the frontal dunes have been scarped and a discontinuous foredune has formed seaward of the scarp face. These characteristics indicate moderate levels of vulnerability and a high level of instability.

   Second, from Nine Mile Beach to Cape Burney South much of the coast is stabilized by a high rock platform and beaches are either perched on the platform or occur in small embayments between rock outcrops. The inshore reef pattern alters and the degree of exposure increases with distance north. As a result the susceptibility of the cells in the compartment is low in the southern and moderate in the northern part of the compartment. In contrast to this the coastal barrier is high, narrow and incorporates active blowouts, mobile sand sheets, eroded frontal dunes and off road vehicle tracks which indicate a high level of landform instability.

   Third, the three compartments north of Bowes River contain extensive reaches of rocky coast with cliffs and/or shore platforms. The susceptibility of cells within the compartments is mainly moderate, although the cliffed coast between Bluff Point and the Murchison River adjoins a deep inshore and is potentially highly susceptible to erosion at a seabed level. Low lagoonal shores landward of exposed linear reefs at Horrocks, Port Gregory and along the coast Eagles Nest to Waygoe Well are indicative of long-term coastal erosion and in many places the coast is backed by mobile dunes and sand sheets. Correspondingly, the compartment has a high instability ranking.

WEB SUMMARY

Certain landforms and coastal features are more vulnerable to climate and sea level variation than others. Hence the immediate aim of this project was to determine the vulnerability of landforms on the Mid-West coast to changing weather and oceanographic (metocean) conditions, including projected changes in climate. Information was gathered on coastal landforms and coastal processes to identify vulnerable locations and assist decision-making regarding proposed coastal development and for coastal management purposes.

The structure and formation of landforms and coastal features between North Head and Nunginjay Springs Coast North is tied to rock outcrops along the shore as well as the presence and shape of the nearshore reef system. Coastal limestone forms much of the coast but merges with sandstone north of Bluff Point. The bedrock geological control was used to identify discrete sediment cells where changes to landforms in one part of a cell were highly likely to affect the remainder of the cell but potentially with limited affect on adjoining cells. Sixty four cells were identified along approximately 160 km of coast. Potential relationships between the sand ridges (barriers) and the underlying coastal limestone topography were determined; landform patterns comprising the dune systems identified; and individual landforms described for sixty one of the cells. The remaining three cells include the engineered environments at Geraldton, including the port and town beach. The scales of description respectively correspond to scales used in the compilation of coastal management strategies and plans.

Landform vulnerability was estimated as a combination of the susceptibility of the geological structure supporting the landforms to environmental change and the current condition of the landforms as indicated by existing evidence of erosion. Together, a geological structure and the landforms it supports define a land system. The assessment linked the integrity of the geological or geomorphologic structures of land systems and the condition or stability of the landforms supported in a matrix to estimate five grades of vulnerability (Figure A). Susceptibility rankings were determined from values assigned to marine topography near the shore; the shape of the shoreline; coastal orientation; and the prevailing type landforms present in the cell. Similarly, instability rankings were based on the proportion of rocky versus sandy seabed; beach type and/or beachface shape; whether the frontal dune complex was eroded; and an overall estimate of vegetation cover on the sand barrier. The analysis was intended to be indicative rather than prescriptive, with applications for strategic planning purposes as a first step to more detailed risk assessment procedures.

Results included the location of cells, which were named after their southern boundaries, and the estimated vulnerability of each cell as shown in Table A and Figures B and C. Vulnerability rankings determined on a five-point scale for each sediment cell indicated four (6.5%) of the 61 cells examined had a low level of vulnerability; 14 (23%) were of low-to-moderate vulnerability; 17 (28%) were moderately vulnerable; 22 (36%) were of moderate-to-high vulnerability and four (6.5%) had a high ranking. More detail is available from the full technical report *The Mid-West Coast, Western Australia: Shires of Coorow to Northampton. Geology, Geomorphology & Vulnerability*.

			INSTABILITY (CONDITION) (Existing morphologic change to land surface)		
			Low (Stable)	Moderate	High (Unstable)
			Example		
SUSCEPTIBILITY (STRUCTURE) (Potential change to geological structure	Low	Barrier perched on extensive tracts of coastal limestone	(1) Vegetated swales in parabolic dunes landwards of a vegetated frontal dune ridge overlying coastal limestone above HWL	(2) Vegetated dunes landwards of a vegetated frontal dune ridge and perched on coastal limestone at HWL	(3) High foredune ridge and/or vegetated foredune plain overlying coastal limestone below HWL
	Moderate	Weakly lithified barrier with intermittent limestone outcrops	(2) Mainly vegetated swales in parabolic dunes landwards of a mainly vegetated frontal dune ridge	(3) Vegetated dunes landwards of a mainly vegetated frontal dune ridge (50 to 75% cover) and overlying coastal limestone	(4) Cliffed or discontinuous foredune fronting moderate numbers of mobile blowouts and sand sheets (<50% of the alongshore reach)
	High	Barrier comprised wholly of sand. No bedrock apparent along shore or in dunes	(3) Swales in parabolic dunes landwards of a partly vegetated frontal dune ridge	(4) Mainly vegetated dunes landwards of a partly vegetated frontal dune ridge with 25 to 50% cover	(5) No foredune. Eroded frontal dune with numerous mobile blowouts and sand sheets (>50% of the alongshore reach)

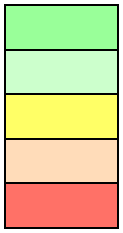

Figure A: Indicative Vulnerability Matrix for a Mixed Sandy and Rocky Coast

Note: Susceptibility of a geologic structure to environmental change and the current instability of coastal landforms were estimated for each coastal cell on a three point scale as being low, moderate or high. In the matrix these were combined to provide a five point estimation of the vulnerability.

Table A: Susceptibility, Instability and Vulnerability Rankings for Each Cell

Cell	Southern Boundary of Cell	Susceptibility	Instability	Vulnerability
64	Murchison River	M	H	M-H
63	Red Bluff	H	M	M-H
62	Pot Alley	H	H	H
61	Bluff Point	H	H	H
60	Waygoe Well	M	H	M-H
59	Waygoe Well S.	M	H	M-H
58	Yanganooka	M	H	M-H
57	Sandalwood Bay	H	H	H
56	Shoal Point	M	H	M-H
55	Eagles Nest	M	H	M-H
54	Broken Anchor Bay	M	H	M-H
53	Menai Cliffs	M	H	M-H
52	White Cliffs	M	H	M-H
51	Whale Boat Cove	M	H	M-H
50	Bowes River	L	H	M
49	Coronation Beach	M	M	M
48	Buller	M	M	M
47	Glenfield	M	M	M
46	Chapman	M	H	M-H
45	Saint Georges	M	L	L-M
44	Marina	H	H	H
43	Geraldton East	Not assessed		
42	Geraldton West	Not assessed		
41	Connell Road	Not assessed		
40	Pages	M	L	L-M
39	West End	M	M	M
38	Point Moore	M	M	M
37	Separation Point	M	H	M-H
36	Cape Burney N.	M	M	M
35	Greenough North	M	M	M
34	Cape Burney South	M	H	M-H
33	West Bank	M	H	M-H

Cell	Southern Boundary of Cell	Susceptibility	Instability	Vulnerability
32	Phillips Road Coast	M	H	M-H
31	Lucys	M	H	M-H
30	Duncans Pool	M	H	M-H
29	Flat Rocks	M	M	M
28	Headbutts	L	M	L-M
27	Shire Boundary	L	H	M
26	Bookara South	L	H	M
25	Nine Mile Beach	M	H	M-H
24	Seven Mile Beach	L	M	L-M
23	Harleys Hole	L	M	L-M
22	Dongara North	L	M	L-M
21	Leander Point	L	M	L-M
20	South Leander Point	M	H	M-H
19	White Point	M	H	M-H
18	Cliff Head	M	H	M-H
17	North Knobby Head	L	L	L
16	South Illawong	L	L	L
15	Gum Tree Bay	L	M	L-M
14	Coolimba	L	M	L-M
13	Tailor Bay	L	M	L-M
12	Leeman	L	M	L-M
11	Webb Islet	L	L	L
10	unsurveyed point	M	L	L-M
9	Little Anchorage	M	M	M
8	Point Louise	M	M	M
7	Greenhead	M	M	M
6	South Bay	M	M	M
5	Fisherman Islands	L	M	L-M
4	South Fisherman	L	L	L
3	Sandy Cape	M	L	L-M
2	Sandland	M	M	M
1	North Head	M	M	M

Key	Vulnerability of environmental change	Implications for coastal management (see Table 2-11 for further description)
	Low	Coastal risk is unlikely to be a constraint to coastal management
	Low -to-moderate	Coastal risk may present a low constraint to coastal management
	Moderate	Coastal risk may present a moderate constraint to coastal management
	Moderate-to-high	Coastal risk is likely to be a significant constraint to coastal management
	High	Coastal risk is a highly significant constraint to coastal management

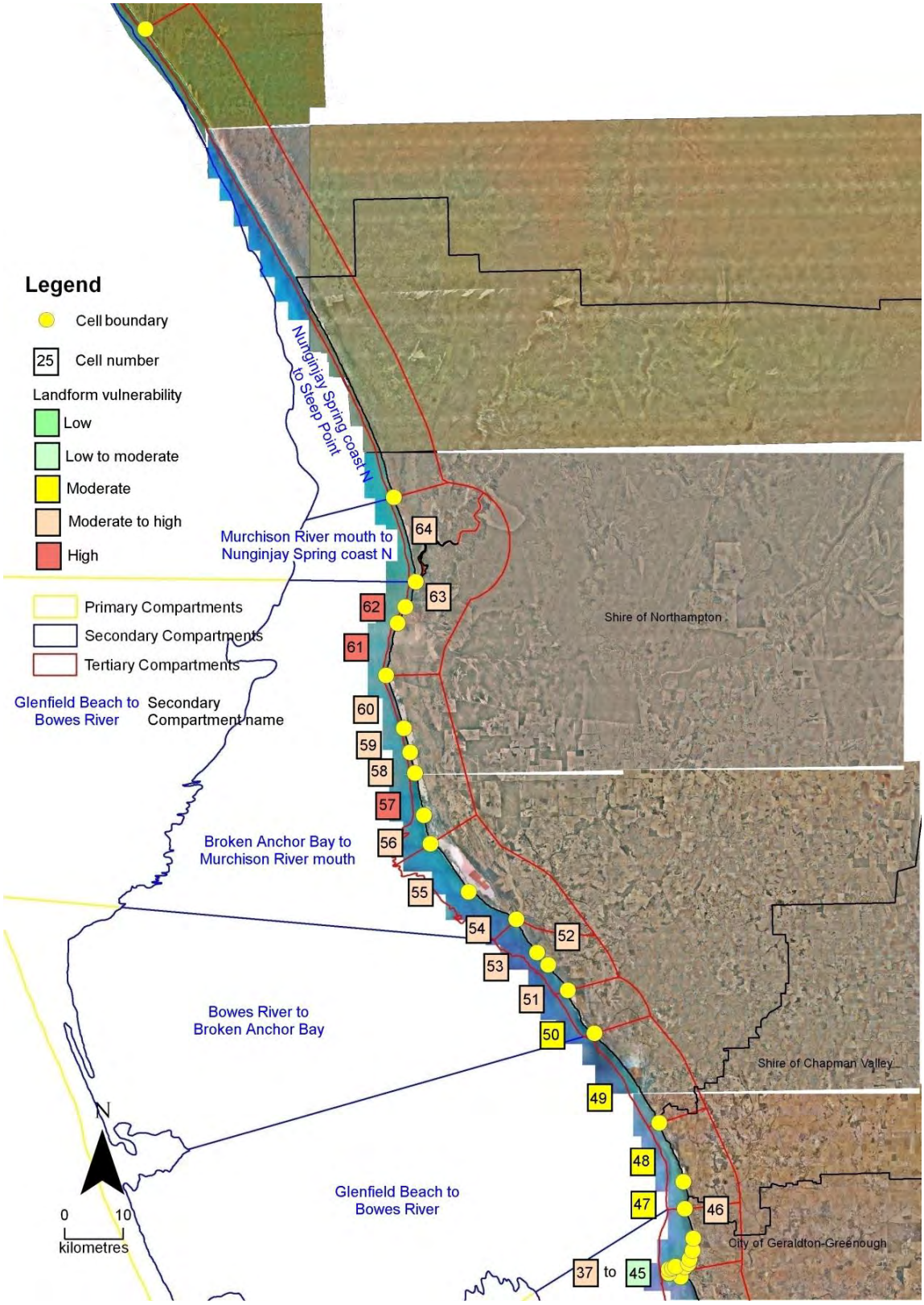

Figure B: Estimated Vulnerability Rankings for the Mid-West Coast – Point Moore to Nunginjay Spring Coast North

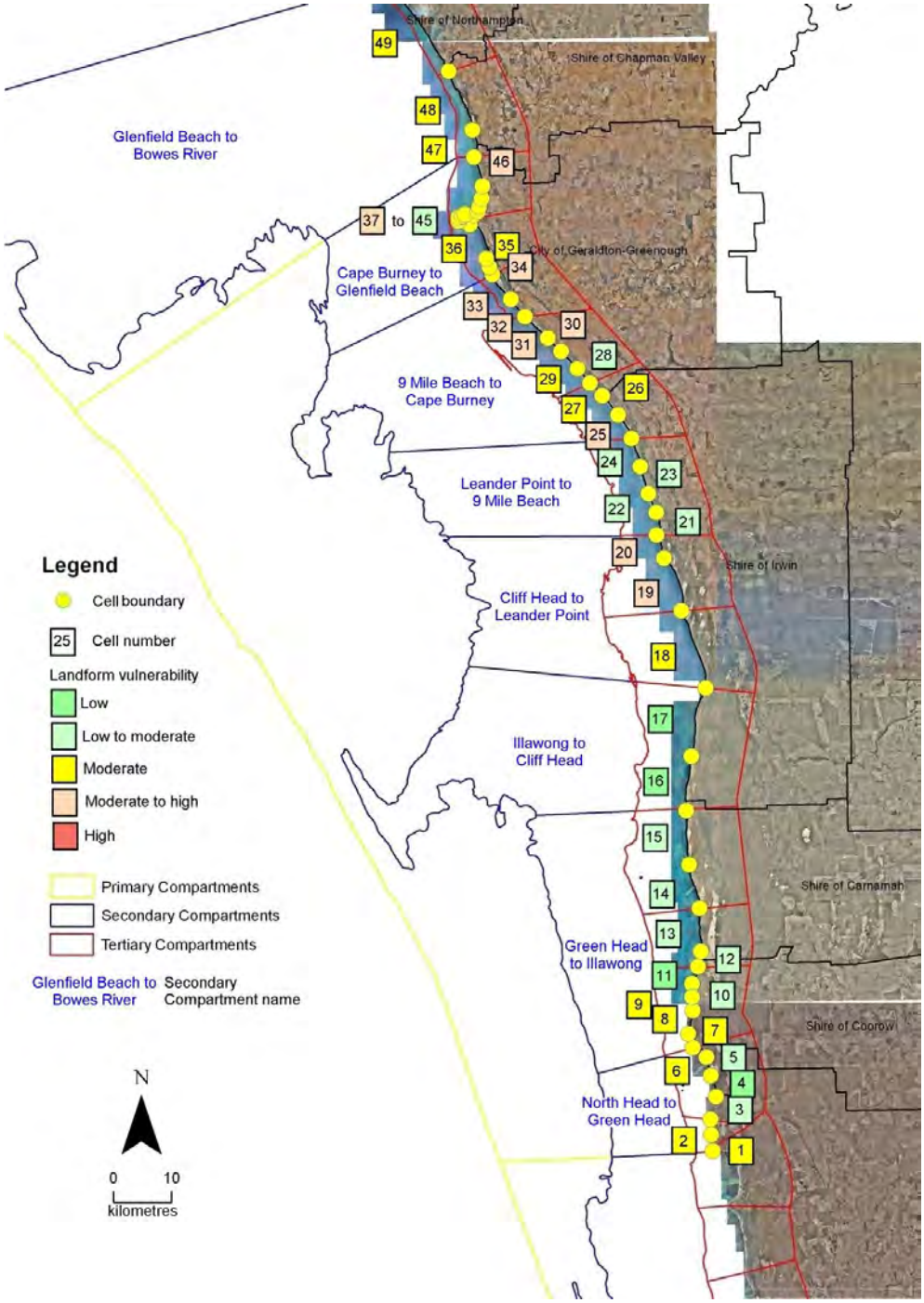

Figure C: Estimated Vulnerability Rankings for the Mid-West Coast – North Head to Coronation Beach

Note: Compartments were defined as large sections of coast with a common land system. Three levels were identified from primary to tertiary compartments, with the offshore boundaries at the 130m, 50m and 20m depth contours. Each compartment contained a number of sediment cells to which the vulnerability rankings were ascribed. The vulnerability rankings referred to the cell as a whole but not to individual landforms. Different landforms within each cell were likely to have higher or lower levels of vulnerability than the cell as a whole.