Department of
Transport

Coastal Sediment Cells for the Pilbara Coast

Between Giralia and Beebingarra Creek, Western Australia

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The custodian of the digital dataset is the Department of Transport.

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Geological Survey of Western Australia

Seashore Engineering

Executive summary

The aim of this report is to identify a hierarchy of sediment cells to assist planning, management, engineering, science and governance of the Pilbara coast.

Sediment cells are spatially discrete areas of the coast within which marine and terrestrial landforms are likely to be connected through processes of sediment exchange. They are often described in the estimation of sediment budgets. Cells include areas of sediment supply (sources), sediment loss (sinks), and the sediment transport processes linking them (pathways). The transport pathways include both alongshore and cross-shore processes, and therefore cells are best represented in two-dimensions.

Sediment cells are natural management units with a physical basis and commonly cross jurisdictional boundaries. They provide a summary of coastal data in a simple format and can be used to:

1. Identify the spatial context for coastal evaluations;
2. Provide a visual framework for communicating about the coast with people of any background;
3. Support coastal management decision-making;
4. Support a range of technical uses largely relating to coastal stability assessment, such as interpreting historic trends, understanding contemporary processes and basis for projection of potential future coastal change; and
5. Reduce problems caused by selection of arbitrary or jurisdictional boundaries.

Boundaries of sediment cells have been identified for the Pilbara coast between Giralia (southern Exmouth Gulf) and Beebingarra Creek (east of Port Hedland) in Western Australia. Five primary cells, 11 secondary cells and 48 tertiary cells were identified. The eastern primary cell extends 365 km east of Beebingarra Creek to Cape Jaubert in the Canning Region to include the influence of the De Grey River. The cell hierarchy for the Pilbara coast is presented as maps and tables in this report, and in electronic datasets available from the Department of Transport. They were defined in three steps through selection of:

1. Points along the shoreline (beachface) that incorporate river system influence;
2. Offshore and onshore boundaries; and
3. Alongshore boundaries connecting the beachface points to the offshore and onshore boundaries.

The extent of cells in the Pilbara were defined to include areas with likely sediment supply by river systems, such that whole deltas were incorporated within broader cells.

The cells have been mapped as a hierarchy of primary, secondary and tertiary levels to incorporate three space and time (spatio-temporal) scales. This hierarchical representation of cells provides a basis for implementation of integrated planning and management at a number of scales, from small-scale engineering works, through to large-scale natural resource management.

- Primary cells are related to areas with sediment supply from river systems and large rock barriers to alongshore sediment transport. They are most relevant to potential change in large landform assemblages or land systems over extended coastal management timescales of more than 50 years.
- Secondary cells incorporate contemporary sediment movement on the shoreface, variation in supratidal landforms and potential landform responses to inter-decadal changes in coastal processes.
- Tertiary cells are defined by the reworking and movement of sediment in the nearshore and are most relevant for seasonal to inter-annual changes to the intertidal landforms on the beachface. Mapping of tertiary cells was limited to the beachface point because of insufficient resolution of the available datasets.

Common use of cells is intended to facilitate better integration of coastal management decision-making between governance, science and engineering at a regional and local level.

Contents

Introduction

This report presents a hierarchy of sediment cells along the Pilbara Coast for application in planning, management, engineering, science and governance of the region.

Sediment cell boundaries were mapped and identified at three spatio-temporal scales, along approximately 810km of the Western Australian coast between Giralia (Exmouth Gulf) and Beebingarra Creek (east of Port Hedland). The area includes the inner continental shelf together with the coastal lands of the Northern Carnarvon Basin and the Pilbara Craton (Figure 1; Figure 2; Appendix A). The three scales range from landforms and the day-to-day processes and extreme events affecting them to large coastal systems changing over millennia in response to global processes. At each scale the cells identify boundaries within which to consider the potential implications of proposed coastal engineering works as well as for assessment of coastal planning and management practices.

The hierarchy of cells facilitates understanding of contemporary sediment movement, encourages improved projection of future coastal change, and establishes a context for qualitative investigations. Additionally, the hierarchy is intended to assist identification of differences in the processes driving coastal change at each scale.

Cells within this report are labelled according to a system described in *Cell labels.*

What are sediment cells?

Sediment cells are spatially discrete areas of the coast within which marine and terrestrial landforms are likely to be connected through processes of sediment exchange. They are commonly described in the estimation of sediment budgets. Each cell includes areas of sediment supply (sources), loss (sinks), and areas through which sediment is moved between sources and sinks (pathways)[1]. These components are illustrated in Figure 3 for all levels in the hierarchy. Cells are natural management units with a physical basis and commonly cross jurisdictional boundaries.

Box 1: Literature on sediment cells

Sediment cells are spatially discrete areas of the coast within which marine and terrestrial landforms are likely to be connected through processes of sediment exchange. They are commonly described in the estimation of *sediment budgets*. Extensive global literature related to coastal sediment cells and sediment budgets is available and has previously been reviewed[2,3,4,5,6,7,8]. The literature includes a number of terms similar in meaning to coastal sediment cell, with slight disparities in their use, although the broad concepts underpinning cell identification and sediment budget estimation are well established[6].

Alternative terms for coastal sediment cell at varied spatial scales are littoral cell[1,9], coastal compartment[10], coastal sector[11], beach compartment or coastal segment[12], sediment cell with smaller coastal process units or sub-cells[13], coastal cell[14], process defined management unit or coastal management unit[15,4], coastal tract[5] and three nested systems of coastal behaviour systems, shoreline behaviour units and geomorphic units[16]. The term sediment cell is used in this report for the Pilbara Region.

Sediment cells are commonly identified as self-contained where little or no sediment movement occurs across cell boundaries[16,8]. This concept is most applicable at a broad scale, such as when defining the scale and limits of coastal investigations[5]. Restriction of sediment movement is not a fundamental characteristic of cells at a fine scale or those not markedly compartmentalised by extensive rocky headlands. For less compartmentalised coasts with extensive reworking of river sediments, such as the Pilbara coast, the sediment cell approach retains meaning, although cells may have substantial sediment exchange across their boundaries[2,17].

Constraints to sediment transport vary over time for different spatial scales and types of cell boundaries, as well as sediment availability. For example, some rocky headlands are bypassed under infrequent high-energy conditions, but are a major constraint to sediment transport on a seasonal basis. Similarly, on sandy coasts cell boundaries may correspond to ephemeral areas of sediment transport convergence which indicate zones of reduced transport[18,19].

Variability in sediment bypassing at boundaries prompts the incorporation of time-dependence when relating sediment fluxes at different levels of the sediment cell hierarchy[10], such as using dilation or 'morphodynamic' factors. This concept is considered less applicable in the Pilbara than in south-west Australia because of an increased dependence of sediment flux on the volume and distribution of available sediment, the broad shelf structure, and influence of large episodic sediment pulses caused by tropical cyclones or river flood events. Although these factors cause greater interplay between processes active over different time and space scales, there is a general spatio-temporal relationship between levels of the cell hierarchy. Larger (primary) cells are generally related to longer-term processes and secondary and tertiary cells are more dependent on the supply and spatial distribution of available sediment.

Cell boundaries defined in this document extend landward from points on the shoreline to include terrestrial landforms, and seaward to encompass the nearshore marine environment in which waves and currents are most active. The offshore and onshore boundaries of cells should be determined by the scale of sediment transport processes operating within a cell, as well as by topographic features.

Why use sediment cells?

Sediment cells define natural units with each cell encompassing adjoining marine and terrestrial environments. The cells thereby provide a base for integrated coastal management in which the components of each cell is considered holistically as an interactive system. In this context sediment cells aid interpretation of historic trends, add to an understanding of contemporary processes and provide an important basis for projection of future coastal change. The objectives of determining a three-scale hierarchy of cells were to:

- Identify sediment cells which are recognisable as natural management units for regional, sub-regional and local scale coastal studies;
- Establish a framework for linking marine and terrestrial projects that is founded on the connectivity of subaqueous and submarine coastal landforms, and which supports integrated coastal planning and management;
- Identify areas of coast where sediment budget estimates may provide a useful tool for coastal planning and management based on landforms at varying time and space scales[20,21,22]; and
- Avoid clashes of policy and practice where coastal management is required by neighbouring coastal agencies, particularly local government authorities, within single or adjacent cells.

Characteristics of the sediment cell approach which make it a fundamental tool for assessment of hazards to land use caused by coastal change are that[23]:

- There is a plausible connectivity of geology, landform and hydrodynamics for coastal evolution and change that can be established and used in identification of the cells[24];
- It focuses on the integration of coastal and marine processes with landform responses to them rather than more static, quasi-equilibrium approaches such as those forming the basis for numerical models of beach profile change; and
- The consistent methodology applied to identifying the cell hierarchy facilitates up-scaling and down-scaling in assessments of coastal change, a capability recommended in the assessment of coastal vulnerability to meteorologic and oceanographic change[25].

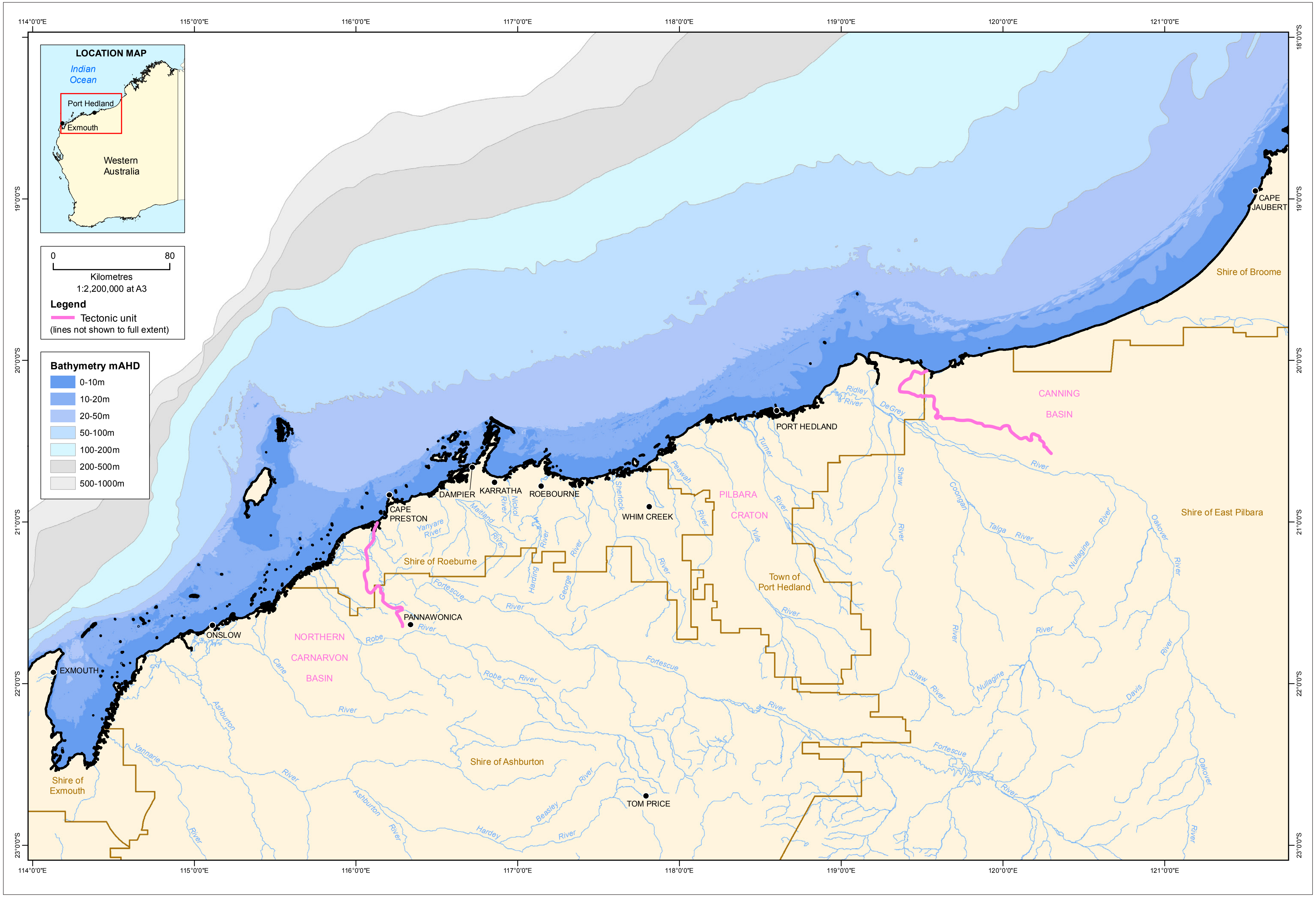


Figure 1: Pilbara Region coast from Giralia to Beebingarra Creek

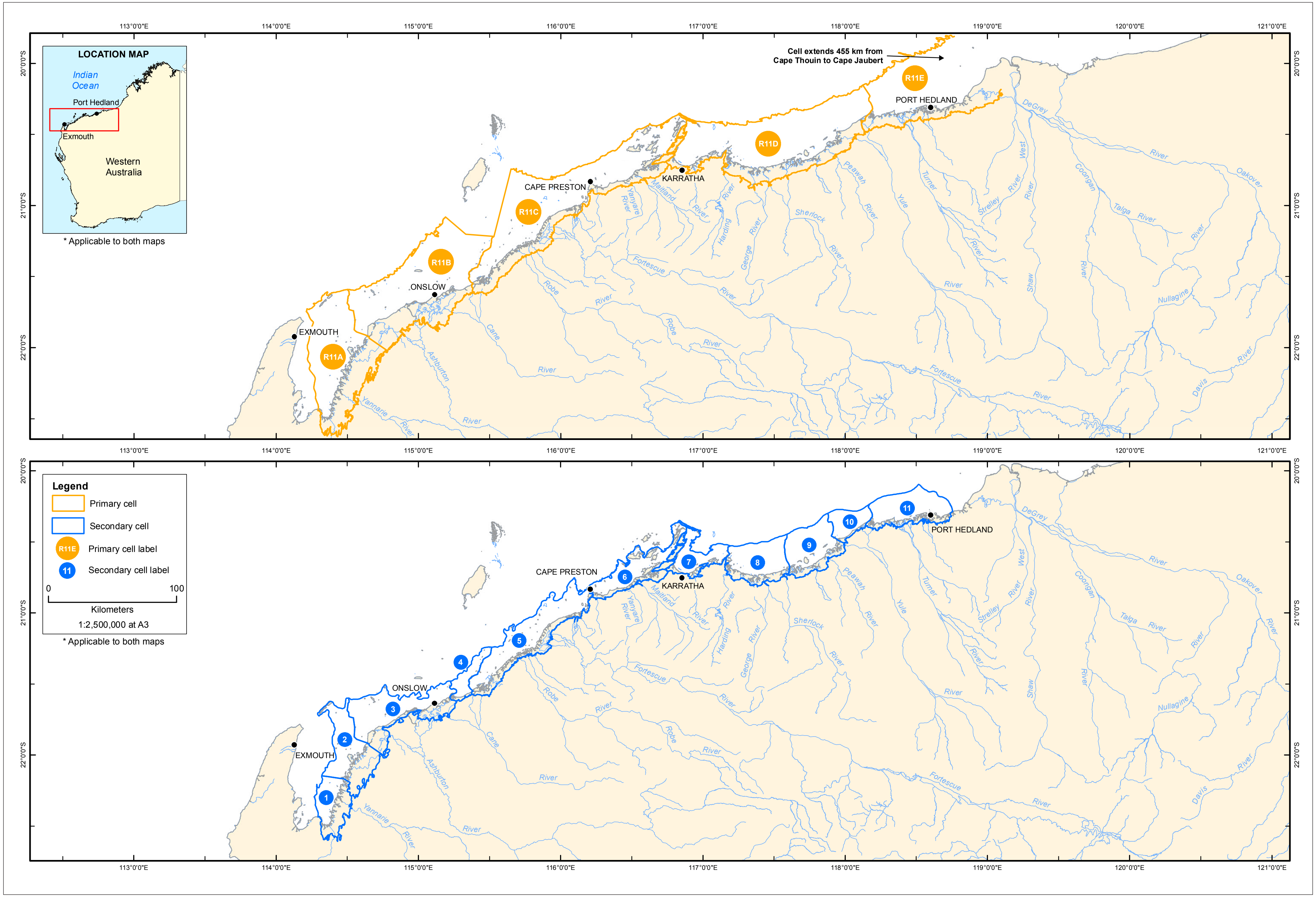


Figure 2: Primary and secondary cells of the Pilbara Region

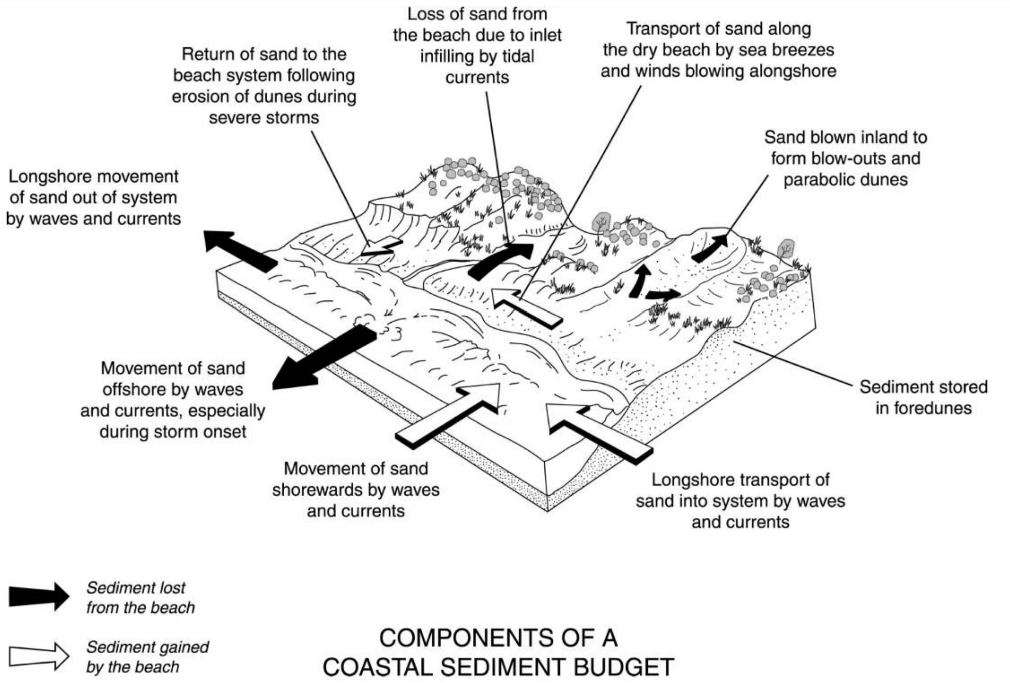


Figure 3A: Components of a coastal sediment cell (WAPC 2003)

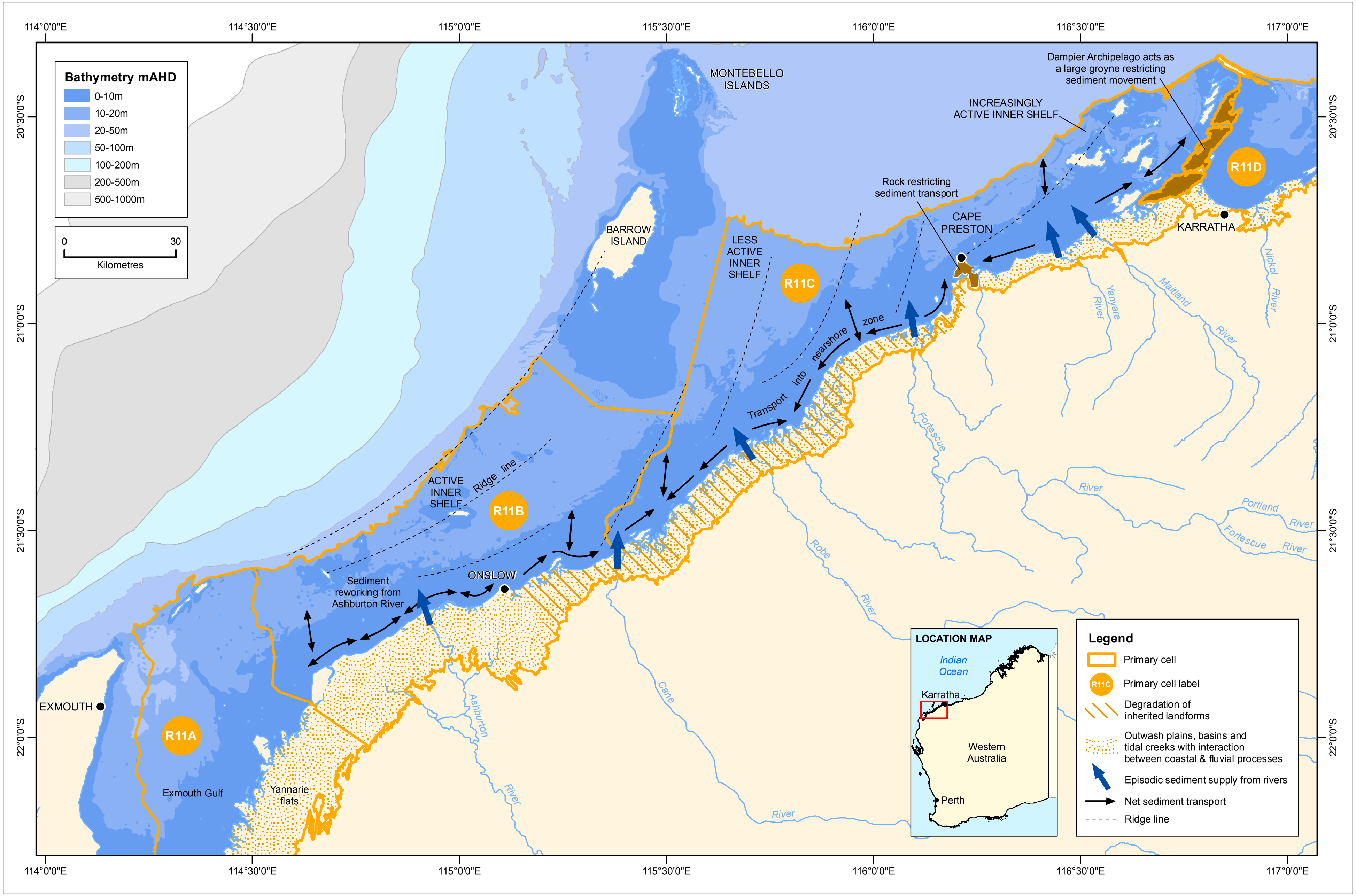


Figure 3B: Example primary cells (R11A-R11D)

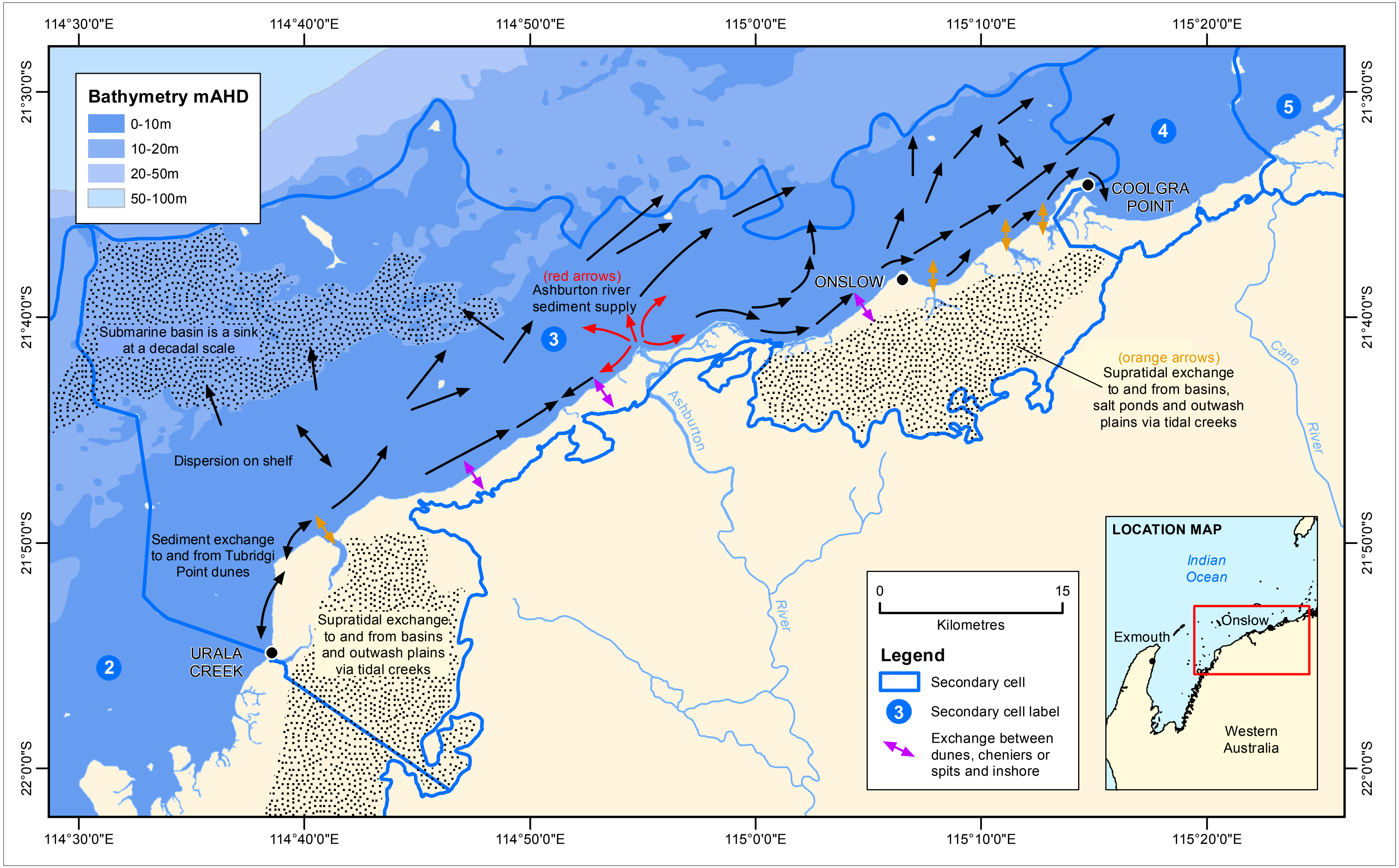


Figure 3C: Example secondary cell (R11B3)

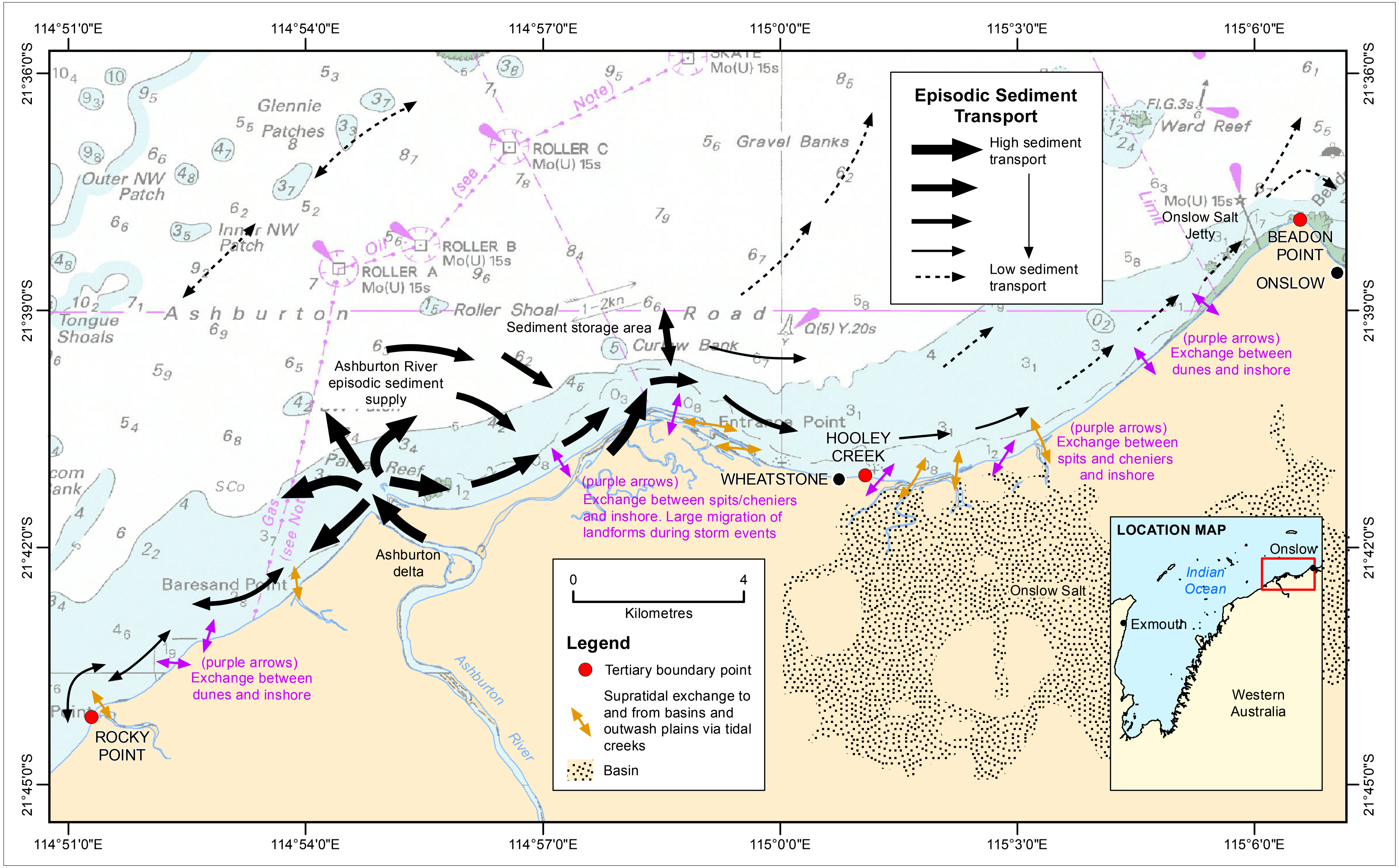


Figure 3D: Example tertiary cell (R11B3c,d)

The Pilbara coast

The Pilbara coast is an inherited coast, with a complex array of ancient and modern landforms. Its sedimentary coastal landforms incorporate features developed under environmental conditions existing millennia or centuries before present. Its ancient hard-rock terrain is overlain or abutted by sediments from coral reefs, floodplains and river deltas deposited through multiple phases over millions of years. In places the riverine sediments have been lithified, which along with old reefs and beachrock, now form coastal limestones. Elsewhere, active sedimentary landforms abut and overlie a complex and old terrain cut into the hard-rock Archean geology of the Pilbara Craton and more recently formed sedimentary rocks. At present the Pilbara coast is mainly macro-tidal, subject to impacts of tropical cyclones, and has a highly variable supply of sediment from rivers. Most of the sediment has been dispersed on the flat inner shelf or lost offshore. As a result little sediment has been captured in coastal barriers over the late Holocene[26].

Unconsolidated landforms of the Pilbara coast[27] are largely comprised of low-lying arid floodplains, flanking a broad continental shelf. The presence and nature of sedimentary features are highly variable across the broad and shallow shelf, with the shelf structure and features important considerations in defining sediment cells in the Pilbara Region. The sedimentary features generally occur as shallow deposits overlying rock platforms, structurally constrained by retention or shelter from chains of limestone ridges and islands, many of which are remnants of previous shorelines.

The coast is dominated by meso- to macro-tidal variation, with the occasional effect of severe tropical cyclones. The latter deliver floods and marine inundation events that impact on the landscape and drive geomorphologic change. Coastal landforms, including river deltas and tidal flats, extend more than 2km inland for the majority of the Pilbara Region[28, 29]. The interaction of marine and terrestrial processes thus occurs over a very broad coastal strip, from bedrock high ground in the hinterland to the outer margin of wave and tidal activity on complex shelf topography. The nature of sheltering or retention may be significantly disturbed during tropical cyclones, causing a large shift in structure, which typically returns gradually towards the previous state under less energetic conditions. The nature of this cycle has been inferred from management of Port Hedland's shipping channel. Significant sedimentation was not identified immediately after tropical cyclone impact, but elevated and gradually declining sedimentation rates were observed for several years following, with winnowing of surface sediments measured[30,31,32].

The unconsolidated landforms provide an indication of the sediment source areas, transport pathways and sinks; although the functions need to be established in relation to the processes driving coastal change. The river channels, riverine outwash plains, river deltas, tidal flats, coastal dunes, cheniers and spits, wide subtidal terraces and extensive sand shoals of the coast are all subject to significant change under extreme meteorologic and oceanographic conditions. However, the nature of landform response varies according to the relative resistance of the coast, which is a combination of material types (geology, sediment type and presence of vegetation) and the coastal form (which may be aspect, plan form, profile, or configuration of landform elements). The factors of environmental forcing, materials and landform have considerable interaction, in which variation of one factor potentially changes the other two. In this context there is an apparent disconnection between the fixed geologic framework and unconsolidated inshore sediment bodies.

The geologic framework of the Pilbara Region provides controls to sediment transport and coastal response[28,29,33]. At the largest scale, the large ancient hard-rock terrain (e.g. Cape Preston, Burrup Peninsula, Cape Lambert) and smaller rocky headlands are barriers to sediment transport along the shore at varying scales. However sediment transported offshore from the coast and inshore areas is distributed within the broad inner shelf plain, with some bypassing of these features. This pattern of dispersal is also influenced by chains of limestone ridges and islands. Along the shore, the geologic framework is comprised of headlands, cliffs, bluffs, lithified cheniers, remnant reefs, lithified river and tidal creek banks, underlying pavement, beach rock ramps and platforms. Further onshore, the geologic framework in the form of cliffs and bluffs may constrain sediment transport to landward (e.g. Cape Preston, Burrup Peninsula, Cleaverville coast, Anketell Point, Cape Lambert, Point Samson, Downes Island) with beach and bar 'ribbons' forming on the seaward side of some of these features.

Rivers and streams

River systems provide a sediment source to active coastal dynamics in the Pilbara Region through the episodic release of massive quantities of sediment[29,33,34]. The largest rivers are the De Grey, Ashburton and Fortescue Rivers (Figure 1) with some rivers (Ashburton, Cane, Robe, Fortescue, Maitland, Harding, Sherlock, Yule, Turner and De Grey) directly connected to the ocean contributing to delta building and floodplain development. Other streams and rivers (Yannarie, Yanyare, Nickol, George, Peawah and Ridley) do not discharge directly into the ocean, with many releasing water and sediments into tidal-flat basins that occur landward of the coastal ridge[35,36,37]. However, these systems are connected to the coast via tidal creeks and irregularly contribute sediment to the coast at times of flood. While much of the released material is fine-grained, and is broadly dispersed, the coarser fraction form deltaic features on the larger river systems and may contribute to sediment fans on the inner shelf[38]. In addition to sediment deposition from larger rivers, smaller stream systems and tidal channel networks interact within the broad areas of tidal flats prevalent along the Pilbara coast. These areas display the majority of inter-tidal and supra-tidal coastal change, with rapid switching between accretion and erosion of the tidal flats indicating adjustment to changing meteorologic and oceanographic conditions[39]. Further, ephemeral creeks adjacent to rocky topography, such as at Dampier and Karratha, have small catchments that are locally important at times of high flood discharge when they are affected by coastal processes.

The geographic distribution of the rivers and their intermittent flow, results in sediment availability along the coast being extremely variable. Where sediment supply is limited, coastal variability is largely constrained by the rock framework (e.g. Burrup Peninsula) and old landforms (e.g. palaeo-deltas) forming its inherited structure. Where the barrier system constrains sediment supply to coastal floodplains, there is opportunity for floodplain drowning[40]. Conversely, for areas of the Pilbara coast where sediment supply is effectively unrestricted, landform changes are highly variable and may readily adjust to fluctuations in coastal processes (e.g. Ashburton Delta[41]).

Coastal processes

Coastal dynamics in the Pilbara are brought about through an irregular combination of tidal flows, episodic tropical cyclone impacts, variable sediment release from river systems and generally mild ambient wave conditions[42]. These diverse environmental conditions produce change that is rarely responsive to a single forcing mechanism, with many sedimentary features in the Pilbara displaying perturbation-recovery behaviour. The large range of both tides and cyclone-induced waves means that many sedimentary coastal features are capable of being heavily eroded over short timeframes. However, the underlying or abutting geological framework may provide a physical limit to change at different scales. Sedimentary features in the Pilbara tend to fall into the following classes:

- *Supply maintained features*, including deltas and strandplains, having a sufficiently high sediment supply to enable maintenance of a permanent presence;
- *Ephemeral features*, including spits, bars and beach 'ribbons', which experience periods of declined supply or enhanced erosion sufficient to cause short-term loss, with subsequent rebuilding. Ephemeral features are avoided as cell boundaries where possible, with many boundaries linked to rock;
- *Controlled features*, such as perched beaches or zones of updrift detention, where there is structural control that prevents the total disappearance of a feature, even under severe conditions;
- *Uncontrolled features*, including sand sheets, where neither supply nor structural control is sustained. These features may be formed due to a single event such as a tropical cyclone, and progressively evolve. These features are avoided as cell boundaries.

The distribution and relative permanence of sedimentary features is strongly linked to proximity to river systems and their rate of fluvial sediment release[43]. Estimates of fluvial sediment delivery to the coast are not yet reliable[34,44], with the proportions of fine or coarse sediment and the estuarine structure having a significant influence on sediment fate as plumes or deposition. The approximate extent of influence of river system sediment delivery is used as a criterion for separating cells in the Pilbara.

Further information on geology, geomorphology, landforms, rivers, meteorological and oceanographic processes for the Pilbara Region is included in recent vulnerability and geomorphic framework reports[27,29] and in previous work by Semeniuk[33,45,40,46] . Additional geology and geomorphology information is included in WACoast[28] database and from a country-scale study of Australian beaches[47]. Information on terminology used in this report is contained in previous reports[29 45 48 49] and global publications[50]. A glossary relevant to landforms in the Pilbara Region is included in Appendix B of the landform vulnerability report[29].

Methods for the definition of sediment cells

Coastal sediment compartments and cells have previously been investigated along the Pilbara Region[29,33] with other previous studies of regional coastal geomorphology available to define future cells[45,40,46,27,51,52]. A hierarchy of large-scale compartments was defined for the whole Western Australian coast[48] to provide a geological context for coastal processes within each compartment, hence supporting identification and description of sediment cells. At a finer scale, cells for the Pilbara Region were reported in 2013 comprising a set of points along the coast at each level in a three-scale hierarchy with limited coverage of tertiary cells[29]. This project refines the previous cells, determines a cell hierarchy and identifies cross-shore boundaries along the entire Pilbara Region.

In the present analysis established techniques[53] have been applied to map sediment cell boundaries along the Pilbara coast between Giralia and Beebingarra Creek, albeit with some modification of terminology and slight differences in the approach used. The modifications were necessary due to regional differences in coastal processes and landforms. It is worth bearing in mind that the Pilbara is a meso- to macro-tidal coast with substantial geological control, large river systems and outwash plains, palaeo-deltas and high levels of sediment reworking, with some areas experiencing sediment deficit. Notably, some adaptation of the technique used to identify and map sediment cells for the Vlamingh, Mid-West and Northampton Regions[53,54,55] was required for the Pilbara Region. It is expected that further revision of the criteria used (Figure 4; Table 1; Table 2; Appendix C) will be required for application to other parts of the WA coast or elsewhere.

A threefold hierarchy of cells was defined by the shelf structure, the influence of rivers, the type and shape of landforms present, frequency of coastal processes, and potential landform responses relevant to each scale. Each larger primary cell is an area influenced by sediment supply from large river systems and reworking of inherited deltas, changes in inner shelf (<-20 m AHD) structure and broad shifts in types of land systems. The smaller secondary and tertiary cells identify additional rock controls relevant at each scale, broad patterns of coastal degradation or aggradation, deltaic features and specific land systems at increasingly detailed scales. Further offshore, larger cells may extend to a ridge of islands and other continental shelf features well offshore, whereas a smaller cell may capture an offshore rock ridge encompassing the extent of tidal reworking in extreme events. At each scale cells are likely to vary in area based on the significance of river systems, dimensions of the geologic framework, extent of inherited and contemporary land systems, along with meteorologic and oceanographic processes driving coastal landform change.

Tasks undertaken were based on available data, and involved:

1. Review of available literature to determine prevailing regional and local processes driving geomorphic change[29], including their temporal and spatial attributes;
2. Identification of the geologic framework and environmental context in which processes operate;
3. Establishment of criteria to identify cell boundaries at each level in the hierarchy of spatial scales indicated in Task 1;
4. Application of the criteria along the Pilbara coast between Giralia and Beebingarra Creek to identify sediment cells;
5. Preparation of digital datasets and maps showing the cells at primary and secondary levels in the hierarchy, and points along the shoreline at the tertiary level; and
6. Comparison of potential differences in the morphodynamic processes active at each level in the cell hierarchy.

Information used to define the cells

Points along the shoreline that separate sediment cells were derived using the existing knowledge base of the coast, remotely sensed datasets and landform digital datasets (Table B.1 in Appendix B). Datasets used were:

1. 1:1M scale rivers dataset from Department of Water;
2. Landgate Mean High Water Mark (MHWM) shoreline compiled to 2006;
3. Australian Navy hydrographic charts and isobaths, along with Department of Planning isobaths derived from the hydrographic charts;
4. Onshore geology and geomorphology (including land systems and landforms) from the Geological Survey of Western Australia[28];
5. A shaded relief model from the Geological Survey of Western Australia;
6. Aerial orthophotography from Landgate; and
7. High-angle oblique aerial photography from the Geological Survey of Western Australia[28].

The datasets cover most of the Pilbara Region but vary with respect to time, spatial scale of capture and level of resolution. These factors limit use of the project datasets which may be reviewed as more detailed information becomes available. Information from which the secondary cell onshore boundaries were determined also included recent oblique aerial photography, the shaded relief model, 2011 field surveys and land system/ landform mapping at various scales using 2006 aerial orthophoto mosaics[28]. Hydrographic charts, isobaths and 2006 aerial orthophoto mosaics were used for delineation of the offshore boundaries and marine sections of the alongshore boundaries at both the primary and secondary cell levels.

Additional information, particularly at a local scale, may facilitate refinement of cell boundaries and provide data to map tertiary cell boundaries. In no particular order the extra information could include:

1. Local seismic surveys to determine rock coverage and depth of sediments;
2. Landform mapping of foredunes and frontal dunes for onshore boundaries of tertiary cells;
3. Sediment distributions;
4. Long-term analysis of aerial photographs for dune activity;
5. Benthic habitat information;
6. Collection of LiDAR bathymetry across further areas of the Pilbara; and
7. Contemporary and projected local variations in water levels, waves, currents and winds.

For example, detailed assessment of sediment characteristics and processes contributing to their distribution is useful for boundary verification[56] (see *Detailed evaluation of coastal behaviour*). An ongoing review process, say every 5 to 10 years, may allow the implications of observed coastal change to be incorporated.

Cell boundaries

A threefold hierarchy of cells is considered for the Pilbara coast with each cell represented as two-dimensions because sediment transport pathways include both alongshore and cross-shore processes. Each cell may be thought of holistically as a collection of marine and terrestrial landforms, inter-related by sediment exchange between the landforms.

In this study, cells have first been identified by distinguishing where major coastal landforms change or limits to the influence of river systems are apparent. These boundaries were then identified along the shoreline as a point on the beachface (Table 1). Thus the point may indicate a change in land system or landform (non-ephemeral), a rock structure or a change in orientation of the coast. Offshore and onshore boundaries are connected by mapping through the beachface points at the shoreline boundaries (Figure 4; Table 1; Table 2). Only points were identified for tertiary cells as available data were inadequate for accurate mapping of the onshore and offshore boundaries.

Alongshore cell boundaries (beachface points) are principally determined by one or several geologic, geomorphic or engineered features at the shoreline (Table 1). Each alongshore boundary has marine and terrestrial sections that connect the offshore and onshore cell boundaries through the beachface point (Figure 4). Distinctions between morphology and processes at each sediment cell scale are incorporated in criteria used to identify the beachface points and cell boundaries. Separate criteria are described for each level in the hierarchy (see *Primary cells, Secondary cells and Tertiary cells*). Sediment cells with cliffed coasts may have alongshore boundaries with no terrestrial section where the beachface point is coincident with the Landgate MHWM to 2006.

A list of features used to determine the alongshore boundary lines for marine and terrestrial sections is included in Table 1. Those identifying the marine section of the alongshore boundaries were not simple to resolve due to extensive tidal reworking of sediments derived from multiple rivers and spread across the broad nearshore area. The marine sections of the alongshore boundaries provide some restriction to sediment transport at the spatial scale of interest, generally in the form of a depression or a ridge (islands, rock promontory, engineered structure, sandbanks), or as an arbitrary line in places where no marine feature could be defined. The terrestrial sections of the alongshore boundaries also were not simple to resolve due to extensive marine and fluvial interactions over low-lying topography (basins). The terrestrial sections of alongshore boundaries follow ridge lines and high points, the interfluves between tidal creeks, reclaimed ground or as an arbitrary line in places where there is no variation within a basin or in landform elevations. Exceptions occur on cliffed coasts where there is no terrestrial section of the alongshore boundary, because the beachface point is coincident with the Landgate MHWM to 2006 or with the onshore boundary between adjacent cells (e.g. Cape Legendre R11C/D). In places where there is no marine or terrestrial feature to define a boundary, a notional boundary is mapped as a line through the beachface point to the offshore or onshore boundaries, respectively.

High-relief rocky topography at Cape Preston and the Burrup Peninsula is excluded from sediment cell boundaries as it is effectively immobile over coastal management timescales (Figure A.7 in Appendix A).

Points along the shore separating the cells are characterised according to the restriction of sediment transport (open or closed); the extent of the restriction (point or zone) and the potential for migration (fixed or ambulatory). For example the apex of a rocky headland is defined as a fixed point whereas a salient sustained by wave convergence behind a large area of reef is recognised as a fuzzy boundary or zone, although it is geographically fixed. Ambulatory features may be points (e.g. large spits) or zones (e.g. deltas). By definition, an alongshore boundary cannot be ambulatory and closed. A zone that is fixed and open, corresponding to a small and straight section of rocky coast, is a common feature of the Pilbara coast.

The concept of spatio-temporal scales, whereby larger spatial units are influenced by longer time scale processes[5] is valid for the Pilbara. However, due to the extreme variation in metocean conditions and the width of shallow shelf, the ability to discretely associate processes with spatial scale is much weaker than for the west and southwest coast. This implies that the hierarchy of spatial scales (primary, secondary, tertiary) should be used in parallel when exploring coastal dynamics.

Primary cells generally evolve over centuries and millennia. They are linked to large geological barriers, the influence of large rivers[29,33] and changes in coastal land systems[57,58,59]. Secondary cells are based on large coastal dune landforms[28], along with variation in supratidal landforms, mostly subject to inter-decadal change or due to large extreme events. Tertiary cells are based on the intertidal coastal landforms, which are subject to change on a seasonal to inter-annual scale and likely to be significantly impacted by extreme events.

Method overview

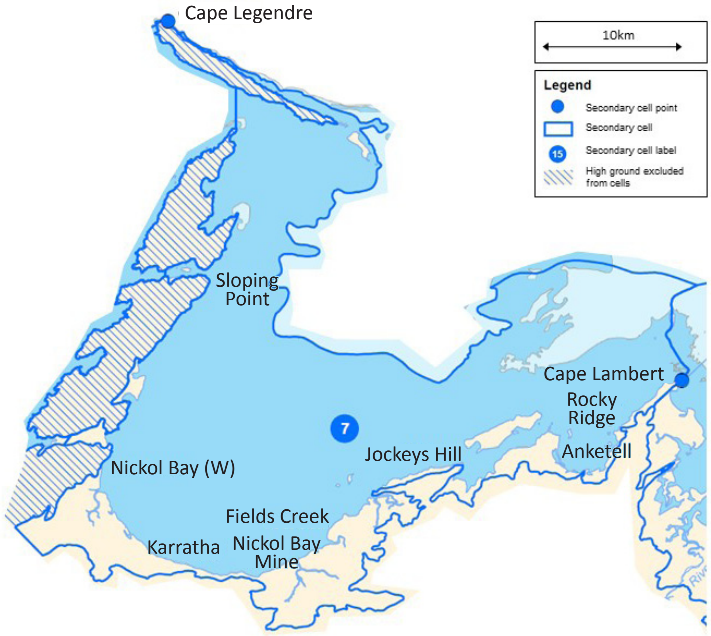
1) Identify boundary locations as points at the beachface, incorporating river system influence.

2) Identify offshore and onshore boundaries.

3) Map alongshore boundaries that connect onshore and offshore boundaries through the beachface point.

Each alongshore boundary has a marine and a terrestrial section.

4) Process is iterative and is checked between cell scales.



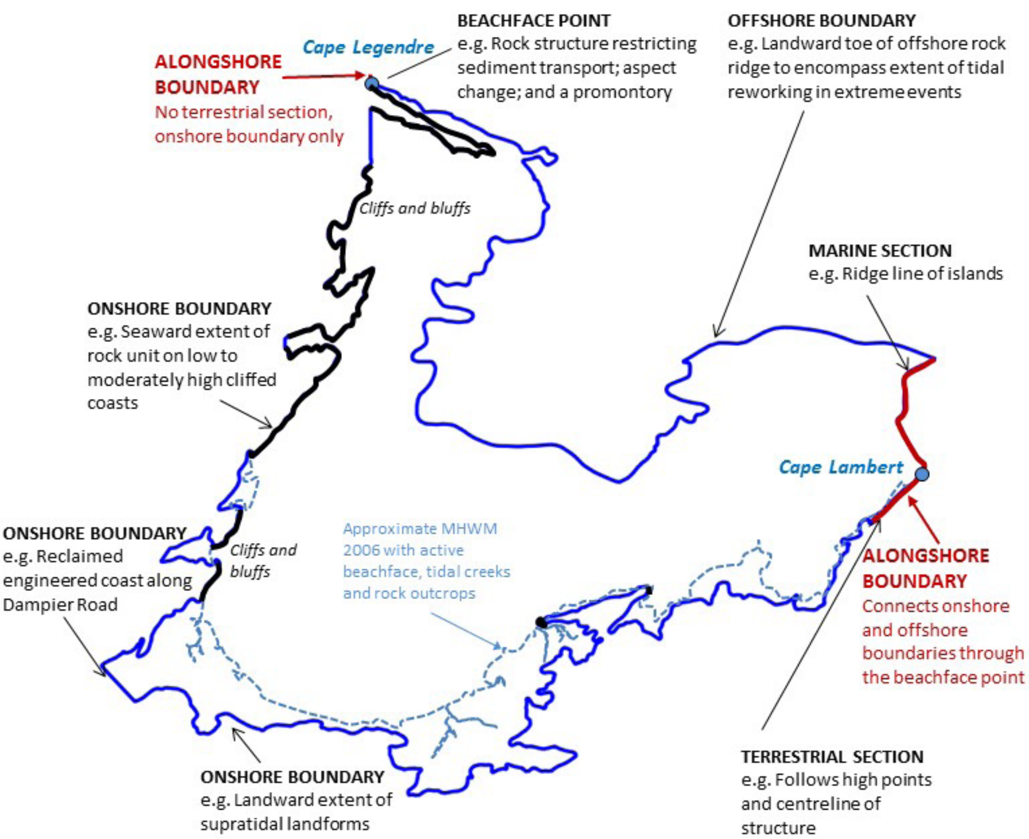


Figure 4: Cell boundaries - example for R11D7

Data Source: Bathymetry by Department of Planning and Australian Hydrographic Office and rivers by Department of Water.

Primary cells: rivers, geologic framework and long-term changes

Primary cells (Figure 2) encompass the geologic framework controlling long-term evolution of the coast, areas of sediment supply and large river systems. They encompass reworking of palaeo-deltas as well as the development of river deltas, tidal flats and coastal dunes. Although substantial changes to these large land systems occur at time scales longer than 100 years, they are significant as trends when considered over coastal management time scales.

At the shoreline, cells were first identified through large-scale change in the land systems or landforms present and separation of broad river systems, followed by change of coastal aspect and the influence of the geologic framework.

The broad geomorphic features in each of the primary cells include:

- R11A - supratidal Yannarie Flats from Giralia to Urala Creek
- R11B - deposition from the Ashburton River from Urala Creek to Yardie Landing
- R11C - palaeo-deltas of the Cane, Robe, Fortescue (active), Yanyare and Maitland Rivers between Yardie Landing and Cape Legendre
- R11D - Nickol Bay and broad regressed Sherlock Bay, including outwash from the Harding, George, Sherlock and Peawah Rivers between Cape Legendre and Cape Thouin
- R11E - littoral transport from the De Grey River and smaller Yule and Turner Rivers until the start of Pindan sediments at Cape Jaubert in the Canning Region.

Table 1: Criteria for mapping alongshore boundaries in the Pilbara Region

Variation of criteria will be required when applied to other coastal regions

	Primary cell	Secondary cell	Tertiary cell
Alongshore Boundary	**Marine Section** (i) Deepest point of depression/gulf or re-entrant of contours (ii) Ridge line of islands (iii) An extension of the beachface point to the offshore boundary	**Marine Section** (i) Deepest point of depression or re-entrant of contours (ii) Ridge line of islands (iii) Rock promontory (iv) High point of sandbanks (v) Centreline of engineered structure (vi) An extension of the beachface point to the offshore boundary	**Marine Section** (i) Deepest point of depression or re-entrant of contours (ii) Ridge line of islands, reefs or sandbanks (iii) An extension of the beachface point to the offshore boundary (iv) Rock promontory (v) Centreline of engineered structure (vi) Cliff line in the case of plunging cliffs (vii) No marine extension
	Beachface Point (May be multiple reasons for selection of position) (i) Rock structures restricting sediment transport at an inter-decadal scale (ii) Geomorphic feature (broad river system influence, followed by land system or landform on the boundary) (iii) Adjacent cells have a different shoreline aspect restricting sediment transport at a decadal scale	**Beachface Point** (May be multiple reasons for selection of position) (i) Rock structures restricting sediment transport at an inter-annual scale (ii) Geomorphic feature (broad geomorphic shifts, followed by land system or landform on the boundary) (iii) Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (iv) Engineered structure (e.g. large marina) or dredged channel	**Beachface Point** (May be multiple reasons for selection of position) (i) Rock structures restricting sediment transport at an extreme event scale (ii) Geomorphic feature (broad geomorphic shift, followed by landform on the boundary) (iii) Adjacent cells have a different shoreline aspect restricting sediment transport at an extreme event scale (iv) Engineered structure (e.g. small harbour) or dredged channel
	Terrestrial Section (i) An extension of the beachface point to the onshore boundary, following ridge lines and high points (ii) An orthogonal extension to the onshore boundary where there is no differentiation within a basin (iii) No terrestrial section, onshore boundary only	**Terrestrial Section** (i) An extension of the beachface point to the onshore boundary following ridge lines and high points (ii) An orthogonal extension to the onshore boundary where there is no clear differentiation in landform height (iii) No terrestrial section, onshore boundary only	**Terrestrial** (i) An extension of the beachface point to the onshore boundary, following ridge lines and high points (ii) Interfluves between tidal creeks (iii) Made ground (iv) No terrestrial section, onshore boundary only

Table 2: Criteria for mapping onshore and offshore boundaries in the Pilbara Region

Variation of criteria will be required when applied to other coastal regions

	Primary cell	Secondary cell	Tertiary cell
Offshore Boundary	(i) -20m AHD[1] isobath furthest from shore (ii) No offshore boundary, marine section of the alongshore boundary only	(i) -10m AHD[1] isobath closest to shore (ii) Landward toe of offshore rock ridge to encompass extent of tidal reworking in extreme events (iii) Connection across a channel	(i) -10m AHD[1] isobath closest to shore (ii) Landward toe of offshore rock ridge to encompass extent of tidal reworking in extreme events (iii) Connection across a channel
Onshore Boundary	(i) Continuous +7m AHD level for maximum tidal range of <2.5m (i) Continuous +8m AHD level for maximum tidal range of 2.5-5m (iii) Continuous +9m AHD level for maximum tidal range of >5m	(i) Landward extent of supratidal landforms (ii) Landward extent of coastal dunes (iii) Seaward extent of rock unit on low to moderately high cliffed coasts. If this extends to the beachface the Landgate MHWM to 2006 has been used (iv) Landgate MHWM to 2006 on engineered coasts with extensive shore parallel structures without coastal landforms to landward. Ports and made ground may be included	(i) Landward extent of intertidal landforms (ii) Landward extent of coastal dunes (iii) Seaward extent of rock unit on bluffed to cliffed coasts. If this extends to the beachface the Landgate MHWM to 2006 has been used (iv) Landgate MHWM to 2006 on engineered coasts with shore parallel structures without dunes to landward

Note: 1. Isobaths were mapped to the vertical datum of Australian Height Datum (AHD).

In mapping the sediment cells the distinction between adjacent large geomorphic features, or river systems, was identified as a beachface point at the shoreline. Each point corresponded to a non-ephemeral feature at the inter-decadal scale. Except for Urala Creek, these non-ephemeral features are mainly rock structures including promontories, lithified river banks and rock platforms. There are no alongshore boundaries controlled by an engineered structure at a primary cell level.

The offshore boundary of primary cells is the -20m AHD isobath or depth contour. It is located on the edge of the inner shelf. It encompasses ridges, platforms, channels, palaeo-deltas and chains of islands some of which reflect historic shorelines on the inner shelf. Formation and reworking of these broad landforms is also related to the interaction of rock outcrops, deltas and river channels with the coast during the Holocene rise in sea level[40,60]. At the -20m AHD contour all large rock features (e.g. Legendre Island) are able to be bypassed. Much of the sediment supplied by rivers in the Pilbara is dispersed and reworked on the inner shelf. Sediment transport across the -20m AHD contour would occur in the Pilbara Region, but at present the sediment dynamics have not been resolved. Further investigation of the sediment transport behaviour is recommended to refine the offshore boundaries of the primary cells and to determine how available offshore sediments are to return to the nearshore system.

The onshore boundary of primary cells is linked to elevation. The contours selected encompass areas of potentially active coastal processes in extreme events and during higher mean sea levels. They varied from +7m AHD to +9m AHD depending on the maximum tidal range of the coast. The contours were generated from a Landgate Digital Elevation Model. The +7m AHD contour was used for the two western cells (R11A, R11B) with maximum tidal range less than 2.5m and the +9m AHD contour was used for the eastern cell (R11E) with tidal range greater than 5m. The onshore boundary of primary cells is not related to the landward extent of Holocene accretionary landforms with any consistency, as was used elsewhere on the WA coast[53,64,65], because existing coastal landforms demonstrate divergent responses to sea-level rise over the Holocene and the complexity of Holocene fluvial deposits.

Secondary cells: supratidal, regional-scale processes and morphology

Secondary cells contain the broad patterns of contemporary (inter-decadal) sediment movement on the inner continental shelf and the variation in supratidal landforms with consideration of impacts of extreme events (Figure 2).

At the beachface, cells were first identified through separation of moderate-scale variation in supratidal landforms or influence of river systems, followed by broad change of coastal aspect and the influence of the geologic framework. The landform changes incorporated in each of the secondary cells are similar to those listed above for primary cells with further subdivision based on:

- R11A1 and R11A2 - variation in supratidal features
- Cape Preston at R11C5/R11C6 and Cape Lambert at R11D7/R11D8 - the geological framework
- R11D - separation of areas of regressed shorelines with outwash plains
- Turner River in cell R11E11 as part of broader R11E - the influence of river systems.

Determination of differences in adjacent supratidal landforms or adjacent river systems was translated to a beachface point along the shoreline corresponding to a non-ephemeral feature at the extreme event scale. Except for Urala Creek and Cape Cossigny, these non-ephemeral features are mainly rock structures including promontories, lithified river banks, cheniers, rock platforms and islands controlling salient features. Two boundaries at Cape Preston and Cape Lambert are also controlled by an engineered structure.

Alongshore boundary points are mainly fixed (58% of boundaries), with five (42%) ambulatory boundaries (Table 1; Table 7). The ambulatory boundaries are associated with a broad peninsula (Giralia R11A1), whereas ambulatory boundaries on accretionary landforms are located on rock platforms (Hope Point R11A2, Urala Creek R11B3, Coolgra Point R11B4) or in the lee of islands (Cape Cossigny R11D10). No ambulatory boundaries for secondary cells have been stabilised using engineered structures in the Pilbara Region.

The offshore boundary of secondary cells follows the continuous -10m AHD isobath closest to shore or the landward toe of offshore rock ridges (Table 2). The -10m AHD depth is near the outer margin of discontinuous ridges and island chains close to shore that are present in cells east of Cape Legendre (R11A1 to R11C6). Selecting this depth incorporates contemporary sediment transport by currents[61] and nearshore wave[62] processes within the cell, including dispersal of locally derived river sediments and biogenic material[33,56]. West of Cape Legendre (R11D7 to R11E11) the offshore boundaries were mapped to the landward toe of an offshore rock ridge to encompass the extent of tidal reworking in extreme events (Figures A.8 to A.12 in Appendix A). A localised variation to the offshore boundaries is in Mermaid Sound where the offshore boundary connects across a channel between the Burrup Peninsula and the Lewis Islands to ensure the channel is included within the cell.

Onshore boundaries of secondary cells include potential landform activity during a supratidal, extreme event and at an interdecadal scale. The onshore boundary corresponds to the landward extent of supratidal landforms (such as tidal flats and cheniers) and coastal dunes. As noted above, an exception to this is cliffed coasts, engineered or reclaimed coasts with extensive shore parallel structures (e.g. seawalls) without dunes to landward. For coasts with low to moderately high cliffs the onshore boundary is the seaward extent of the rock outcrops. If this extends to the beachface the Landgate MHWM to 2006 has been used as the onshore boundary (Table 2). Cliffed coasts are present in some areas between Cape Preston and Cape Lambert (R11C6, R11D7). Many port facilities in the Pilbara require large operational areas that are reclaimed to elevations above adjacent supratidal or coastal dune landforms, with onshore boundaries in these areas mapped to the Landgate MHWM to 2006. Onshore boundaries on engineered coasts at the secondary cell scale occur for the Wheatstone project (R11B3), along Dampier Road (R11C6, R11D7) and at Cape Lambert (R11D7, R11D8). All sections of coast with the onshore boundaries being the Landgate MHWM to 2006 require further investigation at a more detailed scale. Sediment activity could extend beyond the onshore boundaries of secondary cells in some circumstances, particularly due to flooding and outwash associated with river activity.

Tertiary cells: intertidal-scale, short-term processes and morphology

Tertiary cells incorporate the reworking and movement of sediment near the shore and associated potential seasonal to interannual responses likely to be significantly impacted by extreme events (Figure A series in Appendix A). These smaller cells perform similar functions to those of secondary cells, often on a finer scale. Their alongshore boundaries coincide in some places. Beachface points on the alongshore boundaries of tertiary cells (mapped; Table 1), along with onshore and offshore boundaries (not mapped; technique could follow Table 2) are highly subject to change. They may be transgressed by extreme events and modified by low frequency coastal processes.

Tertiary sediment cells were identified for the Pilbara coast, excluding islands and with only the beachface points on the alongshore boundaries mapped.

At the beachface, cells were first identified through variation in adjacent inter-tidal landforms or the influence of individual tidal creeks and river systems; the presence of upper intertidal and supratidal basins; followed by small changes of coastal aspect and the influence of the geologic framework. Landform changes incorporated in each of the tertiary cells are similar to those listed above for primary cells with further subdivision based on the presence of lagoons, outwash basins, changes in drainage networks of tidal creeks, changes in coastal dune and chenier landforms, zeta-form bays, river deltas, control of high-level rocky topography, passages between islands and engineered modifications (e.g. Port Hedland Spoil Bank in Cell R11D11).

Beachface points on the alongshore boundaries of tertiary cells restrict sediment transport at a seasonal to inter-annual scale, with bypassing during extreme events. Fixed boundaries include (71%; Table 7) rocky headlands, promontories, lithified river banks, lithified cheniers, rock platforms, rocky salients and tombolos. They also include engineered structures (10%); coincident with rock structures. The installation of engineered structures potentially may change the alongshore boundaries of tertiary cells and lead to development of new cells. Ambulatory boundaries at a tertiary scale may be located at the tip of accretionary landforms such as salients or spits, on lithified cheniers or on river banks. They also may be associated with broad peninsulas or rocky salients, as accretionary landforms on rock platforms or in lee of islands, or on artificial features such as the Spoil Bank at Port Hedland (Cell R11E11e).

Offshore boundaries of tertiary cells would have been mapped as they were for secondary cells to ensure the area of active reworking and redistribution of sediments is captured (Table 2). However, there may be local areas where rock ridges or the toe of reef platforms may be a more appropriate offshore boundary to investigate in further detail.

When mapped, the onshore boundary of tertiary cells should indicate the landward extent of intertidal landforms that would likely be significantly affected by extreme events (Table 2). Onshore boundaries would be the alongshore swales between foredunes and frontal dunes; the landward toe of frontal dunes if foredunes are eroded or absent; and the landward extent of tidal inundation in intertidal basins. The non-lithified landforms are highly changeable. Exceptions to the landward extent of intertidal landforms as onshore boundaries are cliffed coasts, engineered or reclaimed coasts with extensive shore parallel structures (e.g. seawalls) without dunes to landward. The onshore boundary of tertiary cells would not be indicative of the landward extent required for engineering, planning and management investigations. It represents the landward extent of intertidal landforms or average seasonal processes which may be superseded annually. However, it may be used as a marker to establish higher frequency changes at the shore.

Rivers

The main river systems of the area (Figure 1) are listed in *The Pilbara coast* section of this report, with all rivers releasing sediments intermittently directly to the ocean or into tidal-flat basins that occur landward of the coastal ridge, with sediment dispersed through connections with tidal creeks and during floods. Cells in the Pilbara Region have been selected to include areas with likely sediment supply by large river systems, ensuring whole deltas were incorporated within broader cells.

Onshore boundaries for rivers in the Pilbara Region have been represented in datasets and this report with truncation across elevation contours, supratidal landforms and alluvial land systems on opposite banks of rivers. In this respect the onshore boundary does not comprehensively represent the onshore extent of alluvial landforms or oceanographic forcing in rivers during extreme events.

Further investigation of landforms and sediment budgets for the Pilbara should include:

- All alluvial land systems with connection to the coast (see Figure 3-3 in the Landform Vulnerability Assessment[29]);
- The potential for alluvial landforms to become estuarine with changing climatic conditions;
- Capacity for flooding in rivers and creeks;
- Sediment transport along the river;
- Mobilisation of sediment stored in fluvial landforms;
- Sediment transport pathways and fluxes within deltas, in tidal creeks, tidal flats and outwash plains. This should also consider the oceanographic and meteorologic conditions which cause tidal flats to switch from modes of accretion to erosion; and
- Consideration that sea-level rise may result in basin drowning, as evidenced by late Holocene evolution of the Pilbara coast[40].

Cell labels

The cell labelling convention follows the direction of prevailing littoral drift according to:

1. Region – increasing order of R01, R02 to R13 from the South Australia border[48]. The Pilbara Region is region R11;
2. Primary cell – upper case letter resetting for each region;
3. Secondary cell – number resetting for each region;
4. Tertiary cell – lower case letter resetting for each secondary cell with letters increasing in the direction of littoral drift or clockwise around islands, for example 14a; and
5. Quaternary cell – Roman numeral resetting for each tertiary cell, for example 14ai. Quaternary cells were not evaluated in this investigation.

Pilbara cells are labelled to the tertiary cell, for example R11A1a, broadly from west to east following the direction of prevailing littoral drift considered at a regional level, with localised variation.

Sediment cell results along the Pilbara coast

Five primary cells, 11 secondary cells and 48 tertiary cells were identified along the Pilbara coast between Giralia and Beebingarra Creek. The eastern primary cell (R11E) extends 365 km east of Beebingarra Creek to Cape Jaubert in the Canning Region (R12) and encompasses the influence of the De Grey River. The hierarchy of cells is presented as maps, tables and electronic datasets available from the Department of Transport (Table 3).

Table 3: Location of cell results for the Pilbara Region

Item	Further information included	Location in report
Beachface points on the alongshore boundaries[1]	Information on the beachface point on alongshore boundaries at all three sediment cell scales. This includes cell definition according to river sediment supply as well as features that define the beachface point, coordinates and character of the boundary	Tables in Appendix E (separate document)
Alongshore boundaries[1]	Information on the features that define the marine and terrestrial sections of the alongshore boundaries for cells at the primary and secondary scales	
Onshore and offshore boundaries[1]	Information on the features that define the onshore and offshore boundaries for cells at the primary and secondary scales	
Cell names	Hierarchy of cell names including cell labels	Table 4
Maps of cells	Primary and secondary cells are presented at 1:2,500,000 scale at A3 size	Figure 2
	Secondary and tertiary cells at 1:300,000 scale at A4 size	Figures A.1-A.12 in Appendix A
Coincidence of cell boundaries	Boundary names and coincidence at different levels in the hierarchy	Table 5
Comparison to previous study	Comparison with previously defined sediment cell boundaries[29 29] in the landform vulnerability report.	Tables D.1-D.2 in Appendix D

Note: 1. Electronic datasets of boundaries and beachface points available from Department of Transport in ESRI shapefile format or as Google Earth KMZ files. The kmz filename is 'R11 Pilbara Cells.kmz'. The shapefile filenames are Primary_Cells.shp and Secondary_Cells.shp and are available upon request from the Department of Transport officers.

Cell boundaries

The alongshore spatial scale of cells in the Pilbara Region varies with supply of sediment from rivers, coastal orientation, exposure to extreme waves, geologic framework and landform irregularity at the timescale of interest. Further information on these parameters is provided in the landform vulnerability report[29], but should be updated at an appropriate scale in any analysis of sediment budgets. The mean length of cells was 234km (100-455km), 73km (18-138km) and 17km (6-57km) for primary, secondary and tertiary cells respectively (Table 6). The largest cells in each level in the hierarchy appear to be associated with flat, shallow inner shelf areas without large-scale, high-relief rock along the coast. Smaller cells are found where this is a significant change in coastal aspect and increased geological control in the offshore and onshore. Secondary and tertiary cell boundaries may be coincident for coasts that are open or have inherited features.

There is some consistency in scale with littoral cells reported from overseas and elsewhere on the WA coast. Spatial scales of primary cells (100-455km) are similar to the larger littoral cells in England, Wales and Scotland (50-300km)[13,14]. The primary cells are larger than many other reported cells, with Pilbara secondary cells at a similar scale to the cells in the Vlamingh Region (13-87km)[53], Mid-West Region (37-78km)[54], Northampton Region (33-66km)[55], California (10-95km)[20] and Hawkes Bay, New Zealand (20-60km)[63].

Overall, the Pilbara Region has larger primary cells than those along the south-west coast of Western Australia[53,54,55]. This is related to differences in tidal character of the Pilbara coast, larger volumes of sediment supply from the Pilbara rivers and the influence of episodic drivers from tropical cyclones and flooding across a broad, flat shelf. The size of the local primary cells are similar or slightly larger than the cell scale in the United Kingdom.

Primary cell boundaries are also secondary and tertiary cell boundaries (Table 5). All 11 (100%) secondary cell boundaries are also tertiary cell boundaries, with 38 (78%) unique tertiary cell boundaries.

The cell hierarchy and boundary character classification (Table 4: Table 7) reveal the complexity of the coastal system of the region which has varied shelf structure, rock control, inherited features, large tidal ranges and rivers. All boundaries are open at all three scales with varying degrees of sediment transport leakage. Notably, sediment flow directions may be reversed with changes in meteorologic and oceanographic conditions, particularly during extreme tropical cyclone and river flooding events, with some boundaries effectively closed for one sediment transport direction. For example, if large volumes of sediment are discharged by a river during a flood event it may overwhelm prevailing processes and related landform responses.

Table 4: Primary, secondary and tertiary sediment cells of the Pilbara Region

Region	Primary	Secondary	Tertiary
R12. Canning Region	E. Cape Thouin to Cape Jaubert (455km east of Cape Thouin)	Beyond Study Area	
R11. Pilbara Region from Giralia to Beebingarra Creek		11. Cape Thouin to Petermarer Creek	f. Cooke Point to Petermarer Creek
			e. Spoil Bank (W) to Cooke Point
			d. Finucane to Spoil Bank (W)
			c. Downes Island to Finucane
			b. Turner River to Downes Island
			a. Cape Thouin to Turner River
	D. Cape Legendre to Cape Thouin	10. Cape Cossigny to Cape Thouin	b. Victory Well to Cape Thouin
			a. Cape Cossigny to Victory well
		9. Padthureena Creek to Cape Cossigny	a. Padthureena Creek to Cape Cossigny
		8. Cape Lambert to Padthureena Creek	e. Little Sherlock River to Padthureena Creek
			d. East Harding River to Little Sherlock River
			c. Reader Head to East Harding River
			b. Point Samson to Reader Head
			a. Cape Lambert to Point Samson
		7. Cape Legendre to Cape Lambert	i. Rocky Ridge to Cape Lambert
			h. Anketell to Rocky Ridge
			g. Jockeys Hill to Anketell
			f. Fields Creek to Jockey Creek
			e. Nickol Bay Mine to Fields Creek
			d. Karratha to Nickol Bay Mine
			c. Nickol Bay (W) to Karratha
			b. Sloping Point to Nickol Bay (W)
			a. Cape Legendre to Sloping Point
	C. Yardie Landing to Cape Legendre	6. Cape Preston to Cape Legendre	h. Searipple Passage to Cape Legendre
			g. Dampier to Searipple Passage
			f. Sharp Peak to Dampier
			e. West Intercourse Island to Sharp Peak
			d. Regnard Bay to West Intercourse Island
			c. Pelican Point to Regnard Bay
			b. Little Hill to Pelican Point
			a. Cape Preston to Little Hill
		5. Yardie Landing to Cape Preston	g. Preston Spit to Cape Preston
			f. James Point to Preston Spit
			e. Mt Salt to James Point
			d. Cowle Island to Mt Salt
			c. Thringa Island to Cowle Island
			b. Port Weld to Thringa Island
			a. Yardie Landing to Port Weld
	B. Urala Creek to Yardie Landing	4. Coolgra Point to Yardie Landing	a. Coolgra Point to Yardie Landing
		3. Urala Creek to Coolgra Point	e. Beadon Point to Coolgra Point
			d. Hooley Creek to Beadon Point
			c. Rocky Point to Hooley Creek
			b. Locker Point to Rocky Point
			a. Urala Creek to Locker Point
	A. Giralia to Urala Creek	2. Hope Point to Urala Creek	b. Tent Point to Urala Creek
			a. Hope Point to Tent Point
		1. Giralia to Hope Point	b. north Giralia Bay to Hope Point
			a. Giralia to north Giralia Bay
R10. Exmouth Region	Beyond Study Area		

Boundaries are ambulatory (≈35%) where rock control is on the sub-tidal to intertidal part of the shoreface with mobile or lithified landforms (such as spits, salients or cheniers) perched on the rock. The boundaries may be defined as a zone where there is limited or no rock control crossing the beachface and extending into the nearshore. At all scales, 50-60% of all cell boundaries are points and 40-50% are zones with approximately 35% ambulatory boundaries

Table 5: Sediment cell alongshore boundaries of the Pilbara Region

Coordinates, alongshore boundary character, onshore and offshore boundaries, along with marine and terrestrial sections of the alongshore boundary are in the KMZ file, shapefile and Appendix E.

Cell alongshore boundary name	Cell boundaries
Cape Jaubert	1°, 2°, 3°
2°, 3° boundaries not defined in Canning Region (R12)	
Petermarer Creek	2°, 3°
Cooke Point	3°
Spoil Bank (W)	3°
Finucane	3°
Downes Island	3°
Turner River	3°
Cape Thouin	1°, 2°, 3°
Victory Well	3°
Cape Cossigny	3°
Padthureena Creek	2°, 3°
Little Sherlock River	3°
East Harding River	3°
Reader Head	3°
Point Samson	3°
Cape Lambert	2°, 3°
Rocky Ridge	3°
Anketell	3°
Jockeys Hill	3°
Fields Creek	3°
Nickol Bay Mine	3°
Karratha	3°
Nickol Bay (W)	3°
Sloping Point	3°
Cape Legendre	1°, 2°, 3°

Cell alongshore boundary name	Cell boundaries
Searipple Passage	3°
Dampier	3°
Sharp Peak	3°
West Intercourse Island	3°
Regnard Bay	3°
Pelican Point	3°
Little Hill	3°
Cape Preston	2°, 3°
Preston Spit	3°
James Point	3°
Mt Salt	3°
Cowle Island	3°
Thringa Island	3°
Port Weld	3°
Yardie Landing	1°, 2°, 3°
Coolgra Point	2°, 3°
Beadon Point	3°
Hooley Creek	3°
Rocky Point	3°
Locker Point	3°
Urala Creek	1°, 2°, 3°
Tent Point	3°
Hope Point	2°, 3°
north Giralia Bay	3°
Giralia	1°, 2°, 3°

Table 6: Alongshore length of cells of the Pilbara Region

Cell level	Minimum length (km)	Maximum length (km)	Mean length (km)	Median length (km)
1°	100	455	234	231
2°	18	138	73	64
3°	6	57	17	16

Table 7: Alongshore boundary characteristics of cells of the Pilbara Region

Alongshore boundary characteristics for each cell are in the KMZ file, shapefile and Appendix E.

	Alongshore boundaries					
	Primary		Secondary		Tertiary	
	Count	%	Count	%	Count	%
Point	3	50%	7	58%	28	57%
Zone	3	50%	5	42%	21	43%
Fixed	4	67%	7	58%	35	71%
Ambulatory	2	33%	5	42%	14	29%
Open	6	100%	12	100%	49	100%
Closed	0	0%	0	0%	0	0%

Along coast variation of sediment cells

Geographic differences in geology, rivers, sediments and processes cause alongshore variation in the characteristics of sediment cells over both regional and sub-regional scales. These differences change the relative influence of the criteria used to define sediment cells boundaries. Consequently, along coast variation affects the sediment cell attributes and scales.

Intra-regional variation in sediment cells of the Pilbara coast is related to the shelf structure, rivers, rock control, sediment supply and onshore sedimentary landforms, following a loose order of the influence scale.

- There is a distinct change of inner shelf structure at the Burrup Peninsula, with the western shelf comprising a series of sand islands and ridges and the eastern shelf comprising a series of basins.
- There a progressive change of meteorologic and oceanographic forcing along the shelf, with tropical cyclone frequency and tidal range decreasing from east to west along the Pilbara coast.
- Proximity to active rivers alters the available sediment and therefore influences coastal landforms. The largest active rivers are the Ashburton and De Grey Rivers.
- The geologic framework provides controls to sediment transport and coastal response. Rock control may act as barriers to sediment transport along the coast. A wide range in the volume of sediment bypassing boundaries is likely to occur in response to the scale of rocky features, offshore influences of chains of limestone ridges and islands, and the onshore influence of cliffs, bluffs and lithified features.
- Feedback between sediment supply and onshore sedimentary landforms indicates the processes driving coastal change and relative resistance of the coast.

The western part of the region (Cells R11A to R11C) is located where the inner shelf comprises a series of sand islands and ridges in the area west of the Burrup Peninsula. The western cell (R11A) comprises the supratidal Yannarie Flats in the eastern Exmouth Gulf. This section of coast does not have an active river system and has low-elevation rock control. Broad supply of sediment from the Ashburton River is the dominant feature to the east of the Yannarie Flats (Cell R11B), with a large active delta, spits, cheniers and tidal creeks. West of the Burrup Peninsula (Cell R11C) would have experienced greater sediment supply in the past, with a series of palaeo-deltas as the dominant land systems. Large hard rock terrain provides barriers to sediment transport at Cape Preston and along the Burrup Peninsula.

The eastern part of the region (Cells R11D to R11E) is influenced by a series of basins impounded by limestone ridges east of the Burrup Peninsula. The cells are separated at Cape Thouin; with the broad regressed Sherlock Bay to the west and influence of the Turner River to the east. The western cell (R11D) comprises Nickol Bay and Sherlock Bay, including broad outwash plains. The eastern cell (R11E) is dominated by contemporary sediment supply from the De Grey River and smaller Yule and Turner Rivers, and extends into the Canning Region (R12).

Inter-regional variation in sediment cells is suggested by changes to the criteria used for mapping cells for the four regions of Vlamingh[53], Mid-West[54], Northampton[55] and Pilbara. Criteria for defining sediment cells in the Pilbara Region expanded due to a shift in dominant processes driving coastal change. This varies from wave forcing in the southern regions to tidal reworking, extreme events and increased river activity in the Pilbara region (Table C.1 in Appendix C). This shift in dominant forcing is superimposed on differences in lithology and the geologic frameworks between regions.

Despite the differences between regions, a consistent approach has been used to determine the beachface point on the alongshore boundaries and follows the procedure described in the coastal compartments report[48]. In the Pilbara Region, cells have been based on limits to the influence of river systems, in addition to major change to coastal landforms. These boundaries are identified along the shoreline as a point on the beachface attributed to a non-ephemeral landform or feature.

Differences to landform vulnerability assessments

The cells defined in this report differ slightly from those described within the recent landform vulnerability report by the same authors[29]. Previous tertiary compartment and tertiary cell descriptions and vulnerability assessments[29] should not be aggregated into the revised cell hierarchy presented here (if boundaries are not coincident) without reassessing the main landforms within each cell appropriate to the scale of interest. The hierarchy of cells presented here should be used in preference to those previously defined for Giralia to Beebingarra Creek[29].

Cells reported in 2013 were hierarchical, but only comprised a set of points along the coast (not two-dimensional), with incomplete coverage of tertiary cells. They were used for a landform-based coastal vulnerability assessment with consideration of a hierarchical approach as the work was conducted following commencement of the preparation of the

Vlamingh Region[53]. The two-dimensional mapping of cells in this present report captures interactions between marine and terrestrial environments at comparable scales along the coast. It also facilitates interpretation of the interactions between and within scales. The process of completing the tertiary cell points and the two-dimensional mapping of the primary and secondary cells resulted in minor migration of some cell boundaries.

Comparison of the cell hierarchy with previous cell and coastal compartment definitions[29] is demonstrated in Tables D.1 and D.2 in Appendix D. The comparison of primary and secondary cells is included in Table D.1. The five primary cells are similar to those defined in the landform vulnerability report[29], with a shift in a boundary from Port Weld to Yardie Landing to capture the majority of sand supply from the Ashburton River, transitioning to palaeo-deltas at Yardie Landing. Port Weld was a geological boundary used in the compartments report[48]. The different spatial extents of the two investigations caused some variation in the number of secondary cell boundaries defined (Table D.1). However, for the overlapping areas of Urala Creek to Petermarer Creek the present study has nine secondary cells and the previous study[29] defined seven secondary cells. The difference is the secondary cell from Cape Lambert to Cape Thouin was separated into three cells (R11D8 to R11D10) to capture the areas of regressed shorelines of Sherlock Bay with outwash plains and direct supply by the Yule River. The secondary cell boundary at Port Weld was also shifted to Yardie Landing as per the discussion for the primary cell boundary above. The previously[29] incomplete coverage of tertiary cells has been extended to cover the whole Pilbara Region with similar spatial extents (Table D.2). The previously defined boundary at Butcher Inlet E was neglected in the present study.

Tertiary cells are similar size or smaller than tertiary compartments (Table D.2 in Appendix D). In the same study area there are 23 tertiary compartments[48,29] and 46 tertiary sediment cells (this study) with 15 coincident boundaries. This dissociation of cell boundaries from compartment boundaries may be indicative of the dissociation of contemporary sediment transport processes and the geologic framework.

Applications

In this report, sediment cells are areas in which there is strong connectivity between marine and terrestrial landforms. Hence, they are natural management units, presented in a simple spatial format. Applications of sediment cells include identification of spatial context for coastal evaluations; a common framework for dialogue about the coast; support to coastal management decision-making and a range of technical uses largely relating to coastal stability assessment. Some uses of sediment cells are listed in Table 8 and briefly described below.

Table 8: Applications of sediment cells

Context	• Identification of area to be evaluated • May be used for problem scaling
Communication	• Cross-jurisdictional co-operation • Spatial basis readily comprehended by non-technical audience • Common framework for discussion between disciplines
Decision-Making	• Screening destabilising actions from high coastal amenity • Recognition of stabilisation trade-offs
Technical Use	• Improved coastal erosion assessment • Sediment budget development • Upscaling and downscaling of coastal information • Identification of key coastal processes • Landform vulnerability assessment

Context

As defined in this report, sediment cells provide an indication of a spatial area within which marine and terrestrial landforms are likely to be connected through processes of sediment exchange. This implies that either natural or imposed changes at any point in the cell may affect any other part, recognising such relationships are strongly bound by proximity. A fundamental use of sediment cells is therefore one of ***context***, to identify an area that should be considered in a coastal study. Specifically, questions that should be considered are:

- How may an imposed action, such as installation of a groyne, affect the wider coast through changes to the sediment budget?
- Have changes to the wider area influenced locally observed response?

Note that this does not mean that sediment cells must be used to define a study area or model area. These are typically smaller due to data or budget limitations.

A qualitative assessment within the sediment cells context is often valuable for problem scaling when dealing with coastal instability. Considering whether an observed issue is prevalent within a cell or adjacent cells may provide guidance on the type of management solutions available, and therefore suggest the form of technical advice most likely to be useful (Figure 5). For example (labelling corresponds to panels in Figure 5):

A. If there is a balance of erosion and accretion within a sediment cell, there is potential opportunity to manage the problem through coastal stabilisation works, which transfer stresses along the coast;
B. For a coastal stability issue that is affecting the majority of a sediment cell, it is appropriate to improve coastal resilience, including techniques that improve the transfer of sand from the nearshore to the beach and dune system;
C. If erosion and accretion occur differently between cells, it is possible that the stress can be more evenly distributed, including artificial interventions such as bypassing. However, limited natural sediment transfer at cell boundaries determine that balancing erosion and accretion requires long-term management;
D. If erosion or accretion is prevalent across multiple cells, the issue is likely to be dominant in the long term. This typically requires a decision about where to focus the problem, such as through identification of sacrificial coastal nodes.

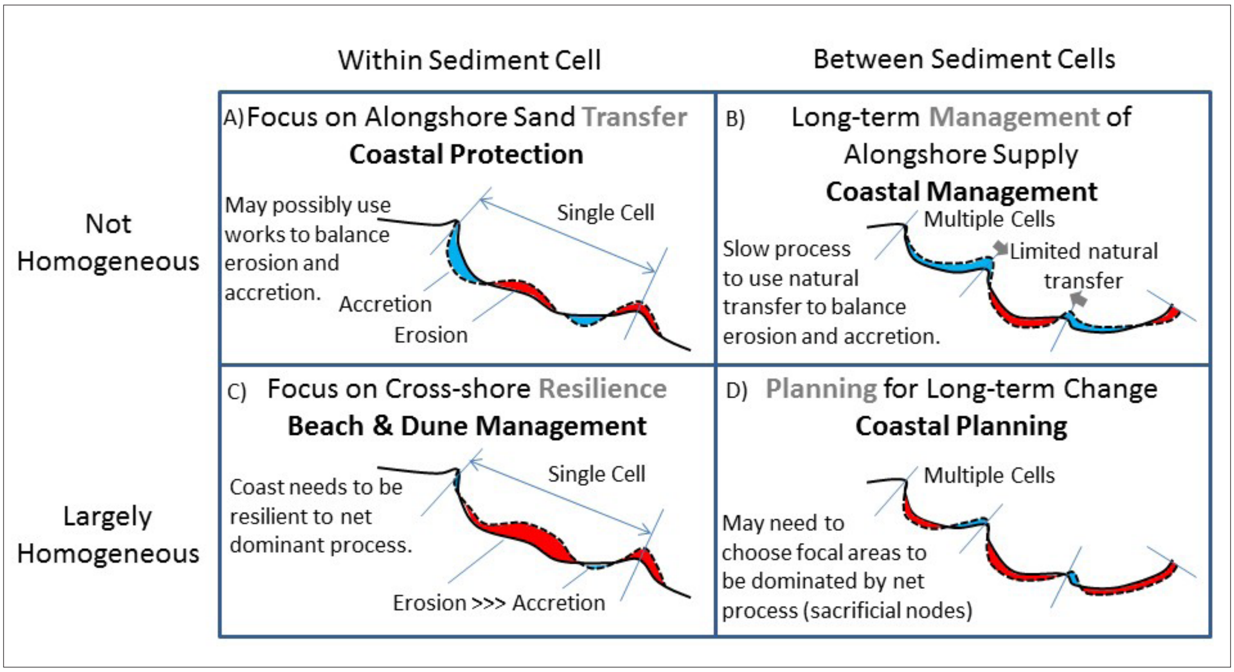


Figure 5: Use of sediment cells for problem scaling

Communication

A key feature of the sediment cell framework is its development from physical attributes rather than a jurisdictional basis. This highlights situations where communication between coastal managers may be necessary, and supports formation of strategic planning groups such as the Peron-Naturaliste Partnership or Cockburn Sound Coastal Alliance in the Vlamingh Region.

The relatively simple spatial representation of sediment cells may be a valuable tool for communication between technical agencies and the general public. Recent application of coastal process connectivity mapping[24] has highlighted the value of simple spatial tools to help explain the basis for coastal management decisions to a non-technical audience.

The value of communicating through a common spatial framework may also enhance dialogue between technical staff involved in different disciplines. The framework of sediment cells and coastal compartments are designed to be of use for coastal management across multiple scales, from engineering through to strategic planning[48]. However, the strong relationship between habitats and morphology[52], includes links between catchments areas and sediment cells. This more broadly suggests that sediment cells may have value as natural management units when considering natural resource management or coastal ecosystem services.

Decision-making

Recognition of the inter-connected nature of marine and terrestrial landforms within a sediment cell may support simplified decision-making by coastal managers, including local and State government agencies.

For agencies managing large areas, sediment cells can be used for low-cost geographic screening, particularly when combined with the direction of net alongshore sediment transport. As the cells provide preliminary guidance regarding the possible extent of development impacts, the cells framework may be used to guide the distribution of infrastructure. For example, destabilising infrastructure may be preferentially excluded from a cell containing sensitive or high amenity coastal areas. Alternately, a largely isolated single cell may be identified as a strategic coastal node, with focused coastal protection works and interventions creating a minimised coastal footprint.

An objective of the sediment cells definition is to focus coastal managers' attention upon the connected nature of marine and terrestrial landforms. This is intended to disrupt expectation that the whole coast under management can be made stable. For every effort toward stabilisation, the consequent trade-off should be clearly identified and understood. This way of thinking reduces the likelihood of tail-chasing through successive coastal stabilisation works.

Technical use

The major technical use for sediment cells is to improve erosion hazard assessments by better integrating regional and local coastal change. Regional changes may include the effects of climate or sea level fluctuations and the consequent variations in sand supply. Local changes include storm responses and coastal interactions with natural and artificial structures. Improved knowledge of how local changes may have broader impact is essential to good coastal planning[20,21,22,64,65,66]. Equally, refined understanding of how regional change influences local response can improve setback assessment[27] and structural design[67].

Sediment cells evaluated for regional processes should be identified based on the relative magnitude of local coastal change and the proximity to cell boundaries. Large-scale engineering works, such as ports and harbours, should be considered over the full hierarchy of primary, secondary and tertiary sediment cells to ensure adequate identification of possible effects. However, most planning and engineering investigations require consideration at a secondary cell scale as this incorporates broad sediment transport processes over inter-decadal timescales. In all cases, proximity to a cell boundary may suggest the need to consider adjacent cells. Coastal investigations using sediment cells in the Pilbara should generally consider multiple adjacent cells, rather than an individual cell, because of the non-discrete spatio-temporal scales represented by the cell boundaries.

Landform information used to develop the sediment cells, including indications of sediment transport pathways and sinks, is equally important to the development of quantitative sediment budgets. Consequently, the sediment cells framework provides a useful spatial basis for the development of sediment budgets[1,2,6]. The effect of timescale on sediment budget variability is acknowledged along the Pilbara coast, with dispersal of sediment on the shelf; migration of sedimentary features on the shelf; pulses of sand supply; and exchange within tidal creeks, river channels and tidal flats contributing to coastal fluctuations. A recent example of a detailed application of a sediment budget-based coastal assessment is the study in the Geraldton area of the Mid-West Region[56] (Cell R07F).

Definition of sediment cells (and coastal compartments[48]) over multiple spatial scales supports the processes of upscaling and downscaling, where information collected or applicable at one particular scale is made meaningful at another larger or smaller spatial scale. Upscaling involves the aggregation of information from a finer scale, often sparse across the wider area. Downscaling involves interpretation of coarse scale information at a finer scale, usually through the use of additional information. The concepts of upscaling and downscaling are important tools for combining regional and local coastal change assessments, often using a sediment budget approach.

Connectivity of marine and terrestrial landforms is used as a basis for sediment cell definition. The identified landforms and pathways for transport may also suggest the key active coastal process and therefore indicate appropriate conceptual models for coastal dynamics. Mapping of coastal morphology in the Pilbara Region has been described as part of the WACoast series[28] and in a landform vulnerability report[29].

Sediment cells have previously been used as a spatial framework for landform-based coastal vulnerability assessment in the Pilbara Region[29]. This assessment involved coastal classification based on landform characteristics considering both present-day mobility and the potential sensitivity to disturbance of existing conditions.

Modification of cell boundaries

Although the cell boundaries have been presented as a spatial framework, they are based upon interpretation of geomorphic information. Therefore boundaries may require variation according to either the intended application or due to further relevant information being obtained. Common reasons to update the database describing the cells may include:

- Large-scale change that will affect cell connectivity;
- Coastal change near a cell boundary;
- Modification due to engineering works; or
- More detailed evaluation of active coastal behaviour.

Sediment cell connectivity

Determination of the number and scale of sediment cells used for coastal assessment should involve consideration of the magnitude and timescale of coastal change as well as the relative connectivity between sediment cells. It is appropriate to consider multiple sediment cells when evaluating larger or more sustained coastal change, or when assessing cells with moderate or high connectivity. Cell connectivity is indicated by the nature of the coastal boundary, with higher connectivity occurring where:

- The boundary is open or ambulatory; for example, sediment transfer occurring across boundaries on salients and cuspate forelands;
- Reversal of littoral drift direction is known to occur;
- There is an onshore feed of sediment;
- A boundary is located on a sediment source or sink; or
- Boundaries providing headland control of estuary entrances to coastal lowlands.

Investigation of coastal processes should recognise the potential role of connectivity between cells, including the relative significance of prevailing and extreme events in driving linkage of adjacent cells.

In situations where coastal change is substantial, such as coastal adjustment subsequent to mass deposition from a river system, or the potential impact of sea level rise over the next hundred years, there is potential for change to affect even rock boundaries. Users of the cell framework on mixed rock and sand coasts, such as the Pilbara coast, should consider:

1. Sections of coast which have occasional outcrops of rock and are progressively eroding will potentially reach points where either the rock has reduced influence on the coast, or a newly exposed area of rock starts to control the coastal configuration. These changes of coastal state may effectively alter sediment cell boundaries.
2. The influence of rock features that control the coast through sheltering may change with sediment supply. The resulting sandy features, salients or cuspate forelands, may migrate under changing meteorological, oceanographic or sediment supply conditions. This can occur following a loss of offshore reef control, as has been reported for a calcarenite coast[68], or if there is a reduction in sediment supply such as what may be caused by the Wheatstone project or the proposed Anketell Port breakwater.

Proximity to cell boundaries

As the influence of a local coastal change is strongest in its immediate vicinity, it is possible for the effect of a moderate change to be transferred across a cell boundary. In such a situation, adjacent sediment cells should be assessed simultaneously.

Modification due to engineering works

Engineering works may modify the nature of sediment cell boundaries and in some instances, might create new boundaries. Two examples of modifying cell boundaries has occurred at the Port Hedland Spoil Bank (Cell R11E11e), where a new boundary was created by the dredged material travelling onshore, and altering the onshore boundary at Dampier Road between Dampier and Karratha (Cells R11C and R11D).

Detailed evaluation of coastal behaviour

Detailed coastal assessment, including sediment analysis, sediment transport assessment or higher frequency evaluation of coastal configuration may provide better representation of how the sediment cell boundary operates. Cell boundaries may need to be reviewed following such investigations.

Recent work in the Mid-West Region provides an example of how sediment analysis may be used to verify and resolve cell boundaries[56]. An overview of the study findings is included in the Mid-West Region cells report[64]. Useful studies in the Pilbara Region containing previous sediment analysis are referred to in Table B.1 (Appendix B). An example is provided by the relationship between regionally varying oceanography and the resulting shelf sediments in the Pilbara Region[69]. Processes affecting the distribution of sediments and variability in sediment supply from nearshore sources in the studies could be investigated to help develop sediment budgets.

Possible studies to further resolve cell boundaries requires consideration of how the cells are to be applied, the time and space scales and the range of landforms within the domain of interest. For example, when assessing over an extended time scale for climate change adaptation assessment, there may be sensitivity to buried rock. A program of seismic surveys could therefore refine the onshore boundary. A second example is where coastal dunes define the onshore boundary of secondary cells, as the degree of dune mobility and the time scale of change will directly affect the area of interest. In this situation, active dune movement may be identified through aerial photograph interpretation or sediment analysis.

Further work to increase the resolution of cell boundaries may involve:

1. Ensuring the temporal and spatial resolution of data are consistent between datasets and fit for purpose at the scale at which they are being applied;
2. Extension of the criteria used to identify the cell boundaries to include criteria describing sediment characteristics and the limits to their distribution;
3. Identification of the potential for change of ambulatory boundaries at a local scale related to projected variation in climate and ocean processes, along with more detailed information of underlying rock structures;
4. Verification of sediment cells through determination of sediment character, composition, depth and distribution;
5. Determination of the contribution of barred estuaries to cell functions; and
6. Revision of cell boundaries in the event of large-scale engineering works, such as ports or harbours, restrict sediment transport at relevant time and space scales.

In the future, the beachface points identifying the alongshore boundaries of tertiary cells in the Pilbara Region should be extended to include their marine and terrestrial sections and link them with onshore and offshore boundaries, according to the recommended criteria in Table 1 and Table 2. This work could be conducted when datasets of sufficient resolution are available, such as LiDAR imagery of the nearshore (see *Information used to define the cells*).

Proposed modification of cell boundaries should be presented to the dataset custodian, the Western Australian Department of Transport. The modifications should be presented in either ESRI Shapefile format or as Google Earth KMZ files with metadata and supporting documentation.

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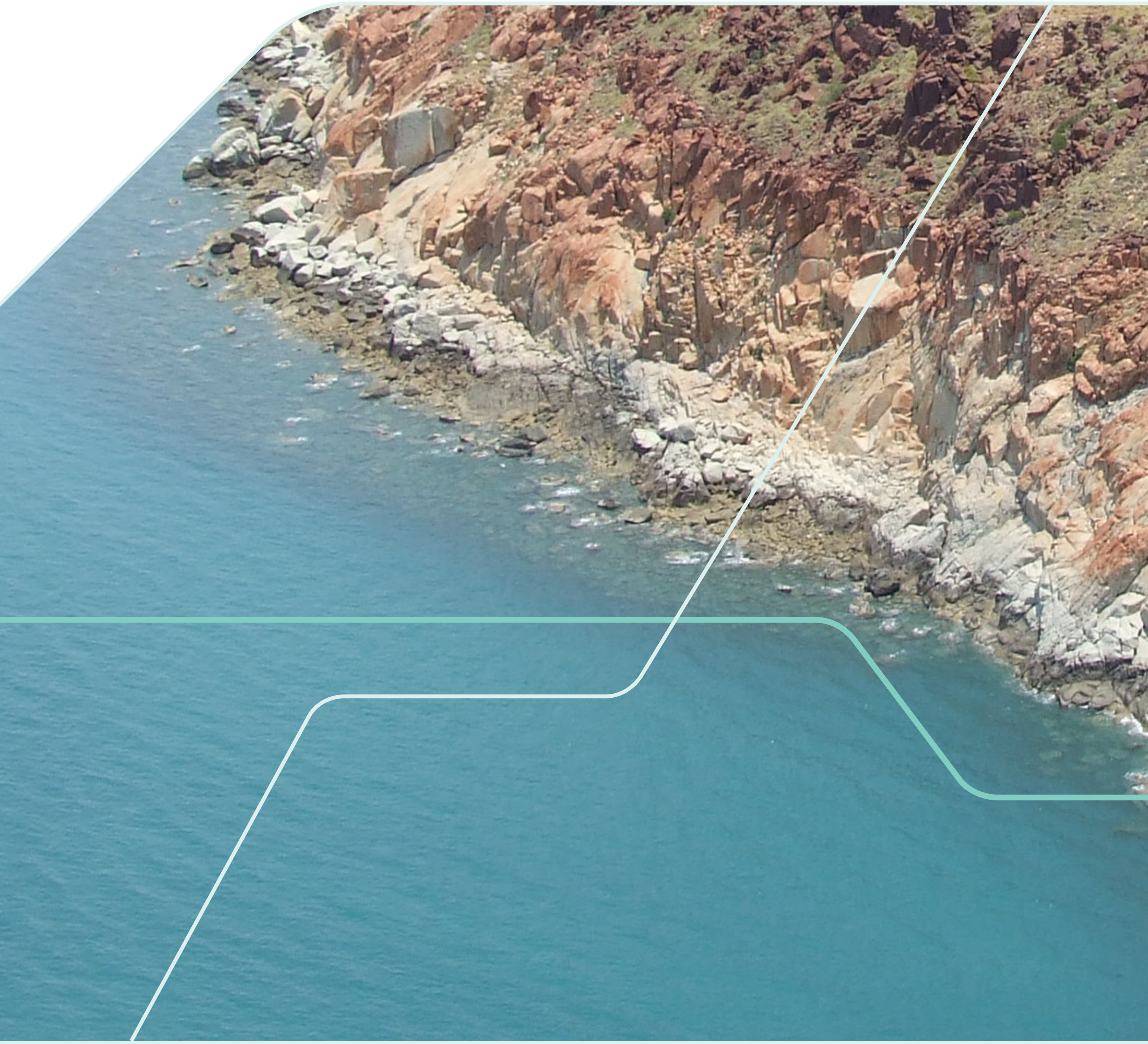
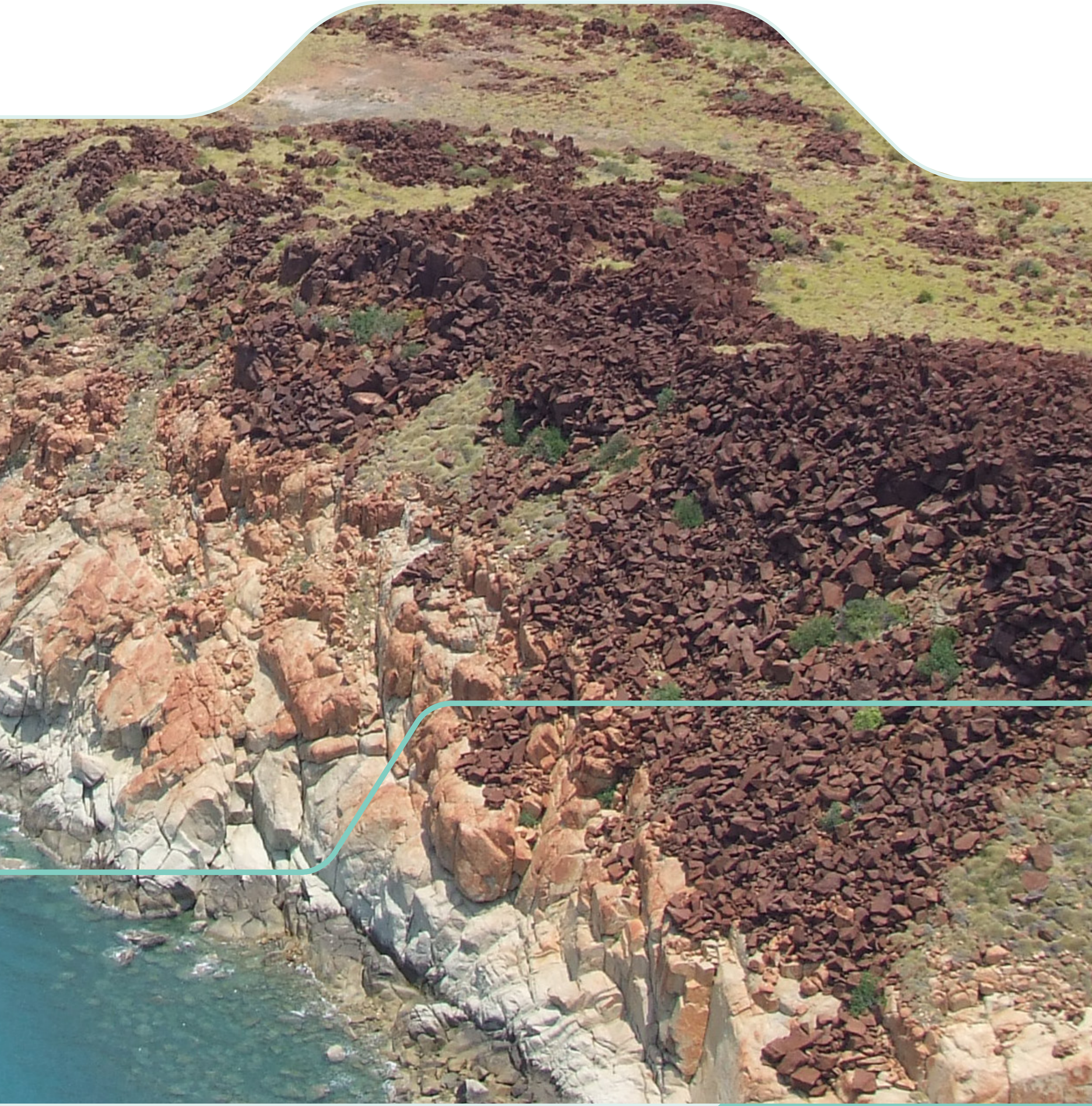
Coastal Sediment Cells for the Pilbara Coast

Appendices A to E



Appendix A
Secondary and Tertiary Cells



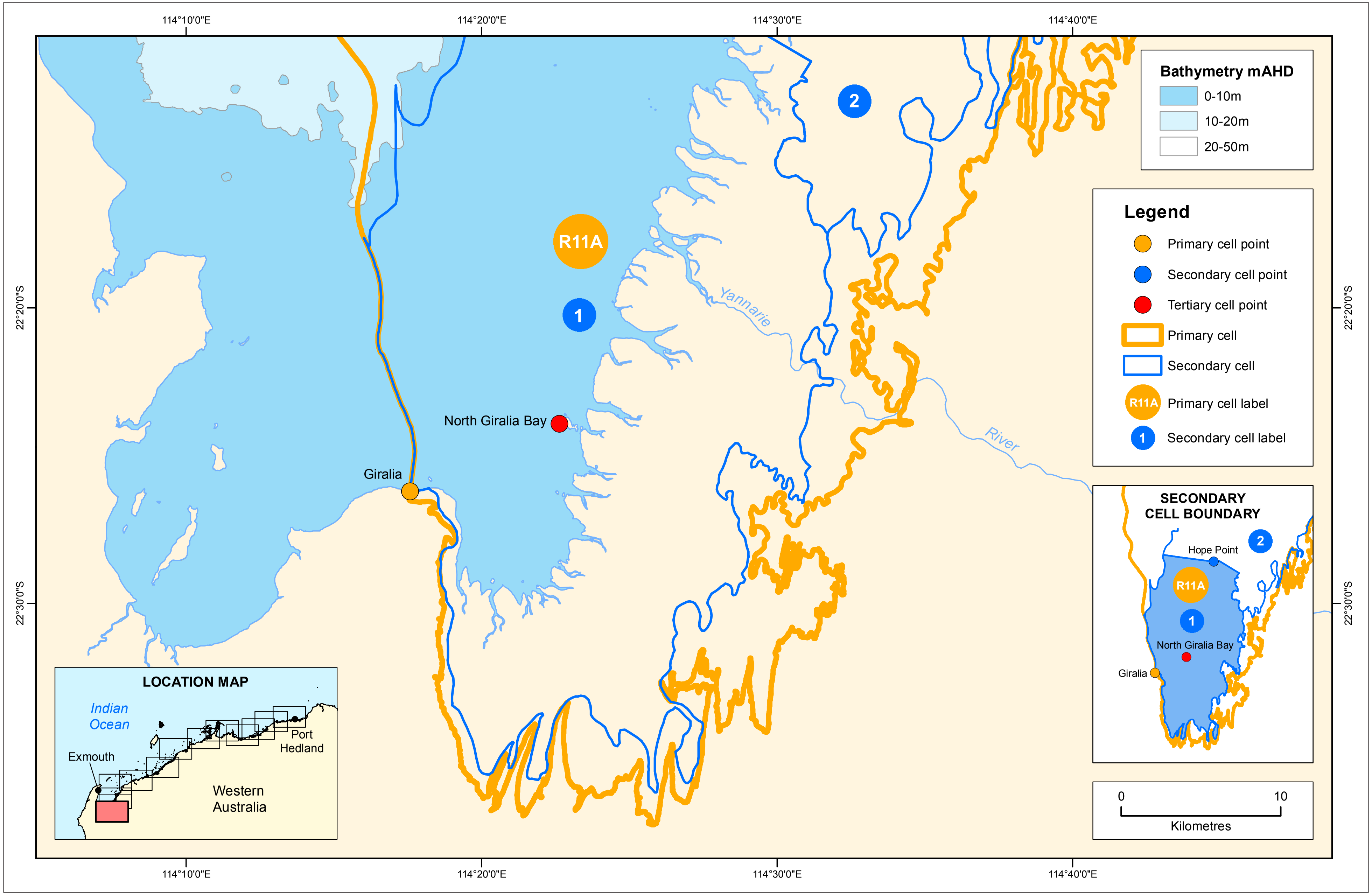


Figure A.1: Secondary and tertiary cells of the Pilbara Region

Figure is at scale of 1:300,000 at A4. A primary cell point is also a secondary and tertiary cell point. A secondary cell point is also a tertiary cell point. This map should not be used for navigation purposes. Bathymetry information supplied by Department of Planning and Australian Hydrographic Office. Rivers dataset provided by Department of Water.

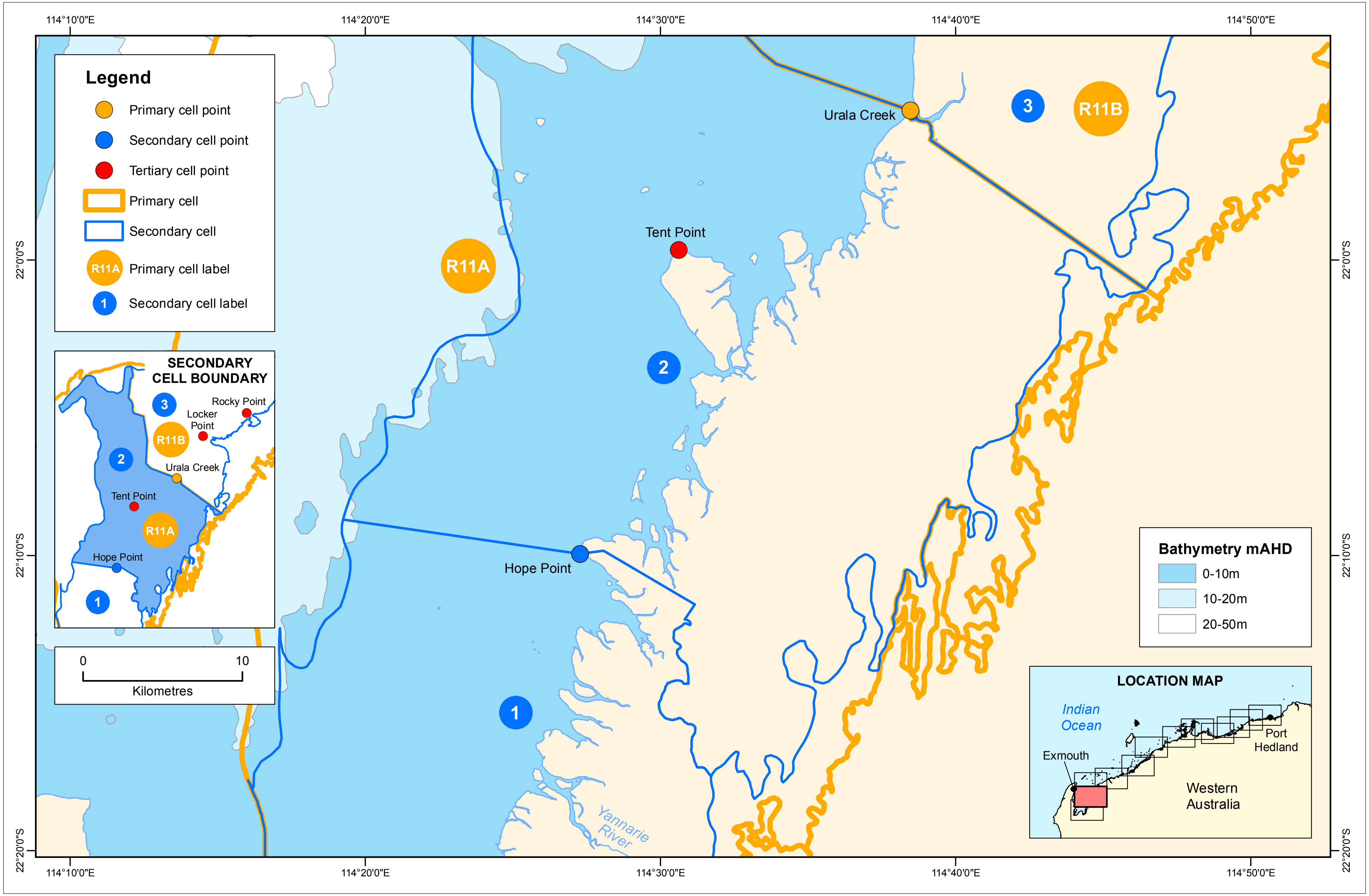


Figure A.2: Secondary and tertiary cells of the Pilbara Region

Figure is at scale of 1:300,000 at A4. A primary cell point is also a secondary and tertiary cell point. A secondary cell point is also a tertiary cell point. This map should not be used for navigation purposes. Bathymetry information supplied by Department of Planning and Australian Hydrographic Office. Rivers dataset provided by Department of Water.

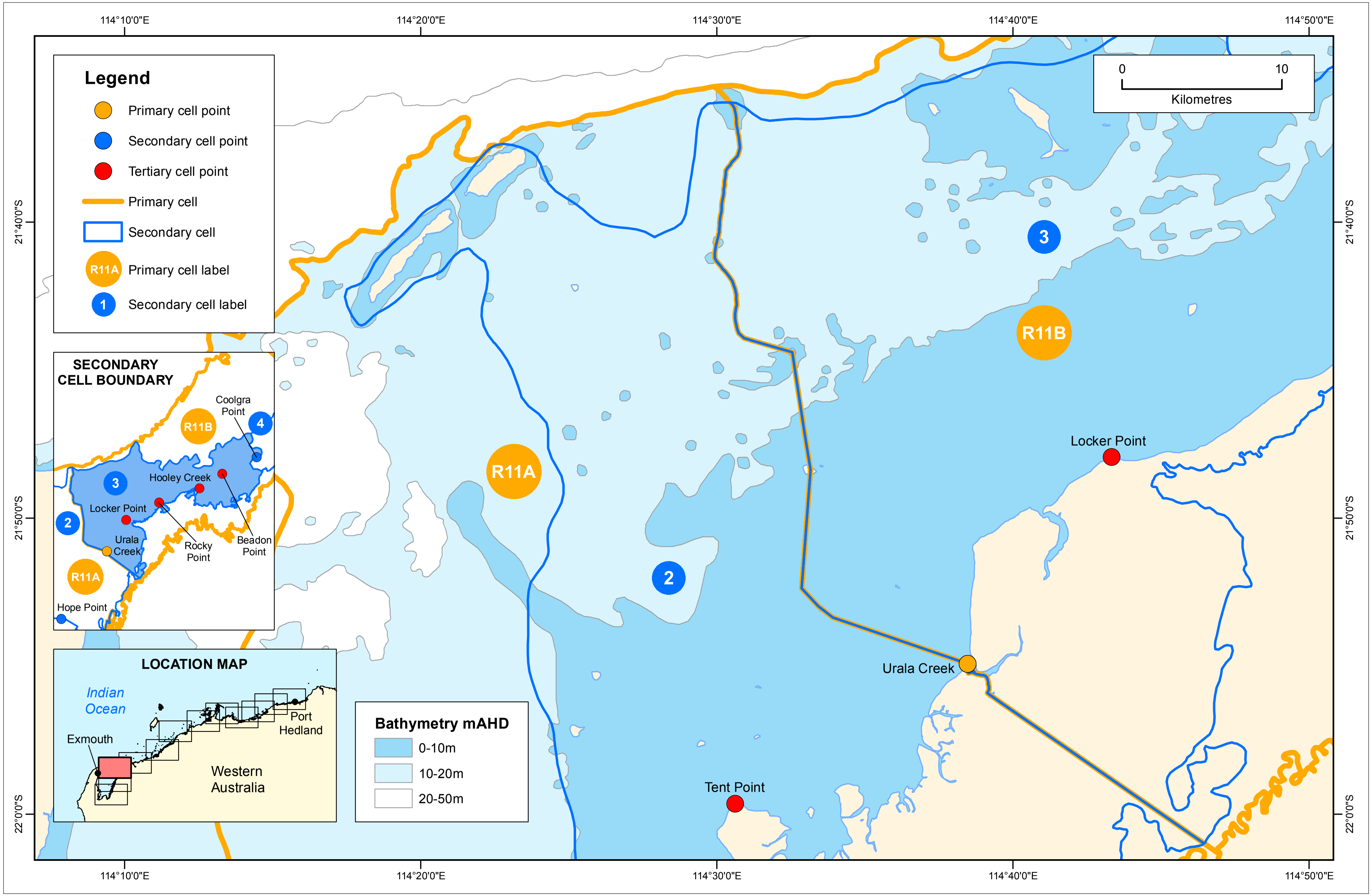


Figure A.3: Secondary and tertiary cells of the Pilbara Region

Figure is at scale of 1:300,000 at A4. A primary cell point is also a secondary and tertiary cell point. A secondary cell point is also a tertiary cell point. This map should not be used for navigation purposes. Bathymetry information supplied by Department of Planning and Australian Hydrographic Office. Rivers dataset provided by Department of Water.

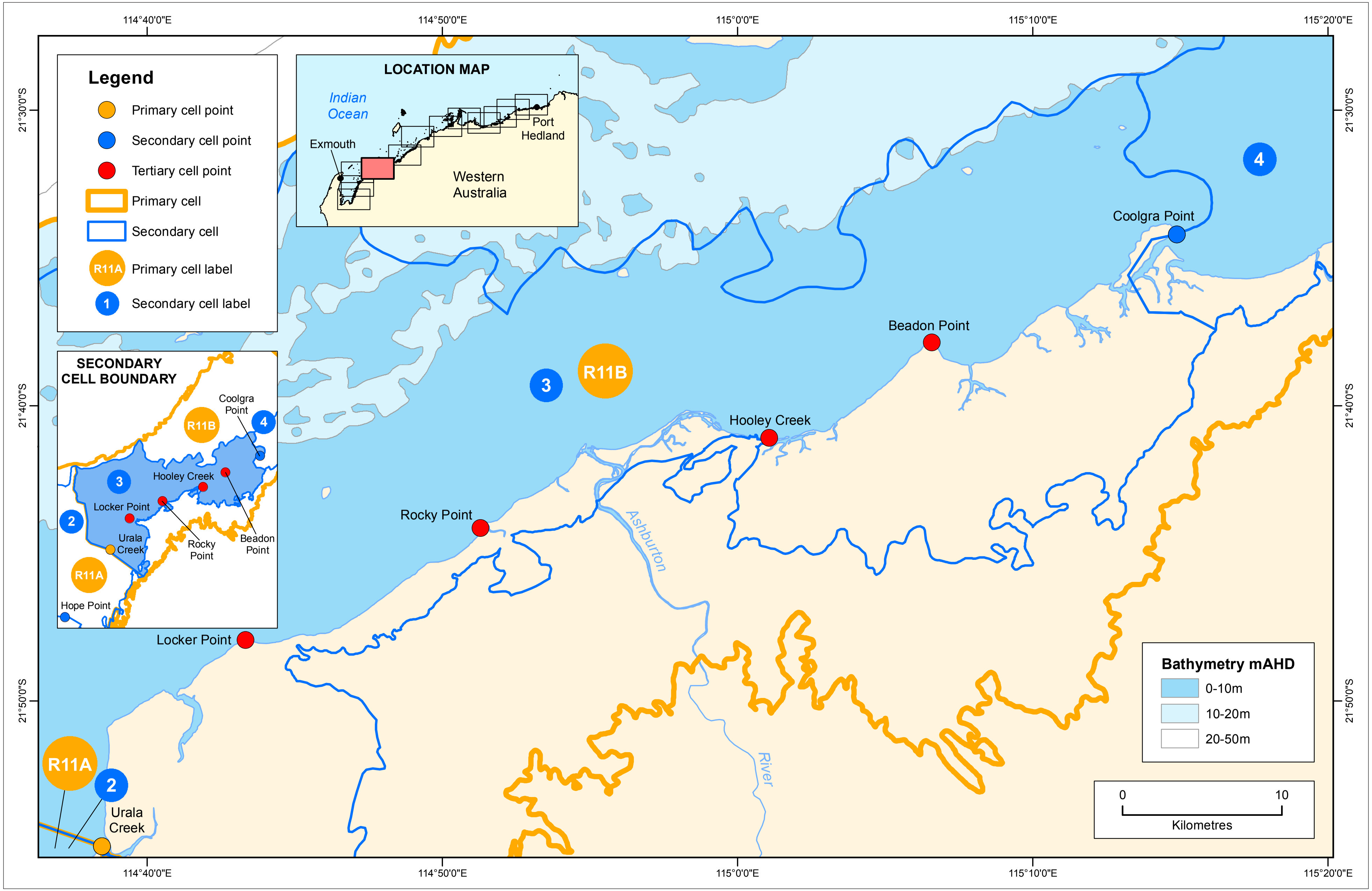


Figure A.4: Secondary and tertiary cells of the Pilbara Region

Figure is at scale of 1:300,000 at A4. A primary cell point is also a secondary and tertiary cell point. A secondary cell point is also a tertiary cell point. This map should not be used for navigation purposes. Bathymetry information supplied by Department of Planning and Australian Hydrographic Office. Rivers dataset provided by Department of Water.

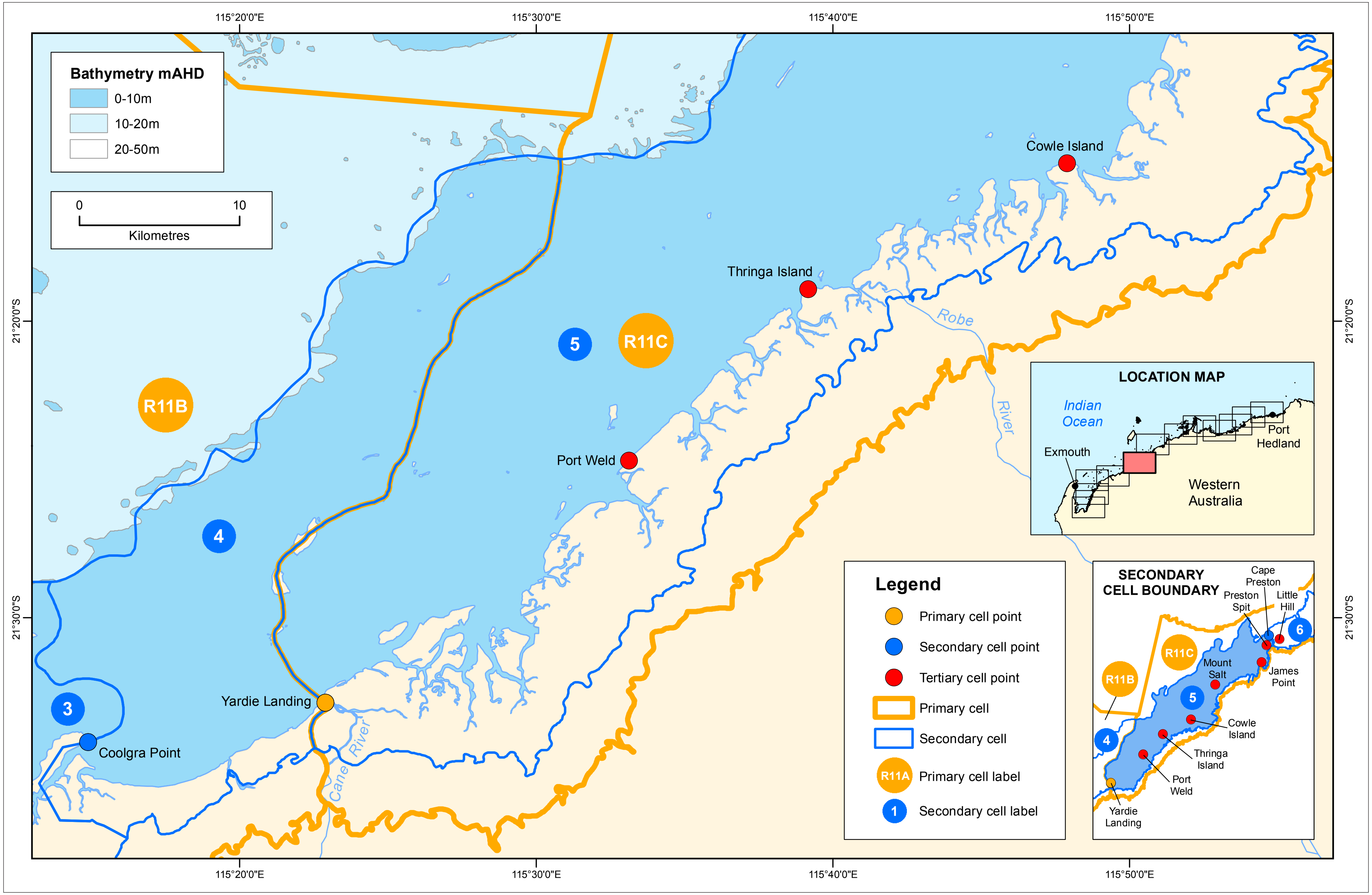


Figure A.5: Secondary and tertiary cells of the Pilbara Region

Figure is at scale of 1:300,000 at A4. A primary cell point is also a secondary and tertiary cell point. A secondary cell point is also a tertiary cell point. This map should not be used for navigation purposes. Bathymetry information supplied by Department of Planning and Australian Hydrographic Office. Rivers dataset provided by Department of Water.

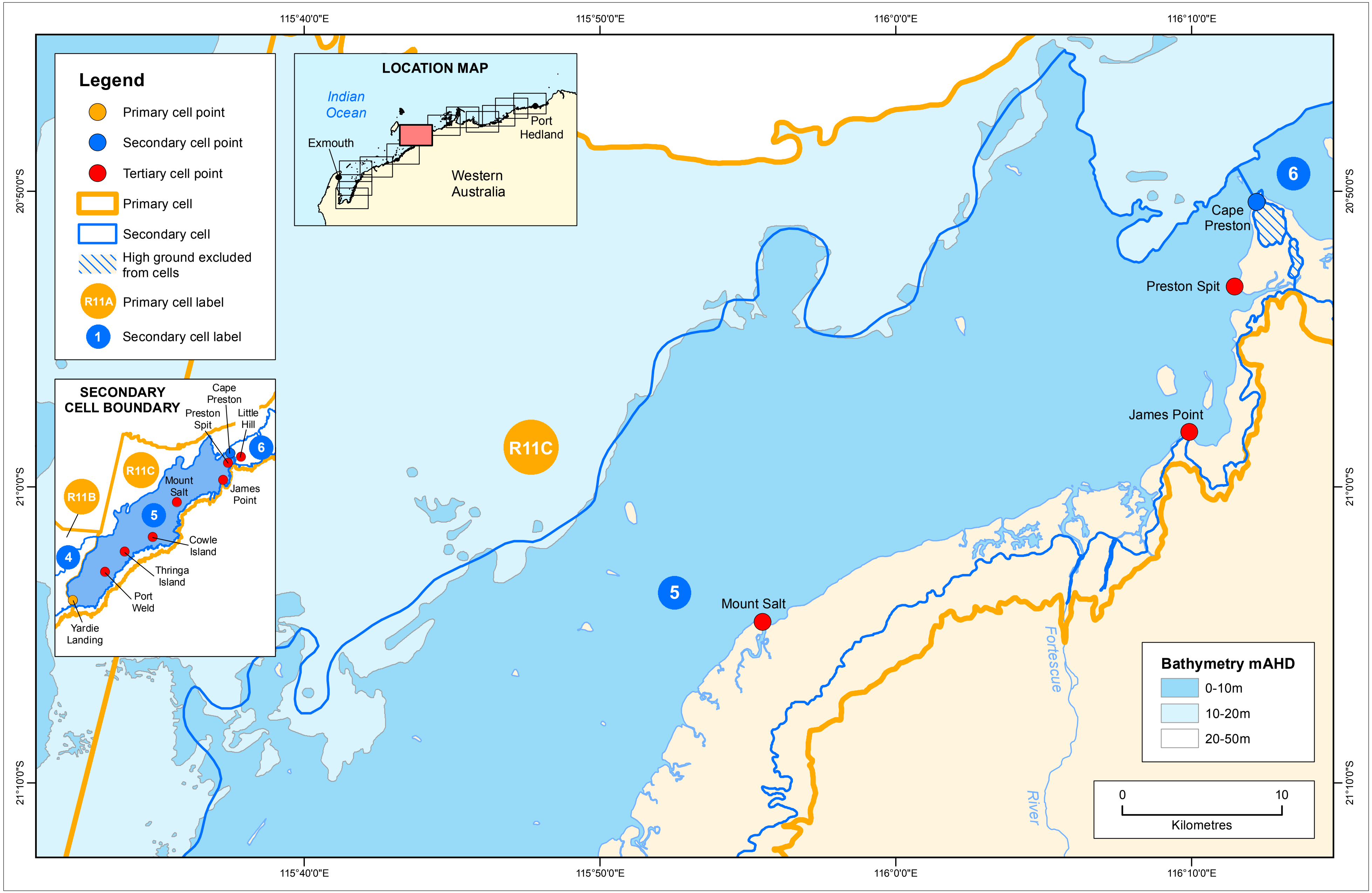


Figure A.6: Secondary and tertiary cells of the Pilbara Region

Figure is at scale of 1:300,000 at A4. A primary cell point is also a secondary and tertiary cell point. A secondary cell point is also a tertiary cell point. This map should not be used for navigation purposes. Bathymetry information supplied by Department of Planning and Australian Hydrographic Office. Rivers dataset provided by Department of Water.

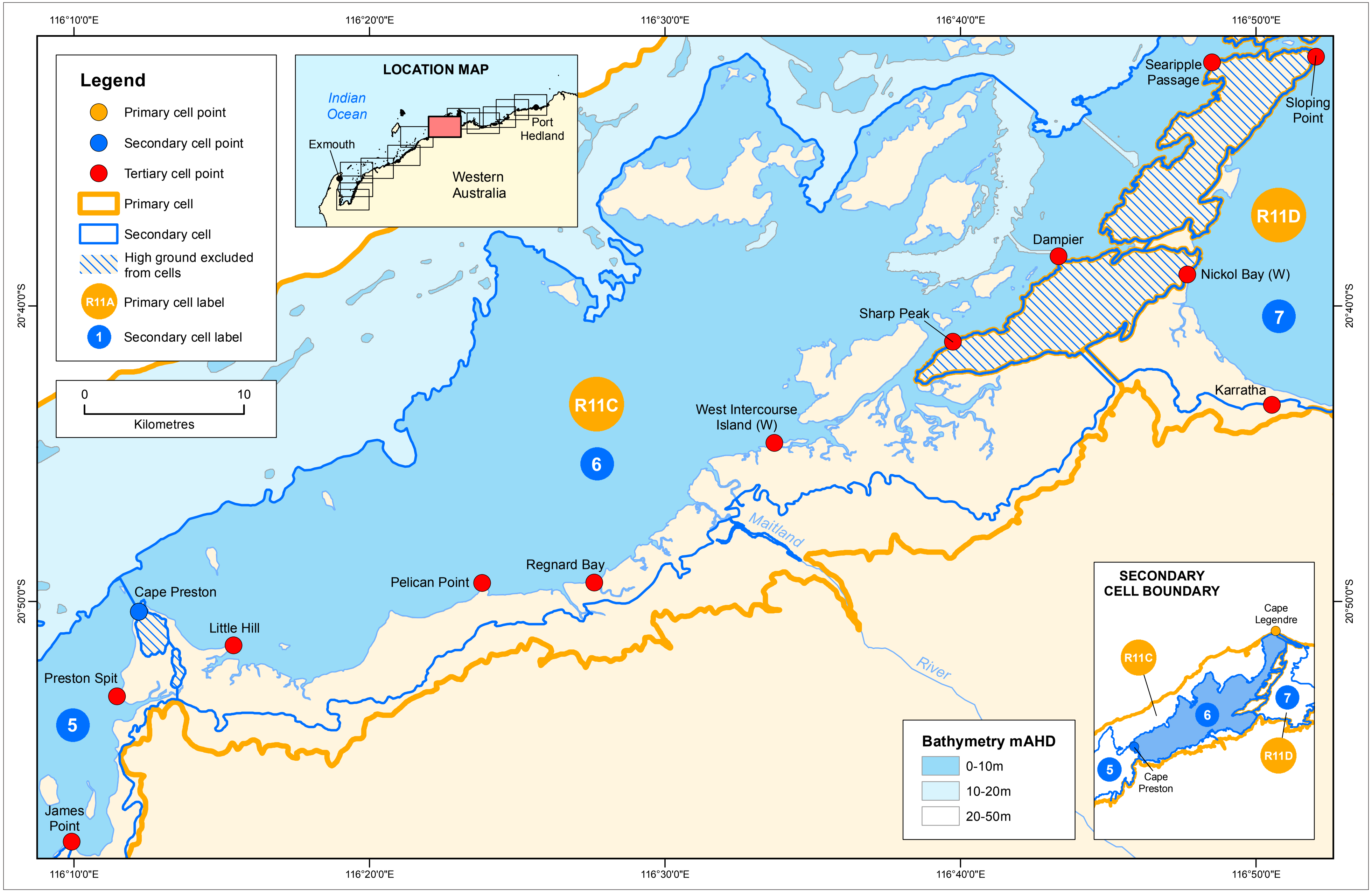


Figure A.7: Secondary and tertiary cells of the Pilbara Region

Figure is at scale of 1:300,000 at A4. A primary cell point is also a secondary and tertiary cell point. A secondary cell point is also a tertiary cell point. This map should not be used for navigation purposes. Bathymetry information supplied by Department of Planning and Australian Hydrographic Office. Rivers dataset provided by Department of Water.

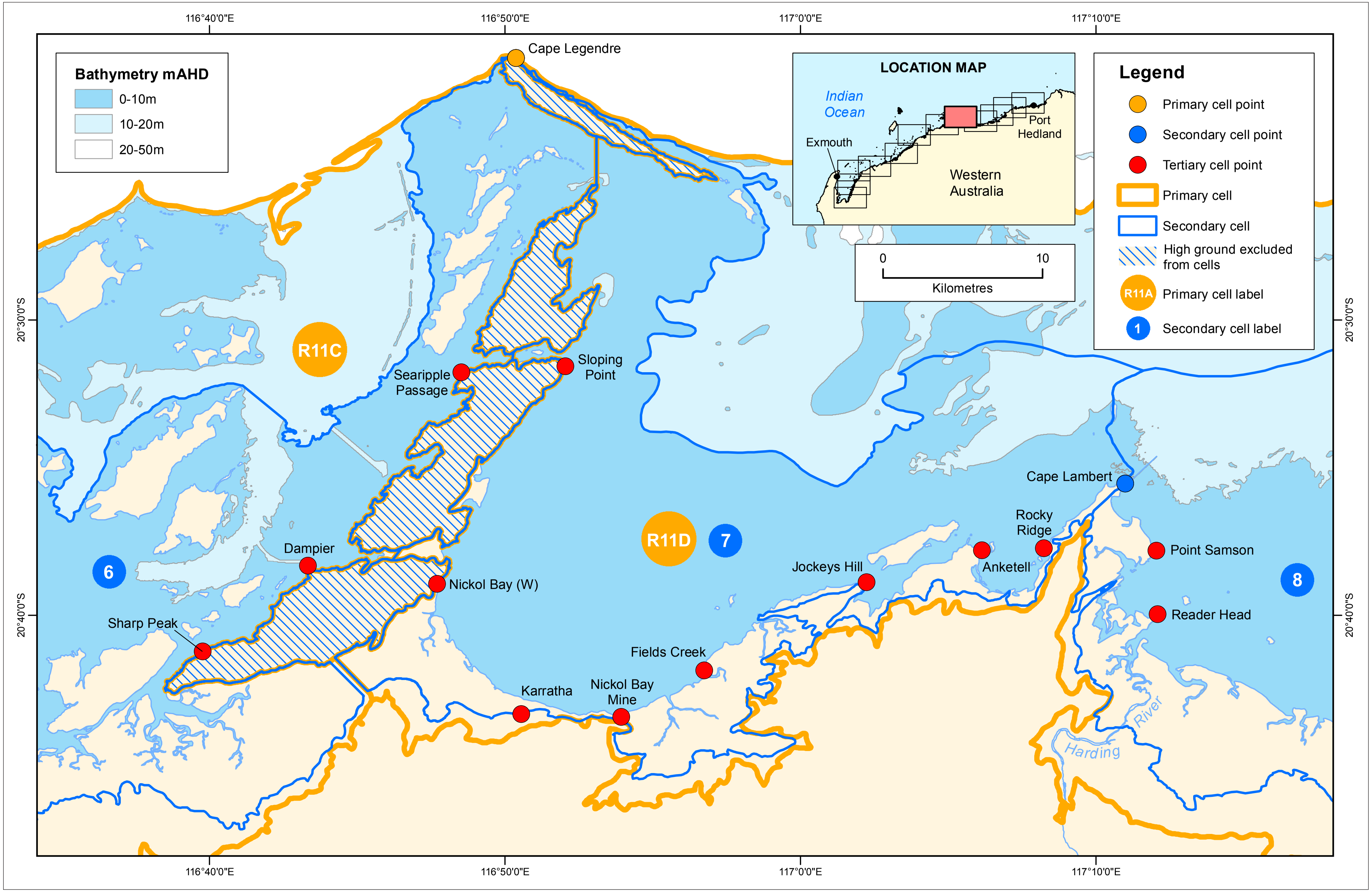


Figure A.8: Secondary and tertiary cells of the Pilbara Region

Figure is at scale of 1:300,000 at A4. A primary cell point is also a secondary and tertiary cell point. A secondary cell point is also a tertiary cell point. This map should not be used for navigation purposes. Bathymetry information supplied by Department of Planning and Australian Hydrographic Office. Rivers dataset provided by Department of Water.

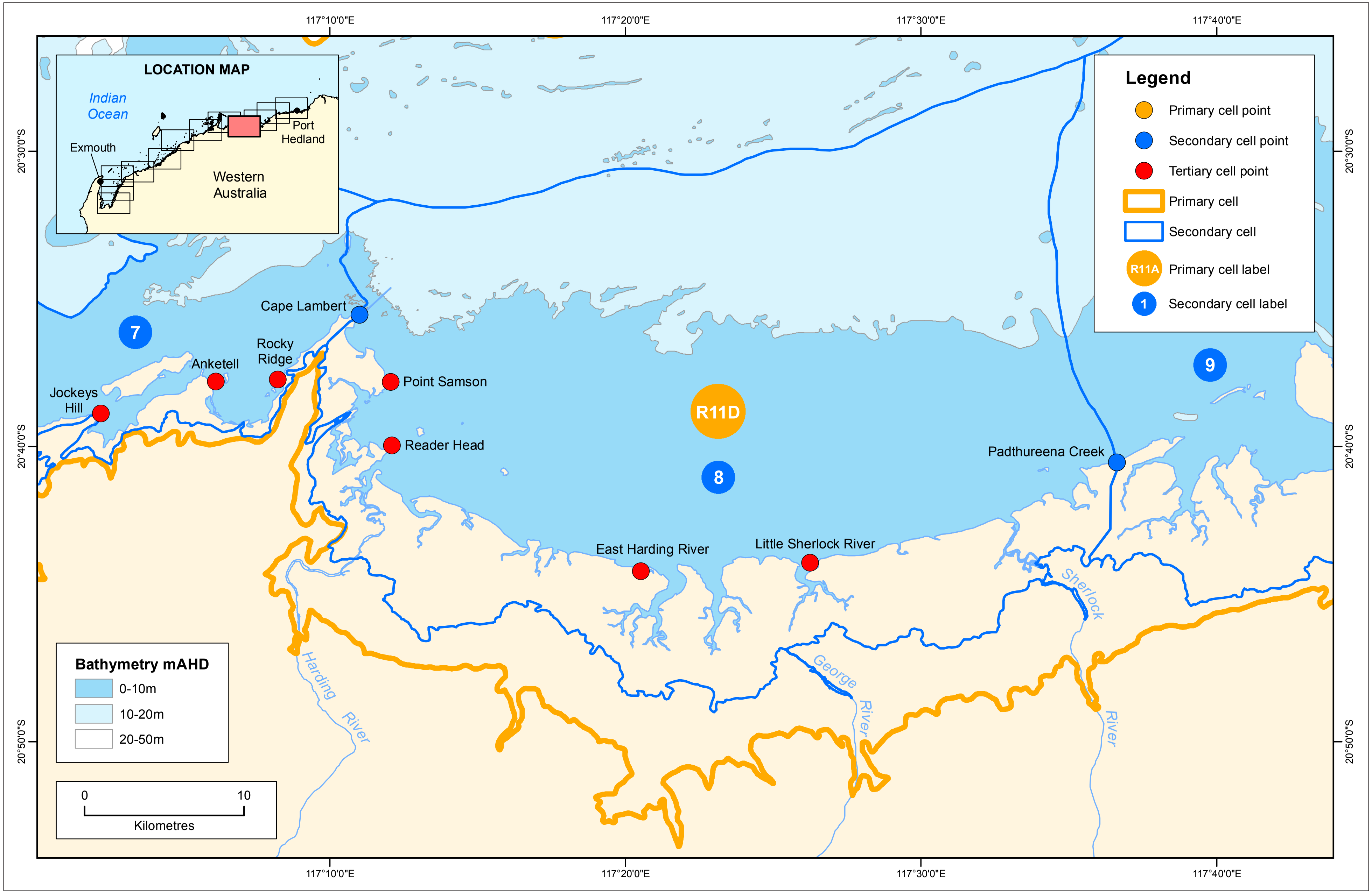


Figure A.9: Secondary and tertiary cells of the Pilbara Region

Figure is at scale of 1:300,000 at A4. A primary cell point is also a secondary and tertiary cell point. A secondary cell point is also a tertiary cell point. This map should not be used for navigation purposes. Bathymetry information supplied by Department of Planning and Australian Hydrographic Office. Rivers dataset provided by Department of Water.

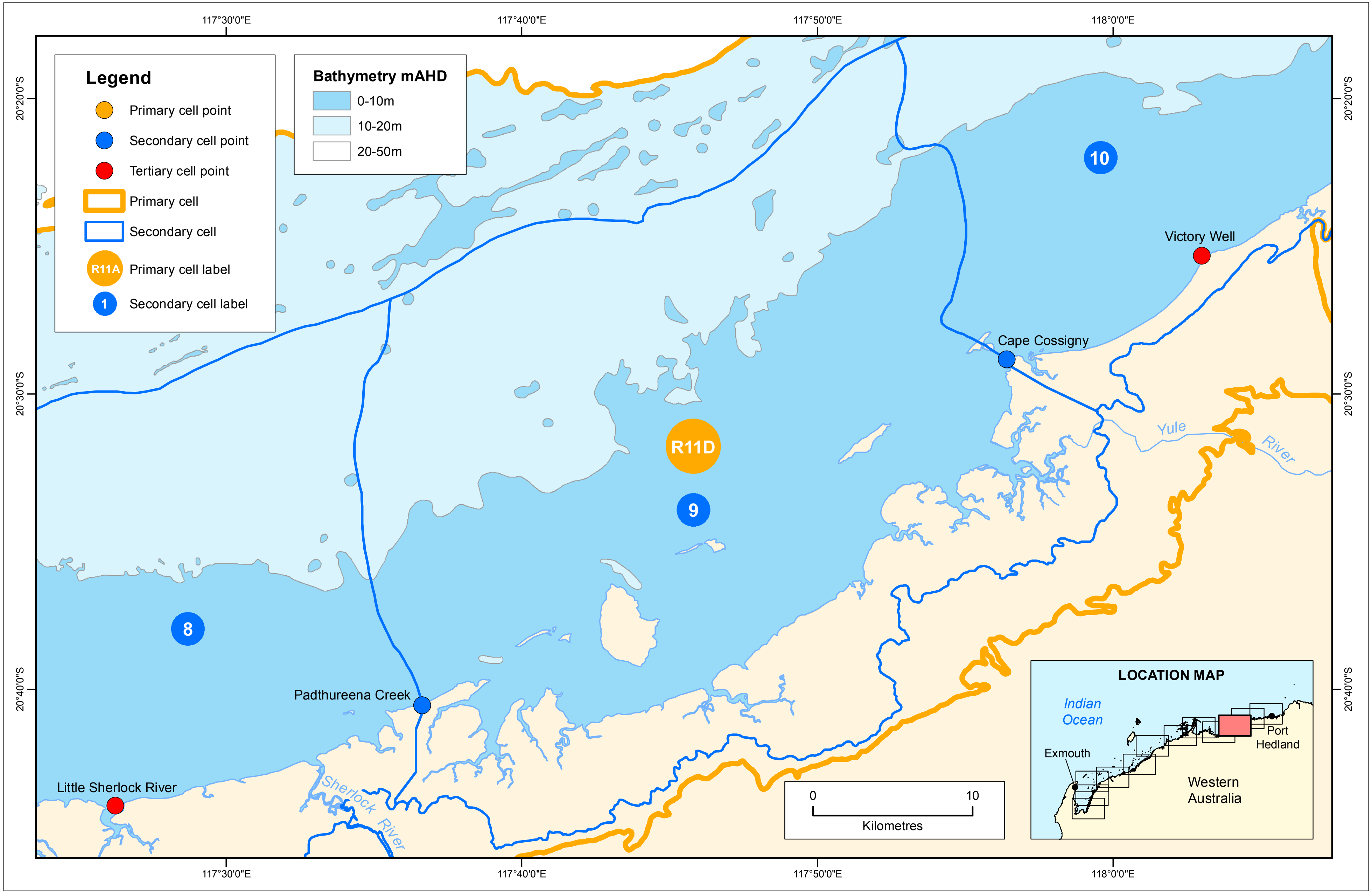


Figure A.10: Secondary and tertiary cells of the Pilbara Region

Figure is at scale of 1:300,000 at A4. A primary cell point is also a secondary and tertiary cell point. A secondary cell point is also a tertiary cell point. This map should not be used for navigation purposes. Bathymetry information supplied by Department of Planning and Australian Hydrographic Office. Rivers dataset provided by Department of Water.

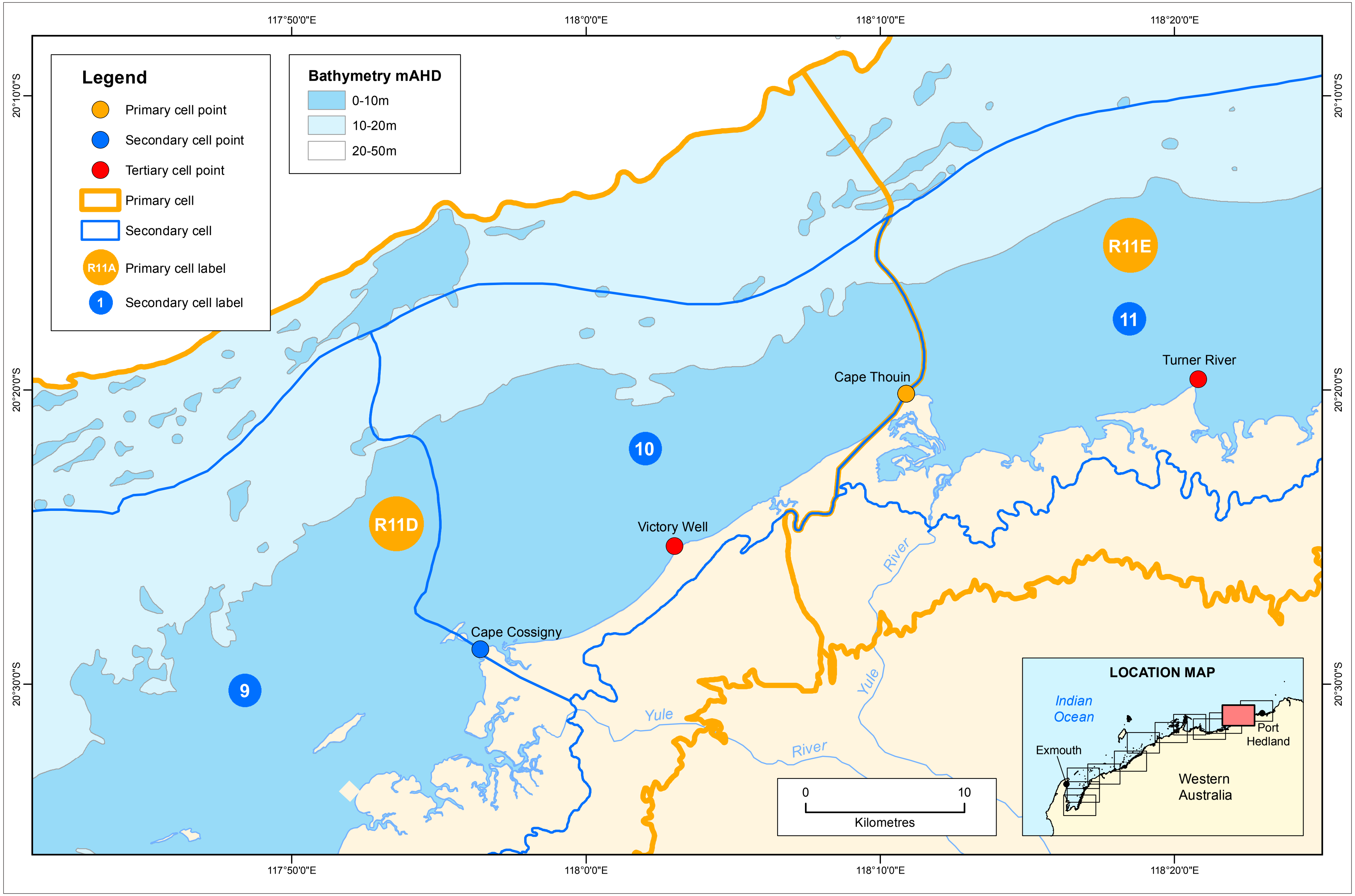


Figure A.11: Secondary and tertiary cells of the Pilbara Region

Figure is at scale of 1:300,000 at A4. A primary cell point is also a secondary and tertiary cell point. A secondary cell point is also a tertiary cell point. This map should not be used for navigation purposes. Bathymetry information supplied by Department of Planning and Australian Hydrographic Office. Rivers dataset provided by Department of Water.

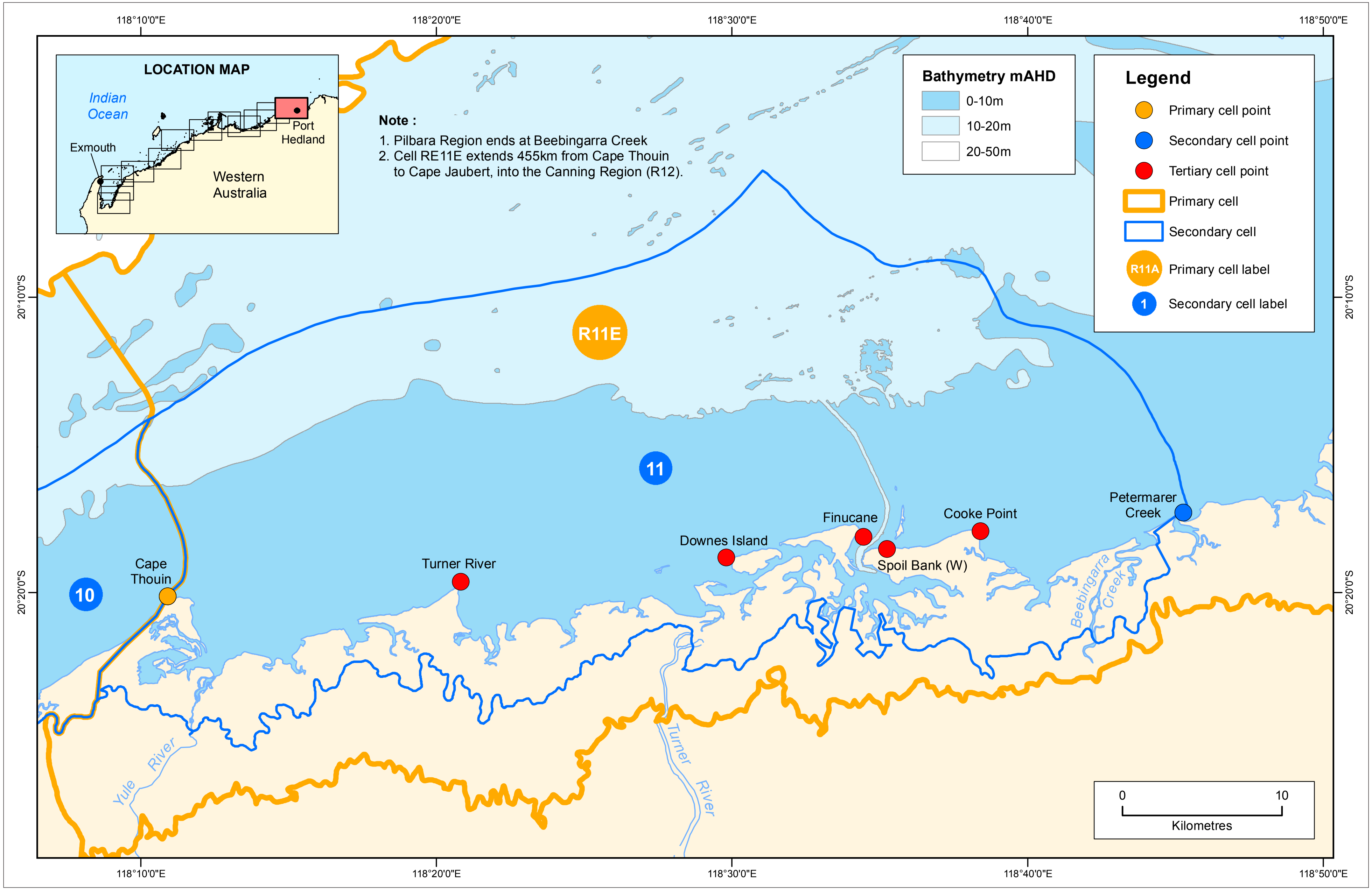


Figure A.12: Secondary and tertiary cells of the Pilbara Region

Figure is at scale of 1:300,000 at A4. A primary cell point is also a secondary and tertiary cell point. A secondary cell point is also a tertiary cell point. This map should not be used for navigation purposes. Bathymetry information supplied by Department of Planning and Australian Hydrographic Office. Rivers dataset provided by Department of Water.

Appendix B
Data sets

Table B.1: Data Sources used for determining cell boundaries in the Pilbara Region

Source	Dataset
Context	• Geological and geomorphological information and photographs contained in the WACoast[1] database. Beach information, including site photos[1,2].
	• Sediment information, with most data focussed on offshore sediment characteristics[3]. Some local studies of sediments for new ports at Wheatstone and Anketell.
Remotely sensed datasets	• *Bathymetry:* The preferred bathymetric data source for mapping sediment cells is nearshore and inshore LiDAR, with data available for this project only in the vicinity of Onslow, Dampier, Karratha and Port Hedland. Datasets used at the regional scale were mainly the Australian Navy hydrographic charts; and Department of Planning polygons derived from these hydrographic charts. All depths use the vertical datum of Australian Height Datum (AHD). Alternative information could have been used, however it was generally of a larger spatial resolution than needed, with reduced spatial accuracy. These datasets include the Geoscience Australia bathymetry and General Bathymetric Chart of the Oceans (GEBCO) bathymetry.
	• *Topography*: Geological Survey of Western Australia shaded relief model derived from the Landgate high-resolution digital elevation model. Alternative sources include Landgate topographic contours and spot heights; and any LiDAR collected in future.
	• *Vertical aerial imagery*: Landgate orthophotography from 2000-2012. Satellite imagery could be an alternative information source, but is generally of reduced spatial resolution and accuracy.
	• Historic coastal change: Historic aerial imagery provided context for coastal change, including recent changes identified by the time-series available through NearMap or Google Earth. There were limited Department of Transport shoreline movement plots for this coast, with only planbook 5 available near Onslow townsite. Recent shoreline movement plots were prepared for areas near townsites, proposed ports and onshore facilities[4]. *Shoreline:* The shoreline used as the basis for mapping is the Mean High Water Mark (MHWM) to 2006 prepared by Landgate and used by the Department of Environment and Conservation as the basis for the coastal compartment mapping[5]. This dataset is based on a combination of the cadastral and topographic coasts and is updated in areas as required based on government priority. It is unlikely to represent the location of the MHWM in 2006.
	• *Rivers*: 1:1M and 1:250k scale rivers by the Department of Water.
Landform mapping	• Digital dataset of land systems at 1:20,000 scale to a minimum of 10km (maximum of extent of alluvial land systems) inland of Landgate MHWM to 2006 as part of WACoast datasets[1]. Other land system information available from the Department of Agriculture Western Australia inventory of rangelands series maps and reports.
	• Digital dataset of landforms at 1:20,000 scale to 10km inland of Landgate MHWM to 2006 as part of WACoast datasets[1] in tertiary compartments from Bare Sand Point to Coolgra Point (Onslow), James Point to Sherlock (Karratha) and Downes Island to Beebingarra Creek E (Port Hedland). Heads up digitising (not photogrammetric) of dunes and supratidal landforms from orthophotographs at various scales.
	• 1:100k geology maps (GSWA) for mapping primary cell onshore boundaries.
Naming conventions	• AUSLIG. (1993) Topographic Series, 1:100 000 Map Sheets for Western Australia. Commonwealth Government, Canberra.
	• Geological Survey of Western Australia. (2007) Atlas of 1:250 000 Geological Series Map Images.
	• Department of Transport nautical charts and Australian Navy hydrographic charts.

Footnote references included on the subsequent page

(Footnotes)

1 Gozzard JR. (2012) *WACoast – Pilbara*. Geological Survey of Western Australia digital dataset.

2 Short AD. (2005) Beaches of the Western Australian Coast: Eucla to Roebuck Bay. University Press, Sydney.

3 Baker C, Potter A, Tran M & Heap AD. (2008) Sedimentology and Geormophology of the Northwest Marine region, a Spatial Analysis. Geoscience Australia. Record 2008/07.
Harris P, Baker E and Cole A. (1991) *Physical Sedimentology of the Australian Continental Shelf with Emphasis on Late Quaternary Deposits in Major Shipping Channels, Port Approaches and Choke Points*, Ocean Sciences Institute, The University of Sydney, Report no. 51.
James N, Bone Y, Kyser T, Dix G & Collins L. (2004) The importance of changing oceanography in controlling late Quaternary carbonate sedimentation on a high-energy, tropical, oceanic ramp: north-western Australia. *Sedimentology,* 51, 1-27.
Li F, Griffiths CM, Asiles-Taing T & Dyt CP. (2008) Modelled seabed response to possible climate change scenarios over the next 50 years in the Australian Northwest. Report No. 08-001, Predictive Geoscience, CSIRO Petroleum, The fourth report of Australian seabed model, Wealth from Oceans Flagship.
Margvelashvili N, Andrewartha J, Condie S, Herzfeld M, Parslow J, Sakov P & Waring J. (2006) Modelling suspended sediment transport on Australia's North West Shelf. North West Shelf Joint Environmental Management Study. Technical Report No. 7. CSIRO.
Porter-Smith R, Harris P, Anderson O, Coleman R, Greensale D & Jenkins C. (2004) Classification of the Australian continental shelf based on predicted sediment threshold exceedance from tidal currents and swell waves, *Marine Geology*, 211(1): 1-20.

4 Cardno. (2011) Port Hedland Coastal Vulnerability Study. Prepared for the Western Australian Planning Commission and LandCorp. Report Rep1022p. Two Volumes. 10 August 2011.
Damara WA Pty Ltd. (2010a) Coastal Geomorphology of the Ashburton River Delta and Adjacent Areas. Report to Chevron Australia.
Global Environmental Modelling Systems: GEMS. (2008c) Cape Preston Coastal Stability Study. Appendix D In: LeProvost Environmental Pty Ltd (2008) *Sino Iron Project: Marine Management Plan*. Prepared for CITIC Pacific Mining Management Pty Ltd.
MP Rogers & Associates. (2011) Onslow Townsite Planning: Coastal Setbacks & Development Levels. Prepared for LandCorp. Report R299 Rev 0.
JDA Consultant Hydrologists, Global Environmental Modelling Systems, Damara WA Pty Ltd, Coastal Zone Management and DHI Water & Environment. (2011a) Karratha Coastal Vulnerability Study – Main Report. Prepared for Landcorp. Volume 1 of 2.
JDA Consultant Hydrologists, Global Environmental Modelling Systems, Damara WA Pty Ltd, Coastal Zone Management and DHI Water & Environment. (2011b) Karratha Coastal Vulnerability Study – Attachments. Prepared for Landcorp. Volume 2 of 2.

5 Eliot I, Nutt C, Gozzard B, Higgins M, Buckley E and Bowyer J. (2011) *Coastal Compartments of Western Australia: A Physical Framework for Marine and Coastal Planning*. Report 80-02. Damara WA Pty Ltd. Report to the Departments of Environment and Conservation, Planning and Transport. Environmental Protection Authority.

Appendix C
Regional variation in criteria

Table C.1: Comparison of cell criteria for the Pilbara, Mid-West and Vlamingh Regions

The same criteria apply for Mid-West and Northampton Regions. All reference to Mid-West Region should be read as Mid-West and Northampton Regions.

<table>
<tr><th></th><th>Pilbara Region compared to Vlamingh Region</th><th>Pilbara Region compared to Mid-West Region</th></tr>
<tr><td>Beachface point</td><td>Same criteria used, except engineering structures did not define any primary beachface points in the Pilbara Region. Pilbara cells are frequently defined to include areas with likely sediment supply by individual river systems, incorporating whole deltas within broader cells. Vlamingh cells were defined based on changes in land systems and the geological framework.</td><td>Same criteria used. Cells in the Pilbara Region are frequently defined to include areas with likely sediment supply by individual river systems, incorporating whole deltas within broader cells. Rivers in the Mid-West discharge smaller volumes of sediment, with cells more frequently defined based on changes in barrier land systems.</td></tr>
<tr><td rowspan="2">Offshore boundaries and marine section of the alongshore boundary</td><td>Offshore boundaries of cells in the Pilbara Region are related to tidal reworking of sediment and waves, whereas waves are the primary process for cells in the Vlamingh Region. One consequence of this difference is offshore boundaries generally occur at shallower depths for the Pilbara Region in areas where tidal reworking and extreme waves provide the dominant environmental forcing.
The Vlamingh Region has multiple depth criteria for offshore boundaries at secondary and tertiary cell levels due to sheltering by continuous ridgelines of elongate reefs, large offshore islands within primary cell offshore boundaries, large sediment banks and basins.</td><td>Offshore boundaries of cells in the Pilbara Region are related to tidal reworking of sediment and waves, whereas waves are the primary process for the Mid-West Region. One consequence of this difference is offshore boundaries generally occur at shallower depths for the Pilbara Region in areas where tidal reworking and extreme waves provide the dominant environmental forcing.</td></tr>
<tr><td>Marine sections of the alongshore boundaries in the Vlamingh Region are fixed by toes of Holocene sediment banks, submerged rock outcrops and islands and follow lines of sediment transport convergence on banks and reefs. Marine sections cannot be easily resolved in the Pilbara Region due to extensive tidal reworking of sediments from multiple rivers across the broad nearshore area, combined with limited bathymetric information. Marine sections were often not orthogonal to the coast, but were skewed in the direction of the dominant current or wave forcing following high points in the bathymetry or ridge lines of islands.</td><td>Marine sections of the alongshore boundaries in the Mid-West Region are fixed by submerged rock outcrops and islands and follow lines of sediment transport convergence on banks and reefs. Marine sections cannot be easily resolved in the Pilbara Region due to extensive tidal reworking of sediments from multiple rivers across the broad nearshore area, combined with limited bathymetric information. Marine sections were often not orthogonal to the coast, but were skewed in the direction of the dominant current or wave forcing following high points in the bathymetry or ridge lines of islands.</td></tr>
<tr><td rowspan="3">Onshore boundaries and terrestrial section of the alongshore boundary</td><td>The Vlamingh and Pilbara coasts have been modified in densely populated or industrialised areas. The physical extent of the engineered structures and reclaimed land in the Pilbara tends to not extend beyond the area of the majority of tidal reworking of riverine sediments. Therefore engineering works tend to be excluded as criteria for onshore boundaries and terrestrial sections of alongshore boundaries in the Pilbara.</td><td>Rivers, creeks and outwash plains are common features of the Pilbara Region, with fluvial breakouts and interactions with marine processes at multiple scales. Due to this interaction of estuarine and alluvial land systems, onshore boundaries at a primary cell scale cannot be represented by the landward extent of Holocene and alluvial land systems because the onshore boundaries would be more than 70km landward of mean sea level.</td></tr>
<tr><td colspan="2">Natural onshore boundaries for primary cells in the Pilbara Region are linked to elevation contours for the extensive systems of outwash plains, with Holocene land systems used in the Mid-West and Vlamingh Regions. Onshore boundaries for secondary and tertiary cell scales in the Pilbara Region relate to the landward extent of supratidal landforms and inter-tidal landforms respectively, excluding the presence of dunes, cliffs and engineered coasts.</td></tr>
<tr><td colspan="2">Terrestrial sections of the alongshore boundaries are defined in the Vlamingh and Mid-West Regions by discontinuities in dune barriers and large landforms, or following the centerline of an engineered structure. The terrestrial sections cannot easily be resolved in the Pilbara Region due to extensive marine and fluvial interactions at multiple scales over the low-lying topography. Most frequently the boundary was mapped to ridgelines and connecting high points that separate basins.</td></tr>
</table>

Appendix D
Comparison to previously defined cells in the Pilbara Region

Table D.1: Primary and secondary cells compared to the Landform Vulnerability Report

Comparison between the primary and secondary cells identified in a previous landform vulnerability study for the Shire of Ashburton to Town of Port Hedland[1] to the revised hierarchy of boundaries in this report. The cell hierarchy presented in this report should be used in coastal studies rather than the cell boundaries used in the 2013 study. Further discussion is included in the Results section of the report.

<table>
<tr><th colspan="2">Cell Hierarchy</th><th colspan="2">Cells from Shire of Ashburton to Port Hedland Report[1]</th></tr>
<tr><td>Primary</td><td>Secondary</td><td>Primary</td><td>Secondary</td></tr>
<tr><td rowspan="4">R11E.
Cape Thouin to Cape Jaubert</td><td rowspan="3">Not defined as Study Limit was Beebingarra Creek E</td><td rowspan="4">Cape Thouin to Cape Jaubert</td><td>Eighty Mile Beach Caravan Park to Cape Jaubert</td></tr>
<tr><td>Cape Keraudren to Eighty Mile Beach Caravan Park</td></tr>
<tr><td>Petermarer Creek to Cape Keraudren</td></tr>
<tr><td>11. Cape Thouin to Petermarer Creek</td><td>Cape Thouin to Petermarer Creek</td></tr>
<tr><td rowspan="4">R11D.
Cape Legendre to Cape Thouin</td><td>10. Ronsard Island coast to Cape Thouin</td><td rowspan="4">Cape Legendre to Cape Thouin</td><td rowspan="3">Cape Lambert to Cape Thouin (separated into three cells in new report)</td></tr>
<tr><td>9. Padthureena Creek to Cape Cossigny</td></tr>
<tr><td>8. Cape Lambert to Padthureena Creek</td></tr>
<tr><td>7. Cape Legendre to Cape Lambert</td><td>Cape Legendre to Cape Lambert</td></tr>
<tr><td rowspan="3">R11C.
Yardie Landing to Cape Legendre</td><td>6. Cape Preston to Cape Legendre</td><td rowspan="2">Port Weld to Cape Legendre[A]</td><td>Cape Preston to Cape Legendre</td></tr>
<tr><td rowspan="2">5. Yardie Landing to Cape Preston</td><td>Port Weld to Cape Preston[A]</td></tr>
<tr><td rowspan="3">Urala Creek to Port Weld[A]</td><td rowspan="2">Coolgra Point to Port Weld[A]</td></tr>
<tr><td rowspan="2">R11B.
Urala Creek to Yardie Landing</td><td>4. Coolgra Point to Yardie Landing</td></tr>
<tr><td>3. Urala Creek to Coolgra Point</td><td>Urala Creek to Coolgra Point</td></tr>
<tr><td>R11A.
Giralia to Urala Creek</td><td>2. Hope Point to Urala Creek</td><td>Not defined as Study Limit was Hope Point</td><td>Not defined as Study Limit was Hope Point</td></tr>
</table>

Note: A. Port Weld shifted to Yardie Landing in new report for primary and secondary cells

(Footnotes)

1 Eliot I, Gozzard B, Eliot M, Stul T and McCormack G. (2013) *Geology, Geomorphology & Vulnerability of the Pilbara Coast, In the Shires of Ashburton, East Pilbara and Roebourne, and the Town of Port Hedland, Western Australia.* Damara WA Pty Ltd and Geological Survey of Western Australia, Innaloo, Western Australia.

Table D.2: Tertiary cells compared to cells in the Landform Vulnerability Report

Comparison between the tertiary cells identified in a previous landform vulnerability study for the Shire of Ashburton to Town of Port Hedland[1]. to the revised hierarchy of boundaries in this report. The cell hierarchy presented in this report should be used in coastal studies rather than the cell boundaries used in the 2013 study. Further discussion is included in the Results section of the report.

Tertiary Cells in Present Hierarchy	Tertiary Cells from Ashburton to Port Hedland Report[1]	Tertiary Compartment ranked and described[1,2]
R11D11f. Cooke Point to Petermarer Creek	22. Cooke Point to Petermarer Creek	Turner River to Beebingarra Creek E
R11D11e. Spoil Bank (W) to Cooke Point	21. Spoil Bank (W) to Cooke Point	
R11D11d. Finucane to Spoil Bank (W)	20. Finucane to Spoil Bank (W)	
R11D11c. Downes Island to Finucane	19. Downes Island to Finucane	
R11D11b. Turner River to Downes Island		
R11D11a. Cape Thouin to Turner River		Cape Thouin to Turner River
R11D10b. Victory Well to Cape Thouin		Cape Cossigny to Cape Thouin
R11D10a. Cape Cossigny to Victory Well		
R11D9a. Padthureena Creek to Cape Cossigny		Sherlock coast (now Padthureena Creek) to Cape Cossigny
R11D8e. Little Sherlock River to Padthureena Creek		Cape Lambert to Sherlock coast (now Padthureena Creek)
R11D8d. East Harding River to Little Sherlock River		
R11D8c. Reader Head to East Harding River	18. Reader Head to Butcher Inlet E	
R11D8b. Point Samson to Reader Head	17. Point Samson to Reader Head	
R11D8a. Cape Lambert to Point Samson	16. Cape Lambert to Point Samson	
R11D7i. Rocky Ridge to Cape Lambert	15. Rocky Ridge to Cape Lambert	Cleaverville Creek to Cape Lambert
R11D7h. Anketell to Rocky Ridge	14. Anketell to Rocky Ridge	
R11D7g. Jockeys Hill to Anketell	13. Jockeys Hill to Anketell	
R11D7f. Fields Creek to Jockeys Hill	12. Fields Creek to Jockeys Hill	
R11D7e. Nickol Bay Mine to Fields Creek	11. Nickol Bay Mine to Fields Creek	Karratha Back Beach to Cleaverville Creek
R11D7d. Karratha to Nickol Bay Mine	10. Karratha to Nickol Bay Mine	
R11D7c. Nickol Bay (W) to Karratha	9. Nickol Bay (W) to Karratha	Cinders Road to Karratha Back Beach
R11D7b. Sloping Point to Nickol Bay (W)		Dolphin Island Point to Cinders Road (now Nickol Bay W)
R11D7a. Cape Legendre to Sloping Point		
R11C6h. Searipple Passage to Cape Legendre		West Intercourse Island to Dolphin Island Point
R11C6g. Dampier to Searipple Passage		
R11C6f. Sharp Peak to Dampier	8. Sharp Peak to Dampier	
R11C6e. West Intercourse Island (W) to Sharp Peak		
R11C6d. Regnard Bay to West Intercourse Island (W)		Pelican Point to West Intercourse Island
R11C6c. Pelican Point to Regnard Bay		

Tertiary Cells in Present Hierarchy	Tertiary Cells from Ashburton to Port Hedland Report[1]	Tertiary Compartment ranked and described[1,2]
R11C6b. Little Hill to Pelican Point	7. Little Hill to Pelican Point	Cape Preston to Pelican Point
R11C6a. Cape Preston to Little Hill	6. Cape Preston to Little Hill	
R11C5g. Preston Spit to Cape Preston	5. Preston Spit to Cape Preston	James Point to Cape Preston
R11C5f. James Point to Preston Spit	4. James Point to Preston Spit	
R11C5e. Mt Salt to James Point		Mt Salt to James Point
R11C5d. Cowle Island to Mt Salt		Peter Creek to Mt Salt
R11C5c. Thringa Island to Cowle Island		Weld Island to Peter Creek
R11C5b. Port Weld to Thringa Island		
R11C5a. Yardie Landing to Port Weld		Yardie Landing to Weld Island
R11B4a. Coolgra Point to Yardie Landing		Coolgra Point to Yarding Landing
R11B3e. Beadon Point to Coolgra Point	3. Beadon Point to Coolgra Point	Hooley Creek to Coolgra Point
R11B3d. Hooley Creek to Beadon Point	2. Hooley Creek to Beadon Point	
R11B3c. Rocky Point to Hooley Creek	1. Rocky Point to Hooley Creek	Bare Sand Point to Hooley Creek
R11B3b. Locker Point to Rocky Point		Locker Point to Bare Sand Point
R11B3a. Urala Creek to Locker Point		Hope Point to Locker Point
R11A2b. Tent Point to Urala Creek		
R11A2a. Hope Point to Tent Point		
R11A1b. north Giralia Bay to Hope Point		
R11A1a. Giralia to north Giralia Bay		

(Footnotes)

1 Eliot I, Gozzard B, Eliot M, Stul T and McCormack G. (2013) *Geology, Geomorphology & Vulnerability of the Pilbara Coast, In the Shires of Ashburton, East Pilbara and Roebourne, and the Town of Port Hedland, Western Australia.* Damara WA Pty Ltd and Geological Survey of Western Australia, Innaloo, Western Australia.

2 Eliot I, Nutt C, Gozzard B, Higgins M, Buckley E and Bowyer J. (2011) *Coastal Compartments of Western Australia: A Physical Framework for Marine & Coastal Planning.* Damara WA Pty Ltd, Report to the Departments of Environment & Conservation, Planning and Transport.

Appendix E
Beachface points and cell boundary information

Table E.1: Rationale for selection of primary cell beachface points in the Pilbara Region

Co-ordinates in Latitude and Longitude rounded to 3 decimal places.

Beachface Point Name	Lat.	Long.	Other Boundaries	Alongshore Boundary Character	Beachface Point	Associated Primary Cells
Cape Jaubert	-18.944	121.557	2°, 3°	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-decadal scale; Geomorphic feature (Pindan soils commence to the north, promontory)	R11E, R12A
Cape Thouin	-20.335	118.181	2°, 3°	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-decadal scale; Geomorphic feature (Eastern extent of the transport from Sherlock Bay and western extent of the littoral transport from the Yule River, recurved spit on rock platform); Adjacent cells have a different shoreline aspect restricting sediment transport at a decadal scale (NW to ENE)	R11D, R11E
Cape Legendre	-20.352	116.839	2°, 3°	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-decadal scale (Legendre Island); Geomorphic feature (promontory); Adjacent cells have a different shoreline aspect restricting sediment transport at a decadal scale (NW to NE)	R11C, R11D
Yardie Landing	-21.548	115.381	2°, 3°	Zone, Fixed, Open	Rock structures restricting sediment transport at an inter-decadal scale; Geomorphic feature (Eastern extent of the majority of littoral drift from Ashburton River and transition to palaeodeltas, rock control on southern bank of Cane River)	R11B, R11C
Urala Creek	-21.915	114.641	2°, 3°	Zone, Ambulatory, Open	Geomorphic feature (Northern extent of supratidal Yannarie flats and western extent of deposition from Ashburton River, recurved spit on southern flank of Urala Creek); Adjacent cells have a different shoreline aspect restricting sediment transport at a decadal scale (NW to W)	R11A, R11B
Giralia	-22.437	114.293	2°, 3°	Zone, Ambulatory, Open	Rock structures restricting sediment transport at an inter-decadal scale; Geomorphic feature (Southern section of supratidal Yannarie flats, peninsula)	Last cell in region R10, R11A

Table E.2: Rationale for selection of primary cell onshore, offshore and alongshore boundaries in the Pilbara Region

Primary Cell	Offshore Boundary	Onshore Boundary	"From" Alongshore Boundary			"To" Alongshore Boundary		
			Point	Marine Section	Terrestrial Section	Point	Marine Section	Terrestrial Section
R11E. Cape Thouin to Cape Jaubert	-20 mAHD isobath furthest from shore Not mapped beyond Beebingarra Creek E	Continuous +9mAHD level for maximum tidal range of >5m; Not mapped beyond Beebingarra Creek E	Cape Thouin	Ridge line of islands; An extension of the beachface point to the offshore boundary	An extension of the beachface point to the onshore boundary, following ridge lines and high points (capture deltaic features that discharge to NE)	Cell extends 455 km from Cape Thouin to Cape Jaubert in the Canning Region (R12)	Not mapped	Not mapped
R11D. Cape Legendre to Cape Thouin	-20 mAHD isobath furthest from shore	Continuous +8mAHD level for maximum tidal range of 2.5-5m	Cape Legendre	An extension of the beachface point to the offshore boundary	No terrestrial section, onshore boundary only (follows onshore boundaries on cliffed coast and Dampier Road)	Cape Thouin	Ridge line of islands; An extension of the beachface point to the offshore boundary	An extension of the beachface point to the onshore boundary, following ridge lines and high points (capture deltaic features that discharge to NE)
R11C. Yardie Landing to Cape Legendre	-20 mAHD isobath furthest from shore; No offshore boundary, marine section of the alongshore boundary only (Barrow Island influence)	Continuous +8mAHD level for maximum tidal range of 2.5-5m	Yardie Landing	Ridge line of islands (No offshore limit due to Barrow Island)	An extension of the beachface point to the onshore boundary, following ridge lines and high points (not clearly defined high points, but attempted to separate the tidal creeks to the east)	Cape Legendre	An extension of the beachface point to the offshore boundary	No terrestrial section, onshore boundary only (follows onshore boundaries on cliffed coast and Dampier Road)

Table E.2: Rationale for selection of primary cell onshore, offshore and alongshore boundaries in the Pilbara Region

Primary Cell	Offshore Boundary	Onshore Boundary	"From" Alongshore Boundary			"To" Alongshore Boundary		
			Point	Marine Section	Terrestrial Section	Point	Marine Section	Terrestrial Section
R11B. Urala Creek to Yardie Landing	-20 mAHD isobath furthest from shore; No offshore boundary, marine section of the alongshore boundary only (Barrow Island influence)	Continuous +7mAHD level for maximum tidal range of <2.5m	Urala Creek	Ridge line of islands (Brown Island, Tubridgi Reef, Fly Island, Observation Island, Dayley shoal and Peak Island)	An orthogonal extension to the onshore boundary where there is no differentiation within a basin	Yardie Landing	Ridge line of islands (No islands, No offshore limit due to Barrow Island)	An extension of the beachface point to the onshore boundary, following ridge lines and high points (not clearly defined high points, but attempted to separate the tidal creeks to the east)
R11A. Giralia to Urala Creek	-20 mAHD isobath furthest from shore	Continuous +7mAHD level for maximum tidal range of <2.5m	Giralia	Deepest point of depression/ gulf or re-entrant of contours (line through Exmouth Gulf)	An extension of the beachface point to the onshore boundary, following ridge lines and high points	Urala Creek	Ridge line of islands (Brown Island, Tubridgi Reef, Fly Island, Observation Island, Dayley shoal and Peak Island)	An orthogonal extension to the onshore boundary where there is no differentiation within a basin

Table E.3: Rationale for selection of secondary cell beachface points in the Pilbara Region

Co-ordinates in Latitude and Longitude rounded to 3 decimal places.

Beachface Point Name	Lat.	Long.	Other Boundaries	Alongshore Boundary Character	Beachface Point	Associated Secondary Cells
Petermarer Creek	-20.288	118.754	3°	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Eastern extent of transport from Yule and Turner Rivers and western extent of De Grey delta, chenier on rock platform)	R11E11, R11E12
Cape Thouin	-20.335	118.181	1°, 3°	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Eastern extent of the transport from Sherlock Bay and western extent of the littoral transport from the Yule River, recurved spit on rock platform); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NW to ENE)	R11D10, R11E11
Cape Cossigny	-20.480	117.940	3°	Zone, Ambulatory, Open	Geomorphic feature (Eastern extent of the regressed shoreline of Sherlock Bay and approximate western extent of the Yule River influence, delta and salient in lee of Reef Island, chenier); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NNW to WNW)	R11D9, R11D10
Padthureena Creek	-20.676	117.610	3°	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Transition to the east with a regressed shoreline of Sherlock Bay, rock platform at centre of rocky chenier)	R11D8, R11D9
Cape Lambert	-20.592	117.183	3°	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (promontory separating zeta bays Nickol Bay to the west and Sherlock Bay to the east, mapped to Port); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NW to NE); Engineered structure or dredged channel	R11D7, R11D8
Cape Legendre	-20.352	116.839	1°, 3°	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale (Legendre Island); Geomorphic feature (promontory); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NW to NE)	R11C6, R11D7

Table E.3: Rationale for selection of secondary cell beachface points in the Pilbara Region

Co-ordinates in Latitude and Longitude rounded to 3 decimal places.

Beachface Point Name	Lat.	Long.	Other Boundaries	Alongshore Boundary Character	Beachface Point	Associated Secondary Cells
Cape Preston	-20.839	116.203	3°	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (promontory separating sediments from Robe and Fortescue deltas to the west and Yanyare and Maitland to the east, foreland); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (WNW to NE); Engineered structure or dredged channel (Port)	R11C5, R11C6
Yardie Landing	-21.548	115.381	1°, 3°	Zone, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Eastern extent of the majority of littoral drift from Ashburton River and transition to palaeodeltas, rock control on southern bank of Cane River)	R11B4, R11C5
Coolgra Point	-21.570	115.248	3°	Zone, Ambulatory, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Eastern extent of supratidal flats at Onslow and eastern extent of modern Ashburton sediments, recurved spit on rock platform)	R11B3, R11B4
Urala Creek	-21.915	114.641	1°, 3°	Zone, Ambulatory, Open	Geomorphic feature (Northern extent of supratidal Yannarie flats and western extent of deposition from Ashburton River, recurved spit on southern flank of Urala Creek); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NW to W)	R11A2, R11B3
Hope Point	-22.166	114.454	3°	Point, Ambulatory, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Shift in supratidal features with more basins to the north, salient on a rock platform)	R11A1, R11A2
Giralia	-22.437	114.293	1°, 3°	Zone, Ambulatory, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Southern section of supratidal Yannarie flats, peninsula)	Last cell in region R10, R11A1

Table E.4: Rationale for selection of secondary cell onshore, offshore and alongshore boundaries in the Pilbara Region

Secondary Cell	Offshore Boundary	Onshore Boundary	"From" Alongshore Boundary			"To" Alongshore Boundary		
			Point	Marine Section	Terrestrial Section	Point	Marine Section	Terrestrial Section
R11E11. Cape Thouin to Petermarer Creek	Landward toe of offshore rock ridge to encompass extent of tidal reworking in extreme events.	Landward extent of supratidal landforms; Landward extent of coastal dunes	Cape Thouin	Ridge line of islands; An extension of the beachface point to the offshore boundary	An extension of the beachface point to the onshore boundary following ridge lines and high points	Petermarer Creek	High point of sandbanks	An extension of the beachface point to the onshore boundary following ridge lines and high points (chenier ridge and then interfluves separating tidal creeks)
R11D10. Cape Cossigny to Cape Thouin	Landward toe of offshore rock ridge to encompass extent of tidal reworking in extreme events.	Landward extent of supratidal landforms; Landward extent of coastal dunes	Cape Cossigny	Ridge line of islands (Reef Island); High point of sandbanks	An orthogonal extension to the onshore boundary where there is no clear differentiation in landform height (delta)	Cape Thouin	Ridge line of islands; An extension of the beachface point to the offshore boundary	An extension of the beachface point to the onshore boundary following ridge lines and high points
R11D9. Padthureena Creek to Cape Cossigny	Landward toe of offshore rock ridge to encompass extent of tidal reworking in extreme events	Landward extent of supratidal landforms	Padthureena Creek	Rock promontory; Deepest point of depression or re-entrant of contours	An extension of the beachface point to the onshore boundary following ridge lines and high points (interfluves separating tidal creeks)	Cape Cossigny	Ridge line of islands (Reef Island); High point of sandbanks	An orthogonal extension to the onshore boundary where there is no clear differentiation in landform height (delta)
R11D8. Cape Lambert to Padthureena Creek	Landward toe of offshore rock ridge to encompass extent of tidal reworking in extreme events.	Landward extent of supratidal landforms; Landgate MHWM to 2006 on engineered coasts with extensive shore parallel structures without coastal landforms to landward. Ports and made ground may be included (Cape Lambert only)	Cape Lambert	Ridge line of islands	An extension of the beachface point to the onshore boundary following ridge lines and high points (centreline of structure)	Padthureena Creek	Rock promontory; Deepest point of depression or re-entrant of contours	An extension of the beachface point to the onshore boundary following ridge lines and high points (interfluves separating tidal creeks)

Table E.4: Rationale for selection of secondary cell onshore, offshore and alongshore boundaries in the Pilbara Region

Secondary Cell	Offshore Boundary	Onshore Boundary	"From" Alongshore Boundary			"To" Alongshore Boundary		
			Point	Marine Section	Terrestrial Section	Point	Marine Section	Terrestrial Section
R11D7. Cape Legendre to Cape Lambert	Landward toe of offshore rock ridge to encompass extent of tidal reworking in extreme events.	Landward extent of supratidal landforms; Seaward extent of rock unit on low to moderately high cliffed coasts. If this extends to the beachface the Landgate MHWM to 2006 has been used; Landgate MHWM to 2006 on engineered coasts with extensive shore parallel structures without coastal landforms to landward. Ports and made ground may be included (Dampier Road and Cape Lambert only)	Cape Legendre	An extension of the beachface point to the offshore boundary	No terrestrial section, onshore boundary only	Cape Lambert	Ridge line of islands	An extension of the beachface point to the onshore boundary following ridge lines and high points (centreline of structure)
R11C6. Cape Preston to Cape Legendre	-10 mAHD isobath closest to shore; Connection across a channel (across channel in Mermaid Sound between Burrup Peninsula and Lewis Islands)	Landward extent of supratidal landforms; Seaward extent of rock unit on low to moderately high cliffed coasts. If this extends to the beachface the Landgate MHWM to 2006 has been used; Landgate MHWM to 2006 on engineered coasts with extensive shore parallel structures without coastal landforms to landward. Ports and made ground may be included (Dampier Road)	Cape Preston	Centreline of engineered structure	No terrestrial section, onshore boundary only	Cape Legendre	An extension of the beachface point to the offshore boundary	No terrestrial section, onshore boundary only
R11C5. Yardie Landing to Cape Preston	-10 mAHD isobath closest to shore	Landward extent of supratidal landforms	Yardie Landing	Ridge line of islands (No offshore limit due to Barrow Island)	An extension of the beachface point to the onshore boundary following ridge lines and high points	Cape Preston	Centreline of engineered structure	No terrestrial section, onshore boundary only

Secondary Cell	Offshore Boundary	Onshore Boundary	"From" Alongshore Boundary			"To" Alongshore Boundary		
			Point	Marine Section	Terrestrial Section	Point	Marine Section	Terrestrial Section
R11B4. Coolgra Point to Yardie Landing	-10 mAHD isobath closest to shore	Landward extent of supratidal landforms; Landward extent of coastal dunes	Coolgra Point	Ridge line of islands	An extension of the beachface point to the onshore boundary following ridge lines and high points (includes salt evaporator levees)	Yardie Landing	Ridge line of islands (No offshore limit due to Barrow Island)	An extension of the beachface point to the onshore boundary following ridge lines and high points
R11B3. Urala Creek to Coolgra Point	-10 mAHD isobath closest to shore	Landward extent of supratidal landforms; Landward extent of coastal dunes; Landgate MHWM to 2006 on engineered coasts with extensive shore parallel structures without coastal landforms to landward (Wheatstone made ground)	Urala Creek	Ridge line of islands (Brown Island, Tubridgi Reef, Fly Island, Observation Island, Dayley shoal and Peak Island)	An extension of the beachface point to the onshore boundary following ridge lines and high points	Coolgra Point	Ridge line of islands	An extension of the beachface point to the onshore boundary following ridge lines and high points (includes salt evaporator levees)
R11A2. Hope Point to Urala Creek	-10 mAHD isobath closest to shore	Landward extent of supratidal landforms	Hope Point	An extension of the beachface point to the offshore boundary	An extension of the beachface point to the onshore boundary following ridge lines and high points (followed western boundary of remnant mounds on the mudflats)	Urala Creek	Ridge line of islands (Brown Island, Tubridgi Reef, Fly Island, Observation Island, Dayley shoal and Peak Island)	An extension of the beachface point to the onshore boundary following ridge lines and high points
R11A1. Giralia to Hope Point	-10 mAHD isobath closest to shore	Landward extent of supratidal landforms	Giralia	Deepest point of depression or re-entrant of contours (Exmouth Gulf)	An extension of the beachface point to the onshore boundary following ridge lines and high points	Hope Point	An extension of the beachface point to the offshore boundary	An extension of the beachface point to the onshore boundary following ridge lines and high points (followed western boundary of remnant mounds on the mudflats)

Table E.5: Rationale for selection of tertiary cell beachface points in the Pilbara Region

Co-ordinates in Latitude and Longitude rounded to 3 decimal places
No information was reported for offshore boundaries, onshore boundaries and the marine and terrestrial sections of the alongshore boundaries

Beachface Point Name	Lat.	Long.	Other Boundaries	Alongshore Boundary Character	Beachface Point	Associated Tertiary Cells
Petermarer Creek	-20.288	118.754	2°	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Eastern extent of transport from Yule and Turner Rivers and western extent of De Grey delta, chenier on rock platform)	R11E11f, R11E12a
Cooke Point	-20.299	118.640	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (transition from zeta bays, supratidal rock platform); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NNW to N)	R11E11e, R11E11f
Spoil Bank (W)	-20.309	118.587	-	Zone, Ambulatory, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Western extent of spoil bank with boundary to migrate west over time); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NNE to NNW); Engineered structure or dredged channel (onshore transport of dredged material)	R11E11d, R11E11e
Finucane	-20.302	118.574	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Large tidal creek with anthropogenic influences, supratidal rock platform); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NNW to NNE)	R11E11c, R11E11d
Downes Island	-20.314	118.497	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (transition from eroded shorelines with numerous small tidal creeks penetrating broad supratidal creeks to the west and large scale tidal creeks with large lithified chenier islands to the east, supratidal rock platform); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (N to NNW)	R11E11b, R11E11c
Turner River	-20.327	118.347	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Control point for erosion in the embayments to the east with eroded shorelines with numerous small tidal creeks penetrating broad supratidal flats; interference of littoral transport from Yule and Turner Rivers, cuspate foreland in lee rocky salient)	R11E11a, R11E11b

Beachface Point Name	Lat.	Long.	Other Boundaries	Alongshore Boundary Character	Beachface Point	Associated Tertiary Cells
Cape Thouin	-20.335	118.182	1°, 2°	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Eastern extent of the transport from Sherlock Bay and western extent of the littoral transport from the Yule River, recurved spit on rock platform); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NW to N)	R11D10b, R11E11a
Victory Well	-20.422	118.050	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (rocky salient separating two shallow embayments on western flank of the Yule River delta, rocky salient)	R11D10a, R11D10b
Cape Cossigny	-20.480	117.940	2°	Zone, Ambulatory, Open	Geomorphic feature (eastern extent of the regressed shoreline of Sherlock Bay with broad supratidal flats and extensive tidal creeks and spits and barrier dunes to the east associated with the western extent of the Yule River delta, delta and salient in lee of Reef Island); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (WNW to NW)	R11D9a, R11D10a
Padthureena Creek	-20.676	117.610	2°	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Transition to the east with a regressed shoreline of Sherlock Bay with supratidal flats and incorporates the Balla Balla Creek delta and Peawah River delta, rock platform at centre of rocky chenier)	R11D8e, R11D9a
Little Sherlock River	-20.732	117.437	-	Zone, Ambulatory, Open	Geomorphic feature (transition from funnel shaped estuaries of the Jones, George and Little Sherlock Rivers to the east to large cheniers and small tidal creeks on broad supratidal flats and the western half of the Sherlock River delta, distal end of chenier-spit associated with the eastern flank of the Little Sherlock River); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NE to N)	R11D8d, R11D8e
East Harding River	-20.737	117.342	-	Zone, Ambulatory, Open	Geomorphic feature (transition from large cheniers and small tidal creeks on broad supratidal flats to the east to funnel shaped estuaries of the Jones, George and Little Sherlock Rivers to the west, distal end of chenier-spit associated with western flank of East Harding River); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NE to N)	R11D8c, R11D8d

Table E.5: Rationale for selection of tertiary cell beachface points in the Pilbara Region

Co-ordinates in Latitude and Longitude rounded to 3 decimal places

No information was reported for offshore boundaries, onshore boundaries and the marine and terrestrial sections of the alongshore boundaries

Beachface Point Name	Lat.	Long.	Other Boundaries	Alongshore Boundary Character	Beachface Point	Associated Tertiary Cells
Reader Head	-20.666	117.201	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (infill between two NE-trending rock ridges to the north and wide supratidal flats fronted by cheniers dissected by tidal creeks to the east, rock); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (E to NE)	R11D8b, R11D8c
Point Samson	-20.630	117.201	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (infill between two NE-trending rock ridges, rock); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NE to E)	R11D8a, R11D8b
Cape Lambert	-20.592	117.183	2°	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (transition from rocky coast on the west to infilled embayments and salt flats with perched dunes to east with small tidal creeks, mapped to Port); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NW to NE); Engineered structure or dredged channel	R11D7i, R11D8a
Rocky Ridge	-20.629	117.137	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (transition from embayed coast to the south to open northwest facing coast to the north, southern extent of intertidal rock platform); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (N to NW)	R11D7h, R11D7i
Anketell	-20.630	117.102	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (transition from irregular rock and sand flat topograhy to the west and a bay to the east with narrow perched dunes, rocky point); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NNW to N)	R11D7g, R11D7h
Jockeys Hill	-20.648	117.037	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (western extent of Bouguer entrance [Port Robinson] with broad salt flats to the east, rocky point)	R11D7f, R11D7g

Beachface Point Name	Lat.	Long.	Other Boundaries	Alongshore Boundary Character	Beachface Point	Associated Tertiary Cells
Fields Creek	-20.698	116.945	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Transition from extensive salt flats and tidal creeks associated with the Nickol River to higher rocky topography of Cleaverville with tidal creeks, rock control on eastern flank of Fields Creek)	R11D7e, R11D7f
Nickol Bay Mine	-20.727	116.901	-	Zone, Ambulatory, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (transition from barrier dunes to Nickol River delta and tidal flats, eastern extent of rock salient); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NNE to NNW)	R11D7d, R11D7e
Karratha	-20.721	116.843	-	Zone, Ambulatory, Open	Geomorphic feature (tidal flats cheniers and overwash to barrier dunes, recurved spit welded to rock); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (ENE to NNE)	R11D7c, R11D7d
Nickol Bay (W)	-20.649	116.795	-	Zone, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (northern extent of Nickol Bay tidal flats and shift from rocky to sand coast, rock promontory); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (SE to ENE)	R11D7b, R11D7c
Sloping Point	-20.526	116.867	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (southern point of Searipple Passage, rock promontory); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (ENE to SE)	R11D7a, R11D7b
Cape Legendre	-20.352	116.839	1°, 2°	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale (Legendre Island); Geomorphic feature (Burrup Peninsula, promontory); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (WNW to ENE)	R11C6h, R11D7a
Searipple Passage	-20.529	116.807	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (southern point of Searipple Passage, rock promontory); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NW to WNW)	R11C6g, R11C6h

Table E.5: Rationale for selection of tertiary cell beachface points in the Pilbara Region

Co-ordinates in Latitude and Longitude rounded to 3 decimal places

No information was reported for offshore boundaries, onshore boundaries and the marine and terrestrial sections of the alongshore boundaries

Beachface Point Name	Lat.	Long.	Other Boundaries	Alongshore Boundary Character	Beachface Point	Associated Tertiary Cells
Dampier	-20.639	116.72	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (southern point of King Bay, rock promontory); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NNW to NW); Engineered structure or dredged channel (port)	R11C6f, R11C6g
Sharp Peak	-20.687	116.663	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (northern extent of basin in lee of West Intercourse island and northern extent of tidal creek mouth, eastern flank of tidal creek)	R11C6e, R11C6f
West Intercourse Island (W)	-20.744	116.562	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Western extent of influence of Dampier Archipelago, rock outcrop on a chenier foreland)	R11C6d, R11C6e
Regnard Bay	-20.823	116.460	-	Zone, Ambulatory, Open	Geomorphic feature (western flank of the Maitland delta, western bank of a tidal creek); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (N to NW)	R11C6c, R11C6d
Pelican Point	-20.823	116.397	-	Zone, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (broad supratidal basin to east to narrow supratidal basin landward of lithified cheniers, remnant lithified shoreline acting as promontory); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NNW to N)	R11C6b, R11C6c
Little Hill	-20.858	116.257	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Rocky coast with perched dunes and spits to the east transitioning to complex inherited topography with supratidal basins and salt flats to landward and lithified dunes and unconsolidated cheniers, eastern extent of rocky chenier); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NNE to NNW)	R11C6a, R11C6b
Cape Preston	-20.839	116.203	2°	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (WNW to NE); Engineered structure or dredged channel (Port)	R11C5g, R11C6a

Beachface Point Name	Lat.	Long.	Other Boundaries	Alongshore Boundary Character	Beachface Point	Associated Tertiary Cells
Preston Spit	-20.887	116.191	-	Zone, Ambulatory, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (intertidal flats to the south and foredune plains and spits to the north, recurved spit on rock platform)	R11C5f, R11C5g
James Point	-20.969	116.165	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (eastern extent of Fortescue delta and transition to rugged rocky topography to the east, rock point); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NNW to WNW)	R11C5e, R11C5f
Mt Salt	-21.076	115.925	-	Zone, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (transition from western half of the Fortescue delta with broad intertidal flats to the eastern half of the Fortescue delta with continuous cheniers and supratidal flats, western bank of tidal creek breaching the cheniers); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NW to NNW)	R11C5d, R11C5e
Cowle Island	-21.244	115.798	-	Zone, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Transition from Robe delta to Fortescue delta with more sandy sediments to the east, eastern point of eroded cheniers on rock platform); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NNW to NW)	R11C5c, R11C5d
Thringa Island	-21.315	115.653	-	Zone, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (transition from eastern half of Robe delta with cheniers and wide intertidal flats with numerous tidal creeks to the western half of Robe delta with small islets that are remnants of older chenier chain, northern point of the eastern flank of a major tidal creek); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NW to NNW)	R11C5b, R11C5c
Port Weld	-21.412	115.552	-	Zone, Ambulatory, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Transition from large tidal creek system with offshore sand islands to the west to small cheniers and small tidal creeks to the east, chenier on eastern flank of a tidal creek)	R11C5a, R11C5b

Table E.5: Rationale for selection of tertiary cell beachface points in the Pilbara Region

Co-ordinates in Latitude and Longitude rounded to 3 decimal places

No information was reported for offshore boundaries, onshore boundaries and the marine and terrestrial sections of the alongshore boundaries

Beachface Point Name	Lat.	Long.	Other Boundaries	Alongshore Boundary Character	Beachface Point	Associated Tertiary Cells
Yardie Landing	-21.548	115.381	1°, 2°	Zone, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Barrier dunes to west and southern extent of outwash plains and large network of tidal creeks, rock control on southern bank of Cane River)	R11B4a, R11C5a
Coolgra Point	-21.570	115.248	2°	Zone, Ambulatory, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Eastern extent of supratidal flats at Onslow and eastern extent of modern Ashburton sediments, recurved spit on rock platform)	R11B3e, R11B4a
Beadon Point	-21.631	115.110	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Rocky headland control of zeta-form bays, rocky point)	R11B3d, R11B3e
Hooley Creek	-21.685	115.018	-	Zone, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Active Ashburton delta transition to barrier dunes, lagoons, supratidal flats and tidal creeks to the east, perched dune on rocky salient); Engineered structure or dredged channel (Port)	R11B3c, R11B3d
Rocky Point	-21.736	114.855	-	Zone, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (high dune ridge to east to chenier plains to the west, rock control on western bank of tidal creek)	R11B3b, R11B3c
Locker Point	-21.799	114.722	-	Zone, Ambulatory, Open	Rock structures restricting sediment transport at an inter-annual scale (sub-tidal); Geomorphic feature (lagoonal basins and supratidal flats with tidal creeks to the east to dunes further west, salient on a rock platform); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NW to NNW)	R11B3a, R11B3b
Urala Creek	-21.915	114.641	1°, 2°	Zone, Ambulatory, Open	Geomorphic feature (Northern extent of supratidal Yannarie flats and western extent of deposition from Ashburton River, recurved spit on southern flank of Urala Creek); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (NW to W)	R11A2b, R11B3a

Beachface Point Name	Lat.	Long.	Other Boundaries	Alongshore Boundary Character	Beachface Point	Associated Tertiary Cells
Tent Point	-21.994	114.510	-°	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Transition from tidal creeks to increased littoral drift to the north, northern point of Tent Island which is salient on a rock platform); Adjacent cells have a different shoreline aspect restricting sediment transport at an inter-annual scale (WNW to NW)	R11A2a, R11A2b
Hope Point	-22.166	114.455	2°	Point, Ambulatory, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Shift in supratidal features with more lagoons to the north, salient on a rock platform)	R11A1b, R11A2a
north Giralia Bay	-22.399	114.377	-	Point, Fixed, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (northern extent of Giralia Bay, rock platform)	R11A1a, R11A1b
Giralia	-22.437	114.293	1°, 2°	Zone, Ambulatory, Open	Rock structures restricting sediment transport at an inter-annual scale; Geomorphic feature (Southern section of supratidal Yannarie flats, peninsula)	Last cell in region R10, R11A1a

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