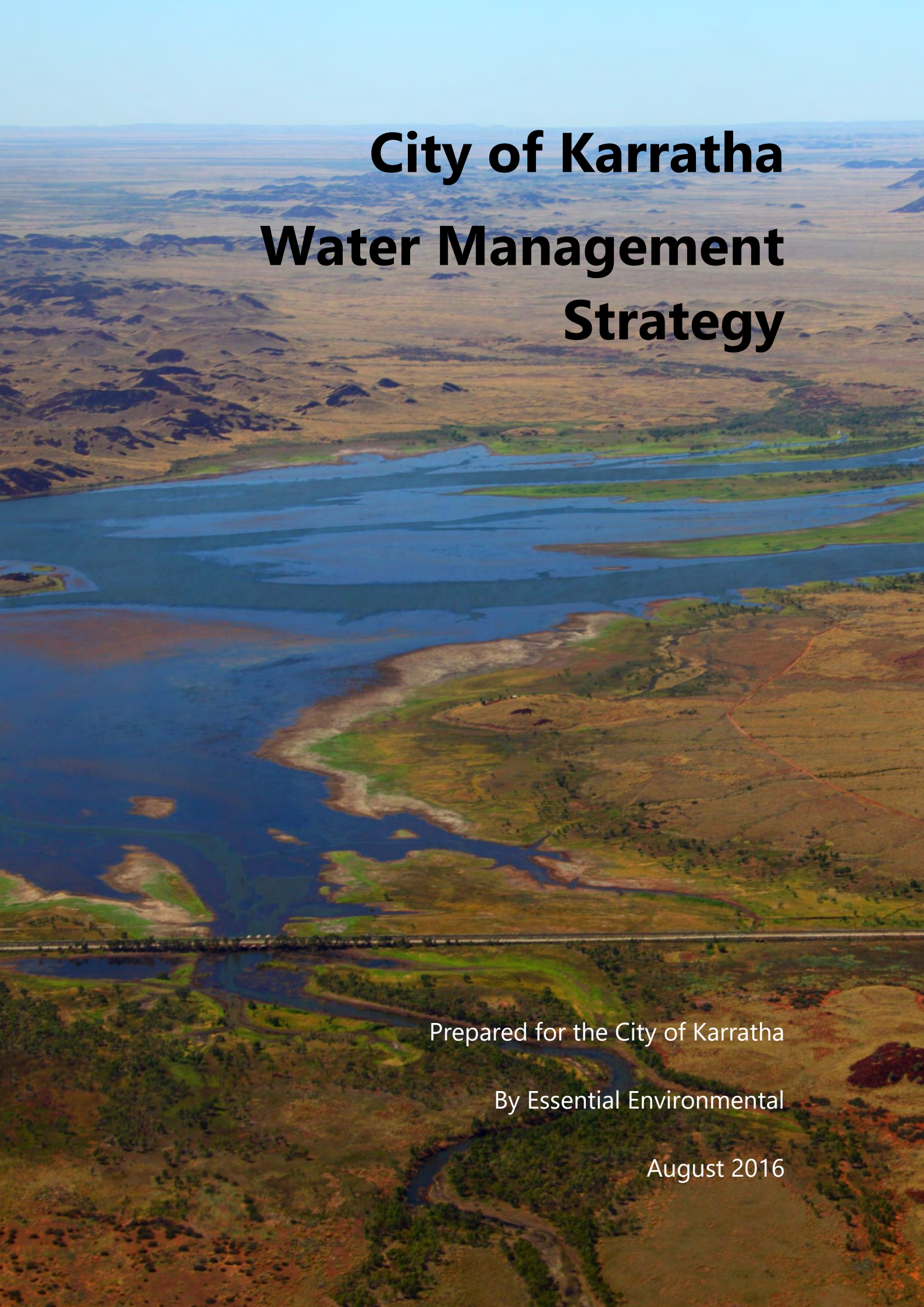

City of Karratha Water Management Strategy

Prepared for the City of Karratha

By Essential Environmental

August 2016

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EXECUTIVE SUMMARY

The City of Karratha Water Management Strategy highlights important values associated with the critical water resources of the City which include drinking water, surface water, groundwater and wastewater. It proposes objectives, strategies and actions for the City in regards to the management of these water resources.

The objectives of the City of Karratha Water Management Strategy are to:

- Adequately manage the risk of flooding;
- Increase water use efficiency, recycling and reuse to provide fit-for-purpose sources;
- Manage discharges to ground and surface waters to avoid contamination and health risks; and
- Maintain environmental, cultural and social values and provide for the water needs of the future community through advocacy and informed decision making.

This water management strategy will be delivered by the City. It is recognised; however, that the protection and management of water resources is largely controlled by agencies other than the City. The City's role is limited to its local government functions which include regulatory and operational activities and provision of various community services. Key areas of action that are relevant to the management of water resources by the City of Karratha are:

- Planning decision-making on future planning and development proposals;
- Management and maintenance of drainage infrastructure;
- Maintenance of public open space including irrigation; and
- Advocacy for increased water conservation, efficiency and reuse and enhancement of cultural and community connections to water.

The recommendations of this water management strategy are consistent with and supported by the City's local planning strategy and local planning scheme. They will guide planning decision-making with regards to water resource management, ensuring that water resources are addressed at all stages of the land use planning and development approvals process, consistent with *State Planning Policy 2.9 Water Resources,* and *Better Urban Water Management* (WAPC, 2008). Particular attention has been paid to areas identified for future development in the City's Local Planning Strategy and a broadscale assessment of the water resources issues requiring consideration has been provided for each future development area

The water management strategy also provides recommendations in relation to the management and maintenance of the City's stormwater drainage system; maintenance of water efficient public open spaces; and leadership and advocacy in the improved management of water resources. These recommendations should inform the City's Strategic Community Plan, Corporate Business Plan, and Operational Plan.

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1 INTRODUCTION

The water management strategy clarifies the future development requirements of the City, consistent with *State Planning Policy 2.9 Water Resources, Better Urban Water Management* (WAPC, 2008) and the legislations, policies and guidelines of the State's water agencies. It also provides guidance for the activities of the City in relation to the management and maintenance of critical water resources and infrastructure such as drinking water, groundwater, irrigation and drainage to achieve agreed objectives for the City.

The objectives of the City of Karratha Water Management Strategy are to:

- Adequately manage the risk of flooding;
- Increase water use efficiency, recycling and reuse to provide fit-for-purpose sources;
- Manage discharges to ground and surface waters to avoid contamination and health risks; and
- Maintain environmental, cultural and social values and provide for the water needs of the future community through advocacy and informed decision making.

1.1 The strategy area

The City of Karratha forms the central coastal part of the Pilbara region. With an area just over 15,000 square kilometres, it is bounded by the Indian Ocean to the north and west, the Town of Port Hedland to the east, and the Shire of Ashburton to the south (Figure 1). Settlement is largely confined to a string of towns along the coastal strip and the North West Coastal Highway which include Karratha, Point Samson, Wickham, Cossack, Roebourne and Dampier.

Karratha is the regional centre of the City and provides administrative and service support to the resources industry in the Pilbara, including Woodside's North West Shelf gas fields. Cape Lambert and Dampier provide port infrastructure for the iron ore operations of Rio Tinto supported by their settlement at Wickham, while tourism opportunities are provided by the towns of Point Samson, Roebourne and Cossack, which also have recognised heritage significance. Land use in the City includes town sites and tourism activities; agricultural activities and pastoralism; as well as resources extraction at Sino Cape Preston Iron and Dampier Salt.

1.2 Strategic context

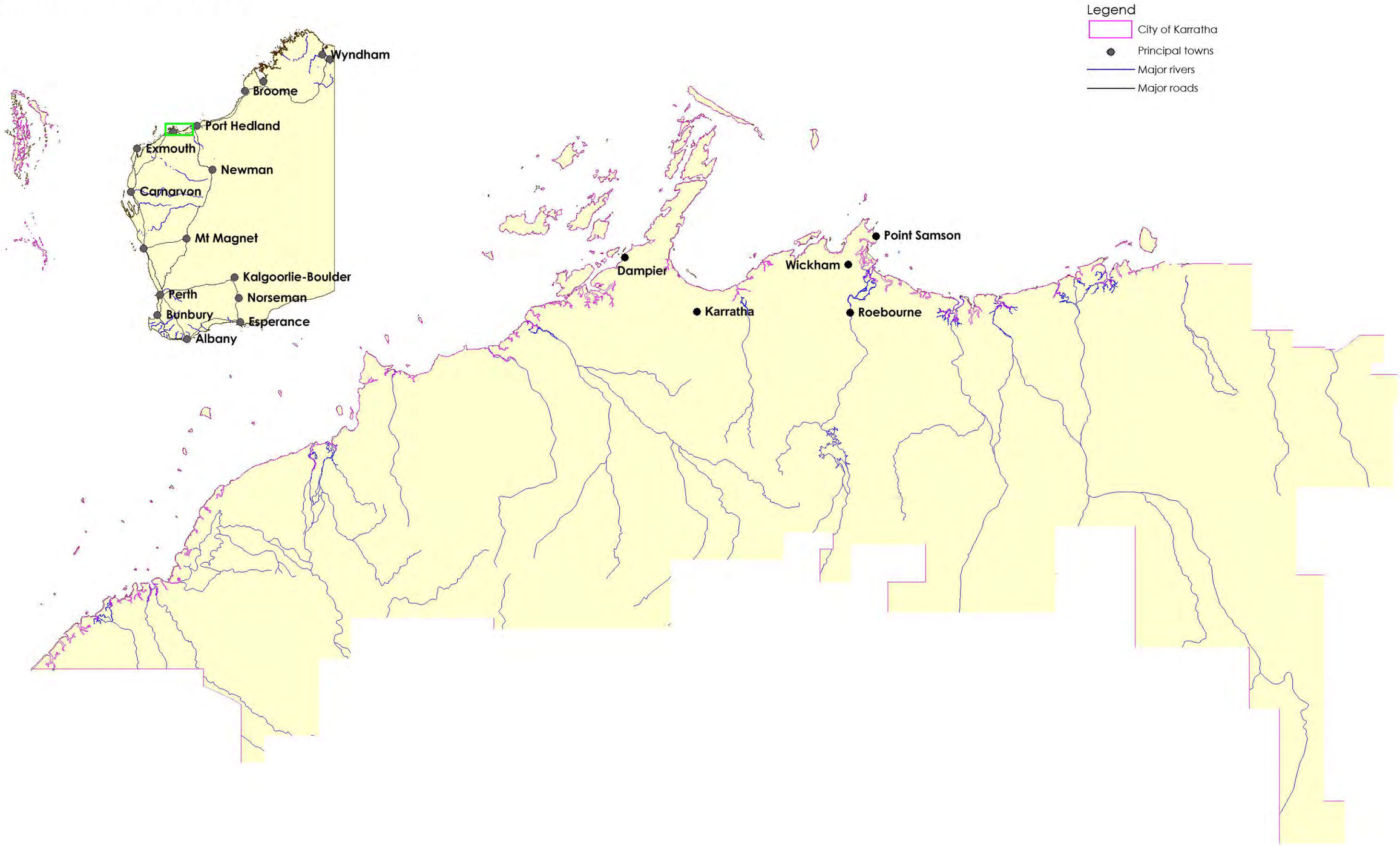
The City of Karratha experienced dramatic growth on the back of the Pilbara Region's resource industry expansion over recent years. This placed pressure on the delivery of community services and infrastructure, as well as on the environment and supporting ecosystems.

Recent changes in economic and operational requirements of the resources sector have resulted in a slowing of growth and pressures on infrastructure. This provides an opportunity to consider future growth strategically and optimise planning and delivery frameworks for the future.

The Pilbara natural environment is highly valued by the community (OCM Agenda Item 11.5, 21 October 2015). It is imperative that the social, environmental and cultural values of the City's water resources are considered and managed in a sustainably responsible way. This is supported by the City's *Strategic Community Plan 2012- 2022* (City of Karratha, 2012) which has an associated goal to "strive to ensure our community lives sustainably in a thriving natural environment"

This strategy provides guidance for the incorporation of water resources management objectives and requirements into the City's Local Planning Strategy and future planning and development activities, consistent with objectives of *State Planning Policy 2.9: Water Resources* (2006) and the legislations, policies and guidelines of the State's water agencies.

City of Karratha - City of Karratha Water Management Strategy
Figure 1 - Location



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Data sources: Landgate, Geoscience Australia, Created by: R Mackintosh. Projection: MGA50: zone 50.

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0 30 km

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1.3 Purpose and use

The City of Karratha Water Management Strategy will become one of several key strategy documents that inform the City's Strategic Community Plan, Corporate Business Plan, and Operational Plan. These documents, known as informing strategies, form part of the Integrated Planning Framework which will deliver the City's Vision to be a cohesive and vibrant community, celebrating diversity and working together to create a sense of place and a sustainable future.

This water management strategy proposes objectives, strategies and actions for the City in regards to the management of water resources. The objectives of the Strategy are intended to be met by the City, through the delivery of its roles and services.

The recommendations of this water management strategy are consistent with and supported by the City's local planning strategy and local planning scheme. They will also guide planning decision-making with regards to water resource management, ensuring that water resources are addressed at all stages of the land use planning and development approvals process.

The water management strategy also provides recommendations for the management of the City's stormwater drainage system; maintenance of water efficient public open spaces; and leadership and advocacy in the improved management of water resources.

1.4 Preparation of the report

Preparation of the water management strategy has considered the City's strategic and environmental context in order to develop a range of strategies and actions that will assist in the improved management of water resources across the City. This has involved a number of stages and tasks. Key inputs include:

- Stage 1 Findings Report - which scoped the issues to be addressed by the Strategy including the identification of opportunities and constraints for integrated land and water planning; urban water management; and infrastructure and asset management appropriate to City of Karratha townsites and management areas.
- Stage 2 Opportunities and Constraints Report – which reviewed the key findings and gaps identified from Stage 1 in more detail to inform preparation of this Citywide water management strategy.
- Community and stakeholder consultation – which included seeking comments from the community on the Findings report and the opportunity to meet with the project team to discuss key issues of importance. The outcomes of the engagement are summarised in the Engagement Summary Report in Appendix 1.
- City of Karratha Officer workshop – which considered the draft actions contained within the opportunities and constraints report to identify priorities, responsibilities and discuss resourcing.

1.5 Structure of the report

This report summarises the relevant strategic, environmental and delivery context of the City of Karratha that has guided preparation of the water management strategy (Section 2). Additional detail regarding the relevant technical studies and policy framework for land and water management is contained in Appendices 2 and 3.

Section 3 contains the objectives of the Strategy and outlines a number of strategies and actions that are to be implemented in order to achieve the objectives in the short, medium and longer term. Where these actions are not already being addressed, it is anticipated that they will be incorporated into the City's Corporate Business Plan, Asset Management Plan and/or Operational Plan.

Section 4 provides guidance for future planning decision-making for areas identified in the City's local planning strategy as Urban expansion; development investigation; and Industrial expansion; highlighting water resource management issues that are to be addressed at the time of rezoning through a district water management strategy. This information is based on a desktop assessment of available information and is to be used as a guide only.

2 ENVIRONMENTAL CONTEXT

2.1 Climate

The City of Karratha is located within the Pilbara region which is characterised by high temperatures, particularly during the summer months, with variable rainfall patterns interspersed with long dry periods. The Bureau of Meteorology (BoM) defines the wet season for the Pilbara as the period extending from December to the end of March. Tropical cyclones are a feature of the summer months and usually develop between November and May, often bringing intense rainfall resulting in flooding. Some areas of the Pilbara have the highest average annual evaporation rate in Australia (Van Vreeswyk *et al.*, 2004). The annual evaporation rate throughout the Pilbara is considerably higher than the average rainfall.

The climate of the City of Karratha can be broadly described by two climate categories: tropical along the coastal areas and arid through the central and eastern parts of the region. Regional variations in rainfall occur, with the coastal areas and western inland areas of the City located in the path of tropical cyclones often receiving higher rainfall, in comparison to the arid desert areas in the central east of the Pilbara.

During most of the cooler times of the year, winds tend to be easterly or south-easterly over most of the Pilbara, influenced by the passage of winter high pressure systems that move east across the mainland. In spring prevailing winds weaken as a semi-permanent heat low develops over the land. In coastal areas the wind direction becomes more variable, particularly in the warmer months, when the wind direction often reverses in the afternoon and sea breezes from the north and north-west dominate (*Van* Vreeswyk *et al.*, 2004).

Maximum temperatures in the City of Karratha (Chart 1) are generally higher through the summer months of November to March, with average maximum temperatures reaching up to 36˚C at the Karratha aerodrome and 39 ˚C at the Roebourne Aerodrome.

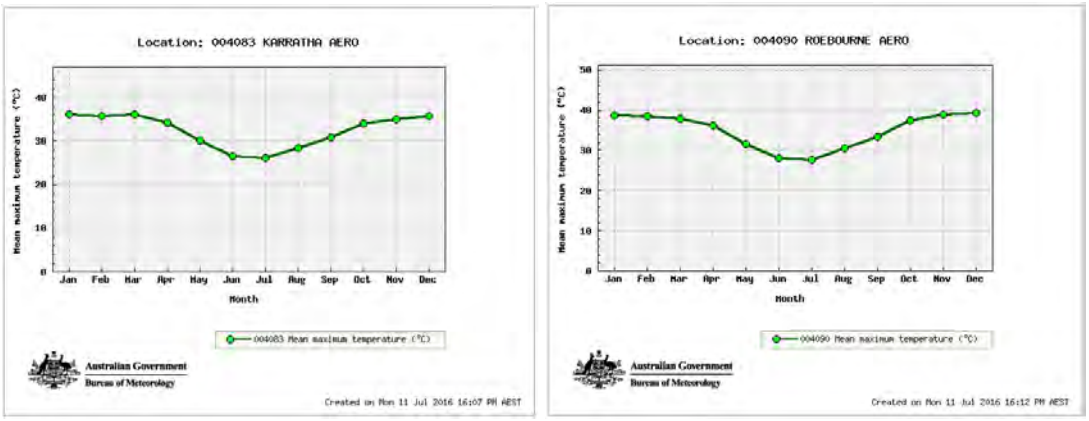


Chart 1: Karratha Aerodrome and Roebourne Aerodrome mean maximum temperature (Source: BoM, 2016)

Average minimum temperatures (Chart 2) across the City are significantly lower in winter, reaching approximately 14˚C in July-August at the Karratha aerodrome and 12˚C in July at the Roebourne Aerodrome.

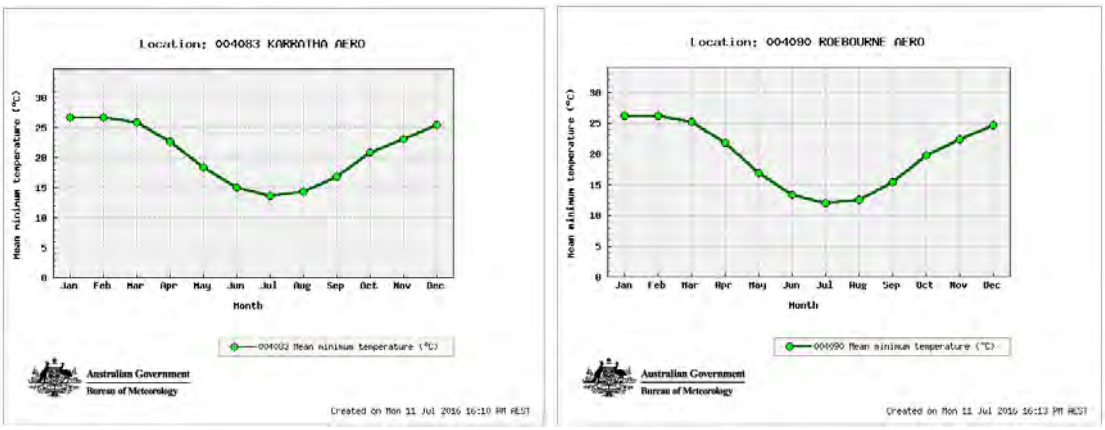


Chart 2: Karratha Aerodrome and Roebourne Aerodrome mean minimum temperature (Source: BoM, 2016)

Average annual rainfall in the City is typically around 300 mm (299 mm at Karratha Aerodrome and 297 mm at Roebourne Aerodrome) (Chart 3). The majority of rainfall occurs during the summer ("wet season") rains (Chart 3).

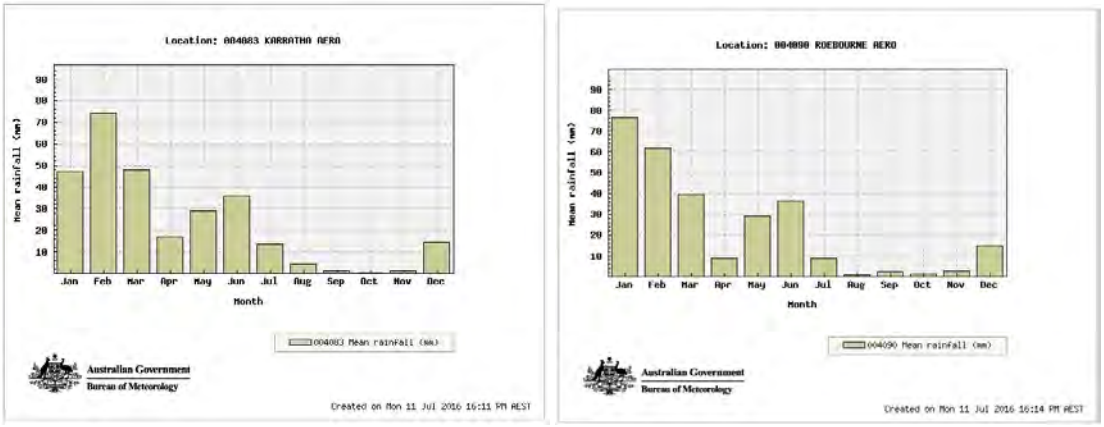


Chart 3: Karratha Aerodrome and Roebourne Aerodrome mean rainfall (Source: BoM, 2016)

2.1.1 Tropical cyclones

The City of Karratha's coast is in one of the most cyclone-prone areas of the world (Van Vreeswyk *et al.*, 2004). The severe and unpredictable nature of cyclones in the region has historically caused significant widespread damage to infrastructure and domestic livestock and even human death. Damage is often caused as a result of destructive winds and flooding from rain and storm surge.

Notwithstanding the severe destruction caused by cyclones, they are also critical for supplying up to 50% of average annual rainfall (Van Vreeswyk, 2004). However, the high intensity of cyclonic events, particularly after long periods of dry weather, often results in minimal retention of rainfall within the landscape due to high velocity run-off and dry, hydrophobic soils.

2.1.2 Climate change

Reports from the International Panel on Climate Change (IPCC) provide limited detail on Australian climate change, particularly when it comes to regional climate change projections. *Climate change in Australia: Information for Australia's Natural Resource Management Regions: Technical Report* (2015) was developed by the Department of Environment together with CSIRO and the Bureau of Meteorology. It is based upon international

climate change research including conclusions from the IPCC's fifth assessment report. It also builds on a large body of climate research that has been undertaken for the Australian region in recent years.

The general trend shown for Karratha and Roebourne is indicative of gradually increasing temperatures, which supports modelled scenarios (Chart 4).

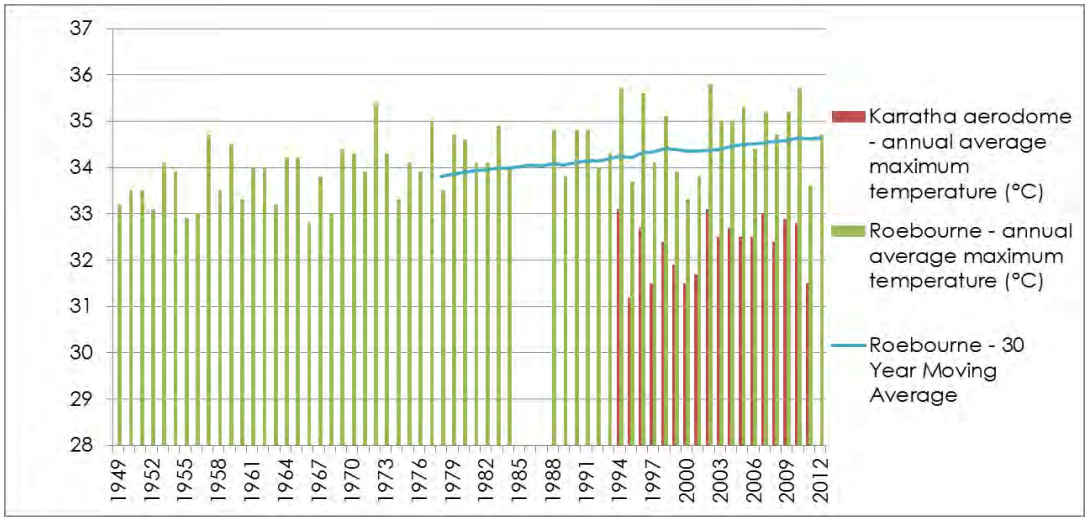


Chart 4: Karratha & Roebourne climate trend – temperature

The trend in rainfall does not indicate an obvious decline or increase in Karratha or Roebourne (Chart 5). More significant than annual rainfall amount, is the change in distribution of events. There is a clear trend in recent rainfall records towards less frequent, more significant events which is also in agreement with CSIRO model scenarios and may have significant implications for the City of Karratha.

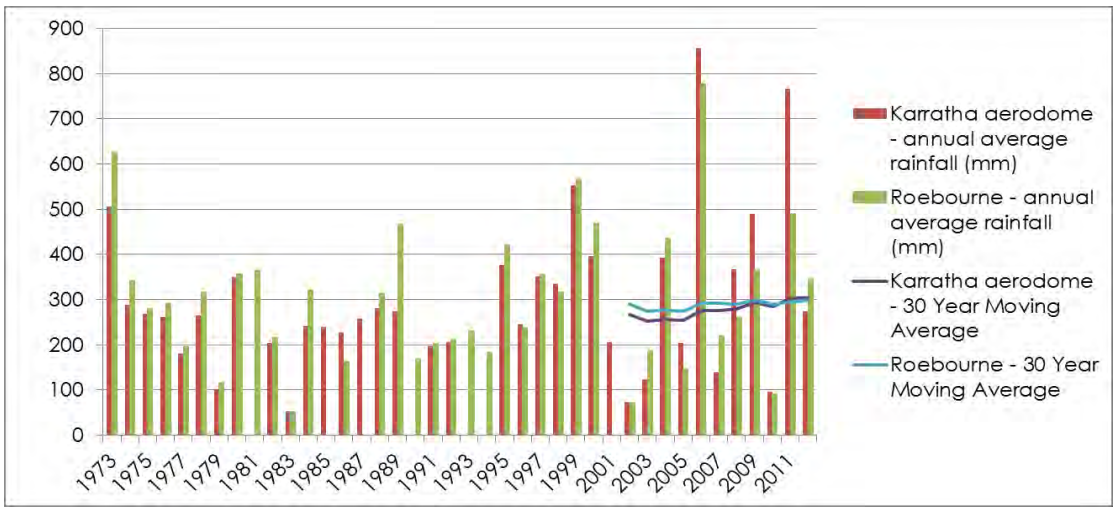


Chart 5: Karratha and Roebourne climate trend - rainfall

Key land use planning and water management issues

- **Temperature** – Increases in temperature are likely to result in increased needs for cooling and/or impacts on public health. Development should incorporate passive solar design and breezeways and provide shade in public and private places.
- **Rainfall change** – may result in localised flooding and pressure on stormwater systems, as well as pressure on available water sources and the natural environment.
- **Extreme weather** – may require improved emergency management responses and plans.

2.2 Geology, soils and contamination

2.2.1 Topography and geology

Figure 2 presents mapping from Geoscience Australia's *Surface geology of Australia 1:1,000,000 scale, Western Australia* (Stewart *et al*. 2008). The soils in the City are predominantly alluvial and colluvial sand in coastal areas, with silt and clay deposited on floodplains, and clay soils surrounding the rocky and stony soils further inland at the Karratha hills.

2.2.2 Acid sulfate soils

Acid sulfate soils are soils and sediments that contain iron sulfides. They occur naturally in Western Australia and are harmless when left in a waterlogged, undisturbed environment. However, when exposed to air, through drainage or excavation, the iron sulfides in the soil react with oxygen and water to produce iron compounds and sulfuric acid. This acid can release other substances, including heavy metals, from the soil and into the surrounding environment and waterways (DEC, 2013b).

Much of Western Australia's acid sulfate soil material lies just below current water-tables. Continuing declines in annual rainfall, changes in land uses and increasing ground-water abstraction will lead to lower water-tables, resulting in possible widespread acid sulfate soil oxidation (DEC, 2013b).

The Western Australian Planning Commission has released the *Acid Sulfate Soils Planning Guidelines* (WAPC, 2008b) which outline a range of matters that need to be addressed at various stages of the planning process to ensure that the subdivision and development of land containing acid sulfate soils is planned and managed to avoid potential adverse effects on the natural and built environment.

The City currently includes a link on its website to the Western Australian Planning Commission's *Acid Sulfate Soils Self-Assessment Form*, required as part of any potentially soil disturbing activity, particularly in relation to the preparation of development applications.

Although current information suggests the presence of soils with high to moderate risk of acid sulfate soils along the coastline and mudflat areas of the City (see Figure 3, site investigations have yet to encounter any actual acid sulfate soils.

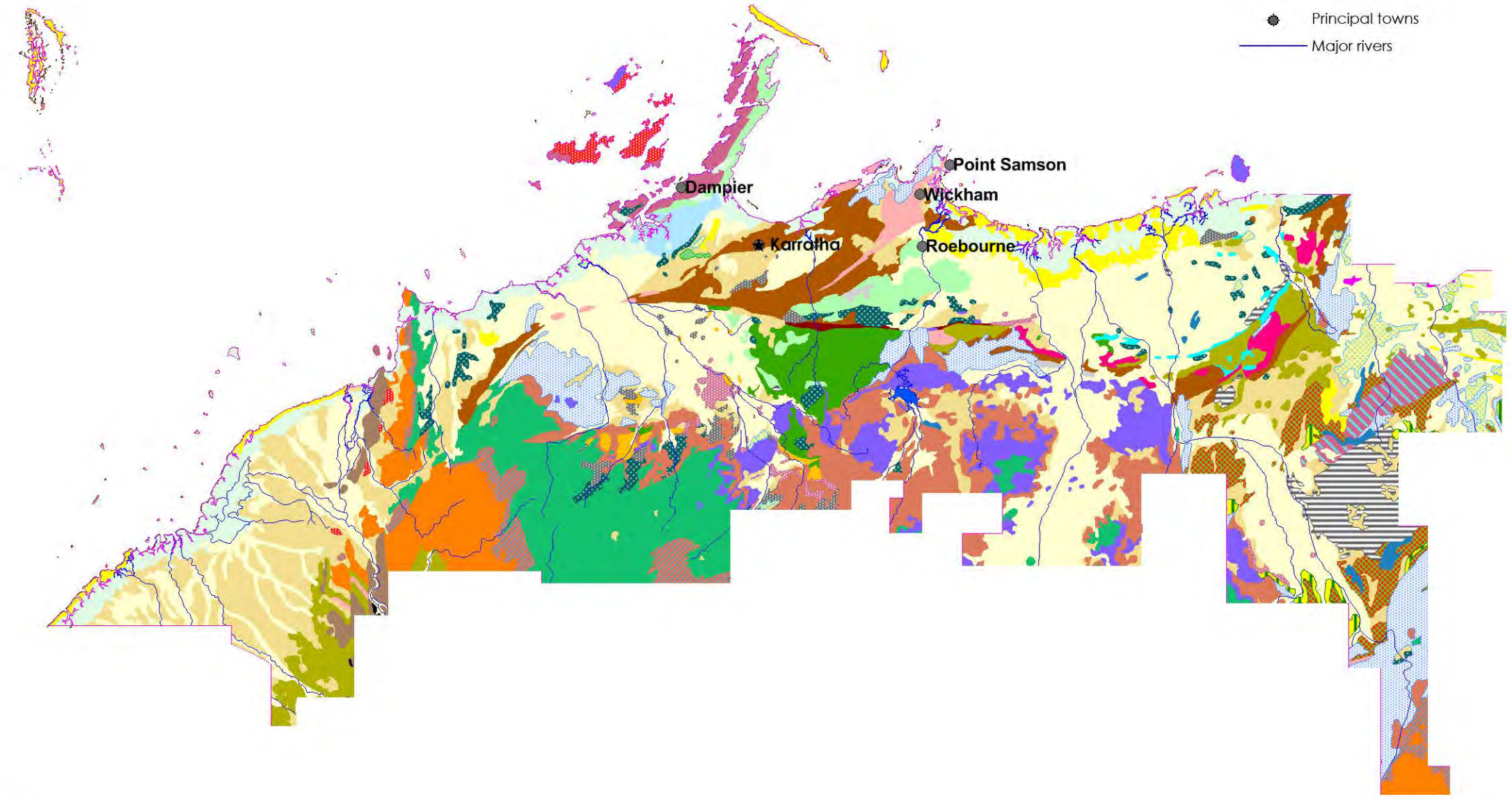
Contaminated sites

Western Australia's contaminated sites legislation aims to protect people's health and the environment from harm. Under the *Contaminated Sites Act 2003*, contaminated sites must be reported to the Department of Environment Regulation, investigated and, if necessary, cleaned up. The polluter is responsible under the Act for clean-up.

Land owners, occupiers and polluters are required to report all known or suspected contaminated sites to the Department of Environment Regulation. Reported sites are then classified, in consultation with the Department of Health, based on the risks posed to the community and environment.

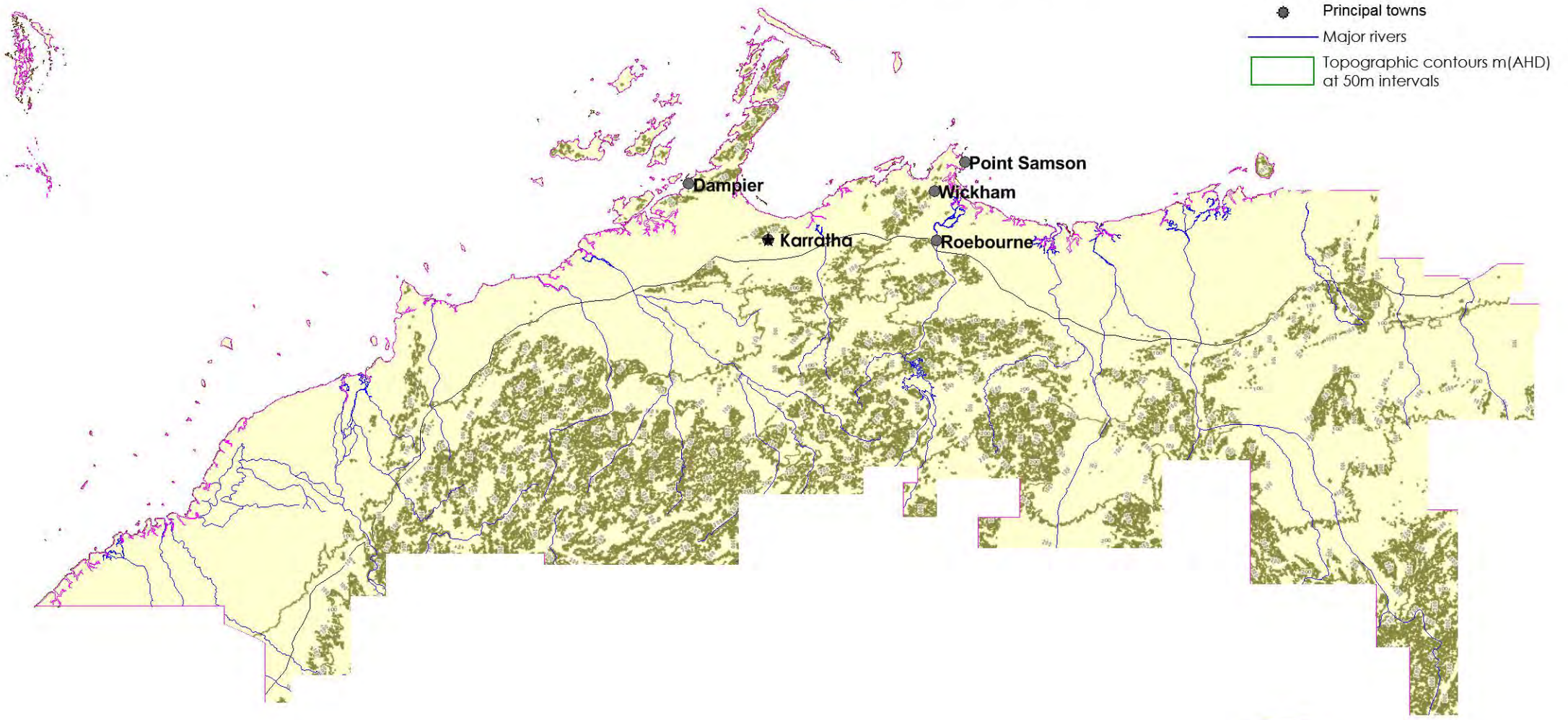
Figure 3 provides a map of sites currently registered on the Department of Environment Regulation's database. There are nine registered contaminated sites in the City, most of which are in relation to hydrocarbon contamination; although it is noted that none of the currently registered sites provide a significant risk to water resources. Other sites reported to the Department of Environment Regulation, including sites awaiting classification are recorded separately by the Department of Environment Regulation and have not been mapped.

City of Karratha - City of Karratha Water Management Strategy
Figure 2 - Surface geology and topography



Surface geology

- Basalt, komatite - Awr, Abcl
- Clay (metamorphic rock) - Anyp
- Granophyre (igneous felsic rock) - Aggy
- Lake sediments - Qt
- Andesite (basalt, chert) - Awf
- Estuarine sediments - Qe
- Basalt, dolerite - Abh
- Colluvial sediment - Qrc
- Greywacke, banded iron formation - Ascc
- Alkali feldspar granite - Agir
- Calcrete - Czk
- Lateritic duricrust - Czl
- Diorite - Agipw
- Basalt, andesite - Abfk
- Rhyolite - Lfhw
- Iron formation, chert - Lchb
- Basalt, basaltic andesite - Abfm
- Sandstone, siltstone - Awfh
- Greenstone (metamorphosed rock) - Atp
- Tuff, limestone, shale - Awft
- Ultramafic volcanic rock - Aep
- Basalt - Abcn
- Mylonite - Azp
- Sand (coastal dunes, limestone, sand plain) - Qdc, Qi, Qd, Czs
- Olivine gabbro - Adlo, Adrs
- Alluvial sediment - Qa, Cza
- Chert, banded iron formation, mudstone - Acg, Achm
- Granite - Agi, Agis, Agnl
- Monzogranite - Agpo, Agyn, Agaie, Agail, Agiel Agpb, Agyt, Agai, Ag, Agaia, Agair, Agaic
- Mafic volcanic rock - Abfr, Adlm
- Shale - Ashm, Asd, Ascm, Awc, Kswn, Lsy, Awfj
- Dolerite - Adfc, Adp, Adf, Ad, Adrm
- Gabbro - Adgy, Adbh, Adrd, Adro Adrr, Adrw, Adav
- Dacite - Afpr, Afck
- Granodiorite - Agaiw, Agaij, Agpf Ager
- Tonalite - Agbif, Agzl, Agait, Agij
- Water



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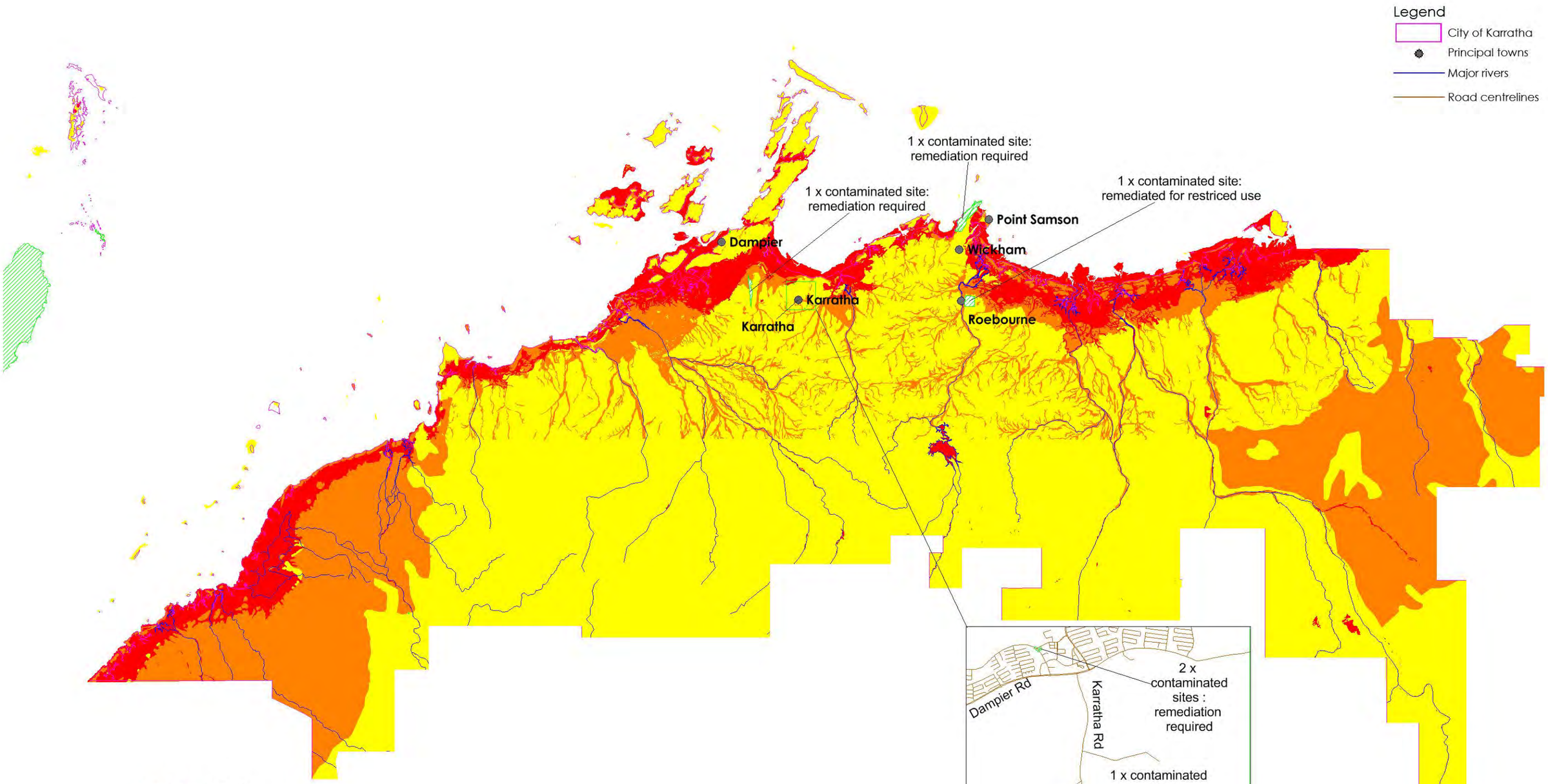
City of Karratha - City of Karratha Water Management Strategy
Figure 3 - Acid sulphate soil risk and contaminated sites



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Data sources: Landgate, Geoscience Australia, Created by: R Mackintosh. Projection: MGA50: zone 50.

Scale 1: 750,000 @A3

0 30 km

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Key land use planning and water management issues

- **Acid sulfate soils** - Declining soil and land quality can occur as a result of development where acid sulfate soils are disturbed. This leads to the release of acid and heavy metals which can cause significant harm to the environment and infrastructure. There is a need to continue to identify the presence of acid sulfate soils in areas of medium and high risk where changes in groundwater are likely. Management should be consistent with current best practice.
- **Contaminated sites** - Unsewered residential and industrial areas have the potential to lead to contamination of land and groundwater. Consideration should be given to the remediation of contaminated sites by the landowner as part of any future development.

2.3 Vegetation, flora and fauna

The City is characterised by a diverse range of terrestrial, aquatic and marine landscapes, flora and fauna. The City's biological uniqueness includes its large areas of relatively intact native vegetation and healthy ecological processes. Although other areas across the State have been largely cleared for agriculture or development, within the City, native vegetation remains largely uncleared with the exception of areas for mining and associated infrastructure as well as for townsite development. It should be noted that pastoral use of land is classified as "uncleared", although this gives no indication of vegetation condition.

The City of Karratha is an important area for persisting populations of threatened and endangered flora and fauna species as well as threatened and priority ecological communities. Threats of species extinction are recognised at both Commonwealth and State levels, with 78 threatened and priority flora and fauna species listed under the *Wildlife Conservation Act, 1950* (State) and a number of matters of national environmental significance protected under the *Environment Protection Biodiversity Conservation Act (*EPBC Act) *1999* including one National Heritage Place (Dampier Archipelago and the Burrup Peninsula), 19 threatened species and 49 migratory species (Figure 4).

Forty four percent of the Burrup Peninsula is contained within the Murujuga National Park. The national park is the first Aboriginal owned and jointly managed national park in the State, providing protection to the highest concentration of indigenous rock art engravings in the world.

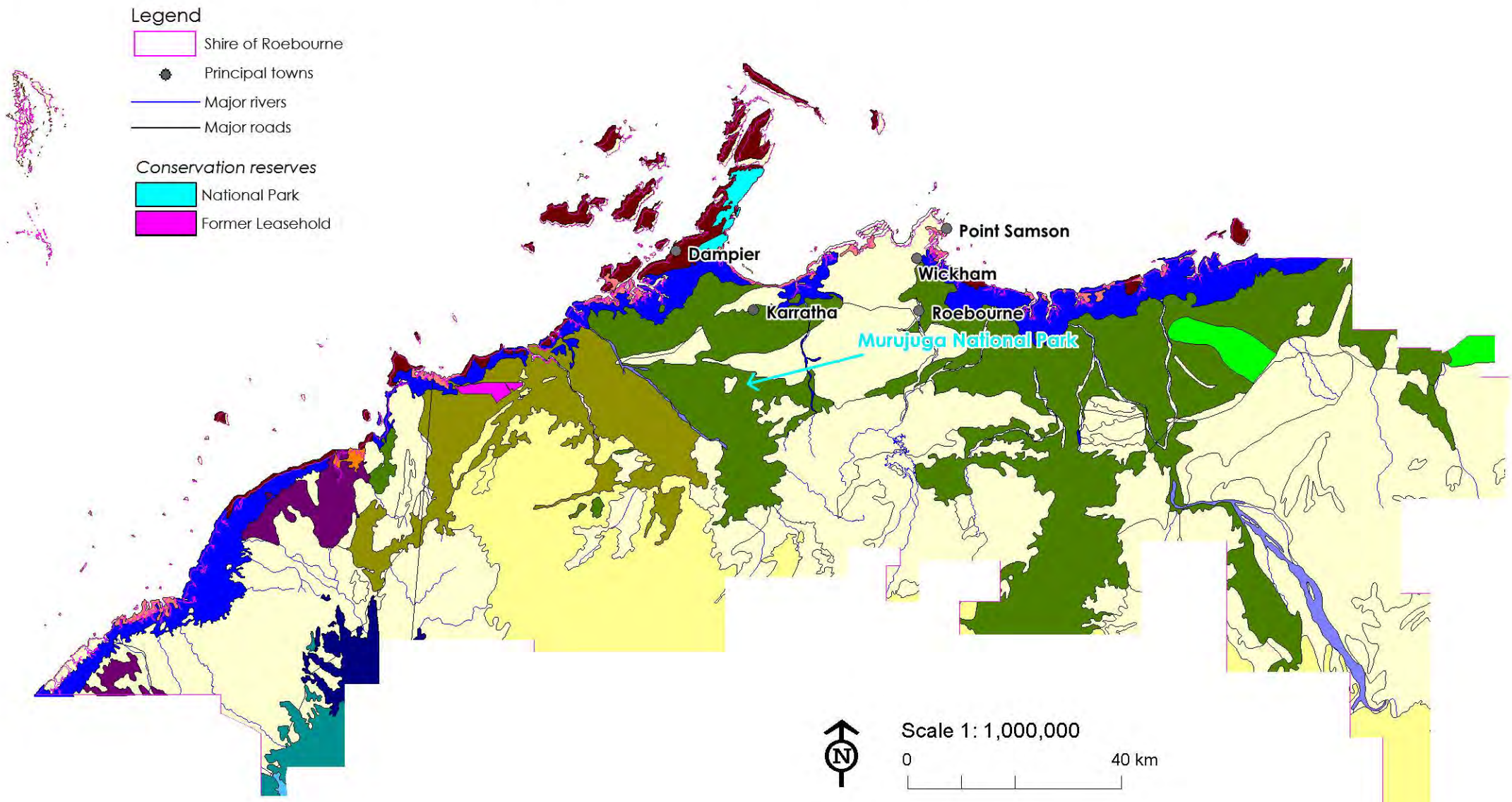
Major threats to biodiversity arise from the clearing of land for development including infrastructure. The construction of substantial linear infrastructure such as railways and roads poses additional threats to biodiversity resulting from fragmentation of land and the creation of barriers and risks to fauna movements.

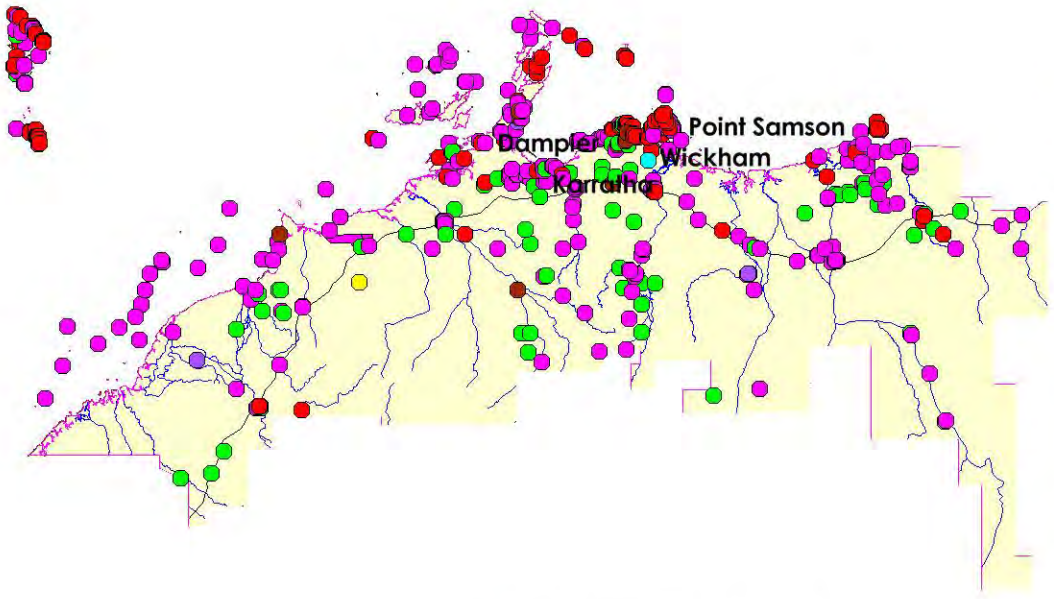
Further loss of vegetation and biodiversity including fauna occurs as a result of the introduction of weeds, pests and feral animals, both accidentally or commercially introduced, which compete for food, water, soil and land. Environmental weeds require a substantial management effort to control. Bushfires are also a significant threat to biodiversity and infrastructure across the City.

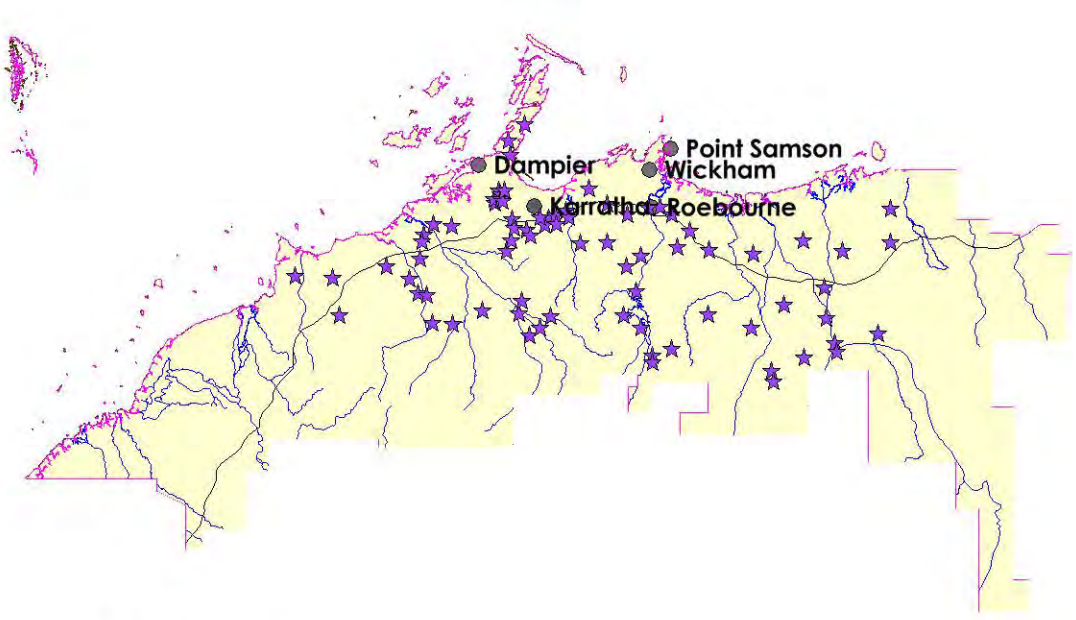
Key land use planning and water management issues

- **Land management** – The City is responsible for management of lands within its control. Key issues include **rubbish/illegal dumping, off-road vehicles and uncontrolled access.** There is a need to identify areas for off-road vehicle use within the City and reduce rubbish dumping by the community and visitors. Opportunities for joint management of the land with traditional owners, as well as opportunities for the establishment of indigenous businesses in areas with high natural and cultural values should be sought.

City of Karratha - City of Karratha Water Management Strategy
Figure 4 - Vegetation types, flora, fauna, Priority Ecological Communities of conservation significance







Fauna of conservation significance

- Threatened - rare / likely to become extinct
- Birds protected - international agreement
- Other specially protected fauna
- Priority 1
- Priority 2
- Priority 3
- Priority 4
- Priority 5

TEC / PEC location

N

Scale 1: 2,000,000

0 80 km

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- **Weeds, feral animals, introduced species and pests –** Management of weeds, feral animals and pests is an important action to reduce the decline in biodiversity in partnership with key agencies. Consider the establishment of collaborative programs, such as the Mesquite Management Committee, for the management of other priority pests, weeds and feral animals. Improve the awareness of the need to control introduced species including cats, mice, rats and cattle.
- **Bushfires –** Continue to work cooperatively in the management of fire, having regard for the impact of fire on the landscape and biodiversity, as well as human health. Consider opportunities for input into fire management practices from traditional owners and extend the Western Desert Traditional and Contemporary Fire Project approach across the Pilbara.

2.4 Water resources

2.4.1 Surface water

The City contains significant water resource assets such as the Fortescue River and other surface water systems, including a large proportion of the Harding Dam catchment area which provides important drinking water resources for the majority of towns in the City (Figure 5).

All waterways in the City of Karratha are highly variable, flowing for only part of the year in response to larger, generally cyclonic, rainfall events. The only surface water source that is used as a major water supply in the City is the Harding Dam; however, due to evaporation losses and high levels of sediment it is only able to supply water at current levels of demand for approximately two years without a large recharge event (DoW, 2010).

Neither Ramsar nor nationally important wetlands are located within the City of Karratha. However, surface expressions of fresh water are highly valued by the community and often contain important ecological values.

Drainage and flood protection

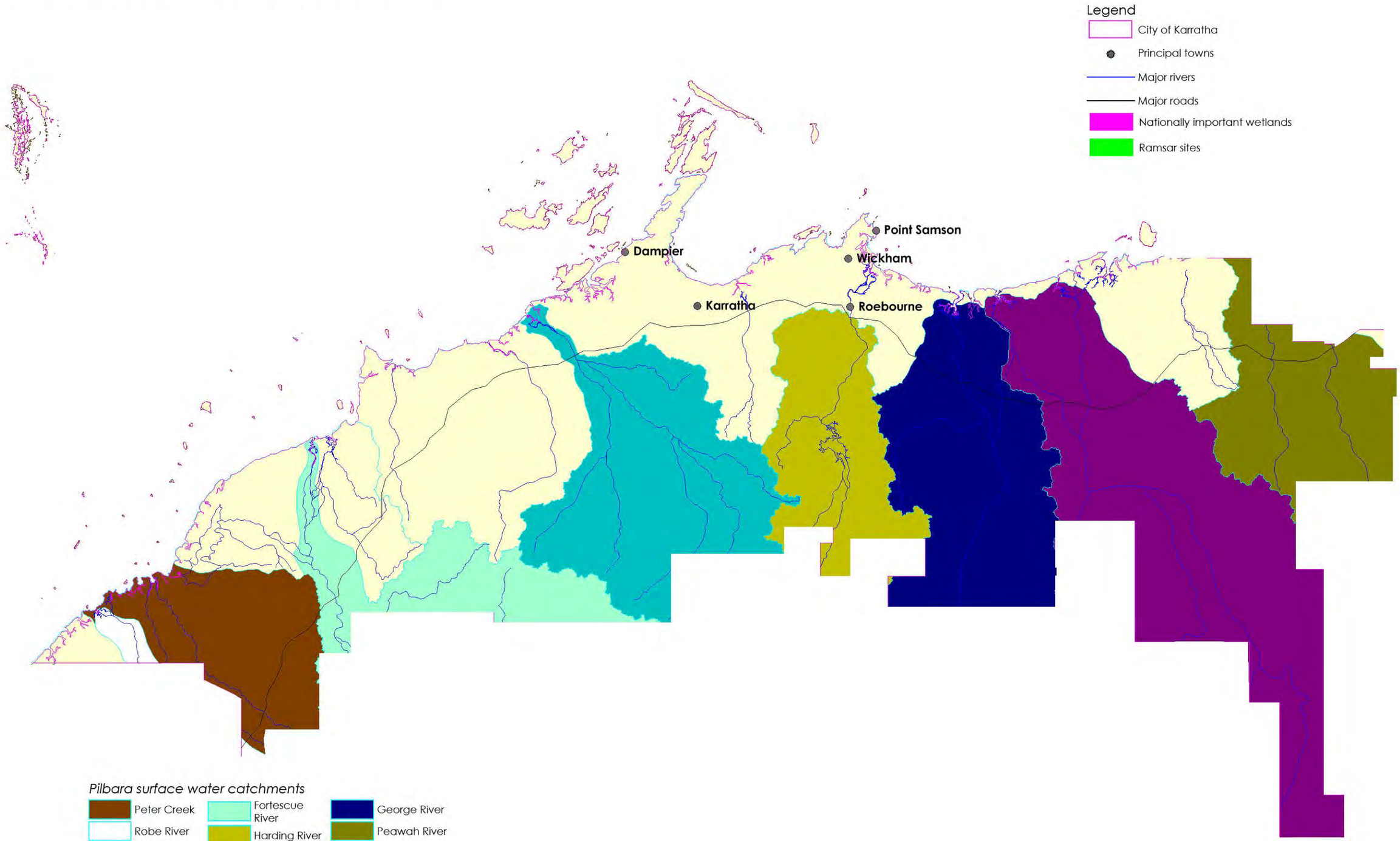
Where development occurs, surface water needs to be managed so as to not impact on the environment or cause flooding. The City is responsible for the management of flooding and drainage in the major townsites of Karratha, Dampier, Point Samson, Roebourne, Wickham and Cossack. This includes routine maintenance of systems and approval of new systems for new areas of development.

Key stormwater management issues associated with development in the City include the management of erosion, silt, sediment, water quality and weeds, particularly in sensitive environments. It is recognised that the red soils of the Pilbara region have a high capacity for erosion. This, coupled with the high volumes of stormwater which flow in the wet season, requires active and effective management to adequately control erosion and sediment transport. These require different approaches to those currently being implemented in the South-West of the State across the Swan Coastal Plain, largely due to the different soil conditions and nature and volumes of rainfall.

A number of studies have investigated the capacity of the existing drainage systems of Karratha, Dampier, Point Samson, Wickham and Roebourne (Figures 6 to 11 and Attachment 2). These studies are utilised by the City to inform asset management planning and infrastructure upgrades where possible. In addition, these studies are used to guide the design and construction of new drainage systems in new urban areas. Key studies which provide guidance for the future planning and development of the key townsites within the City are:

- Point Samson District Water Management Strategy (draft, Cardno, 2015);
- Karratha drainage management plan (GHD, 2010);
- Dampier stormwater management study (GHD, 2015);
- Roebourne local water management strategy (Essential Environmental, 2013);
- Wickham townsite accommodation expansion project – LWMS (JDA, 2011); and
- City of Karratha Stormwater Design Guidelines for Residential Developments (June 2011).

City of Karratha - City of Karratha Water Management Strategy
Figure 5 - Surface water resources



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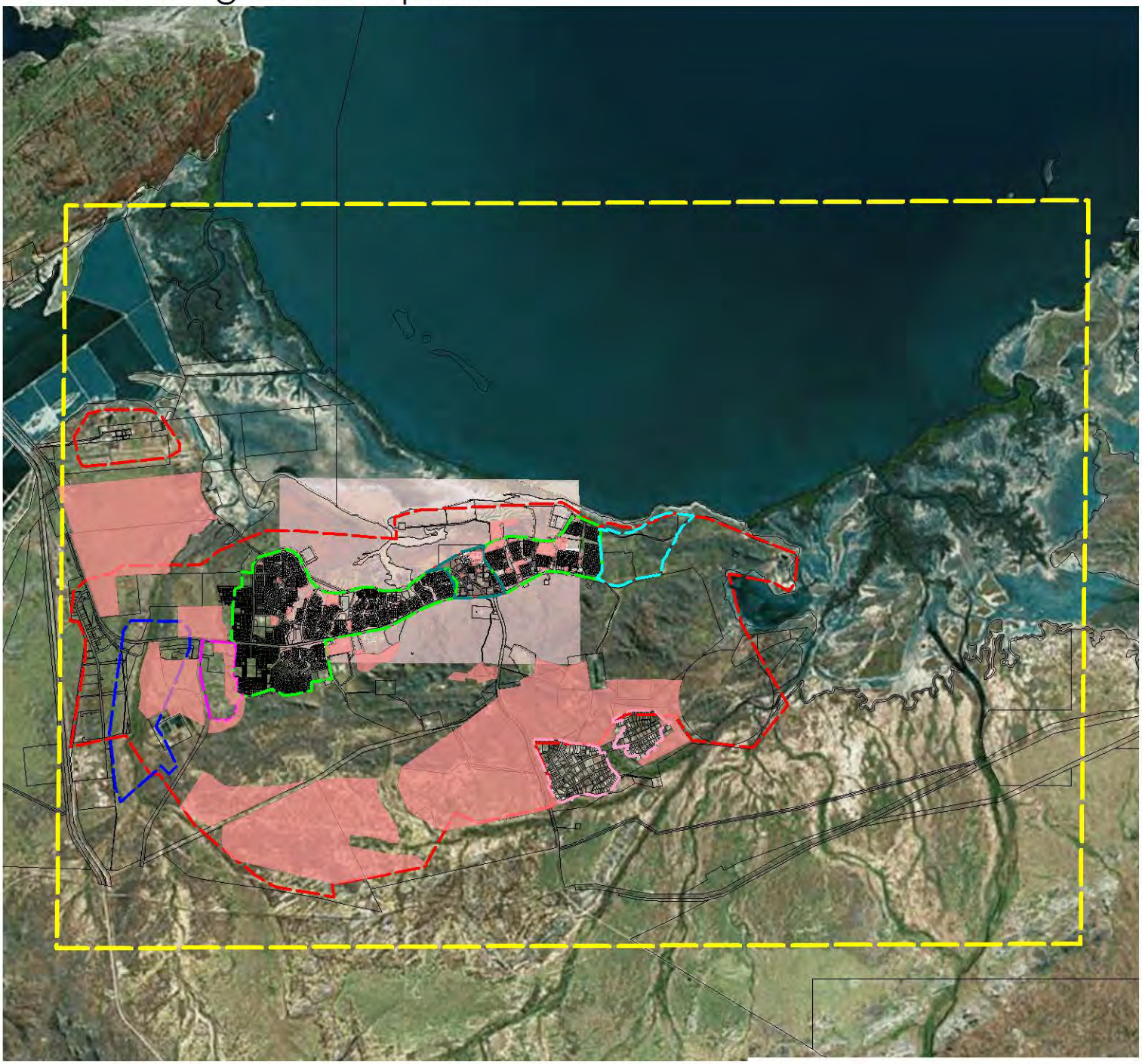
Data sources: Landgate, Geoscience Australia, Created by: R Mackintosh. Projection: MGA50: zone 50.

Scale 1: 750,000 @A3

0 30 km

essential environmental

City of Karratha - City of Karratha Water Management Strategy
Figure 6: Karatha Townsite - Future development areas and water management reports



Legend

- Lazy Lands - 2D Flood Study & Local Water Management Framework (JDA/TME, 2013)
- Mulataga Creek – 2D Flood Study (JDA, 2012)
- Karratha Vulnerability Study (KCVS) (JDA et al, 2012)
- Karratha Drainage Management Plan (GHD, 2010)
- 7 Mile Creek Flood Study (GHD, 2009)
- Madigan development - 2D Flood Study (JDA, 2012)
- Karratha LIA Drainage Study (TME,
- Karratha Local Water Managemer
- Cadastre
- Future development areas

N

0 2400m

Scale 1: 120000 @ A4

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Data source: Landgate, GHD, JDA, Shire of Roebourne. Created by: BM. Projection: MGA: zone 50.

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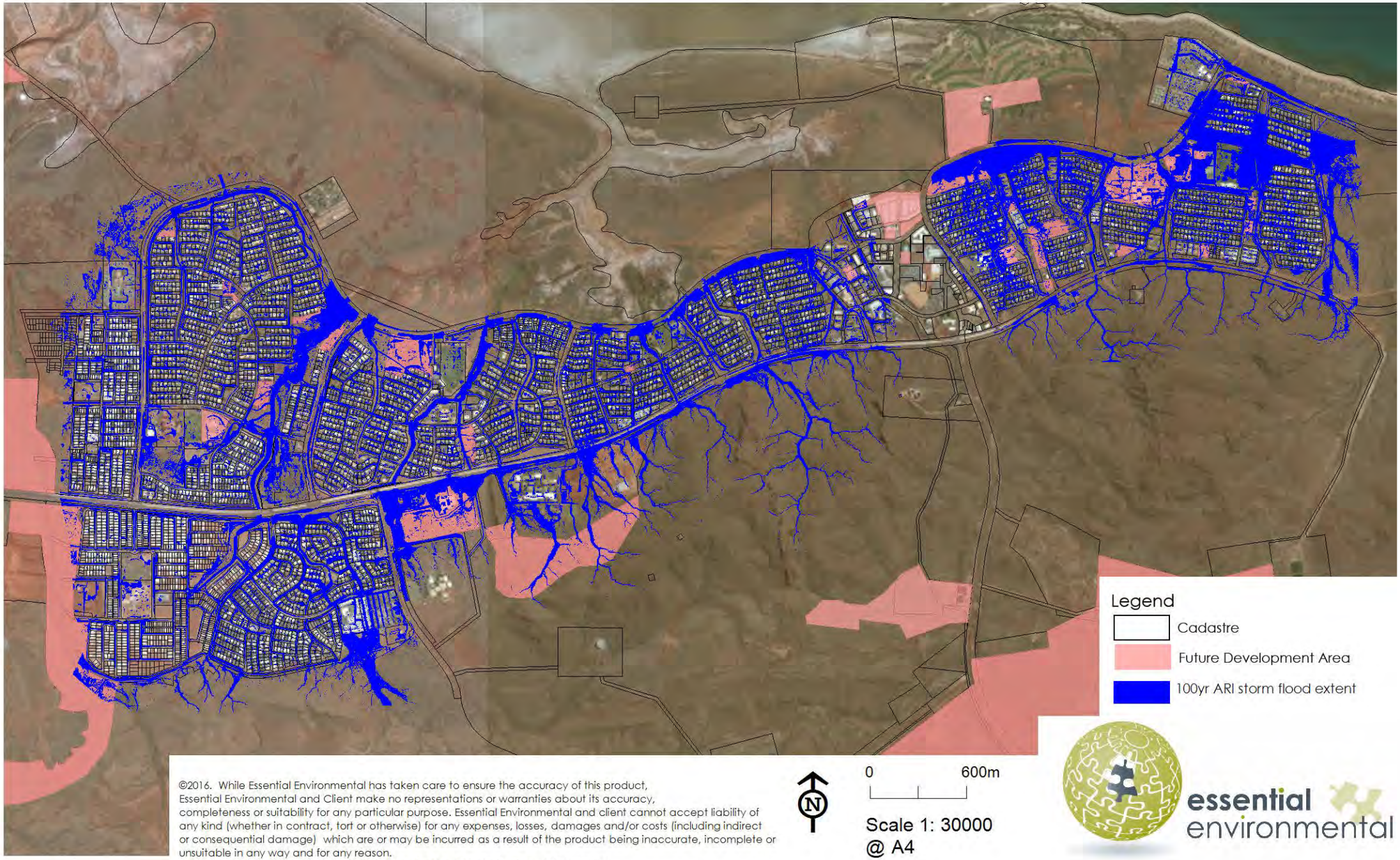
City of Karratha - City of Karratha Water Management Strategy
Figure 7: Karratha Townsite - 100yr ARI stormwater flood extent



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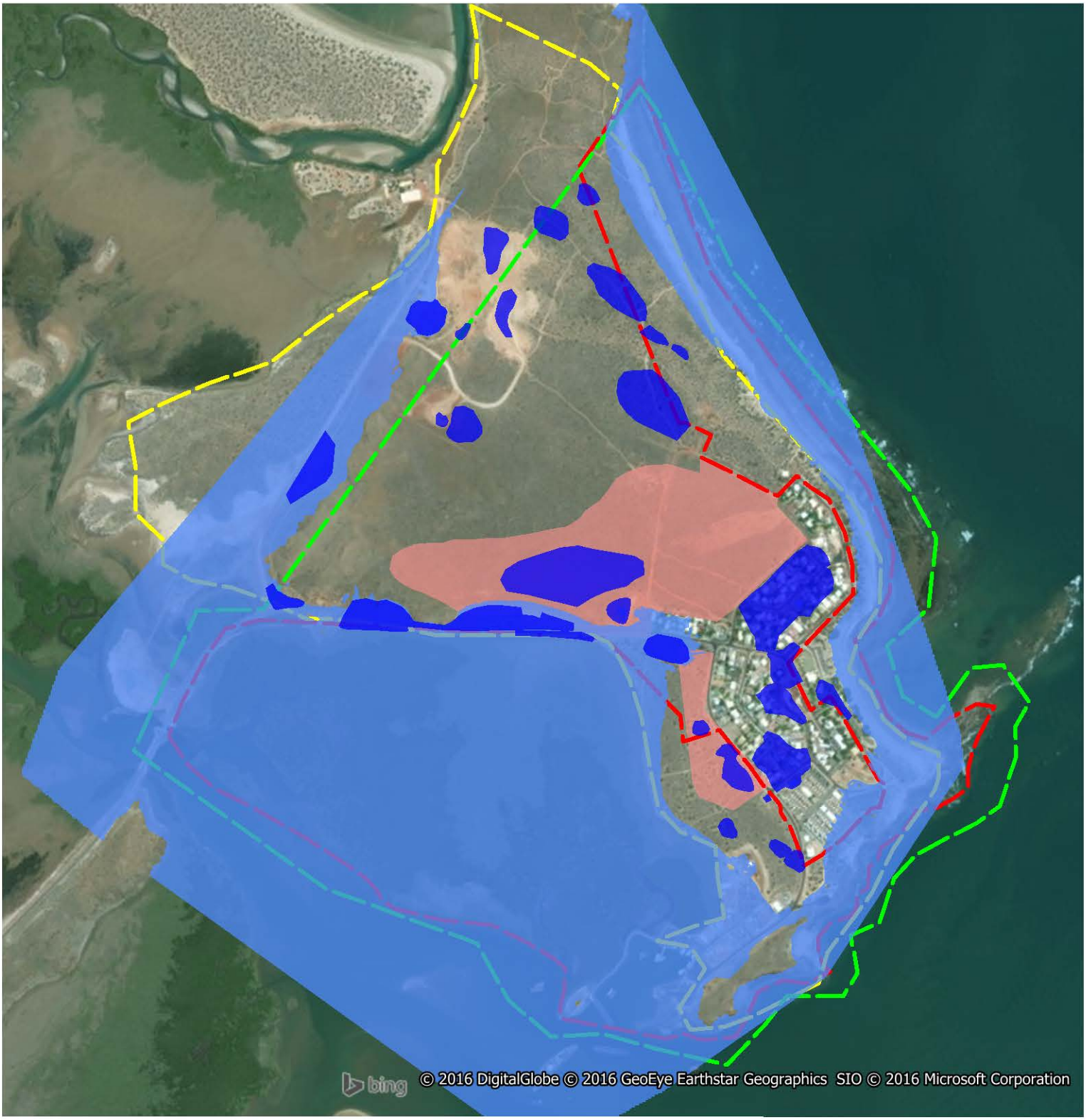
Data source: Landgate, GHD, JDA, CoK. Created by: RM. Projection: MGA: zone 50.

City of Karratha - City of Karratha Water Management Strategy
Figure 8: Point Samson Townsite - Future development areas, water management reports and flood risk



Legend

- Point Samson Water and wastewater servicing report (Essential Environmental, 2014)
- Point Samson District Water Management Strategy (Cardno, 2015)
- Point Samson Stormwater and coastal management strategy (Essential Environmental, 2014)
- Future development areas
- 100yr ARI storm flood extent
- 100yr ARI storm surge

N

Scale 1: 15000
@ A4

0 300m

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Data source: Landgate, Cardno, EE, CoK. Created by: RM. Projection: MGA: zone 50.

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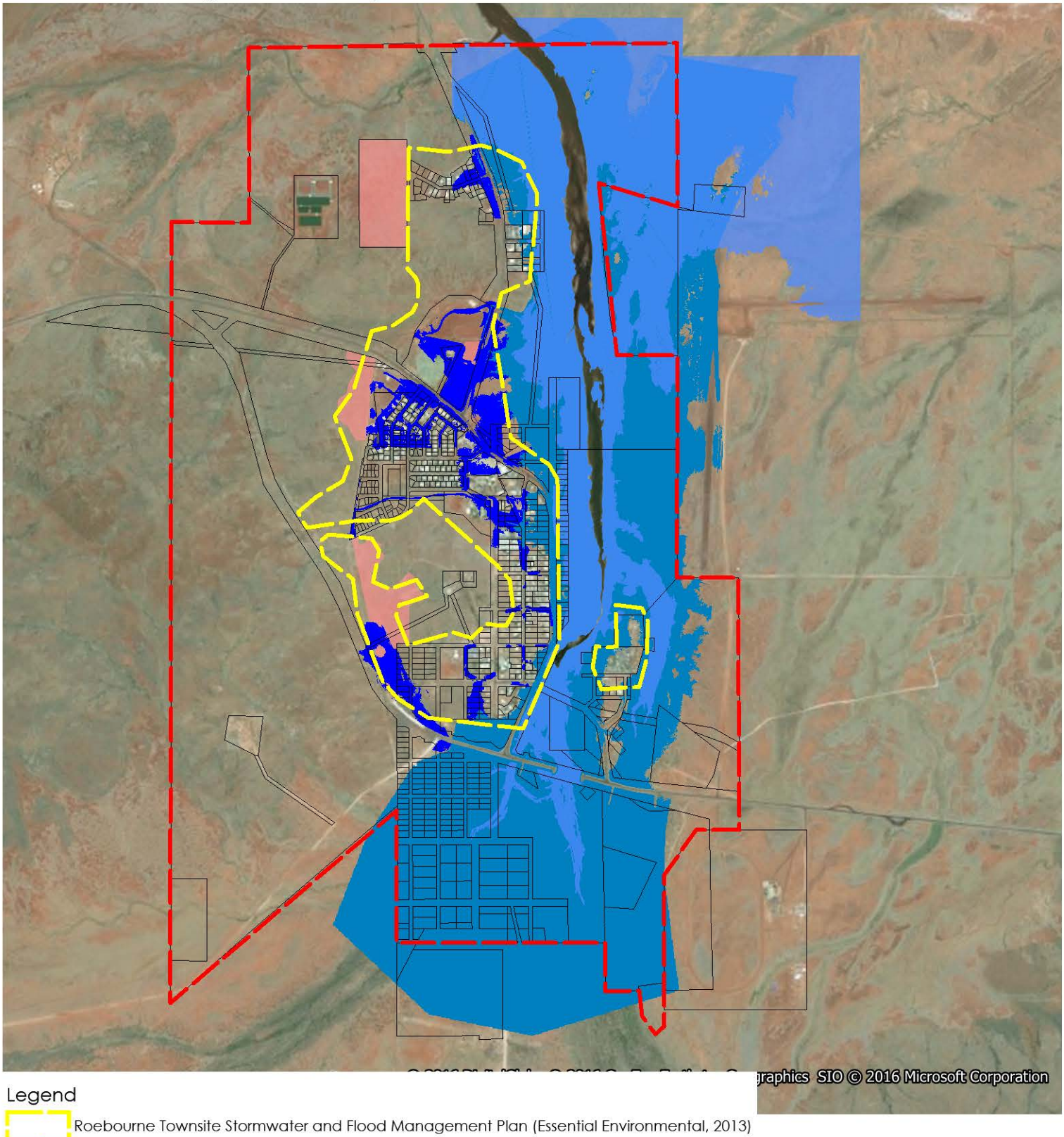
City of Karratha - City of Karratha Water Management Strategy
Figure 9: Roebourne Townsite - Future development areas, water management reports and flood risk



Legend

- Roebourne Townsite Stormwater and Flood Management Plan (Essential Environmental, 2013)
- Roebourne Townsite Local Water Management Strategy (Essential Environmental, 2013)
- Future Development Areas
- Cadastre
- 100yr ARI storm flood extent
- 100yr ARI storm surge
- Harding dam flood extent

N

Scale 1: 30000
@ A4

0 600m

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Data source: Landgate, EE, CoK. Created by: RM. Projection: MGA: zone 50.

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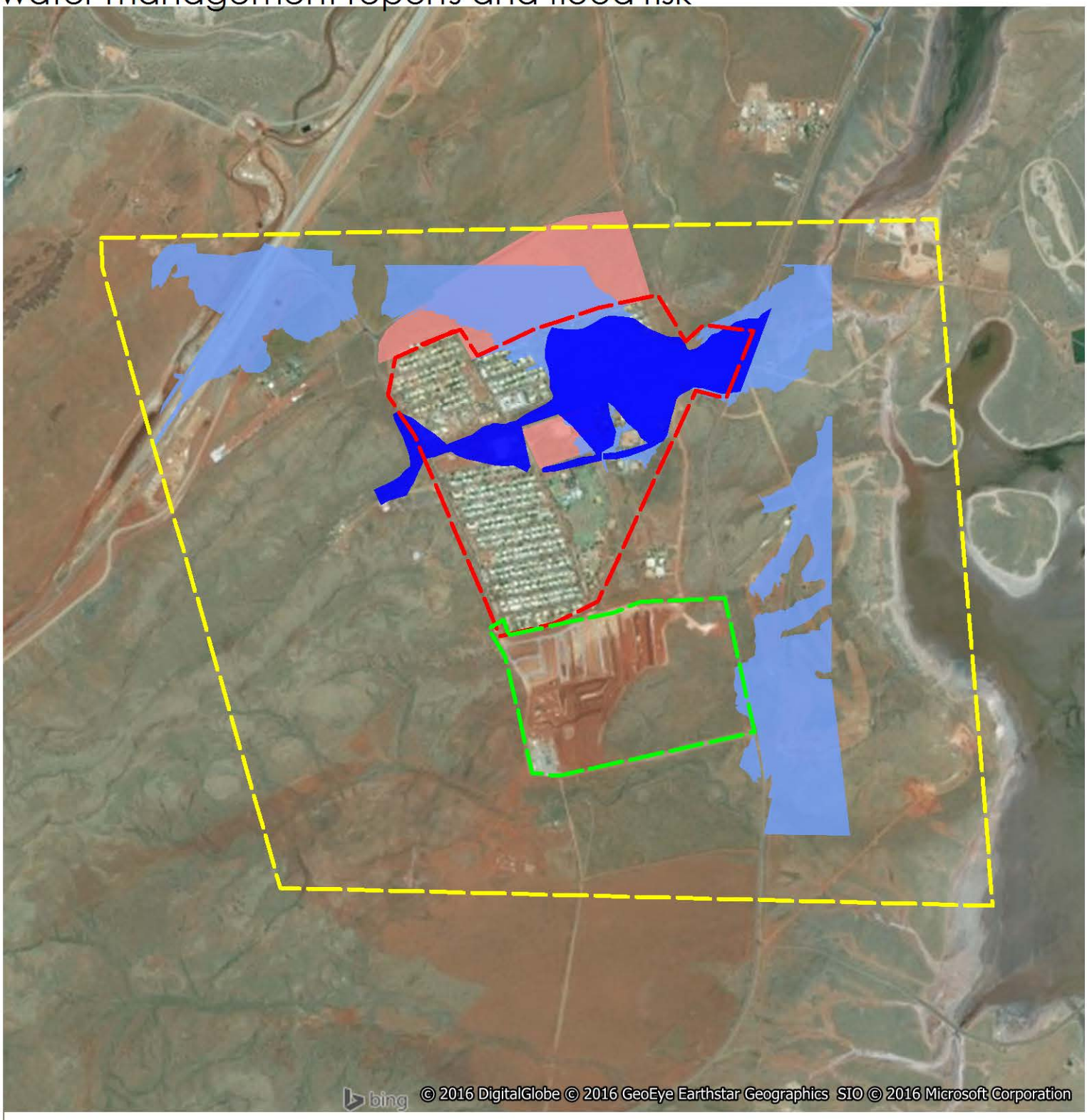
City of Karratha - City of Karratha Water Management Strategy
Figure 10: Wickham Townsite - Future development areas, water management reports and flood risk



Legend

- Wickham townsite accommodation expansion project (JDA, 2011)
- Wickham Storm Surge Modelling Study (MP Rogers & Associates, 2015)
- Wickham flood study (JDA, 2011)
- Future development areas
- 100yr ARI storm flood extent
- 100yr ARI storm surge

N

Scale 1: 25000
@ A4

0 500m

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Data source: Landgate, JDA, MP Rogers, CoK. Created by: RM. Projection: MGA: zone 50.

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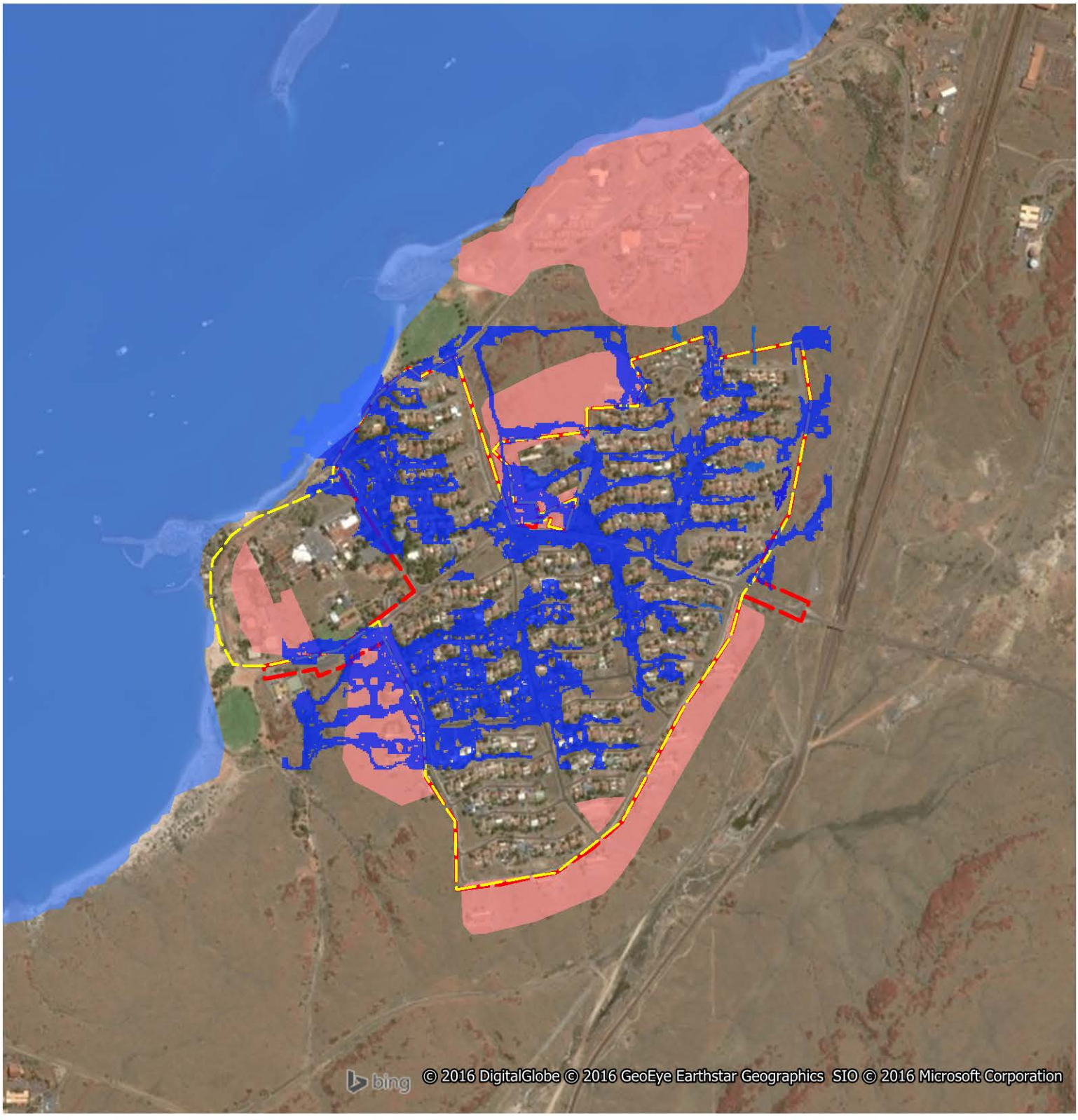
City of Karratha - City of Karratha Water Management Strategy
Figure 11: Dampier Townsite - Future development areas, water management reports and flood risk



Legend

- Dampier stormwater management study (GHD, 2015)
- Dampier drainage review (GHD, 2010)
- Future development areas
- 100yr ARI storm surge
- 100yr ARI storm flood extent

N

Scale 1: 15000
@ A4

0 300m

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Data source: Landgate, CoK, GHD. Created by: RM. Projection: MGA: zone 50.

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2.4.2 Groundwater

Because of the variability in rainfall and high evaporation rate in the Pilbara, groundwater is a very important water resource in the City. Groundwater occurs throughout the region but is most easily located and accessed near surface water drainage lines (alluvial channels) typically found in coastal areas.

The key groundwater aquifers in the City of Karratha are the Hamersley fractured rock aquifer, Pilbara fractured rock aquifer, Lower Fortescue Alluvial, Carnarvon – Birdrong, and Pilbara coastal saline aquifer (Figure 12). The alluvial aquifers on the coast are relatively small, typically receiving an annual recharge of less than 10 GL/yr. They also play an important role during periods of low or no recharge, in sustaining permanent pools – which in turn support ecosystems in an otherwise arid environment (DoW, 2013). Allocation limits and water availability for the aquifers present in the City of Karratha are provided in Table 1.

Table 1: Groundwater allocation limits

Aquifer	Allocation limit (kL/year)^	Availability (July 2015)**
Lower Fortescue Alluvial	7,000,000	Water available
Pilbara - Coastal Saline	2,000,000	Fully allocated
Pilbara - Fractured Rock	Not set*	Unknown
Hamersley - Fractured Rock	Not set*	Unknown
Carnarvon – Birdrong.	300,000	Water available

Notes:
^Pilbara groundwater allocation plan draft for public comment (DoW, 2012a)
*For fractured rock aquifers, where most mining occurs, water availability will be assessed on a case-by-case basis through licensing (DoW, 2012a)
**Obtained from DoW's online Water Register: http://www.water.wa.gov.au/ags/WaterRegister/

Water in fractured rock aquifers is harder to locate than in the coastal alluvial aquifers and the amount of water available from them is difficult to predict. Water supplies in these inland areas can, therefore, be problematic both in quantity and quality (DoW, 2010). The water abstracted from these aquifers is mainly for mine use and mine dewatering purposes.

Due to the low yield capacity of fractured rock aquifers, there is currently no groundwater being abstracted by the City, although the Department of Water has issued licenses to National Lifestyle Villages for 10,000kL per annum and St Pauls Primary School for 500kL per annum, both for irrigation purposes.

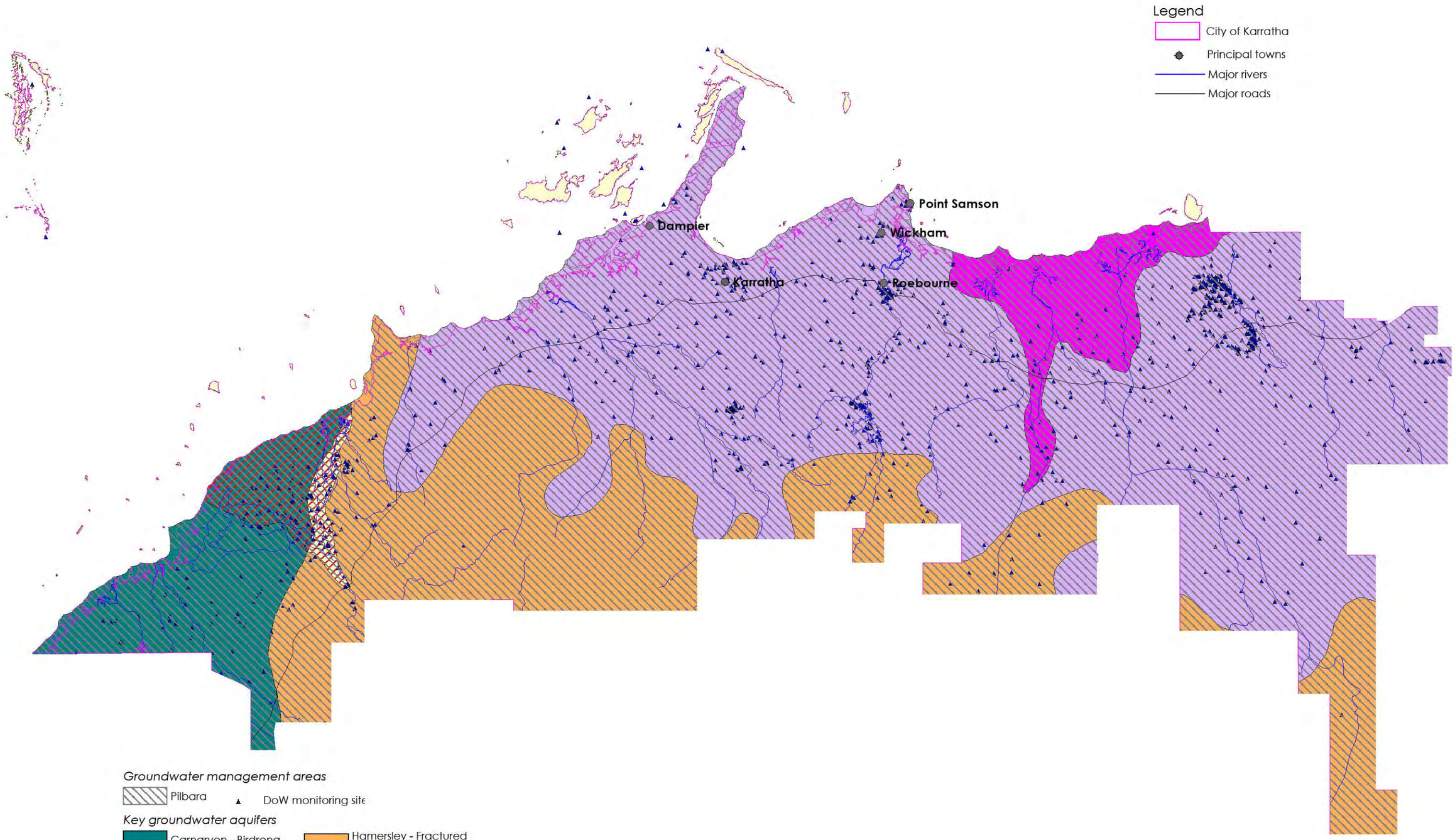
2.4.3 Drinking water

Water for the West Pilbara water supply scheme comes from the combined sources of the Lower Bungaroo Valley borefield, Harding Dam and Millstream aquifer. The West Pilbara water supply scheme supplies most of the coastal towns and port facilities of the City including Karratha, Dampier, Roebourne, Wickham, Point Samson and Cape Lambert and proposed ports at Anketell and Cape Preston (Figure 13).

Prior to 2014, the West Pilbara water supply scheme was sourced from the Harding Dam and Millstream aquifer. The demand on these sources was around 12 to 13 GL/yr, which was largely attributed to dust suppression requirements for iron ore production and other industries to meet health and safety requirements. This amount, however, exceeded the long term reliability of supply which was modelled at 10GL/yr (DoW 2013).

The State Government and Water Corporation undertook negotiations with Rio Tinto to establish another drinking water source and in May 2014, Rio Tinto completed construction of a new 10GL/yr borefield in the Lower Bungaroo Valley in the Shire of Ashburton which now contributes to the West Pilbara water supply scheme. The

City of Karratha - City of Karratha Water Management Strategy
Figure 12 - Groundwater resources



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Data sources: Landgate, Geoscience Australia, Created by: R Mackintosh. Projection: MGA50: zone 50.

Scale 1: 750,000 @A3
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Water Corporation is currently upgrading the capacity of the pipeline from the Millstream borefield to the City's townsites. These upgrades will provide a reliable scheme water supply of an anticipated 16-20 GL/year.

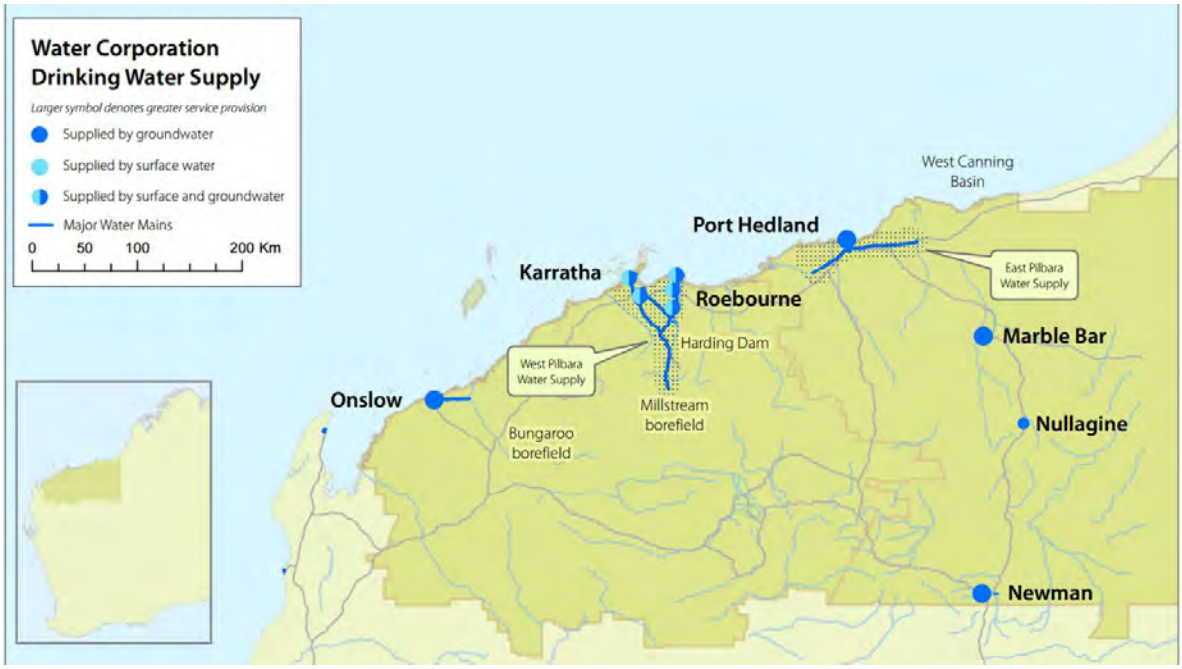


Figure 13: Pilbara region Water Corporation drinking water supply network (Source: Water Corporation, 2013)

Although Dampier is part of the West Pilbara water supply scheme, Dampier is still going through the process of normalisation and drinking water is distributed within the townsite by Rio Tinto. Rio Tinto are currently responsible for management of the distribution assets, wastewater services, maintenance of the potable and wastewater infrastructure and billing of Dampier customers. Accordingly, no Water Corporation led water efficiency programs, including the installation of smart meters, are being implemented in Dampier.

Drinking water is also used for irrigation of some areas of public open space in the City. As stated above, due to the low yield of the aquifers under the City's town sites, it is difficult to source groundwater for irrigation and so a variety of alternative sources are required. This is discussed further below.

Outside of the town sites connected to the West Pilbara water supply scheme, the rural communities, 'fly-in/fly-out' camps, remote aboriginal communities and pastoral industry have their water needs met via a combination of groundwater and surface water features such as springs and permanent pools. Camps and communities are not currently licensed under the *Water Services Licensing Act 1995*, as they are not in a controlled area under the act.

Drinking Water Source Protection Areas

Surface and groundwater resources of the City are contained within the Pilbara Surface and Groundwater Areas, which are proclaimed and protected under the *Rights in Water and Irrigation Act 1914* (RiWI Act). In addition, there are two Public Drinking Water Source Areas (PDWSAs) in the City protected under the *Country Areas Water Supply Act 1947* (CAWS Act). These are the Harding Dam Catchment Area, which includes the Millstream aquifer (Protection Area P1); and the Roebourne Water Reserve (Protection Area not assigned). Any future development will need to consider potential impacts on these PDWSAs, as required under the CAWS Act.

Water use

Although total water use in the Pilbara towns serviced by the Water Corporation has slightly increased in the last year or so (Chart 6), the average scheme water use per connection in Karratha has decreased (Chart 7). Residential scheme water use per connection per annum is around 520kL, with Karratha and Wickham using less water on average than other townsites (440kL and 443kL respectively in 2014). This level of water use is, however, significantly higher than the Perth average of 254kL and above the Western Australian regional town average of 308kL (ERA, 2015).

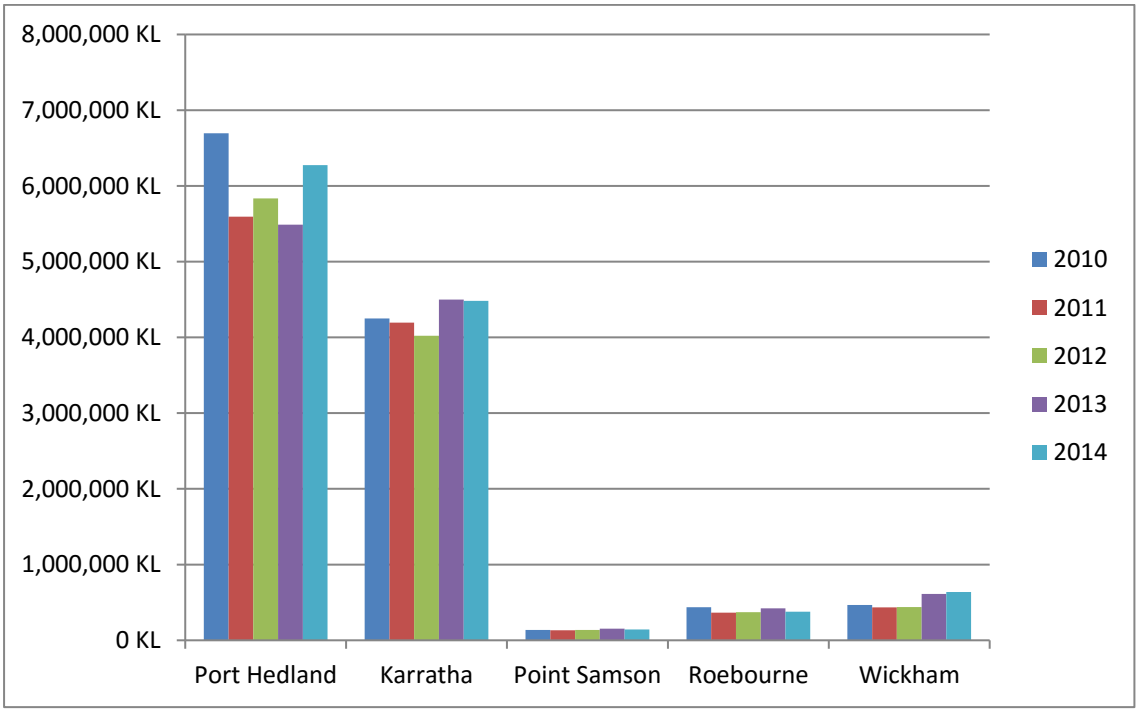


Chart 6: Total scheme water use per town site (source: Water Corporation)

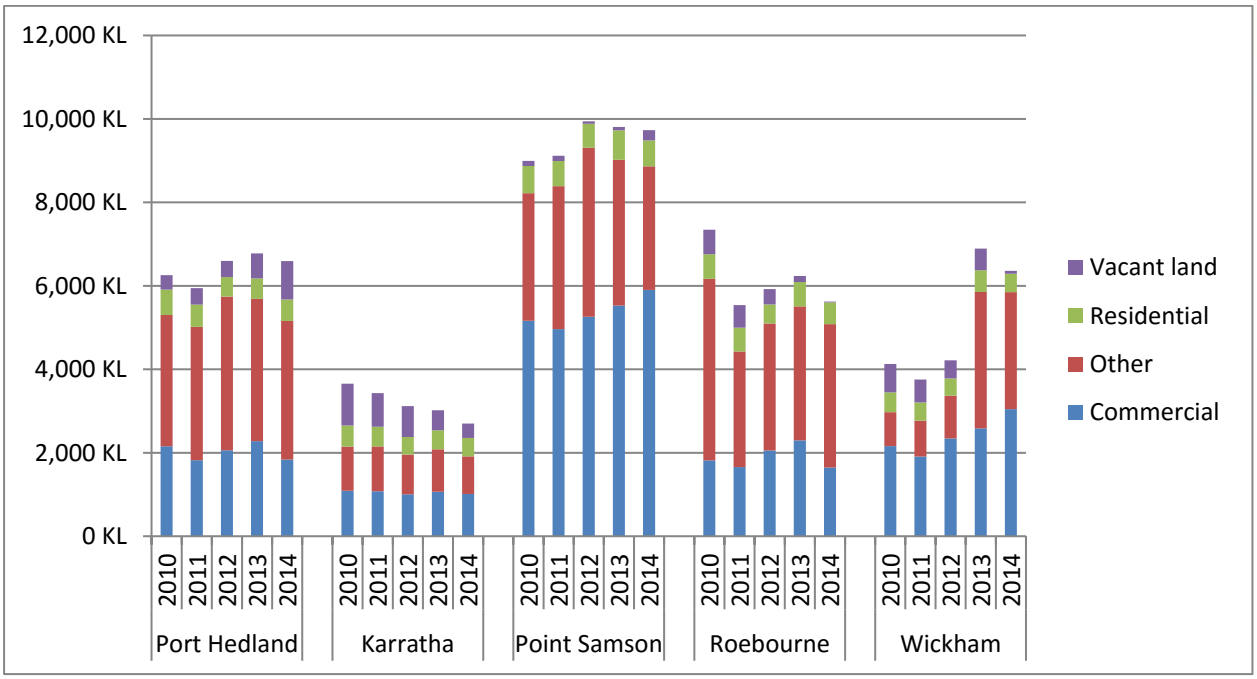


Chart 7: Average scheme water use per connection (source: Water Corporation)

The Water Corporation has installed around 7,400 smart meters in Karratha, Roebourne, Point Sampson and Wickham. This program was initiated due to the region's high per capita water use and to assist in the detection and management of leaks. It was anticipated that it would save 475 000 kL of water per annum from the West Pilbara Scheme, including 375,000 kL from residential users and 100,000kl from non-residential users (Hansard, September 18, 2012). The use of smart meters allows the Water Corporation to detect any unusual increases in water use and inform residents to check for potential leaks. Smart meters also provide customers with information on how and when they use water, allowing them to reduce their water use and in turn save on their water bills. No information was available from the Water Corporation at the time of writing regarding the volumes of water that have been saved.

Scheme water is also used by the City for irrigation of public open space. The Karratha townsite has 46 public open space areas that require irrigation, from ovals to cemeteries to landscaped roundabouts. This equates to 848 044m2 of irrigated area with an associated irrigation demand of 7,308 L/day. Although some of this water is sourced from scheme water, 18 of the 46 sites are irrigated with treated wastewater, and this number is expected to increase with the completion of the Effluent Reuse Scheme. It is noted that the City is recognised as being a leader in water reuse when it initiated the use of recycled water for irrigation some years ago.

Irrigation in Wickham and Dampier is also provided by a mixture of potable and non-potable sources, and this is reliant on the availability of recycled water from the wastewater treatment plants and the irrigation schemes. All public open space in Roebourne and Point Samson is irrigated with potable water as there is no non-potable source available.

The Water Corporation introduced a sprinkler roster in the Pilbara in 2007 as part of state-wide permanent water efficiency measures. Throughout the North West, gardens can only be watered once every alternate day, either before 9am or after 6pm.

2.4.4 Wastewater

Wastewater services in the key towns of the City are provided by either Rio Tinto or the Water Corporation. Point Samson, however, is unsewered and wastewater disposal is via septic tanks.

The upgrade to the Karratha Waste Water Treatment Plant has been completed and will be used to supply non-potable water for the Effluent Reuse Scheme, which will be used to irrigate areas of public open space across the Karratha townsite,. It is noted that the quality of the effluent is of a very high standard. This increases the scope of opportunities for which it can be used such as to supply non-potable water for the future Mulataga development; for dust suppression; and some industrial and construction uses; however these options are limited significantly by the available volumes.

Rio Tinto also provides recycled water for use by the City for irrigation in Wickham and Dampier, which reduces the demand on the West Pilbara water supply scheme.

Key land use planning and water management issues

- **Drinking water supplies –** The State Government is working towards the delivery of adequate water supplies to support the growth of the region; however, there is a need to ensure adequate drinking water is provided to remote Aboriginal Communities.
- **Environmental water requirements –** Although there is a need to supply water for public use, it is also important to sustainably manage the water resources of the region to maintain environmental, cultural and social values. This includes the management of land use and discharges to ground and surface waters (including from mine dewatering) to avoid contamination, as well as the protection of significant waterholes in co-operation with Traditional Owners.
- **Water use efficiency-** Optimisation of irrigation efficiency so as not to overwater public open spaces and increasing water efficiency education can be undertaken through strategies including use of Smart

Meters and by supporting National Water Week and other Water Corporation programs such as they Waterwise Council and Waterwise Schools programs.

- **Water reuse** – Increasing water recycling and reuse to provide fit-for-purpose sources of water for public open space, construction and industrial uses including dust suppression will reduce pressure on scarce water resources. The availability of recycled water is dependent on population and inputs to wastewater treatment plants. Should population growth occur at a rate lower than expected, this may reduce the volumes of water available in the future for reuse. Working with industry will allow identification of opportunities for the use of dewatered groundwater from mine sites in City or community projects.
- **Flooding from stormwater** - Adequately managing the risk of flooding in townsites can be undertaken through a review of townsite drainage systems and ensuring that appropriate levels of service will be maintained as development occurs and water quality of stormwater is addressed.

2.5 Heritage

2.5.1 Aboriginal Heritage

The City of Karratha is home to a number of traditional landowner language groups, many of which have a strong spiritual, physical and cultural connection to the region and landscape. Aboriginal people are thought to have inhabited the region for up to 40,000 years (Pilbara RDA, 2012). As such a rich cultural and historical indigenous heritage exists in the region, particularly in natural features such as rivers, hills and rock formations where people, animals and characters left traces of their journey across the landscape. These places may be valuable because of mythological lore (The Dreaming); because of past use as meeting places for special ceremonies; as burial grounds for ancestors; or as places where culture and history was recorded through rock art. The location of these important cultural sites within the natural landscape means there is considerable overlap between Aboriginal and natural heritage in the region.

The Ngarluma/Yindjibarndi people are recognised as having Native Title rights over a significant portion of the City of Karratha.The Jaburara (or Yaburara) Aboriginal language group are recognised as the original inhabitants of the Burrup Peninsula (known as Murujuga) and Dampier Archipelago. The Dampier Archipelago contains one of the densest concentrations of rock engravings in Australia with some sites containing thousands or tens of thousands of images. It was listed on the National Heritage List in 2007, the National Trust of Australia Endangered Places Register in 2002 (National Trusts in Australia, 2012), the Register of the National Estate and is protected by the *Environment Protection and Biodiversity Conservation Act* as a Matter of National Environmental Significance.

Over two thousand indigenous heritage sites have been identified in the City and are protected under the *Aboriginal Heritage Act 1972* (Figure 14).

2.5.2 Post European Settlement Heritage

The European history of the Pilbara began in the City of Karratha in 1699 when William Dampier's ship, 'The Roebuck,' laid anchor in the Dampier Archipelago at Malus Island (Karratha Visitor's Centre, 2012). A series of townships were established soon after, the most famous being the township of Cossack, as well as Roebourne and Point Samson. As a result the City's European heritage is rich, with a large number of sites recognised on the City's municipal heritage register.

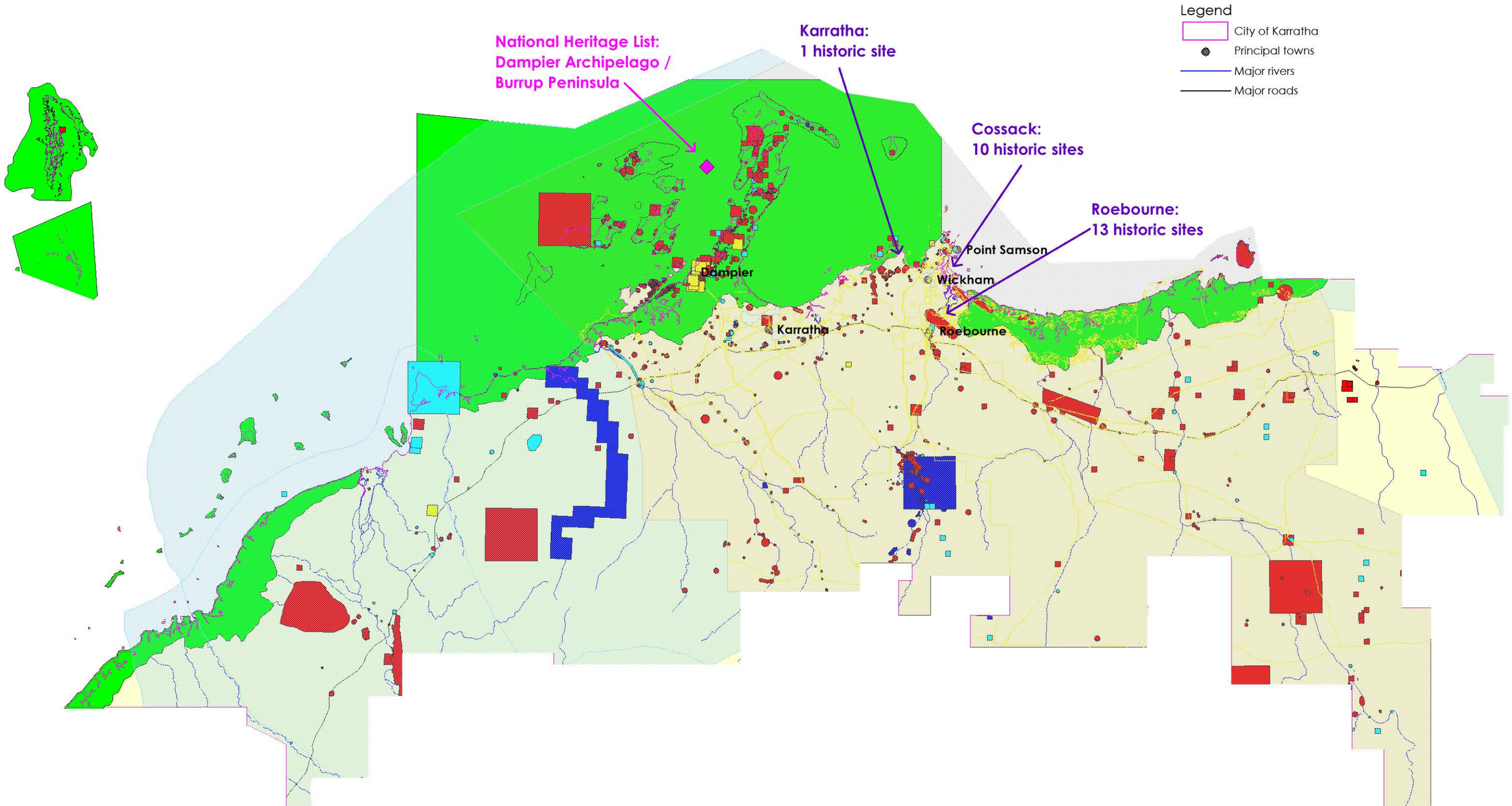
The City of Karratha is well known for the historic town of Cossack and many important heritage buildings and sites in the town of Roebourne. A number of historic shipwrecks have been identified off the City of Karratha coast on the *Australian National Shipwreck Database*, associated with the region's European history. Seven wrecks have been identified in the Montebello Islands, as well as one wreck off Point Samson and one wreck near Dampier, dating back to 1868 (DSEWPaC, 2012).

The City of Karratha *Municipal Heritage Inventory* has recently been revised to incorporate additional information about the acknowledged heritage sites in the municipality. There are currently 76 heritage sites recognised on the City's revised *Municipal Heritage Inventory*, however, these are still under review (pers. comm, City of Karratha, May 2013). It is noted, however, that the Municipal Heritage Inventory does not address heritage sites prior to European occupation.

Key land use planning and water management issues

- **Protection of heritage sites and values** - While heritage is primarily managed through State and Commonwealth legislation, opportunities exist to protect and promote both aboriginal and European cultural heritage through joint management arrangements with traditional owners and optimise opportunities for Indigenous training, employment and businesses.
- **Engagement with traditional owners** – This is required to meet legislative requirements of the Native Title Act, 1993. Increased benefits may be observed through an elevated level of involvement of the traditional owners and indigenous groups within the City in terms of land and cultural heritage management, including the traditional owners Ngarluma, Yindjibarndi, Yaburara, Kuruma, Marthudunera/ Mardudhunera.

City of Karratha - City of Karratha Water Management Strategy
Figure 14 - Heritage sites



Aboriginal Heritage Sites (DAA) - status
- Insufficient information - lodged & not assessed under Section 5 of the AHA
- Lodged with Registrar - not assessed
- Registered site
- Stored - lodged & does not meet terms of Section 5 of the AHA

Register of National Estate - class
- Historic
- Indigenous
- Natural
- National Heritage List

Native Title - classification
- Applications determined by the Federal Court
- Applications lodged with the Federal Court
- Indigenous Land Use Agreements within WA registered with the National Native Title Tibunal

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Data sources: Landgate, DoE, Created by: R Mackintosh. Projection: MGA50: zone 50.

Scale 1: 750,000 @A3

0 30 km

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3 WATER MANAGEMENT STRATEGY

3.1 Objectives and strategies

The objectives and strategies of this water management strategy are outlined in Table 2.

Table 2: Water management objectives and strategies

	Objective		Strategy
1	Adequately manage the risk of flooding	1.1	Recognise and address flood risk (from stormwater and riverine systems) as part of future planning and development assessment and decision-making
		1.2	Prioritise asset upgrades in areas of identified flood risk and maintain drainage infrastructure to optimise environmental and social values.
2	Increase water use efficiency, recycling and reuse to provide fit-for-purpose sources	2.1	Continue to optimise use of treated wastewater for irrigation of public open space including prioritisation of parks, streetscapes and/or drainage swales for use of irrigation to sustain values, vegetation and address urban heat.
		2.2	Support new development which proposes non-scheme water source for non-potable needs where capacity is available.
		2.3	Ensure Council operations maximise water use efficiency.
3	Manage discharges to ground and surface waters to avoid contamination and health risks	3.1	Ensure sediment management is appropriately addressed through suitable drainage design and landscaping.
		3.2	Deliver City operational activities in accordance with best management practices with regards to discharges to ground and surface waters.
		3.3	Protect important drinking water resources through appropriate land use controls and land management activities in the vicinity of any drinking water borefields and surface water supply areas, in accordance with State Planning Policy 2.7: Public Drinking Water Source (2003) and the recommendations of the Department of Water's Water Quality Protection Note: Land Use Compatibility within Public Drinking Water Source Areas (2016) including the requirements for well-head protection zones and any Water Source Protection Plans.
4	Maintain environmental, cultural and social values and provide for the water needs of the future community through advocacy and informed decision making	4.1	Assist state water agencies in the maintenance of environmental, social and cultural values through advocacy for sustainable water management and protection including improved aesthetics and urban amenity, improved water quality, increased urban biodiversity and integrated and enhanced public open space
		4.2	Increase community education regarding the environmental, social and cultural values of water resources including the need for improved efficiency, fit-for-purpose use and water quality management

3.2 Delivery

This water management strategy will be delivered by the City. It is recognised; however, that the protection and management of water resources is largely controlled by agencies other than the City. The City's role is limited to its local government functions which include regulatory and operational activities and provision of various community services. Key areas of action that are relevant to the management of water resources by the City of Karratha are:

- Planning decision-making on future planning and development proposals;
- Management and maintenance of drainage infrastructure;
- Maintenance of public open space including irrigation; and
- Advocacy for increased water conservation, efficiency and reuse and enhancement of cultural and community connections to water.

The water management strategy provides guidance as to how to the City will deliver the above roles in order to meet the agreed objectives of the strategy, having consideration of other Commonwealth, State and local government legislation and policy. The relevant legislatory and policy considerations are summarised in Appendix 3.

Further detail on the delivery of the strategies in the short term is contained in the Action Plan in section 3.3.

3.2.1 Planning decision-making

Urban planning and development is to have due regard for *State Planning Policy 2.9 Water Resources* (2006), in order to improve the achievement of total water cycle outcomes and implementation of water sensitive urban design. The requirements for integrating land and water planning are outlined in *Better Urban Water Management* (WAPC, 2008), which establishes a framework for investigation and reporting (Figure 15).

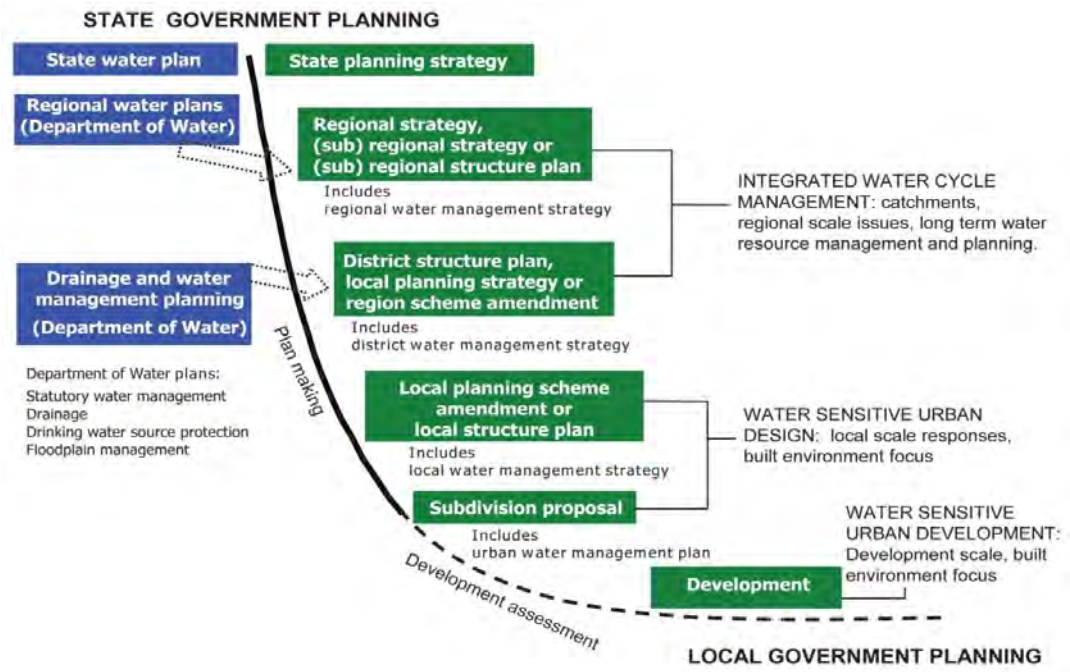


Figure 15: Planning framework integrating water resource planning with the land planning process (WAPC 2008)

The objectives of this water management strategy are to be met as part of the delivery of services within the City which include planning decision-making on future planning and development proposals. The following planning requirements are to apply.

- New development is to be designed to meet appropriate flood risk criteria.
- Land use planning and development within public drinking water source protection areas should be consistent with *State Planning Policy 2.7: Public Drinking Water Source* (2003) and the recommendations of the Department of Water's *Water Quality Protection Note: Land Use Compatibility within Public Drinking Water Source Areas* (2016) including the requirements for well-head protection zones and any Water Source Protection Plans.
- City has prepared a number of documents consistent with *Better Urban Water Management* (2008) which support a number of structure plans for key areas of future development. These water management strategies, which are mapped in Figures 6 to 11, contain criteria for stormwater management for new development in the City's townsites (see Appendix 2). Any development in these areas should demonstrate compliance with these criteria, as well as the City's Stormwater Design Guidelines.
- Appropriate urban water management studies are to be undertaken in areas outside the boundaries of the existing technical studies mapped in Figures 6 to 11, consistent with the Guidance provided in Section 5.
- Any amendment to the local planning scheme outside the existing technical studies mapped in Figures 6 to 11 is to be supported by a District Water Management Strategy which outlines the objectives and strategies for flood protection, water quality management and water use and efficiency, consistent with this Water Management Strategy, *Better Urban Water Management* (WAPC, 2008) and the Department of Water's *Guidelines for district water management strategies* (DoW, 2013). Guidance for issues to be addressed in district water management strategies is provided in section 5.
- Any local structure plan is to be supported by a Local Water Management Strategy which outlines the objectives and strategies for flood protection, water quality management and water use and efficiency, consistent with this Water Management Strategy, any relevant approved district water management strategy, *Better Urban Water Management* (WAPC, 2008) and the Department of Water's *Interim: Developing a Local Water Management Strategy* (DoW, 2008a).
- Any local development plan and/or large subdivision proposal (generally 25 lots or more) is to be supported by an urban water management plan which demonstrates how the objectives and strategies for flood protection, water quality management and water conservation are to be met, consistent with this Water Management Strategy, and approved relevant local water management strategy, *Better Urban Water Management* (WAPC, 2008) and the Department of Water's *Urban water management plans: Guidelines for preparing plans and for complying with subdivision conditions*, DoW, 2008b).

3.2.2 Management and maintenance of drainage infrastructure

The City has undertaken a number of studies to inform the management of stormwater and flooding within the City's townsites (Appendix 2). As highlighted above, these documents contain a range of criteria to guide future development. They also contain information regarding the existing drainage systems, including the identification of areas of increased flood risk as well as current capacity constraints, making recommendations for possible upgrades. These recommendations should be used by the City to guide their asset management program.

Key actions to achieve the objectives of the water management strategy are to:

- Extend the asset management plan across the whole City and provide information on drainage asset life and condition which can be used for prioritisation of works;
- Review and assess existing drains for prioritisation of remedial works;
- Review internal maintenance programs in terms of current drainage management activities and develop a prioritised drainage system management plan including a works program;
- Determine priority areas for emergency planning to adequately manage risks from stormwater and riverine flooding;
- Continue the use of native grasses in the early establishment of vegetation in drains; and
- Include geographical information on drainage including areas affected by 100yr ARI stormwater flood risk in Synergy.

3.2.3 Maintenance of public open space including irrigation

Due to a lack of available groundwater, the City has had to seek alternative sources of water for irrigation and has established, together with the Water Corporation, the Effluent Reuse Scheme. It is recognised, however, that the available volumes are dependent on the population of the town sites, the cost of the source and other users of the recycled water, and so are highly variable and unpredictable. The City has therefore established priorities for the irrigation of open space through the City's Public Open Space Strategy, which recognise the needs of the community and highlights opportunities for conversion of irrigated areas to non-irrigated areas on the basis of function.

There is a critical need to ensure that a sustainable supply of water is available for irrigation of the public domain which is cost effective and optimises fit-for-purpose principles. The City should work with the Water Corporation to ensure it has access to the supply it needs for the Effluent Reuse Scheme in the immediate and longer term future.

Key actions to achieve the objectives of the water management strategy are to:

- Use treated wastewater for the irrigation of new areas of public open space where possible; and
- Continue to optimise irrigation efficiency of parks and public realm.

3.2.4 Advocacy for increased water conservation, efficiency and reuse and enhancement of cultural and community connections to water.

The City has prepared a Water Efficiency Action Plan as part of the process to become a Waterwise Council. The Water Efficiency Action Plan will help the City understand its water usage and consolidate actions to increase water conservation and efficiency across its operations and property.

Consideration should be given to the City's role in advocating for improved water conservation and efficiency in residential areas and in particular, its own housing stock through its community programs and implementation of the Environmental Strategy. The City could also consider encouraging mining companies to consider non-potable water use for dust suppression on stock piles.

Key actions to achieve the objectives of the water management strategy are:

- Replace or retro-fit appliances and fixtures in City facilities with water efficient options;
- Incorporate the requirement for City purchasing decisions to consider waterwise ratings of goods and optimise performance where possible in purchasing policy;
- Continue progressing through the Waterwise Council program and implement the Water Efficiency Action Plan;
- Increase community education of the City's efficiency and reuse program through additional signage and consider other activities which may be cost effective, innovative or deliver significant benefits;

- Engage with the community to understand water values and behaviours including attitudes to water reuse and efficiency;
- Identify opportunities for improved water management in industrial areas, including management of stormwater quality and opportunities for reuse;
- Promote water efficiency measures within the community and workplace including behaviour change and installation of more water efficient fittings and fixtures; and
- Consider advocating for recreational use of Harding Dam to enhance opportunities for tourism and controlled community activities.

3.3 Implementation plan

The implementation plan identifies individual actions against each of the four objectives which are recommended to be undertaken to achieve the objectives of the Water Management Strategy. Each action is assigned a priority for delivery, recommended timeframe, responsibility within the organisation and an indicator for measurement and tracking of performance. Partnerships with external agencies and implications for delivery and resourcing are also indicated where possible.

Note that only actions within the City's role and capacity to implement are identified. Responsibility for implementation of each action is allocated to a specific business unit within the City, who will be required to consider the relevant action in setting annual budgets and providing input into the Integrated Planning Framework.

The timeframe reflects the suggested timeframe in which the action should be implemented while the priority reflects the importance of the action in contributing to the overall aim of the Strategy. The priority and timeframe should be considered together; actions which are of low priority but have a short timeframe may represent some early achievements in the Strategy's implementation. Actions that are of high priority may require a long timeframe due to the complexity of the action. These identified timeframes and priority levels should be considered indicative only and should not hinder an action of low priority or long-term timeframe being undertaken if an opportunity should arise. A key containing additional detail is provided in Table 3.

Table 3: Action plan key

Timeframe	Actions to be completed
Short term	2016/17 – 2017/18 - within Annual Budget or Corporate Business Plan
Medium term	2017/18 – 2020/21 - within Corporate Business Plan
Long term	2021/22 – 2026/27 - within Long Term Financial Plan
Ongoing	To occur through operations and absorbed in normal operational budget.

Priority	The approach actions require
High	Of high importance, needs a strong proactive approach, opportunities should be created.
Medium	Of medium importance, opportunities should be sought out.
Low	Of low importance, opportunities should be undertaken as they arise.

Funding consideration	
	Action can be absorbed into operations and does not require additional budget allocation
	Action is included or forms part of an Action in the Corporate Business Plan or Annual Budget
	Action not currently included in Corporate Business Plan or Annual Budget. It is considered a high priority; should be considered in the next review and may require budget allocation
	Action is to be considered for inclusion in the Long Term Financial Plan and future reviews of the Corporate Business Plan

The action plan for delivery of this Water Management Strategy to 2020 is provided in Table 4.

Table 4: Action plan for 2016 - 2020

	Action	Time frame	Priority	Responsibility Partner	Indicator
1.1	Ensure new development is designed to meet appropriate flood risk criteria	Ongoing	High	Planning services Department of Water	Policy developed
1.2	Extend the asset management plan across the whole City and provide information on drainage asset life and condition which can be used for prioritisation of works	Medium	Medium	Technical services	City-wide asset plan completed
1.3	Review and assess existing drains for prioritisation of remedial works	Short	High	Technical services	Works prioritised
1.4	Review internal maintenance programs for drainage management and develop a drainage system management plan including a works program	Medium	Low	Technical services	Maintenance program completed
1.5	Determine priority areas for emergency planning to adequately manage risks from stormwater and riverine flooding	Medium	High	Planning services	Areas identified
1.6	Continue the use of native grasses in the early establishment of vegetation in drains.	Ongoing	Medium	Parks and gardens	#drains seeded
1.7	Include geographical information on drainage including areas affected by 100yr ARI flood risk in Synergy	Medium	Medium	Regulatory services	Information incorporated
1.8	Develop guidance for drainage requirements for single lots for Development Applications	Short	Medium	Planning services Department of Water	Guidance released
2.1	Use treated wastewater for the irrigation of new areas of public open space where possible	Ongoing	High	Parks and gardens Water Corporation	# parks irrigated with ERS
2.2	Replace or retro-fit appliances and fixtures in City facilities with water efficient options	Medium	Low	Technical services Water Corporation	# replaced appliances
2.3	Incorporate the requirement for City purchasing decisions to consider waterwise ratings of goods and optimise performance where possible in purchasing policy	Short	Medium	Corporate compliance	Policy amended
2.4	Continue progressing through the Waterwise Council program and implement the City's Water Efficiency Action Plan	Short	Medium	Regulatory services Water Corporation	Waterwise Council status achieved
2.5	Continue to optimise irrigation efficiency of parks and public realm	Ongoing	High	Parks and gardens	Reduced water usage
3.1	Establish a special control area in the local planning scheme to provide land use controls over the drinking water source protection areas	Short	High	Planning services Department of Water	SCA in scheme
3.2	Develop a strategy to provide surface and groundwater quality and quantity information to inform future land use planning decisions	Long	Low	Planning services Department of Water	Strategy completed

	Action	Time frame	Priority	Responsibility Partner	Indicator
4.1	Ensure planning applications are supported by an appropriate level of water resource information consistent with the provisions in Section 3.2.1.	Ongoing	High	Planning services Department of Water	Applications supported with information
4.2	Increase community education of the City's efficiency and reuse program through additional signage and consider other activities which may be cost effective, innovative or deliver significant benefits.	Ongoing	Low	Recreation facilities Water Corporation	Increased level of education
4.3	Engage with the community to understand water values and behaviours including attitudes to water reuse and efficiency.	Short	Medium	Leisure services Water Corporation	Behaviours and values documented
4.4	Identify opportunities for improved water management in industrial areas, including management of stormwater quality and opportunities for reuse.	Long	Low	Technical services Department of Water	Opportunities identified
4.5	Promote water efficiency measures within the community and workplace including behaviour change and installation of more water efficient fittings and fixtures.	Medium	Medium	Leisure services Water Corporation	Increased level of promotion
4.6	Consider advocating for recreational use of Harding Dam to enhance opportunities for tourism and controlled community activities.	Short	Low	Recreation facilities Water Corporation Department of Water	Opportunity considered by City.

4 GUIDANCE FOR DISTRICT WATER MANAGEMENT STRATEGIES

The City's local planning strategy provides guidance for the future growth of the City. It identifies a number of areas where residential and industrial development may occur in the future. These areas are identified as follows:

- Urban expansion areas – should be a priority for development, as these areas are already zoned for development.
- Development investigation areas – are identified where there are constraints to development. These sites may offer opportunities for accommodating growth in the future should constraints be overcome.
- Industrial Expansion Areas – reflect planned but not necessarily zoned industrial areas.

Any proposed development of the identified sites will need to address environmental issues and constraints consistent with State and Local policy and strategy (including this water management strategy). In order to facilitate the appropriate response to water management issues, the key water resources aspects which will need to be addressed have been highlighted in the following figures.

In accordance with *Better Urban Water Management* (WAPC, 2008), a District Water Management Strategy (DWMS) is required to be prepared to support the rezoning of land for development. It should outline the objectives and strategies for flood protection, water quality management and water use and efficiency. Any DWMS should be consistent with this Water Management Strategy, *State Planning Policy 2.9: Water Resources* and the Department of Water's *Guidelines for district water management strategies* (DoW, 2013).

It is noted that where land is already zoned for development (i.e. Urban expansion areas), a district water management strategy will not be required. However, the following information may also be used to guide preparation of any local water management strategy (LWMS).

4.1 How to prepare a DWMS

The Department of Water's *Guidelines for district water management strategies: Guidelines for preparing a district water management strategy to support a region scheme amendment or district structure plan* (2013) (DWMS guidelines) outline the water management aspects that should be addressed in a DWMS; the principles and objectives which should be demonstrated; and the level and type of information required.

4.1.1 Information required

The DWMS guidelines require demonstration that the proposed development:

- will not detrimentally impact water resources and associated environmental values including receiving environments;
- can manage surface water and groundwater; and
- can be serviced with water and wastewater.

This may be achieved through:

- Establishing objectives for the management of water resources for the proposed development. Consider the objectives contained within the DoW's DWMS guidelines;
- Providing a description of the pre-development environment which identifies relevant site specific assets, risks and constraints. This information may be obtained from this water management strategy, with updates to the information where relevant. Information to be

summarised includes local climate, topography, environmental geology, acid sulfate soils, contaminated sites, existing land use, waterways and drainage lines, groundwater resources, public drinking water source areas, social, cultural and heritage considerations and existing infrastructure; and

- Proposing broad-scale management strategies which are consistent with the objectives of this water management strategy and relevant design criteria (see Attachment 2) and address the issues highlighted above. Issues requiring specialised investigations and management for the subsequent LWMS, including timing and responsibilities for investigations should also be identified.

With regards to pre-development conditions of the future development areas as proposed in the City's Local Planning Scheme, there is no need to address wetlands, shallow groundwater, protected flora/fauna/ vegetation communities or acid sulfate soils.

Due to site specific conditions, one of the most important considerations for the future development areas is the management of surface water and flood risk. This will require a solid understanding of surface water flow direction, water quality, catchment areas, drainage lines and associated features (e.g. controlling culverts, bridges) within the study area as well as upstream and downstream conditions. Reference to relevant flood modelling studies should be made where these are available (see Appendix 2).

Key aspects which will need to be addressed as part of any proposed DWMS are slope/topography, low permeability soils, surface water and flood management (including land requirements), water for irrigation of open space and other non-potable uses (demands and sources), service requirements and available capacity for drinking water and wastewater and conservation and efficiency/reuse strategies.

4.1.2 Level of detail

Better urban water management guidance note 3: Preparation and assessment of water management reports (DoW 2013b) contains guidance on the level of detail which will be required in the future DWMSs. It notes that the level of detail required for water management reports will depend on:

- The number and significance of water resource management issues relevant to the proposal area (e.g. flood risks, high groundwater, nearby wetlands and waterways;
- The planning decision being made (e.g. rezoning, structure plan, subdivision); and
- The type of land use or urban design proposed and how the water resource will be managed (e.g. foreshore areas, subsurface drainage, detention and retention).

As the future development areas contain limited significant water resource issues and the DWMSs will be high level documents likely to propose a drainage management system based on overland flow, it is considered that only a limited amount of information and detail is required. This is supported by the classification of the site as a medium risk site (as per Table 2 of Guidance Note 3) which requires "site assessment to determine management responses in terms of the surrounding (sub) catchment, with some on site monitoring and demonstration of representative sampling." It is considered appropriate for the site investigations to be undertaken to support preparation of the local water management strategy rather than the DWMS.

4.1.3 Objectives and design criteria

Preparation of a DWMS should be consistent with the following policies, strategies and guidelines.

- *State Planning Policy 2.9: Water Resources*, 2006
- *Better Urban Water Management*, WAPC, 2008
- *Guidelines for district water management strategies: Guidelines for preparing a district water management strategy to support a region scheme amendment or district structure plan,* DoW, 2013

- Revised Decision Process for Stormwater Management in WA, DoW, preparation
- Stormwater Management Manual for WA, DoW, 2004 – 2007
- City of Karratha Water Management Strategy, Essential Environmental, 2016
- *City of Karratha Stormwater Design Guidelines for Residential Developments*, 2011.

Criteria from the Department of Water (Revised Decision Process for Stormwater Management in WA, in prep) are to "Manage (retain and/or detain) stormwater runoff from constructed impervious surfaces generated by the first 15 mm of rainfall at-source as much as practical".

The recently released revised draft Australian Rainfall and Runoff (Commonwealth of Australia, Geoscience Australia, 2016) (AR&R) provides recommendations for the design of stormwater drainage systems, including advice on the expected initial losses for urban and rural catchments.

It is considered that climate conditions are such that 15mm of stormwater is likely to be able to be retained/detained within lots without the need for soakwells or connections to street drainage. This is supported by AR&R which recognises that catchment initial losses in the Pilbara are known to be some of the highest in Australia. When the findings of Flavell and Belstead (1986) are applied, initial losses for indirectly connected urban areas in the Pilbara could be reasonably allocated initial loss values of 24 to 32mm, suggesting that the criteria to manage the first 15mm of rainfall within the lots can be adequately met without the need for connected drainage systems.

Additional criteria for management of flooding and drainage in particular town sites are contained in:

- Karratha drainage management plan (GHD, 2010);
- Dampier stormwater management study (GHD, 2015);
- Roebourne local water management strategy (Essential Environmental, 2013);
- Wickham townsite accommodation expansion project – LWMS (JDA, 2011); and
- Point Samson District Water Management Strategy (Cardno, 2015).

4.2 Future development areas

The following pages provide information on future development areas highlighted in the local planning strategy. The information is reflective of the information that was publically available at time of writing and should not be used for detailed planning and design. It focusses on the key issues of importance for the future development areas which include:

- Topography
- Soils
- Waterways and creeklines
- Stormwater and drainage
- Coastal storm surge flooding
- Sewer and water infrastructure
- Non-drinking water sources

Consideration should be given to the issues as they relate to each site as part of the preparation of any future DWMS.

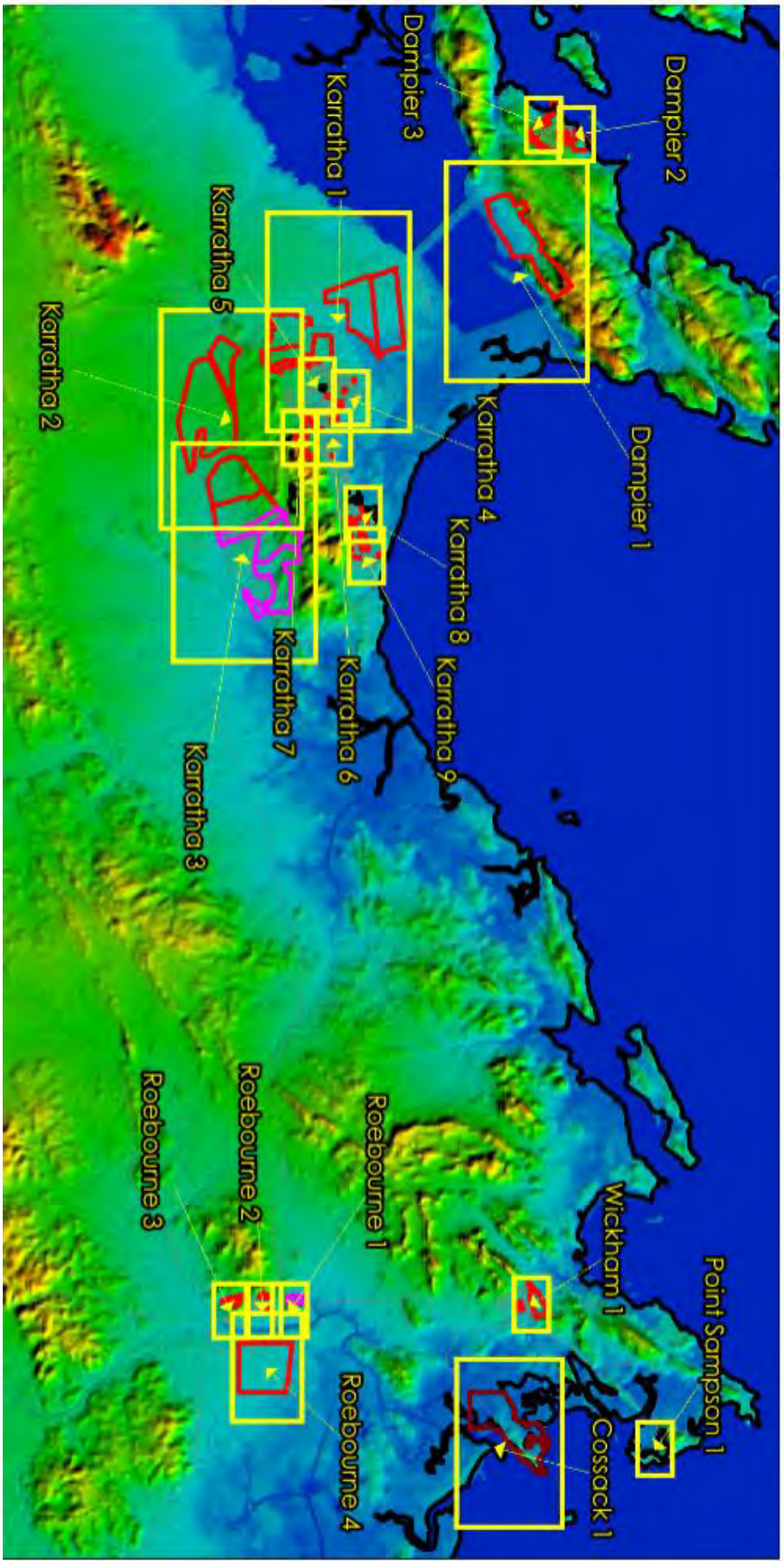
It is noted that although flooding from storm surge is not generally considered in a DWMS, due to the potential for interaction between storm surge and stormwater flood, the information has been provided where it is available.

The future development areas are mapped as follows:

Townsite	Map number	Future development areas
Dampier	Dampier 1	Development investigation area D1
	Dampier 2	Development investigation areas D2 & D3
	Dampier 3	Development investigation areas D4, D5. D6 & D7
Karratha	Karratha 1	Development investigation areas K1, K2, K3, K4 & K5
	Karratha 2	Development investigation areas K6, K7, K8 & K9
	Karratha 3	Urban expansion area K10 and Industrial Expansion Areas K11, K12 & K13
	Karratha 4	Development investigation areas K 14, K15, K16 & K17
	Karratha 5	Urban expansion area K18, Development investigation area K19
	Karratha 6	Development investigation areas K20, K21, K22
	Karratha 7	Development investigation areas K23 & K24
	Karratha 8	Urban expansion areas K126-30, Development investigation areas K31 – K38
	Karratha 9	Development investigation areas K37-43
Point Samson	Point Samson 1	Urban expansion areas P1 & P2
Roebourne	Roebourne 1	Industrial Expansion Area R1
	Roebourne 2	Development investigation areas R2 & R3
	Roebourne 3	Development investigation area R4
	Roebourne 4	Development investigation area R5
Wickham	Wickham 1	Development investigation areas W1 & W2
Cossack	Cossack 1	Tourism and recreational development area C1

Map legend

Key to maps


Dampier 2
Dampier 3
Karratha 1
Karratha 5
Karratha 2
Dampier 1
Karratha 4
Karratha 8
Karratha 9
Karratha 7
Karratha 6
Karratha 3
Roebourne 3
Roebourne 2
Roebourne 1
Roebourne 4
Wickham 1
Point Sampson 1
Cossack 1

Dampier 1

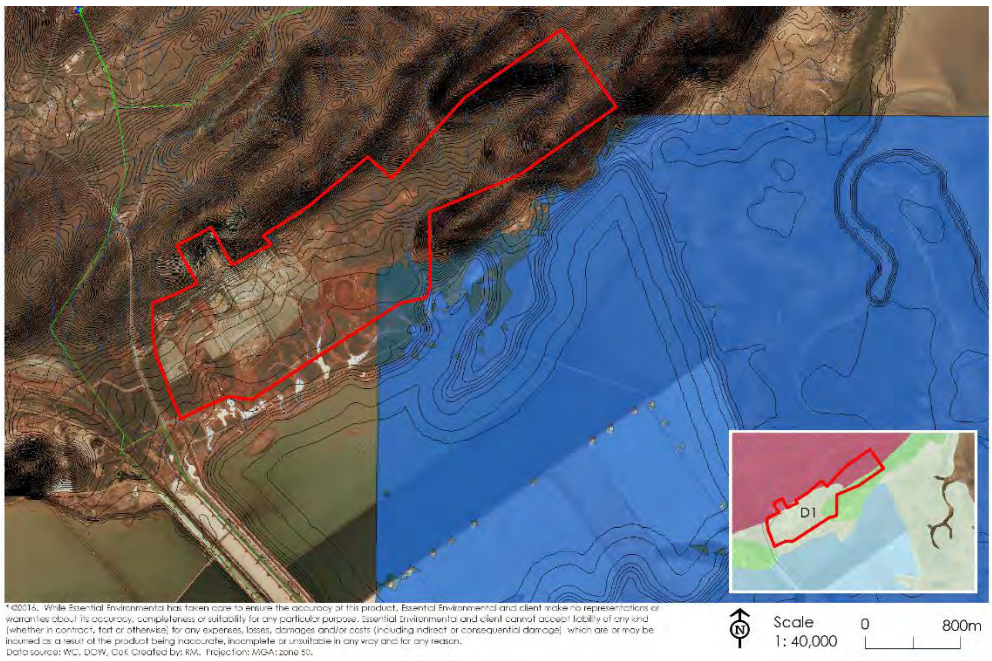
Development investigation area D1

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Relatively steep - Requires management and control of sediment and erosion
Soils	• Channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted • Gabbro, dolerite, anorthosite • Granophyre, commonly porphyritic; remelted granite Consider ability for infiltration and erosion leading to transport of sediment
Stormwater drainage	Consider flooding from local catchments Not mapped. Requires investigation.
Coastal storm surge flooding	Incomplete mapping/investigation although more coastal areas of the site are likely to be affected.
Water infrastructure	Water main access in close proximity
Non-drinking water source	Limited – Pilbara fractured rock aquifer with an opportunity for recycled water from the Dampier wastewater treatment plant
Sewer infrastructure	None nearby but potential to connect to Dampier Wastewater treatment plant if capacity constraints and topography are addressed

Strategies for consideration

- Consider risks of erosion and sediment transport and propose appropriate mitigation and management strategies.
- Identify local stormwater catchments and areas/flow paths required to manage 100yr ARI stormwater flood.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Meet the requirements of Local Planning Policy DP19: Storm Surge Risk Policy.
- Obtain advice from Rio Tinto and the Water Corporation regarding the capacity of water and wastewater systems and likely cost of connection.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.



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Dampier 2

Development investigation area D2

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Relatively steep - Requires management and control of sediment and erosion
Soils	Granophyre, commonly porphyritic; remelted granite Consider ability for infiltration and erosion leading to transport of sediment
Stormwater drainage	Consider flooding from local catchments Not mapped. Requires investigation.
Coastal storm surge flooding	Part of the site likely to be affected.
Water infrastructure	Water main access in close proximity – Rio Tinto infrastructure
Non-drinking water source	Limited – Pilbara fractured rock aquifer but an opportunity for recycled water from the Dampier wastewater treatment plant
Sewer infrastructure	Potential to connect to Dampier Wastewater treatment plant if capacity constraints are addressed

Strategies for consideration

- Consider risks of erosion and sediment transport and propose appropriate mitigation and management strategies.
- Identify local stormwater catchments and areas/flow paths required to manage 100yr ARI stormwater flood.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Meet the requirements of Local Planning Policy DP19: Storm Surge Risk Policy.
- Obtain advice from Rio Tinto regarding the capacity of water and wastewater systems and likely cost of connection.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse

Development investigation area D3

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Relatively steep - Requires management and control of sediment and erosion
Soils	Granophyre, commonly porphyritic; remelted granite Consider ability for infiltration and erosion leading to transport of sediment
Stormwater drainage	Parts of the site are affected by flooding from local catchments. This land should be set aside for drainage management. Drainage system to be designed for overland flow, with floor levels of habitable buildings a minimum of 300 mm above the 1 in 100yr ARI storm event.
Coastal storm surge	Not applicable
Water infrastructure	Water main access in close proximity – Rio Tinto infrastructure
Non-drinking water source	Limited – Pilbara fractured rock aquifer but an opportunity for recycled water from the Dampier wastewater treatment plant
Sewer infrastructure	Potential to connect to Dampier Wastewater treatment plant if capacity constraints are addressed

Strategies for consideration

- Areas/flow paths required to manage 100yr ARI stormwater flood as depicted in the *Dampier stormwater management* study (GHD, 2015) should not be developed. Stormwater design should be consistent with *Dampier stormwater management* study (GHD, 2015).
- Consider risks of erosion and sediment transport and propose appropriate mitigation and management strategies.
- Obtain advice from Rio Tinto regarding the capacity of water and wastewater systems and likely cost of connection.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.

See also Map Dampier 3.

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Dampier 3

Development investigation area D4

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Relatively flat
Soils	Constructed environment
Stormwater drainage	Consider flooding from local catchments Not mapped. Requires investigation.
Coastal storm surge flooding	Site is affected
Water infrastructure	Water main access – Rio Tinto infrastructure
Non-drinking water source	Limited – Pilbara fractured rock aquifer with likely coastal saline intrusion but opportunity for recycled water from the Dampier wastewater treatment plant
Sewer infrastructure	Potential to connect to Dampier Wastewater treatment plant if capacity constraints are addressed

Strategies for consideration

- Identify local stormwater catchments and areas/flow paths required to manage 100yr ARI stormwater flood.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Meet the requirements of Local Planning Policy DP19: Storm Surge Risk Policy.
- Obtain advice from Rio Tinto regarding the capacity of water and wastewater systems and likely cost of connection.
- Identify source of water for non-potable uses, as well as opportunities for conservation and efficiency and water reuse

Development investigation area D5

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Relatively steep - Requires management and control of sediment and erosion
Soils	Granophyre, commonly porphyritic; remelted granite Consider ability for infiltration and erosion leading to transport of sediment
Stormwater drainage	Consider flooding from local catchments. Mapping of site in GHD 2015 is incomplete. Requires investigation
Coastal storm surge	Not applicable
Water infrastructure	Water main access – Rio Tinto infrastructure
Non-drinking water source	Limited – Pilbara fractured rock aquifer with likely coastal saline intrusion but opportunity for recycled water from the Dampier wastewater treatment plant
Sewer infrastructure	Potential to connect to Dampier Wastewater treatment plant if capacity constraints are addressed

Strategies for consideration

- Consider risks of erosion and sediment transport and propose appropriate mitigation and management strategies.
- Identify local stormwater catchments and areas/flow paths required to manage 100yr ARI stormwater flood.

- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011), having consideration of the findings of the Dampier Drainage Review (GHD, 2010).
- Obtain advice from Rio Tinto regarding the capacity of water and wastewater systems and likely cost of connection.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse

Development investigation area D6

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Relatively steep - Requires management and control of sediment and erosion
Soils	Granophyre, commonly porphyritic; remelted granite Consider ability for infiltration and erosion leading to transport of sediment
Stormwater drainage	Parts of the site are affected by flooding from local catchments. This land should be set aside for drainage management. Drainage system to be designed for overland flow, with floor levels of habitable buildings a minimum of 300 mm above the 1 in 100yr ARI storm event.
Coastal storm surge	Not applicable
Water infrastructure	Water main access in close proximity – Rio Tinto infrastructure
Non-drinking water source	Limited – Pilbara fractured rock aquifer but an opportunity for recycled water from the Dampier wastewater treatment plant
Sewer infrastructure	Potential to connect to Dampier Wastewater treatment plant if capacity constraints are addressed

Strategies for consideration

- Areas/flow paths required to manage 100yr ARI stormwater flood as depicted in the *Dampier stormwater management* study (GHD, 2015) should not be developed. Stormwater design should be consistent with *Dampier stormwater management* study (GHD, 2015).
- Consider risks of erosion and sediment transport and propose appropriate mitigation and management strategies.
- Obtain advice from Rio Tinto regarding the capacity of water and wastewater systems and likely cost of connection.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.

Development investigation area D7

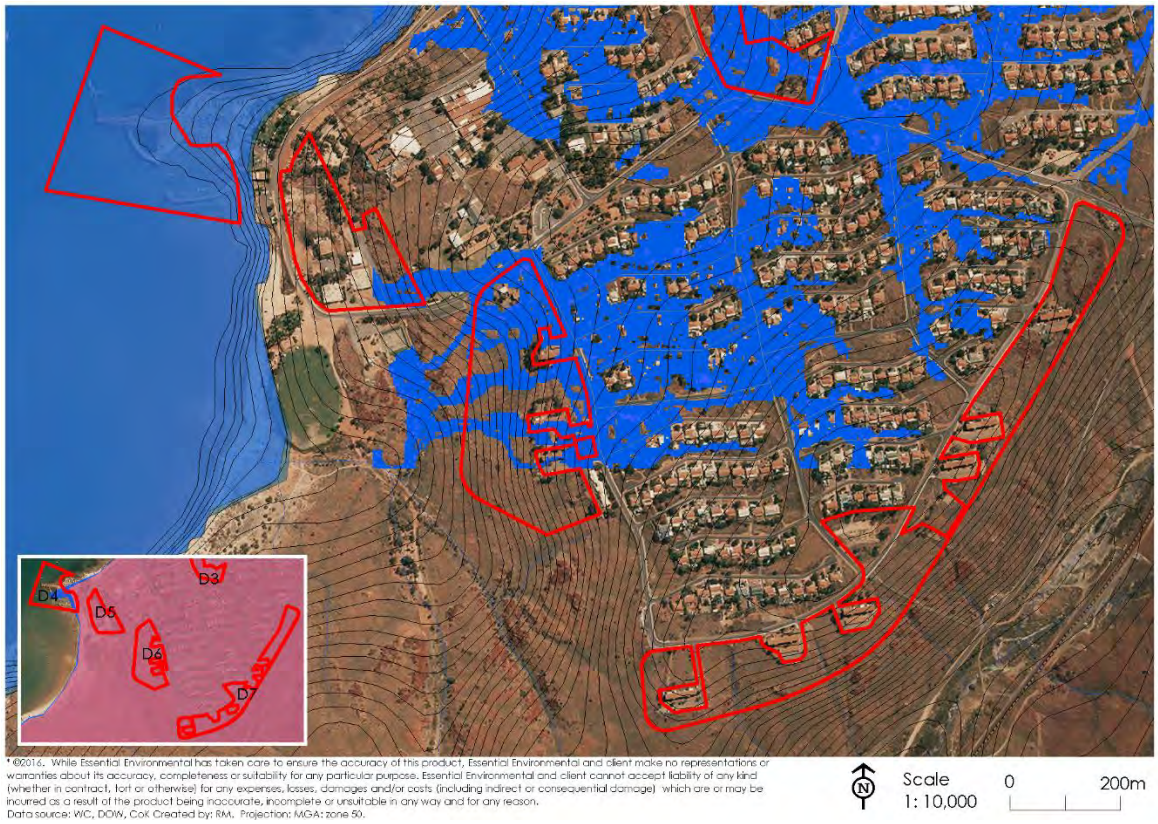
Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Relatively steep - Requires management and control of sediment and erosion
Soils	Granophyre, commonly porphyritic; remelted granite Consider ability for infiltration and erosion leading to transport of sediment
Stormwater drainage	Consider flooding from local catchments Not mapped. Requires investigation.
Coastal storm surge flooding	Not applicable
Water infrastructure	Water main access – Rio Tinto infrastructure
Non-drinking water source	Limited – Pilbara fractured rock aquifer but opportunity for recycled water from the Dampier wastewater treatment plant

Water resource management issue	Site specific considerations
Sewer infrastructure	Potential to connect to Dampier Wastewater treatment plant if capacity constraints are addressed

Strategies for consideration

- Identify local stormwater catchments and areas/flow paths required to manage 100yr ARI stormwater flood.
- Consider risks of erosion and sediment transport and propose appropriate mitigation and management strategies.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Obtain advice from Rio Tinto regarding the capacity of water and wastewater systems and likely cost of connection.
- Identify source of water for non-potable uses, as well as opportunities for conservation and efficiency and water reuse



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Karratha 1

Development investigation areas K1 & K2

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Relatively flat, low lying
Soils	• Channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted • Beach sand, sand dunes, coastal dunes, beaches, and beach ridges; calcareous and siliceous, locally shelly and/or cemented (beach rock); locally reworked Granophyre, commonly porphyritic; remelted granite Consider infiltration capacity of soils
Stormwater drainage	Consider flooding from local catchments Not mapped. Requires investigation.
Coastal storm surge flooding	Parts of both sites affected by 100yr and 500yr ARI Coastal storm surge.
Water infrastructure	Water main access in close proximity (south western portion of K2)
Non-drinking water source	Limited – Pilbara fractured rock aquifer but an opportunity for recycled water from Karratha Effluent Reuse System
Sewer infrastructure	Sewer line adjacent to south western corner of K2.

Strategies for consideration

- Meet the requirements of Local Planning Policy DP19: Storm Surge Risk Policy.
- Identify local stormwater catchments and areas/flow paths required to manage 100yr ARI stormwater flood.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Obtain advice from the Water Corporation regarding the capacity of water and wastewater systems and likely cost of connection.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.

Development investigation area K3

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Relatively flat
Soils	• Channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted • Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite
Stormwater drainage	Consider flooding from local catchments Not mapped. Requires investigation. Flooding from Madigan Creek likely.
Coastal storm surge flooding	Small portion of site affected by 500yr ARI Coastal storm surge.
Water infrastructure	Water main access along southern boundary
Non-drinking water source	Limited – Pilbara fractured rock aquifer but an opportunity for recycled water from Karratha Effluent Reuse System
Sewer infrastructure	Sewer line adjacent to southern boundary.

Strategies for consideration

- Identify local stormwater catchments and areas/flow paths required to manage 100yr ARI stormwater flood with particular reference paid to Madigan Creek and the findings and assumptions of Madigan Creek – 2D Flood Study (JDA Consultant Hydrologists, 2012).
- Consider risks of erosion and sediment transport and propose appropriate mitigation and management strategies.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Meet the requirements of Local Planning Policy DP19: Storm Surge Risk Policy.
- Obtain advice from the Water Corporation regarding the capacity of water and wastewater systems and likely cost of connection.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.

Development investigation area K4

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Gently sloping
Soils	Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite Consider ability for infiltration and erosion leading to transport of sediment
Stormwater drainage	Part site investigated as part of 7 Mile Creek Flood Study (GHD, 2009). Consider flooding from local catchments. Remainder of site requires investigation.
Coastal storm surge flooding	Small portion of site affected by 100yr and 500yr ARI Coastal storm surge.
Water infrastructure	Water main access to the north
Non-drinking water source	Limited – Pilbara fractured rock aquifer but an opportunity for recycled water from Karratha Effluent Reuse System
Sewer infrastructure	Sewer access throughout site.

Strategies for consideration

- Identify local stormwater catchments and areas/flow paths required to manage 100yr ARI stormwater flood with particular reference to the findings and assumptions of 7 Mile Creek Flood Study (GHD, 2009). Drainage system to be designed for overland flow, with floor levels of habitable buildings a minimum of 300 mm above the 1 in 100yr ARI storm event.
- Consider risks of erosion and sediment transport and propose appropriate mitigation and management strategies.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Meet the requirements of Local Planning Policy DP19: Storm Surge Risk Policy.
- Obtain advice from the Water Corporation regarding the capacity of water and wastewater systems and likely cost of connection.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.

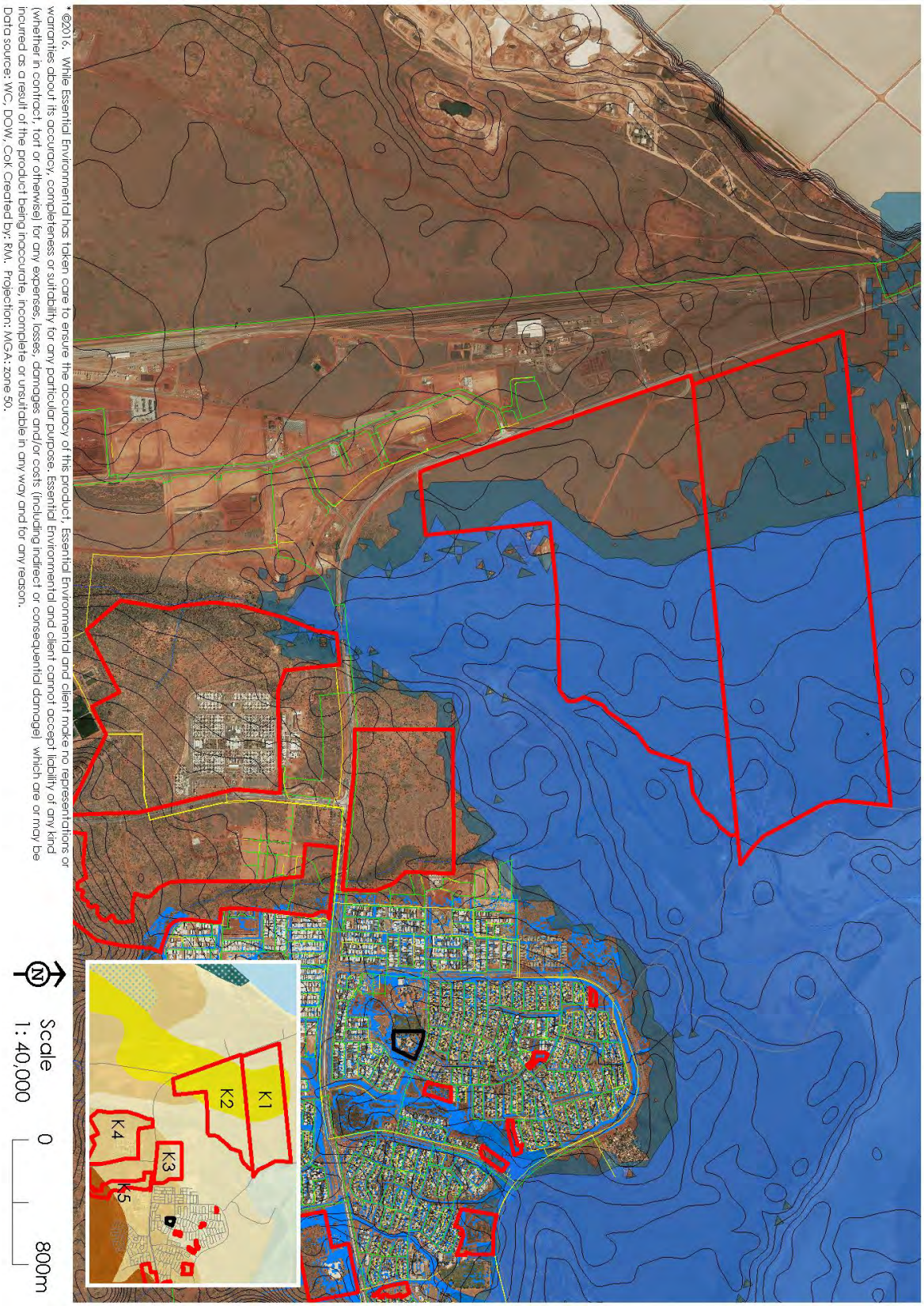
Development investigation area K5

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Gently undulating
Soils	• Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite • Basalt, komatiitic basalt, pyroxene spinifex-textured basalt (high-Mg basalt), sandstone, feldspathic sandstone, conglomerate, chert Consider ability for infiltration and erosion leading to transport of sediment
Stormwater drainage	Majority of site investigated as part of Madigan Creek – 2D Flood Study (JDA Consultant Hydrologists, 2012). Consider flooding from local catchments. Remainder of site requires investigation.
Coastal storm surge	Not applicable
Water infrastructure	Water main crosses the site
Non-drinking water source	Limited – Pilbara fractured rock aquifer but an opportunity for recycled water from Karratha Effluent Reuse System
Sewer infrastructure	Sewer main to north of site.

Strategies for consideration

- Identify local stormwater catchments and areas/flow paths required to manage 100yr ARI stormwater flood with particular reference to the findings and assumptions of Madigan Creek – 2D Flood Study (JDA Consultant Hydrologists, 2012). Drainage system to be designed for overland flow, with floor levels of habitable buildings a minimum of 300 mm above the 1 in 100yr ARI storm event.
- Consider risks of erosion and sediment transport and propose appropriate mitigation and management strategies.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Obtain advice from the Water Corporation regarding the capacity of water and wastewater systems and likely cost of connection.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.



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Karratha 2

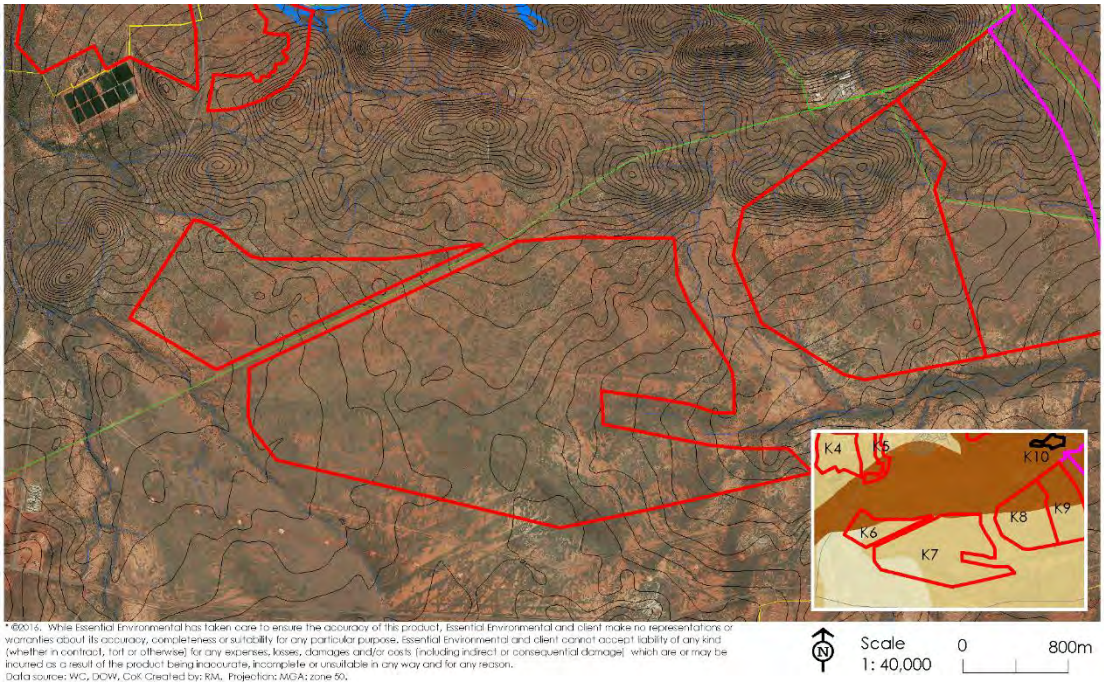
Development investigation areas K6, K7, K8 & K9

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Undulating with areas of relative steepness
Soils	• Channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted • Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite • Basalt, komatiitic basalt, pyroxene spinifex-textured basalt (high-Mg basalt), sandstone, feldspathic sandstone, conglomerate, chert Consider ability for infiltration and erosion leading to transport of sediment
Stormwater drainage	Consider flooding from local catchments Not mapped. Requires investigation.
Coastal storm surge	Not applicable
Water infrastructure	Water main access
Non-drinking water source	Limited – Pilbara fractured rock aquifer but an opportunity for recycled water from Karratha Effluent Reuse System for irrigation and/or plumbed into toilets
Sewer infrastructure	No access to sewer although connection could be established from the north.

Strategies for consideration

- Identify local stormwater catchments and areas/flow paths required to manage 100yr ARI stormwater flood. Consider risks of erosion and sediment transport and propose appropriate mitigation and management strategies.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Obtain advice from the Water Corporation regarding the capacity of water and wastewater systems and likely cost of connection, particularly for sewer.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.



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Karratha 3

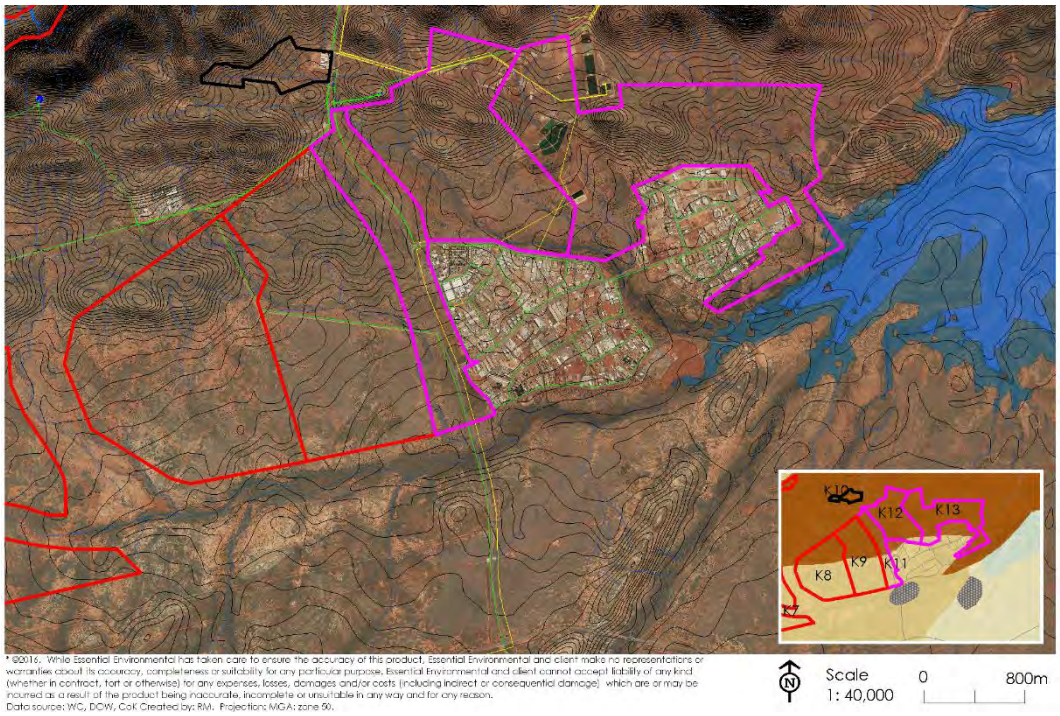
Urban expansion area K10, Industrial expansion areas K11, K12 & K13

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Undulating with areas of relative steepness
Soils	• Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite • Basalt, komatiitic basalt, pyroxene spinifex-textured basalt (high-Mg basalt), sandstone, feldspathic sandstone, conglomerate, chert Consider ability for infiltration and erosion leading to transport of sediment
Stormwater drainage	Consider flooding from local catchments Not mapped. Requires investigation.
Coastal storm surge	Not applicable
Water infrastructure	Water main access
Non-drinking water source	Limited – Pilbara fractured rock aquifer but an opportunity for recycled water from Karratha Effluent Reuse System for industrial use
Sewer infrastructure	No access to sewer although connection could be established from the north.

Strategies for consideration

- Identify local stormwater catchments and areas/flow paths required to manage 100yr ARI stormwater flood. Consider risks of erosion and sediment transport and propose appropriate mitigation and management strategies.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Obtain advice from the Water Corporation regarding the capacity of water and wastewater systems and likely cost of connection, particularly for sewer.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse., particularly for fit-for-purpose industrial use.



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Karratha 4

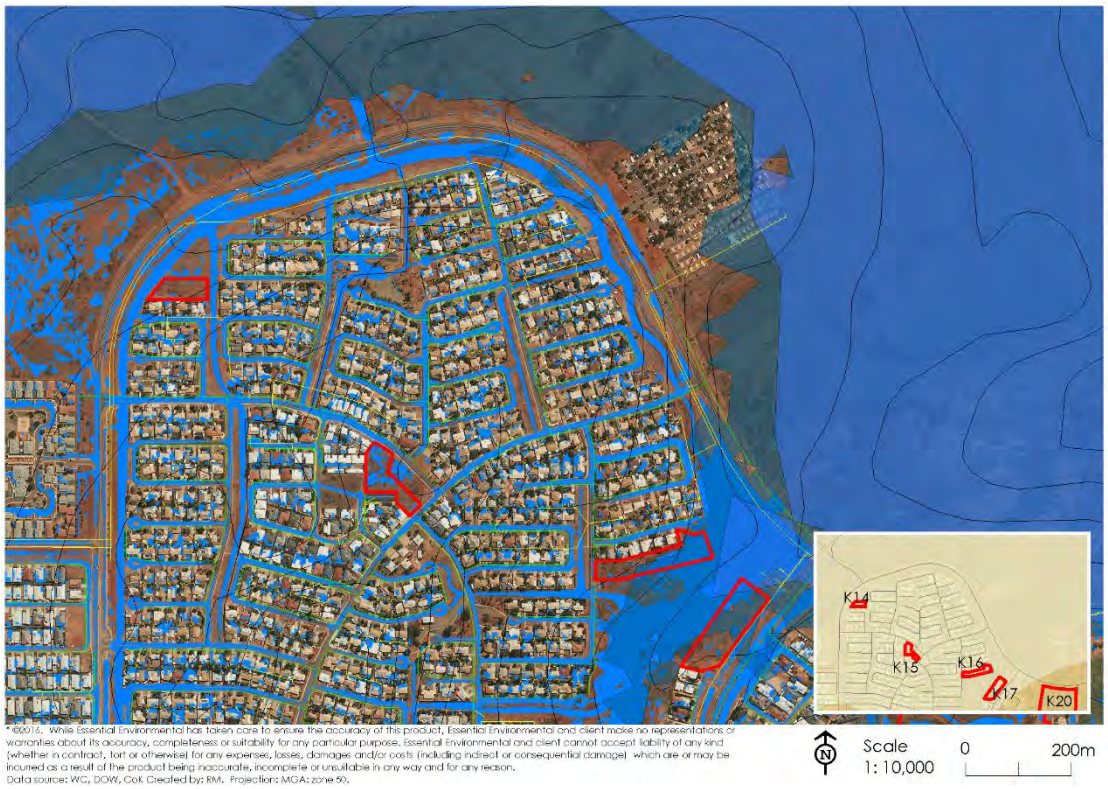
Development investigation areas K14, K15, K16 & K17

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Flat
Soils	• Channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted Consider ability for infiltration and erosion leading to transport of sediment
Stormwater drainage	Some parts of K 14 & K15 are affected by 100yr ARI stormwater flood.
Coastal storm surge	Some parts of K 16 & K17 are affected by coastal storm surge flooding
Water infrastructure	Access to drinking water
Non-drinking water source	Consider use of treated wastewater from Karratha Effluent Reuse System for irrigation and/or plumbed into toilets
Sewer infrastructure	Access to sewer

Strategies for consideration

- Drainage system designed for overland flow with floor levels of habitable buildings a minimum of 500 mm above the 1 in 100yr ARI flood level in the creek, consistent with *Lazy Lands - 2D Flood Study & Local Water Management Framework* (JDA Consultant Hydrologists/TME, 2013).
- Meet the requirements of Local Planning Policy DP19: Storm Surge Risk Policy for K16 & K17.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Obtain advice from the Water Corporation regarding the capacity of water and wastewater systems and likely cost of connection, particularly for sewer.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.



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Karratha 5

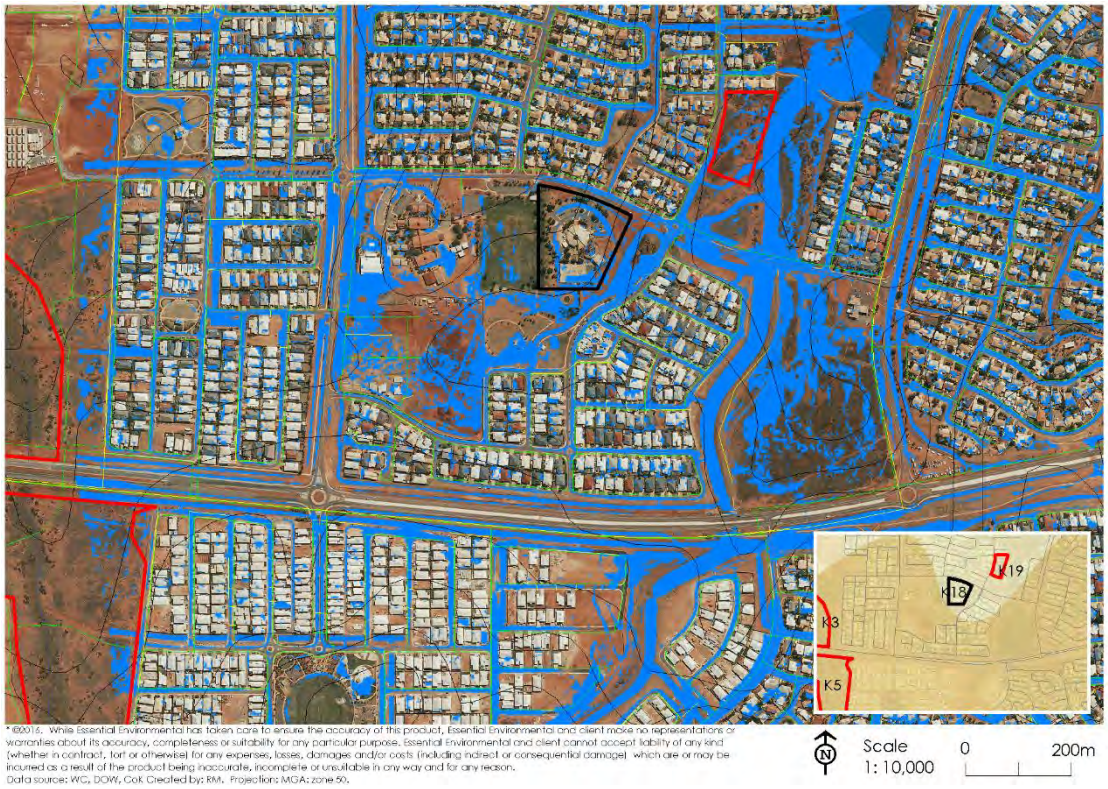
Urban expansion area K18 & Development investigation area K19

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Flat
Soils	• Channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted Consider ability for infiltration and erosion leading to transport of sediment
Stormwater drainage	Some parts of sites are affected by 100yr ARI stormwater flood.
Coastal storm surge	Not applicable
Water infrastructure	Access to drinking water
Non-drinking water source	Consider use of treated wastewater from Karratha Effluent Reuse System for irrigation and/or plumbed into toilets
Sewer infrastructure	Access to sewer

Strategies for consideration

- Drainage system designed for overland flow with floor levels of habitable buildings a minimum of 500 mm above the 1 in 100yr ARI flood level in the creek, consistent with *Lazy Lands - 2D Flood Study & Local Water Management Framework* (JDA Consultant Hydrologists/TME, 2013).
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Obtain advice from the Water Corporation regarding the capacity of water and wastewater systems and likely cost of connection, particularly for sewer.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.



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Karratha 6

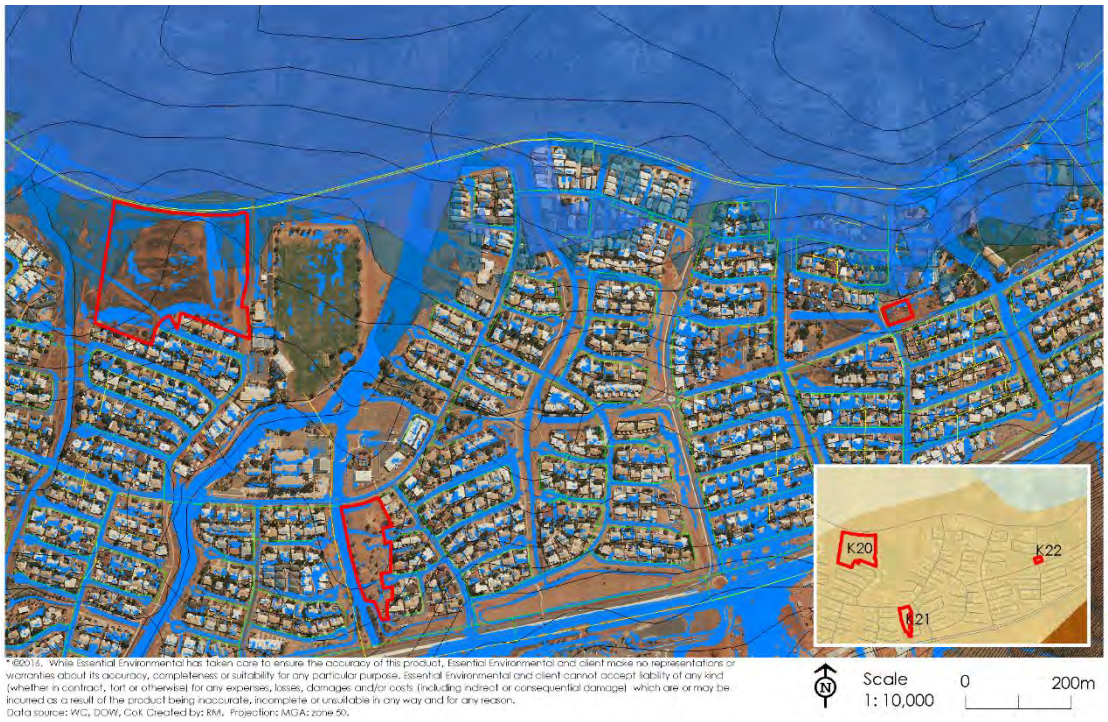
Development investigation areas K20, K21 & K22

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Flat
Soils	• Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite Consider ability for infiltration and erosion leading to transport of sediment
Stormwater drainage	Some parts of all sites are affected by 100yr ARI stormwater flood.
Coastal storm surge	Some parts of K20 are affected by coastal storm surge flooding
Water infrastructure	Access to drinking water
Non-drinking water source	Consider use of treated wastewater from Karratha Effluent Reuse System for irrigation and/or plumbed into toilets
Sewer infrastructure	Access to sewer

Strategies for consideration

- Drainage system designed for overland flow with floor levels of habitable buildings a minimum of 500 mm above the 1 in 100yr ARI flood level in the creek, consistent with *Lazy Lands - 2D Flood Study & Local Water Management Framework* (JDA Consultant Hydrologists/TME, 2013).
- Meet the requirements of Local Planning Policy DP19: Storm Surge Risk Policy for K20.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Obtain advice from the Water Corporation regarding the capacity of water and wastewater systems and likely cost of connection, particularly for sewer.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.



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Karratha 7

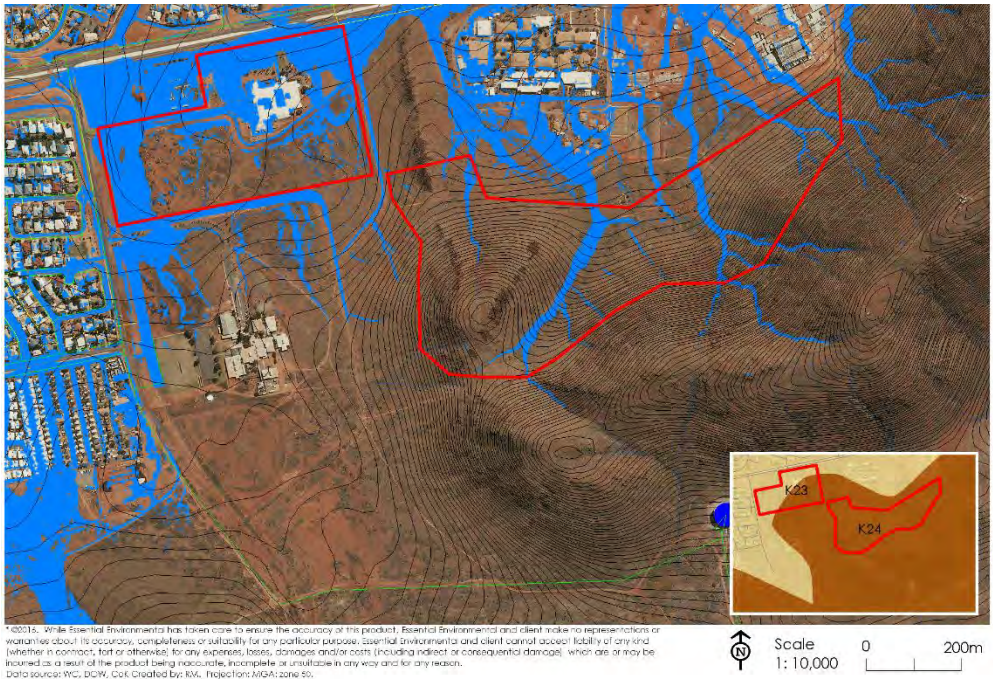
Development investigation areas K23 & K24

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	K23 relatively flat, K24 steeply sloped
Soils	• Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite • Basalt, komatiitic basalt, pyroxene spinifex-textured basalt (high-Mg basalt), sandstone, feldspathic sandstone, conglomerate, chert Consider ability for infiltration and erosion leading to transport of sediment
Stormwater drainage	Some parts of all sites are affected by 100yr ARI stormwater flood.
Coastal storm surge	Not applicable
Water infrastructure	K23 Access to drinking water from the north, K24 no direct access
Non-drinking water source	Consider use of treated wastewater from Karratha Effluent Reuse System for irrigation and/or plumbed into toilets
Sewer infrastructure	K23 Access to sewer from the north, K24 no direct access

Strategies for consideration

- Drainage system designed for overland flow with floor levels of habitable buildings a minimum of 500 mm above the 1 in 100yr ARI flood level in the creek, consistent with *Lazy Lands - 2D Flood Study & Local Water Management Framework* (JDA Consultant Hydrologists/TME, 2013).
- Meet the requirements of Local Planning Policy DP19: Storm Surge Risk Policy for K20.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Obtain advice from the Water Corporation regarding the capacity of water and wastewater systems and likely cost of connection, particularly for sewer.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.



Karratha 8

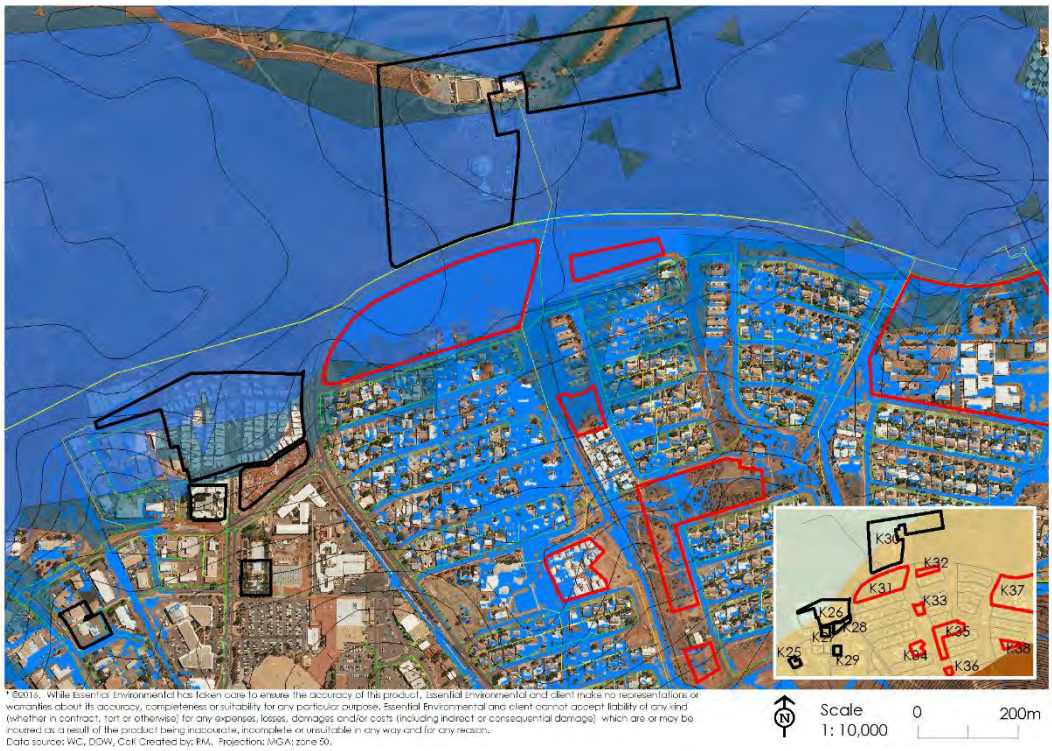
Urban expansion areas K25-K30 & Development investigation areas K31-K36

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Flat
Soils	• Coastal silt and evaporite deposits; estuarine, lagoonal, and lacustrine deposits • Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite
Stormwater drainage	Parts of K31, K32, K33, K34, K35 & K36 affected by 100yr ARI stormwater flood.
Coastal storm surge	K26, K30, K31, K32 & K33 affected by coastal storm surge flooding
Water infrastructure	Access to drinking water
Non-drinking water source	Consider use of treated wastewater from Karratha Effluent Reuse System for irrigation and/or plumbed into toilets
Sewer infrastructure	Access to sewer

Strategies for consideration

- Drainage system designed for overland flow with floor levels of habitable buildings a minimum of 500 mm above the 1 in 100yr ARI flood level in the creek, consistent with *Lazy Lands - 2D Flood Study & Local Water Management Framework* (JDA Consultant Hydrologists/TME, 2013).
- Meet the requirements of Local Planning Policy DP19: Storm Surge Risk Policy.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Obtain advice from the Water Corporation regarding the capacity of water and wastewater systems and likely cost of connection, particularly for sewer.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.



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Karratha 9

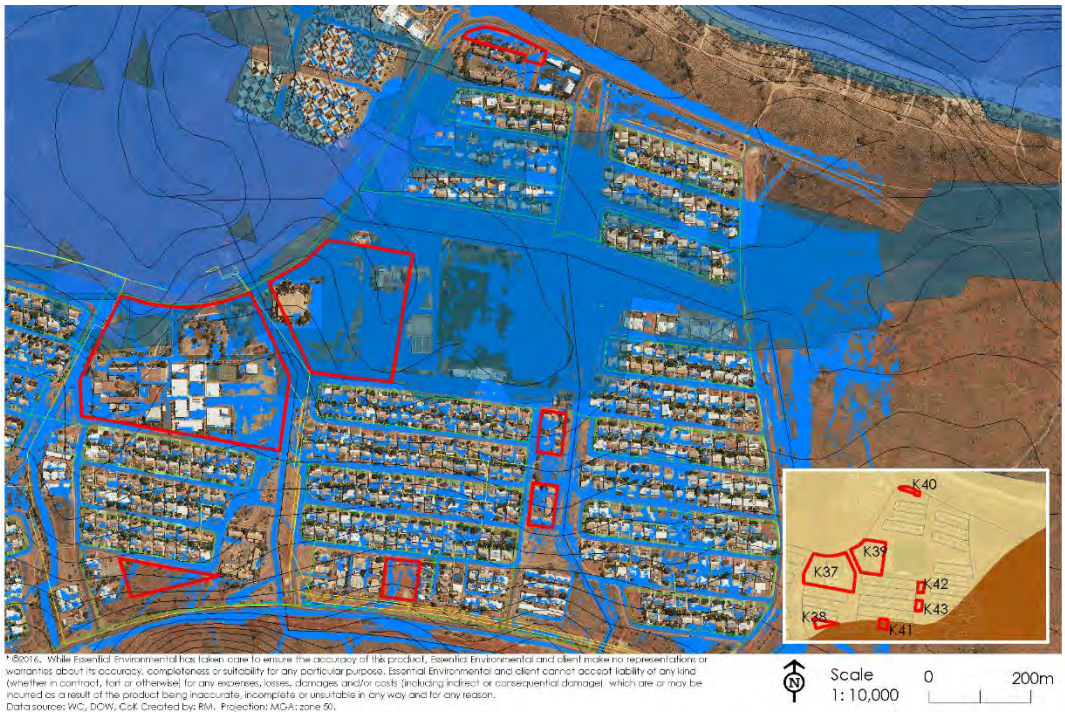
Development investigation areas K37-K43

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Flat
Soils	• Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite • Basalt, komatiitic basalt, pyroxene spinifex-textured basalt (high-Mg basalt), sandstone, feldspathic sandstone, conglomerate, chert
Stormwater drainage	Some parts of all sites are affected by 100yr ARI stormwater flood.
Coastal storm surge	Some parts of K37 & K39 are affected by coastal storm surge flooding
Water infrastructure	Access to drinking water
Non-drinking water source	Consider use of treated wastewater from Karratha Effluent Reuse System for irrigation and/or plumbed into toilets
Sewer infrastructure	Access to sewer

Strategies for consideration

- Drainage system designed for overland flow with floor levels of habitable buildings a minimum of 500 mm above the 1 in 100yr ARI flood level in the creek, consistent with *Lazy Lands - 2D Flood Study & Local Water Management Framework* (JDA Consultant Hydrologists/TME, 2013).
- Meet the requirements of Local Planning Policy DP19: Storm Surge Risk Policy for K37 & K39.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Obtain advice from the Water Corporation regarding the capacity of water and wastewater systems and likely cost of connection, particularly for sewer.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.



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Point Samson 1

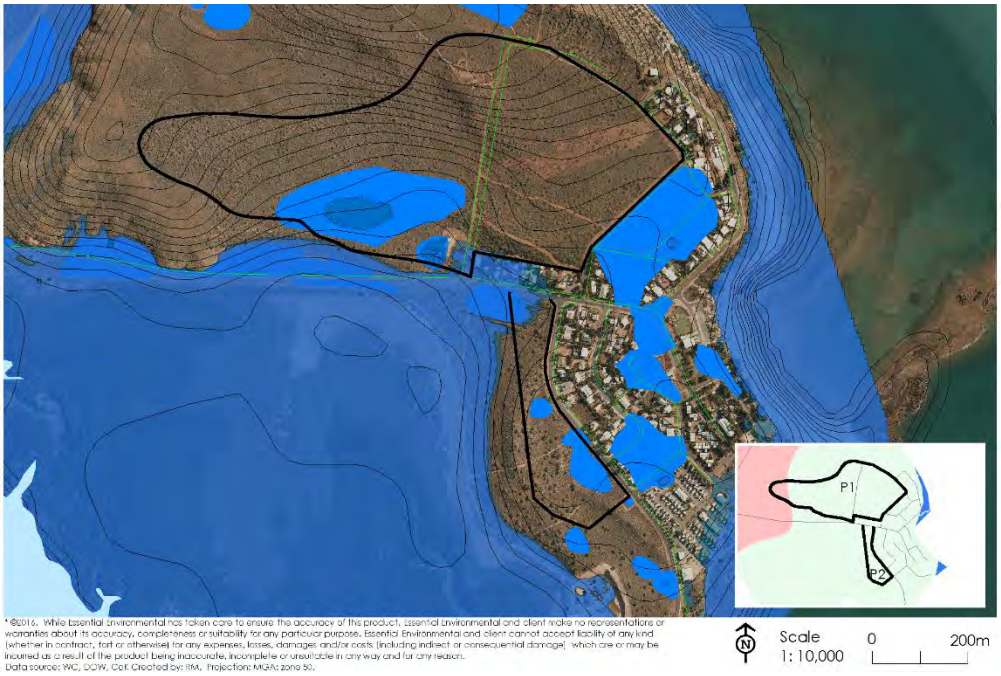
Urban Expansion areas P1 & P2

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	P1 is undulating, P2 is relatively flat
Soils	• Coastal silt and evaporite deposits; estuarine, lagoonal, and lacustrine deposits. • Chert, ferruginous chert, banded iron formation, jaspilite; minor siltstone, shale, sandstone, pebbly sandstone, quartzite, polymictic conglomerate, felsic volcaniclastic rock, basalt, ultramafic schist, mafic schist Consider ability for infiltration and erosion leading to transport of sediment
Stormwater drainage	Some parts of both sites are affected by 100yr ARI stormwater flood.
Coastal storm surge	Small portions of both sites are affected by coastal storm surge flooding
Water infrastructure	Access to drinking water
Non-drinking water source	Limited – Pilbara fractured rock aquifer with likely coastal saline intrusion
Sewer infrastructure	No sewerage infrastructure available. Requires on-sire disposal

Strategies for consideration

- Identify local stormwater catchments and areas/flow paths required to manage 100yr ARI stormwater flood. Consider risks of erosion and sediment transport and propose appropriate mitigation and management strategies. Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Meet the requirements of Local Planning Policy DP19: Storm Surge Risk Policy.
- Obtain advice from the Water Corporation regarding the capacity of water supplies and likely cost of connection.
- Ensure management of sewerage is consistent with the draft Country Sewerage Policy and minimises the risk of discharges to sensitive environments such as the mangroves.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.



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Roebourne 1

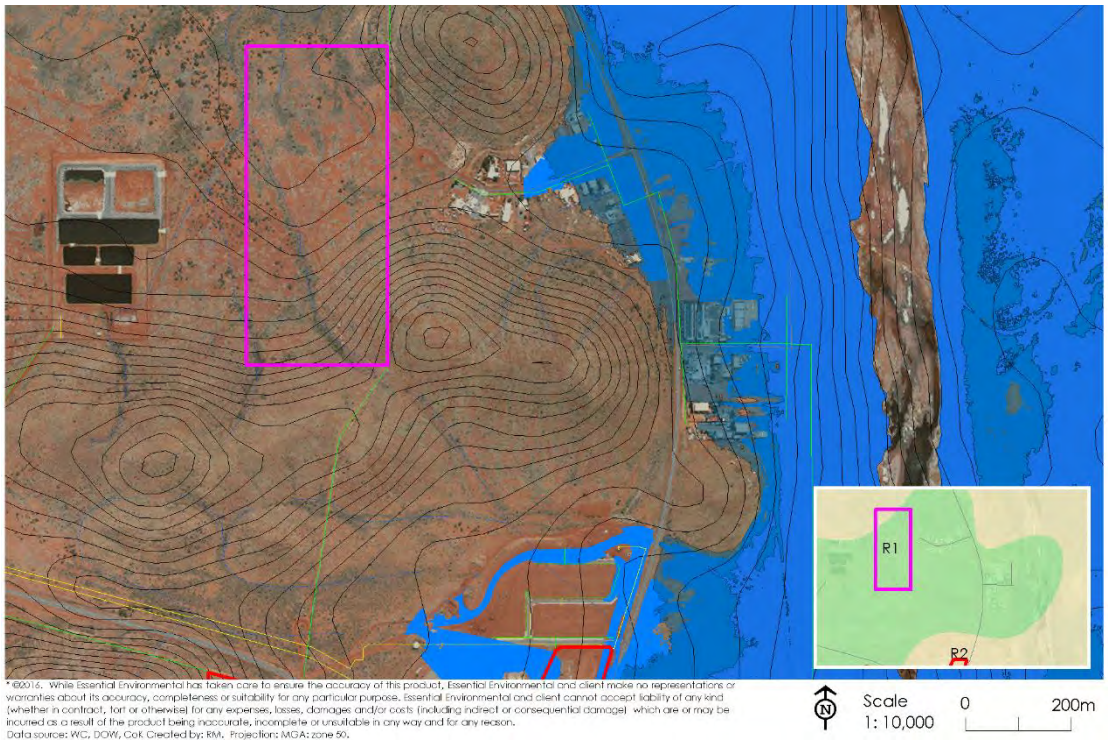
Industrial Expansion area R1

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Undulating - Requires management and control of sediment and erosion
Soils	• Gabbro, dolerite, anorthosite • Colluvium, sheetwash, talus; gravel piedmonts, aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite Consider ability for infiltration and erosion leading to transport of sediment
Stormwater drainage	Consider flooding from local catchments and creek. Requires investigation.
Coastal storm surge	Not applicable
Water infrastructure	Water main access along eastern boundary
Non-drinking water source	Limited – Pilbara fractured rock aquifer
Sewer infrastructure	Potential to connect to adjacent Wastewater treatment plant or trunk line to south

Strategies for consideration

- Identify local stormwater catchments and areas/flow paths required to manage 100yr ARI stormwater flood. Consider risks of erosion and sediment transport and propose appropriate mitigation and management strategies.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Obtain advice from Water Corporation regarding the capacity of water and wastewater systems and likely cost of connection.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.



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Roebourne 2

Development investigation area R2

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Relatively flat
Soils	• Colluvium, sheetwash, talus; gravel piedmonts, aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite Consider ability for infiltration and erosion leading to transport of sediment
Stormwater drainage	Affected by 100 yr ARI event stormwater flooding and flooding from Harding River
Coastal storm surge	Not applicable
Water infrastructure	Drinking water available
Non-drinking water source	Limited – Pilbara fractured rock aquifer
Sewer infrastructure	Access to sewer

Strategies for consideration

- Development should not occur in areas affected by flooding from the Harding River in a 1 in 100yr ARI event. Management of flood risk should not impact on adjacent lands.
- Drainage system to be designed for overland flow with floor levels of habitable buildings a minimum of 500 mm above the 1 in 100yr ARI flood level in the Harding River, consistent with the *Roebourne townsite Local water management strategy* (Essential Environmental, 2013).
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011) and the *Roebourne townsite Local water management strategy* (Essential Environmental, 2013).
- Obtain advice from Water Corporation regarding the capacity of water and wastewater systems and likely cost of connection.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.

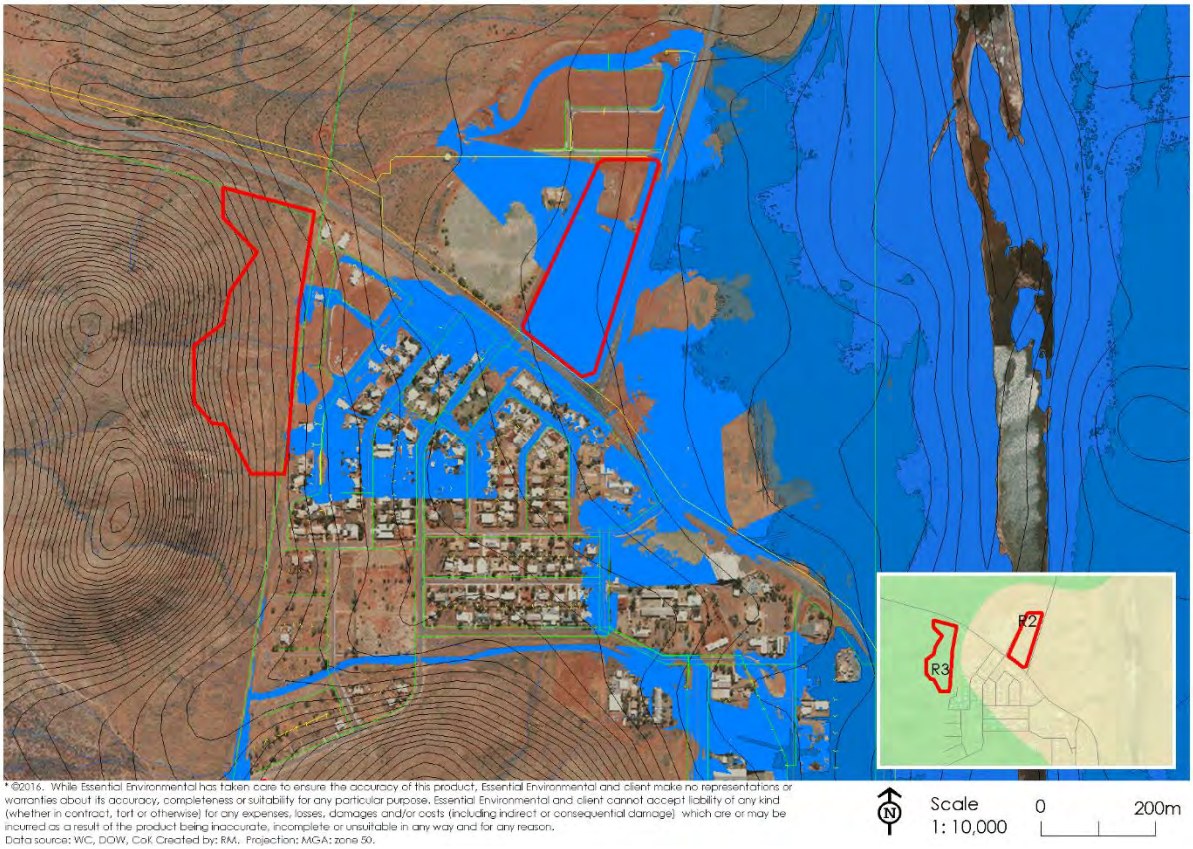
Development investigation area R3

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Steep - Requires management and control of sediment and erosion
Soils	• Gabbro, dolerite, anorthosite Consider ability for infiltration and erosion leading to transport of sediment
Stormwater drainage	Consider flooding from local catchments and creekline so as not to impact downstream.
Coastal storm surge	Not applicable
Water infrastructure	Water main access along western boundary and through the site
Non-drinking water source	Limited – Pilbara fractured rock aquifer
Sewer infrastructure	Access to sewer from the north

Strategies for consideration

- Identify local stormwater catchments and areas/flow paths required to manage 100yr ARI stormwater flood. Consider risks of erosion and sediment transport and propose appropriate mitigation and management strategies.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011) and the *Roebourne townsite Local water management strategy* (Essential Environmental, 2013).
- Obtain advice from Water Corporation regarding the capacity of water and wastewater systems and likely cost of connection.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.



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Roebourne 3

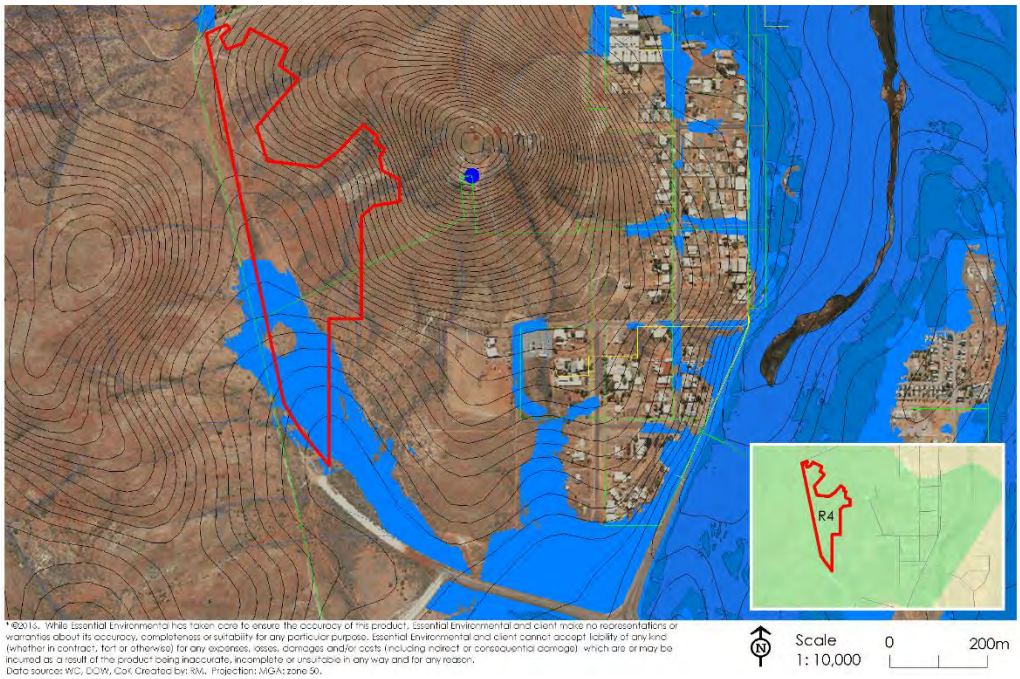
Development investigation area R4

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Steep - Requires management and control of sediment and erosion
Soils	• Gabbro, dolerite, anorthosite Consider ability for infiltration and erosion leading to transport of sediment
Stormwater drainage	Affected by 100 yr ARI event stormwater flooding and flooding from Harding River. Consider flooding from local catchments and creeklines.
Coastal storm surge	Not applicable
Water infrastructure	Water main access along eastern and northern boundary
Non-drinking water source	Limited – Pilbara fractured rock aquifer
Sewer infrastructure	Access to sewer

Strategies for consideration

- Development should not occur in areas affected by flooding from the Harding River in a 1 in 100yr ARI event. Management of flood risk should not impact on adjacent lands.
- Drainage system to be designed for overland flow with floor levels of habitable buildings a minimum of 500 mm above the 1 in 100yr ARI flood level in the Harding River, consistent with the *Roebourne townsite Local water management strategy* (Essential Environmental, 2013).
- Consider risks of erosion and sediment transport and propose appropriate mitigation and management strategies.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011) and the *Roebourne townsite Local water management strategy* (Essential Environmental, 2013).
- Obtain advice from Water Corporation regarding the capacity of water and wastewater systems and likely cost of connection.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.



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Roebourne 4

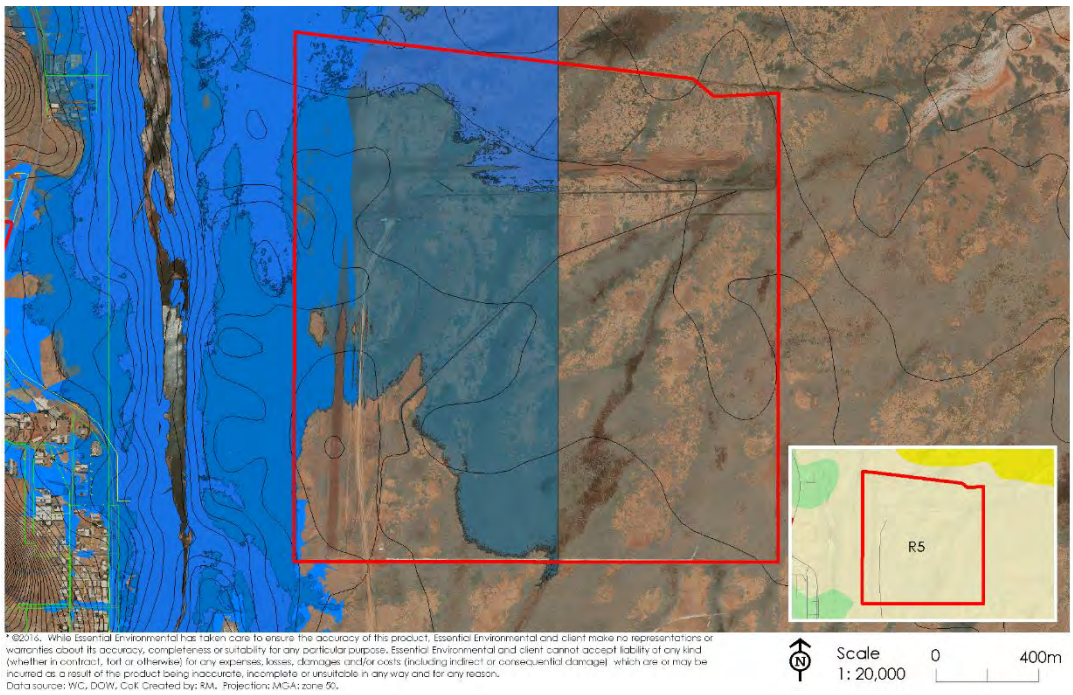
Development investigation area R5

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Relatively flat
Soils	• Colluvium, sheetwash, talus; gravel piedmonts, aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite
Stormwater drainage	Affected by 100 yr ARI event stormwater flooding and flooding from Harding River
Coastal storm surge	Affected by coastal storm surge flooding (mapping/investigation incomplete)
Water infrastructure	No access to drinking water (infrastructure located on other side of Harding River)
Non-drinking water source	Limited – Pilbara fractured rock aquifer
Sewer infrastructure	No access to sewer (infrastructure located on other side of Harding River)

Strategies for consideration

- Development should not occur in areas affected by flooding from the Harding River in a 1 in 100yr ARI event. Management of flood risk should not impact on adjacent lands.
- Drainage system to be designed for overland flow with floor levels of habitable buildings a minimum of 500 mm above the 1 in 100yr ARI flood level in the Harding River, consistent with the *Roebourne townsite Local water management strategy* (Essential Environmental, 2013).
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011) and the *Roebourne townsite Local water management strategy* (Essential Environmental, 2013).
- Meet the requirements of Local Planning Policy DP19: Storm Surge Risk Policy.
- Obtain advice from Water Corporation regarding the capacity of water and wastewater systems and likely cost of connection.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.



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Wickham 1

Development investigation area W1

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Relatively flat
Soils	• Colluvium, sheetwash, talus; gravel piedmonts, aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite • Chert, ferruginous chert, banded iron formation, jaspilite; minor siltstone, shale, sandstone, pebbly sandstone, quartzite, polymictic conglomerate, felsic volcaniclastic rock, basalt, ultramafic schist, mafic schist
Stormwater drainage	Consider flooding from local catchments Not mapped. Requires investigation.
Coastal storm surge	Affected by coastal storm surge flooding (mapping/investigation in progress)
Water infrastructure	Access to drinking water infrastructure
Non-drinking water source	Limited – Pilbara fractured rock aquifer but an opportunity exists to use recycled wastewater from the Wickham waste water treatment plant
Sewer infrastructure	Access to sewer infrastructure operated by Rio Tinto

Strategies for consideration

- Identify local stormwater catchments and areas/flow paths required to manage 100yr ARI stormwater flood. Consider risks of erosion and sediment transport and propose appropriate mitigation and management strategies.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Meet the requirements of Local Planning Policy DP19: Storm Surge Risk Policy.
- Obtain advice from Water Corporation regarding the capacity of water and likely cost of connection.
- Obtain advice from Rio Tinto regarding the capacity of wastewater systems and likely cost of connection.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse, having consideration of opportunities provided by the Wickham water reuse scheme.

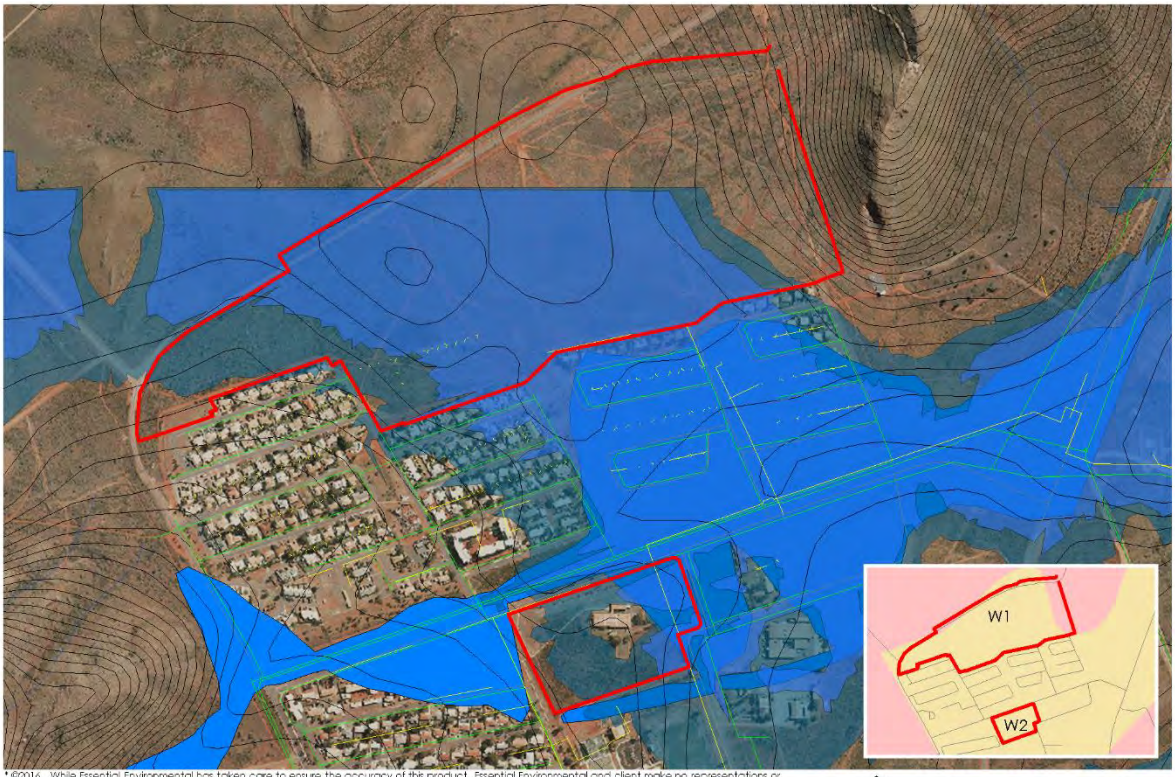
Development investigation area W2

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Relatively flat
Soils	• Colluvium, sheetwash, talus; gravel piedmonts, aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite
Stormwater drainage	Areas affected by stormwater flooding from 1 in 100yr ARI event.
Coastal storm surge	Affected by coastal storm surge flooding
Water infrastructure	Access to drinking water infrastructure
Non-drinking water source	Limited – Pilbara fractured rock aquifer but an opportunity exists to use recycled wastewater from the Wickham waste water treatment plant
Sewer infrastructure	Access to sewer infrastructure operated by Rio Tinto

Strategies for consideration

- Locate development away from areas/flow paths required to manage 100yr ARI stormwater flood. Flood risk management should not impact on adjacent lands.
- Consider risks of erosion and sediment transport and propose appropriate mitigation and management strategies.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Meet the requirements of Local Planning Policy DP19: Storm Surge Risk Policy.
- Obtain advice from Water Corporation regarding the capacity of water and likely cost of connection.
- Obtain advice from Rio Tinto regarding the capacity of wastewater systems and likely cost of connection.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse, having consideration of opportunities provided by the Wickham water reuse scheme.



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Cossack 1

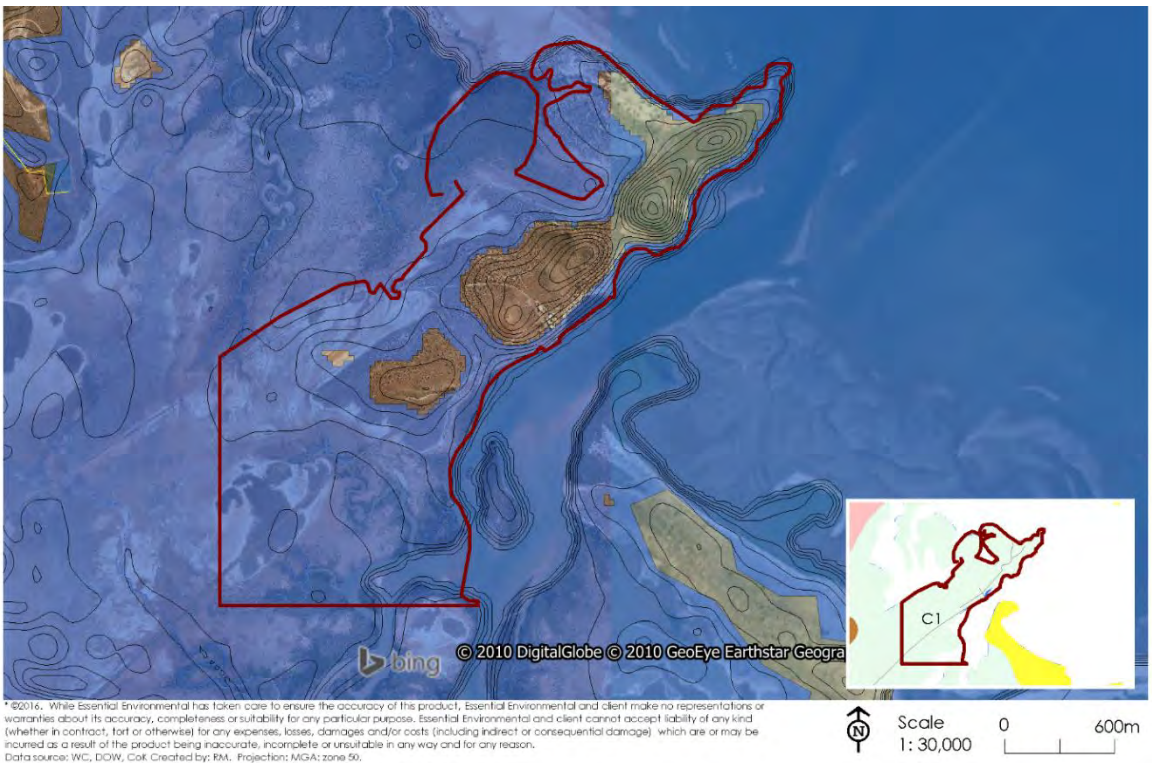
Tourism and recreational development area (C1)

Issues for consideration are as follows:

Water resource management issue	Site specific considerations
Topography/slope	Relatively steep - Requires management and control of sediment and erosion
Soils	Channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted - Consider ability for infiltration and erosion leading to transport of sediment
Waterways	Consider riparian zone and flooding from Harding River
Stormwater drainage	Not mapped. Requires investigation.
Coastal storm surge flooding	Development should not occur in areas within the 1 in 100 year storm surge flood level (1:100 ARI PSWL) plus wave run up (total 6.5m AHD) (GEMS 2009)
Water infrastructure	Limited - self supply
Non-drinking water source	Limited – Pilbara fractured rock aquifer with likely coastal saline intrusion
Sewer infrastructure	None – self supply

Strategies for consideration

- Consider risks of erosion and sediment transport and propose appropriate mitigation and management strategies.
- Identify local stormwater catchments and areas/flow paths required to manage 100yr ARI stormwater flood. Also consider flood risks from the Harding River.
- Stormwater design should be consistent with *City of Karratha Stormwater Design Guidelines for Residential Developments* (June 2011).
- Meet the requirements of Local Planning Policy DP19: Storm Surge Risk Policy
- Identify options for provision of drinking water and wastewater management.
- Identify source of water for irrigation of any proposed public open space, as well as opportunities for conservation and efficiency and water reuse.



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APPENDIX 1: OUTCOMES OF COMMUNITY AND STAKEHOLDER CONSULTATION – ENGAGEMENT SUMMARY REPORT

Introduction

This stakeholder engagement report summarises the outcomes of Phase 2 of Stage 2 of the City of Karratha Water Management Strategy project. The aim of this phase was to engage with the community, relevant Aboriginal groups, industry groups and applicable agencies regarding opportunities and constraints in each area for inclusion in the City of Karratha Water Management Strategy.

This report documents the engagement undertaken by the Consultant as part of Phase 2: Stakeholder engagement and describes:

- Who was engaged;
- When and how engagement occurred;
- Feedback and comments received; and
- How comments were addressed.

This Report completes Phase 2 of Stage 2 of the project: Stakeholder Engagement.

Stakeholders

A number of stakeholders were identified in relation to this project as follows:

- Department of Water
- Water Corporation
- Department of Agriculture
- Housing Authority
- RDA Pilbara
- Ngarluma Aboriginal Corporation (NAC)
- Murujuga Aboriginal Corporation (MAC)
- LandCorp
- Pilbara Development Commission
- Karratha District Chamber of Commerce and Industry
- RioTinto
- Citic Pacific
- Woodside
- Dampier Port Authority
- Karratha Community Association
- Other relevant community and business stakeholders as required.

These stakeholders, together with officers from the City of Karratha, were contacted by the consultant in order to deliver the objectives of this Phase.

Engagement actions

The key engagement tools included meetings, phone calls, emails and two workshops – one for City officers and one for the community. A log of communications activities is included in Attachment 1.

Initially, it was necessary to contact the stakeholders and advise them of the project and its objectives. This initial contact was made via phone calls and followed up with an email which contained information on the outputs of Stage 1 (including the Findings Report as an attachment), project objectives, types of input being sought and details of the community workshop.

Meetings

Some of the phone calls and emails resulted in requests for meetings. Meetings were held with the Pilbara Development Commission, Water Corporation, Housing Authority and Pilbara Ports. The outcomes of these meetings are described in the section below.

Community workshop

Further contact was made with key stakeholders and the community via email on 23 October. This email was sent to 89 members of the community as well as all agencies previously contacted to inform them about the community workshop. The email text was as follows:

> The City of Karratha are in the process of preparing a City-wide Water Management Strategy and we would really appreciate your input!
>
> The City is hosting a Stakeholder and Community Workshop on Tuesday 10th November, from 7 to 9pm at the City's Council Chambers. Light refreshments will be provided.
>
> The aim of the workshop is to inform the community and stakeholders of the project scope and objectives and obtain feedback on the following, particularly in relation to water resources:
>
> - Environmental values;
> - Cultural values;
> - Recreational values and impacts;
> - Community values and impacts ;
> - Opportunities for water protection and management; and
> - Potential costs and benefits (social, cultural, environmental and economic) of recommended water management responses.
>
> If you are interested in attending, please register here for catering purposes.
>
> As background, the City of Karratha Water Management Strategy will provide support to the City's local planning strategy (in preparation) and will include guidance for the future management of stormwater, groundwater, wastewater, waterways and drinking water across the municipality. The water management strategy will address the future development requirements of the City, consistent with State Planning Policy 2.9 Water Resources and Better Urban Water Management (WAPC, 2008). It will also provide guidance for the activities of the City in relation to the management and maintenance of critical water resources and infrastructure such as drinking water, groundwater, irrigation and drainage, to achieve agreed objectives for the City.
>
> The preparation of the City of Karratha Water Management Strategy is being undertaken in two stages. Stage 1 has been completed and the findings of stage 1 are documented in the Stage 1 Findings Report (attached). We are now in the process of preparing an opportunities and constraints report which will lead into the development of the water management strategy. The outcomes of the community workshop will also be incorporated into the Water Management Strategy.

> The City has provided permission for us to use email addresses that we have gathered over the past few years of working for the City so I really hope you don't mind receiving this email. Please feel free to pass it on to anyone else you feel may be interested!
>
> Please also don't hesitate to give me a call on 0403 170 040 if you have any questions as I am happy to chat!
>
> Hope to see you in a few weeks.

Six (6) rsvps were received for the community workshop including three representatives from the Kuruma Marthudunera Aboriginal Corporation.

Officer workshop

A workshop was held with relevant City of Karratha officers representing planning, engineering, community, parks and drainage to present the findings of Phase 1, Stage 2, opportunities and constraints. The aim of the workshop was to explore the options presented and identify preferred approaches, priorities and implementation mechanisms which will then be used as a key input into Phase 3.

Engagement outcomes

Stakeholder meetings

Key points noted during the meetings with the Pilbara Development Commission, Water Corporation, Housing Authority and Pilbara Ports are as follows:

Pilbara Development Commission	• Security of water in the City is sufficient in the short and medium term for projected residential, commercial, industrial and even agricultural activities. • The Pilbara water resource assessment (DoW and CSIRO) provides good information including consideration of climate change • Improvements are planned for the Dampier waste water treatment plant as it has reached the end of its useful life and is impacting on future development areas
Water Corporation	• The use of recycled water is guided by public policy and community need. The recycled water agreement has a 1o year term with a fixed pricing structure. CoK use of the resource is improving with continual learnings being applied. • No recycled water is likely to be available in Roebourne due to the capacity of the ponds, which have recently been upgraded • Water security has been provided by the Bungaroo Valley borefield • Unlikely to support recreation in Harding Dam. The WC is already increasing management of access • Smart meters provide a great opportunity for homeowners to improve the efficiency of their use of water however consumption is strongly related to weather conditions • The resources industry have made significant advances in water efficiency
Housing Authority	Some water bills of Housing Authority tenants are considerable and so they are looking for new ways to educate the community and reduce water use.

	This may include installation of external fixtures that have an automatic shut off. A partnership with the Water Corp may be sought.
Pilbara Ports	• The Pilbara Ports facility is likely to be expanded in the near future. This may require a Development Application which will need to appropriately address drainage and water quality (sediments). • The port already contains best practice hydrocarbon management and washdown bays, as well as water efficiency and reuse strategies including rainwater tanks. • Any new employee housing will be constructed with greywater systems and possibly rainwater tanks.

Officer workshop

The officer workshop provided an opportunity to discuss some key points of relevance to the preparation of the strategy. These included the future update of the City's Strategic Plan; implementation of the requirements of *Better Urban Water Management* (WAPC, 2008) in future development areas; availability of mapping of flood risk areas and criteria; optimising landscape and irrigation practices; requirements for new facilities; and asset management planning. Strategies and actions will be developed in response to the points raised.

Other identified gaps included public drinking water source protection; guidance for drainage at lot levels; opportunities for improved water management in industrial areas; and the need to engage with the community to understand water values and behaviours including attitudes to water reuse and efficiency.

It was agreed that the actions and strategies would be linked to the objectives of the water management strategy rather than the roles of the City. This would assist in different business units understanding linkages between actions and delivery.

Community workshop

Although six (6) rsvps were received for the community workshop, only one member of the community attended. Peta Mott from the Karratha Community Association made the following points to be considered as part of the delivery of the project.

- One of the most significant aspects of water which is valued by the community is recreation.
- A significant tourism and community opportunity exists for recreational use of Harding Dam. This would reduce pressure on other fresh water systems, which are currently being degraded from uncontrolled use. A partnership could be established which supports a local Ranger group which could enforce "rules" of usage of the area. It was noted that this would require a champion and the support of the Department of Water and the Water Corporation (which is likely to be challenging) as well as the traditional owners.
- Activities to raise community awareness about the need to reduce water usage and the significant activities being undertaken by the City including the effluent reuse scheme were supported (but the type of activity, with the exception of signage, was not discussed).
- The amenity brought into the townsites by landscaping and irrigation (including microclimate benefits) was noted and supported - particularly the need for irrigation of ovals for organised sports. The need to better engage the community to improve maintenance of verges (with appropriate landscaping) was also mentioned and a rate rebate suggested as a method of implementation.

Response

It was agreed that the City of Karratha Water Management Strategy would be prepared on the basis of the discussion that occurred at the Officer workshop including identified priorities and actions.

The Strategy would also incorporate information contained within the Findings Report and Opportunities and Constraints report including background information on environmental, cultural and social values of water. References will be enhanced regarding the values associated with freshwater ecosystems in the City including the community desire for enhanced recreation at Harding Dam.

Further consultation occurred with the Department of Water during preparation of the Water Management Strategy.

Attachment 1: Communication log

Date 2015	Form of communication	Name	Representing	Contact objective	Outcome
1-Oct	Phone call and email	Katrina Wheeler	Department of Water	To seek input on WMS and comments on findings report	Katrina will talk with Natalie Leach and provide feedback
1-Oct	Phone message	Sandy Haust	Water Corporation		
1-Oct	Phone call	Noel Wilson	Department of Ag & Food	Seek relevant information on Ag projects re water	Other contacts. Also happy to provide more feedback later
1-Oct	Phone call	Debbie Allcott	RDA Pilbara	To seek input into the preparation of the WMS	send through an email to Diane and they will let me know if they are interested
1-Oct	Email	Diane Pentz	RDA Pilbara	To seek input into the preparation of the WMS	Document and email sent
1-Oct	Phone call and email	Travis Mcnaught	LandCorp	To seek input into the preparation of the WMS	Document and email sent
1-Oct	Phone call and email	Carolyn Biar	Pilbara Development Commission	To seek input into the preparation of the WMS	Document and email sent
1-Oct	Phone call and email	Kim (who will ask John)	Karratha CCI	To seek input into the preparation of the WMS	Document and email sent
1-Oct	Phone call and email	Dan Pedersen	Pilbara Ports	To seek input into the preparation of the WMS	Document and email sent
6-Oct	Email	Katrina Wheeler	Department of Water	Clarification of input being sought	
8-Oct	Phone call	Belinda Churnside	NAC	To seek input into the preparation of the WMS	Call tomorrow
8-Oct	Phone call and email	Ron Critchley	MAC	To seek input into the preparation of the WMS	Document and email sent
8-Oct	Phone call - left a msg	?	YACMAC	To seek input into the preparation of the WMS	Left a message
8-Oct	Phone call and email	Hannah Corbett	KM	To seek input into the preparation of the WMS	Document and email sent
8-Oct	Phone call	Shannon Dremel	Rio Tinto	To seek input into the preparation of the WMS	On holiday, call back on Wednesday
8-Oct	Phone call	?	Woodside	To seek input into the preparation of the WMS	Left a message with Rob McPhee - Regional Communities Manager
8-Oct	Phone call	?	Citic Pacific	To seek input into the preparation of the WMS	Left a message with HSC department
8-Oct	Phone call	Chris Schelfhout	DAFWA	To seek input into the preparation of the WMS	Out of the state, call back on Wednesday
8-Oct	Phone call	Andrew Negline	DAFWA	To seek input into the preparation of the WMS	Left a message
13-Oct	Phone call and email	David Hawkins	Water Corporation	To seek input into the preparation of the WMS	Document and email sent

Date 2015	Form of communication	Name	Representing	Contact objective	Outcome
13-Oct	Phone call and email	Shannon Dremel	Rio Tinto	To seek input into the preparation of the WMS	Document and email sent
13-Oct	Phone call - left a msg	Andrew Negline	DAFWA	To seek input into the preparation of the WMS	Left a message
13-Oct	Phone call	?	Woodside	To seek input into the preparation of the WMS	Left a message with Rob McPhee
13-Oct	Phone call	?	Citic Pacific	To seek input into the preparation of the WMS	Left a message with the Sustainability Manager (Chris Watson?)
14-Oct	Meeting	Richard Bairstowe and Gus Tampalini	Pilbara Development Commission	To better understand linkages between the WMS and PDC priorities	improved understanding of the project and PDC linkages
16-Oct	Phone call and email	Chris Schelfhout	DAFWA	To seek input into the preparation of the WMS	Document and email sent. Will circulate to others in DAFWA.
16-Oct	Phone call	Andrew Negline	DAFWA	To get specific information about relevant Ag projects	No answer
16-Oct	Phone call and email	Peta Mott	KCA	To seek input into the preparation of the WMS	Peta will discuss with Chontay and Robyn and let me know about how to invite people to the workshop
19-Oct	Phone call and email	Harley Barron	Citic Pacific	To seek input into the preparation of the WMS	Document and email sent
20-Oct	Email	Jamie Brown	Water Corporation	information on the results of the smart meter trial	he has forwarded the request on to Andrew McCormick
20-Oct	Phone call and email	Lizeth de la Hoz	Pilbara Ports	arrange a time to meet to discuss the project	meeting arranged
23-Oct	email	89 community and stakeholder people	various	inform them about the community workshop	will get a list of rsvps to the workshop
26-Oct	email	Kevin Cosmos	YACMAC	Invite them to the community workshop	email sent
26-Oct	email	Belinda Churnside	Ngarluma Aboriginal Corporation (NAC)	Invite them to the community workshop	email sent
26-Oct	email	Ron Critchley	Murujuga Aboriginal Corporation (MAC)	Invite them to the community workshop	email sent
26-Oct	email	Hannah Corbett	Kuruma Marthudunera (KM)	Invite them to the community workshop	email sent
10-Nov	Email	Jamie Brown	Water Corporation	information on the results of the smart meter trial	
10-Nov	Officer workshop	Jerom Hurley, Guynasiri deSilva, Martin Waddington, Leigh Cover, John	City of Karratha	Obtain agreement on the strategic framework for delivery of the City of Karratha Water Management Strategy ; and identify key priority actions and discuss responsibilities and timing	outcomes achieved

Date 2015	Form of communication	Name	Representing	Contact objective	Outcome
		Paul MacDonagh, Brad			
10-Nov	Community workshop	Peta Mott, Jerom Hurley, John Paul MacDonagh	KCA and City of Karratha	inform the community about the project and obtain information on community values	
11-Nov	Meeting	David Hawkins	Water Corporation	To seek input into the preparation of the WMS	better understanding of opportunities and objectives of Water Corp
11-Nov	Phone call and email	Katrina Wheeler	Department of Water	to try and arrange a face to face meeting	No answer
11-Nov	Meeting	Kerry Thorby	Housing Authority	To seek input into the preparation of the WMS	Better understanding of relevant issues for Housing Authority
12-Nov	Meeting	Lizeth de la Hoz	Pilbara Ports	To seek input into the preparation of the WMS	Better understanding of relevant issues for Pilbara Ports

APPENDIX 2: STORMWATER AND RIVERINE FLOOD STUDIES IN CITY OF KARRATHA TOWNSITES

The City has undertaken a number of studies to investigate flood risk in key town sites. These are summarised in Table 5 and mapped in figures 6 to 11.

Table 5: Water investigations in City of Karratha town sites

Town site	Study	Author, Year	Key messages
Karratha	7 Mile Creek Flood Study	GHD 2009	Investigation of flood levels in support of proposed industrial development
	Karratha Drainage Assessment	GHD 2010	Examined the existing stormwater drainage network capacity within the Karratha townsite.
	Karratha Drainage Management Plan	GHD 2010	Provides information on the existing drainage network condition, identifies areas for improvement plus locations for major drains in future development areas
	Madigan Creek – 2D Flood Study	JDA Consultant Hydrologists, 2012	2D Mike Flood Model of Madigan Creek to determine flood levels in support of the Madigan residential development.
	Mulataga Creek – 2D Flood Study	JDA Consultant Hydrologists, 2012	2D Mike Flood Model of Mulataga Creek to determine flood levels in support of the Mulataga residential development.
	Karratha Vulnerability Study (KCVS)	JDA Consultant Hydrologists *et. al*, 2012	Regional assessment of the impacts of future climate change on the hydrology, shoreline stability, storm surge and riverine flooding in Karratha to evaluate opportunities and constraints for potential development.
	Lazy Lands - 2D Flood Study & Local Water Management Framework	JDA Consultant Hydrologists/ TME, 2013	Flood assessment of local stormwater flooding over Karratha at a local scale with the results used to inform and identify potential areas of development within existing drainage corridors.
Roebourne	Harding Dam, Extreme flood study	DoE, 2004	Reviewed flood frequency of historical data and estimated peak flows into and out of the Harding Dam.
	Roebourne Townsite Stormwater and Flood Management Plan	Essential Environmental, 2013	Assessment of flood risk from the Harding River and stormwater within the townsite and recommendations for strategies for land use planning, development and building controls, structural measures and flood emergency planning.
	Roebourne townsite Local water management strategy	Essential Environmental, 2013	Prepared to support the development of the Roebourne townsite structure plan, which provides a framework for the redevelopment of the Roebourne townsite. It includes strategies and design criteria for stormwater and groundwater management; water resource use; and landscaping which have been developed in response to the proposed redevelopment and the local site conditions
Point Samson	Point Samson Stormwater and coastal management strategy	Essential Environmental, 2014	Presents the findings of modelling undertaken and an analysis of risks to establish a proposed strategy for addressing the stormwater and coastal vulnerability of Point Samson. It recommends an approach to the mitigation and management of

Town site	Study	Author, Year	Key messages
			coastal and flood risks, highlighting potential limitations to future development and critical stormwater infrastructure required to facilitate development.
	Point Samson Water and wastewater servicing report	Essential Environmental, 2014	Presents an analysis of the water and wastewater services capacity of Point Samson, including current condition and capacity and planned upgrades. An assessment of viable water and wastewater strategies for future development of the town is presented using two different growth scenarios, considering potential constraints and risks under alternative wastewater systems.
	Point Samson District Water Management Strategy	Cardno, 2015	Provides a structure within which subsequent development can occur consistent with the 'total water cycle management' approach described.
Dampier	Dampier drainage review	GHD, 2010	Assessment of original design intent of the drainage network and hydrologic and hydraulic assessment to determine the suitability of the drainage network.
	Dampier stormwater management study	GHD, 2015	Identifies existing encroachments into the drainage system and determines the resultant flood risk and areas unaffected by flood risk.
Wickham	Wickham flood study	JDA, 2011	Guidance for drainage and water management for the proposed Accommodation Expansion Project in the Wickham townsite. The study recommended appropriate fill levels above the 100 year ARI event (0.5m) and upgrading the existing culvert on the Point Sampson-Roebourne Road to mitigate risk to flooding to the existing town and proposed development.
	Wickham townsite accommodation expansion project	JDA, 2011	The Wickham Flood Study considers the impact of using fill to facilitate three proposed developments (Wickham lodge, Cajuput and town office) adjacent to the Creek Wickham Drive Creek, within the existing Wickham Townsite. The study found that filling for the Wickham lodge increased flood levels from 9.73m to 11.70m(AHD). The other sites did not have an impact in flood levels.
	Wickham 2D Flood Study	JDA, 2015	Provides stormwater flood mapping to assist with assessing Local Storm Surge Risk Planning Policy DP19, for pre-Wickham South development and post-Wickham South development.
	Wickham Storm Surge Modelling Study	MP Rogers & Associates, 2015	Provides an assessment of the impacts of a100 ARI and 500 ARI inundation storm surge event to evaluate opportunities and constraints for potential development.
Cossack	None available at this stage		

Key criteria are summarised below.

Roebourne townsite local water management strategy (Essential Environmental, 2014)

As the structure plan area is an existing townsite, implementation of the local water management strategy will occur as development proposals are approved and constructed. The key opportunities for improved water management outcomes include:

- NASH development, northern community hub, business hub and southern development zone, which should be developed in accordance with the objectives, strategies and design criteria in the local water management strategy;
- Installation of water efficient irrigation in all public open spaces and recreation areas;
- Re-use of treated wastewater to irrigate existing and future public open spaces and recreation areas; and
- Improvement of existing drainage networks to increase community amenity, environmental values, and maintain and protect existing and future drainage pathways through effective landscaping.

Point Samson stormwater and coastal management strategy (Essential Environmental, 2014)

The *Point Samson stormwater and coastal management strategy* was prepared to inform the development of a local structure plan for Point Samson.. The following is a summary of the recommendations from the *Point Samson Stormwater and coastal management strategy*.

1. The following land use planning strategies should apply in respect of flooding from storm surge and should be considered as part of any future planning and/or development in the townsite:

    - No new development is to occur within defined storm surge areas.
    - Redevelopment of existing buildings within storm surge areas may be acceptable provided the proposed building is given adequate protection from the 100 year ARI event flood (inundation and erosive forces). Notification on Title may also be required for areas affected by coastal flooding (i.e. between the 100yr and 500yr ARI).
    - Planning and management of facilities and infrastructure within or adjacent to the foreshore reserve should be guided by a Coastal Hazard Risk Management and Adaptation Plan.

2. Hydraulic stormwater modelling of the Point Samson townsite has identified overland drainage flow paths which should be similarly protected through land use planning and development controls. The following strategies apply in respect of defined overland flow paths:

    - No development is to occur within defined overland flow paths and flood areas.
    - Existing buildings within or adjacent to defined overland flow paths and flood areas should be relocated or provided with suitable structural protection from inundation and have a memorial placed on its title stating that “This property is located in a flood risk area”.
    - Existing undeveloped land which is zoned to allow development and located within defined overland flow paths and flood areas should be reserved for drainage.
    - Development in areas adjacent to defined overland flow paths and flood areas are to comply with relevant building and development controls presented in section 9.3.

3. Future planning and development should be undertaken with consideration of the specific mitigation measures identified in the risk assessment presented in section 7 including:

    - Minimum setback for permanent infrastructure should include allowance for erosion (including sea level rise) over 100yrs (139-170m).
    - Control beach access through managed access points designed to minimise impacts.
    - Developments to allow continued appropriate public access for beach access.
    - Design of developments to limit height and consider visual impacts.
    - Rehabilitation to remaining coastal access points to reduce risk of damage.

Point Samson DWMS (Cardno, 2015)

The City of Karratha undertook a district level structure plan for Point Samson to guide future development and facilitate the preparation of the City's new Local Planning Strategy (LPS). In support of this structure plan, a district water management strategy (DWMS) was completed to ensure that water management can be addressed across the site and to inform the LPS. The subject area covers approximately 372 hectares of land, including the Townsite and its surrounds, consisting predominantly of residential dwellings with some commercial and tourism based uses.

The DWMS provides a much broader level stormwater management framework. The DWMS notes the *Point Samson Stormwater and Coastal Management Strategy* as a supporting document and demonstrates understanding of the principals of the stormwater and coastal management strategy such as;

- Ensuring the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.
- Implementing stormwater management systems which are economically viable in the long term.
- Minimising the public risk, including risk of injury or loss of life, to the community.
- Protecting the built environment from flooding and water-logging.

The principle behind the stormwater management strategy is to retain and infiltrate the first 15 mm of any rainfall event as close to the source as possible and direct additional runoff offsite via overland flow. This is proposed to be achieved using Water Sensitive Urban Design features such as soakwells and, where more appropriate, rainwater collection tanks at the lot level and retention basins on a larger scale for runoff generated from the road reserves. Broad scale calculations have been provided which show the anticipated volume of stormwater retention required for the post development scenario.

Karratha drainage management plan (GHD, 2010)

The document aims to provide the following with respect to the Karratha drainage network:

- Drainage design principles and Water Sensitive Urban Design in Karratha;
- Condition assessment of the existing stormwater drainage network;
- A hydrologic and hydraulic assessment of the drainage network at key drainage locations; and
- Recommendations for the future management of the drainage network including maintenance.

The drainage network in Karratha principally operates by capturing flows in developed areas with high runoff coefficients which is then directed to roads. High kerbs contain water within the road network, where water is conveyed to topographic low points and discharged through kerb breaks to open drainage channels. A network of drainage channels and drainage reserves exist and interconnect to discharge stormwater to the north of the townsite onto low lying flats.

The drainage management plan undertook a hydraulic assessment of flood levels within the townsite. Three cases where identified where modelling indicated existing channels are insufficiently designed to handle both the 5 and 10 year ARI event in the existing development environment. Furthermore the study found eight cases where the drainage reserve was efficient for the 5 and 10 year ARI event, but insufficient for the 100 ARI year event. Further stormwater flood mapping was conducted by JDA in 2013.

Karratha lazy lands: 2D flood study and local water management framework (JDA, 2013)

The lazy lands 2D flood study was developed to provide guidance for residential infilling within Karratha, particularly in relation to the analysis, findings and recommendations for drainage and stormwater management plans for specific developments as identified as lazy lands. Lazy lands are areas of vacant crown land that can be quickly bought into the residential land release to help alleviate the-then shortage of development ready land in Karratha.

The study identified the majority of the potential sites are not required as part of the Karratha drainage corridor, though some sites may require additional engineering works to mitigate their development impact on drainage flood levels.

The lazy lands study was to be followed by more comprehensive storm surge and stormwater flood mapping.

Karratha storm surge and stormwater flood mapping (JDA, 2013)

This report has been produced to assist the City of Karratha by the creation of a series of flood maps showing storm surge and stormwater runoff in Karratha for various 100 year and 500 year ARI climate scenarios. This was done to highlight the areas subject to flooding from future 100 year ARI and 500 year ARI storm surge events and mapping which can be used to guide the City in the assessment of Development Applications.

The floodwater mapping of the Karratha townsite depicts some areas of the Karratha townsite that may be affected by the 100 year ARI stormwater flood event.

Dampier drainage review (GHD, 2010 for Rio Tinto Iron Ore)

The Dampier Drainage Review identified that the drainage network in Dampier was appropriately designed to handle flows generated from a 5 and 100 yr ARI storm event (as generated in 2010) without risking damage to infrastructure. 2010 ARI rainfall intensities are significantly greater than corresponding rainfall intensities back in the 1960's. Consequently, assuming there are no encroachments impeding flows, it can be assumed the drainage network is compliant with design standards back in 1960 and today.

However, many encroachments into the drainage network were observed.

Dampier stormwater management study (GHD, 2015)

The study was undertaken to enable the City of Karratha to better define issues surrounding stormwater management in the Dampier townsite. This document builds on the 2010 study Dampier drainage review (GHD 2010) as the previous study's scope lacked sufficient detail to identify land and infrastructure requirements for future planning. The study undertook flood modelling which identified numerous locations of floodwater encroachments within drainage structures due to insufficient capacity, poor positioning and obstruction of drainage paths from vegetation, sedimentation or construction. The results indicate the current drainage system requires alteration and maintenance to the system for both current and future developments.

Wickham townsite accommodation expansion project – LWMS (JDA, 2011)

The local water management strategy (LWMS) was a requirement for approval of the Accommodation Expansion Project proposed by Rio Tinto in the Wickham Townsite. The following key points were contained in the LWMS.

- Recharge and abstraction from the groundwater for not-potable use is unlikely due to high salinity.
- The public open space (POS) irrigation demand is 50,000m^3/yr. The available wastewater to be reused to irrigate POS areas is approximately is 79000m^3/yr.
- Conveyance of stormwater is via open drain systems.
- POS and drainage swales are designed to accommodate up to and including the 100year event
- Groundwater maximum are expected to be 3m below surface with a 0.3-0.5m seasonal fluctuation.
- Minimisation of erosion and sedimentation movement with minor events is of focus in the Pilbara region.
    - Use of vegetated swales
    - Ensure desired longitudinal slope to reduce velocity
    - Infiltrate smaller volumes where possible

The LWMS only addressed the area of the proposed townsite expansion. The flood study for this area concluded that appropriate fill levels above the 100 year ARI event (0.5m) and upgrading the existing culvert on the Point Sampson-Roebourne Road should mitigate risk to flooding to the existing town and proposed development.

Wickham flood study (JDA, 2011)

The *Wickham Flood Study* describes the flood modelling results of a creek located along the Wickham Drive, referred to as Wickham Drive Creek, within the existing Wickham Townsite. The aim of this study was to model the Creek, estimate the

100 and 500 year ARI flood levels along the Creek, and analyse the effect (if any) of the three (Wickham lodge, Cajuput and town office) proposed developments (filling) adjacent to the Creek on flood levels and the hydraulic regime of the Creek.

The study found that filling for the Wickham lodge increased flood levels from 9.73m to 11.70m (AHD). The other sites did not have an impact in flood levels.

City of Karratha Stormwater Design Guidelines for Residential Developments (June 2011)

City of Karratha Stormwater Design Guidelines for Residential Developments (June 2011) were prepared to assist developers meet the expectations of the City in drainage design for new development in residential areas. The guidelines discuss developer responsibilities, water sensitive urban design and innovation, and provide design parameters for small and large developments including flood management. The guidelines also contain recommended species for establishment in new drainage reserves.

APPENDIX 3: POLICY AND REGULATORY FRAMEWORK

Guiding legislation

The management of the water cycle in an urban and regional context is governed by a substantial number of acts and regulations, the most relevant of which are considered to be:

- Country Areas Water Supply Act 1947;
- Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth);
- Environmental Protection Act 1986;
- Local Government Act 1995;
- Planning and Development Act 2005;
- Rights in Water and Irrigation Act 1914;
- Water Agencies (Powers) Act 1984;
- Water Efficiency Labelling and Standards Act 2006;
- Water Resources Legislation Amendment Act 2007;
- Water Services Act 2012;
- Water Services Legislation Amendment and Repeal Act 2013; and
- Waterways Conservation Act 1976.

State policy context

Strategic guidance for the management of our water resources is also provided by a number of State-level policies, strategies and guidelines as outlined below. These documents will be considered as part of stage 2 of the project to ensure that their requirements are addressed in the water management strategy.

Pilbara Planning and Infrastructure Framework (WAPC, 2012)

The *Pilbara Planning and Infrastructure Framework* defines a strategic direction for the future development of the Pilbara region over the next 25 years. It seeks to ensure that development and change in the Pilbara is achieved in a way that improves people's lives and enhances the character and environment of the region.

The *Pilbara Planning and Infrastructure Framework* notes that if growth and development are poorly managed there would be unacceptable impacts on the region's natural environment and a reduction in the desirability of living in the Pilbara. It highlights the need for strategic regional planning to recognise the issues as early in the planning process as possible and identify measures for protection in order to ensure that future development will avoid unacceptable damage to the natural environment.

State Water Strategy (2003)

The *State Water Strategy* was developed in 2003 as a response to having experienced the lowest inflow into our drinking water dams ever recorded (1911-2002), with an 80% reduction in expected inflow. The *State Water Strategy* outlines objectives and planned initiatives and for securing the future of water as a resource in Western Australia.

The key objectives of the *State Water Strategy* include water conservation and efficiency; water reuse; new supply and total water cycle management; innovation research and education; and resource protection and management.

State Water Plan (2007)

The S*tate Water Plan* provides a strategic framework to manage water resources in Western Australia, building upon the *State Water Strategy*. The Plan develops priority actions identified in the preceding *State Water Strategy*, with a larger focus on water policy and planning. Priority actions include developing regional water plans, statutory water management plans, and initiating further study on demand management and supply options for both metropolitan and regional areas.

State Planning Policy 2.9: Water Resources (2006)

State Planning Policy 2.9: Water Resources pledges Western Australia to pursue sustainability through integrating environmental protection, social advancement and economic prosperity. This is consistent with the vision encapsulated in *A State Water Strategy for Western Australia* (2003), which seeks to develop and protect water resources in an economically and environmentally responsible way by providing a whole government framework for setting strategies and plans for water resources.

This policy is directly related to the overarching sector policy *State Planning Policy 2: Environment and Natural Resources Policy*. It provides clarification and additional guidance for planning decision-makers in considering water resources in land use planning strategies, proposals and applications. This can be through local and regional planning strategies, structure plans, town planning schemes and amendments, subdivisions and development applications, and other town planning mechanisms.

Better Urban Water Management

Better Urban Water Management (WAPC, 2008) provides guidance on the implementation of *State Planning Policy 2.9: Water Resources* (2006). It outlines the requirements for integrating land and water planning and improving the achievement of total water cycle outcomes and water sensitive urban design as part of land use planning and development.

Better Urban Water Management is designed to facilitate better management and use of water resources by ensuring an appropriate level of consideration is given to the total water cycle at each stage of the planning process. The document provides guidance for regional, district and local land use planning, as well as subdivision phases of the planning process. *Better Urban Water Management* is to be used by all stakeholders and decision makers and has statewide application for new urban, commercial, industrial and rural-residential developments.

State Planning Policy No 2.7: Public Drinking Water Source (2003)

State Planning Policy No 2.7: Public Drinking Water Source policy applies to proclaimed Public Drinking Water Source Areas (PDWSAs) throughout Western Australia. The objective of this policy is to ensure that land use and development within PDWSAs is compatible with the protection and long-term management of water resources for public water supply.

The policy requires all priority (P1, P2, and P3) source protection areas outside the metropolitan region to be shown as special control areas in region schemes and local government schemes. This should be in accordance with the recommendations of any relevant land use, water management strategy, or water source protection plan. Furthermore, land uses and developments in all priority source protection areas that have the potential to impact detrimentally on the quality and quantity of public drinking water supplies should not be permitted unless it can be demonstrated, having regard to advice from the Water and Rivers Commission (now Department of Water), that such impacts can be satisfactorily managed.

Planning schemes and decisions on land use and development should have regard for any adopted region scheme policy or relevant environmental protection policy on public drinking water supply.

Pilbara Regional Water Supply Strategy: A long-term outlook of water demand and supply (Department of Water, 2013)

The *Pilbara Regional Water Supply Strategy* (2013) identifies ways to meet additional demands for water supply expected to emerge over the next 30 years in a timely and cost-effective way. The strategy aims to identify how new water resources, new infrastructure and improvements in water efficiency and recycling can be combined to deliver secure and reliable water supplies for towns and industry. New opportunities, such as using large volumes of water from mine dewatering for agricultural development, are also considered in this strategy. Many of the options will require further investigation and investment before they can be realised. The *Pilbara Regional Water Supply Strategy* serves to guide this future work and is the foundation for more detailed planning to support continued water security and investment in the region.

Pilbara Groundwater Allocation Plan (Department of Water, 2013)

The *Pilbara Groundwater Allocation Plan* provides direction on how the government will allocate and regulate the use of groundwater in the Pilbara. Investigations were undertaken to understand the Pilbara's groundwater resources and their dependent values to be able to support the region's growth, as well as meet the environmental needs of the future. Subsequently this has allowed an increase of allocation to regional scheme water supplies. The plan provides the framework for licensing, allocation limits, groundwater monitoring and reporting to ensure the Department of Water manages water sustainably and provides security of supply. Nine aquifers are considered by the plan (De Grey, Cane, Fortescue, Robe, Turner, Yule, Millstream, Canning-Broom and Canning-Wallal) with tables specifying licensable, unlicensable and reserved water allocation limits.

Pilbara State of the Environment Report 2013 (RDA Pilbara, 2013)

The *Pilbara State of the Environment Report 2013* provides information on the Pilbara's environmental and cultural systems with the purpose of improving the understanding of future risks, and facilitates effective management of important aspects of these systems.

It contains indicators for monitoring changes over time which can be used to evaluate impacts on the environment that may result from future growth and development in the Pilbara region. This in turn will allow future adaptive management responses and/or mitigation actions to be identified to assist in the achievement of objectives and long term goals.

The report also provides a platform for community action by raising awareness and understanding of key environmental issues which will, in turn, help people and organisations make informed decisions regarding future management actions to reduce negative impacts on the environment.

Local regulatory context

Integrated planning framework

The City of Karratha Water Management Strategy will become one of several key strategy documents that inform the City's Strategic Community Plan, Corporate Business Plan, and Operational Plan. These documents, known as informing strategies, form part of the Integrated Planning Framework (Figure 1) which will deliver the City's Vision to be a cohesive and vibrant community, celebrating diversity and working together to create a sense of place and a sustainable future.

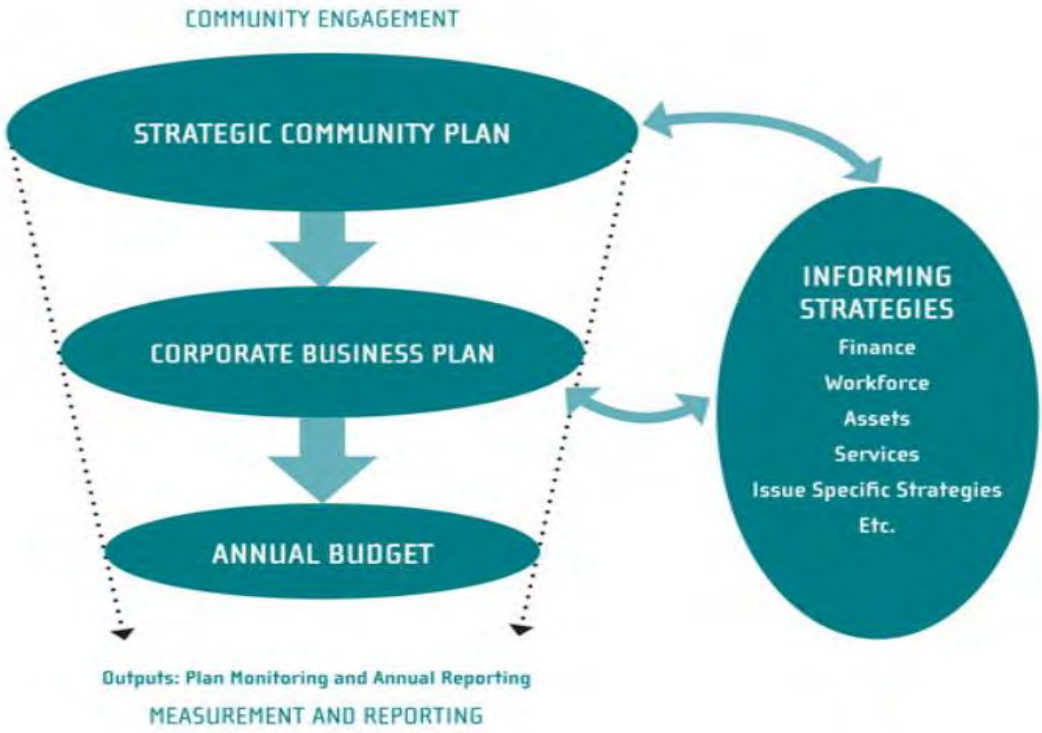

Figure 16: Integrated Planning Framework (Department of Local Government)

The integrated planning framework aims to establish local priorities and the ability to link this information to operational functions. The informing strategies enable the City to create action plans for specific issues where required. This Water Management Strategy is proposed to be endorsed as an issue specific strategy and therefore will provide an important input into the review of the Corporate Business Plan and Operational Plan.

Strategic Community Plan

The community's aspirations for the City are outlined in the City of Karratha *Strategic Community Plan 2012 – 2022*. The plan outlines the outcomes that Council will achieve through strategies contained in the Corporate Business Plan over the next five years. The Strategic Community Plan also incorporates state and regional plans including *Pilbara Planning and Infrastructure Framework 2012*, *Karratha - City of The North Plan* and the *Pilbara Regional Council Strategic Plan 2012-2014*. These linkages help position the City's planning within a much broader context and considers current and emerging community needs and identifies key stakeholders and interdependencies which may affect delivery of appropriate services to the community over time.

The Strategic Community Plan strategic theme 3: *Our Natural and Built Environment – Thriving and Sustainable* has an associated goal to "strive to ensure our community lives sustainably in a thriving natural environment". The City of Karratha is dedicated to achieving the following outcomes as part of their own activities:

- An environmentally responsible and sustainable organisation – through the protection and enhancement of the natural environment, open spaces, beaches and waterways;
- A sustainable and thriving natural environment – by exploring options to reduce, reuse or recycle our waste and minimize our carbon footprint; and
- Environment that promotes healthy lifestyle – by providing shading in meeting places.

The City will review its progress towards meeting the objectives of the Strategic Community Plan and identifies the following outcomes and measures.

Outcomes	Strategic indicators
Community Volunteer Groups	Number of active voluntary groups working for cleaning beaches Number of environmental education programs conducted Number of participants attended
Reduction in Waste and Improvement in water conservation	Developing and implementing Energy Savings Action Plan Developing and implementing a water savings plan

The City of Karratha will report on the progress of the Strategic Community Plan annually as part of the Annual Report and will monitor progress internally against the projects and services outlined in the accompanying Operational Plan. The quarterly reviews of the Operational Plan will be available through the City's website.

City of Karratha Environmental Strategy

The overall aim of this strategy is to:

Protect and enhance the environment of the City of Karratha

This aim is proposed to be achieved through the delivery of a number of actions in the priority theme areas of water, biodiversity, coasts and built environments. Specific objectives and outcomes with regards to water are:

Objective: Protect and enhance waterways, wetlands and the groundwater and ensure sustainable use and management of water resources

Outcomes

The key outcomes with regards to the management of Water Resources are:

- Sustainably manage the water resources of the region to maintain environmental, cultural and social values and provide for the water needs of the future community;
- Increase water use efficiency, recycling and reuse to provide fit-for-purpose sources;
- Adequately manage the risk of flooding; and
- Manage discharges to ground and surface waters to avoid contamination.

Strategies

The following key strategies are recommended to be implemented:

- Develop a water conservation plan for water use across the City;
- Develop stormwater management plans for Karratha, Point Samson, Dampier and Roebourne that ensure appropriate levels of service will be maintained as development occurs and water quality of stormwater is addressed;
- Educate the community regarding the need to use water wisely;

- Optimise use of fit-for-purpose water and substitute alternative sources for drinking water where possible;
- Maximise use of treated wastewater from all wastewater treatment plants for fit-for-purpose use including dual reticulation networks, and irrigation of playing fields and streetscapes;
- Ensure planning and development proposals are consistent with State Planning Policy 2.9: Water Resources and meet the requirements of Better Urban Water Management (WAPC, 2008a);
- Work with the State Government to ensure that remote Aboriginal communities have access to adequate drinking water and wastewater services; and
- Ensure that planning decision-making is consistent with the DoW's Water Quality Protection Note: Land Use Compatibility within Public Drinking Water Source Areas in the vicinity of any drinking water borefields, including the requirements for well-head protection zones.

City of Karratha Town Planning Scheme No 8

The City of Karratha Town Planning Scheme No 8 (hereafter referred to as "the Scheme") was gazetted on 23rd August 2000. One of the objectives of the Scheme is broadly relevant to this strategy. It is outlined in Clause 1.6 as:

(a) Facilitate community input into planning for the appropriate balance between economic and social development, conservation of the natural environment, and improvements in lifestyle and amenity.

Part V of the Scheme also defines objectives for the Burrup Peninsula under Clause 5.4. The first being relevant to this strategy is to:

- "Retain an appropriate balance between the Burrup's recreational, industrial, environmental and heritage assets''

Similar objectives referring to due regard of the natural environment are also defined for:

- Cape Lambert
- Cossack
- Islands (Dampier Archipelago)
- Maitland (Miaree Pool)
- Pastoral stations
- Point Samson

Under the Scheme, all development plans are expected to address:

- "public open space and recreation provision, environmental protection areas, and relationships to natural features"; and,
- "assessment of the impact of the proposal on the natural environment, including management of potential effluent, emissions and other forms of pollution".

Local environmental policy context

Policy and strategy documents have been prepared by the City for a range of areas in the municipality, including codes of conduct, financial management, environmental health, development requirements, landscaping, transient worker accommodation, and waste management. These policies guide how Council operates or puts in place long term strategies in partnership with the community (City of Karratha website).

The local policies which provide guidance for environmental management are limited and include:

- DP6 Landscaping requirements for industrial and commercial areas (2009); and
- Acid Sulphate Soil Assessment (obtained from WAPC, 2009).

Local structure plans

The City has developed or is in the process of developing a number of structure plans for the major townsites within its borders. These include:

- Karratha City of the North Plan (2010)
- Dampier Townsite and Foreshore Enhancement Plan (2015)
- Wickham Townsite Structure Plan (January 2011)
- Roebourne Structure Plan (July 2014)
- Point Samson Structure Plan (Dec 2014)

These structure plans provide guidance for the future planning and development of these townsites. They are supported by water management reports including:

- Roebourne townsite local water management strategy (2014)
- Point Sampson stormwater and coastal management strategy (2014)
- Point Sampson district water management strategy (2015)
- Karratha drainage management plan (2010)
- Karratha storm surge and stormwater flood mapping (2013)
- Dampier storm surge and coastal inundation (2011)
- Dampier drainage review (2010)
- Dampier stormwater management study (2015)
- Wickham townsite accommodation expansion project (2011)
- Wickham flood study (2011)
- Wickham storm surge modelling report (2015)
- Wickham 2D Flood Study (2015)

Client: City of Karratha

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Essential Environmental
land & water solutions
622 Newcastle St Leederville 6007
p: 08 9328 4663 | f: 08 6316 1431
e: info@essentialenvironmental.com.au
www.essentialenvironmental.com.au