City of Armadale Environmental Strategies - Air, Water, Soil and Land

Acknowledgement of Country

The City of Armadale acknowledges the lands we care for are the traditional lands of the Whadjuk Noongar people, and we pay our respects to elders, past, present, and emerging.

Summary

The City of Armadale (the City) has prepared this Air, Water, Soil and Land Strategy (the Strategy) to support the achievement of Outcome 1 of the Strategic Community Plan 2020 – 2030 '*Conservation and restoration of the natural environment',* and to achieve alignment to the City's Strategic Environment Commitment:

- Seek to ensure that development outcomes are sensitive to pre-existing values.
- Minimise pollution to the atmosphere from City operations.
- Minimise the pollution of soil and land that could result from City activities.
- Utilise water efficiently as part of City operations.
- Minimise detrimental impacts to water quality in the City's rivers, streams, brooks and drains.
- The City of Armadale will promote environmental sustainability (incorporating the need to plan, and to plan for mitigating, risks associated with climate change).

This will complement the objectives and actions of the Biodiversity Strategy 2024-29, and the City of Armadale Corporate Greenhouse Action Plan 2020/21 to 2029/30 (CGAP). Atmospheric emissions of carbon, as a result of the City's activities, and potential mitigating actions, are addressed in the CGAP document.

Strategy Development

A series of workshops were undertaken with Subject Matter Experts including officers, environmental community group members and Councillors, to develop the Strategy.

The workshops:

- Presented an indication of the current 'state' of 'Air', 'Water', 'Soil and Land' environmental assets in the City of Armadale, using empirical data.
- Based on the 'state', identified risks and threats, following the protocols of the City's Risk Management Framework and '*AS/NZS ISO 31000:2018 Risk Management – Principles and Guidelines* (ISO 31000)'.
- Identified existing mitigating controls to address the risks identified, and further opportunities to enhance environmental performance and/or City processes.
- Developed high level indicators to track future environmental performance.

A total of 56 risks were identified, with 143 existing controls to mitigate these. This demonstrates the City is taking a proactive approach to environmental management and seeking to adopt innovative approaches.

An additional 48 controls have been created to further limit risks, or to take advantage of potential opportunities. In some instances, the City's limited capacity to 'intervene' to reduce risks should be noted, particularly where alternative organisations have a legislative 'head of power'. In such cases, an advocacy role is appropriate.

Air

Key threats to air quality in the City are dust from the land-use change process, controlled burns and heat. The City is employing a number of actions described in the Strategy to mitigate impacts to air quality.

The National Environment Protection (Ambient Air Quality) Measure (NEPM) is a framework to measure and monitor Australia's ambient (outdoor) air quality, first established by the Australian Government in 1998. The NEPM includes standards for key pollutants; Carbon Monoxide, Nitrogen Dioxide, Photochemical Oxidants (as ozone), Sulfur Dioxide, Lead, and Particles (as PM_{10} and $PM_{2.5}$).

Monitoring data indicates the City of Armadale generally experiences good air quality, with readings below relevant NEPM targets.

Additional controls include the production of policy and guidance documents for specific scenarios (e.g. vacant land/subdivisions). The City's participation in the '*Sediment Control and Prevention'* component of the '*Cleaning up the Canning'* project ($10m Federally funded initiative), will also seek to review additional opportunities for air quality improvements in this area, in conjunction with enhanced controls around the release of water borne sediment during the development process. Any improvements will occur after a baseline audit on existing City processes.

Under the *Respect and Opportunities* component of the *Reconciliation Action Plan*, the City will investigate the potential for Cultural Burning as part of future fire mitigation regimes. In addition, an Education Officer is currently being recruited, to work with the community to effect more efficient Hazard Reduction Burns. Led by Health Services, the City will also undertake an advocacy role with State Government, with a view to facilitate residents to switch from woodfire heaters.

The City is experiencing rising temperatures as a result of a number of factors including the built environment, climate change and canopy coverage. Opportunities for improvement are anticipated in future revisions of the Urban Forest Strategy e.g. targets in relation to canopy cover, which is expected to have direct support from the recently established Canopy Cover Working Group. In addition, the impacts of climate change will be considered in the City's update of the Community Health and Wellbeing Plan, in alignment with the State Government Public Health Plan.

Water flows and availability

The City's rivers are completely dammed. Consequently, environmental water releases are a key mechanism for replenishment and/or maintenance of water levels in the City's river systems. These are vital in maintaining river health. The risk of releases being inadequate is compounded by the impact of climate change.

Water releases are under the control of the Department of Water and Environmental Regulation (DWER) e.g. the Canning River is governed by the *Middle Canning River Surface Water Allocation Plan* (2012). The City has an advocacy role in supporting the community, in ensuring releases remain adequate, and surface water abstraction, along river courses, is appropriately managed.

Scheme and groundwater are used as part of City operations. Continuous improvement is tracked through participation in the Waterwise Councils program. Existing 'Waterwise' initiatives incorporate the support of the *Switch Your Thinking Program* e.g. promotes

community education, *Armadale Gosnells Landcare Group* and the *Native plants for Residents* event.

A key risk to the water environment is the exhaustion of groundwater resources. The efficient use of groundwater is enabled through the deployment of a centrally controlled irrigation system, instantaneously alerting operators to pressure changes and system leaks. In addition, the City has a role in trialing innovative water efficiency projects. For example, the 'Vortex' system is a device attached to groundwater bores that enables greater oxidation as water passes through the system and is currently being installed at select City sites. The initiative is anticipated to realise water savings of 10-30%.

A key recommendation of the strategy is to review the *Asset Life Cycle Management - Infrastructure Renewal Program* in relation to irrigation systems. This will involve an independent audit, with the subsequent development of a future management/implementation strategy. This will ensure that the City has an irrigation system that continues to operate optimally. A one-off budget of $90,000 is requested for this piece of work.

Water Quality

The City has initiated the '*North Forrestdale Water Quality Monitoring Program'*, a district scale program, covering the urbanised area of West Armadale (Piara Waters, Harrisdale etc.). This is the first of its kind in Perth, monitoring 40 groundwater bores and 34 surface water sites. The purpose of the program is to better understand trends in water quality, with a view to enhancing future outcomes. A similar program is underway for the Wungong Urban Water Master Plan Area (under the control of Development WA).

In parts of North Forrestdale, groundwater has been found to contain total nitrogen and phosphorous above guideline levels. If it mobilises into surface waters, this can lead to eutrophication and as a consequence serious detrimental impacts, such as algal growth, impacting local biodiversity. Monitoring suggests that the surface water quality in these areas is improving, but does not yet meet the targets of the State Government '*Healthy Rivers Action Plan*'.

These trends are primarily the result of historic land uses, with few opportunities for improvement, although the City recommends the implementation of appropriate water treatment methods during land-use change processes, and is reviewing all internal guidance materials and policy positions relating to water sensitive urban design (WSUD). This will assist in limiting future nutrient levels in river systems, through 'treatment trains' and appropriately designed biofilters in developing estates.

In addition, a Strategic Water Sensitive Urban Standard has been recommended to ensure the City introduces greater innovation around the management of all WSUD assets, ensuring continued treatment of water discharges (one-off budget of $50,000 requested).

Soil and Land

The City includes areas with a high risk of Acid Sulfate Soils, notably close to the developing areas of Forrestdale, Piara Waters, Harrisdale, Kelmscott, Haynes and Hilbert. There are also 170 registered contaminated sites in the City.

Implementing appropriate controls is an integral part of the land-use change process, for example, through the production of Acid Sulfate Soil Management Plans.

An additional proposed control is the introduction of a '*Potentially Contaminated Investigation Required*' GIS layer in the City's Intramaps system. This will enhance visibility for land parcels that may pose a future environmental risk, and liability, from site disturbance activities.

Innovative techniques are applied to limit the use of herbicides e.g. deployment of sensors over hardstand areas, ensuring chemicals are only released where vegetation is present. However, a strategic review of practices is recommended to ensure the City's performance is optimised around herbicide and pesticide application (one-off budget of $60,000 requested).

Fertiliser is applied as part of the City's management of Public Open Space (POS). The method and quantum of application is tailored to the type of reserve (e.g. active, passive). Where appropriate, application processes are supported by informing monitoring programs (e.g. soil and leaf tissue analysis).

The production of a Strategic Fertiliser Application Program is proposed to further refine the City's approach and improve performance e.g. including reviewing the current application of granular fertilisers (one-off budget of $50,000 requested).

Key City Operations

The Armadale Landfill and Recycling Facility (ALARF) and Depot have the potential to impact the environment across Air, Water, Soil and Land. At both sites, industry standard control measures are in place to prevent contamination (e.g. bunded areas, segregation of hazardous waste, spill kits etc.).

ALARF is licensed to operate under Part 5 of the *Environmental Protection Act* 1986, as a *Prescribed Premises* (a site with the potential to cause pollution or environmental harm). The site is required to complete environmental monitoring in relation to air, water and soil and land e.g. the site has 12 monitoring points for ground/leachate water)..

Reporting, as required under the National Pollution Inventory (NPI), has not identified any issues. Nevertheless, site monitoring practices are currently being formalised into an Environmental Management Plan.

An Environmental Management Plan is also proposed for the Depot, as part of the Depot Redevelopment process with funding already provided within project budget.

Risk mitigation

Most risks identified in the Strategy have been mitigated to a residual level of 'medium' or 'low'. However, four risks remain with a rating of 'critical' or 'high' following the implementation of existing and additional controls:

- Increasing temperatures (urban heat) caused by the built environment (impervious surfaces, dark materials, lack of shade/canopy cover etc.), exacerbated by climate change.
- Changes in State Government requirements and/or assessment of proposals reducing the visibility of environmental issues, reduces the ability to respond (e.g. as part of Structure Planning etc).
- Ecological properties of the City's rivers may be compromised, as a result of damming and limited Environmental Water Releases and bearing the impacts of climate change.
- Inappropriate use of water in the community, places increased pressure upon providers to exhaust supplies from groundwater and/or surface water systems (exacerbated by the impacts of climate change).

These risks remain significant, as the City has limited ability to influence or control them, since they relate to statewide or national issues requiring action by other parties e.g. the Department of Water and Environmental Regulation and the Water Corporation). However, actions have been identified for advocacy, or additional improvements in educational programs.

Resourcing

An analysis of resourcing requirements has been performed by officers for the 48 proposed actions, considering:

- Can the activities be absorbed within Business as Usual (BAU) resourcing levels.
- Are additional internal resources required.
- The need for specialist consultancy.

At this stage, no additional internal resources are requested. However, it is noted that on the completion of additional actions, there may be a requirement for changes in service delivery levels and at this point, requests/business cases presented to Council as necessary (for example, the upcoming review of the Urban Forest Strategy may deem that additional resources are required for any subsequent implementation requirements).

As highlighted above, additional external expertise/consultancy support is requested to produce the following:

- Asset Life Cycle Management – Infrastructure Renewal Program - $90,000.
- Strategic Water Sensitive Urban Design Review - $50,000.
- Development of a Strategic Fertiliser Application Program - $50,000.
- Strategic Review of Practices – Herbicide/Pesticide Application - $60,000.

Hence, a total of $250,000 is requested for external expertise in these areas.

The Strategy has been developed in accordance with the intent and objectives of key corporate integrated planning documents, informing strategies, planning policies and other plans, including the City of Armadale Strategic Community Plan 2020-2023 and the City of Armadale Corporate Business Plan 2023-2027, in addition to State and Commonwealth environmental legislation.

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1 Introduction

The City of Armadale (the City) has prepared this strategy to achieve the objectives of its *Strategic Community Plan 2020-2030* (City of Armadale, 2020), particularly those under Outcome 2.1: Conservation and restoration of the natural environment, and the reduction of environmental impacts, which are to:

- 2.1.1 Utilise water efficiently and effectively as part of City operations.
- 2.1.2 Improve the quality of water in the City's rivers, streams, brooks, drains and wetlands.
- 2.1.3 Minimise impacts on air quality throughout the City.
- 2.1.4 Protect soil and land resources throughout the City.

1.1 Scope of the strategy

This strategy provides guidance for the protection and management of air, water and soil and land assets which may be impacted by City of Armadale activities. This includes decision-making and management associated with land use planning and development, management and operation of city assets and land, but does not include activities of the community or on private land.

Key assets covered by the strategy are:

- air
- soil and land
- groundwater
- surface water
- City of Armadale Depot at Owen Road
- City of Armadale Landfill and Recycling Facility (ALARF)
- other City-managed lands (parks, roads, bushland)
- other City-managed buildings and infrastructure

1.2 Objectives of the strategy

The objectives of this strategy were agreed by City staff as to:

Air	• Minimise pollution to the atmosphere from City operations. • Support and implement sustainability initiatives within City operations.
Soil and Land	• Minimise the pollution of soil and land which could result from City activities. • Optimise the value of land resources for the appropriate use.
Water	• Optimise the use of all sources of water as part of City operations. • Improve the quality of water in the City's rivers, streams, brooks, drains and wetlands and minimise water quality impacts to groundwater sources.

2 Strategy framework

2.1 Environmental management framework

The City's approach to environmental management is guided by an Environmental Management Framework (Figure 1). This strategy will inform the five-year operational plan in accordance with the Environmental Management Framework.

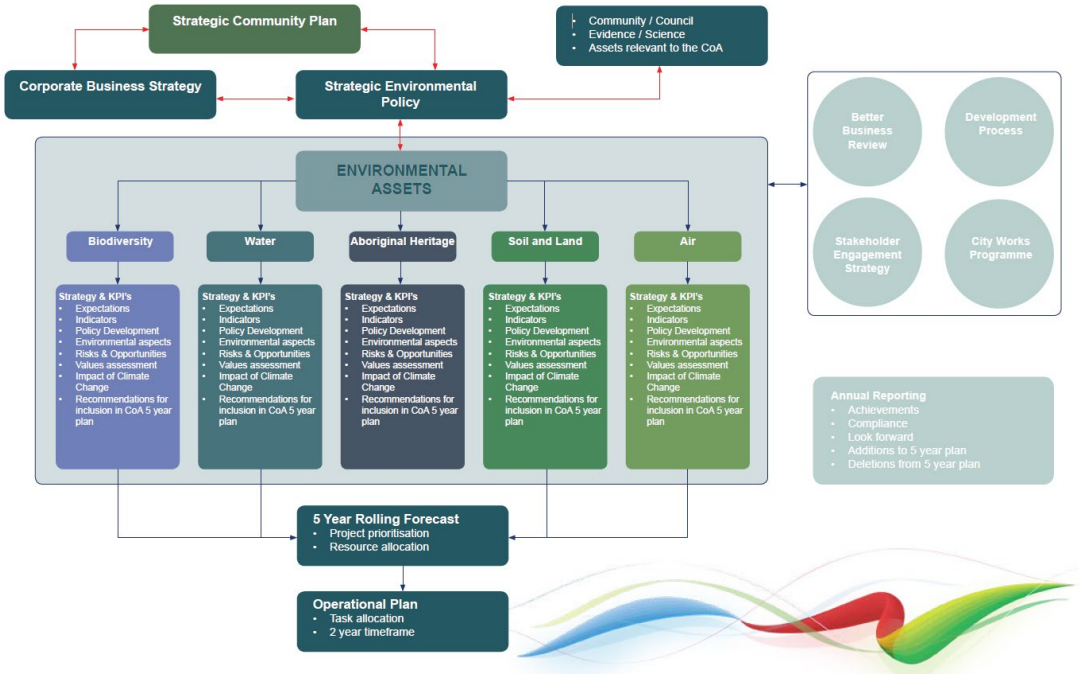


Figure 1: City of Armadale environmental management framework

The City's Biodiversity Strategy 2024-2029 provides an indication of the state of biodiversity assets in the City, with a particular focus on native vegetation and fauna, protected flora, fauna and communities, and ecological corridors and key habitat areas including wetlands and waterways. The Biodiversity Strategy identifies key threats and recommends management actions to address the threats.

The Aboriginal Heritage strategy has yet to be prepared.

2.2 Strategic Environmental Commitment

The City has a Strategic Environmental Commitment (Policy – ENG 21- Strategic Environmental Commitment) that defines the key environmental objectives to be pursued in order to achieve the City's environmental goal of the *Conservation and Restoration of the Natural Environment*, which includes:

- The protection of the environment, including the prevention of pollution.
- Compliance with environmental and heritage legislation.
- The implementation of processes enabling continuous improvement in environmental performance, including consultation with relevant industry stakeholders where appropriate.

This strategy seeks to achieve the City of Armadale's water, soil and land and air quality objectives of the Strategic Environment Commitment as stated in Section 1.

2.3 Strategic Community Plan and Corporate Business Plan

The City's *Strategic Community Plan 2020-2030* (2020) is the guiding document for the City over the decade 2020 to 2030. It identifies the community's expectations for the future and defines the types of services that the City will need to deliver. It is built around four aspirations – Community, Environment, Economy, and Leadership – and outlines the objectives, strategies, outcomes and measures for the success of the plan.

The City's Strategic Community Plan 2020-2030 and Corporate Business Plan 2023-2027 (2023) are intrinsically linked. The Corporate Business Plan recognises the Strategic Community Plan as a key informing plan. It links the Strategic Community Plan to key actions, projects, and strategies. The Strategic Environmental Commitment and the City's environmental strategies are identified as influencing plans and strategies within the Corporate Business Plan.

The Corporate Business Plan 2023-2027 includes actions to:

- 2.1.2.1 Develop and implement a Water Strategy.
- 2.1.3.1 Develop and implement an Air Quality Strategy.
- 2.1.4.1 Develop and implement a Soil and Land Strategy.

This document fulfills the above actions and provides a snapshot view of water, soil and land and air quality assets in the City and, together with the Biodiversity Strategy, aims to update and replace the City's existing State of the Environment Report.

2.4 State and Commonwealth legislation and policy

The air, water, soil and land strategies will complement existing State and Commonwealth laws and policies. In Western Australia, environmental protection is achieved through a hierarchy of legislation, policy, and planning frameworks. Both statutory and non-statutory processes and tools address matters in relation to the management of water, soil, land and air quality. This strategy recognises the requirements of existing national, state and local government legislation and policy as summarised in Table 1.

Table 1: Summary of relevant legislative, policy, and planning frameworks

Government jurisdiction	Statutory mechanisms / legislation	Key strategic policy and planning documents
Commonwealth	• Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	• National Water Initiative • State of the Environment Report 2021 • National Clean Air Agreement • National Environment Protection (Ambient Air Quality) Measure • National Environment Protection (National Pollutant Inventory) Measure
State	• Environmental Protection Act 1986 • Planning and Development Act 2005 • Biodiversity Conservation Act 2016	• State Planning Strategy 2050 (Government of Western Australia 2014a) • Environmental Protection (Peel Inlet - Harvey Estuary) Policy 1992 • State Environmental (Cockburn Sound) Policy 2015

Government jurisdiction	Statutory mechanisms / legislation	Key strategic policy and planning documents
	• Contaminated Sites Act 2003 • Soil and Land Conservation Act 1945 • Biosecurity and Agriculture Management Act 2007 • Aboriginal Heritage Act 1972 • Conservation and Land Management Act 1984	• Perth and Peel@3.5million: South Metropolitan Peel Framework March 2018 • Guidance for the Assessment of Environmental Factors, Separation distances between Industrial and Sensitive Land Uses, No.3 EPA, June 2005. • State Planning Policy 2.0: Environment and Natural Resources Policy • State Planning Policy 2.1: The Peel-Harvey Coastal Plain Catchment • State Planning Policy 2.3: Jandakot Groundwater Protection • State Planning Policy 2.4: Basic Raw Materials • State Planning Policy 2.7: Public Drinking Water Source • State Planning Policy 2.8: Bushland Policy for the Perth Metropolitan Region • State Planning Policy 2.9: Planning for Water and the Planning for Water guidelines (draft, 2021) • State Planning Policy 3.0: Urban Growth and Settlement • State Planning Policy 3.7: Planning in Bushfire Prone Areas and the Planning in Bushfire Prone Areas Guidelines • State Planning Policy 4.1: State Industrial Interface • State Planning Policy 7: Design of the Built Environment and supporting policies and guidelines • Local Government Guidelines for Subdivisional Development • Liveable Neighbourhoods
Local	• Local Government bylaws	• Strategic Community Plan 2020-2030 • Corporate Business Plan 2023-2027 • Reconciliation Action Plan 2023-2025 • City of Armadale Local Planning Policies for environment and natural resources including: • PLN 2.1 Development Envelopes • PLN 2.4 Landscape Feature and Tree Preservation • PLN 2.5 Erosion Prevention and Sediment Control • PLN 2.6 Water Sensitive Design • PLN 2.7 Environmental Management • PLN 2.8 Subdivision • PLN 2.9 Landscaping • PLN 2.10 Environmentally Sustainable Design • Parks Facility Strategy 2019 • Community Development Strategy (2021-2026) • Community Infrastructure Plan City of Armadale 2021-2037 • Local Planning Strategy – Town Planning Scheme No. 4 Version 5. 2015 to 2025 • Local Biodiversity Strategy Nov 2009 • Urban Forest Strategy 2014 • Corporate Greenhouse Action Plan (CGAP 2020/21 to 2029/30) • City of Armadale Subdivision and Development Guidelines and Waterwise Verge guidelines

2.5 Current approach to management and control of threats

The current approach to management and the control of threats to water quality and quantity, soil and land quality and air quality within the City incorporates strategic actions from the Corporate Business Plan, supporting strategies and service delivery (business as usual activities). The existing strategic and service delivery actions are listed below.

Current strategic actions including Corporate Business Plan and supporting strategies are to:

- Recognise the connection that members of the Aboriginal community share with City managed land through the implementation of on-ground initiatives.
- Develop and implement a program for the upgrade and maintenance of waterways within the City's reserves.
- Implement the Switch Your Thinking Business Plan 2020/21 to 2025.
- Present a biennial report on the performance of the City against the Strategic Environmental Commitment and Environmental Management Framework.
- Develop and implement a verge maintenance strategy.
- Develop a Public Realm Strategy and implementation plan for the Armadale City Centre and District Centres throughout the City.
- Review Park Facilities Strategy and implement Parks Improvement Plan.
- Review the City's Building Asset Management Plan.
- Develop and implement the City's Asset Maintenance Strategy for Property and Civil Assets.
- Develop and implement the City Asset Sustainability Strategy.
- Review the City's depot facilities and provide Council with options and costings to consider for incorporation into the Long Term Financial Plans.
- Manage the City's landfill sites safely and the development of the new public transfer area.
- Develop options for improving the sustainability of the City's fleet such as transitioning to electric or non-hydrocarbon vehicles.
- Investigate alternative water sources within the City.
- Install data loggers on new major facilities to monitor water use and detect possible leaks.

Current business as usual activities include, but are not limited to:

- Provision of comment on land use change, structure plan, subdivision and development applications and ensuring the appropriate consideration of environmental risks and opportunities.
- Through planning and engineering policies and processes, advocate for application of water sensitive design approaches in accordance with City Policy PLN 2.6 Water Sensitive Urban Design.
- Management of drainage assets including vegetated water quality treatment assets to an agreed level of service.
- Management of the use of groundwater in accordance with licence limits and reduction of usage where possible through a staged program of irrigation system replacement and hydrozoning.
- Consideration of opportunities for improved water efficiency through the Water and Energy Reference group.
- Support for waterwise planting opportunities through the annual Plants for Residents initiative and Habitat Links Program.
- City representation on the Darling Range Regional Park Advisory Committee, Jandakot Regional Park Advisory Committee, Middle Canning Stakeholder Group,

Southern East Regional Centre for Urban Landcare, and Wetlands Coordinating Committee.

- Support for volunteers through Armadale Gosnell's Landcare Group, Bushcare and Environmental Working Group, and though the Friends Group Manual process to ensure planting is waterwise.
- Review of corporate proposals and provision of advice on environmental legislative framework.
- Coordination of environmental approvals where required.
- Environment personnel participating in the review of the Local Planning Strategy and Local Planning Scheme.
- Implementation, update, and review of environmental Local Planning Polices
- Provision of comment on matters relating to Bushfire Mitigation activities.

3 Stakeholders

The City is committed to assisting and supporting environmental stakeholders managing air, water, soil and land resources and who seek to improve outcomes for the environment and the community. Within the City, the following relevant stakeholders have been identified:

Community Groups:

- First Nations Australians
- The Armadale Community Environmental Centre
- Armadale Gosnells Landcare Group
- Environmental Volunteer Groups, operating under the umbrella of the Bushcare and Environmental Working Group

Key internal stakeholders:

- Elected Members of the City of Armadale
- Executive Management Team
- Environment and Sustainability Department
- Service Delivery (Parks Operation)
- Design (Parks Design)
- Development Services
- Community Development
- Economic Development
- Rangers and Emergency Services

Key external stakeholders Business Partners:

- Department of Biodiversity, Conservation and Attractions (DBCA)
- Department of Water and Environmental Regulation (DWER)
- Department of Planning, Lands and Heritage (DPLH)
- Western Australian Planning Commission (WAPC)
- Water Corporation

These stakeholders will continue to be engaged where appropriate in the delivery of this strategy.

4 Current state of air, water, and soil and land assets in the City

The current state (at 2024) of air, water and soil and land assets in the City is described below.

4.1 Air

A summary of climate and air quality information relevant to the City of Armadale is provided in this section, noting that whilst temperature is discussed, urban heat is addressed as part of Section 4.2 because of the strong links to the City's land-based urban forest assets.

4.1.1 Climate

The climate of the City of Armadale is typical of the south-west of Western Australia, which has a Mediterranean climate comprising of hot dry summers and mild wet winters.

Rainfall data (Figure 2) is provided by the nearby Bureau of Meteorology (BoM) rain gauge at Forrestdale (No.009257) approximately 6.7km west of the Armadale city centre. The annual average rainfall for years (1986 to 2022) was 827mm, with 10-year averages (2011 to 2021) of 795 mm, a 5% reduction, which is consistent with the decreasing rainfall trend across south-west Western Australia (DoW, 2015). The seasonal rainfall distribution indicates approximately 66% of the rainfall occurs during the months of May to August.

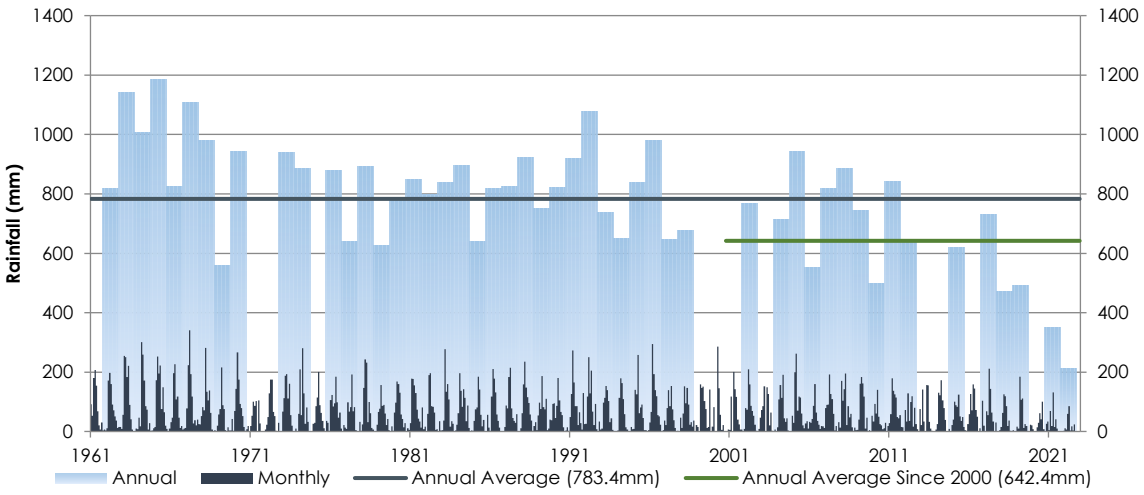


Figure 2: Annual and monthly rainfall showing long-term and recent (since 2020) average
Source: (Rainfall (Gosnells Station #009106), BOM, 2024)

Temperature data (Figure 3) is provided by the nearby BoM station at Gosnells (Station No. 009106) located approximately 11.8 km north of Armadale's city centre. For the period 1991 to 2022, the annual mean maximum temperatures range between 18.8°C and 33.1°C and the annual minimum temperatures range between 8.8°C and 18.8°C (BOM, 2022).

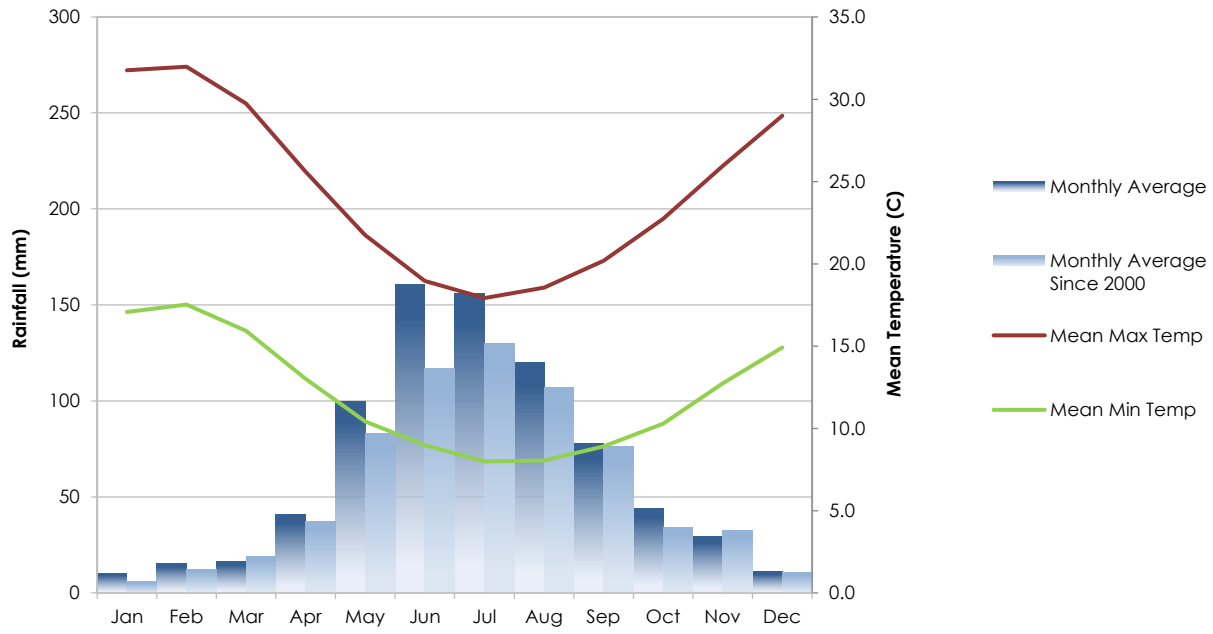


Figure 3: Average monthly rainfall and temperature ranges
Source: (Rainfall (Gosnells Station #009106), BOM, 2024)

Wind speed statistics and direction, shown in Figure 4, collected from the BoM station at Perth airport (Station # 009021) show winter winds in Perth are typically from the south-west and south. Summer is characterised by strong easterly winds. On the hottest days, when the hot easterly winds are strongest, the coastal breezes sometimes do not reach as far inland as Armadale's city centre, due to the distance (37km) to the coast.

Wind speed and direction affect rates of evaporation, mixing of surface waters and the development of storm surges. Wind also influences the speed at which a fire burns, the direction in which a fire travels, the intensity of a fire and the likelihood of spotting when embers are carried ahead of the fire. Easterly winds travelling over the hot, dry desert can bring extremely hot, dry weather conditions increasing fire risk.

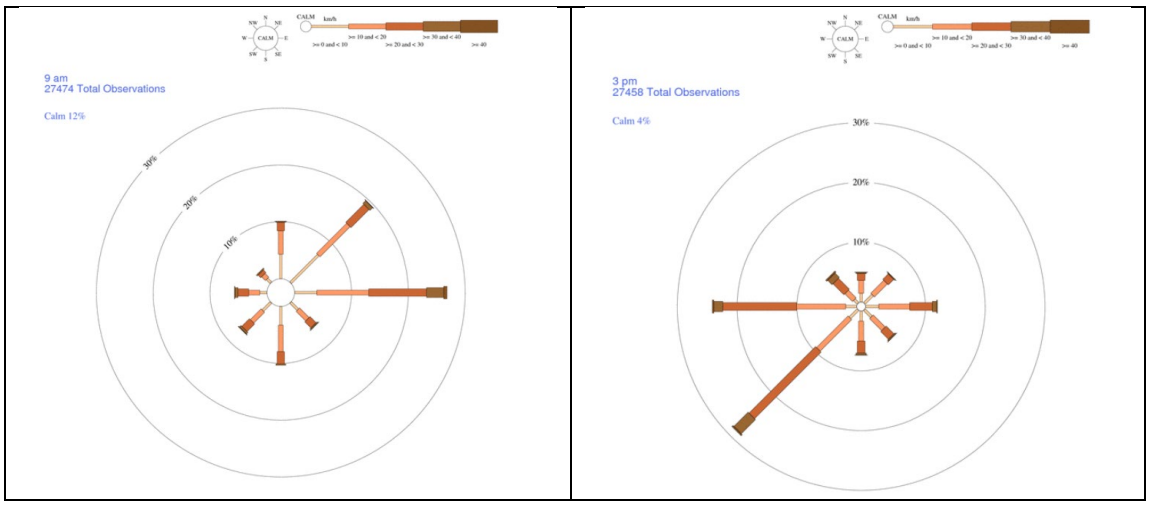


Figure 4: Prevailing winds at Perth aero weather station, 9am and 3pm
Source: Perth airport station #009021(BoM, 2024)

4.1.2 Air quality

Ambient air quality is a measure of the cleanliness of the surrounding air and is determined by the types and amounts of pollutants emitted into the atmosphere, and the processes associated with their transport, transformation, mixing and removal from the atmosphere.

Examples of pollution sources include smoke from bushfires, hydrofluorocarbons (HFCs) (e.g., cooling agents commonly found in air conditioning and refrigeration systems), windblown dust, and biogenic emissions from vegetation (pollen and mould spores). The most common air pollutants of ambient air include particle matter (PM_{10} and $PM_{2.5}$).

The World Health Organization (WHO) established global guidelines for air quality in 2005 which were revised in 2021. The guidelines provide quantitative health-based recommendations for air quality (AQG levels), expressed as long- or short-term concentrations of key air pollutants including Particulate Matter (PM_{10} and $PM_{2.5}$), Ozone, Nitrogen Dioxide, Sulfur Dioxide and Carbon Monoxide (WHO, 2021). Table 2 summarises WHO AQG levels (2021) and provides a conversion to parts per million (ppm) for easy comparison to National Environment Protection Measure (NEPM) targets presented in Table 3.

Table 2: World Health Organisation Air Quality Guideline levels (AQG levels), 2021

Pollutant	Averaging Period	AQG level (2021) (also given in ppm for comparison to NEPM)	
Carbon Monoxide	1 day [a]	4 mg/m^3	(3.49 ppm)
Nitrogen Dioxide	1 day [a]	25 µ/m^3	(0.01 ppm)
	1 year	10 µ/m^3	(0.005 ppm)
Photochemical Oxidants (as Ozone)	Peak season [b]	60 µ/m^3	(0.03 ppm)
	8-hour [a]	100 µ/m^3	(0.05 ppm)
Sulfur Dioxide	1 day [a]	40 µ/m^3	(0.015 ppm)
Particle Matter as PM_{10}	1 day [a]	45 µ/m^3	
	1 year	15 µ/m^3	
Particle Matter as $PM_{2.5}$	1 day [a]	15 µ/m^3	
	1 year	5 µ/m^3	

Note: Annual and peak season is long-term exposure, while 24 hour and 8 hour is short-term exposure.
a 99th percentile (i.e. 3-4 exceedance days per year).
b Average of daily maximum 8-hour mean O3 concentration in the six consecutive months with the highest six-month running-average O3 concentration.

The National Environment Protection (Ambient Air Quality) Measure (NEPM) is a national framework to measure and monitor Australia's ambient (outdoor) air quality, first established by the Australian Government in 1998 and most recently varied in 2021. The NEPM includes national standards for key pollutants; Carbon Monoxide, Nitrogen Dioxide, Photochemical Oxidants (as Ozone), Sulfur Dioxide, Lead, and Particles (as PM_{10} and $PM_{2.5}$). Table 3 summarises NEPM Air Quality Criteria, (2021).

Table 3: National Environment Protection Measure (NEPM) Air Quality Particle Criteria, 2021

Pollutant	Averaging Period	Maximum concentration
Carbon Monoxide	8 hours	9.0 ppm
Nitrogen Dioxide	1 hour	0.08 ppm
	1 year	0.015 ppm
Photochemical Ooxidants (as ozone)	8 hours	0.065 ppm
Sulfur Dioxide	1 hour	0.10 ppm (0.075 ppm from 2025)
	1 day	0.02 ppm
Lead*	1 year	0.50 µ/m^3
Particle Matter as PM_{10}	1 day	50 µ/m^3
	1 year	25 µ/m^3
Particle Matter as $PM_{2.5}$	1 day	25 µ/m^3 (20 µ/m^3 from 2025)
	1 year	8 µ/m^3 (7µ/m^3 from 2025)

Note: There are no maximum allowable exceedances.
**Lead has not been monitored in Perth since 2001 as the average lead level in Perth was very low at less than 5% of the NEPM Standard.*

DWER is responsible for the operation and maintenance of 16 air quality monitoring sites (AQMS) in WA. One of these sites is located within the City of Armadale, nine others are within the Greater Perth region, and the remaining six sites are located regionally. These sites monitor one or more of a range of pollutants such as Ozone (O_3), Nitrogen Dioxide (NO_2), Carbon Monoxide (CO), Sulfur Dioxide (SO_2), Particles less than 10 micrometres in diameter (PM_{10}) and Particles less than 2.5 micrometres in diameter ($PM_{2.5}$). The Armadale site monitors particles (as PM_{10} and $PM_{2.5}$) only.

A summary of data obtained from the Armadale AQMS, which was installed by the City of Armadale in collaboration with state agencies, is presented in Table 4 and Figure 5. Data obtained from Caversham, as a comparable site where a broader range of pollutants are monitored, indicates that exceedances of other pollutants are rare with ozone being the most common. Ozone and Particulate exceedances are typically associated with bushfires and prescribed burns which are classified as exceptional events and are not included in the NEPM air quality goal assessment (DWER, 2022). Another common cause of Particulate exceedances is wood heaters.

Table 4: Air particle monitoring summary (24-hour averages)

	PM_{10} (µ/m3)			$PM_{2.5}$ (µ/m3)		
Year	Maximum (24h average)	Target exceedances NEPM	WHO	Maximum (24h average)	Target exceedances NEPM	WHO
2020	31.2	0	0	26	1	3
2021	96.2	2	2	88.6	6	19
2022	189.3	4	5	180.7	7	14
2023	143.5	5	8	139	20	81
2024*	57	2	4	41.5	10	28

Source: DWER March 2024
**Data for January to March 2024 only.*

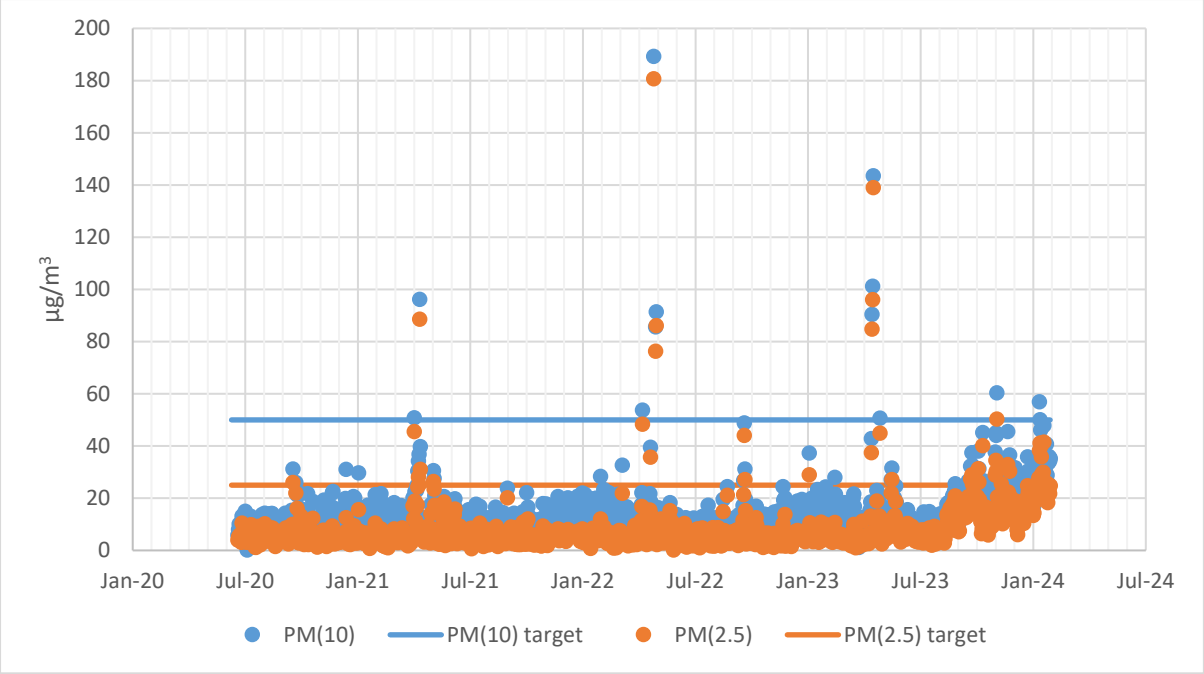


Figure 5: Air quality monitoring data (24-hour) with NEPM targets (2020-2024)
Source: Armadale AQMS (DWER, 2024)

Annual air quality monitoring reports are prepared by DWER, reporting on monitoring undertaken in WA for the NEPM. The latest available annual report containing data collected in 2021 indicates that the two exceedances of the 24-hour NEPM target for PM_{10} and five of the exceedances for $PM_{2.5}$ were associated with prescribed burns. Prescribed burns are classified as exceptional events and are not included in the NEPM air quality goal assessment. Therefore, there was only one included exceedance at Armadale in 2021 which was indicated as being associated with wood heaters (DWER, 2022).

Accordingly, the monitoring data indicates the City of Armadale generally experiences good air quality, below NEPM targets for Particulates (PM_{10} and $PM_{2.5}$) although there have been more frequent exceedances recorded since 2021 and an apparently increasing trend is visible in Figure 5 since 2021 although the causes of this increase are not known. Future trends are uncertain, with increased population and urbanisation likely to increase emissions. Technological improvements such as switching to alternative fuels, may help to reduce air pollution.

The City's website includes a page that provides information about wood heaters and guidance on chimney maintenance, and also enables community members to request investigation of wood smoke from neighbouring properties. The site encourages customers to try and resolve issues directly with their neighbour initially however if that does not resolve the issue, an investigation request form is provided and once this is received, the City will undertake an investigation. <<*https://www.armadale.wa.gov.au/wood-heaters*>>

For the period 1 July 2021 to 30 June 2023 the City received twenty 'smoke from wood heater' complaints and from 1 July 2023 to March 2024 the City received four complaints.

4.2 Soil and land

This section provides a summary of soil and land conditions prevalent in the City of Armadale and some key issues that influence soil and land quality. This includes information on the City's urban forest assets and their relationship with urban heat, noting the links to climate information discussed previously in Section 4.1. This section also discusses on-site wastewater disposal systems and sewage sensitive areas, noting the connections with protection of groundwater, wetlands, and waterways, which are discussed further in sections 4.3 and 4.4.

4.2.1 Topography

The City of Armadale includes areas of Swan Coastal Plan, Darling Scarp, and Darling Plateau landforms. Approximately 10% of the City of Armadale lies on the Swan Coastal Plain and varies in elevation from 20 to 30 metres Australian Height Datum (AHD). Eastward of the coastal plan, there is a relatively narrow strip of foothills (approximately 5% of the City) before the Darling Scarp rises from the Plain from approximately 60m AHD to 240m AHD on the Darling Plateau. The upper reaches of the Daring Plateau ranges from 250 to 410m AHD (Local Planning Strategy, 2015) as shown in Figure 6.

4.2.2 Geology

Broad scale geological mapping is provided in Figure 7 with an explanation of the geological units provided in Table 5.

The study area is located within the Perth Basin, a north trending sediment-filled trough extending approximately 1000 km along the south-western margin of the Australian continent. Rifting of the continental plates and deposition of sediments commenced in the early Permian age along the Darling Fault, culminating in the separation of Greater India from Gondwana by the Early Cretaceous. Post break-up tectonic activity abated, and the Perth Basin subsided. Sediment deposition has continued episodically though to the current day in progradational shallow water and fluvial environments (Pennington Scott 2009).

The Darling Scarp (Darling Fault) provides a distinct line of separation between the Archean Yilgarn Craton to the east and the Mesozoic to Canozoic deposits of the Swan Coastal Plain to the west. The geomorphic units of the Swan Coastal Plain within the study area are the Bassendean Dune System and the Pinjarra Plain supported by Bassendean sands, Guildford formation and colluvium.

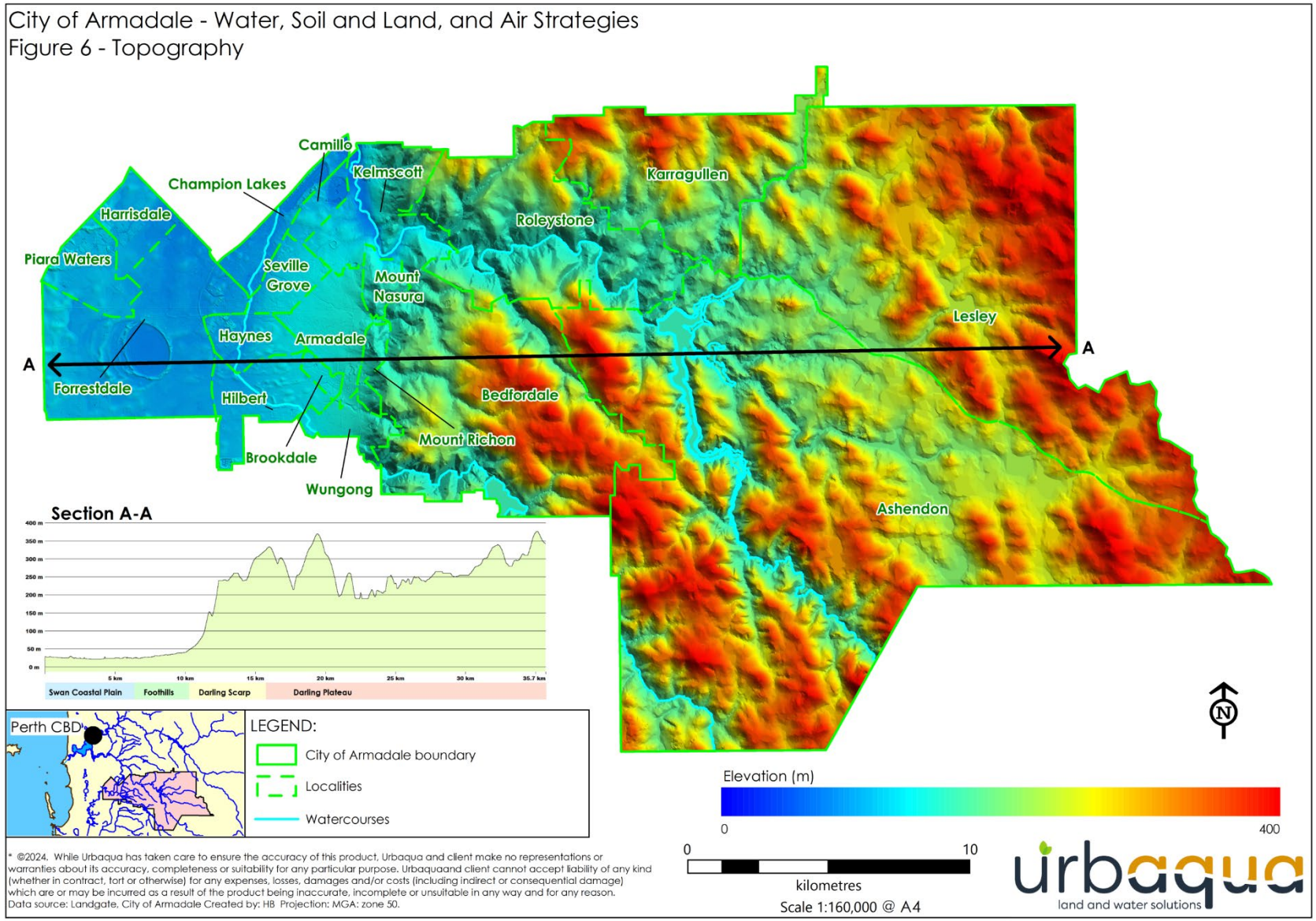


Figure 6: Topography

Table 5: Surface geology

Symbol	Name	Geological age	Description
Ag	Felsic intrusives 74292	Archean	Undifferentiated felsic intrusive rocks, including monzogranite, granodiorite, granite, tonalite, quartz monzonite, syenogranite, diorite, monzodiorite, pegmatite. Locally metamorphosed, foliated, gneissic. Local abundant mafic and ultramafic inclusions
An	Gneiss, granulite, migmatite 74310	Archean	Banded granitic gneiss (monzogranitic to granodioritic), quartzofeldspathic gneiss with mafic bands, migmatite, granofels, mafic and felsic granulites, hypersthene-plagioclase-quartz granulite; schist, pelitic or mafic granofels
Czl	Ferruginous duricrust 38498	Cenozoic	Pisolitic, nodular or vuggy ferruginous laterite; some lateritic soils; ferricrete; magnesite; ferruginous and siliceous duricrusts and reworked products, calcrete, kaolinised rock, gossan; residual ferruginous saprolite
Czs	Sand plain 38499	Cenozoic	Sand or gravel plains; quartz sand sheets commonly with ferruginous pisoliths or pebbles, minor clay; local calcrete, laterite, silcrete, silt, clay, alluvium, colluvium, aeolian sand
Nsca	Cardup Group	Neo-proterozoic	Shale, conglomerate, quartzite, sandstone
Qag	Guildford Formation	Middle Pleistocene	Alluvial sand and clay with shallow-marine and estuarine lenses and local basal conglomerate
Qdcb	Bassendean Sand	Middle Pleistocene	Basal conglomerate overlain by dune quartz sand with heavy mineral concentrations
Qrc	Colluvium 38491	Quaternary	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

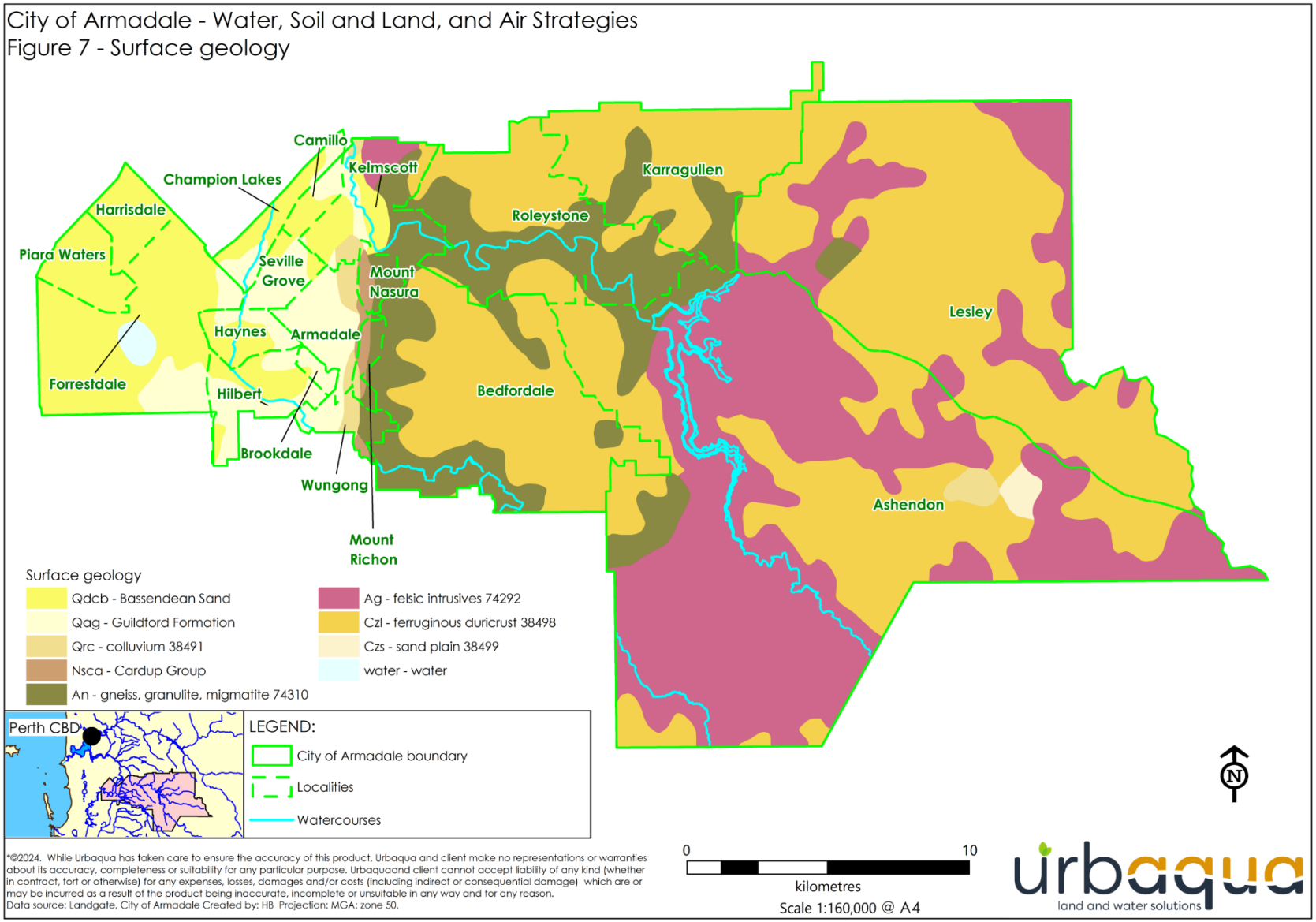


Figure 7: Surface geology

4.2.3 Soils

Broad soil landscape zones are presented in Figure 8. The study area has been characterised by the Department of Primary Industries and Regional Development (DPIRD)(Bolland 1998) as having five soil landscape zones, summarised in Table 6.

Table 6: Soil landscape zones of the strategy area (Bolland 1998 and Moore 2004)

Soil/landscape zone	Description	Permeability	Nutrient retention
Bassendean dunes (Swan Coastal Plain)	These are the oldest of the three dune systems, thought to be about 800,000 years old, and so are the most leached, infertile and acidic. The sands contain little silt or clay, and very low levels of nutrient elements, with any nutrient element content being associated with organic matter. The dunes are low lying hills with poorly drained areas between the hills The depth to groundwater varies from close to the surface to at most 10 m below the surface.	high	low
Pinjarra plain (Swan Coastal Plain)	The soils of the Pinjarra plain are complex and comprise a successive layering of soils formed from erosion of material from the scarp and east of the scarp. Rivers and streams have mostly carried the eroded material, which is deposited from the water as fans of alluvium. Therefore, the plain, is made up of layers of soils of different ages. It occupies about one third of the Swan Coastal Plain, and most of it has been cleared and sown to pasture for the grazing industries, mostly dairy, with some beef. Only small remnants of the indigenous (native) vegetation remain.	low	moderate/ high
Undulating foot slopes of the Darling and Whicher Scarps.	Undulating foot slopes of the Darling and Whicher Scarps. Duplex sandy gravels, pale deep sands and grey deep sandy duplexes. Woodland of *E.marginata*, calophylla and wandoo and some *B.grandis*.	moderate	low
Western Darling Range (Darling Plateau)	Described as an extensive undulating lateritic plateau (Darling Plateau) which is largely intact. The plateau has deeply incised valleys where it has been dissected by the major river systems of the inland zones. The western boundary is the Darling Scarp. To the east there is a gradual increase in dissection as this zone grades into the Eastern Darling Range Zone (Moore 2004). Soil patterns of the Western Darling Range Zone relate to the amount of erosion and valley forms (Mulcahy et al. 1972). Soils are mainly formed on laterite (mainly over granite, some dolerite) and colluvium (mainly from laterite) on the plateau and from rock weathered in situ (granite, gneiss, dolerite) in the incised valleys. On the plateau surface, gravels overlying duricrust are dominant (e.g. shallow gravels, moderately deep sandy gravels and loamy gravels). Pale deep sands and yellow deep sands are also found. Loamy earths and brown loamy duplex soils have formed on freshly exposed rock in valleys.	low	high
Lateritic plateau	Duplex sandy gravels, loamy gravels and wet soils. Jarrah-marri-wandoo forest and woodland.	low	high

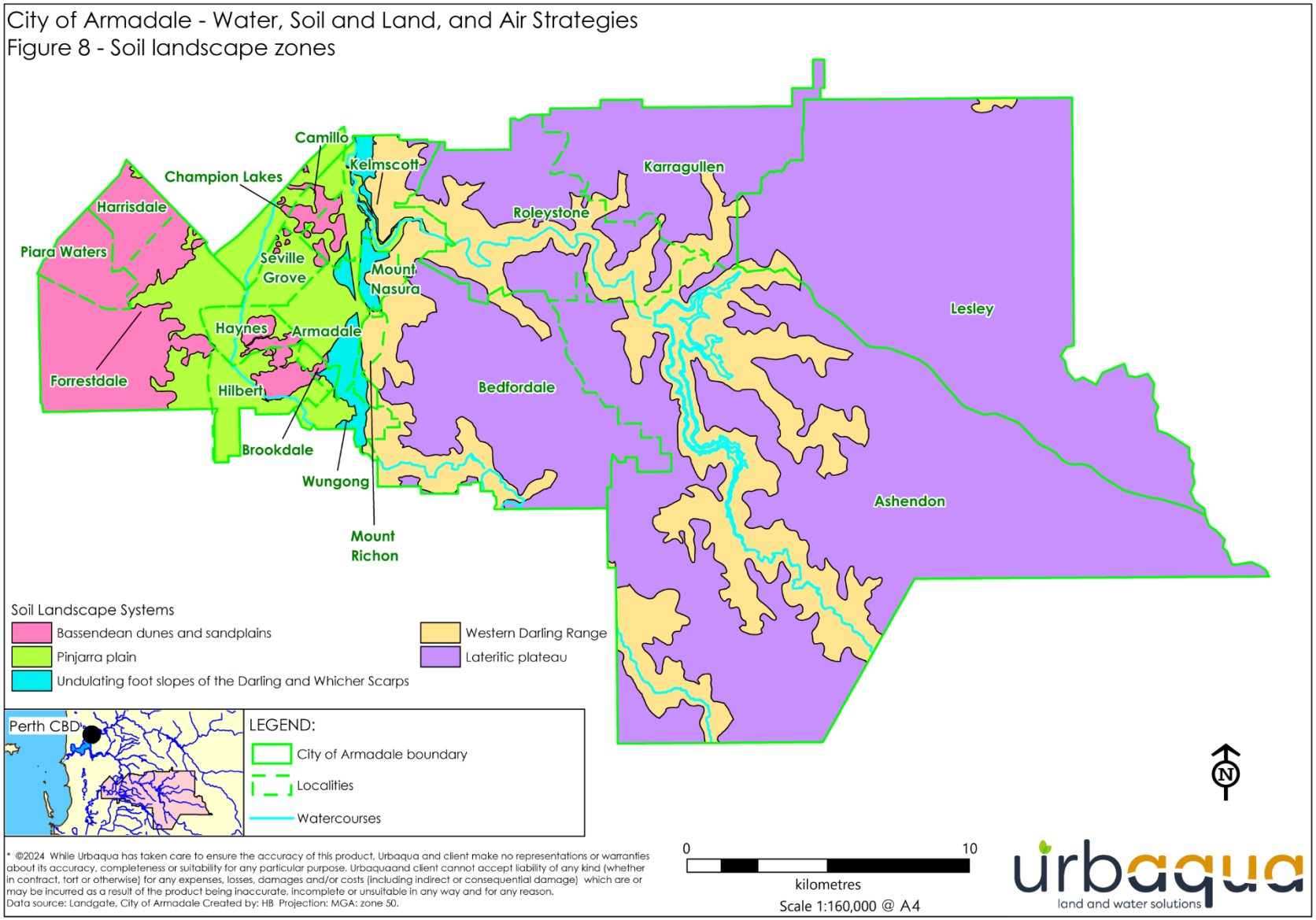


Figure 8: Soil landscape zones

4.2.4 Land quality and capability

DPIRD also provides data on soil landscape land quality and land capability. Issues which have the potential to impact on environmental values include soil and water erosion, poor drainage and nutrient export. Mapping of soil units with these qualities is shown in Figure 9.

Large areas of the City have the potential to be affected by soil and water erosion, poor drainage and nutrient export. The key receptors for eroded soils and exported nutrients are waterways and runoff from streets into urban drainage systems is the key transport mechanism. Therefore, these issues are addressed through discussion of surface water quality (nitrogen, phosphorus, and suspended solids) in Section 4.4.5 and management and maintenance of roads (Section 5.3.1) and drainage systems (Section 5.4.3).

4.2.5 Basic raw materials

There is limited supply of basic raw materials (BRM) in the area as no significant geological supplies, extraction areas or exclusion areas as referred to in *State Planning Policy 2.4: Basic Raw Materials* (2021) occur in the City. The closest BRM resources are located in the adjacent municipalities of Gosnells and Serpentine Jarrahdale. An estimated 90 per cent of all extracted BRM is used in commercial and residential development and demand is increasing.

4.2.6 Onsite wastewater treatment systems

The City's Health Service has a register of all approved onsite wastewater systems which include septic tanks and alternative treatment units (ATUs). Since 2004 to date a total of 466 ATU's and Secondary Treatment Units, and 1,216 septic tanks and leach drains, have been approved by the City.

Service agreements and service reports are required to be provided to the City by service contractors for ATUs, although currently there is no notification process if the ATU quarterly service has not been completed. Received service reports are checked by the Health Administration Team and any service reports that need follow up are assigned to an Environmental Health Officer (EHO). EHOs then contact the service provider to check if the issue has been rectified or if the owner has organised this to be completed. If not, correspondence is sent to the owner for the works to be completed within a specified deadline/ next service.

The City also maintains a record of complaints related to onsite wastewater systems. For the period 1 July 2021 to 30 June 2023 the City received sixty wastewater system complaints and from 1 July 2023 to March 2024 the City received twenty-one complaints.

4.2.7 Acid sulfate soils

DWER has compiled broad-scale risk maps for the Swan Coastal Plain where a high or moderate probability of acid sulfate soil occurrence has been identified. The maps, provided as Figure 10, describe two risk categories:

- Class 1 - (red/pink) high to moderate risk of acid sulfate soils occurring within 3m of natural soil surface.
- Class 2 - (orange) moderate to low risk of acid sulfate soils occurring within 3m of natural soil surface but high to moderate risk of acid sulfate soils beyond 3m of natural soil surface.

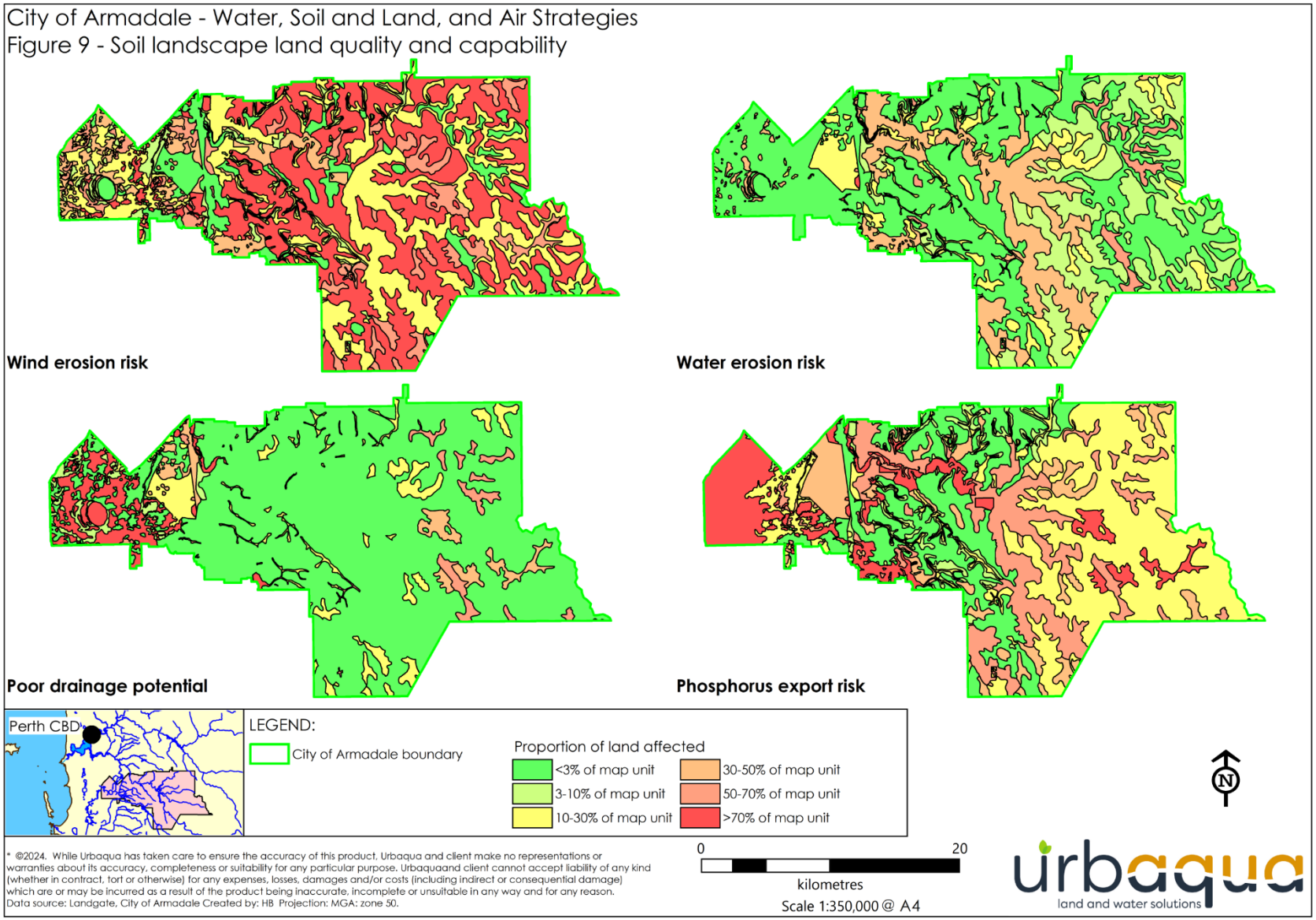


Figure 9: Land quality and capability

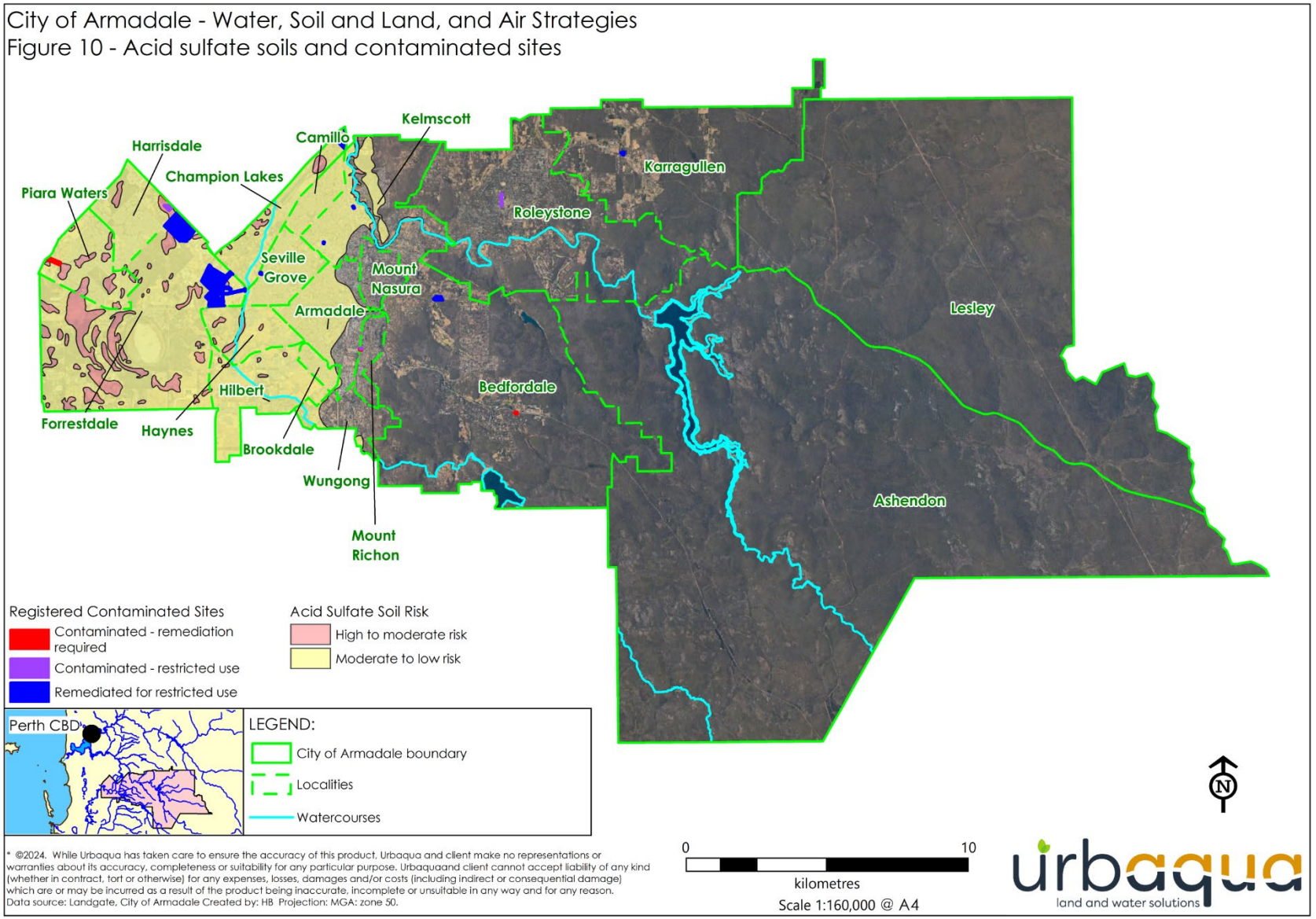


Figure 10: Acid Sulphate Soils and contaminated sites

Figure 10 suggests the presence of soils with high to moderate risk of acid sulphate soils occur largely in proximity to Forrestdale, Piara Waters, Harrisdale, Kelmscott, Haynes and Hilbert.

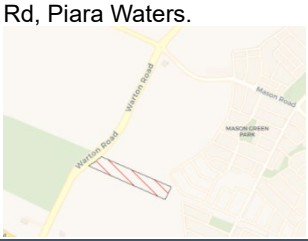
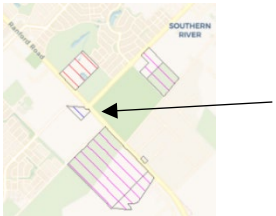
Remaining areas of the Swan Coastal Plain show moderate to low risk of acid sulphate soil occurring within 3m of natural soil surface but high to moderate risk of acid sulphate soil beyond 3m of natural soil surface.

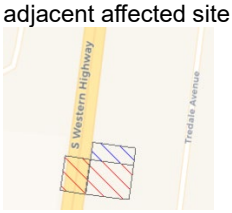
4.2.8 Contaminated sites and light industry inspections

There are 170 individual lots registered on the DWER's Contaminated Sites Database within the City of Armadale. Of these, four are classified as 'Contaminated – remediation required', five are classified as 'Contaminated – restricted use' and the remainder are classified as 'Remediated for restricted use'. In some cases, lots are identified as source sites or affected sites and contamination from a single source may affect several lots. In other cases, where lots have been remediated and then subsequently subdivided for development purposes, there may be numerous connected lots that remain listed individually but relate to a single original source site (Figure 10).

Table 7 provides summary details for 'Contaminated – remediation required' and 'Contaminated – restricted use' lots in the City of Armadale. Other sites reported to DWER, including sites awaiting classification are recorded separately by DWER and have not been mapped.

Table 7: Contaminated sites

Site	Record
Lot 50 on Diagram 79347, at 681 Albany Highway, Bedfordale. Yule-Du Roadhouse/Service Station 	**Contaminated - Remediation Required**. Date classified 13 July 2011. According to (DWER-055) records, hydrocarbons (such as from petrol and/or diesel) are present in groundwater as a plume extending from beneath the Source site in a north-westerly direction to beneath the adjacent road reserve. Other than for analytical testing or remediation, groundwater abstraction is not permitted at this site because of the nature and extent of groundwater contamination. Due to the presence of hydrocarbons in soils, DEC recommends that a site-specific health and safety plan be developed to address the health risks associated with soil impact at the site. At the time of classification, the groundwater impact was present as a plume beneath the site which had migrated off-site approximately 50 metres in a north-westerly direction, beneath the adjacent road reserve.
Lot 88 on Plan 65829 at 843 Warton Rd, Piara Waters. 	**Contaminated – Remediation required**. Date classified 05 April 2016. According to (DWER-055) records, unauthorised disposal of wastes has occurred on this site. A targeted asbestos investigation has been undertaken at the site and has shown that asbestos-containing material as well as free fibres and fines are present within soils at the site. Anecdotal evidence suggests that landfilling activities have been occurring at the site for over ten years.
Lot 173 on Plan 56607 at 7 Balannup Rd, Harrisdale. – Grace Methodist Church 	**Contaminated Restricted Use**. Date classified 20 July 2017. According to (DWER-055) records, asbestos-impacted soil, and asbestos-containing material (ACM) is buried beneath the eastern portion of the site at a depth of between 0.2 and 2.2 m below ground level. The land use of the site is restricted to rural use. The site should not be developed for a more sensitive use such as recreational open space; residential use or childcare centres without further contamination assessment and/or remediation.

Site	Record
Lot 502 on diagram 93609, 174 South Western Highway, Mount Richon and Lot 37 on Plan 6723, at 170 South Western Highway, Mount Richon Quickstop Service Station plus adjacent affected site  	**Contaminated – Remediation Required.** Date classified 31January 2017. According to DWER records, hydrocarbons (such as from diesel/petrol) are likely to be present in soil beneath underground fuel storage infrastructure and in the zone of seasonal groundwater fluctuations. Hydrocarbons are present in groundwater beneath the site and extend off-site in a north-westerly direction. The land use of the site is restricted to commercial/industrial use, which excludes sensitive uses such as childcare centres and schools. The site should not be developed for a more sensitive use such as residential, public open space, childcare centres and schools without further contamination assessment and/or remediation. Other than for analytical testing or remediation, groundwater abstraction is not permitted at this site because of the nature and extent of groundwater contamination. Affected site is classified Contaminated – restricted use.
11 Wygonda Rd, Roleystone Mobil Service Station plus 2 affected lots  	**Contaminated Restricted Use**. Date classified 20 July 2017. According to (DWER-055) records, hydrocarbons (such as from petrol or diesel), metals (copper, lead and zinc) and nutrients (nitrate) are present in groundwater beneath the site, as a plume which extends off-site to the south beneath Dreyer Road. The land use of the site is restricted to its current land use as a service station. The site should not be developed for a more sensitive land use such as recreational open space, residential use or childcare centres, and the layout of buildings at the site should not be changed, without further contamination assessment and/or remediation. Other than for analytical testing or remediation, groundwater abstraction is not permitted at this site because of the nature and extent of groundwater contamination.

The City has a role in preventing new contaminated sites, both within their own landholdings and through light industry inspections which are conducted in partnership with DWER two days a month depending on staff availability.

Premises for inspections are selected based on health compliance issues and intramaps reviews. A notification letter is sent to a list of premises at least two weeks before the inspection with information and a checklist on light industry assessments.

The types of premises inspected include motor vehicle wreckers, mechanical workshops, machinery repair services, equipment hire and saleyards, spray painting and metal coating facilities, abrasive blasters, cement, concrete and stone producers, chemical mixers and blenders, car washes, dry cleaners, plastic manufacturers.

Inspections focus on activities that may impact the environment, with particular emphasis on chemical storage, waste management and preventing unauthorised discharges. The proprietors/managers are provided with information about environmentally acceptable practices, as well as advice to help avoid breaches of the *Environmental Protection (Unauthorised Discharges) Regulations 2004* and City of Armadale Environment, Animals and Nuisance Local Laws 2002.

Any outstanding items requiring corrective actions are followed up on within a reasonable time frame to ensure compliance with the relevant legislation. If there is evidence of unauthorised discharge, the officers follow a graduated enforcement approach. The City's Health Services team will eventually conduct inspections separate to DWER and will maintain a register of the premises.

For the period 1 July 2021 to 30 June 2023 the City received fourteen complaints and from 1 July 2023 to March 2024 the City received three complaints. All sites were inspected and any issues were resolved as described above.

4.2.9 Native vegetation extent

Figure 11 presents mapping of remnant vegetation in the City of Armadale originally compiled as part of the vegetation theme of the National Land and Water Resource Audit (NLWRA) derived from 1995 LandSat TM satellite imagery and corrected using digital aerial photography (orthophotos) acquired for 1996 to 2006. The dataset was progressively updated by the Department of Agriculture post-NLWRA with assistance the Department of Conservation and Land Management until 2020. No further updates are planned.

Based on this mapping, Table 8 provides an assessment of the percentage of cleared land, remnant vegetation, and regrowth vegetation in the City of Armadale via suburb.

Table 8: Cleared land in the City of Armadale (2020)

Suburb	% Cleared land (2020)	% remnant vegetation	% regrowth above 20% cover
Armadale	99.73%	0.23%	0.04%
Ashendon	4.86%	92.96%	2.18%
Bedfordale	25.64%	72.90%	1.46%
Brookdale	100.00%	-	-
Camillo	98.33%	1.67%	-
Champion Lakes	94.54%	3.80%	1.66%
Forrestdale	62.70%	34.03%	3.27%
Harrisdale	76.71%	21.71%	1.58%
Haynes	92.14%	7.86%	-
Hilbert	94.39%	3.43%	2.18%
Karragullen	21.67%	76.75%	1.59%
Kelmscott	70.83%	26.57%	2.60%
Lesley	0.62%	99.38%	-
Mount Nasura	91.41%	8.51%	0.08%
Mount Richon	87.03%	12.96%	0.02%
Piara Waters	90.97%	8.25%	0.78%
Roleystone	44.02%	53.15%	2.83%
Seville Grove	96.84%	2.81%	0.35%
Wungong	68.07%	30.68%	1.25%
Overall City of Armadale	23.73%	74.66%	1.61%

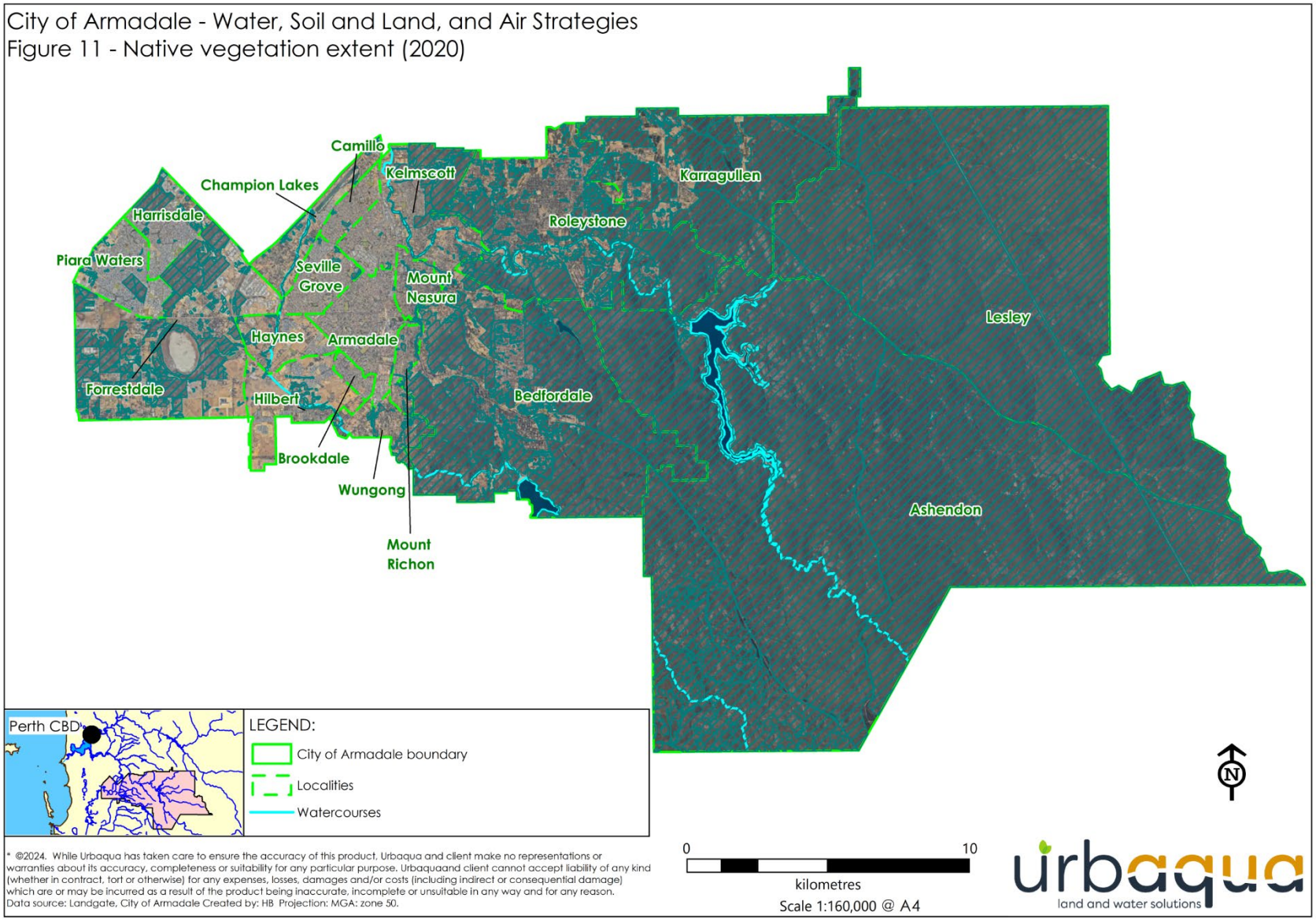


Figure 11: Native vegetation extent (2020)

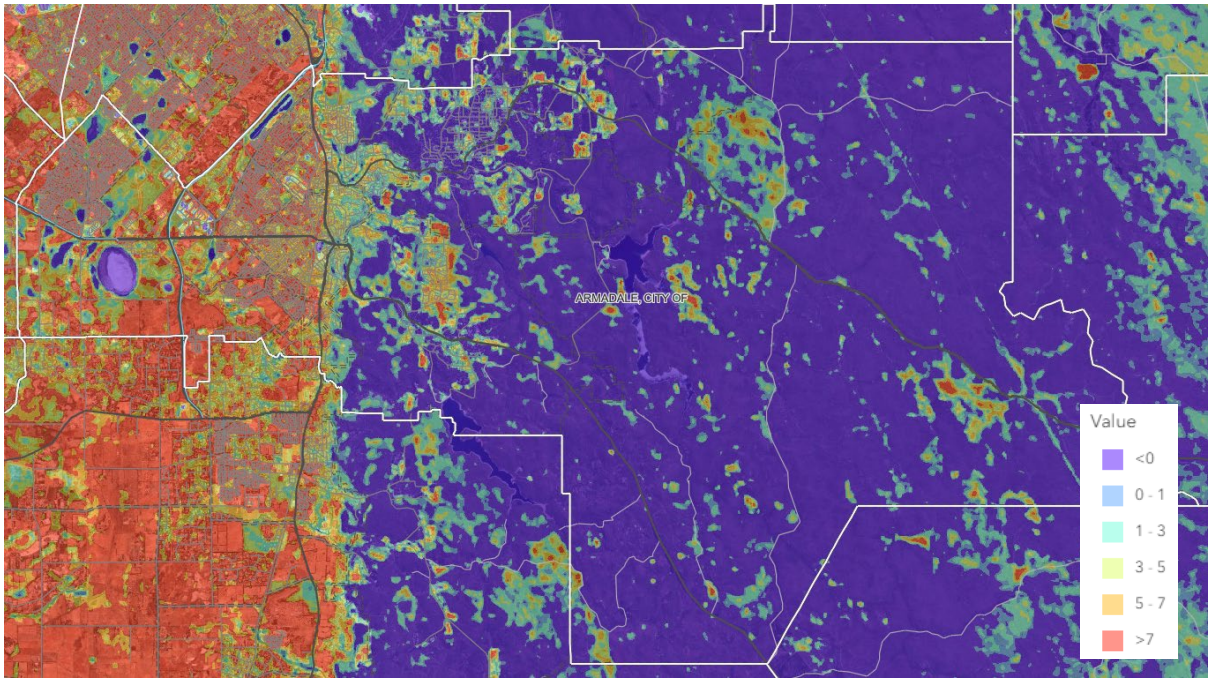
4.2.10 Land surface temperature

The City is monitoring land surface temperatures across the municipality through data obtained from the CSIRO Landsat satellite. Figure 12 shows images from the satellite on 15 December 2021, 31 December 2021, 16 January 2022 and 1 February 2022 at 10.05am. Air temperatures at 10am on these days were 24, 28, 26 and 23 degrees Celsius respectively while maximum air temperatures were 27.5, 32.6, 30.7 and 30.9 degrees Celsius respectively.

Figure 12 clearly shows the cooling potential of tree canopy and wetlands as well as the heat generated by cleared and bare land. Interestingly, whilst the difference in air temperature on 31 December 2021 (28 degrees at 10am with a maximum of 32.6) and 1 February 2022 (23 degrees at 10am with a maximum of 30.9) is relatively small (2-5 degrees), the difference in land surface temperature on these two days is larger (over 10 degrees). There were key differences in preceding conditions between these two days that likely contributed to this difference including temperatures over 40 degrees on four of the five days before 31 December 2021 and cool southerly winds during the 24 hours before 1 February 2022.

The Urban Greening Grant Program was created to expand tree canopy and vegetative cover in high urban heat risk areas in 33 Local Governments within the Boorloo (Perth) and Bindjareb (Peel) regions. Funded by DWER and delivered collaboratively with WALGA, the program provides a total of $3.75 million (ex GST) to support additional planting or to bring forward future tree planting in winter 2024 and winter 2025. While the City did not participant in Round 1 of this program, the opportunity is currently being considered for Round 2.

To assist with Urban Greening Grant applications, WALGA have developed urban heat index (UHI) mapping and a UHI rating of 3 or above has been specified as a criterion for grant eligibility. The mapping can be accessed online and most of the Swan Coastal Plain portion of the City of Armadale is rated UHI3 or above, as shown below:



<<https://walga.maps.arcgis.com/apps/mapviewer/index.html?webmap=2451df5130f74a9d92c08cd3b9ba6940>>

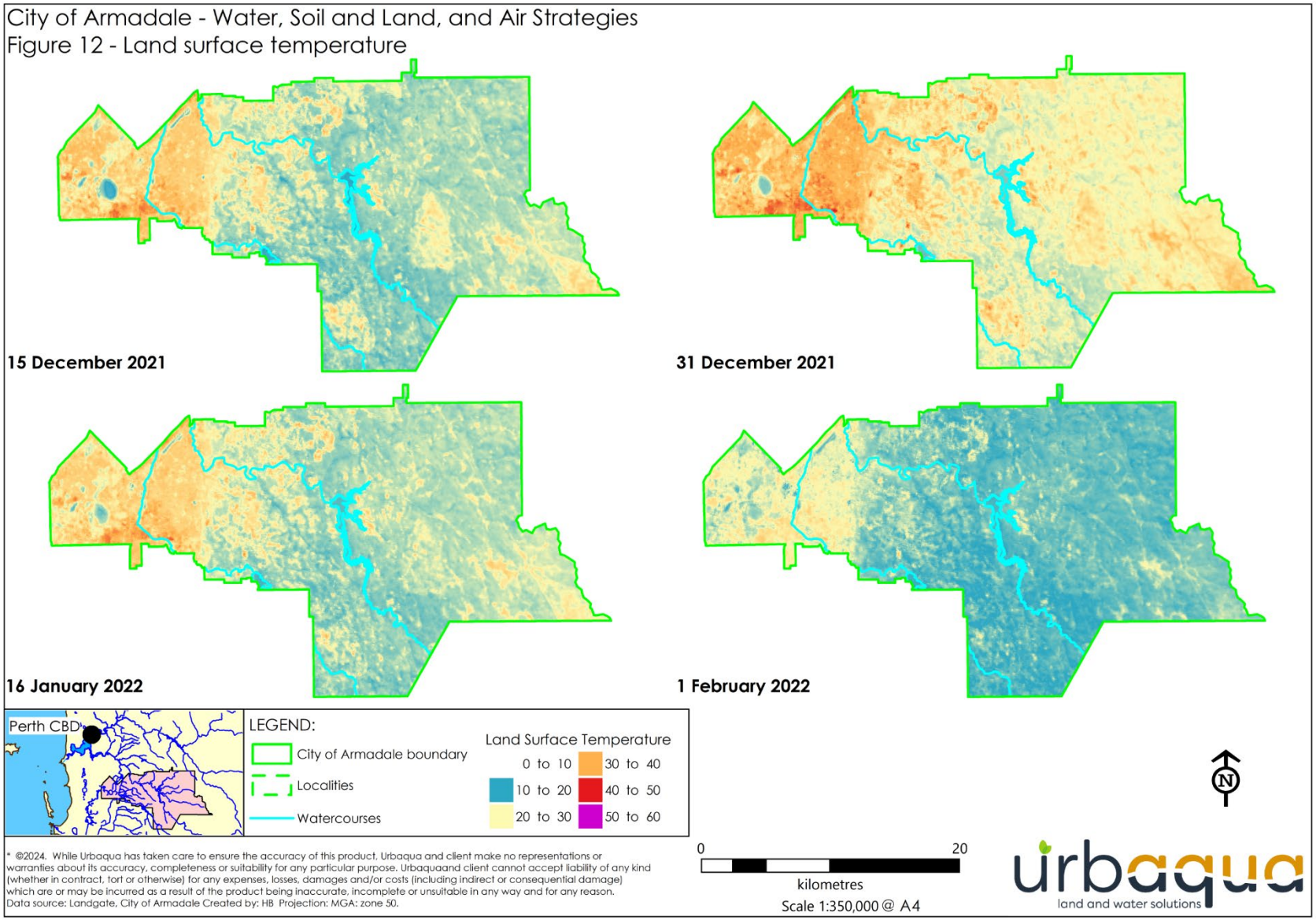


Figure 12: Land surface temperature

4.3 Groundwater

4.3.1 Groundwater levels

DWER data for depth to groundwater levels in superficial aquifers on the Swan Coastal Plan portion of the City are presented in Figure 13. In a large portion of this area, groundwater is shallow and within three metres of the natural ground surface.

Time series plots at selected DWER monitoring sites are also shown in Figure 13 as indicators of groundwater level trends within the City. Most of the selected sites (except JM32) show a fairly consistent declining trend since the 1990's, then stabilising or increasing since around 2010 although in the most recent two years, levels have returned to a declining pattern as shown in Table 9.

Bores located in and adjacent to areas of recent and ongoing urban development (JM23, JM27, JM39, T80) tend to show an increasing trend since the mid 2000's, most likely due to reducing evapotranspiration and increasing recharge in these areas. The four sites outlined in black in Table 9 are recommended as ongoing indicator sites for groundwater levels in the City.

Table 9: Maximum groundwater levels at indicator sites (2020-2023)

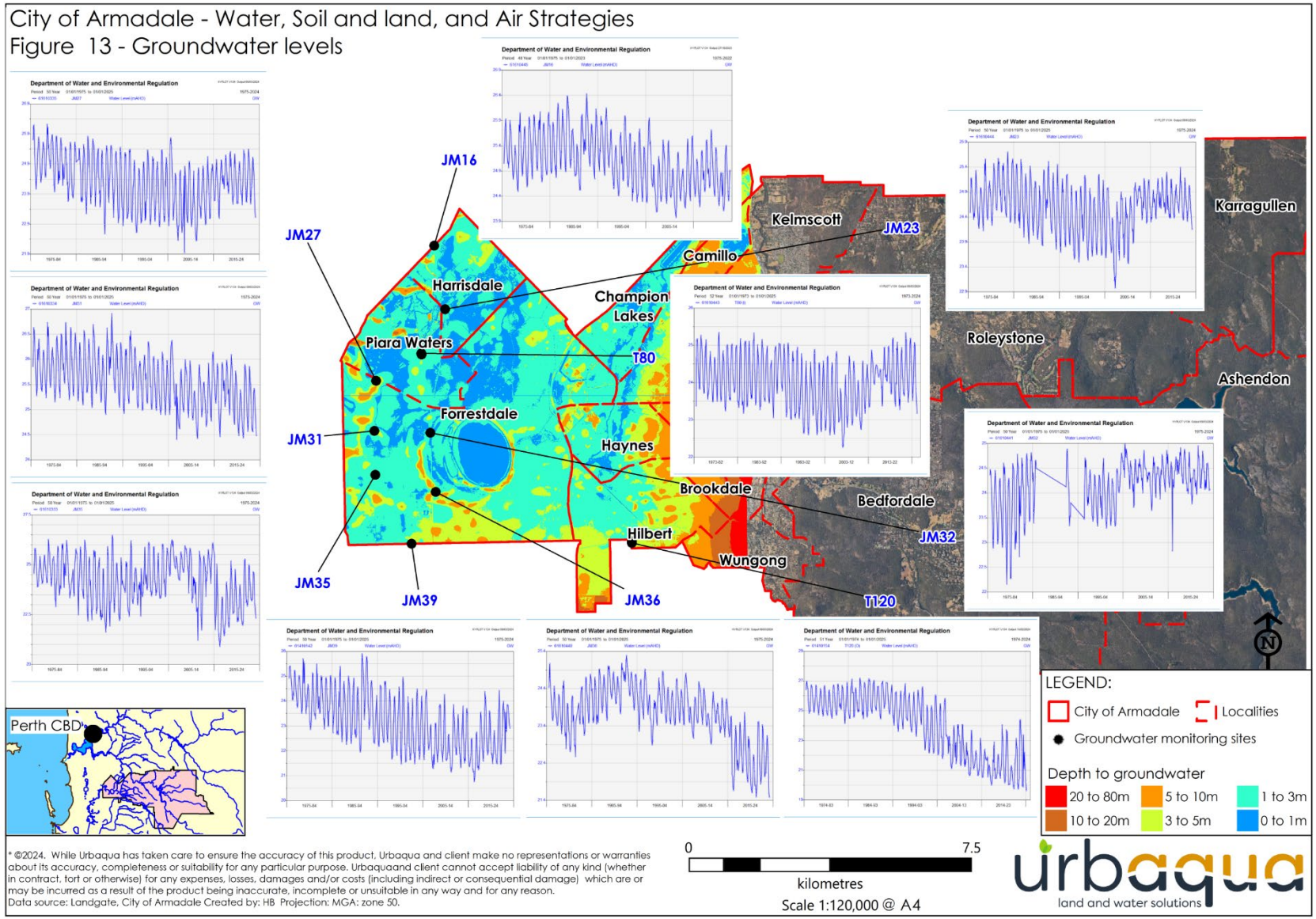
Year	JM39	T120	JM35	JM31	JM27	JM36	JM32	T80	JM23	JM16
2020	22.815	21.293	23.997	25.393	24.968	22.618	24.474	24.942	25.047	24.863
2021	24.425	23.143	25.277	25.898	25.358	23.508	24.949	25.332	25.392	25.408
2022	23.995	24.393	24.992	25.858	25.393	23.423	24.844	25.187	25.183	24.913
2023	23.855	23.383	24.647	25.423	25.123	23.138	24.599	25.077	25.033	

Note: blue shading indicates an increase from the preceding year

4.3.2 Groundwater availability

Limits have been set by DWER for groundwater abstraction to minimise the potential impacts to wetlands and rivers in the future, while sustaining reasonable growth in the region. Table 10 provides information on the committed allocation and remaining volume of groundwater resources crossing the City of Armadale. All existing licensed water entitlements for groundwater resources within the City are ''fully allocated''. The groundwater management subareas are shown in Figure 14.

It is noted the Waterwise Perth Action Plan's target of using 10% less groundwater across the region by 2030 is likely to be applied to individual local governments in the near future. As the allocation limits are reduced for all aquifers, water users will need to become more efficient, using alternative supplies, or trade allowances.



Data source: Landgate, City of Armadale Created by: HB Projection: MGA: zone 50.

Figure 13: Groundwater levels

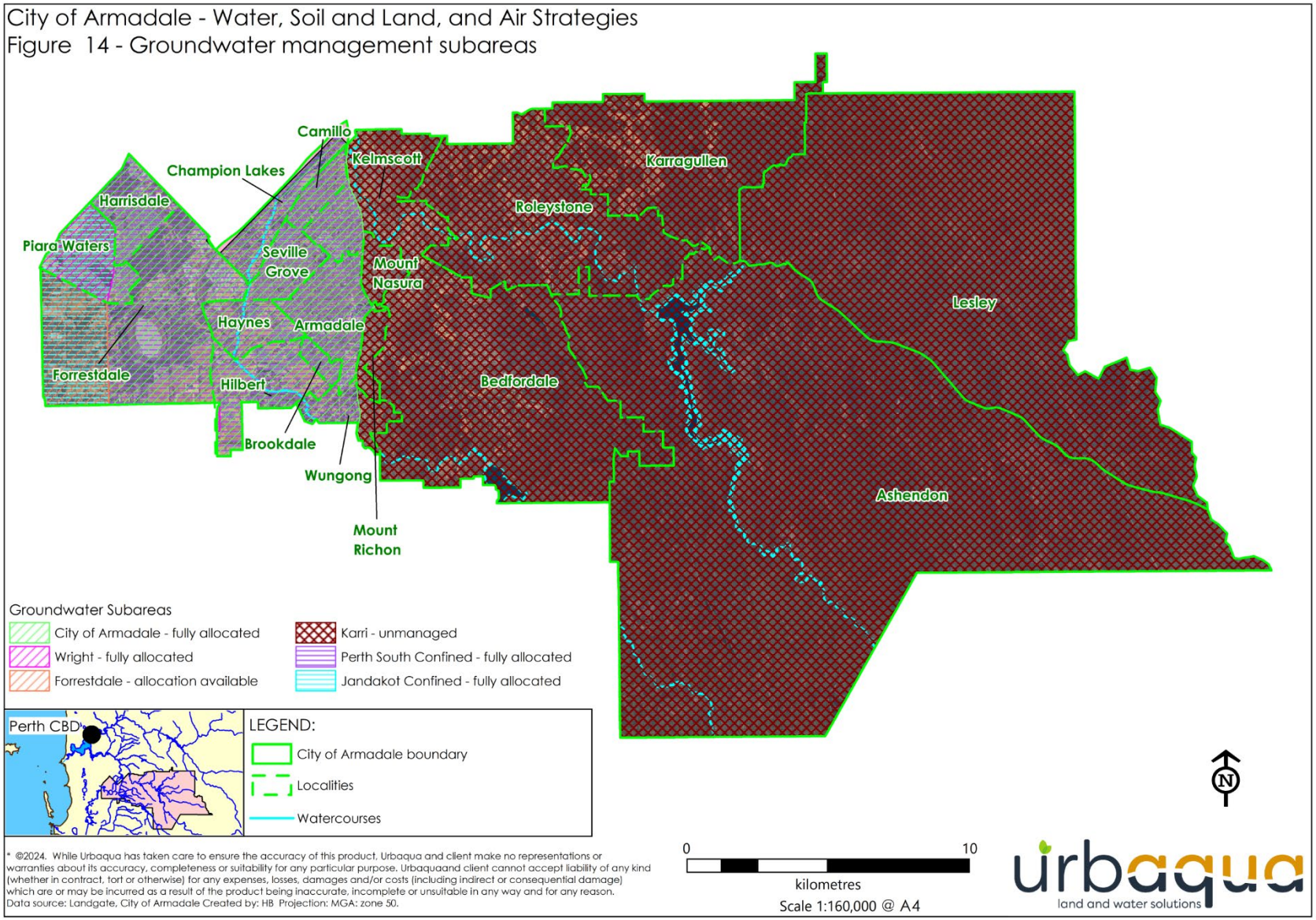


Figure 14: Groundwater management sub-areas

Table 10: Groundwater resource and allocation limits (16 Sep 2022)

Management subarea	Resource	Allocation limit	Allocated volume	Remaining volume	Allocated & committed
Perth South Confined	Perth South Confined, Perth - Yarragadee North.	400,000	801,500	-401,500	200.38%
Perth South Confined	Perth South Confined, Perth - Leederville.	4,500,000	5,941,619	-1,722,394	133.12%
Canning Vale	Jandakot, Canning Vale, Perth - Superficial Swan	310,000	371,248	-61,248	119.76%
City of Armadale	Perth, City of Armadale, Perth - Superficial Swan	3,960,515	4,147,797	-241,782	105.82%
Jarrahdale	Perth, Jarrahdale, Perth Superficial Swan	1,429,405	1,397,492	23,683	97.77%
Forrestdale	Forrestdale, Perth Superficial Swan	910,000	863,000	21,250	94.84%
Wright	Jandakot, Wright, Perth Superficial Swan	910,000	838,888	49,112	92.19%
City of Gosnells	Perth, City of Gosnells, Perth - Superficial Swan	5,484,500	4,388,747	1,095,753	80.02%
Oakford	Jandakot, Oakford, Perth - Superficial Swan	400,000	89,905	310,095	22.48%
Jandakot Confined	Jandakot, Jandakot Confined, Perth - Yarragadee North	0	0	0	0.00%
Karri	Karri, Karri, Combined - Fractured Rock West - Alluvium		470,000	0	0.00%
Karri	Karri, Karri, Combined - Fractured Rock West - Calcrete		0	0	0.00%
Karri	Karri, Karri, Combined - Fractured Rock West - Fractured Rock		45,750	0	0.00%
Karri	Karri, Karri, Combined - Fractured Rock West - Palaeochannel		1,010,000	0	0.00%
Karri	Karri, Karri, Perth - Cattamarra Coal Measures.		0	0	0.00%
Karri	Karri, Karri, Perth - Leederville.		48,650	0	0.00%
Karri	Karri, Karri, Perth - Superficial Swan		0	0	0.00%
Karri	Karri, Karri, Perth - Yarragadee North.		0	0	0.00%
		18,304,420	**20,416,096**	**-1,177,031**	**112.04%**

(source: DWER Resource Allocation Report)

4.3.3 Groundwater quality

There are two ongoing district scale water quality monitoring programs being undertaken in the City of Armadale. Predominantly, these monitoring programs are aimed at providing an assessment of surface water quality impacts to the downstream Swan-Canning River system from the developing catchments of the Southern River including Forrestdale Main Drain and the Wungong River as described in Section 4.4.5. However, both programs also include

groundwater quality monitoring and a summary of groundwater quality at selected indicator sites is presented in Figure 15.

4.3.3.1 Forrestdale Groundwater Quality Summary

A network of 40 bores are monitored as part of the Forrestdale groundwater monitoring program. Five sites, distributed throughout the study area, were chosen to summarise the general groundwater quality trends in the area (XX8, XX9, XX11, XX16, and XX17).

The majority of groundwater sites exceed total nitrogen (TN) and total phosphorus (TP) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018, previously ANZECC & ARMCANZ 2000) default guideline values (DGVs) within the Forrestdale monitoring area. While significant variation in nutrient concentrations has been observed since 2015, analysis of overall mean annual nitrogen suggests that the post-development monitoring program began near the peak of the export of non-point source legacy nutrients resulting from historic landuse in the study area.

Data indicates a slowly decreasing trend of nitrogen levels in groundwater discharging from the study area. Analysis suggests that it takes a minimum of 5-10 years for legacy nutrients to be discharged from development sites with soil and drainage conditions such as observed in the Forrestdale Development Area. Ongoing monitoring will provide further information as to when nutrient export levels in the study area are likely to return to baseline levels. TN trends are displayed on Figure 15, showing selected groundwater quality indicator sites and total nitrogen results since 2015. This decreasing trend is not so evident for phosphorus, with concentrations either maintained or slightly declining since 2015. This is shown in Figure 15.

In addition to general temporal trends, major nutrient hotspots have been identified within the area. Results at these hotspots suggest that either historic landuse activities are continuing to act as a slow-release point source of nutrients, or current land management activities around the bores are resulting in the continued release of nutrients into the local groundwater system.

Elevated concentrations of some dissolved heavy metals (aluminium, copper, iron and zinc) continue to be recorded but are not considered to be of concern or require further investigation.

4.3.3.2 Wungong Groundwater Quality Summary

Four (4) groundwater bores (SRCS01D, F-MB06a, BRM11, and BRM12) have been sampled as part of the Wungong groundwater monitoring programme since 2013, although it is noted BRM11 is located just outside of the City of Armadale. Results are summarised as follows:

- Annual average TN concentration in groundwater data since 2013 indicates no significant trends. Results at SRCS01D and F-MB06a are generally below the ANZG DGV (1.2 mg/L), whereas sites BRM11 and BRM12 record spikes above these.
- Annual average TP concentrations have generally increased since 2013, with most sites consistently displaying TP concentrations above the ANZG DGV (0.065 mg/L).

Unlike in Forrestdale, the Wungong groundwater monitoring sites are mainly (except for FMB06a) located outside of developed or developing land. Nutrient concentrations measured in groundwater samples from bores in the Wungong project area have been generally high which is typical of groundwater in parts of the Swan Coastal Plain that have been historically developed as rural smallholdings or used for horticulture.

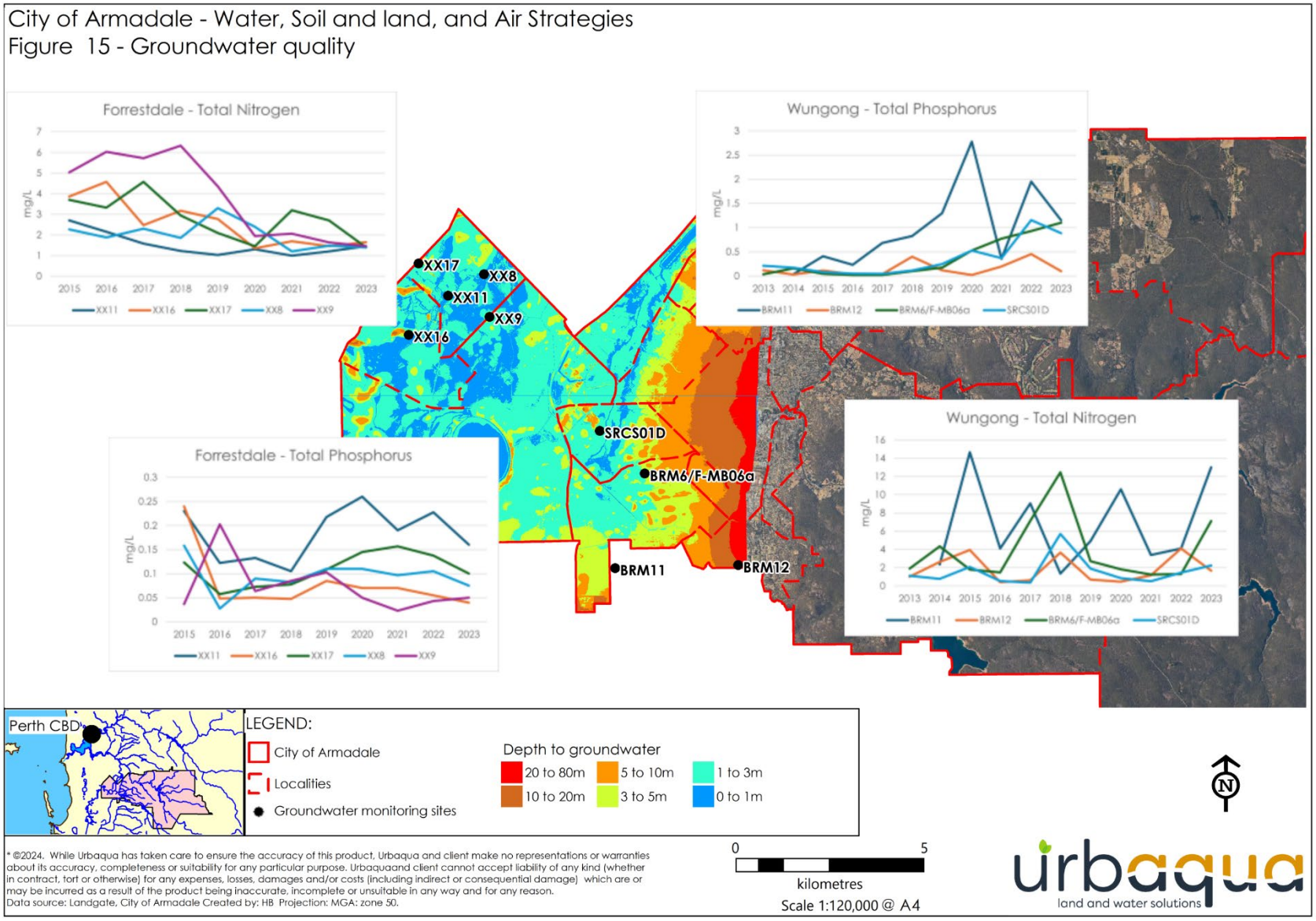


Figure 15: Groundwater quality

4.4 Surface water

4.4.1 Waterways

The natural watercourses in the City of Armadale are the Canning River, Neerigen Brook, Wungong Brook and Southern River (Figure 16). The Canning River is a major feature of the Darling Scarp and Darling Ranges portion and exits the City to the northern lower reaches at Kelmscott. The Wungong River bisects the Swan Coastal Plain portion of the City and extends from the hill's catchments on the City southern boundary to the west across South West highway where it continues to the north to exit the City at Champion Lakes and joins the Southern River, a tributary of the Canning River located in the City of Gosnells. Smaller water courses arise in the Darling Scarp and Darling Ranges and become tributaries of the Wungong and Canning Rivers (Local Planning Strategy Town Planning Scheme No 4, 2015).

Time series plots at a selection of DWER gauging stations are shown in Figure 16 as indicators of streamflow trends within the City. Streamflow at sites upstream of the Canning and Wungong Dams has declined significantly since the late 1990's when records commence at the two downstream sites on the Southern River (includes Wungong River) and Canning River.

The two upstream sites show a significant declining trend, largely due to climate change, that is not visible in the downstream records. However, it should be noted that these sites have been monitored for a much shorter period. This means that the significant declines due to historic construction of upstream dams and more recently due to climate change, that would have been visible in a longer record are not shown.

4.4.2 Wetlands

The Swan Coastal Plain proportion of the City of Armadale is characterised by numerous lakes, wetlands, watercourses and seasonally inundated land. This land, in effect, could be thought of as a single very large, interconnected wetland system and it is useful to consider it in this way, to understand the potential impact that land use change and management including development can have, beyond its own boundaries.

4.4.2.1 Forrestdale Lake

Forrestdale Lake is the largest and most important and protected single wetland in Perth's south metropolitan region. It was designated as a RAMSAR wetland in 1990 as it is a major open breeding, migration stop over and semi-permanent drought refuge for waterbirds. The site was also gazetted as an A-class Nature Reserve in 1957 for the Conservation of Flora and Fauna, is categorised as a Conservation Category Wetland and is listed in the National Directory of Important Wetlands in Australia (Western Australia) (Figure 16).

More than 20,000 water birds were recorded on Forrestdale Lake in January 1986. Annual water depth data indicates that conditions are suitable for use by more than 20,000 waterbirds several times within a 25-year period. Forrestdale Lake regularly supports more than 1% of the national population of five shorebirds: Red-capped Plover (up to 1300); Black-winged Stilt (3840); Red-necked Avocet (1113); Long-toed Stint *Calidris subminata* (up to 80); and Curlew Sandpiper (2000, Jan 1983).

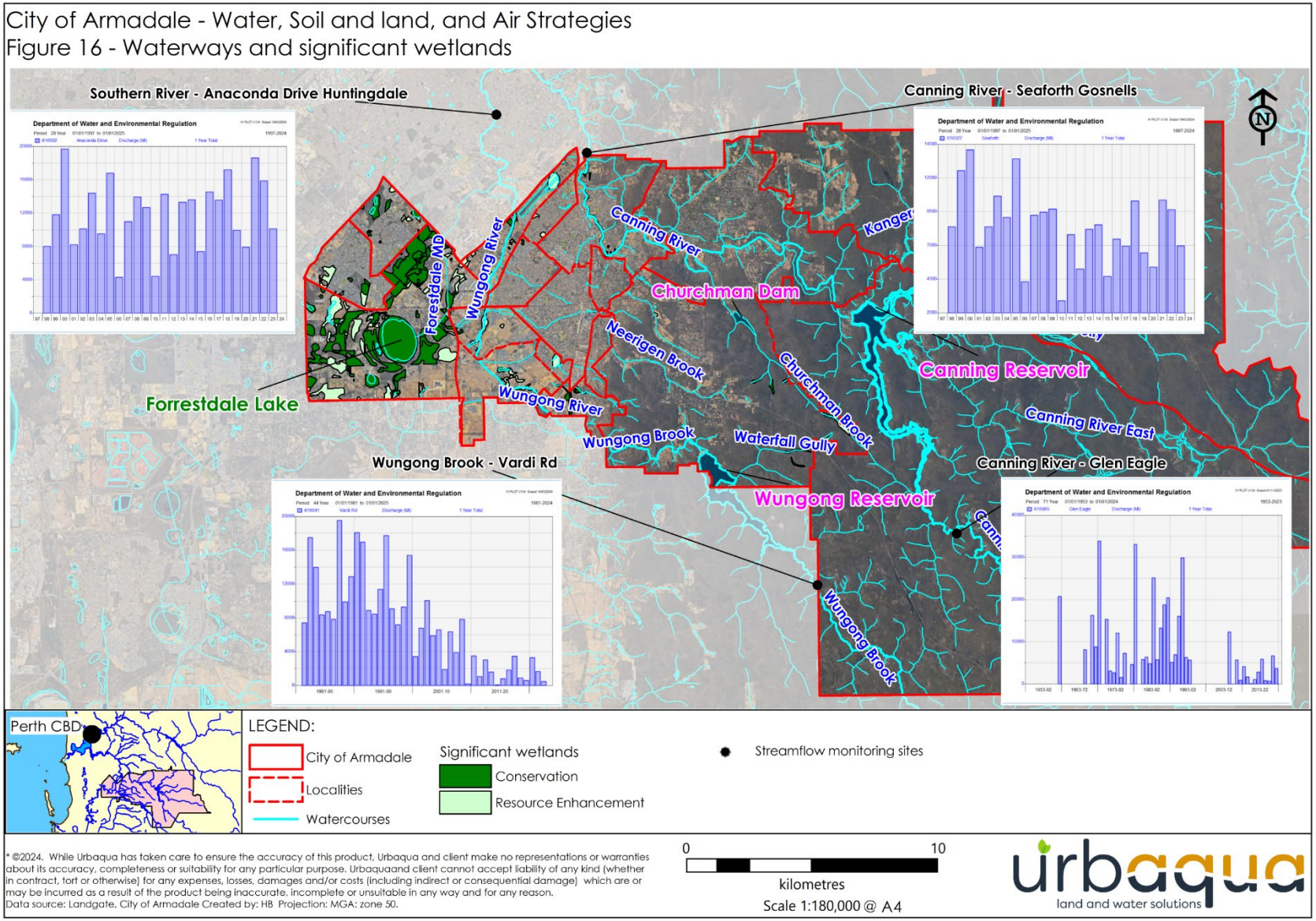


Figure 16: Waterways, wetlands, and streamflow

In June or July, Lake Forrestdale starts to fill and about the end of September, it reaches its maximum depth. By early summer, the lake is usually dry. Diminishing rainfall and groundwater extraction from government and private bores are some of the reasons for the lake's decreasing water levels.

Forrestdale Lake is the best remaining example of a brackish, seasonal lake with extensive fringing sedgeland typical of the Swan Coastal Plain. While these types of wetlands were formerly common, extensive development of the Swan Coastal Plain has resulted in the loss of many of these wetlands, and most of the remaining wetlands of this type have been degraded through drainage, eutrophication and the loss of fringing vegetation.

4.4.2.2 DBCA Geomorphic wetlands

DBCA's geomorphic wetland mapping of conservation and resource enhancement wetlands is shown in Figure 16. The City contains a significant number of conservation category wetlands, and the following are considered to have very significant values:

Anstey Road wetland (UFI: 14891) – according to the Urban Bushland Council, the Anstey-Keane Dampland is the second most floristically diverse Bush Forever site on the Swan Coastal Plain and has more plant species than Kings Park. Its vegetation is in excellent condition, and it is an area of high biological importance.

Hilbert Road Wetland (UFI 14475) – as reported by Emerge Associates (2014) in the *Sienna Woods Local Water Management Strategy*, the Hilbert Road conservation category wetland has a moderate to high degree of naturalness and retained ecological and hydrological functions. It is a perched groundwater system recharged by rainfall runoff from the local catchment rather than recharge from the superficial aquifer. Water is lost from the wetland via evaporation and infiltration, as overland discharge from this wetland occurs only in response to a major flooding event. Water levels measured from May 2010 to November 2011 ranged from 800mm above, to 200mm below ground level.

Balannup Lake is a conservation category wetland, classified as a seasonally inundated basin or sumpland. The lake is contained within Bush Forever site no. 413 and lies across the boundary of the cities of Armadale and Gosnells and is intersected by Ranford Road.

4.4.3 Dams and drinking water catchments

The majority of the City falls within the Canning River catchment, draining north west to the Swan River. The north east corner drains into the Upper Helena catchment while a small area falls into the Lower Serpentine catchment, draining to the Peel-Harvey Estuary.

A large proportion of the Canning River catchment is dammed by three Water Corporation dams, Canning, Churchman Brook and Wungong dams, which supply water into the integrated water supply scheme (Figure 16). The Canning Dam's catchment is protected by the Canning River catchment area public drinking water source area and has an area of 804 km^2, located on the Darling Plateau. Elevation in the catchment is 200m AHD at the reservoir, rising to 582m at Mt Cooke on the southern boundary of the catchment.

The Churchman Brook Dam is located on a tributary of the Canning River. The dam's catchment is protected by the Churchman Brook catchment area public drinking water source area. Approximately 3 km downstream of the dam, the Brook discharges into the Canning River which then continues through the City of Armadale and Gosnells and ultimately its estuary merges with the Swan River estuary at Applecross.

Wungong Dam and most of its catchment area also lies within the Canning River catchment in the City of Armadale and Serpentine-Jarrahdale Shire. The dam's catchment is protected by the Wungong Brook catchment area public drinking water source area. The Wungong Brook is a tributary of the Southern River which joins the Canning River at Maddington in the City of Gosnells.

4.4.4 Surface drainage

The natural hydrology and the historic land use on the Swan Coastal Plain part of the City has resulted in a large number of poorly defined water courses, shallow rural and urban drains, with numerous interconnected wetlands and lakes. The engineered drainage system is currently a mixture of City and Water Corporation assets which includes the Forrestdale Main Drain, Wungong Brook Main Drain and Birrega Drain (which is a Rural drain) (Figure 17).

4.4.5 Surface water quality

Similarly to groundwater, there are two ongoing district scale surface water quality monitoring programs being undertaken in the City of Armadale - the Forrestdale catchment post-development monitoring program, and the Wungong Urban Water monitoring program.

4.4.5.1 Forrestdale catchment post-development monitoring program

Post-development monitoring is being undertaken in accordance with the *Southern River Integrated Land and Water Management Plan* (SRILWMP) (Department of Water, 2009).

The primary purpose of the monitoring program is to establish and assess any change to groundwater and surface water quality in the study area following development. The program will determine the performance of water sensitive urban design and best management practice measures in order to assess whether water quantity and quality objectives are being met within each subdivision in the study area, and across the entire North Forrestdale Development Area.

In 2008, the then Swan River Trust developed the *Healthy Rivers Action Plan* (HRAP) which established short and long-term targets for median total nitrogen (TN) and total phosphorous (TP) concentrations in tributaries of the Swan Canning River system. The relevant targets are:

Short-term HRAP median concentration targets

1. 2.0mg/L Total Nitrogen
2. 0.2mg/L Total Phosphorous

Long-term HRAP median concentration targets

1. 1.0mg/L Total Nitrogen
2. 0.1mg/L Total Phosphorous

In 2009, the HRAP was supported by the development of the *Southern River Local Water Quality Improvement Plan* (SRLWQIP) (SRT, 2009a) which established short and long-term load reduction targets for water quality in the Southern River. These are summarised as:

- Reduce average TN and TP loads by 30% by 2015 as a short-term aspirational target.
- Reduce average TN loads by 47% and TP loads by 50% as a long-term target.
- Meet ANZG 2018 (previously ANZECC & ARMCANZ 2000) guidelines for other monitored parameters at all monitored sites.

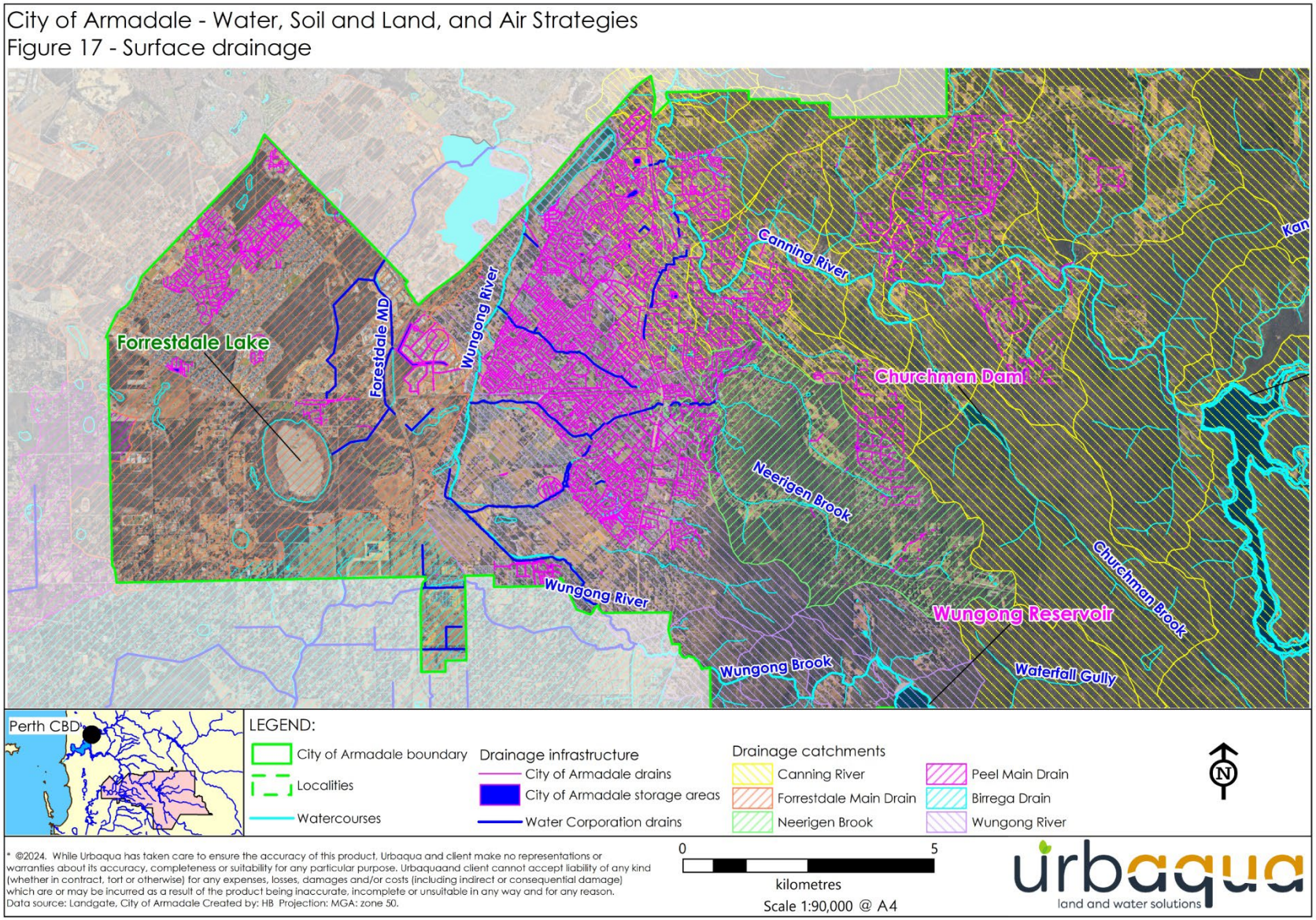


Figure 17: Surface drainage

The SRILWMP outlines requirements for water management at the regional, local and lot scale, including specific targets (design objectives) for the management of surface and groundwater quality. These include:

- water quality management measures to achieve a pollutant load reduction in the average annual load of stormwater runoff pollutants estimated to be generated by the development.
- water quality management measures are to achieve a nutrient load reduction in the average annual load of groundwater pollutants estimated to be discharged from the development.

There are a total of 34 sites monitored as part of the Forrestdale monitoring program. The Balannup Drain is the major surface water flow path through the site, including a combination of traditional concrete open drains and vegetated living streams. It is also the final point of discharge for all conveyed subsurface and surface water flows from the Forrestdale study area. Five indicator sites have been selected to display the surface water quality trends in this area, focussing on the Balannup Drain and Skeet Road Drain (discharges to the Balannup Drain). These sites are SW1a, SW2, SW5, SW7, and SW16 as shown in Figure 18.

Surface water quality results from the Forrestdale monitoring program generally indicate:

- TN and TP concentrations across key surface water sites within the Forrestdale monitoring program area generally exceed the TN and TP ANZG (2018) default guideline values (DGVs) and HRAP long-term targets.
- There has been a notable improvement in TN concentrations in more recent years. This may be due to TN decreasing in groundwater where subsoil drainage is a key input into the drainage network.
- Maximum concentrations of nutrients in Forrestdale surface water sites generally occur after first flush events (autumn or early winter depending on rainfall), or during summer events.
- TP concentrations have remained stable or are declining at most sites, with some spikes in concentration that may be associated with development/construction, or direct subsoil drainage discharge to the Skeet Road and Balannup Drains as described below.

These trends are displayed on Figure 18.

It is typically considered first flush events are responsible for the largest pulse of nutrients in a drainage system during the year. However, long-term results for the Forrestdale program suggest that the interaction of nutrient enriched subsoil (groundwater) discharges with the Balannup drainage system may be the more significant driver of nutrients within the system. This is especially notable for TP, where direct subsoil drainage input into the Skeet Road and Balannup Drains have caused TP spikes during more recent monitoring events, as shown on Figure 18.

Mean nutrient (TN & TP) concentrations in groundwater are still on average higher than surface water, suggesting summer baseflows within the Balannup drain continue to receive upstream surface water flows or other inputs in addition to local subsoil drainage (however groundwater input is still a key driver of nutrients).

Elevated concentrations of some dissolved heavy metals (aluminium, copper, iron and zinc) continue to be recorded in surface water but are not considered to be of concern or require further investigation.

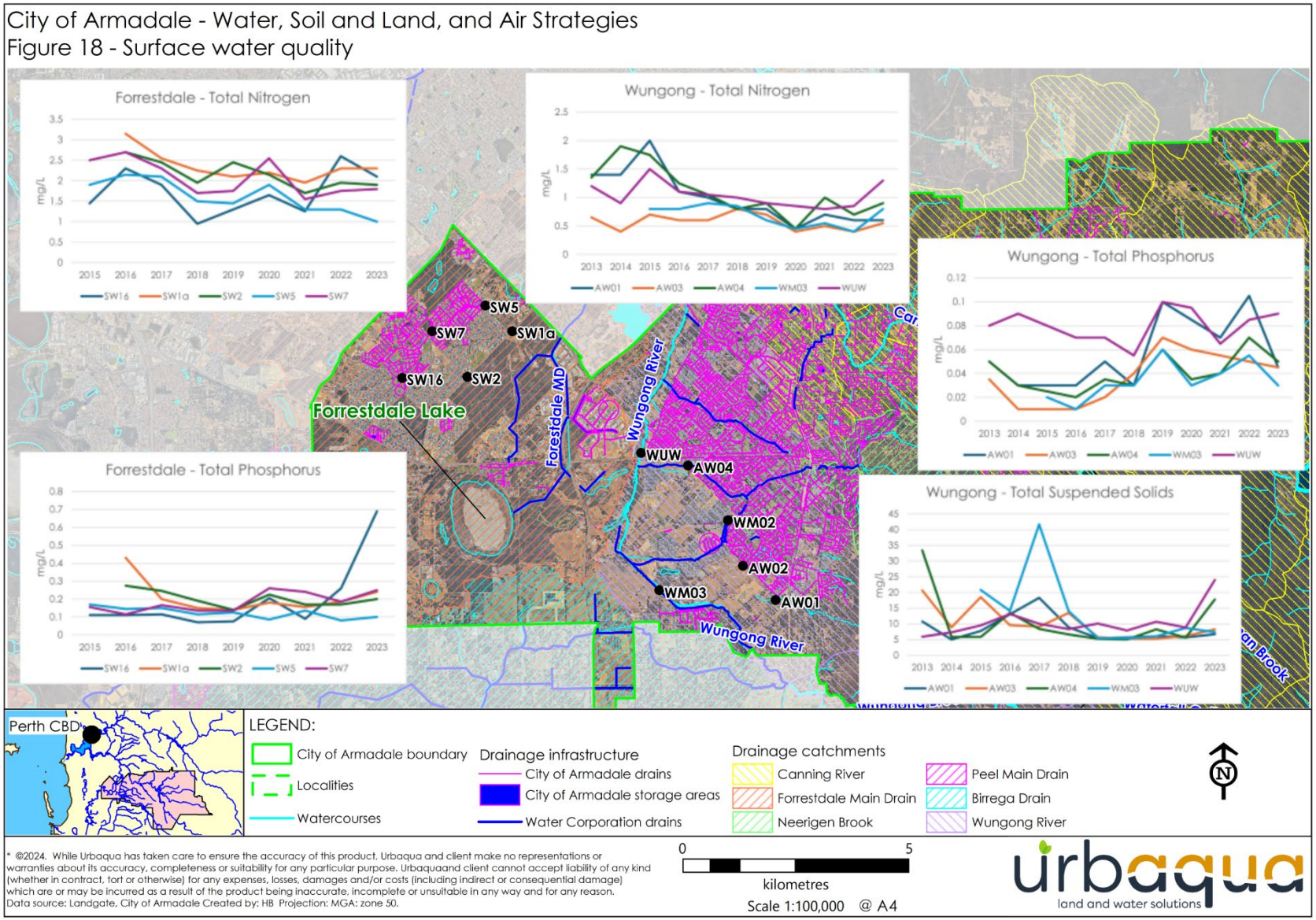


Figure 18: Surface water quality

4.4.5.2 *Wungong Urban Water monitoring program*

Hydrological monitoring is being undertaken in Wungong to assess the performance of the system against defined objectives for the Wungong Urban Water (WUW) area. Water management in the WUW is guided by the Wungong Urban Water Master Plan prepared by the MRA and Commonwealth Science and Research Organisation (CSIRO) (MRA, 2009).

Five indicator sites from this monitoring program (AW01, AW03, AW04, WM03 and WUW) have been selected to display the surface water quality trends in this area, focussing on the major waterways in the development area; the Neerigen Brook, Brickworks Drain, and Wungong River. These sites are shown in Figure 18.

The pre-development WUW area has been defined as typically consisting of seasonally waterlogged areas intersected by natural streams and artificial drains, including the Wungong River that ultimately discharges to the Canning River system. Urban development presents risks to catchment hydrology, flooding impacts downstream and the potential for increase in nutrient and pollutant discharge downstream. Management of flood risk and protection of downstream environments is achieved through the following key components of the Master Plan:

- The use of park avenues for flood storage, conveyance and water quality treatment.
- Modification of existing trapezoidal drains to living streams; and,
- Implementation of buffer zones for protection of the Wungong River, wetlands and tributaries.

The Armadale Redevelopment Scheme 2 (MRA, 2017) is a legislative document setting out the provisions for the development and use of land within the Scheme area. This document outlines specifications for water management, including the following objective:

> ***"Ensure that the quality of surface water post-development is improved compared with pre-development surface water quality (Operational Water Quality Objective)"***

The implementation of the Operational Water Quality Objective (OWQO), prior to 2011, was focused on establishing a suitable pre-development baseline from which to assess compliance at both a catchment and individual development scale. Subsequently a range of specific criteria were adopted to provide a quantitative approach to the Armadale Redevelopment Scheme 2 conditions (MRA, 2017) and the following are applied in reviews of annual monitoring data:

- Flow concentrations (TSS, TN and TP) for the WUW outlet (Armadale Rd).
- Annual nutrient load (TN and TP) and flow for the WUW outlet.
- Flow concentrations (TSS, TN and TP) for inflows to the site.

Since 2013, the WUW outlet has been compliant with concentration targets in ten out of eleven years for total nitrogen, nine out of eleven years for total phosphorus and in all years for total suspended solids. TSS appears to have increased at WUW since monitoring inception, while TN appears to have declined, and no trend is evident for TP. Nutrient and TSS concentrations are displayed on Figure 18.

An assessment of inflow and outflow surface water data since the WUW monitoring program commenced indicates inflows have more frequently exceeded OWQO (2017) targets for all parameters than the WUW outflow site. Since 2018, inflow sites have consistently exceeded the target for TP while the outflow has exceeded the target for two of the five years. Monitoring of Neerigen Brook North indicates the catchment of this waterway may be a significant source

of total nitrogen although the impact of this is limited by relatively small flows from this catchment.

Comparative assessment between inflow and outflow (WUW) sites suggests total nitrogen concentrations are declining consistently, while TP increases. Increases in TP concentrations are largely due to increases in flows entering the site from upstream.

4.4.6 Surface water availability

Surface water availability reporting and licensing is based on surface water allocation areas, subareas and irrigation districts which have been defined by the Department of Water and Environmental Regulation on the basis of natural catchment boundaries and administrative boundaries. The City of Armadale contains, either wholly or partially, three surface water management areas proclaimed under the *Rights in Water and Irrigation Act 1914*. It is illegal to take water from a watercourse in a proclaimed area without a licence. The proclaimed surface water allocation management areas are the Canning River, Serpentine River and Helena River. The allocation status of the sub-areas within these management areas is shown in Figure 19 and Table 11. Addition guidance for management of the Middle Canning is provided in the Middle Canning Surface Water Allocation Plan (DoW, 2012).

Table 11: Surface water resources and allocation limits (16 Sep 2022)

Management Sub Area/resource	Allocation limit	Allocated volume	Remaining volume	% Allocated & committed
Canning Pipehead		0	0	0.00%
Churchmans Brook		0	0	0.00%
Middle Canning	390,000	394,415	-4,415	101.13%
Neerigen Brook		0	0	0.00%
Southern River		45,500	0	0.00%
Stony Brook		9830	0	0.00%
Upper Canning		0	0	0.00%
Upper Wungong		0	0	0.00%
Victoria/Munday		0	0	0.00%
Upper Helena		170927	0	0.00%
Lower Serpentine		124,000	0	0.00%
	390,000	**744,672**	**-4,415**	**190.94%**

(source: DWER Resource Allocation Report)

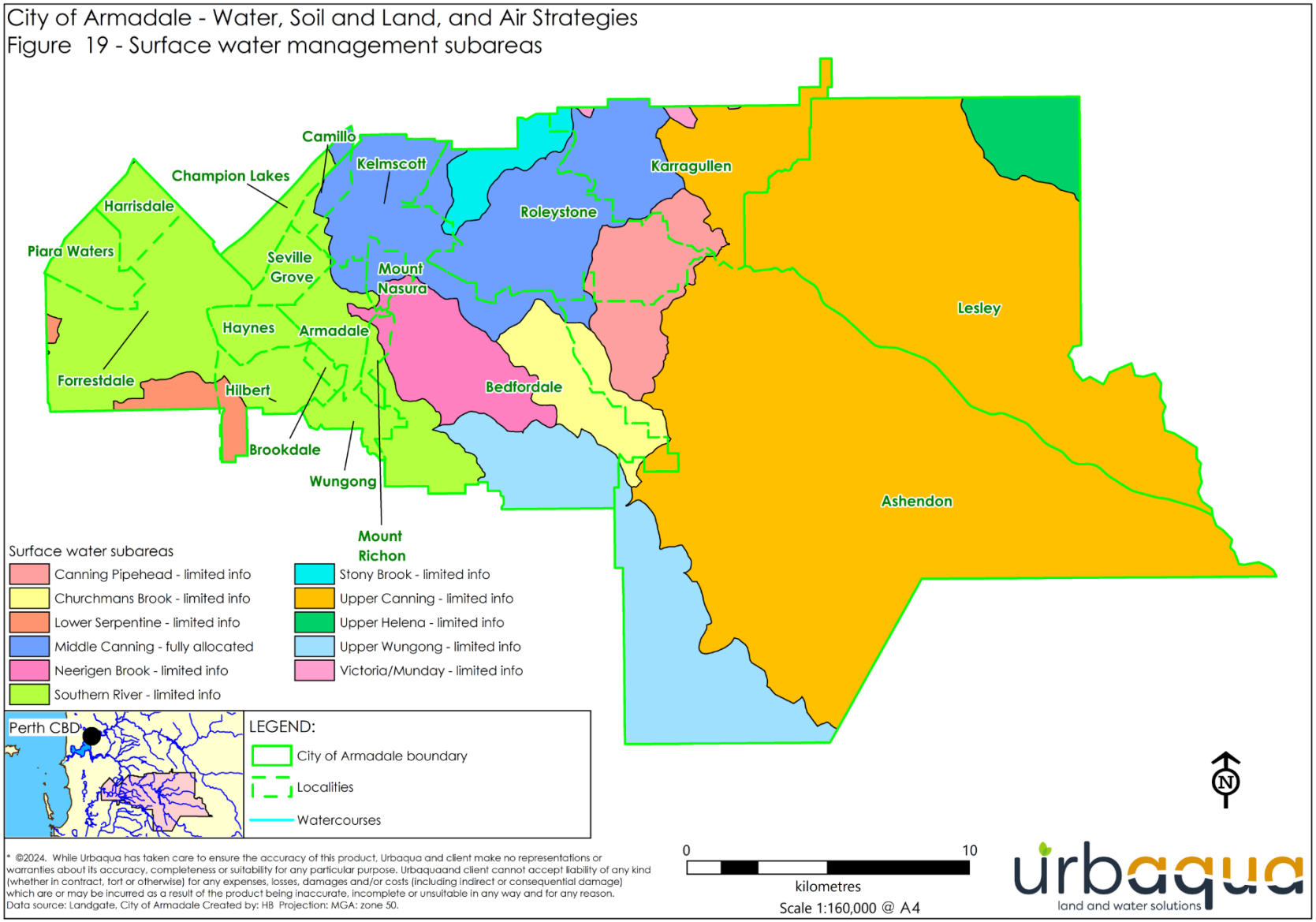


Figure 19: Surface water management sub-areas

5 City activities and environmental considerations

There are a number of City activities that have the potential to impact or be impacted by air, water and soil or land resources. These include:

- City of Armadale Depot at Owen Road
- City of Armadale Landfill and Recycling Facility (ALARF)
- other City-managed lands (parks, roads, bushland)
- other City-managed buildings
- other City activities and areas of influence

The key environmental considerations (air, water and soil or land) associated with these activities are described below. It is noted that these issues are substantially driven by climate change and population growth, the consideration of which will always underpin the assessment of risk and response.

5.1 City of Armadale Depot at Owen Road

Key environmental considerations for the City of Armadale depot at Owen Road include:

- Water consumption
- Environmental management including:
    - Chemical storage and handling
    - Vehicle management and washdown
    - Runoff water quality management
    - Use and storage of construction materials and mulch

5.1.1 Scheme water use

The site is listed as the third largest user of scheme water in the City's corporate account report and a summary of scheme water use at the site is provided in Table 12.

Table 12: Scheme water use at the City of Armadale depot at Owen Road

2020 Water Use Yr (kl)	2021 Water Use Yr (kl)	2022 Water Use Yr (kl)	2023 Water Use Yr YTD (kl)	2024 Water Use Yr YTD (kl)
5,383	5,795	4,870	5,707	2,111

5.1.2 Groundwater use

One of the City's groundwater licenses (GWL 160738) includes an allocation for the site but the amount of groundwater allocated or used specifically at this site is unknown.

5.1.3 Environmental management

The key areas of environmental management at the site are management and maintenance of vehicles (including housing of waste trucks) and handling of stockpiled materials, and all operators are trained in sound housekeeping principles including correct spill containment practices using regularly maintained spill kits present at the site.

Vehicle management activities include:

- Repair and maintenance works conducted in nominated areas only.
- Use of absorbent spill pads / sheets when conducting repairs and maintenance.
- visual and scheduled checks of the fuel / oil tanks on the vehicles and storage containers on site.
- Maintenance of all pressure vessels.
- appropriate spill kits for all vehicles.
- Appropriate storage of virgin hydrocarbon material in suitable containers.
- Regular maintenance of vehicles to minimise fuel and hydraulic tank and line damage.

Other regular environmental management activities at the site include:

- Depot sweeping/cleaning to minimise the impact of dust liberation from vehicle movement.
- Programming of projects to reduce the amount of material stockpiled on site for long durations.

In addition, the City of Armadale, in partnership with SERCUL (South East Regional Centre for Urban Landcare), has implemented Urban Waterway Renewal Drainage retrofit projects to treat water immediately downstream of the Depot (Gillam Park).

5.2 City of Armadale Landfill and Recycling Facility

The Armadale Landfill and Recycling Facility (ALARF) is a Class II or III putrescible landfill site, with a capacity of 100,000 tonnes per year. The facility is a prescribed premises under the *Environmental Protection Act 1986* (EP Act) and holds a license (L6964/1997/11) and works approval (W6814/2023/1) granted by DWER.

Site operations include a sorting and recycling facility, and onsite management of building material (brick, rubble, sand, and fibrocement) and mulch for reuse. The site is also a “Paintback” site, accepting disused paint tins for recycling. Figure 20 shows a site layout plan of the facility.

Sensitive land use and relevant environmental receptors in the immediate vicinity of the premises include residential properties immediately adjacent to the south and east boundaries, and groundwater. The site is required to undertake environmental monitoring and reporting under the conditions of its license including:

- Asbestos containing material (ACM)
- Groundwater quality

Emissions of a broad range of substances from the facility to air, land, and water are also required to be monitored and reported to the National Pollution Inventory (NPI), noting that no emissions to water have been reported to the NPI since 2004 and none of the reported substances were above the required reporting threshold.

Other potential environmental impacts that may be the cause of community complaints, include:

- Odour from putrescible landfill.
- Noise, mainly from mulching and vehicle movements.
- Dust from activities on site.

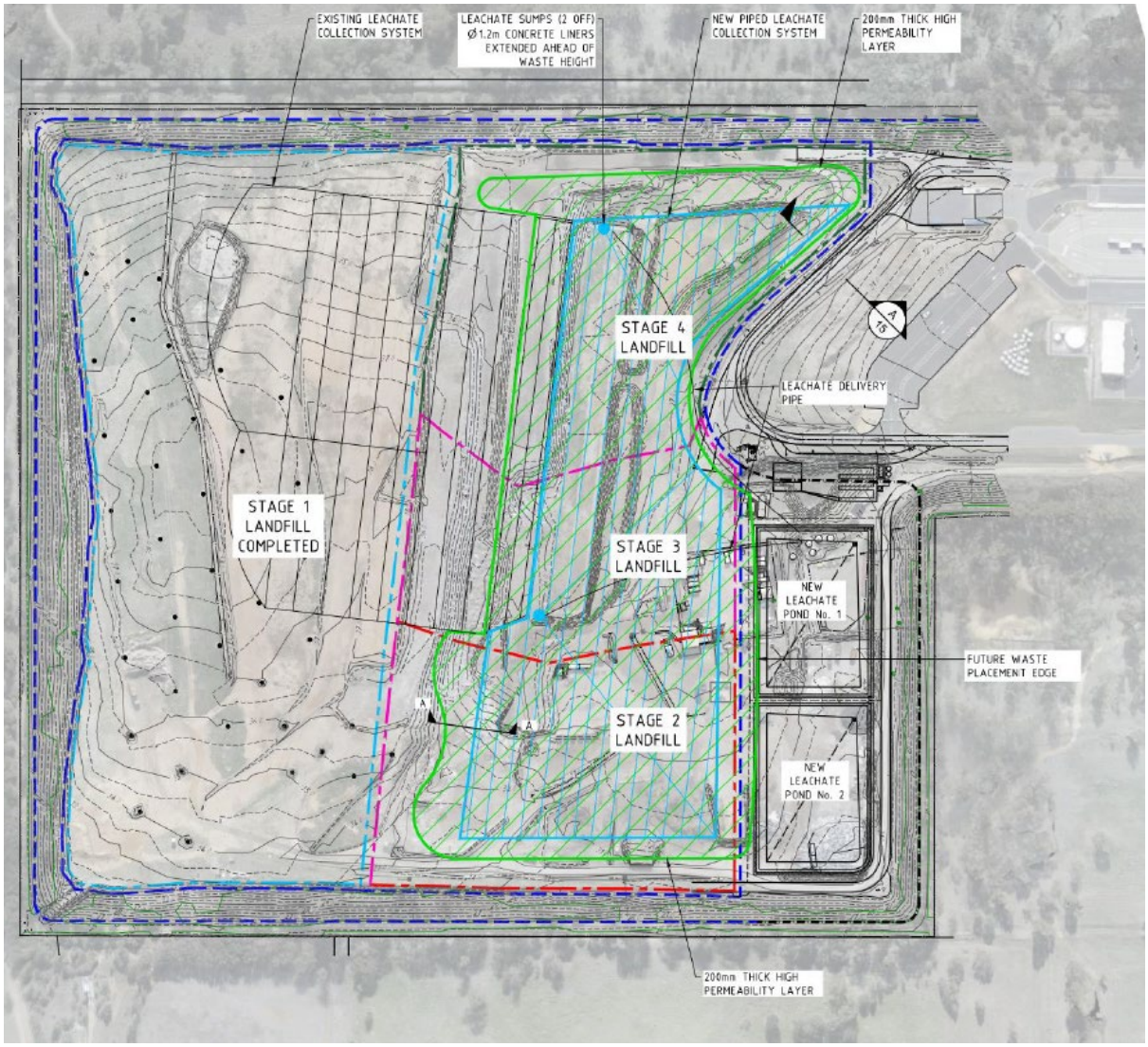


Figure 20: Armadale Landfill and Recycling Facility

The City maintains a record of community complaints for the facility, which are understood to be infrequent.

The following sections summarise relevant environmental reporting and NPI emissions data.

5.2.1 Emissions to air

Airbourne (ACM) fibre testing is undertaken at the facility and classified as Acceptable, Significant, or High Risk based on workplace exposure standards (WES). Airbourne fibre testing undertaken in 2023 indicates all results are acceptable and did not exceed the WES.

NPI reported emissions to air for 2020/21 and 2021/22 are provided in Table 13, noting that none of the listed substances exceeded reporting thresholds. 2022/23 reporting is due to be released at the end of March 2024.

Table 13: National pollution inventory emissions to air

Substance	Air emissions total (kg) 2020/21	2021/22	Reporting threshold
Acetaldehyde	0.28	0.04	10 tonnes per year
Acetone	31.37	9.50	10 tonnes per year
Acetonitrile	4.13	1.25	10 tonnes per year
Acrylonitrile (2-propenenitrile)	27.07	8.20	10 tonnes per year
Antimony & compounds		0.01	10 tonnes per year
Arsenic & compounds		0.05	10 tonnes per year
Benzene	15.44	4.64	10 tonnes per year
Beryllium & compounds		0.09	10 tonnes per year
Boron & compounds		0.36	10 tonnes per year
1,3-Butadiene (vinyl ethylene)	0.01	0.00	10 tonnes per year
Cadmium & compounds		0.00	10 tonnes per year
Carbon disulfide	0.90	0.27	10 tonnes per year
Carbon monoxide	3,086.45	2,278.55	10 tonnes per year
Chloroethane (ethyl chloride)	21.00	6.36	10 tonnes per year
Chloroform (trichloromethane)	0.70	0.21	10 tonnes per year
Chromium (III) compounds		3.63	10 tonnes per year
Cobalt & compounds		0.73	10 tonnes per year
Copper & compounds		1.82	10 tonnes per year
Cumene (1-methylethylbenzene)	4.17	1.29	10 tonnes per year
Cyclohexane	7.02	2.13	10 tonnes per year
1,2-Dichloroethane	0.93	0.28	10 tonnes per year
Dichloromethane	43.04	13.03	10 tonnes per year
Ethanol	0.85	0.26	10 tonnes per year
Ethyl acetate	13.35	4.04	10 tonnes per year
Ethylbenzene	41.59	12.60	10 tonnes per year
Fluoride compounds		34.50	10 tonnes per year
Formaldehyde (methyl aldehyde)	0.44	79.24	10 tonnes per year
n-Hexane	21.54	6.53	10 tonnes per year
Hydrochloric acid	4.21	1.28	10 tonnes per year
Hydrogen sulfide	87.26	26.42	10 tonnes per year
Lead & compounds		0.51	10 tonnes per year
Manganese & compounds		34.50	10 tonnes per year
Mercury & compounds	0.00	0.00	5 kilograms per year
Methyl ethyl ketone	41.21	12.48	10 tonnes per year
Methyl isobutyl ketone	15.10	4.57	10 tonnes per year
Nickel & compounds		2.91	10 tonnes per year

Substance	Air emissions total (kg) 2020/21	2021/22	Reporting threshold
Oxides of Nitrogen	5,301.79	4,937.65	400 tonnes per year, or 1 tonne per hour
Particulate Matter 10.0 um	959.15	18,744.76	400 tonnes per year, or 1 tonne per hour
Particulate Matter 2.5 um	912.32	545.13	400 tonnes per year, or 1 tonne per hour
Polychlorinated dioxins and furans (TEQ)	0.00	0.00	2,000 tonnes per year
Polycyclic aromatic hydrocarbons (B[a]Peq)	0.05	0.18	400 tonnes per year, or 1 tonne per hour
Selenium & compounds		0.00	10 tonnes per year
Styrene (ethenylbenzene)	3.45	1.04	10 tonnes per year
Sulfur dioxide	361.26	111.33	10 tonnes per year
Tetrachloroethylene	27.74	8.40	10 tonnes per year
Toluene (methylbenzene)	219.23	66.37	10 tonnes per year
Total Volatile Organic Compounds	3,859.77	1,643.62	10 tonnes per year
1,1,2-Trichloroethane	1.74	0.53	10 tonnes per year
Trichloroethylene	8.96	2.71	10 tonnes per year
Vinyl Chloride Monomer	7.31	2.21	10 tonnes per year
Xylenes (individual or mixed isomers)	79.09	23.95	10 tonnes per year
Zinc and compounds		6.90	10 tonnes per year

5.2.2 Emissions to land

NPI reported emissions to land for 2020/21 and 2021/22 are provided in Table 14, noting none of the listed substances exceeded reporting thresholds. 2022/23 reporting is due to be released at the end of March 2024.

Table 14: National pollution inventory emissions to land

Substance	Land emissions total (kg) 2020/21	2021/22	Reporting threshold
Ammonia (total)	1520.86	468.50	10 tonnes per year
Antimony & compounds	0.48	0.15	10 tonnes per year
Arsenic & compounds	0.10	0.03	10 tonnes per year
Benzene	0.27	0.08	10 tonnes per year
Beryllium & compounds	0.03	0.01	10 tonnes per year
Cadmium & compounds	0.10	0.03	10 tonnes per year
Chlorine & compounds	4272.88	1316.27	10 tonnes per year
Chloroform (trichloromethane)	0.21	0.06	10 tonnes per year
Chlorophenols (di, tri, tetra)	0.00	0.00	10 tonnes per year
Chromium (III) compounds	0.30	0.09	10 tonnes per year

Substance	Land emissions total (kg) 2020/21	2021/22	Reporting threshold
Chromium (VI) compounds	0.13	0.04	10 tonnes per year
Copper & compounds	0.39	0.12	10 tonnes per year
1,2-Dichloroethane	0.07	0.02	10 tonnes per year
Dichloromethane	3.19	0.98	10 tonnes per year
Ethylbenzene	0.42	0.13	10 tonnes per year
Lead & compounds	0.46	0.14	10 tonnes per year
Mercury & compounds	0.00	0.00	5 kilograms per year
Nickel & compounds	1.23	0.38	10 tonnes per year
Phenol	2.75	0.85	10 tonnes per year
Polychlorinated dioxins and furans (TEQ)	0.00	0.00	2,000 tonnes per year
Polycyclic aromatic hydrocarbons (B[a]Peq)	0.00	0.00	400 tonnes per year, or 1 tonne per hour
Toluene (methylbenzene)	2.97	0.91	10 tonnes per year
Vinyl Chloride Monomer	0.29	0.09	10 tonnes per year
Zinc and compounds	4.92	1.52	10 tonnes per year

5.2.3 Water use and emissions to water

A stormwater drain is located in the north-west portion of the site, which flows to the Birriga Drain. Only uncontaminated stormwater is directed here (currently unmonitored, however this is due to commence in April 2024), with all contaminated stormwater directed to the leachate collection ponds.

The leachate collection network is used to collect leachate from landfill areas, directed to two leachate ponds for reuse and evaporation onsite. The ponds are designed to provide:

- minimum storage capacity of 7,250 m^3
- minimum surface area of 3,625 m^2
- minimum additional storage for a 1% annual exceedance probability 168-hour duration storm event and a design operational freeboard height of 0.5 m.

Water is used for the following activities at the facility:

- Vehicle washdown
- Dust management on stockpiles
- Dust management on roads/gravel tracks
- Wetting of materials.

The City of Armadale has a groundwater licence for the Armadale Landfill Waste Facility, for the abstraction of up to 15,000 kL per year. Previous usage was:

- 6,438 kL in 2021/2022
- 4,177 kL in 2022/2023

The site is monitored as per requirements of DWER Licence L6964/1997/11. Bi-annual compliance groundwater monitoring is undertaken at three sets of nested wells, one leachate pond, the production bore, and the stormwater drain.

The license does not require samples to be held to any assessment levels however, water quality is compared against the following guidelines considering the surrounding sensitive receptors:

- ANZG, March 2021, ANZG (2018) Freshwater 95%LOSP Toxicant DGVs.
- ANZG, March 2021, ANZG (2018) Freshwater 99%LOSP Toxicant DGVs.
- DoH, 2014, DOH NPUG.

The contaminants of potential concern identified for the groundwater monitoring event are inorganics and filtered metals as stated in the Licence L6964/1997/11 conditions (Appendix A) and listed as follows:

- pH
- Electrical Conductivity (EC)
- Total Dissolved Solids (TDS)
- Chloride
- Total potassium
- Nitrate-nitrogen
- Ammonium-nitrogen
- Total nitrogen
- Metals: Cadmium, Chromium, Copper, Manganese, Nickel, Lead and Zinc

Recent results indicate that the contaminants of concern were relatively consistent or lower than those reported in the previous year, except for lead and cadmium, which were slightly higher in LI01 during 2023.

5.2.4 Environmental management

The key areas of consideration for environmental management at the site are monitoring, implementation of site controls, and education and interaction with the community.

The site is managed through the implementation of a Strategic Waste Management Plan, including alignment to the National Waste Policy and State Waste Strategy.

Key site controls include:

- Use of water trucks to control dust
- All machinery complies with noise regulation requirements via procurement processes.
- Segregation of specified items including mattresses, tyres, fridges, and white goods etc.
- Stringent acceptance control measures and sorting procedures for building materials for reuse, which minimise the impact of asbestos contaminated material. Accordingly, the site receives less than 1 ton pa.

Monitoring and inspection activities include:

- Inspection of trailers on entry at the weighbridge.
- Annual tracking of waste recovery targets through submissions to the Waste Authority.
- Weekly tracking of dumped rubbish statistics with a contract in place for dumped rubbish pickup (rapid response).
- Groundwater testing performed as required under the environmental Licence associated with the site.
- Airborne Fibre Testing.

In addition, the City's waste collection services deliver waste to the site.

The Resource Recovery branch of the Environment and Sustainability Department delivers a number of initiatives to limit waste deposition to land:

- Annual Waste Guide and activities of Circular Economy Education Officer. Drop N' Shop facility to enable residents to repurpose items.
- Provision of contracts for residents to prevent uncontrolled waste disposal (e.g. Mattress pickup).
- Incentives for sorted waste (pricing).
- Provision of a transfer station with opportunities for recycling (e.g. household hazardous waste).
- Provision of Yellow lid recycling bins for residents and at City facilities.
- "System of responding to dumped rubbish complaints, and infringements where required (Resident Liaison Officers).
- Preventative measures - bulk verge collections, contracts with recyclers (e.g. mattresses).
- Requirements for City events to adhere to single use plastic regulations.
- Provision of water fountains at City events.
- Trialling of various sustainability initiatives (e.g. Containers for Change etc).

5.3 Other City-managed lands (parks, roads, bushland)

The City of Armadale has management responsibility for extensive areas of land including numerous parks and reserves, over 700 km of roads and several areas of bushland. Figure 21 shows the extent of parks, roads and bushland in the City of Armadale although the City does not manage all of these assets. Notably, areas of State Forest and National Parks are managed by DBCA, and regional roads are managed by Main Roads WA.

5.3.1 Road reserves

Key environmental considerations for these assets include:

- Street tree planting, management, watering and pruning
- Street sweeping (sediment management)
- Runoff water quality management
- Use of materials for road construction, maintenance and renewal, recycled or otherwise.

Note: water use from City owned groundwater bores and irrigation systems, used for irrigation of road reserves, and street drainage system management, are addressed in Section 5.4.2.

5.3.2 Public open space & bushland

Key environmental considerations for these assets include:

- Fuel load management
- Public open space management:
- Tree planting, management and pruning
- Turf management and mowing
- Irrigation management and maintenance
- Fertiliser, herbicide, and pesticide management
- Maintenance of amenities (public toilets, drinking taps, playground equipment)
- Litter and waste removal.
- Runoff water quality management for carparks

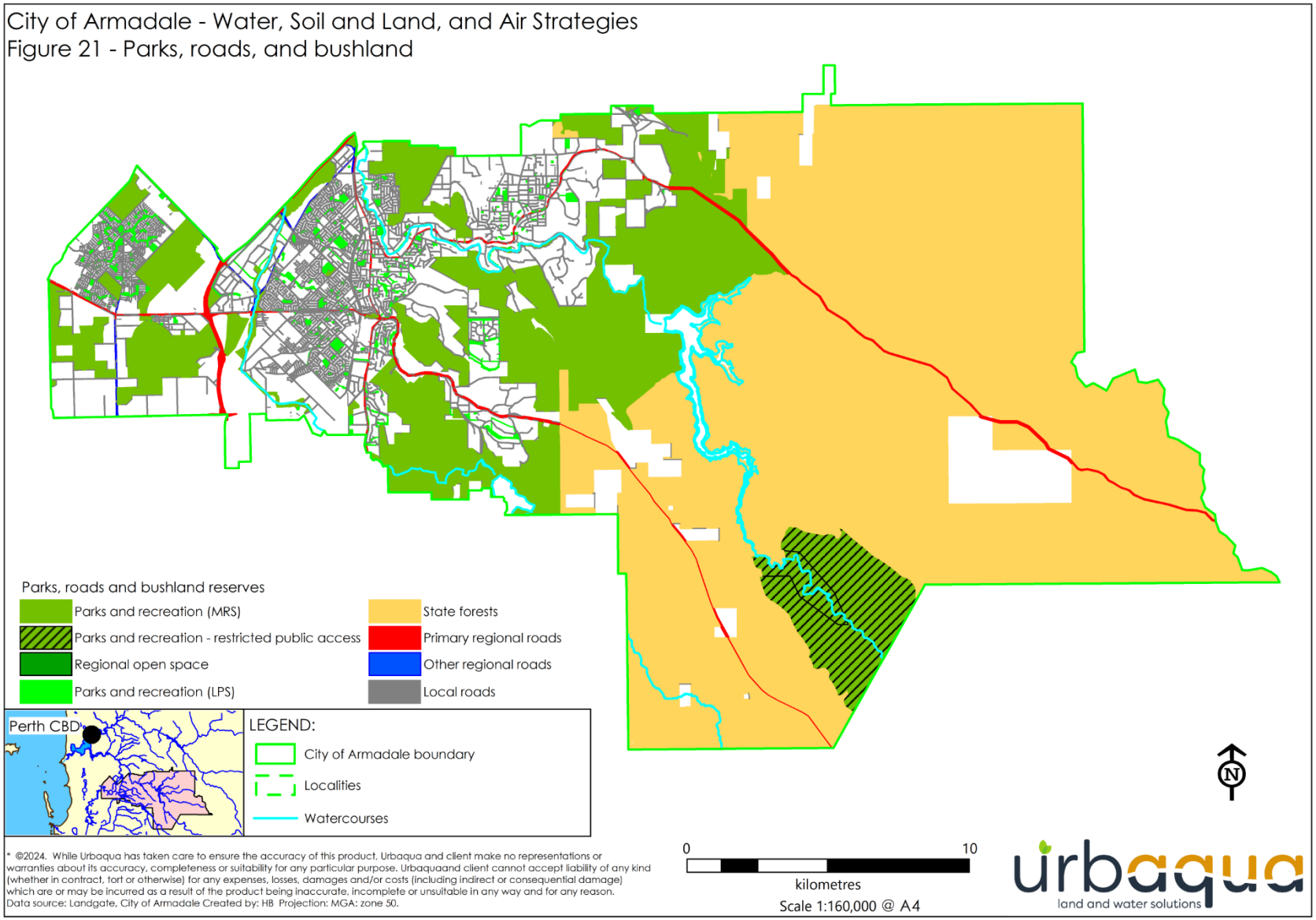


Figure 21: City of Armadale parks, roads, and bushland

- Bushland management
- Weed control and revegetation
- Dieback management and hygiene measures
- Environmental water provisions
- Fencing and access control

Note: Water use for irrigation of public open space is addressed in Section 5.4.2

5.3.3 Urban tree canopy

The WAPC Urban tree canopy dashboard provides an interactive snapshot of the extent of urban tree canopy coverage across the Perth and Peel regions using urban tree canopy mapping data for 2014, 2016, 2018 and 2020 gathered from high resolution aerial imagery through the CSIRO's Urban Monitor program. The dashboard indicates urban tree canopy coverage in 2020 across the City of Armadale was 28%, excluding areas of State Forest and National Park, having declined slightly from 30% in 2016.

Where will all the trees be? The 2020 update of green cover benchmarking in our cities and suburbs by Greener Spaces, Better Places measured the total canopy cover of the City of Armadale at over 60% in 2020 including areas of State Forest and National Park. The report also noted an increase in "grey cover" (hard surfaces) of around 0.5% and a reduction in canopy cover of around 1.5% (Greener Spaces, Better Places, 2020).

Table 15 provides a breakdown of urban tree canopy coverage by suburb showing the amount of coverage in parks, road reserves and within street blocks.

Table 15: City of Armadale urban tree canopy coverage (DPLH Urban tree canopy dashboard, 2020)

	% Canopy coverage (2020)			
Suburb	**Suburb**	**Parks**	**Roads**	**Street blocks**
Armadale	13%	24%	12%	12%
Ashendon	51%	55%	39%	
Bedfordale	40%	42%	27%	25%
Brookdale	9%	16%	9%	8%
Camillo	12%	18%	12%	11%
Champion Lakes	14%	15%	10%	19%
Forrestdale	12%	15%	10%	6%
Harrisdale	14%	36%	4%	8%
Haynes	10%	11%	8%	10%
Hilbert	9%	20%	10%	9%
Karragullen	46%	52%	39%	31%
Kelmscott	21%	28%	15%	16%
Lesley	33%		33%	
Mount Nasura	22%	39%	15%	21%
Mount Richon	21%	43%	14%	20%
Piara Waters	6%	28%	2%	3%
Roleystone	46%	51%	34%	42%
Seville Grove	10%	24%	6%	9%
Wungong	22%	25%	16%	22%
Overall City of Armadale	28%	18%	17%	39%

The *City of Armadale Urban Forest Strategy 2014 and Implementation Plan* guides the planting of street trees within the municipality. The City has also adopted a Street Tree Masterplan which nominates the species to be planted in each street. The Street Tree Masterplan is the guiding document for decisions relating to the management of the Town's Street tree assets. It assumes replacement will occur as part of natural attrition.

The City's local planning scheme also provides for tree protection within the Mixed Business/ Residential, District Centre and Local Centre Zones through Clause 4C.9. This Clause requires the written approval of the City to remove, lop, top, chop, ringbark or otherwise trim or destroy a tree within any of the Commercial zones. Exemptions are provided for fruit trees, hazardous trees (with written support), where removal is necessary to construct an approved fence, to provide a public service and for small trees. Furthermore, the City can issue Tree Preservation Orders under Clause 80A of Schedule A of Town Planning Scheme No 4 which allows the City to serve a notice requiring landholders to preserve a tree or group of trees. This notice prevents landholders from cutting, removing, or otherwise destroying any preserved tree unless the City grants approval or rescinds the notice or order.

Key environmental considerations for these assets include:

- Tree protection and compliance
- Tree replacement and maintenance including watering
- Fuel load management
- Management of pests and diseases (e.g. dieback) including the polyphagous shot-hole borer

5.3.4 Environmental management

The City's Biodiversity Strategy includes actions to mitigate environmental impact on the city's bushland and the City's urban forestry program includes a significant environmental management response to urban heat and the management of parks and roads by creating urban canopy in the public realm. In addition, the City considers the impact of urban heat on its community as part of its health and community programs.

Other relevant environmental management activities include street sweeping for management of sediment, the control of litter, weeds, disease and pests in public open spaces and best practice application of chemicals and nutrients where they are required.

The City also seeks to use recycled materials in road construction and maintenance projects.

5.4 Other City-managed buildings and infrastructure

The City of Armadale manages many other buildings and facilities and extensive infrastructure, including 79 groundwater extraction bores used for irrigation of parks and reserves throughout the City and an extensive network of piped and open drains. Key environmental considerations for these assets include:

- Materials use, disposal, and recycling
- Water use (including scheme, groundwater and surface water use)
- Drainage system management and maintenance
- On-site environmental management (including runoff from carparking and washdown areas and chemical storage and handling)

5.4.1 Scheme water use

Table 16 presents the scheme water use at City managed buildings and facilities over the past five years. The Armadale Fitness and Aquatic Centre is the largest individual water user in all years. There are many scheme water connections listed as road verge or reserve and these may include drinking taps and or public toilets as well as some use for irrigation.

Table 16: Scheme water use at City of Armadale buildings and facilities

Facility type	Annual scheme water use (kL)				
	2020	2021	2022	2023	2024 (part)
Offices	2,452	2,114	2,222	1,838	740
Depot	5,383	5,795	4,870	5,707	2,111
Aged care centres	7,446	5,740	5,487	4,365	519
Community centres	24,826	16,728	16,747	19,203	3,447
Childcare centres	141	189	125	353	145
Library	1,120	1,643	1,517	843	215
Museum	1,402	2,519	1,773	1,463	443
Theatre	3	25	108	69	3
Sports ground	2,785	2,169	4,150	5,678	379
Bowling club	937	491	670	2,498	
Golf course	102	246	412	301	
Aquatic centre	22,216	26,861	25,658	28,407	
Sports centre	643	1,757	485	457	
Tennis club	815	754	661	717	50
Public toilet	636	720	263	370	282
Reserve	11,043	13,091	15,291	15,521	3,316
Road verge	10,398	5,465	2,955	3,153	859
Drinking tap	123	115	84	65	
Fire service	42	40	33	58	7
Total	92,513	86,462	83,511	91,066	12,516

5.4.2 Non-potable water use

The City of Armadale holds 28 groundwater licenses with a combined total allocated volume of 1.59 GL, as presented in Table 17, and one surface water license for up to 26,625 kL.

Table 17: Groundwater licenses held by the City of Armadale

Management Sub Area	Aquifer	License no.	Allocated Volume	Expiry date
City of Armadale	Perth - Superficial Swan	160738	706,383 KL	11/06/2030
		160868	120,000 KL	17/07/2026
		164974	12,000 KL	7/05/2028
		170218	18,000 KL	5/10/2026
		173564	12,525 KL	13/02/2026
		178167	9,750 KL	8/02/2028
		180057	5,625 KL	1/12/2024
		181983	36,020 KL	28/02/2026
		200513	17,750 KL	8/11/2028
		200610	3,000 KL	4/12/2027
		202764	21,600 KL	15/05/2029
		203264	7,125 KL	22/08/2029
		203324	4,875 KL	3/09/2029
		203430	55,335 KL	26/09/2029
		203541	7,722 KL	29/10/2029
		204155	44,700 KL	25/03/2030
		207860	6,728 KL	28/09/2032
		Subtotal	1,089,138 KL	
Karri	Fractured Rock	181040	45,750 KL	4/08/2025
Perth South Confined	Perth - Leederville.	175895	52,433 KL	9/06/2032
		178204	15,000 KL	16/06/2032
	Perth - Yarragadee North.	202074	0 KL*	24/10/2028
		Subtotal	67,433 KL	
Wright	Perth - Superficial Swan	157558	107,250 KL	24/06/2029
		169772	29,625 KL	19/01/2033
		173290	177,405 KL	16/12/2028
		177788	17,475 KL	16/03/2033
		200201	42,400 KL	27/08/2027
		206601	5,321 KL	11/11/2031
		208521	4,125 KL	22/03/2033
		Subtotal	383,601 KL	
		TOTAL	1,585,922	

** License to the Yarragadee Aquifer for geothermal heating of a swimming pool in Armadale Fitness and Aquatic Centre.*

Table 18 presents a summary of groundwater use by the City of Armadale and the Armadale community in the financial year 2022/23 and shows the City of Armadale used 1.33 GL of groundwater for irrigation which is approximately 85% of their total allocated volume. This

headroom is likely to be vital to facilitate meeting the DWER criteria to reduce groundwater use by 10% and address likely additional demands due to rising temperatures.

Table 18: Non-potable water use in the City of Armadale (2022/23)

Management subarea	2022/23 groundwater use
Corporate groundwater	1,332,205
Community groundwater use (garden bores)	1,184,984
Community self-supply groundwater use (licensed)	5,691,233
Total groundwater use	8,208,422
Corporate surface water use	26,453

5.4.3 Irrigation system management

The City of Armadale manages extensive irrigation systems, mainly fed by groundwater, with a central control system providing 24-hour oversight of all systems. Management of this system includes the following elements which are aimed at maximising efficiency:

- Monthly telemetered metre readings
- Annual water chemistry sampling program measuring concentrations of metals (including Iron), salinity and PH
- Annual bore flow testing of every bore
- Program of bore and pump servicing (on rotation so that each site is serviced once every five years as a minimum)
- Continual program of irrigation maintenance including checking reticulation runs and undertaking running repairs as follows:
    - Active open spaces - weekly
    - Passive open spaces - fortnightly
    - All other irrigated areas – monthly
- Use of specialised systems, where required including:
    - Dosing units for non-ionic wetting agents to hold moisture in the ground
    - Chemical injection for sulphate reducing bacteria (Wet well in the ground that injects treatments)
    - Iron filtration systems for water quality
- Implementation of hydrozoning wherever practical which separate turf, garden and tree systems to optimise watering regimes

The City is annually re-endorsed as a Waterwise Council through the Water Corporation's Waterwise Councils program and prepares annual reports on its groundwater usage for each bore and amalgamated reporting for each groundwater aquifer and management subarea.

The Armadale Golf course, as the City's most significant groundwater demand, is a particular focus and has its own water management strategy in place to ensure water quality and water management obligations are met.

The City is actively considering and trialing other innovations including ways to build on the capabilities of the central control system to collect and respond to live data such as weather, soil moisture, and flow rates. The 'Vortex' system is a device attached to groundwater bores that enables greater oxidation as water passes through the system and is currently being installed at select City sites. The result realise water savings of 10-30%.

5.4.4 Drainage system management

As noted in Section 4.4.4 and presented in Figure 17, there is an extensive engineered drainage system in the City of Armadale, much of which is owned and managed by the City of Armadale. Key environmental considerations for the City's management of this drainage system include:

- Water quality management
- Recharge of groundwater aquifers
- Maintenance of environmental flows
- Opportunities for passive watering
- Eduction of drainage pits and gross pollutant traps (sediment management)
- Erosion and sediment management
- Weed control and vegetation management

No information has been identified regarding recorded drainage system incidents or community complaints.

5.4.5 Environmental management

The City participates in the Waterwise Councils program, which tracks and enables implementation of water efficiency programs. The program covers both scheme water and groundwater use.

The City's status as a Waterwise Council is annually reviewed and approved by the Water Corporation and DWER. This re-endorsement process tracks the use of water and includes detailed initiatives to reduce water consumption (e.g. real time water monitoring at key sites, Energy and Water Monitoring Committee, development of a standard building palate for water efficient fixtures etc). The City is currently working towards 'Gold' endorsement and this included undertaking a benchmarking exercise in 2020 using the Cooperative Research Centre for Water Sensitive Cities Index tool. As part of this process, an action plan was prepared that makes recommendations for the City to work towards becoming a water sensitive city. The City is tracking implementation of these recommendations.

The Armadale Fitness and Aquatic Centre is also specifically accredited under the Waterwise Aquatic Centre Program initiative. This tracks the use of scheme water and includes detailed initiatives to reduce water consumption (e.g. installation and monitoring of sub-meters, benchmarking of water use per patron against targets, leak detection processes, rainwater storage viability studies etc).

The City is participating in the '*Sediment Control and Prevention'* component of the '*Cleaning up the Canning'* project which is a $10m Federally funded initiative that seeks to reduce the amount of sediment within the Canning River system. This is likely to recommend improvements in sediment management practices through improved education and awareness within the development industry and enhanced controls and compliance.

5.5 Other City activities

Other city activities have the potential to impact on or be impacted by air, water and soil or land resources. This includes decisions made by the City as part of the land use planning and development assessment process and the City's role in community education and awareness.

While it is noted that the City's planning framework addresses impacts to and from the environment, some of the activities relevant to this Strategy where the environment is a consideration include:

- Input on proposals for land use change, structure plans and applications for subdivision
- Review of water management reports prepared under State Planning Policy 2.9: Planning for Water (draft, 2021)
- Determination of development applications in areas with sensitive environmental receptors or those that could result in a local (rather than significant) environmental impact

The City also has a role in education and building awareness of how actions by the community and/or businesses could impact on air, water, land and soil resources. This includes use of woodfires or burning private garden refuse which can impact on air quality, as well as waste management, stormwater and landscaping practices within light industry areas that can impact on water and land quality.

5.5.1 Environmental management

As noted above, the City's planning framework, including its local planning scheme, local planning strategy and local planning policies, contains substantial guidance for the consideration of impacts on and from the environment. Additional controls are provided by the State's environmental protection and planning frameworks.

The City works in multi-disciplinary teams to optimise input into the land use planning and development approvals process to ensure that decisions have considered all necessary factors and have sought to optimise outcomes. It is noted, however, that many decisions are ultimately the responsibility of other organisations, and accordingly, the City's preferences may not be fully implemented. In these instances, the City may also advocate for alternative outcomes where possible.

The City has an active community engagement program. Some of the activities relevant to this strategy include the *Switch Your Thinking Program*, support for the *Armadale Gosnells Landcare Group* and the *Native plants for Residents* event. The City also promotes the DWER BurnWise program and provides incentives for disposal of private property greenwaste to reduce occurrences of burning.

In addition, under the *Respect and Opportunities* component of the *Reconciliation Action Plan*, the City will investigate the potential for Cultural Burning as part of future fire mitigation regimes.

6 Risk and response

The City conducted a risk assessment with subject matter experts to develop a risk and opportunities matrix as a basis for the recommendations of this strategy. The risk assessment identified the highest risks in relation to impacts to air, water and soil and land assets within the City, documented existing controls and recommended potential additional actions for implementation where necessary.

6.1 Risk Assessment

6.1.1 Methodology

Risk management is defined in AS/NZS ISO 31000:2018 Risk Management – Principles and Guidelines (ISO 31000) as 'Coordinated activities to direct and control an organisation with regard to risk'. The risk assessment and management process is iterative. For this strategy, the risk assessment process engaged key relevant stakeholders and subject matter experts and will require regular monitoring and review throughout the implementation of the strategy, to ensure continual improvement.

As per ISO 31000, the risk assessment followed the process and steps outlined below:

- Establish the context (identifying hazards and risks)
- Risk treatment (applying controls)
- Risk identification
- Risk analysis
- Risk evaluation
- Monitor and review.

An initial list of risks was identified at a workshop with subject matter experts who were further engaged to analyse the individual risks and identify existing controls. Each risk was evaluated to determine the level of risk without and with existing controls. Only risks where a response is within the City's potential influence were included.

Risk ratings were based on the standard combinations of likelihood and consequence of the risk eventuating. Additional controls to further manage the risks were then determined and added, and the risks were then analysed again, with the aim of reducing the level of risk.

Whilst it would be ideal to address all risks and implement all actions identified within the risk assessment, this is not practical nor realistic. The risk assessment has been used, therefore, to assist in the prioritisation of actions and generally recommends a response to the greatest risks, to optimise allocated resources.

6.1.2 Risk Results

A total of 56 risks to air, water and soil and land assets within the City were identified from the risk assessment. Risk ratings were applied in consideration of the descriptions provided in Appendix 2, Table A2 and Table A3.

Five (5) risks have an initial risk rating of 'critical', 17 risks had an initial risk rating of 'high', 29 'medium' and five (5) 'low'.

Table 19 contains a list of risks with an initial rating of ‘critical’ or ’high’ as an outcome of the risk assessment process. The full risk matrix is presented in Appendix 2, and contains all risks identified in subject matter expert workshops.

The risk assessment identified risks within the following key risk categories with initial risk ratings of ‘critical’ or ‘high’:

- Air quality deterioration (five ‘critical’ risks)
- Ecological damage (five risks, two ‘critical’ and three ‘high’)
- Soil and land contamination (one ‘high’ risk)
- Declining water availability (six risks, three ‘critical’ and three ‘high’)
- Declining water quality (four ‘high’ risks)

Four risks remain in the matrix with a residual risk rating of ‘critical’ or ‘high’ following the implementation of existing and additional controls. These are:

- Increasing temperatures (urban heat) caused by built environment (impervious surfaces, dark materials, lack of shade/canopy cover etc.) and exacerbated by climate change causing impacts to environmental attributes, including biodiversity, in urban areas (Note - bushland areas considered under the Biodiversity Strategy).
- Changes of State requirements and/or assessment of proposals reduces the visibility of environmental issues and ability to respond (e.g. as part of Development - Structure Planning and Subdivisional Controls etc).
- Ecological properties of the City's rivers may be compromised as a result of them being 100% dammed (restricted water flows) and suffering the impacts of climate change - Canning and Wungong Rivers.
- Inappropriate use of water in the community places increased pressure upon providers to exhaust supplies from groundwater and/or surface water systems (also, potential embodied energy and environmental impacts associated with desalinisation). Exacerbated by the impacts of climate change.

These risks remain significant because the City has limited ability to influence or control them, since they relate to statewide or national issues requiring action by other parties.

Table 19: Table of extreme and high risks only

Risk category	Asset category	Risk ref. no.	Risk description	Likelihood	Consequence	Risk rating	Actions (existing and proposed)	Likelihood	Consequence	Residual Risk Rating
Air quality deterioration	Air	2	Dust generated from sites that are in the process of being cleared or have completed clearing as part of the Land Use Changes process result in a deterioration in air quality (Note, can also result in sand/sediment accumulation in city bushland areas and waterways, see risks 20 and 49).	4 - Likely	3 - Moderate	High (12)	Existing: • Review Dust Management Plan and issue approval. Monitor compliance through customer service requests. Proposed: • Develop a policy and/or guidance document to state specific requirements for dust management for specific scenarios e.g. vacant land/subdivision (currently it is up to the property owner/developer to determine preventative measures). • See also comment below re; Sediment Awareness Project Implementation.	3 - Possible	2 - Minor	Medium (6)
Air quality deterioration	Air	5	Emissions of noise, light, dust, odour or other pollutants from activities at ALARF result in a deterioration in air quality.	4 - Likely	3 - Moderate	High (12)	Existing: • Use of water trucks to control dust Machinery complies with noise regulation requirements via procurement processes. Proposed: • (In progress) Develop Environmental Management Plan to include dust management, stormwater management (including sampling), noise control, odour management, leachate management, light management (requires compilation and updating of relevant management plans).	3 - Possible	1 - Insignificant	Low (3)
Air quality deterioration	Air	8	Smoke generated from City activities including controlled burns results in a deterioration in air quality and atmospheric pollution.	4 - Likely	3 - Moderate	High (12)	Existing: • Completion of a Burn Prescription Form (based on a DFES template) by the Bushfire Mitigation Officer that considers: Broad logistics around the burn (e.g. traffic management etc). Burn Risk Management (adjacent properties, site services, power, water). • Weather conditions (consider conditions that may adversely affect the burn - e.g. wind direction, smoke drift, restrictions on burning if there is a haze alert in place - issued by BOM). Environmental matters (sensitive trees, rake hoeing etc) Notification of residents/stakeholders (stakeholder approvals/notifications) Proposed: • Under the Respect and Opportunities areas of the Reconciliation Action Plan, investigate the potential for Cultural burning to be implemented. Cultural burning is a term that describes burning practices developed by Aboriginal people to enhance the health of country and culture. Cultural burning involves the application of fire using culturally informed knowledge and ecologically sensitive techniques that are appropriate for the local landscape and ecosystem. Cultural burning also includes protecting certain areas of Country for the health of plants and animals. This technique involves patch burning to create a mosaic of burnt and unburnt areas, which encourages regeneration of food sources and rapid recolonisation of fauna. Cultural burning applies fire management in the right season, at the right time and in the right way to ensure; flames stay low, preserving tree canopy; fires burn slowly; only some fuels are burnt, creating mosaics; insects and animals can move away from the fire; nutrients in the soil are not affected; seed germination is supported; and: flowering and nesting seasons are considered.	2 - Unlikely	2 - Minor	Low (4)

Risk category	Asset category	Risk ref. no.	Risk description	Likelihood	Consequence	Risk rating	Actions (existing and proposed)	Likelihood	Consequence	Residual Risk Rating
Air quality deterioration	Air	9	Smoke generated from Community activities, including controlled burns results in a deterioration in air quality and atmospheric pollution.	4 - Likely	3 - Moderate	High (12)	Existing: • Permit to Set Fire to the Bush issued under the Bush Fire Act 1954, contains standard conditions in relation to burning: • Not allowed during any period where a “Haze Alert” has been issued by BOM for the Perth metropolitan area Prohibits burning of material likely to cause a smoke nuisance, including plastic, rubber, green garden waste or wet material. Alignment of burning rules with requirements of the Environment, Animals and Nuisance Local Law (e.g. no burning on properties less than 1,200sqm). • Rangers respond to smoke nuisance complaints (infringements issued under the Bush Fires Act 1954 if contrary to Burning Permit). Opportunities at ALARF and Roleystone Greenwaste facility to dispose of green waste. • Green waste verge pick ups twice a year. • (In progress) Review of operating hours of Roleystone Green Waste Facility to provide greater opportunities for disposal. Proposed: • Education Officer currently being recruited into Ranger Services. This role will: • Work with the Community in relation to education around Hazard Reduction Burns. • Delivery of Practical Demonstration Days (e.g. possibly a Bushfire Brigade stations and/or private residences). • Raising awareness re; the DFES Burn SMART Program (optimum conditions for burning, planning the burn, materials that should not be burned, moisture content of materials etc). • This role will also cover education around smaller blocks (what is and isn't allowed etc) • Incentivise other ways to dispose of green waste.	2 - Unlikely	2 - Minor	Low (4)
Air quality deterioration	Air	10	Smoke generated from DBCA activities including controlled burns results in a deterioration in air quality and atmospheric pollution.	4 - Likely	3 - Moderate	High (12)	Proposed: • Advocate to DBCA to show greater consideration of climatic conditions, to limit impact on the community from controlled burns.	2 - Unlikely	2 - Minor	Low (4)
Ecological damage	Air	11	Increasing temperatures (urban heat) caused by built environment (impervious surfaces, dark materials, lack of shade/canopy cover etc.) and exacerbated by climate change causing impacts to environmental attributes, including biodiversity, in urban areas (Note - bushland areas considered under the Biodiversity Strategy and health/wellbeing impacts to the community considered under the Community Health Plan.	5 - Almost certain	4 - Major	Critical (20)	Existing: • Implementation of Liveable Neighbourhoods as part of the Land Use Change Process (WAPC Operational policy that guides the structure planning and subdivisional process). • Review and finalisation of Structure Plans as part of the Land Use Change Process (to allow for vegetation retention in Public Open Space) • Implementation of PLN 2.6 Water Sensitive Urban Design, during structure planning and subdivision development process. Implementation of PLN 2.4 Landscape Feature and Tree Preservation. • Urban Forest Strategy Implementation (see additional risk in relation to existing controls and improvements required). Proposed: • Update of the City's Community Health and Wellbeing Plan (in progress) to address Climate Change, in alignment with the approach of State Government (the City's new Public Health Plan will have objectives aligned with the State Public Health Plan on lessening the impact of climate change on community health and hence, the environment). • Commence review of Public Health Assessments in relation to the Land Use Change Process under the Public Health Act 2016 (now allowable under new legislation).	5 - Almost certain	4 - Major	Critical (20)

Risk category	Asset category	Risk ref. no.	Risk description	Likelihood	Consequence	Risk rating	Actions (existing and proposed)	Likelihood	Consequence	Residual Risk Rating
Ecological damage	Soil & land	20	Dust generated from sites that are in the process of being cleared or have completed clearing as part of the Land Use Changes process result in sand/sediment accumulation in city bushland areas (Note, can also result in air quality deterioration and sand/sediment accumulation in city waterways, see risks 2 and 49).	4 - Likely	3 - Moderate	High (12)	Existing: • Review Dust Management Plan and issue approval. Monitor compliance through customer service requests. Proposed: • Develop a policy and/or guidance document to state specific requirements for dust management for specific scenarios e.g. vacant land/subdivision (currently it is up to the property owner/developer to determine preventative measures). • See also comment below re; Sediment Awareness Project Implementation.	3 - Possible	2 - Minor	Medium (6)
Ecological damage	Soil & land	23	Impacts to non targeted vegetation as a result of the application of pesticides/herbicides, including glyphosate (Note, also likely to result in water quality deterioration, see risk 46).	4 - Likely	3 - Moderate	High (12)	Existing: • Application of pesticides/herbicides in accordance with manufacturer instructions etc • City uses alternative non-chemical applications in various locations where possible (e.g. hand weeding, brush cutting, mulching). • Use of contractors that utilise sensors to only spray areas covered by weeds in hardstand areas (reduces herbicide use by 50 to 80%). Proposed: • Review to be performed on the City's application of pesticides/herbicides, including Glyphosate, with a view to minimising impact to Soil and Groundwater assets.	2 - Unlikely	2 - Minor	Low (4)
Ecological damage	Soil & land	24	Management practices within sites undergoing Land Use Change, result in accumulation of waterborne sediment in city bushland areas (Note; can also result in sediment accumulation in waterways, see risk 39).	3 - Possible	4 - Major	High (12)	Existing: • Implementation of PLN 2.5 Erosion Prevention and Sediment Control, during subdivision development process (e.g. requirement for Sediment Control Plans). • Potential application of the provisions of Environment, Animals and Nuisance Local Law 2002 provisions (Part 3, Division 2 - Sand Drift and Dust). Proposed: • Participation in the Sediment Awareness Project under the banner of the Cleaning up the Canning initiative - this will benchmark the activities of Local Governments in relation to sediment control across the Land Use Change process and result in improvements across the City of Armadale, Gosnells and Canning and the Town of Vic Park. Provisionally $1m of funding allocated to this specific project.	3 - Possible	2 - Minor	Medium (6)
Governance	Soil & land	25	Changes of State requirements and/or assessment of proposals reduces the visibility of environmental issues and ability to respond (e.g. as part of Development - Structure Planning and Subdivisional Controls etc).	4 - Likely	3 - Moderate	High (12)	Existing: • City advocates to maintain and increase environmental protection mechanisms Proposed: • WALGA to advocate	4 - Likely	3 - Moderate	High (12)
Soil and land contamination	Soil & land	28	Potentially contaminated sites may impact on soil and land quality, with an associated risk of disturbance, resulting in the release of environmental contaminants.	4 - Likely	3 - Moderate	High (12)	Existing: • Current focus is on contaminated sites (the City has access to the Contaminated Sites register and can factor this knowledge into project planning processes - however, currently un-registered City owned sites may be reported to DWER as potentially contaminated and subsequently classified as PCIR resulting in a project risk) Proposed: • Request from DWER GIS data regarding potentially contaminated sites so all sites are visible and associated documentation is easy to access. The City could investigate these sites to determine if the land is potentially contaminated and remediate as required.	2 - Unlikely	2 - Minor	Low (4)

Risk category	Asset category	Risk ref. no.	Risk description	Likelihood	Consequence	Risk rating	Actions (existing and proposed)	Likelihood	Consequence	Residual Risk Rating
Declining water availability	Water	30	Inefficient use of groundwater for irrigation/lake replenishment etc results in the exhaustion of the environmental asset, with resultant ecological and operational and community impacts (e.g. tree deaths, deterioration in park quality). Aging City irrigation infrastructure may result in the inefficient use of groundwater. Exacerbated by the impacts of climate change.	5 - Almost certain	3 - Moderate	Critical (15)	Existing: • Established irrigation maintenance program Asset life cycle management - Infrastructure Renewal Program (requires review for adequacy/investment levels) • Hydrozoning, waterwise gardens in parks and reserves Central control irrigation system • Dosing units – non-ionic wetting agents to hold moisture in the ground • Iron filtration systems for water quality • Chemical injection for sulphate reducing bacteria (Wet well in the ground that injects treatments) • Bore flow testing of every bore annually • Annual reporting of ground water usage for each bore and amalgamates for each ground water sub area i.e., Jandakot mound, Leederville, surface and fractured • Armadale Golf course water management strategy – objective to ensure we meet obligations water quality and water management Trialling a number innovations (e.g. Vortex system) • Annual Waterwise endorsement. Proposed: • Review the Asset Life Cycle Management - Infrastructure Renewal Program for adequacy via an external audit, and the development of a future management/implementation strategy (e.g. assessment of asset life, how old the assets are - much of the irrigation infrastructure is critically past its useful life). • (In Progress) Delivery of a Bore and Pump Maintenance Program (recently developed and out for tender) • Opportunistic - Significantly invest in infrastructure technology and innovation (software, hardware e.g. weather stations and associated applications). • Consider/scope options for alternative sources of water for irrigation	3 - Possible	3 - Moderate	Medium (9)
Declining water availability	Water	32	Changing rainfall patterns and declining groundwater leads to death of City-managed trees. Note - Natural Area Management Plan to be developed under Biodiversity Strategy that takes into account Climate Change in relation to Bushland Areas.	5 - Almost certain	4 - Major	Critical (20)	Existing: • Undertaking a Street Tree Audit (to understand species assemblage, providing an indication of resultant risk profile). • Under the Urban Forest Strategy utilising more drought resistant species • Undertaking water initiatives as prescribed • Water Sensitive Urban Design (living streams) increasing storm water recovery to recharge ground water • Hydro mulching in parks to increase soil environment of trees and reduce use of ground water in the immediate vicinity • Tree planting under the Urban Forest Strategy to reduce heat islands and make more areas conducive for tree environments Proposed: • As part of the 2025 Review of the Urban Forest Strategy Implementation Program, incorporate the following aspects: • Targets in relation to canopy cover (already intended). • Identify vulnerable tree species and plan for long term replacements and or treatments to maintain health. • Intensify the assessment of irrigated passive parks in view of hydro zoning and reduction of ground water use in each park (under dry parks Strategy) • External consultant to review the City's preferred planting list for both streetscapes and reserves for suitability in terms of future proofing against a more drought related environment. • Ongoing monitoring and evaluation of the success of the Urban Forest Strategy. • Opportunistic - Identify stormwater recovery processes/water recovery to replenish volumes back into the groundwater	3 - Possible	3 - Moderate	Medium (9)
Declining water availability	Water	33	Unproclaimed water resource areas - drawing of water has potential impacts (access to water for the City and local business).	4 - Likely	3 - Moderate	High (12)	Existing: • DWER is currently liaising with operators to map and understand the potential impacts. The City is advocating and supporting DWER's initiative.	3 - Possible	3 - Moderate	Medium (9)

Risk category	Asset category	Risk ref. no.	Risk description	Likelihood	Consequence	Risk rating	Actions (existing and proposed)	Likelihood	Consequence	Residual Risk Rating
							Proposed: • City has an advocacy role in supporting DWER in the implementation of enhanced monitoring and public disclosure around water extraction from commercial enterprises in unproclaimed areas.			
Declining water availability	Water	34	Insufficient water may be provided by developers to water new areas of local and neighbourhood POS	4 - Likely	3 - Moderate	High (12)	Existing: • Work with developer to seek alternative options at time of install such as stormwater harvesting. • Amend designs to limit ongoing water use Proposed: • For development areas with known poor water allocation levels, advocate at state level for alternative schemes such as MAR. or seek MAR schemes within the City (cost prohibitive)	3 - Possible	3 - Moderate	Medium (9)
Declining water availability	Water	35	No groundwater is available to irrigate new regional and district POS areas	4 - Likely	3 - Moderate	High (12)	Existing: • Investigate alternative options at time of install such as stormwater harvesting • Amend designs to limit ongoing water use Proposed: • For development areas with known poor water allocation levels, advocate at state level for alternative schemes such as MAR. or seek MAR schemes within the City (cost prohibitive)	3 - Possible	3 - Moderate	Medium (9)
Ecological damage	Water	36	Ecological properties of the City's rivers may be compromised, as a result of them being 100% dammed (restricted water flows) and suffering the impacts of climate change - Canning and Wungong Rivers.	5 - Almost certain	4 - Major	Critical (20)	Existing: • Environmental Water Releases are the key mechanism for replenishment and/or maintenance of water levels in the City's river systems e.g. the Canning River releases are governed by the Middle Canning River Surface Water Allocation Plan (2012). This is under the control of the Department of Water and Environmental Regulation. Proposed: • The City does not have any head of power in relation to Environmental Water releases. However, the CoA may fulfil an advocacy role in support of the community to ensure that Environmental Water Releases continue to take place and are at appropriate levels. • Provision of support as necessary to DBCA (e.g. Cleaning up the Canning) initiatives to map and investigate deep water pools in the Canning to identify ecological requirements.	5 - Almost certain	4 - Major	Critical (20)
Water quality deterioration	Water	37	WSUD assets are not appropriately maintained, resulting in poor performance and a deterioration in water quality.	4 - Likely	3 - Moderate	High (12)	Existing: • Weed Control contractor maintains the Biofilters and base flow channel of the Living Streams (5x per annum) in the Living Streams and Biofilters (process not formally documented) • (In Progress) Recruitment of new Living Streams Team (team of 2). Proposed: • Development of a WSUD Strategic Plan that: • Maps and describes WSUD assets (vegetated, non-vegetated, water and infrastructure) • Brings in appropriate research on maintenance requirements (WSUD plans submitted at development) • Documents current service level (from existing programs) and performance (from WQ monitoring results) • Sets performance targets • Determines a service level and supporting program of works • Monitors and evaluates	2 - Unlikely	2 - Minor	Low (4)

Risk category	Asset category	Risk ref. no.	Risk description	Likelihood	Consequence	Risk rating	Actions (existing and proposed)	Likelihood	Consequence	Residual Risk Rating
Water quality deterioration	Water	38	Maintenance practices associated with the City's Public Open Space (e.g. fertiliser application) results in a deterioration in water quality in the City's waterways (e.g. inorganic nutrients - phosphorus and nitrogen).	4 - Likely	3 - Moderate	High (12)	Existing: • Active Reserves: • Targeted fertilising through liquid fertilising to minimise application. Soil and leaf analysis prior to fertilising. • Consultant advises on program of application. • Passive Irrigated Reserves: • Granular fertiliser restricted to annual program (further investigation required to establish effectiveness) • Monitoring: • Monthly meter readings – Telemetry readings Annual water chemistry sample testing – concentration of metals and water quality salinity PH and Iron Proposed: • Develop a Strategic Fertiliser Application Program that reviews existing processes to ensure highly efficient use of fertiliser that covers all Parks (Passive as well as Active Reserves, and potentially phase out granular fertiliser). • Incorporate fertiliser use as part of any water management strategy	2 - Unlikely	2 - Minor	Low (4)
Water quality deterioration	Water	39	Management practices within sites undergoing Land Use Change, result in the discharge of water borne sediment to the City's waterways, impacting on water quality and/or water flows (Note, can also result in accumulation in city bushland areas, see risk 24).	3 - Possible	4 - Major	High (12)	Existing: • Implementation of PLN 2.5 Erosion Prevention and Sediment Control, during subdivision development process (e.g. requirement for Sediment Control Plans). • Potential application of the provisions of Environment, Animals and Nuisance Local Law 2002 provisions (Part 3, Division 2 - Sand Drift and Dust). Proposed: • Participation in the Sediment Awareness Project under the banner of the Cleaning up the Canning initiative - this will benchmark the activities of Local Governments in relation to sediment control across the Land Use Change process and result in improvements across the City of Armadale, Gosnells and Canning and the Town of Vic Park. Provisionally $1m of funding allocated to this specific project.	3 - Possible	2 - Minor	Medium (6)
Water quality deterioration	Water	49	Dust generated from sites that are in the process of being cleared/, or have completed clearing as part of the Land Use Changes process result in sand/sediment accumulation in waterways (Note, can also result in air quality deterioration and sand/sediment accumulation in city bushland areas, see risks 2 and 20).	4 - Likely	3 - Moderate	High (12)	Existing: • Review Dust Management Plan and issue approval. Monitor compliance through customer service requests. Proposed: • Develop a policy and/or guidance document to state specific requirements for dust management for specific scenarios e.g. vacant land/subdivision (currently it is up to the property owner/developer to determine preventative measures). • See also comment below re; Sediment Awareness Project Implementation.	3 - Possible	2 - Minor	Medium (6)

Risk category	Asset category	Risk ref. no.	Risk description	Likelihood	Consequence	Risk rating	Actions (existing and proposed)	Likelihood	Consequence	Residual Risk Rating
Declining water availability	Water	50	Inappropriate use of water in the community places increased pressure upon providers to exhaust supplies from groundwater and/or surface water systems (also, potential embodied energy and environmental impacts associated with desalinisation). Exacerbated by the impacts of climate change.	5 - Almost certain	4 - Major	Critical (20)	Existing: • Switch Your Thinking (SYT) team implement the SYT Business Plan and engage in Community awareness programs around energy efficiency, water efficiency and sustainability. • Provision of community workshops in relation to waterwise fittings/appliance and waterwise gardening. • Rewards for Residents initiatives for community and business (e.g. provision of pool blankets). • Social media messaging, Webpage content, content for community publications (native plants, substitution of lawn for native gardens, referral to Water Corporation initiatives, watering days, switch off reticulation). • City of Armadale Native Plants for Residents program - free native plants. • City support of Armadale Gosnells Landcare Group - promotion of planting of native species in the community. Proposed: • Further opportunity to educate the community on City actions to improve water efficiency and irrigation, and to identify here they can help (report leaks etc) - Dedicated Water page on website and messages through comms and social media	5 - Almost certain	3 - Moderate	Critical (15)

6.2 Proposed action plan

Table 20 below contains 48 actions that respond to the identified risks (not just those with an initial risk assessment of 'extreme' or 'high'). The risk number is cross-referenced in the action plan. All risks identified in Appendix F and the proposed controls are presented (without exclusion) in the action plan.

The intention of the action plan is to inform preparation of business unit plans and accordingly, actions are ordered by priority. The action plan proposes a lead responsibility and considers the level of resources required.

At this stage, no additional internal resources are considered to be required. However, it is noted that on the completion of additional actions, there may be a requirement for changes in service delivery levels and at that point, additional requests/business cases would be presented to Council as necessary.

As indicated in the action plan, additional external expertise/consultancy support will be required to produce the following:

- Asset Life Cycle Management – Infrastructure Renewal Program.
- Strategic Water Sensitive Urban Design review.
- Development of a Strategic Fertiliser Application Program.
- Strategic Review of Practices – Herbicide/Pesticide Application.

Table 20: Proposed action plan

Action no.	Proposed action	Risk no.	Priority	Lead Responsibility	Addressed through BAU? Yes/No?	Additional FTE Required? E.G 0.5FTE	Additional External Costs Incurred? $	Both Additional FTE Required and External Costs Incurred? Yes/No?
1	Develop a policy and/or guidance document to state specific requirements for dust management for specific scenarios e.g. vacant land/subdivision (currently it is up to the property owner/developer to determine preventative measures).	1 and 2	HIGH	Health Services	Yes	Potentially, if there is a change in level of service (will be evaluated on completion of activity)	No	No
2	Update of the City's Community Health and Wellbeing Plan (in progress) to address Climate Change, in alignment with the approach of State Government (the City's new Public Health Plan will have objectives aligned with the State Public Health Plan on lessening the impact of climate change on community health and hence, the environment).	11	HIGH	Health Services	Yes	Potentially, if there is a change in level of service (will be evaluated on completion of activity)	No	No
3	Commence review of Public Health Assessments in relation to the Land Use Change Process under the Public Health Act 2016 (now allowable under new legislation).	11	HIGH	Health Services	Yes	No	No	No
4	WALGA to advocate to maintain and increase environmental protection mechanisms	25	HIGH	EMT	Yes	No	No	No
5	Review the Asset Life Cycle Management - Infrastructure Renewal Program for adequacy via an external audit, and the development of a future management/implementation strategy (e.g. assessment of asset life, how old the assets are - much of the irrigation infrastructure is critically past its useful life).	30	HIGH	Service Delivery - Parks/Assets	Yes	No	90,000	No - Just External Consultancy (audit of current information/ practices and improvement/ implementation plan)
6	(In Progress) Delivery of a Bore and Pump Maintenance Program (recently developed and out for tender)	30	HIGH	Service Delivery - Parks	Yes	No	No	No

Action no.	Proposed action	Risk no.	Priority	Lead Responsibility	Addressed through BAU? Yes/No?	Additional FTE Required? E.G 0.5FTE	Additional External Costs Incurred? $	Both Additional FTE Required and External Costs Incurred? Yes/No?
7	Opportunistic - Significantly invest in infrastructure technology and innovation (software, hardware e.g. weather stations and associated applications).	30	HIGH	Service Delivery - Parks	Yes	No	No	No
8	Consider/scope options for alternative sources of water for irrigation	30	HIGH	Service Delivery - Parks	Yes	No	No	No
9	As part of the 2025 Review of the Urban Forest Strategy Implementation Program, incorporate the following aspects: • Targets in relation to canopy cover (already intended). • Identify vulnerable tree species and plan for long term replacements and or treatments to maintain health. • Intensify the assessment of irrigated passive parks in view of hydro zoning and reduction of ground water use in each park (under dry parks Strategy). • External consultant to review the City's preferred planting list for both streetscapes and reserves for suitability in terms of future proofing against a more drought related environment. • Ongoing monitoring and evaluation of the success of the Urban Forest Strategy. Opportunistic - Identify stormwater recovery processes/water recovery to replenish volumes back into the groundwater.	32	HIGH	Design - Parks	Yes	Potentially, if there is a change in level of service (will be evaluated on completion of activity)	No	No
10	Provision of support as necessary to DBCA (e.g. Cleaning up the Canning) initiatives to map and investigate deep water pools in the Canning to identify ecological requirements.	36	HIGH	Environment and Sustainability - Sustainability	Yes	No	No	No
11	The City does not have any head of power in relation to Environmental Water releases. However, the CoA may fulfil an advocacy role in support of the community to ensure that Environmental Water Releases continue to take place and are at appropriate levels.	36	HIGH	Environment and Sustainability - Sustainability	Yes	No	No	No

Action no.	Proposed action	Risk no.	Priority	Lead Responsibility	Addressed through BAU? Yes/No?	Additional FTE Required? E.G 0.5FTE	Additional External Costs Incurred? $	Both Additional FTE Required and External Costs Incurred? Yes/No?
12	Development of a WSUD Strategic Plan that: • Maps and describes WSUD assets (vegetated, non-vegetated, water and infrastructure) • Brings in appropriate research on maintenance requirements (WSUD plans submitted at development) • Documents current service level (from existing programs) and performance (from WQ monitoring results) • Sets performance targets • Determines a service level and supporting program of works • Monitors and evaluates	37	HIGH	Service Delivery - Parks	Yes	No	50,000	No - Just External Consultancy (development of Living Streams Management Plan).
13	Participation in the Sediment Awareness Project under the banner of the Cleaning up the Canning initiative - this will benchmark the activities of Local Governments in relation to sediment control across the Land Use Change process and result in improvements across the City of Armadale, Gosnells and Canning and the Town of Vic Park. Provisionally $1m of funding allocated to this specific project.	39	HIGH	Environment and Sustainability - Sustainability	Yes	No	No	No
14	Further opportunity to educate the community on City actions to improve water efficiency and irrigation, and to identify here they can help (report leaks etc) - Dedicated Water page on website and messages through comms and social media.	50	HIGH	Environment and Sustainability - Sustainability	Yes	No	No	No
15	Perform a review of infrastructure requirements as part of the Depot redevelopment process to ensure that environmental performance is adequate,	4 and 29	MEDIUM	Service Delivery	Yes	No	No	No
16	Develop an Environmental Management Plan for the City's works depot to include dust management, stormwater management, groundwater management, odour management, noise management, light management.	4 and 29	MEDIUM	Service Delivery	Yes	No	Within existing project budget.	No – Just External Consultancy (production of EMP)

Action no.	Proposed action	Risk no.	Priority	Lead Responsibility	Addressed through BAU? Yes/No?	Additional FTE Required? E.G 0.5FTE	Additional External Costs Incurred? $	Both Additional FTE Required and External Costs Incurred? Yes/No?
17	(In progress) Develop Environmental Management Plan for ALARF to include dust management, stormwater management (including sampling), noise control, odour management, leachate management, light management (requires compilation and updating of relevant management plans).	5 and 43	MEDIUM	Environment and Sustainability - Waste	Yes	No	No	No
18	Under the Respect and Opportunities areas of the Reconciliation Action Plan, investigate the potential for Cultural burning to be implemented. Cultural burning is a term that describes burning practices developed by Aboriginal people to enhance the health of country and culture. Cultural burning involves the application of fire using culturally informed knowledge and ecologically sensitive techniques that are appropriate for the local landscape and ecosystem. Cultural burning also includes protecting certain areas of Country for the health of plants and animals. This technique involves patch burning to create a mosaic of burnt and unburnt areas, which encourages regeneration of food sources and rapid recolonisation of fauna. Cultural burning applies fire management in the right season, at the right time and in the right way to ensure; flames stay low, preserving tree canopy; fires burn slowly; only some fuels are burnt, creating mosaics; insects and animals can move away from the fire; nutrients in the soil are not affected; seed germination is supported; and: flowering and nesting seasons are considered.	8	MEDIUM	Ranger and Emergency Services	Yes	Potentially, as the program evolves (opportunities for traineeships etc, although grant funding will also be explored)	No	No

Action no.	Proposed action	Risk no.	Priority	Lead Responsibility	Addressed through BAU? Yes/No?	Additional FTE Required? E.G 0.5FTE	Additional External Costs Incurred? $	Both Additional FTE Required and External Costs Incurred? Yes/No?
19	Education Officer currently being recruited into Ranger Services. This role will: • Work with the Community in relation to education around Hazard Reduction Burns. • Deliver Practical Demonstration Days (e.g. possibly at Bushfire Brigade stations and/or private residences). • Raise awareness re; the DFES Burn SMART Program (optimum conditions for burning, planning the burn, materials that should not be burned, moisture content of materials etc). This role will also cover education around smaller blocks (what is and isn't allowed etc). Incentivise other ways to dispose of green waste.	9	MEDIUM	Ranger and Emergency Services	Yes	Potentially, as the program evolves (opportunities for traineeships etc, although grant funding will also be explored)	No	No
20	Advocate to DBCA to show greater consideration of climatic conditions, to limit impact on the community from controlled burns.	10	MEDIUM	EMT	Yes	No	No	No
21	(Currently in Scoping) Development of Sustainable Event Guidelines for the City (e.g encouraging vendors to be more sustainable in their practices) - may be tiered approach, with implementation at smaller events first.	15	MEDIUM	Environment and Sustainability - Sustainability	Yes	No	No	No
22	Development of Sustainable Building Policy/Guidance that covers use of raw materials/recycled materials to underpin procurement processes and support Project Initiation Documents.	16	MEDIUM	Environment and Sustainability - Sustainability	Yes	No	No	No
23	Review of specifications underpinning road construction projects to identify opportunities to incorporate recycled materials.	16	MEDIUM	Project Delivery	Yes	No	No	No
24	Review to be performed on the City's application of pesticides/herbicides, including Glyphosate, with a view to minimising impact to Soil and Groundwater assets.	23	MEDIUM	Service Delivery - Parks	Yes	No	60,000	No - Just External Consultancy (review of current practices and potential improvements).

Action no.	Proposed action	Risk no.	Priority	Lead Responsibility	Addressed through BAU? Yes/No?	Additional FTE Required? E.G 0.5FTE	Additional External Costs Incurred? $	Both Additional FTE Required and External Costs Incurred? Yes/No?
25	Request DWER GIS data regarding potentially contaminated sites so all sites are visible and associated documentation is easy to access. The City could investigate these sites to determine if the land is potentially contaminated and remediate as required.	28	MEDIUM	Health Services	Yes	Potentially, if the City has to remediate sites (will be considered when there is transparency over the magnitude of any potential issues).	Potentially, if the City has to remediate sites (will be considered when there is transparency over the magnitude of any potential issues).	No
26	Formalise and document the initiatives delivered by the City and seek Gold Waterwise Council Accreditation (process has commenced).	31	MEDIUM	Environment and Sustainability - Sustainability	Yes	No	No	No
27	New Build and Retrofit Building Projects - Build on PLN 2.10 Environmentally Sustainable Design to include detailed guidance on water efficiency requirements for inclusion in Project Initiation and QS Documents (water fittings, landscaping, water tanks etc).	31	MEDIUM	Environment and Sustainability - Sustainability	Yes	No	No	No
28	Procurement of real time energy and water monitoring system to exploit submeters already installed (previous supplier). Feed results into Energy and Water Monitoring Committee. Currently at scoping stage.	31	MEDIUM	Environment and Sustainability - Sustainability	Yes	No	No	No
29	City has an advocacy role in supporting DWER in the implementation of enhanced monitoring and public disclosure around water extraction from commercial enterprises in unproclaimed areas.	33	MEDIUM	EMT	Yes	No	No	No
30	For development areas with known poor water allocation levels, advocate at state level for alternative schemes such as MAR. or seek MAR schemes within the City (cost prohibitive)	35	MEDIUM	Design - Parks	Yes	No	No	No

Action no.	Proposed action	Risk no.	Priority	Lead Responsibility	Addressed through BAU? Yes/No?	Additional FTE Required? E.G 0.5FTE	Additional External Costs Incurred? $	Both Additional FTE Required and External Costs Incurred? Yes/No?
31	Develop a Strategic Fertiliser Application Program that reviews existing processes to ensure highly efficient use of fertiliser that covers all Parks (Passive as well as Active Reserves, and potentially phase out granular fertiliser).	38	MEDIUM	Service Delivery - Parks	Yes	No	50,000	No - Just External Consultancy (review of current practices and development of Strategic Fertiliser Application Program).
32	Desktop Review to identify high risk areas of water quality issues (e.g. industrial areas, heavy road use, proximity to major Parks) with a view to prioritising upgrades in the Renewal program (e. g. compensation basins etc).	41	MEDIUM	Service Delivery	Yes	Potentially, if there is a change in level of service (will be evaluated on completion of activity)	No	No
33	Initiation of quarterly multi-disciplinary project meetings to review the drainage asset renewal/maintenance program, with a view to introducing water treatment features.	41	MEDIUM	Service Delivery - Parks	Yes	Potentially, if there is a change in level of service (will be evaluated on completion of activity)	No	No
34	Continuation of the implementation of the Light Industry Program - Practices will improve once this is currently fully operational	42	MEDIUM	Health Services	Yes	No	No	No
35	The City does not have any head of power in relation to the Rights in Water and Irrigation Act (1914), nor compliance activities associated with the Canning River. However, the CoA may fulfil an advocacy role in support of the community to ensure that abstraction is appropriately controlled.	51	MEDIUM	Environment and Sustainability - Sustainability	Yes	No	No	No
36	Engagement with Water Corporation ahead of Winter season, to ensure alignment of maintenance regimes (potential role for WALGA in coordinating).	52	MEDIUM	Service Delivery	Yes	No	No	No

Action no.	Proposed action	Risk no.	Priority	Lead Responsibility	Addressed through BAU? Yes/No?	Additional FTE Required? E.G 0.5FTE	Additional External Costs Incurred? $	Both Additional FTE Required and External Costs Incurred? Yes/No?
37	DBCA is Land Manager of the Canning River System (all other key drainage outlets in the City are covered by comprehensive water quality monitoring regimes). Advocate for State Government, as part of the Cleaning up the Canning Program, to implement routine monitoring of water quality for selected species at strategic points along the Canning River. This could inform potential water quality improvement projects and highlight the impact of smaller scale land use change and/or sediment discharge.	54	MEDIUM	Environment and Sustainability - Sustainability	Yes	No	No	No
38	Internal workshop/training session 31/1/24 identified issues/actions associated with the implementation of Water Sensitive Urban Design across the City of Armadale, covering a range of matters for resolution - from ownership/approvals to the level of technical guidance required. Project to be initiated to review these matters and identify where City processes and guidance material can be improved and implement any improvements.	54	MEDIUM	Environment and Sustainability - Sustainability	Yes	No	No	No
39	Provision of City generated water quality reports to DWER/DBCA to enable mutual feedback loop on best practice and sharing of best practice metro-wide.	54	MEDIUM	Environment and Sustainability - Sustainability	Yes	No	No	No
40	Perform a review of the level of compliance resources across the City to ensure that there is appropriate capacity in place and/or targeting of existing programs	55	MEDIUM	EMT	Yes	No	No	No
41	Advocate to State Government for the phasing out of woodfire heaters	3	LOW	Health Services	Yes	No	No	No
42	Opportunity - Develop proactive program to identify approved ATU systems in the City that have not been serviced and follow up on these.	26	LOW	Health Services	Yes	No	No	No

Action no.	Proposed action	Risk no.	Priority	Lead Responsibility	Addressed through BAU? Yes/No?	Additional FTE Required? E.G 0.5FTE	Additional External Costs Incurred? $	Both Additional FTE Required and External Costs Incurred? Yes/No?
43	Opportunity - Incorporate into Action 11 from the Biodiversity Strategy a need to also include Acid Sulphate Soil considerations - Prepare an Environmental Protection Policy, applicable to corporate operations that addresses avoidance, mitigation and offset principles. Include Policy support documents including revised internal templates for referral, information sheets for environmental management during works, templates for CEMPs and standard conditions for environmental management documents to be provided as part of tender or quote commissioning as assessment criteria during construction tender process.	27	LOW	Environment and Sustainability - Environment	Yes	No	No	No
44	Complete the review of the provisions of the Environment, Animals and Nuisance Local to improve outcomes.	56	LOW	Health Services	Yes	Potentially, if there is a change in level of service (will be evaluated on completion of activity)	No	No

7 Conclusion

The City of Armadale is proud of its natural environment assets, and recognises action is required in order to protect, preserve and enhance these assets for current and future generations.

This Strategy provides guidance to achieve the Strategic Community Plan objective '*Conservation and restoration of the natural environment'* for air, water and soil and land resources.

The approach to environmental management is guided by an Environmental Management Framework (EMF). This Strategy collectively represents three of five strategic documents informing the five-year operational plan in accordance with the EMF. The others include the Biodiversity Strategy (completed) and the Aboriginal Heritage Strategy (yet to be completed).

This Strategy:

- provides a snapshot view of the current state of environmental assets in the City (**Section 4**)
- describes City activities and associated environmental considerations (**Section 5**)
- uses a risk response-based approach to identify key risks, describing the current management response and recommends additional controls in the Action Plan (**Sections 6.1** and **6.2**)

It has been developed in consultation with key stakeholders including various City of Armadale business units, Council and environmental volunteers and will be reviewed internally on a five-year rolling basis. This will include measurement of the recommended indicators provided in Appendix 2 and a comparison to the 2020-24 baseline outlined in this report.

In total, 56 risks, have been identified in the Strategy, with 143 mitigating controls. An additional 48 actions have been created to further limit risks to the environment (Table 20).

The objectives and actions recommended in this strategy will inform the five-year rolling forecast of the *Environmental and Sustainability* business unit and operational planning.

Reporting of implementation of actions will be achieved through reporting commitment of the Environmental Management Framework.

8 References & Resources

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9 Appendix 1: Risk assessment and risk matrix

Table A1 - Risk Assessment Matrix

Consequence	Likelihood				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	MEDIUM	MEDIUM	CRITICAL	CRITICAL	CRITICAL
Likely	LOW	MEDIUM	HIGH	CRITICAL	CRITICAL
Moderate	LOW	MEDIUM	MEDIUM	HIGH	CRITICAL
Unlikely	LOW	LOW	MEDIUM	MEDIUM	HIGH
Rare	LOW	LOW	LOW	MEDIUM	HIGH

Table A2 – Description of consequences as relates to impact on the Natural Environment

Consequence	Description
Insignificant	Isolated example of damage to an environmental asset that is neither locally, regionally or environmentally significant.
Minor	Larger scale cumulative impact to a locally significant environmental asset that is not regionally or nationally significant.
Moderate	Decimation of locally significant environmental asset, or minor isolated examples of damage to a regionally or nationally significant environmental asset
Major	Larger scale community impact to a regionally or nationally significant environmental asset
Catastrophic	Decimation of regionally or nationally significant environmental asset

Table A3 – Description of likelihood

Description	Detailed description	Frequency	
		City assets	Other categories
Rare	The event has not happened, but there is a possibility of it occurring at some time in exceptional circumstances.	Less than 25 years	Less than once in 10 years
Unlikely	The event could and does occur within the organisation. e.g. 10% - 35% chance of happening.	At least once in 15 years	At least once in 5 years
Possible	The event occurs reasonably frequently within the organisation, e.g. 35% - 65% chance of happening.	At least once in 10 years	At least once every 2 years
Likely	The event has a very high likelihood of occurring within the organisation, e.g. 65% - 90% chance of happening.	At least once in 5 years	At least once per year
Almost certain	The event will almost certainly occur within the organisation, e.g. > 90% chance of happening.	At least once in 2 years	More than once per year

Table A4 – Risk assessment

			Identified risks				Existing risk controls				Additional controls			
Risk category	**Asset category**	**Risk ref. no.**	**Risk description**	**Likelihood**	**Consequence**	**Risk rating**	**Current actions**	**Likelihood**	**Consequence**	**Residual risk rating**	**Proposed actions**	**Likelihood**	**Consequence**	**Residual Risk Rating**
Air quality deterioration	Air	1	Dust from vacant land results in a deterioration in air quality	3 - Possible	2 - Minor	Medium (6)	Respond to customer service requests. Use appropriate enforcement actions under the Local law (Environment, Animals and Nuisance Local law)	3 - Possible	2 - Minor	Medium (6)	Develop a policy and/or guidance document to state specific requirements for dust management for specific scenarios e.g. vacant land/subdivision (currently it is up to the property owner/developer to determine preventative measures). See also comment below re; Sediment Awareness Project Implementation.	3 - Possible	2 - Minor	Medium (6)
Air quality deterioration	Air	2	Dust generated from sites that are in the process of being cleared or have completed clearing as part of the Land Use Changes process result in a deterioration in air quality (Note, can also result in sand/sediment accumulation in city bushland areas and waterways, see risks 20 and 49).	4 - Likely	3 - Moderate	High (12)	Review Dust Management Plan and issue approval. Monitor compliance through customer service requests.	4 - Likely	3 - Moderate	High (12)	Develop a policy and/or guidance document to state specific requirements for dust management for specific scenarios e.g. vacant land/subdivision (currently it is up to the property owner/developer to determine preventative measures). See also comment below re; Sediment Awareness Project Implementation.	3 - Possible	2 - Minor	Medium (6)
Air quality deterioration	Air	3	Combustion in woodfires results in a deterioration in air quality and atmospheric pollution.	3 - Possible	2 - Minor	Medium (6)	Promotion of Department of Water and Environmental Regulation Burnwise program (e.g. on City's website). Respond to customer service requests and use appropriate enforcement actions under the Health (Miscellaneous Provisions) Act 1911 and/or the Environment, Animals and Nuisance Local Law.	3 - Possible	1 - Insignificant	Low (3)	Advocate to State Government for the phasing out of woodfire heaters	3 - Possible	1 - Insignificant	Low (3)
Air quality deterioration	Air	4	Emissions of noise, light, dust or odour from activities at the City's works depot result in a deterioration in air quality.	3 - Possible	3 - Moderate	Medium (9)	Depot sweeping/cleaning program to minimise the impact of dust liberation from vehicle movement. Training of operators to maintain sound housekeeping principles. Program of projects appropriately to reduce the amount of material stockpiled on site for long durations.	3 - Possible	2 - Minor	Medium (6)	Perform a review of infrastructure requirements as part of the Depot redevelopment process to ensure that environmental performance is adequate and develop an Environmental Management Plan to include dust management, stormwater management, groundwater management, odour management, noise management, light management.	3 - Possible	1 - Insignificant	Low (3)

			Identified risks				Existing risk controls				Additional controls			
Risk category	**Asset category**	**Risk ref. no.**	**Risk description**	**Likelihood**	**Consequence**	**Risk rating**	**Current actions**	**Likelihood**	**Consequence**	**Residual risk rating**	**Proposed actions**	**Likelihood**	**Consequence**	**Residual Risk Rating**
Air quality deterioration	Air	5	Emissions of noise, light, dust, odour or other pollutants from activities at ALARF result in a deterioration in air quality.	4 - Likely	3 - Moderate	High (12)	Use of water trucks to control dust Machinery complies with noise regulation requirements via procurement processes.	3 - Possible	2 - Minor	Medium (6)	(In progress) Develop Environmental Management Plan to include dust management, stormwater management (including sampling), noise control, odour management, leachate management, light management (requires compilation and updating of relevant management plans).	3 - Possible	1 - Insignificant	Low (3)
Air quality deterioration	Air	6	Dust generated by City construction activities results in a deterioration in air quality (road construction/maintenance, building construction/maintenance, drain construction/maintenance).	4 - Likely	2 - Minor	Medium (8)	Review Project Execution plans such as Construction Management Plans, method specifications and ensure focus is on dust suppression - e.g. capturing water carts, footpath sweeping, road sweepers being utilised efficiently.	2 - Unlikely	2 - Minor	Low (4)	Low risk - no further actions proposed	2 - Unlikely	2 - Minor	Low (4)
Air quality deterioration	Air	7	Emissions from City operated vehicles, machinery, plant and/or equipment results in a deterioration in air quality (e.g. NOx)	3 - Possible	1 - Insignificant	Low (3)	City only purchase vehicles that comply with Australian Standards in relation to vehicle emissions (light vehicles - ADR 79/04, heavy vehicles - ADR 80/03). Implementation of a 'Fleet Transition Strategy' - to convert to Electric Vehicles over a ten year timescale (the City has currently commenced this process and, for example, has 5 EV vehicles in the fleet).	3 - Possible	1 - Insignificant	Low (3)	Low risk - no further actions proposed	3 - Possible	1 - Insignificant	Low (3)

			Identified risks				Existing risk controls				Additional controls			
Risk category	**Asset category**	**Risk ref. no.**	**Risk description**	**Likelihood**	**Consequence**	**Risk rating**	**Current actions**	**Likelihood**	**Consequence**	**Residual risk rating**	**Proposed actions**	**Likelihood**	**Consequence**	**Residual Risk Rating**
Air quality deterioration	Air	8	Smoke generated from City activities including controlled burns results in a deterioration in air quality and atmospheric pollution.	4 - Likely	3 - Moderate	High (12)	Completion of a Burn Prescription Form (based on a DFES template) by the Bushfire Mitigation Officer that considers: Broad logistics around the burn (e.g. traffic management etc). Burn Risk Management (adjacent properties, site services, power, water). Weather conditions (consider conditions that may adversely affect the burn - e.g. wind direction, smoke drift, restrictions on burning if there is a haze alert in place - issued by BOM). Environmental matters (sensitive trees, rake hoeing etc) Notification of residents/stakeholders (stakeholder approvals/notifications)	2 - Unlikely	3 - Moderate	Medium (6)	Under the Respect and Opportunities areas of the Reconciliation Action Plan, investigate the potential for Cultural burning to be implemented. Cultural burning is a term that describes burning practices developed by Aboriginal people to enhance the health of country and culture. Cultural burning involves the application of fire using culturally informed knowledge and ecologically sensitive techniques that are appropriate for the local landscape and ecosystem. Cultural burning also includes protecting certain areas of Country for the health of plants and animals. This technique involves patch burning to create a mosaic of burnt and unburnt areas, which encourages regeneration of food sources and rapid recolonisation of fauna. Cultural burning applies fire management in the right season, at the right time and in the right way to ensure; flames stay low, preserving tree canopy; fires burn slowly; only some fuels are burnt, creating mosaics; insects and animals can move away from the fire; nutrients in the soil are not affected; seed germination is supported; and: flowering and nesting seasons are considered.	2 - Unlikely	2 - Minor	Low (4)

			Identified risks				Existing risk controls				Additional controls			
Risk category	Asset category	Risk ref. no.	Risk description	Likelihood	Consequence	Risk rating	Current actions	Likelihood	Consequence	Residual risk rating	Proposed actions	Likelihood	Consequence	Residual Risk Rating
Air quality deterioration	Air	9	Smoke generated from Community activities, including controlled burns results in a deterioration in air quality and atmospheric pollution.	4 - Likely	3 - Moderate	High (12)	Permit to Set Fire to the Bush issued under the Bush Fire Act 1954, contains standard conditions in relation to burning: Not allowed during any period where a “Haze Alert” has been issued by BOM for the Perth metropolitan area Prohibits burning of material likely to cause a smoke nuisance, including plastic, rubber, green garden waste or wet material. Alignment of burning rules with requirements of the Environment, Animals and Nuisance Local Law (e.g. no burning on properties less than 1,200sqm). Rangers respond to smoke nuisance complaints (infringements issued under the Bush Fires Act 1954 if contrary to Burning Permit). Opportunities at ALARF and Roleystone Greenwaste facility to dispose of green waste. Green waste verge pick ups twice a year. (In progress) Review of operating hours of Roleystone Green Waste Facility to provide greater opportunities for disposal.	3 - Possible	3 - Moderate	Medium (9)	Education Officer currently being recruited into Ranger Services. This role will: Work with the Community in relation to education around Hazard Reduction Burns. Delivery of Practical Demonstration Days (e.g. possibly a Bushfire Brigade stations and/or private residences). Raising awareness re; the DFES Burn SMART Program (optimum conditions for burning, planning the burn, materials that should not be burned, moisture content of materials etc). This role will also cover education around smaller blocks (what is and isn't allowed etc) Incentivise other ways to dispose of green waste.	2 - Unlikely	2 - Minor	Low (4)
Air quality deterioration	Air	10	Smoke generated from DBCA activities including controlled burns results in a deterioration in air quality and atmospheric pollution.	4 - Likely	3 - Moderate	High (12)		3 - Possible	3 - Moderate	Medium (9)	Advocate to DBCA to show greater consideration of climatic conditions, to limit impact on the community from controlled burns.	2 - Unlikely	2 - Minor	Low (4)

			Identified risks				Existing risk controls				Additional controls			
Risk category	**Asset category**	**Risk ref. no.**	**Risk description**	**Likelihood**	**Consequence**	**Risk rating**	**Current actions**	**Likelihood**	**Consequence**	**Residual risk rating**	**Proposed actions**	**Likelihood**	**Consequence**	**Residual Risk Rating**
Ecological damage	Air	11	Increasing temperatures (urban heat) caused by built environment (impervious surfaces, dark materials, lack of shade/canopy cover etc.) and exacerbated by climate change causing impacts to environmental attributes, including biodiversity, in urban areas (Note - bushland areas considered under the Biodiversity Strategy and health/wellbeing impacts to the community considered under the Community Health Plan.	5 - Almost certain	4 - Major	Critical (20)	Implementation of Liveable Neighbourhoods as part of the Land Use Change Process (WAPC Operational policy that guides the structure planning and subdivisional process). Review and finalisation of Structure Plans as part of the Land Use Change Process (to allow for vegetation retention in Public Open Space) Implementation of PLN 2.6 Water Sensitive Urban Design, during structure planning and subdivision development process. Implementation of PLN 2.4 Landscape Feature and Tree Preservation. Urban Forest Strategy Implementation (see additional risk in relation to existing controls and improvements required).	5 - Almost certain	4 - Major	Critical (20)	Update of the City's Community Health and Wellbeing Plan (in progress) to address Climate Change, in alignment with the approach of State Government (the City's new Public Health Plan will have objectives aligned with the State Public Health Plan on lessening the impact of climate change on community health and hence, the environment). Commence review of Public Health Assessments in relation to the Land Use Change Process under the Public Health Act 2016 (now allowable under new legislation).	5 - Almost certain	4 - Major	Critical (20)
Declining landfill capacity	Soil & land	12	The City's Landfill is used unnecessarily, as a result of inadequate recycling processes in the community.	3 - Possible	2 - Minor	Medium (6)	Provision of Yellow Top bins for recycling. Education of residents - Annual Waste Guide and activities of Circular Economy Education Officer. Implementation of Strategic Waste Management Plan, including alignment to the National Waste Policy and State Waste Strategy. Annual tracking of targets through submissions to the Waste Authority. ALARF - Inspection of trailers on entry at the weighbridge. ALARF - Drop N' Shop facility to enable residents to repurpose items. ALARF - Incentives for Sorted Waste (pricing). ALARF - Provision of a transfer station with opportunities for recycling (e.g. Household Hazardous Waste). Provision of contracts for residents to prevent waste disposal (e.g. Mattress pick up).	3 - Possible	1 - Insignificant	Low (3)	Low risk - no further actions proposed	3 - Possible	1 - Insignificant	Low (3)

			Identified risks				Existing risk controls				Additional controls			
Risk category	**Asset category**	**Risk ref. no.**	**Risk description**	**Likelihood**	**Consequence**	**Risk rating**	**Current actions**	**Likelihood**	**Consequence**	**Residual risk rating**	**Proposed actions**	**Likelihood**	**Consequence**	**Residual Risk Rating**
Declining landfill capacity	Soil & land	13	The City's Landfill is used unnecessarily, as a result of inadequate recycling processes in City facilities/insufficient processing infrastructure (not CoA).	3 - Possible	2 - Minor	Medium (6)	Provision of recycling bins for City facilities. Education of residents - Annual Waste Guide and activities of Circular Economy Education Officer. Implementation of Strategic Waste Management Plan, including alignment to the National Waste Policy and State Waste Strategy. Annual tracking of targets through submissions to the Waste Authority.	3 - Possible	1 - Insignificant	Low (3)	Low risk - no further actions proposed	3 - Possible	1 - Insignificant	Low (3)
Declining landfill capacity	Soil & land	14	The City's Landfill is used unnecessarily, as a result of inadequate recycling processes at site.	3 - Possible	2 - Minor	Medium (6)	Education of residents - Annual Waste Guide and activities of Circular Economy Education Officer. Implementation of Strategic Waste Management Plan, including alignment to the National Waste Policy and State Waste Strategy. Annual tracking of targets through submissions to the Waste Authority. ALARF - Inspection of trailers on entry at the weighbridge. ALARF - Drop N' Shop facility to enable residents to repurpose items. ALARF - Incentives for Sorted Waste (pricing). ALARF - Provision of a transfer station with opportunities for recycling (e.g. Household Hazardous Waste). Mattresses are segregated at ALARF (also applies to tyres, fridges, white goods etc).	3 - Possible	1 - Insignificant	Low (3)	Low risk - no further actions proposed	3 - Possible	1 - Insignificant	Low (3)
Declining landfill capacity	Soil & land	15	City Major Events do not employ appropriate recycling practices, resulting in unnecessary pollution of the City's landfill.	3 - Possible	2 - Minor	Medium (6)	Requirement to adhere to Single Use Plastic regulations. Provision of water fountains. Trialling of various initiatives (Containers for Change etc). Contamination levels associated with recycling initiatives, in the absence of unmanned bins, has led to sub-optimal results.	3 - Possible	2 - Minor	Medium (6)	(Currently in Scoping) Development of Sustainable Event Guidelines for the City (e.g encouraging vendors to be more sustainable in their practices) - may be tiered approach, with implementation at smaller events first.	2 - Unlikely	2 - Minor	Low (4)

			Identified risks				Existing risk controls				Additional controls			
Risk category	**Asset category**	**Risk ref. no.**	**Risk description**	**Likelihood**	**Consequence**	**Risk rating**	**Current actions**	**Likelihood**	**Consequence**	**Residual risk rating**	**Proposed actions**	**Likelihood**	**Consequence**	**Residual Risk Rating**
Declining landfill capacity	Soil & land	16	City construction activities/projects utilise raw materials inefficiently, resulting in deposition to Landfill. (City Construction/Maintenance Activities - Potential Use of Raw Materials/Repurposed Materials - Limiting Landfill Disposal)	3 - Possible	2 - Minor	Medium (6)	Procurement process includes evaluation requirements around sustainability - includes demonstration of waste minimisation and recycling processes. Procurement process underpinned by detailed specifications for specific materials (e.g. bitumen, pavements etc), and includes the opportunity for recycled materials.	3 - Possible	2 - Minor	Medium (6)	Development of Sustainable Building Policy/Guidance that covers use of raw materials/recycled materials to underpin procurement processes and support Project Initiation Documents. Review of specifications underpinning road construction projects to identify opportunities to incorporate recycled materials.	2 - Unlikely	2 - Minor	Low (4)
Declining landfill capacity	Soil & land	17	Illegal dumping in the City leads to an impact on environmentally sensitive areas (e.g. bushland), resulting in the pollution of soil and land (also potential for surface water and groundwater contamination).	3 - Possible	3 - Moderate	Medium (9)	System of responding to dumped rubbish complaints, and infringements where required (Resident Liaison Officers). Weekly tracking of dumped rubbish statistics and contract in place for dumped rubbish pickup (rapid response). Community Education programmes Preventative measures - bulk verge collections, contracts with recyclers (e.g. mattresses).	3 - Possible	1 - Insignificant	Low (3)	Low risk - no further actions proposed	3 - Possible	1 - Insignificant	Low (3)
Ecological damage	Soil & land	18	Damage to soil biota from hot burns	3 - Possible	2 - Minor	Medium (6)	See controls above re; Completion of a Burn Prescription Form (based on a DFES template) by the Bushfire Mitigation Officer that considers environmental factors; and: Education of the community (Education Officer).	3 - Possible	2 - Minor	Medium (6)	See action above in relation to Cultural Burning.	2 - Unlikely	2 - Minor	Low (4)
Ecological damage	Soil & land	19	Growing population leads to greater use of City-managed lands, leading to impacts on the quality of land resources (environmentally sensitive areas - e.g. bushland)	2 - Unlikely	2 - Minor	Low (4)	Implementation of Recreation Strategies for high priority City Reserves (Armadale Settlers Common, Bungendore Park, Roley Pools) with designated trails networks, specifically situated to minimise disruption to the natural environment.	2 - Unlikely	1 - Insignificant	Low (2)	Low risk - no further actions proposed	2 - Unlikely	1 - Insignificant	Low (2)
Ecological damage	Soil & land	20	Dust generated from sites that are in the process of being cleared or have completed clearing as part of the Land Use Changes process result in sand/sediment accumulation in city bushland areas (Note, can also result in air quality deterioration and sand/sediment accumulation in city waterways, see risks 2 and 49).	4 - Likely	3 - Moderate	High (12)	Actions identified under risk 2	4 - Likely	3 - Moderate	High (12)	Actions identified under risk 2	3 - Possible	2 - Minor	Medium (6)

			Identified risks				Existing risk controls				Additional controls			
Risk category	**Asset category**	**Risk ref. no.**	**Risk description**	**Likelihood**	**Consequence**	**Risk rating**	**Current actions**	**Likelihood**	**Consequence**	**Residual risk rating**	**Proposed actions**	**Likelihood**	**Consequence**	**Residual Risk Rating**
Ecological damage	Soil & land	21	Spread of dieback as a result of the movement of soils containing Phytophthora spores during Land Use Change Process.	3 - Possible	2 - Minor	Medium (6)	Implementation of ENG9 Managing Phytophthora Dieback for CoA construction activities. Implementation of Dieback Control Program on City Lands (see Biodiversity Strategy)	2 - Unlikely	2 - Minor	Low (4)	Low risk - no further actions proposed	2 - Unlikely	2 - Minor	Low (4)
Ecological damage	Soil & land	22	Spread of dieback as a result of the movement of soils containing Phytophthora spores during City Construction Activities.	3 - Possible	2 - Minor	Medium (6)	Review of applications as part of the Land Use Change Process, and requirement for Dieback Management Plans. Implementation of Dieback Control Program on City Lands (see Biodiversity Strategy)	2 - Unlikely	2 - Minor	Low (4)	Low risk - no further actions proposed	2 - Unlikely	2 - Minor	Low (4)
Ecological damage	Soil & land	23	Impacts to non targeted vegetation as a result of the application of pesticides/herbicides, including glyphosate (Note, also likely to result in water quality deterioration, see risk 46).	4 - Likely	3 - Moderate	High (12)	Application of pesticides/herbicides in accordance with manufacturer instructions etc City uses alternative non-chemical applications in various locations where possible (e.g. hand weeding, brush cutting, mulching). Use of contractors that utilise sensors to only spray areas covered by weeds in hardstand areas (reduces herbicide use by 50 to 80%).	4 - Likely	2 - Minor	Medium (8)	Review to be performed on the City's application of pesticides/herbicides, including Glyphosate, with a view to minimising impact to Soil and Groundwater assets.	2 - Unlikely	2 - Minor	Low (4)
Ecological damage	Soil & land	24	Management practices within sites undergoing Land Use Change, result in accumulation of waterborne sediment in city bushland areas (Note; can also result in sediment accumulation in waterways, see risk 39).	3 - Possible	4 - Major	High (12)	Actions identified under risk 39	3 - Possible	4 - Major	High (12)	Actions identified under risk 39	3 - Possible	2 - Minor	Medium (6)
Governance	Soil & land	25	Changes of State requirements and/or assessment of proposals reduces the visibility of environmental issues and ability to respond (e.g. as part of Development - Structure Planning and Subdivisional Controls etc).	4 - Likely	3 - Moderate	High (12)	City advocates to maintain and increase environmental protection mechanisms	4 - Likely	3 - Moderate	High (12)	WALGA to advocate	4 - Likely	3 - Moderate	High (12)
Soil and land contamination	Soil & land	26	Inappropriate management of ATU's results in the contamination of soil and land (Note, also likely to result in water quality deterioration, see risk 47)	2 - Unlikely	2 - Minor	Low (4)	Review and approval of ATU system implementation and review of ATU maintenance reports that are provided (actioned as necessary).	2 - Unlikely	2 - Minor	Low (4)	Opportunity - Develop proactive program to identify approved ATU systems in the City that have not been serviced and follow up on these.	2 - Unlikely	2 - Minor	Low (4)

			Identified risks				Existing risk controls				Additional controls			
Risk category	Asset category	Risk ref. no.	Risk description	Likelihood	Consequence	Risk rating	Current actions	Likelihood	Consequence	Residual risk rating	Proposed actions	Likelihood	Consequence	Residual Risk Rating
Soil and land contamination	Soil & land	27	City construction activities lead to the exposure of Acid Sulphate Soils (Note, also likely to result in water quality deterioration, see risk 48).	3 - Possible	2 - Minor	Medium (6)	Review City construction projects and provide advice on environmental legislative framework. Coordinate environmental approvals where required and review Construction and Environmental Management Plans	2 - Unlikely	2 - Minor	Low (4)	Opportunity - Incorporate into Action 11 from the Biodiversity Strategy a need to also include Acid Sulphate Soil considerations - Prepare an Environmental Protection Policy, applicable to corporate operations that addresses avoidance, mitigation and offset principles. Include Policy support documents including revised internal templates for referral, information sheets for environmental management during works, templates for CEMPs and standard conditions for environmental management documents to be provided as part of tender or quote commissioning as assessment criteria during construction tender process.	2 - Unlikely	2 - Minor	Low (4)
Soil and land contamination	Soil & land	28	Potentially contaminated sites may impact on soil and land quality, with an associated risk of disturbance, resulting in the release of environmental contaminants.	4 - Likely	3 - Moderate	High (12)	Current focus is on contaminated sites (the City has access to the Contaminated Sites register and can factor this knowledge into project planning processes - however, currently un-registered City owned sites may be reported to DWER as potentially contaminated and subsequently classified as PCIR resulting in a project risk)	4 - Likely	3 - Moderate	High (12)	Request from DWER GIS data regarding potentially contaminated sites so all sites are visible and associated documentation is easy to access. The City could investigate these sites to determine if the land is potentially contaminated and remediate as required.	2 - Unlikely	2 - Minor	Low (4)

			Identified risks				Existing risk controls				Additional controls			
Risk category	**Asset category**	**Risk ref. no.**	**Risk description**	**Likelihood**	**Consequence**	**Risk rating**	**Current actions**	**Likelihood**	**Consequence**	**Residual risk rating**	**Proposed actions**	**Likelihood**	**Consequence**	**Residual Risk Rating**
Soil and land contamination	Soil & land	29	Potential contamination of soil and land (e.g. hydrocarbons, sediment discharge) as a result of inappropriate management practices at the City's works depot (Note, also likely to result in water quality deterioration, see risk 53).	3 - Possible	3 - Moderate	Medium (9)	Presence of spills kits that are maintained appropriately. Only conduct repair / maintenance works in nominated areas. Use absorbent spill pads / sheets when conducting repairs and maintenance. Complete visual and scheduled checks of the fuel / oil tanks on the vehicles and storage containers on site. Ensure all pressure vessels checks are maintained. Train operators in correct spill containment practices. Ensure vehicles have appropriate vehicle spill kits. Ensure virgin hydrocarbon material is stored appropriately in suitable containers. Regularly maintain the vehicles to minimise fuel and hydraulic tank and line damage. Historical implementation of Urban Waterway Renewal Drainage retrofit projects to treat water immediately downstream of the Depot (Gillam Park).	3 - Possible	2 - Minor	Medium (6)	Perform a review of infrastructure requirements as part of the Depot redevelopment process to ensure that environmental performance is adequate and develop an Environmental Management Plan to include dust management, stormwater management, groundwater management, odor management, noise management, light management.	3 - Possible	1 - Insignificant	Low (3)

			Identified risks				Existing risk controls				Additional controls			
Risk category	**Asset category**	**Risk ref. no.**	**Risk description**	**Likelihood**	**Consequence**	**Risk rating**	**Current actions**	**Likelihood**	**Consequence**	**Residual risk rating**	**Proposed actions**	**Likelihood**	**Consequence**	**Residual Risk Rating**
Declining water availability	Water	30	Inefficient use of groundwater for irrigation/lake replenishment etc results in the exhaustion of the environmental asset, with resultant ecological and operational and community impacts (e.g. tree deaths, deterioration in park quality). Aging City irrigation infrastructure may result in the inefficient use of groundwater. Exacerbated by the impacts of climate change.	5 - Almost certain	3 - Moderate	Critical (15)	Established irrigation maintenance program Asset life cycle management - Infrastructure Renewal Program (requires review for adequacy/investment levels) Hydrozoning, waterwise gardens in parks and reserves Central control irrigation system Dosing units – non-ionic wetting agents to hold moisture in the ground Iron filtration systems for water quality Chemical injection for sulphate reducing bacteria (Wet well in the ground that injects treatments) Bore flow testing of every bore annually Annual reporting of ground water usage for each bore and amalgamates for each ground water sub area i.e., Jandakot mound, Leederville, surface and fractured Armadale Golf course water management strategy – objective to ensure we meet obligations water quality and water management Trialling a number innovations (e.g. Vortex system) Annual Waterwise endorsement.	4 - Likely	3 - Moderate	High (12)	Review the Asset Life Cycle Management - Infrastructure Renewal Program for adequacy via an external audit, and the development of a future management/implementation strategy (e.g. assessment of asset life, how old the assets are - much of the irrigation infrastructure is critically past its useful life). (In Progress) Delivery of a Bore and Pump Maintenance Program (recently developed and out for tender) Opportunistic - Significantly invest in infrastructure technology and innovation (software, hardware e.g. weather stations and associated applications). Consider/scope options for alternative sources of water for irrigation	3 - Possible	3 - Moderate	Medium (9)

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Declining water availability	Water	31	Inefficient use of scheme water in City facilities places increased pressure upon providers to exhaust supplies from groundwater and/or surface water systems (also, potential embodied energy and environmental impacts associated with desalinisation) Aging City facilities with old fixtures and fittings may result in the inefficient use of scheme water.	3 - Possible	3 - Moderate	Medium (9)	CoA is a Waterwise Council, with an annual re-endorsement process that is reviewed and approved by the Water Corporation. This tracks the use of scheme water and includes detailed initiatives to reduce water consumption (e.g. real time water monitoring at key sites, Energy and Water Monitoring Committee, development of a standard building palate for water efficient fixtures etc). Armadale Aquatic Centre is the largest City user, accounting for c30% of water use. The site is accredited under the Waterwise Aquatic Centre Program initiative. This tracks the use of scheme water and includes detailed initiatives to reduce water consumption (e.g. installation and monitoring of sub-meters, benchmarking of water use per patron against targets, leak detection processes, rainwater storage viability studies etc).	3 - Possible	2 - Minor	Medium (6)	New Project – Procurement of real time energy and water monitoring system to exploit submeters already installed (previous supplier). Feed results into Energy and Water Monitoring Committee. Currently at scoping stage. New Build and Retrofit Building Projects - Build on PLN 2.10 Environmentally Sustainable Design to include detailed guidance on water efficiency requirements for inclusion in Project Initiation and QS Documents (water fittings, landscaping, water tanks etc). Formalise and document the initiatives delivered by the City and seek Gold Waterwise Council Accreditation (process has commenced).	2 - Unlikely	2 - Minor	Low (4)
Declining water availability	Water	32	Changing rainfall patterns and declining groundwater leads to death of City-managed trees. Note - Natural Area Management Plan to be developed under Biodiversity Strategy that takes into account Climate Change in relation to Bushland Areas.	5 - Almost certain	4 - Major	Critical (20)	Undertaking a Street Tree Audit (to understand species assemblage, providing an indication of resultant risk profile). Under the Urban Forest Strategy utilising more drought resistant species Undertaking water initiatives as prescribed Water Sensitive Urban Design (living streams) increasing storm water recovery to recharge ground water Hydro mulching in parks to increase soil environment of trees and reduce use of ground water in the immediate vicinity Tree planting under the Urban Forest Strategy to reduce heat islands and make more areas conducive for tree environments	4 - Likely	4 - Major	Critical (16)	As part of the 2025 Review of the Urban Forest Strategy Implementation Program, incorporate the following aspects: Targets in relation to canopy cover (already intended). Identify vulnerable tree species and plan for long term replacements and or treatments to maintain health. Intensify the assessment of irrigated passive parks in view of hydro zoning and reduction of ground water use in each park (under dry parks Strategy) External consultant to review the City's preferred planting list for both streetscapes and reserves for suitability in terms of future proofing against a more drought related environment. Ongoing monitoring and evaluation of the success of the Urban Forest Strategy. Opportunistic - Identify stormwater recovery processes/water recovery to replenish volumes back into the groundwater	3 - Possible	3 - Moderate	Medium (9)

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Declining water availability	Water	33	Unproclaimed water resource areas - drawing of water has potential impacts (access to water for the City and local business).	4 - Likely	3 - Moderate	High (12)	DWER is currently liaising with operators to map and understand the potential impacts. The City is advocating and supporting DWER's initiative.	3 - Possible	3 - Moderate	Medium (9)	City has an advocacy role in supporting DWER in the implementation of enhanced monitoring and public disclosure around water extraction from commercial enterprises in unproclaimed areas.	3 - Possible	3 - Moderate	Medium (9)
Declining water availability	Water	34	Insufficient water may be provided by developers to water new areas of local and neighbourhood POS	4 - Likely	3 - Moderate	High (12)	Work with developer to seek alternative options at time of install such as stormwater harvesting. Amend designs to limit ongoing water use	3 - Possible	3 - Moderate	Medium (9)	For development areas with known poor water allocation levels, advocate at state level for alternative schemes such as MAR. or seek MAR schemes within the City (cost prohibitive)	3 - Possible	3 - Moderate	Medium (9)
Declining water availability	Water	35	No groundwater is available to irrigate new regional and district POS areas	4 - Likely	3 - Moderate	High (12)	Investigate alternative options at time of install such as stormwater harvesting Amend designs to limit ongoing water use	3 - Possible	3 - Moderate	Medium (9)	For development areas with known poor water allocation levels, advocate at state level for alternative schemes such as MAR. or seek MAR schemes within the City (cost prohibitive)	3 - Possible	3 - Moderate	Medium (9)
Ecological damage	Water	36	Ecological properties of the City's rivers may be compromised, as a result of them being 100% dammed (restricted water flows) and suffering the impacts of climate change - Canning and Wungong Rivers.	5 - Almost certain	4 - Major	Critical (20)	Environmental Water Releases are the key mechanism for replenishment and/or maintenance of water levels in the City's river systems e.g. the Canning River releases are governed by the Middle Canning River Surface Water Allocation Plan (2012). This is under the control of the Department of Water and Environmental Regulation.	5 - Almost certain	4 - Major	Critical (20)	The City does not have any head of power in relation to Environmental Water releases. However, the CoA may fulfil an advocacy role in support of the community to ensure that Environmental Water Releases continue to take place and are at appropriate levels. Provision of support as necessary to DBCA (e.g. Cleaning up the Canning) initiatives to map and investigate deep water pools in the Canning to identify ecological requirements.	5 - Almost certain	4 - Major	Critical (20)
Water quality deterioration	Water	37	WSUD assets are not appropriately maintained, resulting in poor performance and a deterioration in water quality.	4 - Likely	3 - Moderate	High (12)	Weed Control contractor maintains the Biofilters and base flow channel of the Living Streams (5x per annum) in the Living Streams and Biofilters (process not formally documented) (In Progress) Recruitment of new Living Streams Team (team of 2).	4 - Likely	3 - Moderate	High (12)	Development of a WSUD Strategic Plan that: Maps and describes WSUD assets (vegetated, non-vegetated, water and infrastructure) Brings in appropriate research on maintenance requirements (WSUD plans submitted at development) Documents current service level (from existing programs) and performance (from WQ monitoring results) Sets performance targets Determines a service level and supporting program of works Monitors and evaluates	2 - Unlikely	2 - Minor	Low (4)

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Risk category	**Asset category**	**Risk ref. no.**	**Risk description**	**Likelihood**	**Consequence**	**Risk rating**	**Current actions**	**Likelihood**	**Consequence**	**Residual risk rating**	**Proposed actions**	**Likelihood**	**Consequence**	**Residual Risk Rating**
Water quality deterioration	Water	38	Maintenance practices associated with the City's Public Open Space (e.g. fertiliser application) results in a deterioration in water quality in the City's waterways (e.g. inorganic nutrients - phosphorus and nitrogen).	4 - Likely	3 - Moderate	High (12)	Active Reserves: Targeted fertilising through liquid fertilising to minimise application. Soil and leaf analysis prior to fertilising. Consultant advises on program of application. Passive Irrigated Reserves: Granular fertiliser restricted to annual program (further investigation required to establish effectiveness) Monitoring: Monthly meter readings – Telemetry readings Annual water chemistry sample testing – concentration of metals and water quality salinity PH and Iron	2 - Unlikely	3 - Moderate	Medium (6)	Develop a Strategic Fertiliser Application Program that reviews existing processes to ensure highly efficient use of fertiliser that covers all Parks (Passive as well as Active Reserves, and potentially phase out granular fertiliser). Incorporate fertiliser use as part of any water management strategy	2 - Unlikely	2 - Minor	Low (4)
Water quality deterioration	Water	39	Management practices within sites undergoing Land Use Change, result in the discharge of water borne sediment to the City's waterways, impacting on water quality and/or water flows (Note, can also result in accumulation in city bushland areas, see risk 24).	3 - Possible	4 - Major	High (12)	Implementation of PLN 2.5 Erosion Prevention and Sediment Control, during subdivision development process (e.g. requirement for Sediment Control Plans). Potential application of the provisions of Environment, Animals and Nuisance Local Law 2002 provisions (Part 3, Division 2 - Sand Drift and Dust).	3 - Possible	4 - Major	High (12)	Participation in the Sediment Awareness Project under the banner of the Cleaning up the Canning initiative - this will benchmark the activities of Local Governments in relation to sediment control across the Land Use Change process and result in improvements across the City of Armadale, Gosnells and Canning and the Town of Vic Park. Provisionally $1m of funding allocated to this specific project.	3 - Possible	2 - Minor	Medium (6)
Water quality deterioration	Water	40	Management practices within sites undergoing Land Use Change, result in the discharge of water borne sediment to the City's drainage network (including WSUD assets), resulting in a deterioration in performance (water quality treatment).	3 - Possible	2 - Minor	Medium (6)	Actions identified under risk 31	3 - Possible	2 - Minor	Medium (6)	Actions identified under risk 31	3 - Possible	1 - Insignificant	Low (3)

			Identified risks				Existing risk controls				Additional controls			
Risk category	**Asset category**	**Risk ref. no.**	**Risk description**	**Likelihood**	**Consequence**	**Risk rating**	**Current actions**	**Likelihood**	**Consequence**	**Residual risk rating**	**Proposed actions**	**Likelihood**	**Consequence**	**Residual Risk Rating**
Water quality deterioration	Water	41	Legacy drainage systems are not designed with Water Sensitive Urban Design in mind, resulting in inadequate water treatment and potential water quality issues (e.g. sediment, hydrocarbons etc).	3 - Possible	3 - Moderate	Medium (9)	Review of opportunities for improvement as part of the drainage renewal program. Street sweeping and eduction programs. Opportunistic participation in initiatives to enhance water quality through grant funded drainage retrofits - Urban Waterway Renewal Projects and Cleaning up the Canning (currently earmarked for $1.7m of funding for two retrofit projects).	3 - Possible	3 - Moderate	Medium (9)	Desktop Review to identify high risk areas of water quality issues (e.g. industrial areas, heavy road use, proximity to major Parks) with a view to prioritising upgrades in the Renewal program (e. g. compensation basins etc). Initiation of quarterly multi-disciplinary project meetings to review the drainage asset renewal/maintenance program, with a view to introducing water treatment features.	3 - Possible	2 - Minor	Medium (6)
Water quality deterioration	Water	42	Business Owner Management Practices lead to the pollution of groundwater and waterways e.g. release of hydrocarbons.	4 - Likely	2 - Minor	Medium (8)	Early stages of implementation of the Light Industry Program (education program for light industry, including provision of guidance on best practice and the implementation of site audit programs). Respond to customer request and use appropriate enforcements options under te Unauthorised Discharge Regulations.	4 - Likely	2 - Minor	Medium (8)	Continuation of the implementation of the Light Industry Program - Practices will improve once this is currently fully operational	3 - Possible	2 - Minor	Medium (6)
Water quality deterioration	Water	43	Potential contamination of surface water (e.g. hydrocarbons, sediment discharge, other pollutants) as a result of management practices at ALARF.	3 - Possible	3 - Moderate	Medium (9)	Groundwater testing performed as per Licence associated with the site.	3 - Possible	2 - Minor	Medium (6)	(In progress) Develop Environmental Management Plan to include dust management, stormwater management (including sampling), noise control, odour management, leachate management, light management (requires compilation and updating of relevant management plans).	3 - Possible	1 - Insignificant	Low (3)
Water quality deterioration	Water	44	CoA construction activities and/or maintenance of infrastructure result in the contamination of groundwater and/or surface water systems (e.g. hydrocarbons, water borne sediment).	4 - Likely	2 - Minor	Medium (8)	Review Project Execution plans such as Construction Management Plans to ensure appropriate controls e.g. spill management.	2 - Unlikely	2 - Minor	Low (4)	Low risk - no further actions proposed	2 - Unlikely	2 - Minor	Low (4)
Water quality deterioration	Water	45	CoA Major Events result in the pollution of stormwater/groundwater, resulting in a deterioration of water quality (e.g. hydrocarbons etc).	2 - Unlikely	1 - Insignificant	Low (2)	Completion of an event specific Risk Management Plan, with evaluation of risks and mitigating actions/controls.	2 - Unlikely	1 - Insignificant	Low (2)	Low risk - no further actions proposed	2 - Unlikely	1 - Insignificant	Low (2)

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Risk category	Asset category	Risk ref. no.	Risk description	Likelihood	Consequence	Risk rating	Current actions	Likelihood	Consequence	Residual risk rating	Proposed actions	Likelihood	Consequence	Residual Risk Rating
Water quality deterioration	Water	46	Contamination to water resources as a result of the application of pesticides/herbicides, including glyphosate (Note, can also cause ecological damage, see risk 23).	3 - Possible	2 - Minor	Medium (6)	Actions identified under risk 23	4 - Likely	2 - Minor	Medium (8)	Actions identified under risk 23	2 - Unlikely	2 - Minor	Low (4)
Water quality deterioration	Water	47	Inappropriate management of ATU's results in water quality deterioration (Note, can also cause soil and land contamination, see risk 26).	2 - Unlikely	2 - Minor	Low (4)	Actions identified under risk 26	2 - Unlikely	2 - Minor	Low (4)	Actions identified under risk 26	2 - Unlikely	2 - Minor	Low (4)
Water quality deterioration	Water	48	City construction activities lead to the exposure of Acid Sulphate Soils resulting in water quality deterioration (Note, can also cause soil and land contamination, see risk 27).	3 - Possible	2 - Minor	Medium (6)	Actions identified under risk 27	2 - Unlikely	2 - Minor	Low (4)	Actions identified under risk 27	2 - Unlikely	2 - Minor	Low (4)
Water quality deterioration	Water	49	Dust generated from sites that are in the process of being cleared/, or have completed clearing as part of the Land Use Changes process result in sand/sediment accumulation in waterways (Note, can also result in air quality deterioration and sand/sediment accumulation in city bushland areas, see risks 2 and 20).	4 - Likely	3 - Moderate	High (12)	Actions identified under risk 2	4 - Likely	3 - Moderate	High (12)	Actions identified under risk 2	3 - Possible	2 - Minor	Medium (6)

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Declining water availability	Water	50	Inappropriate use of water in the community places increased pressure upon providers to exhaust supplies from groundwater and/or surface water systems (also, potential embodied energy and environmental impacts associated with desalinisation). Exacerbated by the impacts of climate change.	5 - Almost certain	4 - Major	Critical (20)	Switch Your Thinking (SYT) team implement the SYT Business Plan and engage in Community awareness programs around energy efficiency, water efficiency and sustainability. Provision of community workshops in relation to waterwise fittings/appliance and waterwise gardening. Rewards for Residents initiatives for community and business (e.g. provision of pool blankets). Social media messaging, Webpage content, content for community publications (native plants, substitution of lawn for native gardens, referral to Water Corporation initiatives, watering days, switch off reticulation). City of Armadale Native Plants for Residents program - free native plants. City support of Armadale Gosnells Landcare Group - promotion of planting of native species in the community.	5 - Almost certain	3 - Moderate	Critical (15)	Further opportunity to educate the community on City actions to improve water efficiency and irrigation, and to identify here they can help (report leaks etc) - Dedicated Water page on website and messages through comms and social media.	5 - Almost certain	3 - Moderate	Critical (15)
Declining water availability	Water	51	Regulations (e.g. RIWI Act 1914) allowing water abstraction by individuals may be outdated and not fit for purpose, resulting in water level decline in the Canning River. Illegal abstraction along the river also results in the same impact.	5 - Almost certain	2 - Minor	Medium (10)	Water abstraction licences are issued and controlled by the Department of Water and Environmental Regulation - hence the City has no head of power in this area. In addition, the Canning River is under management control by the Department of Biodiversity and Conservation - compliance in relation to illegal abstraction structures on the River is under their control.	5 - Almost certain	2 - Minor	Medium (10)	The City does not have any head of power in relation to the Rights in Water and Irrigation Act (1914), nor compliance activities associated with the Canning River. However, the CoA may fulfil an advocacy role in support of the community to ensure that abstraction is appropriately controlled.	5 - Almost certain	2 - Minor	Medium (10)

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Risk category	**Asset category**	**Risk ref. no.**	**Risk description**	**Likelihood**	**Consequence**	**Risk rating**	**Current actions**	**Likelihood**	**Consequence**	**Residual risk rating**	**Proposed actions**	**Likelihood**	**Consequence**	**Residual Risk Rating**
Ecological damage	Water	52	Climate Change results in a higher frequency of storm events - drainage network may not have the capacity for this, resulting in flooding.	3 - Possible	3 - Moderate	Medium (9)	New development - Review and approval of Local Water Management Strategies/Urban Water Management Plans, with consideration of statistical data flood modelling data, obtained from the Australian Bureau of Meteorology. Street Sweeping/Eduction/Drainage maintenance program. Noting that issues associated with City drainage assets are mainly the result of water 'backing up' from Water Corp Main Drains due to maintenance scheduling issues.	3 - Possible	3 - Moderate	Medium (9)	Engagement with Water Corporation ahead of Winter season, to ensure alignment of maintenance regimes (potential role for WALGA in coordinating). Lobby Water Corp for improvement in drainage practices.	3 - Possible	2 - Minor	Medium (6)
Water quality deterioration	Water	53	Potential contamination of surface water and groundwater (e.g. hydrocarbons, sediment discharge) as a result of inappropriate management practices at the City's works depot (Note, also likely to result in soil and land contamination, see risk 29).	3 - Possible	3 - Moderate	Medium (9)	Actions identified under risk 29	3 - Possible	2 - Minor	Medium (6)	Actions identified under risk 29	3 - Possible	1 - Insignificant	Low (3)

			Identified risks				Existing risk controls				Additional controls			
Risk category	**Asset category**	**Risk ref. no.**	**Risk description**	**Likelihood**	**Consequence**	**Risk rating**	**Current actions**	**Likelihood**	**Consequence**	**Residual risk rating**	**Proposed actions**	**Likelihood**	**Consequence**	**Residual Risk Rating**
Water quality deterioration	Water	54	Drainage design of new developments results in a deterioration in water quality, through surface water discharge and groundwater flows with elevated levels of environmental pollutants (e.g. inorganic nutrients - nitrogen and phosphorus). Note, also results in community complaints - algal blooms, mosquitos, weeds etc.	3 - Possible	3 - Moderate	Medium (9)	Review and finalisation of Local Water Management Strategies at Structure Plan stage by the Department of Water and Environmental Regulation (advice also provided by the CoA) Incorporation of WSUD principles, as per guidelines of the Department of Water and Environmental Regulation (Better urban Water Management). Review and finalisation of Urban Water Management Plans by the CoA at Subdivision stage - incorporation of WSUD principles. Implementation of PLN 2.6 Water Sensitive Urban Design, during structure planning and subdivision development process. Implementation of CoA Water Resource Management for Land Development - A Position Paper. Implementation of North Forrestdale Water Quality Monitoring Programme (10 year monitoring program funded by Developer Contribution Scheme), with Annual reporting to identify issues and implement corrective actions.	3 - Possible	3 - Moderate	Medium (9)	Internal workshop/training session 31/1/24 identified issues/actions associated with the implementation of Water Sensitive Urban Design across the City of Armadale, covering a range of matters for resolution - from ownership/approvals to the level of technical guidance required. Project to be initiated to review these matters and identify where City processes and guidance material can be improved and implement any improvements. DBCA is Land Manager of the Canning River System (all other key drainage outlets in the City are covered by comprehensive water quality monitoring regimes). Advocate for State Government, as part of the Cleaning up the Canning Program, to implement routine monitoring of water quality for selected species at strategic points along the Canning River. This could inform potential water quality improvement projects and highlight the impact of smaller scale land use change and/or sediment discharge. Provision of City generated water quality reports to DWER/DBCA to enable mutual feedback loop on best practice and sharing of best practice metro-wide.	2 - Unlikely	2 - Minor	Low (4)
Governance	All	55	Compliance - Limited staff resources to effectively monitor and enforce and/or risk of program not monitoring in the right areas (Dust Industrial Areas/Unauthorised Discharges (EP Act) Industrial Areas/Oil and Household Chemicals)	4 - Likely	2 - Minor	Medium (8)	See comments above against implementation of Light Industry Program.	4 - Likely	2 - Minor	Medium (8)	Perform a review of the level of compliance resources across the City to ensure that there is appropriate capacity in place and/or targeting of existing programs	3 - Possible	2 - Minor	Medium (6)

			Identified risks				Existing risk controls				Additional controls			
Risk category	**Asset category**	**Risk ref. no.**	**Risk description**	**Likelihood**	**Consequence**	**Risk rating**	**Current actions**	**Likelihood**	**Consequence**	**Residual risk rating**	**Proposed actions**	**Likelihood**	**Consequence**	**Residual Risk Rating**
Governance	All	56	Environmental, Animals and Nuisance Local Law needs to be improved to achieve improved compliance outcomes and decrease potential environmental degradation (air quality, smoke, sediment control, woodfires).	3 - Possible	2 - Minor	Medium (6)	(In Progress) Periodic review of Environment, Animals and Nuisance Local Law	2 - Unlikely	2 - Minor	Low (4)	Complete the review of the provisions of the Environment, Animals and Nuisance Local to improve outcomes.	2 - Unlikely	2 - Minor	Low (4)

10 Appendix 2: Summary of recommended indicator baselines

Recommended Indicators - AIR		Unit	2020	2021	2022	2023	2024 (part)
Ambient Air Quality	PM2.5 exceedances	Count	1	6	7	20	10
	PM10 exceedances	Count	0	2	4	5	2
Wood heater complaints	Received	Count			20		4
ALARF	Various Atmospheric Emissions		Tracked annually as part of Licencing Requirements and Annual Environmental Compliance Report				
	Complaints (odour/dust/noise)	Count	8 – odour, 2 – noise				
DEPOT	Indicators to be developed as part of development of Environmental Management Plan.						

Recommended Indicators – SOIL and LAND		Unit	2020	2021	2022	2023	2024 (part)
Contaminated sites	Contaminated - remediation required	Count	5	5	4	4	4
	Contaminated – restricted use	Count	5	5	5	5	5
	Remediated for restricted use	Count	158	160	161	161	161
Light industry inspections	Inspections undertaken	Count					
Light industry complaints	Received	Count			14		3
Sediment export	See tracking of Total Suspended Solids – TSS - below (WATER)						
Urban tree canopy	Total	%	28				
	Parks	%	18				
	Roads	%	17				
	Street blocks	%	39				
ALARF	Volume of material to landfill/material recycled	Tonnes	Tracked annually as part of Annual Waste Plans submitted to the Department of Water and Environmental Regulation				
DEPOT	Indicators to be developed as part of development of Environmental Management Plan.						

Recommended Indicators – WATER		Unit	2020	2021	2022	2023	2024 (part)
Annual maximum groundwater level	T120	mAHD	21.09	21.58	21.49	21.17	19.92
	JM23	mAHD	25.05	25.39	25.18	25.03	24.38
	JM27	mAHD	24.97	25.36	25.39	25.12	23.66
	JM36	mAHD	22.62	23.51	23.42	23.14	22.03
Streamflow - total annual	616065 - Canning (Glen Eagle)	ML	642	6,673	3,692	519	-
	616027 - Canning R. (Seaforth)	ML	5,383	10,360	9,654	6,965	287
	616041 - Wungong R. (Vardi)	ML	602	3,310	1,648	471	-
	616092 - Southern R. (Anaconda)	ML	7,931	18,640	15,890	10,110	193
Corporate water use	Surface and Groundwater Use					1,328,028	
	Surface water use	kL				26,453	
	Scheme water use	kL	92,513	86,462	83,511	91,066	12,516
Groundwater quality (total nitrogen)	BRM11	mg/L	10.60	3.40	4.10	13.00	
	BRM12	mg/L	0.45	1.15	4.10	1.65	
	BRM6/F-MB06a	mg/L	1.82	1.25	1.30	7.10	
	SRCS01D	mg/L	0.85	0.51	1.45	2.24	
	XX11	mg/L	1.30	1.00	1.20	1.45	
	XX16	mg/L	1.35	1.70	1.45	1.65	
	XX17	mg/L	1.45	3.20	2.70	1.40	
	XX8	mg/L	2.40	1.20	1.48	1.40	
	XX9	mg/L	1.95	2.07	1.63	1.45	
Groundwater quality (total phosphorus)	BRM11	mg/L	2.78	0.36	1.95	1.15	
	BRM12	mg/L	0.02	0.20	0.46	0.10	
	BRM6/F-MB06a	mg/L	0.53	0.77	0.93	1.10	
	SRCS01D	mg/L	0.53	0.37	1.16	0.89	
	XX11	mg/L	0.26	0.19	0.23	0.16	
	XX16	mg/L	0.07	0.07	0.06	0.04	

Recommended Indicators – WATER		Unit	2020	2021	2022	2023	2024 (part)
	XX17	mg/L	0.15	0.16	0.14	0.10	
	XX8	mg/L	0.11	0.10	0.11	0.08	
	XX9	mg/L	0.05	0.02	0.04	0.05	
Surface water quality (total nitrogen)	AW01	mg/L	0.45	0.70	0.60	0.60	
	AW03	mg/L	0.40	0.50	0.40	0.55	
	AW04	mg/L	0.45	1.00	0.70	0.90	
	WM03	mg/L	0.45	0.55	0.40	0.80	
	WUW	mg/L	0.85	0.80	0.85	1.30	
	SW16	mg/L	1.65	1.25	2.60	2.10	
	SW1a	mg/L	2.20	1.95	2.30	2.30	
	SW2	mg/L	2.15	1.70	1.95	1.90	
	SW5	mg/L	1.90	1.30	1.30	1.00	
	SW7	mg/L	2.55	1.55	1.75	1.80	
Surface water quality (total phosphorus)	AW01	mg/L	0.09	0.07	0.11	0.05	
	AW03	mg/L	0.06	0.06	0.05	0.05	
	AW04	mg/L	0.04	0.04	0.07	0.05	
	WM03	mg/L	0.03	0.04	0.06	0.03	
	WUW	mg/L	0.10	0.07	0.09	0.09	
	SW16	mg/L	0.21	0.09	0.26	0.69	
	SW1a	mg/L	0.18	0.16	0.19	0.24	
	SW2	mg/L	0.23	0.17	0.17	0.20	
	SW5	mg/L	0.09	0.14	0.08	0.10	
	SW7	mg/L	0.26	0.24	0.19	0.25	
Sediment export/surface water quality (total suspended solids)	AW01	mg/L	5.63	6.00	5.63	6.67	
	AW03	mg/L	5.22	5.25	6.07	8.25	

Recommended Indicators – WATER		Unit	2020	2021	2022	2023	2024 (part)
	AW04	mg/L	5.00	8.22	5.56	17.71	
	WM03	mg/L	5.33	6.00	8.67	7.32	
	WUW	mg/L	7.83	10.67	8.83	23.91	
ALARF - nominated guideline exceedances	Various Emissions to Water	Count	Tracked annually as part of Licencing Requirements and Annual Environmental Compliance Report				
DEPOT	Indicators to be developed as part of development of Environmental Management Plan.						

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