9 IMPACTS TO HUMAN HEALTH AND AMENITY

In this section human health and amenity factors are discussed together since there is considerable overlap in respect of issues such as odour and noise.

9.1 KEY FINDINGS

- Removal of East Keralup from the development footprint avoids associated recognised potentially substantial health and amenity risks from mosquitos.

- Enhanced urban heat island effect, combined with future climate change is a significant potential impact on health and amenity, particularly in respect of urban consolidation in the central sub-region.

- Mitigation is proposed that will see further investigation of urban heat island vulnerabilities, development of a framework for maintaining or enhancing a network of green space and tree canopy cover, and conduct of five yearly monitoring of urban tree canopy cover to track and evaluate effectiveness.

- Noise and odour impacts are proposed to be mitigated through determination and implementation of buffers around strategic industrial areas and development of further policy to guide implementation.

- A quantitative determination of the impacts to human health and amenity has not been possible, however, the proposed mitigation and management measures put forward will ensure a strategic approach to the buffers necessary to mitigate noise and odour impacts, and establish an adaptive response to the urban heat island effect. Combined with substantial avoidance already achieved, implementation of these measures will mean that the EPA's objectives for Human Health and Amenity can be met over time.

9.2 EPA OBJECTIVE

The following EPA objectives are applicable to this assessment:

To ensure that human health is not adversely affected.

To ensure that impacts to amenity are reduced as low as reasonably practicable.
9.3 ENVIRONMENTAL POLICY AND GUIDANCE

The following policy and guidelines are relevant to this assessment with regard to human health and amenity:

- State Planning Policy 2 Environment and Natural Resources Policy (WAPC 2003a).
- State Planning Policy 2.5 Agricultural and Rural land Use Planning (WAPC 2012).
- State Planning Policy 2.6 State Coastal Planning Policy (WAPC 2013).
- State Planning Policy 2.10 Swan - Canning River System (WAPC 2006b).
- State Planning Policy 3 Urban Growth and Settlement (WAPC 2006d).
- State Planning Policy 4.1 State Industrial Buffer (and draft revision) (WAPC 1997)
- State Planning Policy 5.1 Land use Planning in the Vicinity of Perth Airport (and current draft amendment) (WAPC 2015b).
- State Planning Policy 5.3 Jandakot Airport Vicinity (WAPC 2006e).
- State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning (WAPC 2009).
- Odour Methodology Guideline (DEP 2002).
- EPA Guidance Statement 33 Environmental Guidance for Planning and Development (EPA 2008c) and draft revision released September 2015.
- Visual Landscape Planning in Western Australia - A manual to address visual landscape in planning (WAPC 2007).
- Western Australian Waste Strategy: Creating the right environment (WAWA 2012).

9.4 EXISTING ENVIRONMENT

9.4.1 Key values

Human health

Human health is the state of physical, mental and social wellbeing and is determined by biological, behavioural, social, economic and environmental factors. Hazards in our environment with the potential to harm human health may arise from technological, industrial, economic and social changes and act on the factors and conditions that influence health outcomes (DoH 2007). Determinants of health are varied, however, those considered relevant to the strategic assessment of future development are those related to the natural and physical environment (Table 9-1 adapted from DoH 2007).
Table 9-1: Potential determinants of health relevant to the strategic assessment

<table>
<thead>
<tr>
<th>Health determinant category</th>
<th>Potential health determinants</th>
</tr>
</thead>
</table>
| Natural and physical environment | • Greenspace  
• Vector borne diseases  
• Air quality  
• Contaminated land: soil and groundwater  
• Health hazards in the built environment such as the urban island heat effect  
• Water quality: drinking, recycled, recreational, wastewater  
• Noise, odour, dust, light  
• Waste disposal/management |

Amenity

Amenity means all those factors that combine to form the character of an area (Schedule 1, Town Planning Regulations). More generally, the Australian Concise Oxford Dictionary defines amenity to be the pleasant or useful features or overall pleasantness of a place. Assessment of amenity is therefore intrinsically subjective and it is best assessed against community expectations, reasonably held in the particular circumstance and time.

Landscape is an important contributor to the amenity of a region. The EPA considers ‘landscape’ to be: "All the features of an area that can be seen in a single view, which distinguish one part of the earth’s surface from another part. Landscapes can be either natural (largely unaffected by human activity) or human (created or significantly modified by human activity)" (EPA 2015c).

Perth’s beaches, parks and bushland, the Swan River, lakes and wetlands habitats, and the Darling Escarpment provide amenity that is highly valued and forms a strong part of community identity. Careful planning has protected a series of high quality natural areas such as Kings Park, Bold Park, Whiteman Park and Yanchep National Park. Perth’s rivers and beaches are publicly accessible and the extensive coastal and river system is one of the city’s most valued features (DoP and WAPC 2010). The landscapes of the Advice Area also hold ecological (see Chapter 5- Impacts to Flora and Vegetation) and cultural heritage values.

Regionally significant landscapes of the Perth and Peel region were mapped and analysed by DoP with a particular focus on landscapes that were likely to be subject to pressure for change in land use over the coming decades (national parks, the Darling plateau water catchments and existing urban landscapes were not assessed). The landscapes were mapped at a regional scale but included a few specific areas that, while relatively small, were considered to be of regional significance. The key elements considered were: landform (including water bodies), vegetation, and land use. Visual access to these landscapes, for example from major roads and viewpoints, was also a consideration. Important landscape features within the Advice Area that were identified through the mapping exercise are summarised in Table 9-2. Many landscapes are important for more than one of these features.
Table 9-2: Important landscape features identified within the Strategic Advice Area

<table>
<thead>
<tr>
<th>Landform features</th>
<th>Landscapes identified within Advice Area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• coast</td>
</tr>
<tr>
<td></td>
<td>• estuaries</td>
</tr>
<tr>
<td></td>
<td>• rivers</td>
</tr>
<tr>
<td></td>
<td>• wetlands,</td>
</tr>
<tr>
<td></td>
<td>• dune systems</td>
</tr>
<tr>
<td></td>
<td>• limestone ridges</td>
</tr>
<tr>
<td></td>
<td>• Darling Plateau escarpment and major valley systems</td>
</tr>
<tr>
<td>Vegetation features</td>
<td>• Tuarts</td>
</tr>
<tr>
<td></td>
<td>• banksia woodlands</td>
</tr>
<tr>
<td></td>
<td>• remnant groves of casuarina and paperbarks on the palus plain.</td>
</tr>
<tr>
<td>Land use</td>
<td>• equestrian purposes</td>
</tr>
<tr>
<td></td>
<td>• vineyards</td>
</tr>
<tr>
<td></td>
<td>• market gardens and orchards</td>
</tr>
</tbody>
</table>

9.4.2 Key threats

At a strategic scale, the primary threats to health and amenity derive from insufficient separation of conflicting land uses (resulting in noise, odour and mosquito impacts), the fragmentation and loss of important landscape features and removal of trees from the urban environment.

Other influences on amenity such as reduced air or water quality are discussed in Chapters 7 and 8. In particular, dust is discussed in Chapter 8 (Impacts to Air Quality).

Consideration of climate change

Heatwaves in Australia have a greater negative impact on population health than any other natural hazard (Loughnan et al. 2013). The projected increases in temperature and heat waves (summer day temperatures over 40°C) for the south-west region of WA are likely to result in more heat-related deaths per capita (DEC 2012a). Additional heat-related illness and death is likely to be greatest among older people, young children, people with chronic disease and those living in built-up areas in cities. Increased vulnerability in Perth has been identified in the inner city suburbs, north of the city and south along the Swan River (Loughnan et al. 2013).

Other climate change related health risks include (DoH 2008; DoE 2015b):

- the impact of severe weather events including bushfires;
- food-borne infectious diseases;
- mosquito borne diseases;
- water stress
• increases in air pollution (discussed in Chapter 8- Impacts to Air Quality); and
• mental health consequences.

Adaptation to climate change will be critical to limiting health impacts. Changing behaviours and living environments to reduce exposure will be critically important as will building resilience by understanding the nature and location of high-risk areas and developing targeted heatwave adaptation planning (Loughnan et al. 2013). Interactions between local urban form, public health and local climate will influence adaptive capacity to the wider changes arising from climate change. This is particularly the case in respect of the urban heat island effect.

The WA Government's approach to climate change adaptation (DEC 2012a) emphasises:

• identifying areas of the State and communities that are vulnerable to climate change impacts, and developing integrated adaptation strategies to address public health, sport and recreation and emergency management;
• supporting research into climate and health impacts;
• promoting public health training, monitoring and management of pests and diseases;
• implementing behaviour change and urban development initiatives that reduce emissions and waste, promote recycling, reduce energy and water consumption, and provide health and wellbeing benefits
• ensuring that early warning and management systems for severe weather events (including cyclones and bushfires) and high quality prevention and control programs adequately address increasing risks from climate change impacts; and
• developing training and skills development programs for local government and community emergency management groups to incorporate climate change considerations into local disaster management plans.

9.5 CURRENT MANAGEMENT ARRANGEMENTS

9.5.1 Noise and odour

Mitigation measures applied in a planning and land use context for noise and odour are established in a range of existing State Planning Policies, regulations guidelines and approval requirements. The measures include:

• Compliance / adherence to standards at source, and in the receiving environment.
• Minimum buffers, separation distances and set-backs for maintaining adequate separation between activities generating emissions and more sensitive land uses.
• Risk assessment processes to ensure management attention is placed on highest risk activities.
• Best practice management measures applied at source – with a focus on avoidance and minimisation wherever possible.
• Adherence to appropriate standards of practice, secured through construction EMPs and approval conditions under the EP Act.

To avoid land use conflicts, strategic management and mitigation of impacts focuses on the maintenance of minimum buffers, separation distances and setbacks to establish adequate separation of future development generating noise and odour, from sensitive land uses.

Existing State Planning Policies will play a strong role in embedding these measures in future planning and decision making on future development. In particular, State Planning Policy 4.1 State Industrial Buffer (WAPC 1997) is intended to provide a consistent approach to securing buffers. SPP 4.1 is supported by the EPA's Guidance Statement No. 3: Separation Distances between Industrial and Sensitive Land Uses. Both the State Industrial Buffer policy and the EPA's guidance on separation distances are currently under review and the EPA recently released a draft revision of the guidance statement (EPA 2015d).

9.5.2 Urban tree canopy

Mitigating tree canopy loss and over time, increasing tree canopy over the Advice Area would lessen urban heat island effects and associated health impacts, particularly in the Central sub-region where infill development pressures will be greatest and there is a potential for significant loss of tree canopy >25 per cent. Planning strategies and frameworks at both regional and local scales have begun to support retention and improvement to the urban tree canopy coverage including:

• Directions 2031 Spatial Framework for Perth and Peel, 2010.
• Perth Capital City Framework, 2013.
• City of Belmont Urban Forest Strategy, 2014.
• City of Armadale Urban Forest Strategy, 2014.
• City of Vincent Greening Plan, 2014.

Other local government areas such as City of Perth have announced an intention to prepare an urban forest plan (CoP 2014) and the WA Local Government Association released a policy discussion paper on urban street trees with the intent to prepare a guidance note to assist Local Government decisions about street tree establishment and management (WALGA 2014). Some local governments have adopted or are trialling methodologies and processes for calculating the ‘amenity value’ of trees to ensure these values are accounted for, and replacement costs can be identified (Brown et al. 2013).

9.5.3 Landscape values

State Planning Policy No. 2 Environment and Natural Resources Policy (WAPC 2003e) requires that planning strategies, schemes and decision-making should:

• Identify and safeguard landscapes with high geological, geomorphological or ecological values, as well as those of aesthetic, cultural or historical value to the community, and encourage the restoration of those that are degraded.
• Consider the level or capacity of the landscape to absorb new activities and incorporate appropriate planning and building design and siting criteria to ensure that new development is consistent and sensitive to the character and quality of the landscape.

• Consider the need for a landscape, cultural or visual impact assessment for land use or development proposals that may have a significant impact on sensitive landscapes.

The identified regionally significant landscape features (Table 9-2) provide a basis for further detailed examination of values and potential mitigation, and their resolution in local planning strategies/schemes and specific land management controls. Land identified for future development can be subject to specific landscape assessment to identify key features and values, develop measures for their integration into development, and maintain linkages wherever possible. In some cases the use of landscape precincts within planning schemes will be appropriate. While not entirely coincident, there is considerable overlap of regionally significant landscapes with the Green Network and measures to maintain and enhance the network will further support retention of important landscapes.

9.5.4 Waste management

Cities with a large population, supporting a variety of industrial and commercial activities produce large volumes of waste. Health impacts derive from inappropriate/poor waste disposal practices and emissions from treatment and disposal facilities. Waste generation for 2012-13 in the Perth and Peel regions was around five million tonnes and this is projected to increase to six million tonnes by 2019-20 and approximately 9.5 million tonnes when the population reaches 3.5 million (DER 2014b).

There are 30 landfills in and around the Perth metropolitan region and a similar number of transfer stations and sorting facilities (WAWA 2012). The majority (57 per cent) of Perth’s waste is sent to landfill. The remainder is currently recovered through Material Recovery Facilities, Alternative Waste Treatment plants or by composters (DER 2014b).

The Western Australian Waste Strategy: Creating the Right Environment (WAWA 2012) calls for progressive increases in waste diversion until 2020. For example the strategy calls for 65 per cent diversion from landfill of municipal solid wastes presented for collection in the metropolitan region by 2020. On current projections Perth’s landfills have capacity until around 2025 or until 2030 if the waste diversion targets in the Strategy are met (DER 2014b). Objectives of the Strategy are:

• Initiate and maintain long-term planning for waste and recycling processing, and enable access to suitably located land with buffers sufficient to cater for the State’s waste management needs.

• Enhance regulatory services to ensure consistent performance is achieved at landfills, transfer stations and processing facilities.

• Develop best practice guidelines, measures and reporting frameworks and promote their adoption.

• Use existing economic instruments to support the financial viability of actions that divert waste from landfill and recover it as a resource.

• Communicate messages for behaviour change and promote its adoption, and acknowledge the success of individuals and organisations that act in accordance with the aims and principles in the Strategy and assist in its implementation.
Actions to improve waste diversion to meet the established target will need to respond to pressures of increased waste generation from an expanding population and development, facilitated through the sub-regional structure plans. Both the expansion of existing waste management and recovery facilities and development of new waste infrastructure will be required (Hyder 2013), along with other measures in the Waste Strategy, targeting behavioural change.

The WA Government has established the Strategic Waste Infrastructure Planning Working Group (SWIPWG) with representation from the WA Waste Authority, DER, DoP, Water Corporation as well as key local government and industry representation. The Working Group is tasked with resolving the waste infrastructure planning needs for all solid waste streams through the development of the Waste and Recycling Infrastructure Plan for the Perth Metropolitan and Peel Regions. A key focus is the determination of likely waste and recycling infrastructure needs, including landfill sites, to 2031, and liaison with the WAPC to integrate the Plan into the planning framework.

Allied to this work is the review of the Waste Avoidance and Resource Recovery Act 2007. The review is focussing on improvements to the alignment of local government or regional council waste planning with State plans and strategies, and coordination of procurement of waste services on behalf of member local governments (DER 2014b).

9.6 AVOIDANCE TO DATE

9.6.1 Mosquito risk

The footprint planning phase for future urban residential development resulted in a decision by the Western Australia Government to re-consider and not proceed with the previously proposed East Keralup development, in favour of urban development at Gnangara and Pinjar.

In its section 16(e) advice on the 2007 Keralup Masterplan (EPA 2008a), the EPA identified on-site and regional health impacts of mosquitos as a key risk. The decision not to proceed with the low lying East Keralup development as a component of the future urban residential footprint has resulted in substantial avoidance of potential health risks arising from mosquitos and mosquito borne diseases.

9.6.2 Noise impacts

The extraction of BRM has the potential to cause noise and conflict with surrounding sensitive land uses such as urban development. During master planning, nodes of BRM resources were identified constituting groupings of strategically located BRM resources that were sufficiently large to supply future development. As these areas are likely to host long-term BRM quarries, new sensitive land use such as urban development was planned to avoid these areas and their surrounding buffers. However, existing and proposed BRM quarries outside of the nodes have provided the opportunity for sequential land use principles to be applied in several localities.

Where extraction sites have been identified for future long term development for urban residential purposes, measures allowing for the efficient transition between land uses will be adopted. This will involve restricting encroachment of nearby urban development while BRM activities are operating (buffers around the BRM quarry sites), undertaking extraction on a programmed basis, and quarry
closure planning aligned to be compatible for an intended future (sequential) land use. Both a spatial and a programmed temporal buffer between BRM activities and sensitive land uses will therefore be created.

Further details are contained in Action Plan D of the Strategic Conservation Plan in regards to planning and management of BRM operations. Combined with reduced demand for BRM for fill (through avoidance of low lying areas during footprint planning for future urban development), the effect of these measures will be to considerably avoid land use conflict from BRM extraction and processing-related noise emissions and urban development.

9.6.3 Urban tree canopy

Footprint planning for future urban, industrial and rural residential development focused on maximising development on land already cleared of native vegetation (see Strategic Conservation Plan), resulting in significant avoidance of loss of urban forest canopy that would otherwise contribute to urban heat island effect. For urban and industrial expansion areas alone it is estimated this process avoided large areas of remnant vegetation, reducing the potential maximum clearing of native vegetation from 6,148 to 2,735 ha.

9.7 POTENTIAL IMPACTS

Potential impacts to human health and amenity associated with future development arise from the following:

- Reduction in quantity and quality of potable water.
- Reduction in air quality.
- Altered landscapes.
- Increased generation of waste and demand on waste management infrastructure (including the establishment of new waste management facilities).
- Noise and odours from industrial and waste management sources.
- Localised increase in temperature associated with the urban heat island effect.
- Increased mosquito impacts on health and amenity.

Impacts to potable water and air quality are discussed in Chapters 7 and 8 and are not considered further in this chapter. Existing management arrangements identified in Section 9.5 are considered adequate to manage potential impacts to landscapes and increased waste generation, and these are therefore not discussed further. The remaining potential impacts of noise and odour, urban tree canopy and increased mosquito impacts are discussed below.
9.8 IMPACT ANALYSIS

9.8.1 Noise and odour

Noise and odour generated by commercial, industrial and other activities can adversely impact on human health and the reasonable enjoyment of places that are valued by the Perth and Peel community, in particular residences and areas of open space. No quantitative modelling of impacts at the strategic scale has been undertaken and instead a qualitative analysis is provided.

Conflict most commonly occurs when sensitive land uses such as residences are located too close to commercial areas or industrial estates. Expectations and community norms play an important role, and these vary. The expectation of amenity from residents in respect of noise is likely to be different in densely occupied inner suburbs compared to outer suburbs. Expectations in respect of odour can be different in the rural or peri-urban areas compared to urban communities. Timing, duration, the tendency to recur, or the incremental nature of exposure can similarly influence community expectations around amenity.

Over the long term, high levels of noise (whether perceptible to the human ear or inaudible vibration) from future development could result in significant impacts to health, learning and development (WAPC 2009). At lower noise levels, reduction in amenity may occur. Potential impacts from future development are most likely to arise from the establishment of road and rail infrastructure, industrial centres and extraction of basic raw materials. The level of impact will be determined by the juxtaposition of those new noise sources with existing or proposed sensitive premises. Noise sensitive premises include for example residential premises, hospitals and child and other care facilities.

Odour has the potential to significantly disrupt community comfort and amenity and is generally one of the most complained about environmental pollution issues (EPA 2013d). Potential impacts from future development are most likely to arise from the establishment of industrial centres and waste management facilities. As with impacts from noise and dust, the extent of impact is determined by proximity to sensitive premises.

Consideration of the location of urban expansion areas (with associated sensitive land uses) relative to BRM nodes and industrial areas during planning of these areas (Section 9.6.2) should reduce the potential for adverse impacts.

9.8.2 Urban tree canopy

The urban tree canopy helps mitigate urban heat island effect, provides important amenity values and increasingly, links between improved health (including mental) and access to urban greenspace (encompassing urban tree canopy) have been drawn although determining causality has been difficult (Lee and Maheswaren 2010). Potential impact deriving from enhanced urban heat island effect has been carried forward for specific assessment.

The urban heat island is a well-known phenomenon whereby the paved surfaces, buildings and other infrastructure prevalent in urban environments absorb a greater amount of solar energy (when compared to natural landscapes), establishing a localised increase in urban temperatures compared to

Two types of heat islands are recognised. Surface heat islands reflect the differences in land surface temperatures and generate the most pronounced temperature differences between urban and natural landscapes. Air temperature differences between urban and natural landscapes (atmospheric heat islands) are less pronounced. Air temperatures are indirectly, but significantly, influenced by surface temperatures and any surface heat island effects; though the relationship between surface and air temperatures is not constant since air mixes within the atmosphere (US EPA 2008). Some key features of each heat island type are summarised in Table 9-3.

Table 9-3: Key features of Surface and Urban Heat Islands

<table>
<thead>
<tr>
<th>Feature</th>
<th>Surface Urban Heat Island</th>
<th>Atmospheric Heat Island</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change over time</td>
<td>Present at all times of the day and night</td>
<td>May be small or non-existent</td>
</tr>
<tr>
<td></td>
<td>Most intense during the day and in the summer</td>
<td>during the day</td>
</tr>
<tr>
<td>Peak intensity (most intense urban</td>
<td>More spatial and temporal variation</td>
<td>Less spatial and temporal variation</td>
</tr>
<tr>
<td>heat island conditions)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adapted from US EPA 2008

No evaluation of Perth’s urban heat island profile has been published however by way of example the night time profile of the Melbourne metropolitan area indicates a maximum effect of approximately 4°C for the more densely built central locations (Brown et al. 2013). The direct health impacts of heat exposure are well known and include heat related illnesses, and sometimes fatality. Vulnerability is greater in the elderly, very young children, people with disabilities, indigenous communities, homeless people and people who are already health compromised (Spickett et al. 2007). People living in areas with higher temperatures due to urban heat island effect may face additional vulnerabilities (Brown et al. 2013).

Vegetation and in particular, trees, play a very important role in mitigating the effects of urban heat island by providing a natural cooling effect through evapotranspiration and absorptive and reflective processes. Internationally and in Australia the evidence indicates that decreases in tree canopy are occurring primarily on private land within urban areas as a result of urban infill and the tendency for larger dwellings on single blocks (DSE 2011 and Hall 2010 as cited in Brown et al. 2013). In the Perth and Peel region city wide changes in canopy cover over time are not available although significant reductions in tree canopy associated particular urban infill have been reported (Brunner and Cozens 2012 as cited in Brown et al. 2013). Some individual cities within the Advice Area have documented tree canopy cover and noted declines. For example the average canopy cover in the City of Belmont reduced from 12.0 per cent to 11.4 per cent in 2012. The majority of losses have occurred in areas zoned residential as a result of urban infill and densification (City of Belmont 2014).

Recently DoP established a 2009 baseline of the tree canopy cover of the Perth and Peel region using high resolution digital photography modelling by the CSIRO under the Urban Monitor project (DoP 2014). The project also categorised canopy cover according to the degree of risk to the health and longevity of the canopy based on its location and likelihood of future development impacts. Very broad
land use categories were used to reflect low risk (e.g. public parks, open space), medium risk (e.g. road reserves) and high risk (e.g. private lands).

Potential impacts from loss of urban tree canopy leading to enhanced urban heat island effect are most likely to arise in the Central sub-region, where accommodation of an expected increase in population of approximately 29 per cent by 2031 (to around 910,000) will largely be achieved through urban infill.

Tree canopy coverage within the central sub-region has been mapped using the Urban Monitor data, and applied to the three land use risk categories described in DoP (2014) (Figure 9-1, Figure 9-2, Figure 9-3). A total of 44,837 ha of this sub-region contains some level of tree canopy, although at the higher canopy coverage more likely to contribute to ameliorating urban heat island (coverage >25 per cent), this reduces to 1,577 ha.

Intersection of the urban infill and activity centre footprint with the mapped tree canopy indicates a potential impact to 11,915 ha of land supporting some level of tree canopy, of which up to 231 ha of land supports canopy coverage at >25 per cent per cent. The majority (83 per cent) of the intersection of the urban infill footprint with mapped tree canopy (of any coverage) occurs on lands rated as high risk however, when considering only more significant canopy coverage of >25 per cent, this falls to 35 per cent (80 ha). Almost half (49 per cent) of the intersect of the urban infill footprint with canopy coverage of >25 per cent occurs on lands rated at low risk because the underlying tenure is public park or open space (Table 9-4).

The above estimates represent a likely upper bound to the loss of urban tree canopy. The infill footprints themselves have been developed at a coarser scale than the urban forest data and further refinement of the footprints through the planning phases could be expected to avoid the identified intersect with public park and open space areas, nominally rated as low risk but present in the intersect analysis (Table 9-4).

Trees in road reserves (medium risk) will be placed under increased pressure from construction associated with infill along major transport corridors although there is also significant opportunity for mitigation to limit loss and for good design and planning to increase tree canopy over time. Other elements of urban infill such as activity centre development could, depending on final design and configuration, potentially benefit urban tree canopy in places assessed as having very low tree cover.

Nevertheless, the potential loss of up to 118 ha of tree canopy of >25 per cent coverage on lands rated medium to high risk due to underlying land use and tenure, is significant within the sub-regional context and requires additional mitigation.
Table 9-4: Area of urban tree canopy in central sub-region and intersection with infill footprint

<table>
<thead>
<tr>
<th>% Canopy Coverage</th>
<th>High Risk (ha)</th>
<th>Medium Risk (ha)</th>
<th>Low Risk (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Central sub-region</td>
<td>Intersection with infill</td>
<td>Central sub-region</td>
</tr>
<tr>
<td>&gt;0-5</td>
<td>7,617</td>
<td>3,432</td>
<td>2,955</td>
</tr>
<tr>
<td>5-10</td>
<td>7,951</td>
<td>2,987</td>
<td>2,828</td>
</tr>
<tr>
<td>10-15</td>
<td>6,249</td>
<td>2,212</td>
<td>1,790</td>
</tr>
<tr>
<td>15-20</td>
<td>2,855</td>
<td>933</td>
<td>840</td>
</tr>
<tr>
<td>20-25</td>
<td>792</td>
<td>200</td>
<td>410</td>
</tr>
<tr>
<td>25-30</td>
<td>223</td>
<td>58</td>
<td>262</td>
</tr>
<tr>
<td>30-40</td>
<td>79</td>
<td>19</td>
<td>169</td>
</tr>
<tr>
<td>40-100</td>
<td>10</td>
<td>3</td>
<td>61</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>25,776</strong></td>
<td><strong>9,843</strong></td>
<td><strong>9,315</strong></td>
</tr>
</tbody>
</table>
Figure 9-1: High Risk (Commercial, Industrial and Residential Blocks) Urban Tree Canopy in the Central Sub-Region

Legend
- Advice Area
- Central Sub-Region

Percentage of Canopy Coverage
- >0 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 40
- 40 - 100

Datum/Projection: GDA 1994 MGA Zone 50
Data Source: DoT (2014)
Prepared by: SM Date: 27/07/2015

Kilometres
Figure 9-2: Medium Risk (Road Reserves) Urban Tree Canopy in the Central Sub-Region

Legend
- Advice Area
- Central Sub-Region

Percentage of Canopy Coverage
- >0 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 40
- 40 - 100

Datum/Projection: GDA 1994 MGA Zone 50
Data Source: DoT (2014)
Prepared by: SM Date: 29/10/2015
Figure 9-3: Low Risk (Park Lands) Urban Tree Canopy in the Central Sub-Region

Legend
- Advice Area
- Central Sub-Region

Percentage of Canopy Coverage
- Orange: >0 - 5
- Red: 5 - 10
- Dark Green: 10 - 15
- Green: 15 - 20
- Light Green: 20 - 25
- Neon Green: 25 - 30
- Dark Grey: 30 - 40
- Black: 40 - 100

Datum/Projection: GDA 1994 MGA Zone 50
Data Source: DoT (2014)
Prepared by: SM Date: 29/10/2015
9.8.3 Increased mosquito impacts

The EPA notes that mosquitoes and mosquito borne diseases are likely to have a public health impact when urban residential development is located in close proximity to natural mosquito breeding habitat, although elimination of all risk is impracticable as some mosquitoes will travel considerable distance (EPA 2015a). No quantitative analysis of the additional risk arising from implementation of future development has been possible but considerable avoidance measures have been employed and are noted in Section 9.6.1.

9.9 MITIGATION AND MANAGEMENT

9.9.1 Noise and odour

Section 8.9 noted the role of buffers in managing impacts of dust and other air emissions on sensitive land uses such as urban residential. Related commitments in Action Plan G provide for the determination and implementation of buffers around strategic industrial areas and development of a policy to guide their implementation. The development and application of buffers will incorporate noise and odour considerations and assist in mitigating future impacts.

9.9.2 Urban tree canopy

Mitigating the effects of urban heat island requires a balance between built form and management of vegetation, particularly tree canopy (Brown et al. 2013). Existing measures outlined in Section 9.5 reflect an emerging engagement by local governments with the planning requirements needed to mitigate impacts through retention and expansion of the urban tree canopy.

Managing the future impacts of the urban heat island effect within a more compact, densely occupied city facing increased warming from climate change will require a focus on minimising tree canopy loss from future infill development as well as active measures to establish tree canopy cover in new areas and to increase the percentage tree canopy cover in green spaces. While future urban infill along road corridors and development of activity centres will place pressure on the existing tree canopy, good urban design and planning settings offer the opportunity to achieve a net increase in tree canopy by requiring additional plantings.

Retention and expansion of urban tree canopy will be assisted by implementation of the Green Network concept foreshadowed in Directions 2031 in which the new urban growth in the 'connected city' scenario is planned to occur in a more balanced way supported by a green network of parks conservation and biodiversity areas. The aim is to maintain a healthy, natural environment allowing for meaningful connections between people and nature – particularly in urban areas.

The Green Network (Figure 9-4) incorporates the network of green spaces, water systems, biodiversity corridors and green streets in the Advice Area that deliver environmental, economic and social values and benefits. The network comprises State, Crown or freehold land reserved for natural resource conservation, passive and active outdoor recreation, transport corridors, and community facilities. The urban tree canopy is an important element of the Green Network.
The Green Network is discussed in Section 2 of the Strategic Conservation Plan and will be further progressed in sub-regional structure planning in support of the broad principles of multi-functionality through integration of different activities and land uses, and the connectedness of people, places and habitat. It is anticipated that local governments will produce local Green Network strategies and design guidelines that will implement the strategic assessment objectives and Green Network planning principles. Enhancement of existing elements such as the urban forest will be an important component.

Additional mitigation measures are proposed (Action Plan G) to better understand urban heat island vulnerabilities, establish a framework for maintaining or enhancing a network of green space and tree canopy cover, and measure progress and evaluate effectiveness over time.

Other measures proposed in the Action Plans aimed at retaining and revegetating native vegetation habitat will have important co-benefits in helping ameliorate urban heat island effect and associated impacts to human health by enhancing urban tree canopy retention.

**Commitment:** Better understand and manage urban heat island vulnerabilities by undertaking studies and monitoring. This would include investigation of barriers to minimising heat island effect through design and where they exist how they might be remedied.

**Commitment:** Support human health and amenity values in existing and proposed urban areas by developing a framework for maintaining or enhancing a network of green space and tree canopy cover which will include:

- guidance and support for local government strategies in setting and achieving minimum standards for canopy cover and on ground actions for achieving a net increase in tree canopy cover;
- communication and knowledge sharing concerning the benefits of urban tree canopy retention and expansion; and
- response to the outputs of the preceding commitment.

**Commitment:** Conduct monitoring of urban tree canopy and publishing of data to support local governments track trends in canopy coverage, and evaluate the effectiveness of their heat island effect reduction strategies.

### 9.9.3 Increased mosquito impacts

Mitigation of future health impacts from mosquitoes will be directed toward future avoidance. Action Plan G of the Strategic Conservation Plan provides for the development and implementation of a new wetland buffer policy. This is likely to have co-benefits through by avoiding encroachment of sensitive land uses such as urban residential, whereby impacts from mosquitoes may be problematic.
Figure 9-4: The Green Network (from DoP 2010)
9.9.4 Additional commitments

No specific offsets are proposed for this factor, although offset commitments for Land factors requiring the protection, restoration and recreation of habitat (see Chapter 5- Impacts to Flora and Vegetation and Chapter 6- Impacts to Fauna) are likely to have important co-benefits in respect of urban tree canopy and mitigation of urban heat island effect.

9.10 SUMMARY OF OUTCOME FOR EPA OBJECTIVE

A quantitative determination of the impacts to human health and amenity has not been possible however, the proposed mitigation and management measures put forward in Action Plan G of the Strategic Conservation Plan will ensure a strategic approach to the buffers necessary to mitigate noise and odour impacts, and establish an adaptive response to the urban heat island effect. Combined with substantial avoidance already achieved, implementation of these measures will mean that the EPA’s objectives for Human Health and Amenity can be met over time.
10 IMPACTS TO MARINE ENVIRONMENTAL QUALITY

10.1 KEY FINDINGS

- Increased nutrient and contaminant movement from land based activities into the marine environment via surface water and groundwater inflow and aerial deposition, is the key risk identified in the strategic assessment.

- Existing processes and policies contribute to reducing the risk of pollutants ending up in the marine environment, including those described in Chapter 7 relating to water quality and Chapter 8 relating to air quality. Commitments presented in these chapters, including updates to Better Urban Water Management and expansion of the air quality monitoring network and Air Quality Management Plan, will also strengthen the protection of marine environmental quality.

- The Environmental Quality Management Framework described in Environmental Assessment Guideline 15 (EPA 2015e) provides a structure through which to determine whether environmental quality objectives are being met. Cockburn Sound is currently the only location where the Environment Quality Management Framework has been fully implemented and water quality criteria have been developed.

- Industrial expansion within the Cockburn Sound catchment presents the greatest risk to additional nutrient and contaminant inputs (additional urban and rural residential development being minimal) to the Sound, however the exact impact to marine environmental quality from activities is difficult to predict at this stage of planning and needs to be seen within the context of the cumulative effects of all direct and indirect contaminant sources entering the marine environment. The proposed strengthening of the Cockburn Sound State Environmental Policy is the best way to ensure future adaptive management can address his uncertainty.

- The identification of environmental quality criteria and an associated management plan (through application of the Environmental Quality Management Framework), would provide the means to identify and then manage the key areas of uncertainty and a commitment is made to extent the implementation of the framework to include the broader Perth and Peel coastal regions.

- Full implementation of this framework will mean that the EPA’s objective for marine environmental quality can be met in the future as development within the Advice Area takes place.

10.2 EPA OBJECTIVE

The following EPA objective for marine environmental quality is applicable to this assessment:

*To maintain the quality of water, sediment and biota so that the environmental values, both ecological and social, are protected.*
10.3 ENVIRONMENTAL POLICY AND GUIDANCE

The following policy and guidelines are relevant to this assessment with regard to marine environmental quality:

- Environmental Assessment Guideline No. 15 for Protecting the Quality of Western Australia’s Marine Environment (EPA 2015e).
- State Environmental (Cockburn Sound) Policy 2005 (Government of Western Australia 2005).
- Perth’s Coastal Waters Environmental Values and Objectives (EPA 2000b).
- State Planning Policy 2.6 State Coastal Planning Policy (WAPC 2013).

There are also various Marine Park Management Plans in operation.

10.4 EXISTING ENVIRONMENT

10.4.1 Key values

An environmental quality management framework for maintaining the quality of WA coastal waters has been outlined in Environmental Assessment Guideline No. 15 for Protecting the Quality of Western Australia’s Marine Environment (EAG 15, EPA 2015e). The framework is based on establishing key environmental values for marine waters as set out in the National Water Quality Management Strategy and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000). The key marine environmental quality values associated with the Advice Area and the objectives for each, as identified in EAG 15 are described below.

**Ecosystem health**

The south-west region of WA is situated on the southern end of one of the world’s largest temperate reef systems (IMCRA Technical Group 1998). Shallow sandy areas of this region contain the highest number of seagrass species in the world for a temperate region, which provide nursery areas and habitat for numerous fish species (Kirkman and Kuo 1990). Seagrass meadows are particularly well developed in less exposed areas, especially in Warnboro Sound and Cockburn Sound (IMCRA Technical Group 1998).

Waters and sediments off much of the south-west coast of WA are generally nutrient-poor, owing to naturally low levels of nutrient inputs from rivers and the absence of significant upwelling of nutrient-rich waters from the deeper ocean (DEC 2007). Consequently, biological productivity in south-west WA waters (including adjacent to the Advice Area) is limited, resulting in naturally high water clarity and penetration of light to seagrass and macro-algae, which contribute significantly to primary productivity (DEC 2007).
The extensive sand/silt habitats of the marine environment adjacent to the Advice Area support benthic invertebrate communities and microphytobenthos. Benthic communities and habitats play important roles in maintaining the integrity of many fundamental ecological processes. Strong evidence suggests that the presence of some benthic communities (e.g. seagrass meadows, coral reefs and filter feeders) enhances biodiversity through provision of refuge, structurally complex habitat and increased food supply (EPA 2009c).

The nearshore intertidal reefs and sub-tidal reefs of the Marmion and Shoalwater Islands Marine Parks support extensive and highly diverse macroalgae communities that provide important refuge areas for a diverse range of finfish and invertebrates (CALM 1992; DEC 2007).

The environmental quality objective for ecosystem health outlined in EAG 15 is to maintain the structure (e.g. the variety and quantity of life forms) and functions (e.g. the food chains and nutrient cycles) of marine ecosystems to an appropriate level, representing long-term objectives for environmental quality. This environmental value applies throughout all marine waters within the State’s jurisdiction with three levels of ecological protection (high, moderate and low) considered relevant along the coast of the Advice Area (EPA 2015e).

Fishing and aquaculture

The marine waters adjacent to the Advice Area feature a wide range of recreational fishing opportunities and it is one of the State’s most popular pastimes with an estimated one third of the population fishing recreationally (Government of Western Australia 2015b). In addition, the marine area adjacent to the Advice Area is one of the various locations along the WA coast which provides economic value by supporting commercial fishing and aquaculture. The WA commercial fishing industry in general is mainly based on low-volume, high-value products, such as Panulirus cygnus (Western Rock Lobster) which is one of the key species fished commercially along the coast of the Advice Area. A major blue mussel farming operation is also located in Cockburn Sound (Government of Western Australia 2015b).

The environmental quality objectives for fishing and aquaculture outlined in EAG 15 are as follows:

- Seafood (caught or grown) is of a quality safe for eating.
- Water quality is suitable for aquaculture purposes.

The environmental quality objective of seafood being safe for human consumption should be protected in all waters except small approved areas around some treated wastewater outfalls.

Recreation and aesthetics

The use of beaches and nearshore waters for recreational activities has long been part of WA’s culture. The coast is used for many types of recreation including; swimming, boating and water sports, and the high marine environmental quality of the Perth coastline is a significant attraction influencing recreational usage.

The environmental quality objectives for recreation and aesthetics outlined in EAG 15 are as follows:

- Water quality is safe for primary contact recreation (e.g. swimming and diving).
• Water quality is safe for secondary contact recreation (e.g. fishing and boating).
• Aesthetic values of the marine environment are protected.

These environmental quality objectives should be applied to all marine waters except small approved areas around some wastewater outfalls where water quality is considered unsafe for human contact.

**Industrial water supply**

Approximately 150 billion litres a year, almost half of Perth’s water needs, is supplied by water desalinated at two desalination plants (Water Corporation 2015a), one of which is located within the Advice Area at Kwinana and includes the desalination of sea water for industry use. Sea water intake pipes are located within Cockburn Sound.

The objective for industrial water supply outlined in EAG 15 is that water quality should be suitable for industrial use. The guideline recognises that the water quality requirements for industrial water supply are specific to the industry and the industrial process used, although specific water quality requirements have been provided for the Perth Desalination Plant sea water intake (EPA 2015e).

**Cultural and spiritual**

Historically, the main source of food for the Noongar People in the Perth area came from the sea, the Swan River and the extensive system of freshwater lakes that once lay between the coast and the Darling Escarpment (SWALSC 2015a). The cultural and spiritual values of the marine environment adjacent to the Advice Area may relate to a range of uses and issues including spiritual relationships, sacred sites, customary use, the plants and animals associated with water, drinking water or recreational activities (ANZECC & ARMCANZ 2000).

The environmental quality objective for this value outlined in EAG 15 is the protection of cultural and spiritual values of the marine environment. In the absence of any specific environmental quality requirements for protection of this value it is assumed that if water quality is managed to protect ecosystem integrity, protect primary and secondary contact recreation, protect the quality of seafood for eating and maintain aesthetic values, then this may go some way toward maintaining cultural values, but it is more difficult to define spiritual value in terms of specific environmental quality requirements (EPA 2015e).

**10.4.2 Marine areas of high conservation, commercial and social value**

The interim strategic advice of the EPA identified several areas with significant marine values that need to be considered in the final sub-regional structure plans and the Strategic Conservation Plan. These are described below.

**Marine protected areas**

State marine parks recognise and conserve the values of marine biodiversity. The waters and shorelines within State marine parks provide important habitats for various protected marine and terrestrial flora and fauna species; including migratory birds and conservation significant marine
mammals. The marine parks are of high value to the community, as they provide areas for recreation, education, tourism and commercial fishing (DEC 2007).

The following State marine parks occur immediately adjacent to, or within, the Advice Area: (Figure 10-1):

- Shoalwater Islands Marine Park;
- Marmion Marine Park; and
- Swan Estuary Marine Park.

The Shoalwater Islands Marine Park embayment areas and adjacent Cockburn Sound, provide nearshore habitats for one of the most diverse finfish populations on the lower west coast of WA (DEC 2007). In the north of the marine park, a broken chain of islands and reefs protects the coast from south-westerly swell and waves. These habitats are also home to a diverse range of invertebrates and a variety of wildlife including little penguins (Eudyptula minor), other sea and shore birds and marine mammals such as bottlenose dolphins (Tursiops truncatus) and Australian sea lions (Neophoca cinerea) (DEC 2007). The Marmion Marine Park comprises a similar diversity of marine communities in a variety of marine habitats which provide for marine mammals, such as sealions, dolphins and whales (CALM 1992).

The Swan Estuary Marine Park provides important feeding habitats for internationally protected, trans-equatorial migratory wading birds as well as rich and diverse estuarine and terrestrial communities and habitats which provide feeding, resting and breeding habitat for fauna, including fish species and waterbirds. Potential impacts to the Swan Estuary as a result of proposed future development are considered in detail in Chapter 7 (Impacts to Hydrological Processes and Inland Waters Environmental Quality).

The Cottesloe reef system, a Fish Habitat Protection Area, is located off the coast of Cottesloe, and stretches approximately 4.4 km north-south and up to 1 km to the west of the shore. The reef is considered to have attributes unique to the Perth metropolitan area and contains a diverse range of marine habitats, including sand, seagrass, limestone reef with large kelp and macro-algae, sponge beds and garden bottoms (Department of Fisheries 2010). The habitats within the reef system support many different species of invertebrates, fish, aquatic plants and other organisms. The reef is ecologically significant, and due to its accessibility and popularity, it is considered particularly vulnerable to human impact (Department of Fisheries 2010).

**Cockburn Sound**

The water and sediment quality of Cockburn Sound is of particular value given the status of the Sound to the Western Australian community. The Sound supports a rich variety of commercial, industrial, defence, tourism commercial fishing and recreational uses for the broader community, and because of its proximity to major population centres and its usually calm waters, is the most heavily used marine embayment in WA (Trefry et al. 2006).
**Areas of high human use**

Certain areas along the coast of the Advice Area experience high human usage for recreational or commercial purposes. Beaches such as City Beach, Scarborough and Cottesloe are all highly popular locations for recreation and tourism, particularly during the summer months. Recreational fishing locations include Fremantle and Hillarys and within the Swan River, and seasonal abalone fishing is popular at Mettam’s Pool in Trigg.

**Wildlife usage and breeding areas**

The waters along the coast of the Advice Area provide habitat for a wide variety of marine fauna, including conservation significant species listed under the WC Act and/or the EPBC Act including some species of whales and sharks. The seagrass and subtidal reef habitats along the coast of the Advice Area, particularly within the State Marine Parks, provide important habitats for many species. Important areas for the feeding and resting of marine fauna include Penguin Island, Seal Island, Garden Island, Cockburn Sound and the Swan River. The Shoalwater Islands Marine Park embayment areas and adjacent Cockburn Sound in particular, provide nearshore habitats for one of the most diverse finfish populations on the lower west coast of WA (DEC 2007).

Seal and Carnac islands are important to the Australian Sea Lion (Neophoca cinerea) (listed as Vulnerable, Marine under the EPBC Act and under Schedule 4 of the WC Act), and used almost exclusively by mature and juvenile males during the non-breeding season for resting (DEC 2007). Penguin Island is of importance to the Little Penguin (Eudyptula minor) (listed as Marine under the EPBC Act) for breeding.

**Benthic primary producer habitat**

Benthic communities are made up of organisms that live in and on the bottom of the ocean floor. These organisms are known as benthos. Benthos include organisms that utilise photosynthesis to produce organic matter, such as seagrasses, algae and some corals and sponges (where they contain microalgae). These organisms are termed ‘Benthic Primary Producers’ and are important components of benthic communities since they fix carbon and form the basis of marine food webs. Benthic communities can also include filter feeder communities (e.g. sponges, ascideans, octo-corals), barnacles, molluscs, polychaetes, etc. that are suspension or bottom feeders. Maintaining diverse and healthy benthic communities will go a long way toward supporting ecosystem integrity and maintaining fundamental ecological processes (EPA 2009c).

Strong evidence suggests that the presence of some benthic communities (e.g. seagrass meadows, coral reefs and filter feeders) enhances biodiversity through provision of refuge, structurally complex habitat and increased food supply (EPA 2009c).

Several maps of the spatial distribution of benthic habitats in the Advice Area have been produced for certain areas, i.e. Owen Anchorage, Cockburn Sound, Warnbro Sound and Marmion Marine Park (Ong et al. 1998; Kendrick et al. 2002; DAL Science and Engineering 2004). A broader study was undertaken in 2008 to develop regional mapping of benthic communities and habitats in the region from Two Rocks in the north to Singleton in the south entitled *Classifying shallow water benthic habitats in the Swan Marine Region* (Wildsmith et al. 2008). Mapping of benthic habitat within and adjacent to the...
Advice Area has been collated by the EPA and areas of high environmental value are shown on Figure 10-2.

**Other key areas**

The Peel-Harvey Estuary is another area of high conservation value within the Advice Area. Specific impacts to water quality in the Peel-Harvey Estuary are discussed in Chapter 7 (Impacts to Hydrological Processes and Inland Waters Environmental Quality) and in the Commonwealth IAR.

The Two Rocks and Perth Canyon Commonwealth Marine Reserves and Rottnest Island are all areas of high value located offshore of the Advice Area. All three of these areas are beyond the scope of this assessment and are not discussed further.

### 10.4.3 Environmental Values and Objectives for Perth’s Coastal Waters

*Environmental Values and Objectives for Perth’s Coastal Waters* was released by the EPA in 2000 and outlines its position with respect to implementation of environmental values, environmental quality objectives and levels of ecological protection in the coastal waters off the Perth metropolitan region.

This document was primarily intended to guide environmental impact assessment, and regulation and management of outfalls. It is becoming dated, however still provides important guidance at a high level. The document provides environmental quality objectives for four of the five values included in the more recent EAG 15. Objectives described in *Environmental Values and Objectives for Perth’s Costal Waters* are provided in (Table 10-1).

**Table 10-1: Environmental quality objectives identified in *Environmental Values and Objectives for Perth’s Costal Waters* (EPA 2000b)**

<table>
<thead>
<tr>
<th>Environmental Value</th>
<th>Environmental quality objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecosystem health</td>
<td>EQO 1: Maintenance of ecosystem integrity (naturally diverse and healthy ecosystems)</td>
</tr>
<tr>
<td>Fishing and aquaculture</td>
<td>EQO 2: Maintenance of aquatic life for human consumption (seafood safe to eat)</td>
</tr>
<tr>
<td>Recreation and aesthetics</td>
<td>EQO 3: Maintenance of primary contact recreation values (waters safe for swimming)</td>
</tr>
<tr>
<td></td>
<td>EQO 4: Maintenance of secondary contact recreation values (waters safe for boating)</td>
</tr>
<tr>
<td></td>
<td>EQO 5: Maintenance of aesthetic values (pleasant, attractive environment)</td>
</tr>
<tr>
<td>Industrial water supply</td>
<td>EQO 6: Maintenance of industrial water supply values (water suitable for industry use)</td>
</tr>
</tbody>
</table>
10.4.4 Key threats

Key threats to marine environmental quality in the waters off the Advice Area include:

- Contamination and nutrient enrichment from diffuse sources.
- Point source discharges including wastewater outfalls.
- Inappropriate marine or coastal infrastructure development.
- Pollution and litter resulting from boating and recreational activities.
- Climate change.

Potential impacts include fish kills, loss of benthic communities, reduced health of marine fauna, increased risk to human health through the consumption of contaminated seafood or contact with contaminated water, and changes to ecosystem processes. The introduction of marine pest species could be enhanced as a result of changes in water or sediment quality. Intertidal reef communities and beaches are especially vulnerable to pollution from oil and floating debris from boating, fishing, shipping, and from stormwater out flows.

Contaminants can affect and harm a wide range of marine life and if particularly significant, or if the presence of the contaminants is persistent, a decrease in the diversity and abundance of marine communities can occur. Over time, contaminants can accumulate in marine sediments and can alter the structure of benthic communities in these areas. Benthic communities that contain primary producers such as seagrass meadows or macroalgal reefs can also be impacted by changes in water quality affecting light availability for photosynthesis, which in turn may cause reductions in primary production and cause bottom up effects for the rest of the ecosystem. Contaminants can enter the marine environment from land-based activities (e.g. stormwater discharges, groundwater discharge to marine waters, river outflows as well as aerial deposition of contaminants and particulates transported to marine waters from the adjacent city urban and industrial areas (see Chapter 8 for a discussion of Air Quality) and from marine vessels (e.g. anti-fouling chemicals, ballast and bilge water discharges and hydrocarbon spills).

Elevated nutrient levels can result in the growth of toxic algae that can effect human health as well as marine organisms and also cause phytoplankton blooms within the water column that decrease the quantity and quality of light available for benthic plant photosynthesis (DEC 2007). Prolonged instances of decreased availability of light can result in severe degradation of highly productive benthic plant communities such as seagrass meadows, which are particularly vulnerable to these effects (DEC 2007). The increased organic detrital load to marine sediments from phytoplankton blooms can also lead to deoxygenation of the sediments and bottom waters of marine and (particularly) estuarine environments resulting in mortality of benthic organisms that are unable to escape. Nutrients can be introduced to the marine environment indirectly from land based activities through groundwater flows and surface runoff or through wastewater discharges such as sewage from treatment plants or vessels.

The development of coastal infrastructure can threaten marine environmental quality in a number of ways, either directly through the introduction of contaminants during construction and operational phases, or indirectly by altering flushing characteristics. For example, where marinas or boating facilities are introduced, there is potential for increased leaching of antifoulant chemicals, and introduction of boat cleaning chemicals into the marine environment, coupled with increased water
retention times. Antifouling paint in particular can become an issue by accumulating in sediments and impacting on marine biota, particularly if appropriate application methods and hull cleaning practices aren’t undertaken by boat owners.

All of these threats should be considered in the context of climate change, which also presents a significant threat to marine ecosystems of the Advice Area. Climate change pressures are likely to alter the current marine environment over time. Factors such as sea temperature, ocean acidification and sea level rise have the potential to impact marine environmental quality to varying extents. This has the power to alter the structure, integrity and biodiversity of marine ecosystems and would likely affect benthic communities (in particular seagrasses) and also has the potential to facilitate the establishment of new introduced marine pests.

Future development that may directly impact the marine environment includes outfalls (e.g. discharge of treated wastewater or direct discharge of industrial effluent), marina facilities, coastal access, canal developments and expansion to port facilities. These types of infrastructure and activities are not within the scope of the Strategic Assessment of the Perth Peel Region. Any proposals for these types of projects, where it is likely to have a significant impact on the environment, will be dealt with on a project by project basis through conventional project specific assessment and existing approval processes.

10.5 CURRENT MANAGEMENT ARRANGEMENTS

The following measures are currently employed within the Advice Area and contribute to maintaining the quality of water, sediment and biota within the marine environment.

10.5.1 State Marine Parks

State Marine Parks are managed under existing plans specific to each area. The *Conservation and Land Management Act 1984* provides the mechanisms by which marine parks and reserves are established, vested and managed. Under the Act, a Marine Parks Regulatory (now Reserves) Authority has been established and is responsible for development of policies as well as the review and auditing of management plans for marine reserves. The Act also provides a mechanism to manage human impacts in marine parks and reserves, through enforcement and licensing. This mechanism is given strength through Conservation and Land Management Regulations 2002.

The following Marine Park Management Plans have been developed under the Marine Parks and Reserves Authority for waters within and adjacent to the Advice Area:

- Shoalwater Islands Marine Park Management Plan (DEC 2007).

Relevant management measures outlined in the relevant marine park management plans (DEC 2007, CALM 1999 and CALM 1992) include provisions around water quality, management of boating and mooring and litter reduction.
In recent years, management plans for both the Shoalwater Islands and Marmion Marine Parks have undergone a periodic audit by the Marine Parks and Reserves Authority. The assessment of the Shoalwater Islands Marine Park Management Plan (Marine Parks and Reserves Authority 2014) highlighted that the management system is operating effectively and that Parks and Wildlife are progressively meeting management objectives through the implementation of strategies in the Shoalwater Islands Marine Park Management Plan.

The assessment of the Marmion Marine Park Management Plan (Marine Parks and Reserves Authority 2012) found that despite the urban setting of the marine park and the subsequent pressures acting upon it, the Park is generally in good condition. Management of the marine park was found to operate efficiently despite inadequate resource allocations, given the scale of the park and the importance of the values that are subject to increasing human use (Marine Parks and Reserves Authority 2012). A number of recommendations were made as a result of the review, including a recommendation for the preparation of a new management plan.

Section 9.6.8 addresses the Swan Estuary Marine Park for inland water quality and hydrological processes. Migratory shorebird habitat management including that associated with the Swan Estuary is addressed in Chapter 20 of the Commonwealth IAR.

10.5.2 Fish Habitat Protection Areas

Under the Fish Resources Management Act 1994, Department of Fisheries has responsibility for fish habitat, aquatic environment protection, fisheries management, fish health and the prevention of marine pest incursions. Fish Habitat Protection Areas (FHPAs) are listed under section 115 of the FRM Act. Under the Fish Resources Management Act, fish can include a range of organisms including finfish, crustaceans, molluscs, corals, seagrass and algae at all stages of their life cycles (Department of Fisheries 2014). WA has six FHPAs, one of which falls adjacent to the Advice Area; Cottesloe Reef FHPA.

The purpose of the Cottesloe FHPA is for the conservation and protection of fish, fish breeding areas, fish fossils or the aquatic ecosystem; and the management of fish and activities relating to the appreciation or observation of fish. The Management Plan created for the Cottesloe FHPA includes consideration of the management of water quality issues.

10.5.3 Cockburn Sound SEP

Cockburn Sound is declared as a protected area under the State Environmental (Cockburn Sound) Policy 2005, incorporating high, moderate and low ecological protection areas (Figure 10-3) (Government of Western Australia 2005). A State Environmental Policy (SEP) is a non-statutory flexible policy instrument developed by the EPA through public consultation under the EP Act and adopted on a whole of government basis. The Cockburn Sound State Environment Policy 2005 provides a policy framework for the establishment of a Cockburn Sound Management Committee and the development and implementation of an Environmental Management Plan for Cockburn Sound and its catchment. In 2013 a Draft revised SEP was released for stakeholder and public comment; however this has not yet been finalised. The 2005 version of the SEP therefore remains current.
The SEP identifies a set of environmental values that apply specifically to Cockburn Sound and are to be protected under the policy. Each of these values has linked Environmental Quality Objectives, describing the specific management goal for that value. The SEP refers to a supporting document, Environmental Quality Criteria Reference Document for Cockburn Sound, for the determination of environmental quality criteria. Each of these aspects, together with the operational elements outlined in the Environmental Management Plan for Cockburn Sound and its Catchment provides a framework for the protection of marine environmental quality within Cockburn Sound consistent with the EPA’s EAG 15.

A 2010 report by the WA Auditor General found that a strong policy and management framework has been established for Cockburn Sound, but that gaps exist in policy implementation, management oversight and monitoring (OAG 2010).
Figure 10-1: State marine parks and fish habitat protection areas adjacent to and within the Advice Area.
Figure 10-2: High value benthic habitat areas within and adjacent to the Advice Area

Legend
- Advice Area
- High Value Benthic Habitat
  - Marmion Marine Park
  - Peel-Harvey Inlet
  - Shoalwater Islands Marine Park
  - Shoalwater Islands Marine Park - Garden and Carnac Islands
  - Swan Estuary Marine Park - Alfred Cove
  - Swan Estuary Marine Park - Milyu
  - Swan Estuary Marine Park - Pelican Point

Datum/Projection: GDA 1994 MGA Zone 50
Data Source: EPA
Prepared by: SM  Date: 17/11/2015
Figure 10-3: Cockburn Sound ecological protection levels

Legend
- Advice Area
- Ecological Protection Areas
  - High
  - Moderate
  - Low

Datums/Projections: GDA 1994 MGA Zone 50
Data Source: EPA
Prepared by: SM Date: 17/11/2015
10.5.4 Management of groundwater and surface water inflow quality

There are a number of existing processes and policies in place for the management of water quality contaminants associated with land based activities. Implementation of these measures contributes to reducing the risk of these pollutants ending up in the marine environment.

Key management measures include the Contaminated Sites Act 2005 and associated guidelines and the BUWM Framework. The contaminated sites guidelines are a key management tool for preventing and minimising the movement of pollutants from known contaminated sites into the marine environment. The BUWM Framework outlines a process and guidance to be applied to new urban areas, with an objective to either maintain or improve ground water and surface water quality (See Section 7.5.6). This framework provides the mechanism for minimising impacts from future urban development on the marine environment.

In addition, risks to marine environmental quality from terrestrial construction activities can be effectively avoided and mitigated using best practice construction environmental management controls to protect groundwater and surface water quality. These controls are implemented through the land planning process. Examples of such controls include:

- Construction Environment Management Plans;
- Acid Sulfate Soil Management Plans;
- Sediment and Erosion Control Plans;
- spill response procedures; and
- appropriate storage and stockpiling of oils, greases, heavy metals and other potential contaminants.

10.5.5 Coastal Planning Policy

State Planning Policy 2.6 State Coastal Planning provides the following guidance for water management within the coastal zone, which is used to inform decision making through the land planning process:

- Coastal development should manage water resources in accordance with the principles of water sensitive urban design and integrated water cycle management.
- Development on or near the coast should maintain or restore pre-existing or desirable environmental flows and hydrological cycles within foreshore reserves.
- Development on or near the coast should not discharge any waste or stormwater that could significantly degrade the coastal environment, including the coastal foreshore reserve, coastal waters and marine ecosystems.
- Coastal areas should be avoided for the management of wastewater.
- Acceptable stormwater management options are specified.

Additionally, this policy provides guidance on acceptable development and settlement within the coastal zone and the location, vesting and management of foreshore reserves. All of these measures
contribute to the protection of marine environmental quality from indirect impacts as a result of inappropriate development.

10.5.6 Environmental quality management framework

The National Water Quality Management Strategy was developed in the 1990s and provides a blueprint for a nationally consistent approach to water quality management. In Western Australia, a State Water Quality Management Strategy (SWQMS) was developed to guide implementation at the State level. Recently, the EPA has issued an Environmental Assessment Guideline for Protecting the Quality of Western Australia’s Marine Environment (EAG 15) (EPA 2015e) which provides an update to the Environmental Quality Management Framework, and guidance on how this should be applied to the Western Australian Marine environment and to the environmental impact assessment of new development proposals. Its objective is to provide an environmental quality management framework to protect the environmental values of Western Australia’s marine environment from waste discharges and contamination.

EAG 15 identifies the following key structural elements of the Environmental Quality Management Framework: the Environmental Values (EVs) and Environmental Quality Objectives (EQOs) spatially representing the community’s and other stakeholder’s desired outcome for marine environmental quality; Environmental Quality Criteria; and an Environmental Quality Management Plan.

Within Perth and Peel coastal waters, Cockburn Sound is currently the only location where this framework has been fully implemented (through the Cockburn Sound SEP and Management Plan). There is opportunity to expand this framework outside of the Cockburn Sound area.

10.5.7 Marine pollution

There is also a raft of regulations in existence relating to specific sources of marine pollution aimed at managing threats relating to recreational, industrial and commercial activities. These regulations are implemented by Department of Transport, where they relate to shipping and boating, Department of Fisheries and DER.

Discharge of sewage by vessels in State waters is guided by Department of Transport’s Strategy for Management of Sewage Discharge from Vessels into the Marine Environment 2004, which identifies zones for sewage disposal based on health and environmental risks.

10.6 AVOIDANCE TO DATE

The footprints identified for future development in the Advice Area avoid the marine environment entirely and the activities being considered under the Strategic Assessment are unlikely to have any direct impact on it. Proposed new developments are generally more than 2 km from the coast in the Advice Area. This is primarily a result of the fact that coastal areas, and in particular the central coastal areas, of the Advice Area have largely been developed. However, the focus on strategic infill and prioritisation of land for development that is already cleared and has access to infrastructure has also meant that sensitive undeveloped coastal areas have been avoided.
10.7 POTENTIAL IMPACTS

Land based developments could impact marine environmental quality by delivering an increase in contaminant or nutrients loads to the marine environment, transported through groundwater or surface water flows or through aerial deposition. These are considered to be the key potential impacts resulting from the proposed future development within the scope of the strategic assessment. However, it is important to understand that these indirect sources of contamination should not be considered in isolation, but within the context of the cumulative effects of all direct and indirect contaminant sources.

A significant increase in population is also likely to result in increased pressure on the marine environment for recreation. The increase in recreation likely to result from urban growth within the Advice Area would see more vessels on the water and higher usage of marinas and other boating facilities. This would increase the risks of localised marine water contamination from fuel leaks, oil spills, or inappropriate use of boat cleaning chemicals and/or inappropriate disposal of effluent from vessels. It is estimated that 33 per cent of all the oil that enters the marine environment in Australia each year comes from general vessels (DoT 2014). More people accessing the coast and using the marine environment may also contribute increased litter.

Whilst increased population is likely to result in increased recreational and boating pressures which can impact on marine environmental quality, policy and management arrangements currently exist to address some of these pressures. This includes the management provisions discussed in sections 10.5.5 and 10.5.7. These issues have therefore not been considered as issues of strategic importance for the assessment of acceptability of the proposed development.

This impact analysis therefore focuses on potential impacts owing to land based development and the potential for increased nutrient and contaminant concentrations as a result.

10.8 IMPACT ANALYSIS

Discharge of nutrients and other contaminants to the marine environment from land based activities can occur through groundwater, surface water or stormwater outflows as well as aerial deposition. Typical contaminant sources include vehicle emissions in road run-off, fertilizers and other garden chemicals, industrial chemicals, industrial emissions, cleaning chemicals, soil erosion, and existing contaminated sites. Land use change associated with the proposed development has the potential to increase the occurrence of potential marine pollutants, as well as alter the pathways that deliver these pollutants to the marine environment.

The potential for contamination of upstream surface water and/or the groundwater underlying the terrestrial component of the Advice Area by hydrocarbons or hazardous substances may increase in certain areas as a result of the urban and industrial growth. The direct relationship between increased land use intensification (development) and contamination risk is well recognised. This is a direct result of the increased frequency of contamination incidents that occur when more people, buildings, roads fuel and other chemical and biological products are introduced into an area. In addition, new development may intersect existing contaminated sites, potentially mobilising contaminants that may otherwise have been contained.
Stormwater flows can deposit contaminants including heavy metals, oil and petrol residues and a range of chemicals that could come from an accidental spill on a nearby road (CALM 1999). Many contaminants (e.g. heavy metals) can also accumulate and be stored for a long time in sediments. Notwithstanding this, some of the contaminants in soils will find their way into downstream waterbodies via overland flow or through the soil profile into groundwater, although the rate of leaching is dependent on the chemical characteristics and soil chemistry. The Australian Petroleum Production and Exploration Association advises that, of all the oil that enters the marine environment in Australia each year 37 per cent comes from industrial discharge and urban runoff (DoT 2014).

As discussed in Chapter 7 (Impacts to Hydrological Processes and Inland Waters Environmental Quality), the development of new urban, industrial and rural residential areas brings the potential for greater use of domestic fertilisers and organic wastes, which can result in high levels of nutrient contaminants including phosphorus, ammonia and other nitrogen compounds (Trefry et al. 2006). Where these increased nutrient inputs are not adequately contained and managed, they have the potential to pollute groundwater, waterways and stormwater, all of which may discharge to the marine environment. The combined effect of all these diffuse and indirect contaminant sources, in combination with more direct sources of contaminants not addressed in this strategic assessment, may result in significant cumulative effects on the quality of the downstream marine environment.

Pathways for increased nutrient concentrations and loads to the marine environment include the following:

- catchment runoff to waterways such as the Peel-Harvey and Swan Canning River systems;
- existing surface water drains;
- storm water drainage;
- sub-marine groundwater discharge; and
- aerial deposition.

Potential impacts to marine environmental quality are particularly pertinent for Cockburn Sound, which has been historically influenced by the established on-shore industrial, semi-rural and urban developments in the vicinity, including heavy industry and horticulture, landfills and the HMAS Stirling naval base (Trefry et al. 2006).

Due to its semi-enclosed nature and limited flushing, along with industrial discharges and the high intensity land uses within its catchment, Cockburn Sound has historically experienced perhaps the most significant water quality issues of any area along the Advice Area coast. As a result of these issues there has been a long history of marine environmental quality monitoring and reporting for the Sound. In 2013 a review of historical and contemporary contaminant loads entering Cockburn Sound was undertaken (GHD 2013). The review indicated that the major contemporary pathway for contaminants to Cockburn Sound was through surface runoff entering drains or the groundwater from all land uses in the catchment. Residential use is estimated to be the largest contributor of nitrogen (21-53 tonnes/year) and phosphorus (3-6 tonnes/year) in the Cockburn Sound catchment (CSMC 2013). Despite significant nutrient inputs, the environmental quality of Cockburn Sound is known to be improving over time (CSMC 2015) largely as a result of the improved management of industrial discharges.
Of the land uses being considered in the Strategic Assessment, those with the most potential to contribute increased nutrients to the marine environment are urban, industrial and rural residential land uses. Table 10-2 and Figure 10-4 indicate the area within Cockburn Sound Strategic Environmental Policy boundary which intersects each of these footprints. Very little additional urban area is proposed and no new rural residential land use; however, more than 2000 ha of new industrial land is proposed within the catchment.

### Table 10-2: Area in hectares of footprints within the Cockburn SEP boundary

<table>
<thead>
<tr>
<th>Total (land) area</th>
<th>Urban</th>
<th>Industrial</th>
<th>Rural residential</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>16,679</td>
<td>87</td>
<td>2,258</td>
<td>0</td>
<td>2,345</td>
</tr>
</tbody>
</table>

This is a significant expansion of the industrial area. If not properly managed, this expansion has potential to contribute to increased pollutant concentration of surface water and groundwater discharging to the Sound.

The likely increase in nutrient loads to Cockburn Sound, as a result of these changes is uncertain and will depend on the type of industry that is developed. However, generally industrial land uses would be expected to have lower nutrient input rates than the rural land uses they will be replacing. Discussion of relative nutrient inputs rates between land uses is included in Chapter 7 (Impacts to Hydrological Processes and Inland Waters Environmental Quality).

Many of the high value marine areas identified in Section 10.4.2, including Marmion Marine Park, Cottesloe FHPA and the Swan Estuary have groundwater and surface water catchment areas within the Central sub-region. This sub-region is largely developed for urban and some industrial land use and the proposed future development consists of urban consolidation activities. Again, the impacts to nutrient export to the marine environment are difficult to determine at this level.
10.9 MITIGATION AND MANAGEMENT

Measures described in Section 10.5.4 and discussed in detail Chapter 7 (Impacts to Hydrological Processes and Inland Waters Environmental Quality) will be critical to ensuring that impacts the marine environmental quality are minimised.

The exact impact to marine environmental quality from activities associated within the proposed development is difficult to predict. Cumulative impacts to marine environmental quality are also uncertain due to the likelihood of future impacts from activities outside the scope of the strategic assessment such as the introduction of new point source discharges.

The existing management plans for marine protected areas, combined with the identification of environmental values and environmental quality objectives for the area (through application of the environmental quality management framework), should provide the means to identify and then manage the key areas of uncertainty. The environmental quality management framework can be used to guide and assess the acceptability of new development, but also for identifying and managing unacceptable impacts from existing activities in the downstream marine environment.

The first two elements of the framework, (EVs and EQOs) are identified in the document Perth’s Coastal Waters: Environmental Values and Objectives (EPA 2000b), although this only addresses coastal waters adjacent to the metropolitan region and not the full extent of the Advice Area. Currently Cockburn Sound is the only area where the Framework has been fully implemented through the identification of Environmental Quality Criteria; and creation of an Environmental Quality Management Plan (Environmental Management Plan for Cockburn Sound and its Catchment, CSMC 2005). There is potential to build on these two documents to achieve implementation of the Framework across the broader Perth and Peel Coastal region.

Implementation of this framework across the whole of the coast adjacent to the Advice Area would provide:

- a statement of agreed environmental quality outcomes for these waters;
- baseline monitoring data against which to evaluate trends and predict threats and impacts;
- criteria against which to assess the acceptability of marine environmental quality and hence the performance of environmental management;
- triggers for determining whether additional management responses are required to be implemented;
- a mechanism for considering cumulative impacts on marine environmental quality from both indirect and direct impacts; and
- guidance for location of new point source discharges and a clear indication of likely acceptability.

**Commitment:** Facilitate the development of environmental marine quality criteria, to provide appropriate environmental protection outcomes for marine environmental quality and to inform environmental impact assessment and ongoing management programs for the entire Advice Area coastal region.
In Cockburn Sound the framework has been fully implemented through the development of environmental quality criteria and an environmental management plan and is supported by the Cockburn Sound SEP. A report by the Auditor General in 2010 indicated that there were areas of the policy and framework that could be strengthened to ensure it was fully effective. These recommendations largely focused around monitoring and reporting and have been addressed in a subsequent review of the Cockburn Sound SEP and of the supporting document Environmental Quality Criteria Reference Document for Cockburn Sound.

The EPA has since released a revised Environmental Quality Criteria Reference Document for Cockburn Sound in March 2014 and the Minister for Environment is currently considering a draft of the revised Cockburn Sound SEP.

**Commitment:** Protect the values of Cockburn Sound through improved adaptive management, monitoring and reporting requirements through updates to and implementation of relevant policy

In addition, the commitments in Chapter 7 (Impacts to Hydrological Processes and Inland Waters Environmental Quality) relating to improved management of hydrology and water quality and Chapter 8 relating to management of air quality are critical to ensuring that impacts the marine environmental quality are minimised.

### 10.10 SUMMARY OF OUTCOME AGAINST EPA OBJECTIVE

At this time it is difficult to quantitatively determine the likely impacts to marine environmental quality as a result of the development being assessed under the Strategic Assessment, particularly given that impacts will be cumulative with other more direct impacts resulting from developments and activities that are not included in this strategic assessment. In addition, along much of the Advice Area coastline there are no clear criteria against which to determine whether ecological and social values have been adequately protected. A commitment to review and extend the document Perth’s Coastal Waters: Environmental Values and Objectives (EPA 2000b) to include the broader Perth and Peel Coastal regions, including the development of environmental quality criteria, is an essential step in ensuring that appropriate environmental protection outcomes for marine environmental quality are developed and agreed by relevant stakeholders (including the broader community). Full implementation of this framework will mean that the EPA’s objective for marine environmental quality can be met in the future as development within the Advice Area takes place.

Existing measures for managing marine environmental quality are discussed in Section 10.5 and in Chapter 7, where they relate to management of groundwater and surface water quality. A robust marine environmental quality framework will inform the future implementation of these measures and provide early identification of when and where adaptive management responses are required.
11 ENVIRONMENTAL MANAGEMENT FRAMEWORK

The outcomes of the strategic assessment and in particular the Strategic Conservation Plan will be implemented over a long period (30 + years). An environmental management framework is required to drive the implementation of commitments, adapt them as new information becomes available, and to monitor and report on progress.

11.1 STRATEGIC ASSESSMENT GOVERNANCE AND IMPLEMENTATION

The responsibility for implementing the commitments to mitigate impacts to environmental factors contained in Action Plan G of the Strategic Conservation Plan lies with the Western Australian Government.

Implementation of the assurance framework (see below) and the commitments made in the Commonwealth IAR and State IAR will require long term action by State and Local Government agencies working together. In turn this will require ongoing coordination and reporting for the duration of strategic assessment and in particular the Strategic Conservation Plan.

A governance framework has been developed that sets out the roles and responsibilities of key Ministers, State Agencies and other stakeholder bodies with respect to implementing the Strategic Conservation Plan and ensuring that the outcomes and objectives relating to MNES and State environmental values are met.

Implementation will be coordinated by an over-arching Executive body reporting to a select group of State Government Ministers. The Executive body will commence operations following endorsement of the Strategic Conservation Plan by the Commonwealth Minister for the Environment. This body will facilitate partnerships with local government associations, government and non-government service providers, developers, landowners, Noongar groups and other community representatives in effectively delivering the Strategic Conservation Plan. It will have responsibility for the implementation, review and revision of the action plans of the Strategic Conservation Plan.

11.2 ONGOING AVOIDANCE

Chapter 2 outlines significant efforts aimed at avoiding impacts to environmental values during the planning phase and development of the future development footprints. Ongoing efforts aimed at avoidance of impacts will occur over the life of the Strategic Conservation Plan and incorporate new information as it comes to hand. This is supported by periodic strategic review of the relevant Action Plans and embedded processes for the Strategic Assessment Executive Body to coordinate relevant Government agency input.

Ongoing avoidance measures will be applied to:
• Urban and industrial development (see Action Plan A of the Strategic Conservation Plan).
• Rural residential development (see Action Plan B of the Strategic Conservation Plan).
• Infrastructure (see Action Plan C of the Strategic Conservation Plan).

11.2.1 Urban and industrial

Ongoing avoidance within the urban and industrial classes of action will occur through implementation of detailed planning for new sites.

This process will involve examining potential urban and industrial expansion precincts in significant detail including determining what measures could be put in place to protect/avoid environmental values. The planning will result in designation of areas of open space to retain/protect these values to be consistent with environmental policy and legislation and the commitments of Action Plans F and G of the Strategic Conservation Plan.

11.2.2 Rural residential

As with urban and industrial, proposed rural residential development areas will be subject to a planning process to define areas to be avoided for rural residential lots and put aside in open space.

11.2.3 Infrastructure

The final location and alignment of infrastructure is subject to a future process of refinement following detailed planning and design to further avoid and minimise impacts to environmental values. This will include consideration of opportunities to reduce the development footprint through co-location of infrastructure (e.g. shared corridors).

11.3 MITIGATION OF IMPACTS

Mitigation of impacts to State environmental values incorporates:

• Application of various management measures to address potential indirect impacts to be applied:
  o in further planning and design of future development;
  o for implementation during development activities; and
  o for ongoing implementation.
• Rehabilitation of land to rectify direct impacts from development within the footprints and restore ecological function and values as much as practicable over time.
• Monitoring.
• Adaptive management.
11.3.1 Management measures

Application of mitigation measures to implementation of the future development footprints is a standard part of the development processes at the WA State Government level. Mitigation measures include (amongst other things):

- Appropriate supporting investigations and studies prior to development to inform planning and design of projects to reduce environmental risk (e.g. groundwater and acid sulfate soil investigations).
- Appropriate planning and design of projects according to policy and guidance to reduce potential impacts (e.g. Water Sensitive Urban Design measures in urban and industrial development to reduce water quality and erosion issues, fencing to avoid fauna mortality on roads).
- Management measures to be applied during construction activities to reduce the risk of impacts occurring (e.g. on-site fauna management, dieback and weed hygiene measures).
- Ongoing activities to address potential indirect impacts of development, including:
  - fragmentation and edge effects;
  - introduction of weeds and/or pests;
  - issues associated with dust and/or noise;
  - changed fire regimes;
  - disturbance related to increasing numbers of people; and
  - alterations to groundwater and/or surface water.

Action Plans A to D of the Strategic Conservation Plan detail the implementation framework for each future development footprint. This includes the consideration and incorporation of appropriate mitigation measures.

Where such measures represent a new or revised management approach, there are specific commitments to implement under the Strategic Conservation Plan, as described under the related environmental factor (Chapters 5 to 10) and listed in Action Plan G.

11.3.2 Rehabilitation

Rehabilitation of land to restore ecological functions and values as far practicable is another important mechanism to contribute to the long-term delivery of the conservation outcomes and objectives. This is ‘on-site’ rehabilitation and should not be confused with rehabilitation or restoration works in conservation areas as part of the on-ground management component of the conservation program.

Action Plans C and D of the Strategic Conservation Plan detail the general situations in which rehabilitation will occur. A portion of direct impacts of disturbance from implementation of the future development footprints would be rectified through rehabilitation for the following type of projects:

- BRM extraction projects, which would be rehabilitated progressively or at point of closure of operations unless the land is designated for sequential industrial or urban use.
• Infrastructure projects where permanent above ground structures are not required (e.g. pipelines).
• Infrastructure projects for which the ongoing development footprint is not as large as the required construction footprint and therefore disturbed areas not required for the permanent structures can be revegetated (e.g. railway and road corridors and reserves, high voltage powerlines).

11.3.3 Monitoring

A monitoring program will be implemented that focuses on progress in achieving the outcomes, objectives and commitments. This is detailed further as part of the assurance framework in Section 11.4 below.

11.4 ASSURANCE FRAMEWORK

The Western Australian Government has developed an assurance framework to ensure that the Action Plans that are part of the Strategic Conservation Plan are delivered and the outcomes, objectives and commitments for both State and Commonwealth values are achieved.

The assurance framework is made up of the following elements:
• monitoring program;
• compliance program;
• annual reporting;
• five yearly review; and
• dispute resolution

An overview of these elements is provided below and in Figure 11-1. Importantly, monitoring and compliance outcomes provide input to annual reporting and five-yearly review to ensure Action Plans and supporting processes are updated and improved as necessary. The details of the assurance framework are provided in Action Plan I of the Strategic Conservation Plan.

11.4.1 Monitoring program

A monitoring program will be implemented that focuses on progress in achieving the outcomes, objectives and commitments. The monitoring program will address (but not be limited to):
• progress in development activities (Action Plans A to D of the Strategic Conservation Plan);
• progress in implementing the conservation and environmental commitments (Action Plans F and G of the Strategic Conservation Plan);
• progress in implementing the conservation program (Action Plan H of the Strategic Conservation Plan);
• the status of environmental outcomes and objectives for State environmental values (see Chapter 4 of the Strategic Conservation Plan); and
- the status of conservation outcomes and objectives for MNES (see Chapter 4 of the Strategic Conservation Plan).

The results of the monitoring program will feed directly into the compliance program, annual reporting and the five yearly reviews.

Figure 11-1: Assurance framework
11.4.2 Compliance program

A compliance program will be implemented to ensure activities within the Action Plans are carried out appropriately. The program will be made up of three components:

- regular compliance and enforcement;
- non-compliance actions; and
- compliance audits.

Implementation of the program is described in detail in Section 6.2 of the Strategic Conservation Plan.

11.4.3 Annual reporting

An annual report highlighting performance against the requirements of the Strategic Conservation Plan achieved in the previous year will be published by the Western Australian Government. This report will be completed within six months of the end of each financial year and will be made publicly available.

The annual reports will comprise (at a minimum):

- a review of the processes implemented through the Action Plans;
- an evaluation of progress in implementation of commitments; and
- any non-compliances including the State’s response.

The annual report will be provided to the DoE and to the EPA.

11.4.4 Five yearly review

Every five years, the Western Australian Government will undertake a comprehensive review of the Strategic Conservation Plan. The purpose of the review will be to assess progress in achieving the outcomes, objectives and commitments for both State and Commonwealth matters.

The five yearly review will (at a minimum):

- review the efficiency and effectiveness of the Action Plans (and associated systems/processes);
- review achievement of outcomes and objectives;
- identify improvements and corrective actions required to ensure outcomes and objectives will be achieved; and
- assess implementation of improvements and corrective actions from previous reviews.

The review will be undertaken in accordance with a set of Terms of Reference developed in consultation with the Commonwealth. A report will be developed to outline the results of the review process. This report will be provided to the DoE and EPA and will also be made publicly available.
11.4.5 Dispute resolution

In the event that any dispute arises between the Western Australian and Commonwealth Governments in relation to the Strategic Conservation Plan, the parties will settle it by direct negotiation using their best endeavours, acting in a spirit of cooperation. The parties agree that in the event of a dispute, discussions aimed at resolution will normally take place at officer level in the first instance.

11.5 OFFSETS

Where significant residual impacts have been identified during the course of assessment, offsets have been proposed. These are set out in Action Plan H of the Strategic Conservation Plan. Offsets are intended to deliver significant co-benefits to state environmental values and MNES.

11.6 COMMITMENTS

Commitments have been proposed in this IAR to further mitigate impacts to environmental factors. The commitments are summarised in Table 1 of Action Plan G of the Strategic Conservation Plan.
REFERENCES


Allen, M.G., Beatty, S.J., and Morgan, D. M. 2012. *Strategic action plan for protecting aquatic biodiversity in the Cape to Cape region*, Freshwater Fish Group & Fish Health Unit (Murdoch University) report to the Cape to Cape Catchments Group and Department of Environment and Conservation, Government of Western Australia.


City of Belmont (CoB) 2014. City of Belmont Urban Forest Strategy.


CSIRO 2009. Water in south-west Western Australia; South-West Western Australia Sustainable Yields Project Overview Factsheet. National Research Flagship - Water for a Healthy Country Flagship. CSIRO.


CSIRO and Bureau of Meteorology (BoM) 2015. Climate Change in Australia 2015: Southern and South-Western Flatlands Cluster Report, available online via http://www.climatechangeinaustralia.gov.au/media/ccia/2.1.4/cms_page_media/172/SSW_FLATLANDS_CLUSTER_REPORT.


Department of Aboriginal Affairs (DAA) 2013a. Aboriginal Heritage Due Diligence Guidelines, Department of Aboriginal Affairs & Department of the Premier and Cabinet, Western Australia.


Department of Conservation and Land Management (CALM) 2002. *Invertebrate Communities of caves on the South West coastal plain. Threatened Ecological Communities of Western Australia*. Department of Conservation and Land Management, Perth.


Department of Environment Regulation (DER) 2011. *A guideline for managing the impacts of dust and associated contaminants from land development sites, contaminated sites remediation and other related activities*.

Department of Environment Regulation (DER) 2014a. *Assessment and management of contaminated sites: Contaminated sites guidelines*.


Department of Environmental Protection (DEP) 2002. *Odour Methodology Guideline*.


Department of Fisheries (DoF) 2012. *Aquatic Invaders Identification Guide*. WA Aquatic Biosecurity Program, Department of Fisheries, Perth.


Department of Health (DoH) 2008. *Health Impacts of Climate Change: Adaptation Strategies for Western Australia*, Government of Western Australia. Western Australia.


Department of Parks and Wildlife (Parks and Wildlife) 2015b. *List of Threatened Ecological Communities endorsed by the Western Australian Minister for Environment (June 2015)*, Species and Communities Branch, Department of Parks and Wildlife, Perth.


Department of Planning (DoP) and Western Australian Planning Commission (WAPC) 2010. *Directions 2031 and Beyond: Metropolitan Planning Beyond the Horizon*, WAPC, Perth, Western Australia.


Department of the Environment (DoE) 2015b. *Climate change impacts in Western Australia*, available online via http://www.environment.gov.au/climate-change/climate-science/impacts/wa.


Department of Water (DoW) 2004. *Stormwater Management Manual for Western Australia*.

Department of Water (DoW) 2007. *Water Quality Protection Note (WQPN) 83: Infrastructure corridors near sensitive water resources*.

Department of Water (DoW) 2009b. *Gnangara groundwater areas allocation plan*.


Department of Water (DoW) 2012a. *Water Quality Protection Note 75, Proclaimed Drinking Water Source Areas*.


Department of Water (DoW) 2015. *Selection of future climate projections for Western Australia*, Water Science Technical Series, report no. 72, Department of Water, Western Australia.


Environmental Protection Authority (EPA) 2000a. *Environmental Protection of Native Vegetation in Western Australia: Clearing of Native Vegetation, with particular reference to the agricultural area*, EPA Position Statement No. 2, EPA, Perth, Western Australia.

Environmental Protection Authority (EPA) 2000b. *Perth’s Coastal Waters Environmental Values and Objectives*, EPA, Perth, Western Australia.


Environmental Protection Authority (EPA) 2006. Position Statement 9: Environmental Offsets, EPA, Perth, Western Australia.


Environmental Protection Authority (EPA) 2006b. Guidance Statement 10: Guidance for the Assessment of Environmental Factors. Level of Assessment for Proposals Affecting Natural Areas Within the System 6 Region and Swan Coastal Plain Portion of the System 1 Region, EPA, Perth, Western Australia.

Environmental Protection Authority (EPA) 2008a. Bulletin 1281. Keralup (formerly Amarillo) Masterplan, Karnup: Advice of the Environmental Protection Authority to the Minister for the Environment under Section 16(e) of the Environmental Protection Act 1986, EPA, Perth, Western Australia.

Environmental Protection Authority (EPA) 2008b. Water Quality Improvement Plan (WQIP) for the Rivers and Estuary of the Peel-Harvey System - Phosphorus Management, EPA, Perth, Western Australia.


Environmental Protection Authority (EPA) 2009c. Environmental Assessment Guideline No. 3 (EAG 3) for Protection of Benthic Primary Producer Habitat in Western Australia’s Marine Environment, EPA, Perth, Western Australia.

Environmental Protection Authority (EPA) 2010a. Strategic Environmental Advice on the Dawesville to Binningup Area Advice of the Environmental Protection Authority to the Minister for Environment under Section 16(e) of the Environmental Protection Act 1986. EPA Report 1359, EPA, Perth, Western Australia.

Environmental Protection Authority (EPA) 2010b. Environmental Protection Bulletin No. 12 Swan Bioplan - Peel Regionally Significant Natural Areas, EPA, Perth, Western Australia.

Environmental Protection Authority (EPA) 2012. A review of subterranean fauna assessment in Western Australia, EPA, Perth, Western Australia.
Environmental Protection Authority (EPA) 2013a. *Environmental Protection Bulletin No. 20 Protection of naturally vegetation areas through planning and development*, EPA, Perth, Western Australia.


Environmental Protection Authority (EPA) 2013c. *Environmental Assessment Guideline 12 – Consideration of subterranean fauna in environmental impact assessment in Western Australia*, EPA, Perth, Western Australia.


Environmental Protection Authority (EPA) 2015a (in draft). *Perth and Peel@3.5 million: Environmental impacts, risks and remedies. Interim strategic advice of the Environmental Protection Authority to the Minister for Environment under section 16(e) of the Environmental Protection Act 1986*, EPA, Perth, Western Australia.

Environmental Protection Authority (EPA) 2015b. *Environmental Assessment Guideline No. 8 (EAG 8) for Environmental Principles, Factors and Objectives*, EPA, Perth, Western Australia.


Environmental Protection Authority (EPA) 2015e. *Environmental Assessment Guideline No. 15 (EAG 15) for Protecting the Quality of Western Australia’s Marine Environment*, EPA, Perth, Western Australia.


GHD 2013. *Cockburn Sound Contaminant Review*, prepared for the Cockburn Sound Management Council and the Department of Environment and Conservation (Environmental Regulation Division), Perth WA.


Harvey, M. S. 2002. 'Short-range endemism among the Australian fauna: some examples from non-marine environments'. *Invertebrate Systematics*, 16:555-570.


Indian Ocean Climate Initiative (IOCI) 2012. Western Australia’s Weather and Climate: A Synthesis of Indian Ocean Climate Initiative Stage 3 Research, CSIRO and BoM, Australia.


McArthur WM. Bettenay E. 1974. *The Development of the soils of the Swan Coastal Plain, Western Australia*, Soil publication No. 16, CSIRO.


Western Australian Planning Commission (WAPC) 2003b. *Statement of Planning Policy 2.1 the Peel-Harvey Coastal Plain Catchment*.


Western Australian Planning Commission (WAPC) 2003e. *Statement of Planning Policy 2 Environment and Natural Resources Policy.*


Western Australian Planning Commission (WAPC) 2006e. *Statement of Planning Policy 5.3 Jandakot Airport Vicinity.*


Western Australian Planning Commission (WAPC) 2009. *State Planning Policy 5.4 Road and Rail Transport noise and freight considerations in land use planning, Western Australia.*

Western Australian Planning Commission (WAPC) 2010a. *State Planning Policy 2.8 Bushland Policy for the Perth Metropolitan Region.*

Western Australian Planning Commission (WAPC) 2010b. *State Planning Policy 4.2 Activity Centres for Perth and Peel.*


Western Australian Planning Commission (WAPC) 2015b. *State Planning Policy 5.1 Land use Planning in the Vicinity of Perth Airport (and current draft amendment)*.


Williams, A.R. 2011. ‘*Austrostipa* (Poaceae) subgenus *Lobatae* in Western Australia’, *Telopea* vol. 13, no. 1-2, pp 177-192