

Figure 42 illustrates the alignment options as assessed. As assessment of the options developed, two new alignment options (N1 – HAL02 and N1 – HAL02A) were produced following an Alignment Selection Workshop.

### 6.7.6.3 IMPACTS ON MNES

Although there will be broader environmental benefits generated by the project, there will also be local impacts on flora and fauna, waterways, natural landscapes and cultural heritage. Where possible the chosen alignment has aimed to avoid areas of known significance, and where impacts are anticipated mitigation strategies will be introduced to lessen impacts.

### FLORA AND FAUNA IMPACTS

The Regional Rail Link – West of Werribee to Deer Park will impact on local flora and fauna. Although the environmental values of the area have been degraded by clearing and agriculture since European settlement, there are still important habitats containing significant flora and fauna species. The project has avoided larger areas of ecological significance found further west around Mount Cottrell, but it is difficult for a project of this scale to completely avoid flora and fauna impacts. The project will minimise flora and fauna impacts in both terrestrial and aquatic habitats and ensure that the requirements of the applicable Commonwealth and State legislation are met. Key impacts include:

- > Removal of native flora and habitat areas through clearing and potential spread of noxious weeds and pests;
- > Impacts on native fauna; and
- > Potential damage to aquatic fauna habitat, of relevance to the Werribee River, Skeleton Creek and Lollypop Creek.

The project is predominantly within the Victorian Volcanic Plains Bioregion and the Werribee River basin as defined by the Department of Sustainability and Environment. The project traverses the Plains Grassland Ecological Vegetation Class (EVC 132), which is classified as endangered within the Victorian Volcanic Plain bioregion. The proposed alignment will impact on Natural Temperate Grassland of the Victorian Volcanic Plain which is a critically endangered ecological community listed on the EPBC Act.

The project has sought to avoid known areas of high ecological significance found further west towards Mount Cottrell. A preliminary flora and fauna assessment estimated that removal of 45ha of native vegetation, mainly in the Plains Grassland Ecological Vegetation Class. Subsequent estimates produced by the Department of Sustainability and Environment based on an updated project footprint including grade separations, station footprints and train stabling areas concluded that a total of 95ha of Natural

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Temperate Grassland will be impacted. This loss will be managed by implementing the net gain policies in the Victorian Native Vegetation Framework and by applying relevant prescriptions approved by the Commonwealth Minister for the Environment.

Table 10 presents the losses as a result of likely clearing within the three transport corridors, together with the Habitat Hectare offset target. Further details can be found in Appendix 1 and Section 6.1.

Although the project does not intersect directly with a Ramsar site, the project crosses the Werribee River, Skeleton Creek and Lollypop Creek which drain into the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar sites. Construction and operation techniques will be employed to avoid impacts on these waterways or the Ramsar site downstream.

One EPBC Act listed flora species (Spiny Rice-flower) will be impacted by the alignment. There is suitable habitat within the broader study area for one other species (Large-fruit Groundsel), and this species is most likely to be encountered in close proximity to the Melbourne to Ballarat Railway. Two EPBC Act listed fauna species (Striped Legless Lizard and Growling Grass Frog) have previously been recorded from the broader study area, although up to an additional seven species could also occur. No listed migratory fauna species are recorded from within the corridor for the project, although thirty-one species have previously been recorded in the broader study area. Three additional migratory species are predicted to occur, or their habitat is predicted to occur, within five kilometres of the alignment. Detailed survey will be undertaken for all such species prior to detailed design and planning of construction.

The presence of Natural Temperate Grassland has been identified as the most significant ecological issue for the Regional Rail Link – West of Werribee to Deer Park alignment, although the project has sought to avoid the most significant areas of this ecological community in the Melton/Wyndham region found around Mount Cottrell and west of Wyndham Vale

Of all the alignments, the impact on the Plains Grassland community is greatest for N2. However, the existing land use approved for the Boral Quarry means that much of the grassland traversed by N2 has already been approved for development and the net impact of N2 could therefore be less than any of the N1 options. The project involves a minor area of the remaining extent of Natural Temperate Grassland and it was noted offsetting of any native vegetation removed as part of the project is possible for all alignment options.

The primary mechanism for mitigating the flora and fauna impacts is through adherence to the Environment Effects Act conditions determined by the Victorian Minister for Planning, the Victorian Government's Native Vegetation Framework (DNRE 2002), and relevant prescriptions for managing matters of National Environmental Significance once

approved by the Commonwealth Minister for the Environment. As a result of the Native Vegetation Framework, the options assessment has sought to avoid and minimise native vegetation loss through appropriate route selection, and then ensure native vegetation losses are suitably offset. Further mitigation measures will ensure the project minimises impacts on flora and fauna.

These include:

- > Further targeted flora and fauna surveys to establish the precise impacts on key species, and whether additional prescriptions will be required to manage matters of national environmental significance;
- > Detailed design to minimise vegetation and habitat loss, including reducing the footprint of the corridor to minimum extent practicable;
- > Provision of fauna underpasses or overpasses (if appropriate) at key locations, particularly for watercourses draining into Ramsar sites;
- > Use of best-practice design for crossing waterways to maintain aquatic habitats and for dealing with runoff; and
- > Use of best-practice construction protocols to minimise impacts associated with soil disturbance, spread of weeds and pathogens and incidental damage to retained areas.

## WATERWAY IMPACTS

Various waterways intersecting the Regional Rail Link – West of Werribee to Deer Park include the Werribee River, Skeleton Creek, Lollypop Creek, Cherry Creek, Davis Creek, Laverton Creek, Kororoit Creek, Kayes Drain and tributaries of these watercourses. As noted earlier, many of these waterways flow into Ramsar wetland sites on the western shores of Port Phillip Bay.

The infrastructure needed to traverse waterways, (such as bridges, culverts and pylons) will be located and designed to minimise impacts on the hydraulic patterns of the waterways and the habitats they support. Particular care will be taken to ensure that existing flood regimes are not impacted through careful design of embankments and structures where the railway crosses watercourses. Impacts on the environmental values of waterways will be further reduced by implementing best practice water sensitive design treatments for rail track and stormwater runoff and implementing an Environmental Management Plan during construction. In conjunction with mitigation measures to reduce impacts on flora and fauna, the project will not cause major impact to waterways.

Of the northern alignments, N1B was the preferred alignment as it crossed the least number of waterways and had the lowest Aggregate Potential Impacts on Waterway

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and Floodplain Function Score. Alignment Option N1A has fewer waterway crossings, however it provides an alternative connection to the existing Ballarat railway for alignment options N1 and N1B. N2 and N1 both crossed one more waterway of ecological value, thereby increasing their impacts.

## **6.8 IMPACTS ON HERITAGE SITES AND COMMONWEALTH PROPERTIES**

There are seven historic sites listed on the Register of the National Estate within the Melbourne North Investigation Area and three within the Melbourne West Investigation Area (Table 3). All are built structures and all will be sympathetically retained and protected as part of the Precinct Structure Planning process. All these sites will be progressively added to the relevant planning scheme, where that has not already occurred, with appropriate controls applied to protect their character.

In addition to these historic sites, the Craigieburn to Cooper Street Grasslands is registered as a site of natural significance on the register of the National Estate. The majority of this site is within the strategic assessment study area (Melbourne's north) and these areas will be protected from development and managed for their conservation values. The site includes the existing Craigieburn Grasslands Reserve. The Biodiversity Conservation Strategy for the Whittlesea Growth Area will document the management arrangements for areas of the registered site not already in a conservation reserve.

It is not considered likely that actions resulting from the Program will impact significantly on Heritage sites or Commonwealth properties.

## **6.9 INFORMATION SOURCES AND CONFIDENCE LEVELS**

The assessment of impacts described in this report draws on a range of recent and historical information sources as outlined in Section 3.7. Definitive expertise has been sourced on key issues for which we have high levels of confidence.

As acknowledged in the report there are many issues for which it is known that information is incomplete and where additional information will be required to finalise aspects of the response. However the overall management process allows for such uncertainty. As this is a strategic assessment, we have confidence in the accuracy and reliability of information used to make the big decisions, in particular the proposed locations of the new Urban Growth Boundary, OMR/E6 Transport Corridor and Regional Rail Link. However where detailed information was not available to the standard required (i.e. in most areas except the well-surveyed Melbourne West

Investigation Area Investigation Area and western grasslands) significant fine tuning at the precinct level and development of site specific responses will occur in conjunction with additional information collection. This information collection is mandated as part of the Precinct Structure Planning process (e.g. flora and fauna surveys). In some cases this assessment report has committed additional information to be collected on key issues.

There are several plant and animal species that are identified in this report as being currently listed under the EPBC Act but for which a prescription has not been prepared for managing it as part of the Program. This is due to uncertainty about whether the species will actually be impacted. Surveys for all the following species will be undertaken prior to precinct design or transport planning where relevant, and if the species is detected a prescription will be developed in consultation with the Commonwealth. The list is as follows:

- Adamson’s Blown-grass
- Austral Toadflax
- Australian Painted Snipe
- Basalt Peppercress
- Basalt Sun Orchid
- Button Wrinklewort
- Clover Glycine
- Cream Spider Orchid
- Dwarf Galaxias
- Frankston Spider Orchid
- Grassland Earless Dragon
- Green-striped Greenhood
- Large Fruit Fireweed
- Maroon Leek Orchid
- Metallic Sun Orchid
- Pale Swamp Everlasting
- Plains-wanderer
- Purple Diuris
- Regent Honeyeater
- River Swamp Wallaby Grass
- Small Golden Moths
- Sunshine Diuris
- Swamp Everlasting
- Swamp Fireweed
- Swift Parrot

Overall the information used is considered appropriate for the level of assessment.

### **PROPERTIES WHERE ACCESS TO PSP BIODIVERSITY SURVEYS HAS BEEN REFUSED**

An agreed approach for properties that deny the Growth Areas Authority access to complete a biodiversity assessment is required. Unfortunately about 10 per cent of properties, sometime more, deny access to the GAA for it to complete biodiversity assessments in accordance with the *Biodiversity Precinct Planning Kit*.

The Precinct Structure Plan can attempt to draw a broad conclusion about the biodiversity values on these properties through modelling and aerial photography interpretation, but it can not satisfy the Kit’s survey requirements. The Precinct Structure Plan is required to make urban structure and open space planning decisions

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for these properties in the absence of this information. The Native Vegetation Precinct Plan will not apply to these properties.

Development of these properties should not be approved until a separate site specific referral under the EPBC Act is approved by the Commonwealth. This might delay the planning approvals process for these properties by at least 6 to 12 months due to seasonal biodiversity assessment requirements. A condition of this approval would be the requirement that these properties undertake site specific surveys in full accordance with the Biodiversity Kit prior to planning approval being granted for urban development at the owner's expense. It is considered that this is the only equitable and appropriate approach. It would not be equitable to 'reward' an owner who does not allow access to benefit for the streamlined assessment afforded under the Precinct Structure Planning process.

## 6.10 MANAGEMENT COMMITMENTS

The following section sets out the various commitments made by Victoria to manage impacts on matters of national environmental significance that are relevant to the Program. The table presents conservation activities for addressing these matters, as discussed throughout this report, together with the responsibilities of government agencies, councils and the private sector; timeframes; resourcing and performance measures. The details of the legal and other mechanism for delivery of each of these activities are described in the accompanying Program Report.

### NOTES ON TABLE

#### Timing:

- > Short term means the activity is expected to occur within the period 2010 to 2013.
- > Medium term means the activity is expected to occur within the period 2014 to 2019.
- > Long term means the activity is expected to occur beyond 2020.

## NATURAL TEMPERATE GRASSLANDS

Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
To establish a reservation for 15,000ha grasslands (nature conservation reserve or National Park) outside of the Urban Growth Boundary in Melbourne's west.	Prepare amendment to relevant planning schemes to apply a Public Acquisition Overlay to land within the western grassland reserves.	Department of Planning and Community Development	Short term	Covered under existing allocations	Public Acquisition Overlay in planning scheme by 2010
	Publicly acquire land (10 year acquisition program by the State Government).	Department of Sustainability and Environment	Short to medium term	Required resources have been committed by the Victorian Government	Acquisition schedule provided to Department of the Environment, Water, Heritage and the Arts following the Victorian Government's gazettal of the planning scheme amendment  Purchase and reservation under <i>Crown Land Reserves Act 1978</i> completed by 2020 (excluding quarries) (end stage 2)
To provide interim management of the Western Grassland Reserves before they are acquired, achieved by assisting landholders to manage threats and strengthening regulation to prevent degradation.	Amend local planning schemes to apply an Environmental Significance Overlay or other appropriate statutory planning controls to the western grassland reserves.	Department of Planning and Community Development	Short term	Covered under existing allocations	Appropriate planning controls in relevant local planning schemes by 2010
	Amend or make declarations under the <i>Catchment and Land Protection Act 1994</i> to legally protect grasslands on the Volcanic Plains grasslands from environmental weeds.	Department of Primary Industries	Short term	Covered under existing allocations	Declarations to lists or areas under the <i>Catchment and Land Protection Act 1994</i> gazetted by December 2010
	Prepare Interim Management Plan.	Department of Sustainability and Environment	Short term	Covered under existing allocations	Interim Management Plan provided to the Department of the Environment, Water, Heritage and the Arts by 2010
	Undertake urgent works from December 2009 (weed control), then in accordance with the Interim Management Plan schedule with landholders and relevant local councils. Conduct on ground surveillance and enforcement.	Department of Sustainability and Environment	Short term	Required resources have been committed by the Victorian Government	Monitor and report on implementation of the Interim Management Plan in accordance with the reporting schedule  Reports provided to Department of the Environment, Water, Heritage and the Arts every 6 months in 2010–2011 then annually until land acquired.

Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
To manage the western grasslands as conservation reserve or National Park for a range of particular vegetation and species requirements.	Establish expert advisory group and define performance standards for best practice adaptive management of native grassland and threatened species.	Department of Sustainability and Environment	Short term	Covered under existing allocations	Performance standards for management, and monitoring methodology provided to DEWHA by June 2011
	Progressively survey and assess flora and fauna values on acquired parcels.	Department of Sustainability and Environment	Short to medium term	Covered under offset arrangements (underwritten by Victorian Government)	Flora and fauna survey undertaken on each newly acquired land parcel with report prepared for the Department of Sustainability and Environment on values and management issues.
	Prepare National Park or Reserve Management Plan that incorporates best practice adaptive management for the western grassland reserves.	Parks Victoria	Medium term	Covered under existing allocations	Prepare National Park or Reserve Management Plan by December 2012 following community consultation.  Management Plan revised and updated by 2022
	Undertake works, manage and monitor park activities in accordance with the National Park or Reserve Management Plan and best practice performance standards. This includes undertaking detailed flora and fauna surveys for the Striped Legless Lizard, Plains-wanderer, Grassland Earless Dragon, Spiny Rice-flower, Large-fruit groundsel and other nationally listed species across whole reserve area.			Short to long Term	Required resources have been committed by the Victorian Government



Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
To identify and protect other grassland remnants on the Werribee Plains	Amend local planning schemes to apply appropriate statutory planning controls to remnant grasslands identified by Department of Sustainability and Environment mapping outside the Urban Growth Boundary and to relevant non-urban land within the Urban Growth Boundary.	Department of Planning and Community Development	Short term	Covered under existing allocations	Environmental Significance Overlays in relevant local planning scheme by June 2010
	New mapping program undertaken on private land to inform improved or expanded Environmental Significance Overlays.		Short term	Covered under existing allocations	Environmental Significance Overlays in relevant local planning scheme by June 2010
	Revise Environmental Significance Overlays as a result of new data.	Department of Planning and Community Development	Medium term	Subject to funding	Revised statutory planning controls in local planning schemes by 2015
To implement the prescription approved by the Commonwealth Minister for Environment for managing impacts on Natural Temperate Grasslands	Prepare Native Vegetation Precinct Plans and Conservation Management Plans as part of the precinct structure planning process following the methodology of the Biodiversity Precinct Planning Kit and detailed guidance.	Growth Areas Authority Growth area councils Department of Sustainability and Environment	Short term	Covered under existing allocations	Surveys undertaken according to Biodiversity Precinct Planning Kit methodology
	Monitor planning permits and enforce illegal clearing that is not in accordance with the requirements of the Native Vegetation Precinct Plan or Conservation Management Plan, or relevant approval document for transport infrastructure or other land use.	Growth area councils Department of Primary Industries	Ongoing	Covered under existing allocations	Offsetting according to Native Vegetation Management Framework. Grassland offsets located within proposed grassland reserves. Breaches reported to Department of Environment, Water, Heritage and the Arts as agreed

## GRASSY EUCALYPT WOODLANDS

Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
To progressively secure the long-term protection of retained areas of Grassy Eucalypt Woodland on private land within the Hume-Whittlesea and Sunbury Growth Areas through implementation of the prescription approved by the Commonwealth Minister for Environment for managing impacts on Grassy Eucalypt Woodland and other strategic planning mechanisms	Amend Hume Planning Scheme and Whittlesea Planning Scheme to introduce appropriate statutory planning controls (Conservation zoning plus an Environmental Significance Overlay) to protect constrained land identified for conservation of Grassy Eucalypt Woodland.	Department of Planning and Community Development	Short term	Covered under existing allocations	Appropriate planning controls in Hume Planning Scheme and Whittlesea Planning Scheme by June 2010
	Prepare Biodiversity Conservation Strategy for the Northern Growth Areas that sets out the mechanism by which retained Grassy Eucalypt Woodland will be permanently protected and managed to improve its quality within the Growth Area.	Department of Sustainability and Environment	Short term	Covered under existing allocations	Northern Biodiversity Conservation Strategy prepared by December 2009
	Prepare revised Growth Area Framework Plans for Hume and Whittlesea that identify conservation corridors and principles for managing the protection of Grassy Eucalypt Woodland.	Growth Areas Authority Department of Planning and Community Development	Short term	Covered under existing allocations	Revised Whittlesea Growth Area Framework Plan prepared by 2010 Conservation strategy reflected in revised Whittlesea and Hume Growth Area Framework Plans
	Prepare Precinct Structure Plans in accordance with the Growth Area Framework Plans and Precinct Structure Planning Guidelines (including requirements for biodiversity conservation).  Prepare Native Vegetation Precinct Plans with the Precinct Structure Plans in accordance with Clause 52.16 of local planning schemes.	Growth Areas Authority Hume City Council Whittlesea City Council	Short term	Covered under existing allocations	Precinct structure planning results in the permanent protection and management of 80 per cent of Grassy Eucalypt Woodland in Hume and Whittlesea Growth Areas by 2025

Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
	Monitor planning permits and enforce illegal clearing that is not in accordance with the requirements of the Native Vegetation Precinct Plan or Conservation Management Plan, or relevant approval document for transport infrastructure or other land use.	Growth area councils Department of Primary Industries	Ongoing	Covered under existing allocations	Offsetting according to Native Vegetation Framework.  Grassy Eucalypt Woodland offsets located within proposed Northern Grassy Woodland reserves.  Breaches reported to Department of Environment, Water, Heritage and the Arts as agreed
Establish a large (at least 1200ha) Grassy Eucalypt Woodland reserve (nature conservation reserve) south west of Whittlesea outside the Urban Growth Boundary	Prepare and consult on a proposal for a Grassy Eucalypt Woodland reserve concurrently with the preparation and public consultation of the revised Whittlesea Growth Area Framework Plan. The proposal is to identify the funding and acquisition mechanisms and potential statutory planning controls to be applied to the land.	Department of Sustainability and Environment	Short term	Covered under existing allocations	Reserve proposal, acquisition and management approach and schedule provided to Department of the Environment, Water, Heritage and the Arts by 2010
	Implement agreed Grassy Eucalypt Woodland reserve proposal.	Department of Sustainability and Environment	Short to medium term	Funding generated from developer's offset requirements	Reports to Department of the Environment, Water, Heritage and the Arts on progress of reserve establishment in accordance with the acquisition schedule by 2012 and 2015 or as determined by approved Monitoring and Reporting Framework  Reserve established and land manager appointed by 2020

GOLDEN SUN MOTH, SPINY RICE-FLOWER AND MATTED FLAX-LILY

Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
To determine the extent of the Golden Sun Moth to inform Sub-Regional Species Strategy and Precinct Structure Plans	Undertake targeted surveys for the Golden Sun Moth across its historic Victorian range for at least two seasons in accordance with the Biodiversity Precinct Planning Kit methodology. Survey period to be extended if required.	Growth Areas Authority (growth areas and periurban)  Department of Sustainability and Environment (rural and regional)	Short term	Resources available and committed	New data provided annually to the Department of the Environment, Water, Heritage and the Arts for recovery planning purposes
	Prepare Sub-Regional Species Strategy for the Golden Sun Moth.	Department of Sustainability and Environment	Short term	Covered under existing allocations	Sub-Regional Species Strategy for the Golden Sun Moth completed by June 2011 for Commonwealth approval
To implement the prescriptions approved by the Commonwealth Minister for Environment for managing impacts on Golden Sun Moth, Spiny Rice-flower and Matted Flax-lily	Prepare detailed guidance note for stakeholders as part of Sub-Regional Species Strategy outlining assessment and accounting process for the Golden Sun Moth, Spiny Rice-flower and Matted Flax-lily to assist precinct structure planning and other development approvals processes, and to track progress towards bioregional protection targets.	Department of Sustainability and Environment	Short term	Covered under existing allocations	Guidance note published by 2010
	Provide regular reports on Victoria's progress towards meeting the '80 per cent of confirmed highest priority sites' (as defined in prescriptions) for Golden Sun Moth, Spiny Rice-flower and Matted Flax-lily.	Department of Sustainability and Environment	Ongoing	Covered under existing allocations	Reports published every two years commencing 2010 and in line with Monitoring and Reporting Framework
	Prepare Native Vegetation Precinct Plans and Conservation Management Plans as part of the precinct structure planning process following the methodology of the Biodiversity Precinct Planning Kit and detailed guidance.	Growth Areas Authority  Growth area councils  Department of Sustainability and Environment	Short term	Covered under existing allocations	Surveys undertaken according to Biodiversity Precinct Planning Kit methodology

Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
	Monitor planning permits and penalise illegal clearing that is not in accordance with the requirements of the Native Vegetation Precinct Plan or Conservation Management Plan, or relevant approval document for transport infrastructure or other land use.	Growth area councils	Ongoing	Covered under existing allocations	Breaches reported to Department of Environment, Water, Heritage and the Arts as agreed

## SMALL GOLDEN-MOTHS ORCHID

Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
To protect areas of Clarke's Road grassland containing Small Golden Moths Orchid by applying appropriate planning controls and by land purchase or by securing private land management agreement/s	Amend the Melton Planning Scheme to introduce appropriate statutory planning controls (conservation zoning and Environmental Significance Overlay) to protect the Small Golden-Moths Orchid and other grassland values.	Department of Planning and Community Development	Short term	Covered under existing allocations	Appropriate planning controls in planning scheme by June 2010
	Reflect the values of Clarke's Road Grassland in the Biodiversity Conservation Strategy and Growth Area Framework Plan for this Growth Area, including identifying and consulting on potential reserve boundaries and determining the funding and acquisition mechanisms to be applied to the land.	Department of Sustainability and Environment Growth Areas Authority Department of Planning and Community Development	Short term	Covered under existing allocations	Growth Area Framework Plans in place by June 2011 reinforce protection of this area  Provide reserve proposal together with acquisition and management approach to Department of the Environment, Water, Heritage and the Arts as part of Biodiversity Conservation Strategy for the Growth Area by March 2011
	Legal agreements prepared and negotiated with landowners (under s69 of <i>Conservation Forests and Land Act</i> , <i>Victorian and Conservation Trusts Act</i> or s173 agreements under the <i>Planning and Environment Act 1987</i> ).	Department of Sustainability and Environment	Short to medium term	Covered under existing allocations	Land purchased or in private land management agreement by June 2012
To manage native grassland areas along Clarke's Road to improve their quality over the long-term and maximise habitat condition for threatened and other resident species, with particular emphasis on Small Golden-moths Orchid	Prepare a Reserve Management Plan for the Clarke's Road area.	Department of Sustainability and Environment Parks Victoria	Medium term	Covered under existing allocations	Conservation Management Plan in place that provides appropriate protection and management regimes for persistence of the Small Golden Moth at the Clarke's Road area in perpetuity
	Undertake works and monitor use of the reserve in accordance with the Conservation Management Plan. If not a public reserve, monitor planning permits and enforce any land management obligations in accordance with the requirements of the Conservation Management Plan and legal agreement.	Parks Victoria Department of Sustainability and Environment Department of Planning and Community Development	Medium term to ongoing	Resources available and committed	Performance standards for management and monitoring provided to Department of the Environment, Water, Heritage and the Arts by June 2011  Each land parcel managed by Parks Victoria or private landowner according to Conservation Management Plan and/or legal agreement

**SOUTHERN BROWN BANDICOOT AND GROWLING GRASS FROG**

Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
To protect important landscape/habitat areas of the Southern Brown Bandicoot and Growling Grass Frog	Undertake field surveys, population viability analyses and develop models for sub-regional planning, then prepare Sub-regional Species Strategies for conservation of Southern Brown Bandicoot and Growling Grass Frog to inform preparation of Biodiversity Conservation Strategies and Growth Area Framework Plans, and provide guidance to urban development planning	Department of Sustainability and Environment	Short to medium term	Covered under existing allocations	Sub-regional Strategies for Growling Grass Frog reflected in Casey-Cardinia, Melton-Caroline Springs and Hume-Whittlesea Growth Area Framework Plans by June 2011  Sub-regional Strategy for the Southern Brown Bandicoot reflected in Casey-Cardinia Growth Area Framework Plan by June 2011
	Implement key strategic management measures identified in the Sub-regional Species Strategies informing relevant Precinct Structure Plans.	Department of Planning and Community Development  Department of Sustainability and Environment  Growth Areas Authority	Short term	Funding to be sought when required	Priority existing habitat protected and mechanism for future management established for Growling Grass Frog and Southern Brown Bandicoot by March 2011
To implement Conservation Management Plans and prescriptions approved by the Commonwealth Minister for Environment for the Growling Grass Frog and Southern Brown Bandicoot	Prepare Conservation Management Plans as part of the precinct structure planning process following the methodology of the Biodiversity Precinct Planning Kit and responding to requirements of relevant prescriptions.	Growth Areas Authority  Growth area council  Developer	Short term	Covered under existing allocations	Conservation Management Plans prepared to the satisfaction of Department of Sustainability and Environment and consistent with Sub-Regional Species Strategy (once prepared)  Monitoring reports provided to Department of Environment, Water, Heritage and the Arts at least every two years according to agreed schedule to demonstrate the effectiveness of management approaches for Southern Brown Bandicoot and Growling Grass Frog
	Monitor planning permits and enforce land management obligations that are not in accordance with the requirements of the Native Vegetation Precinct Plan and Conservation Management Plan.	Growth area councils	Ongoing	Covered under existing allocations	Performance reported to Department of Environment, Water, Heritage and the Arts as agreed

Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
To ensure the water quality of known and potential Growling Grass Frog habitat is maintained at the level necessary to contribute to their persistence across greater Melbourne	Incorporate best practice urban water management techniques through preparation of Integrated Water Management Plans as specified in the Precinct Structure Planning Guidelines for Precinct Structure Plans and/or equivalent process for transport infrastructure and other development planning.	Growth Areas Authority Growth area councils Developer	Short to medium term	Covered under existing allocations	Integrated Water Management Plans prepared in accordance with the Precinct Structure Planning Guidelines  All precincts, transport and other infrastructure included within the Program developed in accordance with best practice urban water management
	Protect relevant habitat identified in the Sub-Regional Strategy or individual Conservation Management Plan from potential point source water quality contaminants by adherence to Environment Protection Authority guidelines and procedures.	Growth Areas Authority Growth area councils Developer Environment Protection Authority	Ongoing	Covered under existing allocations	All precincts, transport and other infrastructure included within the Program managed in accordance with published Environment Protection Authority guidelines and remediation procedures



## STRIPED LEGLESS LIZARD

Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
To implement prescription approved by the Commonwealth Minister for Environment for the Striped Legless Lizard prior to detailed planning and construction (precinct planning and transport infrastructure and other development)	Undertake detailed surveys for Striped Legless Lizard.  Prepare Conservation Management Plans and Biodiversity component of Precinct Structure Plans following the methodology outlined in the Biodiversity Precinct Planning Kit and responding.	Growth Areas Authority	Short to medium term	Covered under existing allocations	Surveys undertaken in accordance with the Biodiversity Precinct Planning Kit methodology  Surveys undertaken prior to commencement of precinct planning  All data provided to the Department of Sustainability and Environment within three months of submission to the Growth Areas Authority  Precinct Structure Plan reflects relevant conservation management plan
	Prepare translocation protocol in consultation with the Striped Legless Lizard recovery team.	Department of Sustainability and Environment	Short term	Covered under existing allocations	Protocol for translocation provided to Department of the Environment, Water, Heritage and the Arts by 2010
Manage and monitor populations in western grassland reserves and any populations translocated from or within the Program area		Parks Victoria  Department of Sustainability and Environment	Medium to long term	Required resources have been committed by the Victorian Government (refer to Natural Temperate Grasslands above)	Monitoring results provided to national recovery team and to Department of the Environment, Water, Heritage and the Arts as per park management plan  Community in vicinity of grassland reserves and translocated populations is provided with relevant information regarding consequences relating to control of domestic animals

## AUSTRALIAN GRAYLING

Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
To protect and actively manage riparian vegetation along Cardinia Creek to improve vegetation quality and extent	Identify Cardinia Creek and land within the buffer in the revised Casey-Cardinia Growth Area Framework Plan as important for Australian Grayling conservation.  Apply appropriate statutory planning controls (e.g. Environmental Significance Overlay) to land within the buffer area of Cardinia Creek.	Growth Areas Authority  Department of Planning and Community Development	Short term	Covered under existing allocations	Appropriate planning controls in Cardinia Planning Scheme and Casey Planning Scheme by June 2010
	Prepare Conservation Management Plans for precincts that abut Cardinia Creek.	Growth Areas Authority	Short term	Covered under existing allocations	Protection/management measures affording to instream  Australian Grayling habitat and adjacent buffers.
	Precinct Structure Plans are developed to reflect relevant conservation management plan.	Growth Areas Authority	Short term		Protection/management measures affording to instream  Australian Grayling habitat and adjacent buffers.
	Undertake works consistent with the Conservation Management Plans.	Melbourne Water Casey City Council Cardinia Shire Council	Ongoing	Covered under existing allocations	Management consistent with Port Phillip and Westernport Regional River Health Strategy targets
To protect potential habitat for the Australian Grayling through enhanced water management measures	Incorporate best practice urban water management techniques through preparation of Integrated Water Management Plans as specified in the <i>Precinct Structure Planning Guidelines</i> for Precinct Structure Plans and/or equivalent process for transport infrastructure.	Growth Areas Authority Growth area councils Developer	Short term	Covered under existing allocations	Integrated Water Management Plans prepared in accordance with the <i>Precinct Structure Planning Guidelines</i>  All precincts and transport infrastructure included within the Program developed in accordance with best practice urban water management
	Protect Cardinia Creek from potential point source water quality contaminants by adherence to Environment Protection Authority guidelines and procedures.	Growth Areas Authority Growth area councils Developer Environment Protection Authority	Ongoing	Covered under existing allocations	All precincts, transport and other infrastructure included within the Program managed in accordance with published Environment Protection Authority guidelines and remediation procedures

**BUTTON WRINKLEWORT, LARGE-FRUIT GROUNDSEL**

Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
To protect and manage all known populations on public land	Identify Truganina Cemetery grassland and land within the buffer (e.g. 200 m) in revising the Wyndham Growth Area Framework Plan.	Growth Areas Authority	Short term	Covered under existing allocations	Wyndham Growth Area Framework Plan in place by June 2011
	Determine the land management buffer for Truganina Cemetery grassland through precinct structure planning and the preparation of Native Vegetation Precinct Plans.	Growth Areas Authority Growth area council Developer	Short term	Covered under existing allocations	Precinct Structure Plan recognises the significance of Truganina Cemetery grassland
	Renegotiate current Public Authority Management Agreement for Truganina Cemetery to protect grassland and values of threatened species.	Department of Sustainability and Environment	Short term	Covered under existing allocations	Management agreement sets out clear standards for managing grassland values
	Monitor threatened species populations and results of management interventions in Truganina Cemetery, rail reserves (within urban Growth Boundary) and western grassland reserves, adapting management approach as required.	Department of Sustainability and Environment (Truganina Cemetery); Parks Victoria (Western Grassland Reserves)	Ongoing	Covered under existing allocations	Monitoring results provided to Department of the Environment, Water, Heritage and the Arts as agreed under Monitoring and Reporting Framework

Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
To identify and protect where practicable populations on private land and additional populations on public land	Undertake surveys for these species consistent with the Precinct Structure Planning Biodiversity Kit as part of precinct, transport and other development planning.	Growth Areas Authority  Growth area council  Department of Transport / VicRoads  Developer	Short to medium term	Covered under existing allocations	Surveys undertaken in accordance with the Biodiversity Precinct Planning Kit methodology  Surveys undertaken prior to commencement of precinct planning  All data provided to the Department of Sustainability and Environment within three months of submission to the Growth Areas Authority
	Develop a prescription for Large-fruit Groundsel based on its occurrence at the Rockbank site to inform the Growth Area Framework Planning, Precinct Structure Planning and transport planning processes. This prescription will guide mitigation and management decisions for the remainder of the Program including whether to retain the species on site.	Department of Sustainability and Environment	Short term	Covered under existing allocations	Prescription approved by the Commonwealth Minister for Environment
	Develop a prescription for Button Wrinklewort if new populations are located, to inform relevant planning process.	Department of Sustainability and Environment	Short to medium term	Covered under existing allocations	Prescription approved by the Commonwealth Minister for Environment Department of the Environment, Water, Heritage and the Arts

**MAROON LEEK-ORCHID, SWAMP EVERLASTING**

Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
To protect the Maroon Leek-orchid, Swamp Everlasting within the disused railway at Clyde	Investigate establishing the disused railway at Clyde as a potential conservation area through preparing the Biodiversity Conservation Strategy for the south-east and subsequent revised Casey-Cardinia Growth Area Framework Plan.	Department of Sustainability and Environment  Growth Areas Authority	Short term	Covered under existing allocations	Biodiversity Conservation Strategy for south-east reflects values of disused railway line and provided for Commonwealth approval by March 2011
	Prepare Conservation Management Plan for the Clyde railway as part of preparing a Precinct Structure Plan for the area, which provides for the protection, management and monitoring of Maroon Leek-orchid and Swamp Everlasting.	Growth Areas Authority  Casey City Council  Developers	Short to medium term	Covered under existing allocations	Management plan in place prior to commencement of construction  Precinct Structure Plan reflects Conservation Management Plan

LISTED SPECIES WITHOUT CURRENT PRESCRIPTIONS, AND SPECIES AND COMMUNITIES THAT MAY BE LISTED IN THE FUTURE

Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
To provide further data to inform the preparation of Precinct Structure Plans and transport infrastructure and to establish prescriptions for listed species without current prescriptions, and for species and communities that may be listed in the future	Conduct targeted surveys for all species listed in the <i>Strategic Impact Assessment Report</i> for which a prescription has not been prepared, prior to detailed planning and construction of program activities.	Department of Sustainability and Environment	Ongoing	Covered under existing allocations	<p>Surveys undertaken in accordance with Biodiversity Precinct Planning kit standards</p> <p>Surveys undertaken prior to commencement of precinct planning</p> <p>All data provided to the Department of Sustainability and Environment within three months of submission to Growth Areas Authority</p>
	Develop prescriptions for any species likely to be impacted through implementation of the Program.	Department of Sustainability and Environment	Ongoing	Covered under existing allocations	<p>All new prescriptions to be provided to the Commonwealth Minister for Environment for approval prior to their application</p> <p>Approved prescriptions for any species likely to be impacted as a result of the Program must be in place prior to construction</p>

## MIGRATORY SPECIES, WATERWAYS, WETLANDS AND RAMSAR SITES

Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
Protect and reestablish the area of former wetlands adjacent to Casey-Cardinia Growth Area for use as flood and water quality mitigation and biodiversity conservation	Investigate establishing a wetland area in conjunction with the preparation of the Biodiversity Conservation Strategy for the south-east and subsequent revised Casey-Cardinia Growth Area Framework Plan, including identifying the funding and acquisition mechanism.	Growth Areas Authority Melbourne Water	Short term	Funding not secured	Outcome of wetland investigation provided to Department of the Environment, Water, Heritage and the Arts by March 2011
	Prepare Management Plan for the wetlands.	Melbourne Water	Short term	Covered under existing allocations	Management Plan results in a major portion of the area being actively managed for biodiversity conservation, including threatened and migratory species
	Undertake works in accordance with the Management Plan.	Melbourne Water	Medium to long term	Funding not secured	Works undertaken in accordance with management plan
	Monitor threatened and migratory species, management activities and enforce compliance with the Management Plan.		Short to Medium term	Covered under existing allocations	Monitoring results provided to Department of the Environment, Water, Heritage and the Arts as part of 2,4 yearly (initially) then five yearly audit reports or as agreed in Monitoring and Reporting Framework
To manage habitat for migratory species in accordance with the prescriptions approved by the Commonwealth Minister for Environment established for precinct structure planning and infrastructure planning	Identify important wetlands and other habitat areas for migratory species as part of the Biodiversity Conservation Strategies prepared for each growth area.	Growth Areas Authority	Ongoing	Covered under existing allocations	Biodiversity Conservation Strategies identify important wetland areas for retention and management
	Prepare Conservation Management Plans and Biodiversity component of Precinct Structure Plans, including specifying the design and construction of wetland areas (where appropriate) and the management requirements for retained wetlands; incorporate requirements of relevant prescriptions.	Growth Areas Authority Growth area councils Developer	Short to medium term	Covered under existing allocations	Surveys undertaken in accordance with the Biodiversity Precinct Planning Kit  Nationally significant migratory bird sites protected with a 200m buffer as part of Precinct Structure Plan

Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
	Undertake works in accordance with the Conservation Management Plan and conditions of any planning approval.	Growth area councils Developer	Ongoing	Covered under existing allocations	Wetlands within precincts suitably buffered from disturbances (including dogs and actively managed to retain or enhance values)
	Monitor and enforce any land management obligations in accordance with the conditions of planning approval.	Growth area councils	Ongoing	Covered under existing allocations	Breaches reported to Department of Environment, Water, Heritage and the Arts as agreed
To protect significant areas within Ramsar sites and downstream Ramsar sites through enhanced management measures	Incorporate best practice urban water management techniques through preparation of Integrated Water Management Plans as specified in the <i>Precinct Structure Planning Guidelines</i> for Precinct Structure Plans and/or equivalent process for transport infrastructure.	Growth Areas Authority Growth area councils Developer	Short term	Covered under existing allocations	Integrated Water Management Plans prepared in accordance with the <i>Precinct Structure Planning Guidelines</i>  All precincts and transport infrastructure included within the Program developed in accordance with best practice urban water management
	Increase protection measures and monitoring of areas of Port Phillip Bay Ramsar site within 2km of new urban areas.  Undertake control and management of feral and domestic animals to protect wetland sites and wildlife from disturbance.	Parks Victoria	Ongoing	Covered under existing allocations	Process of updating Ramsar management plans incorporates specific measures to protect, monitor and adaptively manage these sites  Dogs and pedestrians effectively excluded at least 200 metres from important shorebird sites (within 2km of urban areas) from December 2010  Communities in vicinity of Ramsar sites and upstream waterways are provided with relevant information regarding consequences relating to control of domestic animals and protection of wildlife
	Monitor and enforce land management obligations in accordance with planning permits.	Growth area councils	Ongoing	Covered under existing allocations	Breaches reported to Department of Environment, Water, Heritage and the Arts as agreed

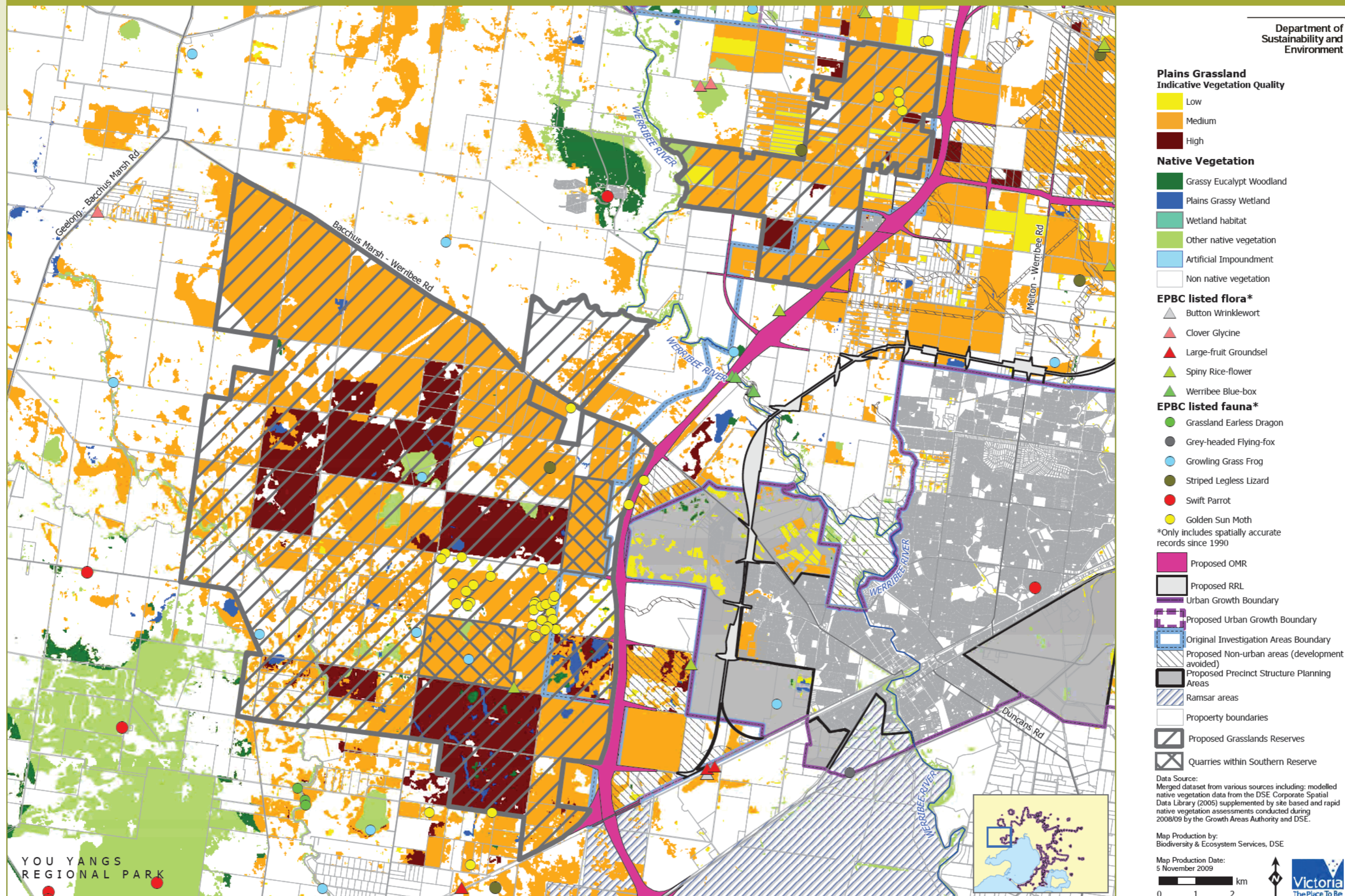


Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
	Monitor water quality entering Ramsar sites and prepare adaptive management response as required.	Independent reporter Environment Protection Authority	Ongoing	Covered under existing allocations	Water entering waterways upstream of Ramsar sites complies with published standards consistent with relevant State Environmental Protection Policy  Remedial management plan to deal with potential water quality breaches prepared for Department of Environment, Water, Heritage and the Arts by 2010  Results of water quality testing, and compliance with proposed conservation outcomes submitted to Department of Environment, Water, Heritage and the Arts as part of independent monitoring and auditing of Program. Remedial action taken as necessary.
	Protect Ramsar sites and upstream waterways from potential point source water quality contaminants by adherence to Environment Protection Authority guidelines and procedures.	Environment Protection Authority Melbourne Water	Ongoing	Covered under existing allocations	All precincts, transport and other infrastructure included within the Program managed in accordance with published Environment Protection Authority guidelines and remediation procedures
To protect Ramsar site and downstream impacts associated with the OMR/E6 Transport Corridor	Provide specific measures for protecting and adaptively managing potential impacts on Ramsar values in the Environment Impact Report prepared for the OMR/E6 and translate these measures into the overarching environmental protection strategy and relevant Environmental Management Plans.	VicRoads		Covered under existing allocations	Mechanism for protecting Ramsar site values included in report to Commonwealth as agreed in Monitoring and Reporting Framework

## HERITAGE

Objective	Action	Responsible Agency	Timing	Resources	Performance Measures
To protect all known sites on the Register of National Estate and to protect sites of Aboriginal cultural heritage	Retain and protect sites of heritage significance through the precinct structure planning process and implement appropriate statutory controls.	Growth Areas Authority Growth area councils Developer	Short to medium term	Covered under existing allocations	All known sites on the Register of the National Estate referenced in relevant local planning schemes with appropriate controls in place by 2010
	Prepare Cultural Heritage Management Plan through the precinct structure planning process.	Growth Areas Authority Growth area councils Developer	Short to medium term	Covered under existing allocations	Cultural Heritage Management Plan in place for precincts
To manage all known sites on the Register of National Estate and to protect sites of Aboriginal cultural heritage	Undertake activities in accordance with the Cultural Heritage Management Plan and Precinct Structure Plan.	Growth area councils Developers	Ongoing	From land manager	To be agreed with the Department of Environment, Water, Heritage and the Arts
	Monitor use and enforce any land management obligations that apply with statutory planning controls and Cultural Heritage Management Plan.	Department of Planning and Community Development	Ongoing	From land manager	To be agreed with the Department of Environment, Water, Heritage and the Arts

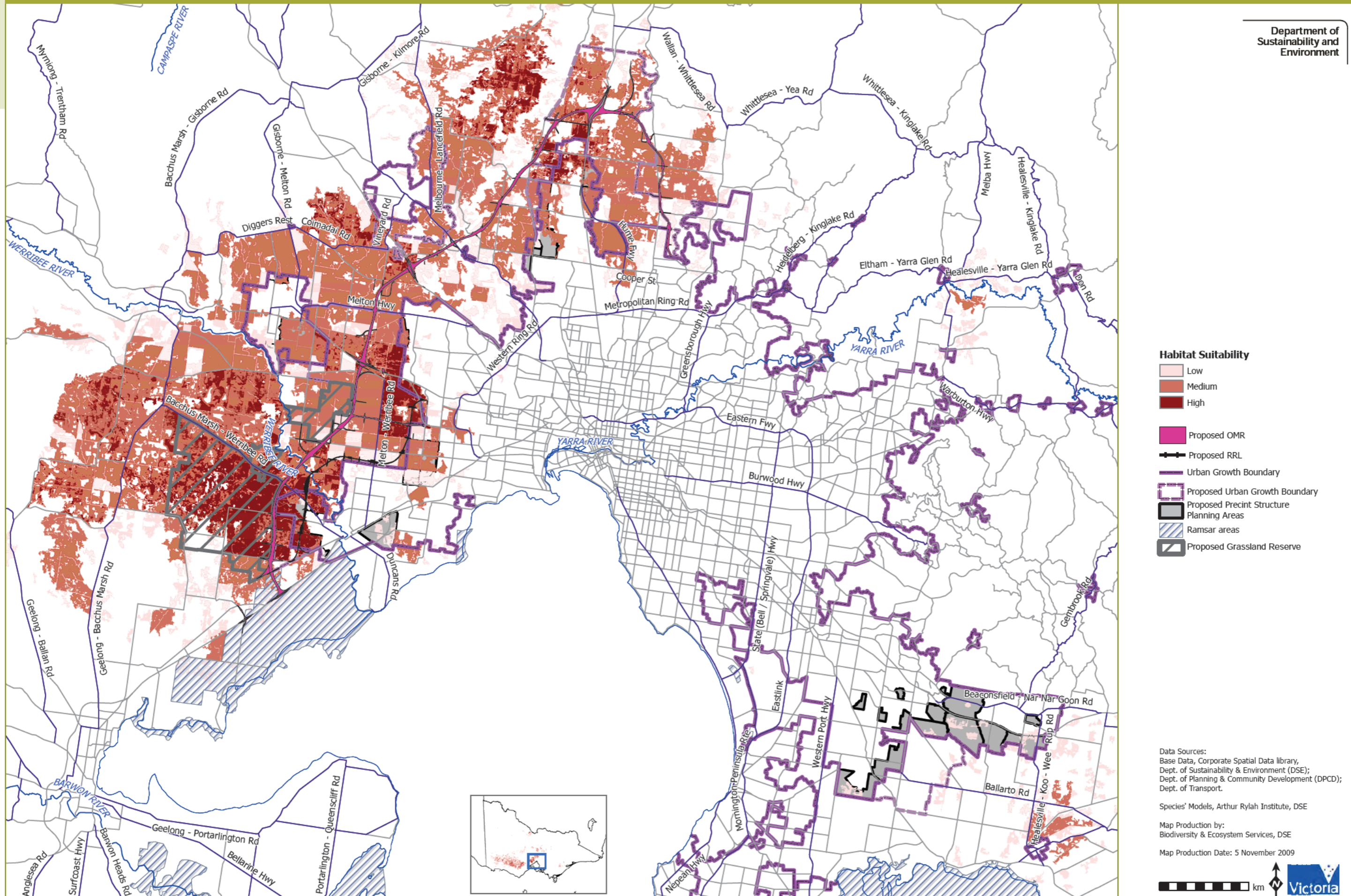
FIGURE 36. PROPOSED WESTERN GRASSLAND RESERVES



YOU YANGS REGIONAL PARK

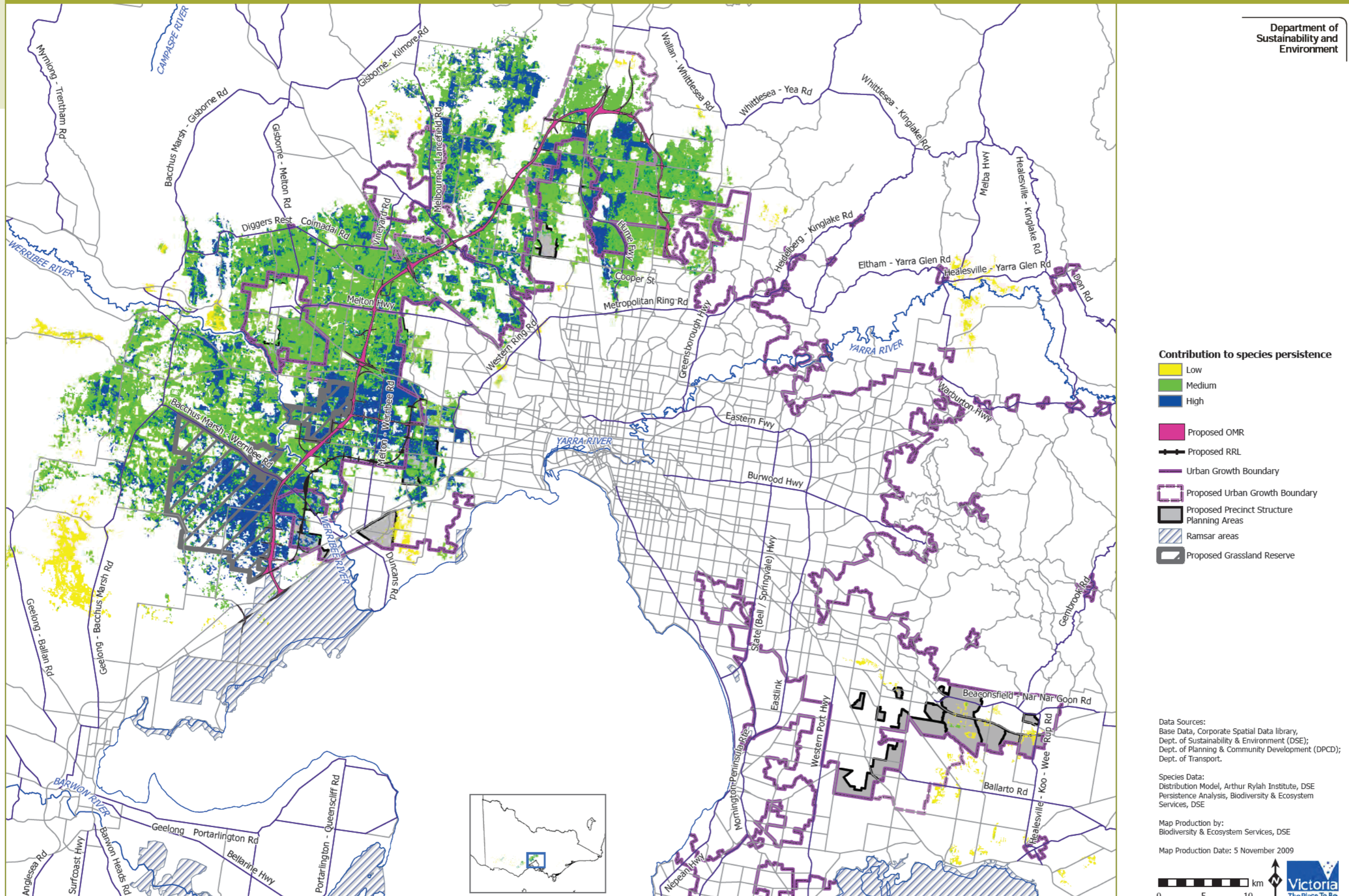
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FIGURE 37. MODELLED HABITAT SUITABILITY FOR STRIPED LEGLESS LIZARD (*Delma impar*)



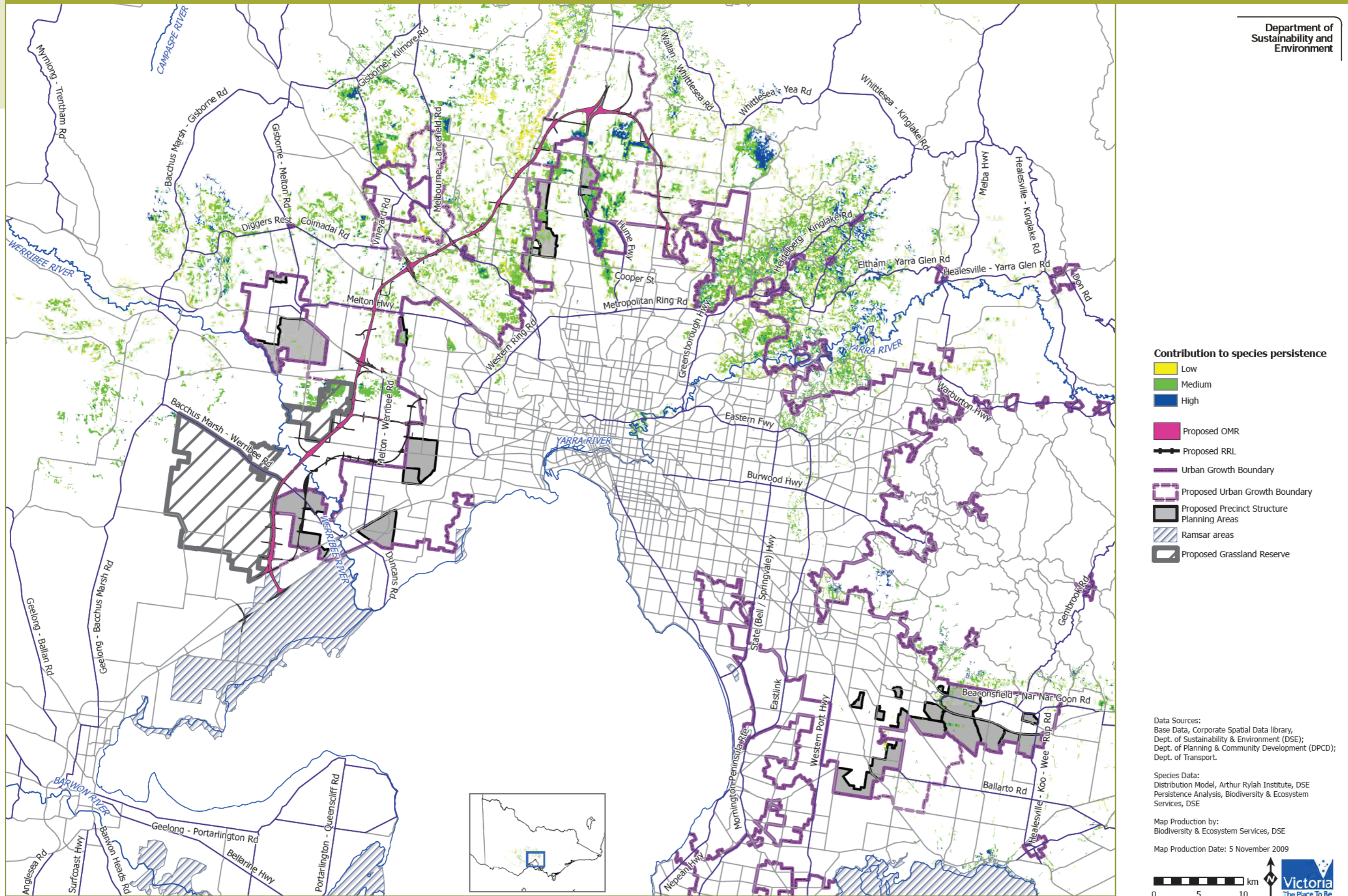
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FIGURE 38. SPECTRUM OF CONTRIBUTION TO SPECIES PERSISTENCE FOR GOLDEN SUN MOTH (*Synemon plana*) HABITAT



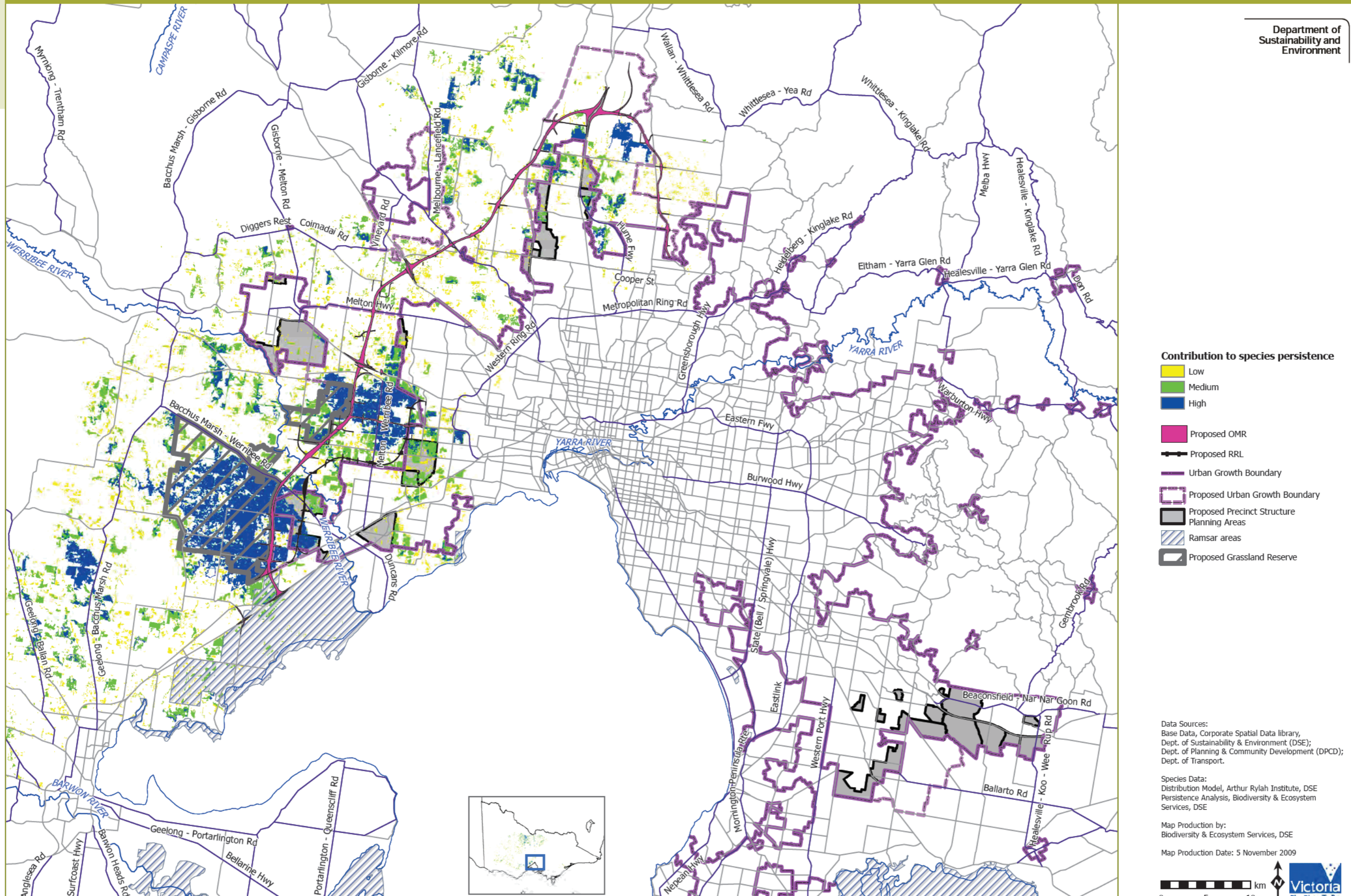
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FIGURE 39. SPECTRUM OF CONTRIBUTION TO SPECIES PERSISTENCE FOR MATTED FLAX-LILY (*Dianella amoena*) HABITAT



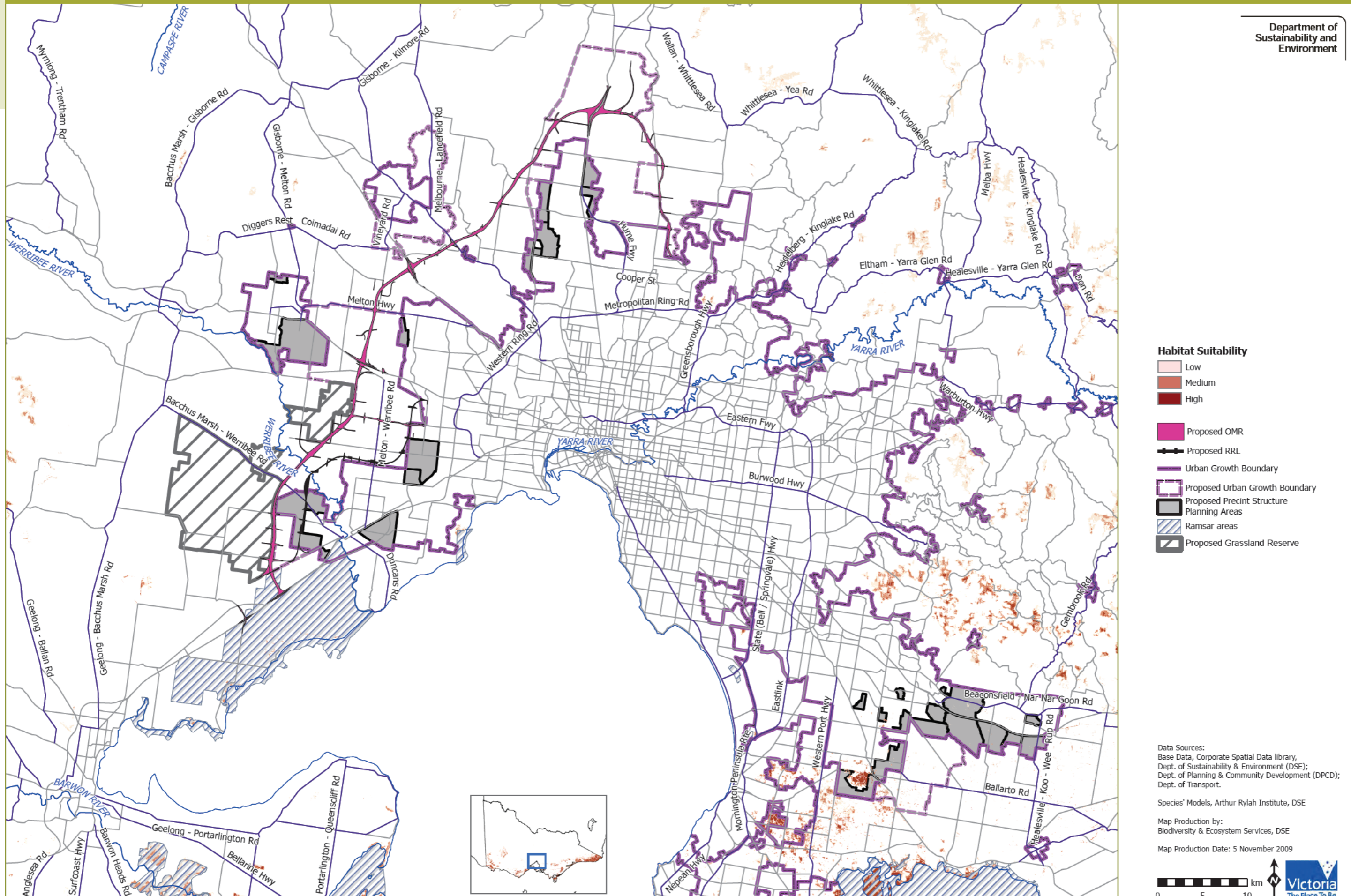
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FIGURE 40. SPECTRUM OF CONTRIBUTION TO SPECIES PERSISTENCE FOR SPINY RICE-FLOWER (*Pimelea spinescens* ssp. *spinescens*) HABITAT



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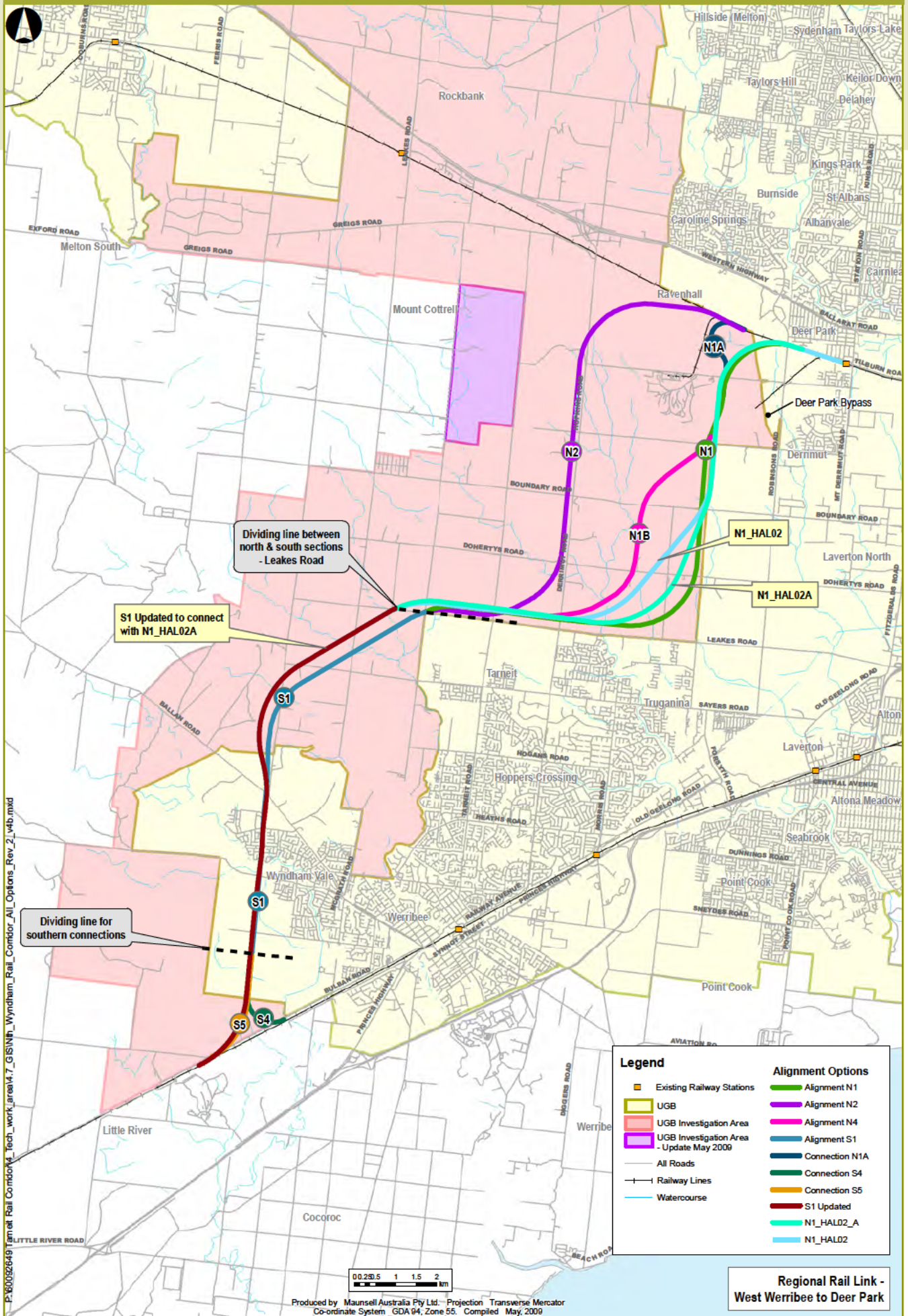
FIGURE 41. MODELLED HABITAT SUITABILITY FOR SOUTHERN BROWN BANDICOOT (*Isodon obesulus obesulus*)



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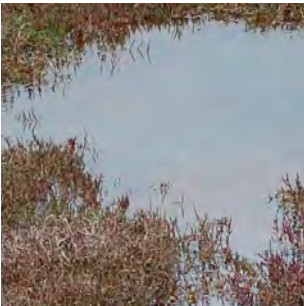


FIGURE 42. ALIGNMENT OPTIONS





# 7 AUDITING, REPORTING AND REVIEW



Three key components need to be monitored to ensure that the prescriptions in this document and other management measures are being followed and to gather information to assess the achievement of stated outcomes. They are:

- > The actual Program and its components and whether any changes become necessary;
- > The areas excluded from or retained within the Urban Growth Boundary for conservation purposes; and
- > The Precinct Structure Planning process, including Native Vegetation Precinct Plans.

An independent auditor will be appointed to assess how well the *Precinct Structure Planning Guidelines* support the protection of matters of national environmental significance under the EPBC Act. Audit reports will be provided to the State and Commonwealth governments every two years. They will also be used to inform the review of the *Precinct Structure Planning Guidelines* which are scheduled to occur every five years.

Key areas retained for conservation purposes, such as the Merri Creek corridor, Grassy Eucalypt Woodland sites and western grassland reserves will be assessed and monitored according to a standard protocol for native vegetation and threatened species being developed by Department of Sustainability and Environment. This monitoring protocol and methodology will be developed to the satisfaction of the Commonwealth.

Responsibility for undertaking this monitoring will rest with Department of Sustainability and Environment for the grassland reserves and public land. The Growth Areas Authority will ensure that monitoring arrangements for retained areas of private land are clarified as an outcome of the Precinct Structure Planning process.

Audit reports on outcomes of vegetation condition and threatened species monitoring will be provided as part of audit reports to the State and Commonwealth governments every five years.

Management plans to be developed for some species, such as the Growling Grass Frog, will set out the monitoring requirements and reporting arrangements.

As outlined in the 'Project purpose and description' it is intended that the objectives of the Program would be implemented through amendments to the Victoria Planning Provisions and the Planning Schemes relevant to the Program.

Clause 12 of the *Victoria Planning Provisions* will contain the main objectives of the Program, which will be implemented through planning scheme amendments to the relevant planning scheme's municipal strategic framework.

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Under the provisions of the P&E Act, planning schemes need to be strategically reviewed regularly: this happens every four to five years, to coincide with the council program. The Minister for Planning oversees the review of planning schemes on this regular basis, which will ensure that the implementation of the Program through municipal strategic statements is monitored and reviewed.

While there is no regular review period imposed on the Victoria Planning Policy, reviews of relevant planning schemes can be used to inform State government policy.

Finally, Victoria will provide an annual report to the Commonwealth on progress of each of the management commitments in Part 3 of the Program report (Section 6.10).

Part 4 of the Program Report sets out the detailed arrangements for monitoring and reporting on all aspects of the Program.

The following section sets out the basic Ideas and proposals In the design of the ecological monitoring and adaptive management regime.

## **MONITORING, REPORTING AND ADAPTIVE MANAGEMENT**

A critical component of the Program will be to track the implementation process and be able to assess and report on the progress and effectiveness of various planning, management and mitigation interventions for achieving required biodiversity outcomes. This will require the design, collection and analysis of baseline and monitoring data that will both be able to quantify progress towards desired outcomes and enable changes in strategy and management over time in response to monitoring data, new information and /or emerging issues.

To achieve this, the Victorian Government will:

1. By 2012, collect relevant species and vegetation data from proposed growth areas to inform sub-regional conservation planning and precinct structure plans that will enable:
  - better assessment of species population viability and habitat quality, and subsequent quantification of the potential impacts of development on species persistence;
  - development of improved methods to mitigate these impacts including improved species offsetting approaches; and
  - design of a satisfactory reserve network within the proposed growth areas (using appropriate software). This will clearly identify areas and their component biodiversity attributes to be retained up to an absolute area limit and will include considerations of functional connectivity to other habitat within and outside the growth areas. It will also identify the required protection and preferred management to achieve desired biodiversity outcomes.

2. By 2012, confirm the presence of EPBC-listed flora and fauna species within various proposed development areas and where applicable arrange for salvaging of individuals or reproductive material for storage, propagation / captive breeding and / or translocation to habitat within in secured reserves in accordance with Commonwealth and Victorian Government-agreed protocols.
3. By 2011, develop a standard monitoring protocol for detecting changes in vegetation and species populations arising from site-based interventions. This protocol will employ quantitative and repeatable measures of the site attributes of interest, ensure that sampling within sites is sufficient to detect changes of interest and ensure adequate plot replication (where relevant) across sites under similar starting conditions and management interventions.
4. Applying the standard protocol, monitor sites subject to management or planning interventions seeking to maintain / improve vegetation quality and species persistence and report to State and Commonwealth Governments on trends over time and the effectiveness of these interventions. This may include monitoring:
  - changes arising from the creation of habitat for species such as Growling Grass Frog;
  - changes from management interventions within existing habitat, such as the Western Grassland Reserve (see below for more detail) and other key areas for retention such as Merri Creek corridor, Clarkes Road Grassland and Truganina Cemetery and any future Grassy Eucalypt Woodland reserves;
  - the effectiveness of management interventions on sites containing populations of key plant species such as Spiny Rice-flower, Matted Flax-lily, Small Golden-moths, Button Wrinklewort and Large-fruit Groundsel.
  - the effectiveness of translocation efforts within reserved areas; and / or
  - the effectiveness of planning overlays and/or compliance activities to reduce the loss and decline of habitat on private and public land outside the formal reserved areas.
5. By 2011, develop a dynamic reserve management planning approach incorporating a spatial decision-support system to inform on-going management within reserved areas that takes account of site characteristics and biodiversity objectives coupled with potential management interventions and their likely impact on all biodiversity in the context of surrounding land use and ecosystem function / dynamics.
6. Applying the principles of adaptive management, periodically incorporate monitoring data (once every three to five years) and new and emerging

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science and information into the reserve management planning approach to inform changes to site management within reserved areas. Required changes to management may arise from a combination of monitoring data analysis (i.e. trends in species populations and / or habitat at a site); new or improved understanding of species distribution, habitat requirements and / or behaviour; development of new management techniques; or identification of a new or emerging threat (e.g. establishment of a newly recorded weed species with a high risk of spread or changed land use in the vicinity of a reserve that may affect species movement).

### **MANAGEMENT OF THE WESTERN GRASSLAND RESERVE – DEVELOPING AND APPLYING A SPATIAL DECISION-SUPPORT TOOL FOR ADAPTIVE MANAGEMENT PURPOSES.**

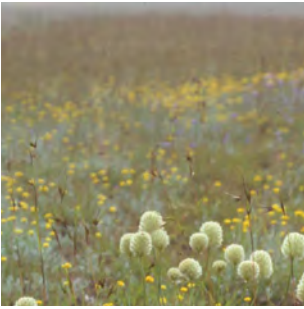
Designing and implementing an adaptive management approach for the Western Grassland Reserves will be critical to achieving desired biodiversity outcomes.

While the general principles of grassland management in south eastern Australia are reasonably well understood, there are very few, if any, known examples of incorporating adaptive management principles into practical spatial decision-support systems to inform on-ground management interventions in the context of broader ecosystem function and dynamics.

Designing a spatially and temporally dynamic decision-support system that connects site based decisions to site and broader ecosystem outcomes will be particularly critical for the Western Grassland Reserve which will:

- > need to meet a range of biodiversity objectives sometimes requiring management interventions that may be in conflict;
- > be progressively established over 10 years and require on-going management thereafter;
- > exist in a mixed tenure landscape with a range of current and future land uses that may positively or negatively impact on biodiversity outcomes within the reserve over time;
- > need to apply management that responds quickly to new information such as monitoring data, emerging science and models, new and emerging threats, and new and emerging management technologies; and
- > need to appropriately incorporate the uncertainties of management interventions on biodiversity objectives into the decision-making process.

## 8 CONCLUSION



As set out in the Terms of Reference, the EPBC Act permits the Commonwealth Minister for the Environment to approve the taking of actions or classes of actions in accordance with an *endorsed* policy, plan or program (section 146(B)). The effect of such a decision is that the approved actions or class of actions would not need further approval from the Minister under the Act.

When deciding whether to endorse a policy, plan, or program the Minister must be satisfied that the assessment report adequately addresses the impacts to which the agreement relates and that any recommendations to modify the policy, plan or program have been responded to appropriately.

In determining whether or not to endorse the Program, the Minister will have regard to the extent to which the Program meets the objectives of the EPBC Act. In particular, the Minister will seek to be satisfied that it:

- > Protects the environment, especially matters of national environmental significance;
- > Promotes ecologically sustainable development;
- > Promotes the conservation of biodiversity; and
- > Provides for the protection and conservation of heritage.

The Department of Sustainability and Environment believes that the Program meets each of these objectives, because the Program and Final Report should:

- > Prevent actions that have an impact on matters of national environmental significance from being taken in any location of high biodiversity or heritage value; or where impacts can not be avoided, then the Program will involve impacts that are less than significant;
- > Provide for effective management, mitigation or offset of the likely impacts; and
- > Contain an effective system of adaptive management that is independently audited and publicly reported.

The Department of Sustainability and Environment does not believe that the Program will impact on heritage matters. Wherever possible the Program has avoided impacts on important biodiversity matters. Where impacts are likely and these are significant at a site (or assumed to be significant) a range of mitigation measures will be undertaken to reduce impacts below a significant level and, in some cases, provide a net positive impact on the species or the asset. Management commitments are clearly spelled out and provide for adaptive management responses. Independent auditing and review is also provided.

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The Commonwealth Minister for the Environment will also consider the extent to which the Program and its associated Final Report adequately incorporates:

- > The precautionary principle;
- > Other principles of ecologically sustainable development;
- > Intergenerational equity; and
- > Matters the Minister considers to have a high likelihood of being potentially eligible for listing as matters of national environmental significance.

The Department of Sustainability and Environment believes that the Program and its related mitigation measures have taken these principles into account. The measures take a long term view and the precautionary principle is built into the assessment of potential impacts. Where relevant, a worse-case scenario has been considered. Several matters that are not yet listed under the EPBC Act have been included in this assessment.

In arriving at a decision to approve an action or a class of actions the Commonwealth Minister for the Environment must act in accordance with his obligations, including giving consideration to:

- > Issues relevant to any matter protected by a provision of the Act; and
- > Social and economic matters.

## **REASONABLE ASSURANCE**

Victoria has a comprehensive legislative and policy framework to manage land use and environmental impacts within Victoria. Part 2 of the Program Report outlines how the legislative processes, policies and guidance will be used to implement the Program; and how these processes will be used to ensure that actions affecting matters of national environmental significance that result from the Program will be managed through these processes.



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# 10 APPENDICES

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# APPENDIX 1: STRATEGIC IMPACT ASSESSMENT: VEGETATION LOSSES AND GAINS FROM THE PROPOSED PROGRAM AND GAINS GENERATED FROM THE WESTERN GRASSLAND RESERVES

**Note:** Due to ‘rounding’, figures that appear in the following tables may differ slightly from those that appear in the text.

## OVERALL VEGETATION LOSSES AND GAINS

### GAINS FROM PROPOSED GRASSLANDS RESERVES

Vegetation	Area (ha) by Habitat Score			Total Area (ha)	Gain (Habitat Hectares)
	Low 0.01 - 0.30	Medium 0.31 - 0.60	High 0.61 - 1		
Grassy Eucalypt Woodland	1	21	19	41	13.3
Natural Temperate Grassland	108	7,375	2,609	10,091	4,145.4
Plains Grassy Wetland	9	132	1	142	58.3
Other native vegetation	2	222	21	245	Not calculated
No native vegetation	0	0	0	3,886	Not calculated
<b>Totals</b>	<b>120</b>	<b>7,750</b>	<b>2,650</b>	<b>14,405</b>	<b>4,217</b>

\*Based on determination of Conservation Significance using Ecological Vegetation Class x Habitat Score only as per Victoria’s Native Vegetation Framework (and does not include requirements for threatened species habitat) – see Determining offset requirements for vegetation and threatened species in Section 6.1.4.

### LOSSES FROM DEVELOPMENT

Vegetation	Area (ha) by Habitat Score				Total Area (ha)	Habitat Hectares	Offset Target
	No Native Vegetation 0	Low 0.01 - 0.30	Medium 0.31 - 0.60	High 0.61 - 1			
Grassy Eucalypt Woodland		466	242		708	188	300
Natural Temperate Grassland		897	3,696	72	4,665	1,921	3,599
Plains Grassy Wetland		6	69		75	30	58
Other native vegetation		549	489	2	1,040	315	480
No native vegetation	40,167				10,167	0	0
<b>Grand Total</b>	<b>40,167</b>	<b>1,918</b>	<b>4,496</b>	<b>74</b>	<b>46,654</b>	<b>2,454</b>	<b>4,437</b>

## LOSSES FROM URBAN DEVELOPMENT BY INVESTIGATION AREA

### LOSSES WITHIN PROPOSED EXTENSION TO THE URBAN GROWTH BOUNDARY

Investigation Area	Vegetation	Area (ha) by Habitat Score				Total Area (ha)	Habitat Hectares	Offset Target
		No Native Vegetation 0	Low 0.01 - 0.30	Medium 0.31 - 0.60	High 0.61 - 1			
Melbourne North (excluding Sunbury)	Grassy Eucalypt Woodland		232	62		294	69	107
	Natural Temperate Grassland		167	145	0	313	108	180
	Plains Grassy Wetland		0	2		2	1	1
	Other native vegetation		21	28		49	16	27
	No native vegetation	8,680				8,680	0	0
<b>Melbourne North (excluding Sunbury) Total</b>		<b>8,680</b>	<b>421</b>	<b>237</b>	<b>0</b>	<b>9,338</b>	<b>194</b>	<b>315</b>
Melbourne North (Sunbury)	Grassy Eucalypt Woodland		60	85		144	47	79
	Natural Temperate Grassland		10	19		30	10	17
	Plains Grassy Wetland			1		1	0	1
	Other native vegetation		3	2		5	2	2
	No native vegetation	2,748				2,748	0	0
<b>Melbourne North (Sunbury) Total</b>		<b>2,748</b>	<b>73</b>	<b>107</b>		<b>2,928</b>	<b>59</b>	<b>99</b>
Melbourne South-East	Other native vegetation		214	115		329	91	133
	No native vegetation	3,597				3,597	0	0
<b>Melbourne South-East Total</b>		<b>3,597</b>	<b>214</b>	<b>115</b>		<b>3,926</b>	<b>91</b>	<b>133</b>
Melbourne West	Grassy Eucalypt Woodland		9	1		11	2	3
	Natural Temperate Grassland		430	2,464	41	2,935	1,236	2,344
	Plains Grassy Wetland		0	61		62	26	50
	Other native vegetation		18	34		51	16	25
	No native vegetation	8,539				8539	0	0
<b>Melbourne West Total</b>		<b>8,539</b>	<b>457</b>	<b>2,560</b>	<b>41</b>	<b>11,598</b>	<b>1,280</b>	<b>2,423</b>
<b>Grand Total</b>		<b>23,565</b>	<b>1,165</b>	<b>3,019</b>	<b>41</b>	<b>27,790</b>	<b>1,624</b>	<b>2,969</b>

**LOSSES WITHIN CURRENT URBAN GROWTH BOUNDARY (PROPOSED PRECINCT STRUCTURE PLANNING AREAS)**

Investigation Area	Vegetation	Area (ha) by Habitat Score				Total Area (ha)	Habitat Hectares	Offset Target
		No Native Vegetation 0	Low 0.01 - 0.30	Medium 0.31 - 0.60	High 0.61 - 1			
Melbourne North	Grassy Eucalypt Woodland		71	50		121	34	53
	Natural Temperate Grassland		2	75	0	77	37	72
	Other native vegetation		37	41		78	25	40
	No native vegetation	1,864				1,864	0	0
<b>Melbourne North Total</b>		<b>1,864</b>	<b>111</b>	<b>166</b>	<b>0</b>	<b>2,140</b>	<b>95</b>	<b>166</b>
Melbourne South-East	Other native vegetation		216	203	2	421	132	199
	No native vegetation	6,118				6,118	0	0
<b>Melbourne South-East Total</b>		<b>6,118</b>	<b>216</b>	<b>203</b>	<b>2</b>	<b>6,539</b>	<b>132</b>	<b>199</b>
Melbourne West	Grassy Eucalypt Woodland		13	1		14	3	4
	Natural Temperate Grassland		230	461	0	692	253	458
	Plains Grassy Wetland		5	1		5	1	2
	Other native vegetation		35	50		85	26	41
	No native vegetation	6,106				6,106	0	0
<b>Melbourne West Total</b>		<b>6,106</b>	<b>283</b>	<b>512</b>	<b>0</b>	<b>6,902</b>	<b>283</b>	<b>506</b>
<b>Grand Total</b>		<b>14,088</b>	<b>610</b>	<b>881</b>	<b>2</b>	<b>15,581</b>	<b>510</b>	<b>870</b>

## LOSSES WITHIN TRANSPORT CORRIDORS

Footprint	Vegetation	Area (ha) by Habitat Score				Total Area (ha)	Habitat Hectares	Offset Target
		No Native Vegetation 0	Low 0.01 - 0.30	Medium 0.31 - 0.60	High 0.61 - 1			
<b>E6</b>	Grassy Eucalypt Woodland		71	11		83	18	28
	Natural Temperate Grassland		1	3		5	2	3
	Other native vegetation		1	1		2	0	1
	No native vegetation	456				456	0	0
<b>E6 Total</b>		<b>456</b>	<b>73</b>	<b>16</b>		<b>545</b>	<b>20</b>	<b>32</b>
<b>OMR</b>	Grassy Eucalypt Woodland		9	33		42	15	26
	Natural Temperate Grassland		35	457	27	520	239	459
	Plains Grassy Wetland		1	3		3	1	3
	Other native vegetation		4	15		19	7	11
	No native vegetation	1,767				1,767	0	0
<b>OMR Total</b>		<b>1,767</b>	<b>49</b>	<b>508</b>	<b>27</b>	<b>2,351</b>	<b>262</b>	<b>498</b>
<b>RRL</b>	Natural Temperate Grassland		20	71	4	95	37	65
	Plains Grassy Wetland			1		1	0	1
	Other native vegetation			0		0	0	0
	No native vegetation	281				281	0	0
<b>RRL Total</b>		<b>281</b>	<b>20</b>	<b>72</b>	<b>4</b>	<b>377</b>	<b>38</b>	<b>67</b>
<b>Grand Total</b>		<b>2,504</b>	<b>143</b>	<b>596</b>	<b>31</b>	<b>3,273</b>	<b>320</b>	<b>597</b>

OMR – Outer Metropolitan Ring Transport Corridor  
RRL – Regional Rail Link

## VEGETATION RETAINED WITHIN NEW URBAN GROWTH BOUNDARY (EXCLUDED FROM URBAN DEVELOPMENT)

Note. These figures exclude any vegetation likely to be removed within existing quarries.

### OVERALL VEGETATION

Vegetation	Area (ha) by Habitat Score				Total Area (ha)	Habitat Hectares
	No Native Vegetation 0	Low 0.01 - 0.30	Medium 0.31 - 0.60	High 0.61 - 1		
Grassy Eucalypt Woodland		527	316	1	843	232
Natural Temperate Grassland		306	2,211	158	2,674	1,237
Plains Grassy Wetland		0	16		16	7
Other native vegetation		221	500	19	740	274
No native vegetation	9,916				9,916	0
<b>Grand Total</b>	<b>9,916</b>	<b>1,054</b>	<b>3,042</b>	<b>177</b>	<b>14,190</b>	<b>1,750</b>



## VEGETATION BY INVESTIGATION AREA AND CONSTRAINT TYPE

Notes: Type denotes proposed zoning of land as described in the Program Report.

Farming Zone in this case includes quarry buffers, utility easements and other areas of constrained land with few biodiversity values  
Rural Conservation Zone = private land protected due to its biodiversity (or other) values. All land denoted RCZ will also have an Environmental Significance Overlay applied.

Public Conservation Resource Zone = secure conservation reserves

Public Use Zone 7 = proposed parkland (conservation and recreation)

Other parks = open space not necessarily with or for biodiversity conservation (e.g. sports fields).

Investigation Area	Type	Vegetation	Area (ha) by Habitat Score				Total Area (ha)	Habitat Hectares
			No Native Vegetation 0	Low 0.01 - 0.30	Medium 0.31 - 0.60	High 0.61 - 1		
Melbourne North (excluding Sunbury)	Farming Zone	Grassy Eucalypt Woodland		112	77		189	56
		Natural Temperate Grassland		17	110	0	128	49
		Plains Grassy Wetland		0	5		5	2
		Other native vegetation		2	21	0	23	10
		No native vegetation	1,683				1,683	0
	Existing Quarry	Grassy Eucalypt Woodland		32	27		59	16
		Natural Temperate Grassland		18	40		59	20
		Other native vegetation		1	11	2	14	7
		No native vegetation	571				571	0
	Rural Conservation Zone	Grassy Eucalypt Woodland		305	139	1	444	115
		Natural Temperate Grassland		152	203	1	357	116
		Plains Grassy Wetland			0		0	0
		Other native vegetation		10	55	0	65	28
		No native vegetation	2,119				2,119	0
	Public Conservation Resource Zone	Grassy Eucalypt Woodland		1	4		6	2
		Natural Temperate Grassland		0	165	2	168	88
		Other native vegetation		1	57	11	69	37
		No native vegetation	125				125	0
	Urban Floodway Zone	Grassy Eucalypt Woodland		1	1		2	1
		Natural Temperate Grassland			0		0	0
		Other native vegetation		3	15	0	17	7
		No native vegetation	390				390	0
	Other parks	Grassy Eucalypt Woodland		1	1		2	1
		Other native vegetation			1		1	0
No native vegetation		19				19	0	
<b>Melbourne North (excluding Sunbury) Total</b>			<b>4,906</b>	<b>655</b>	<b>933</b>	<b>19</b>	<b>6,513</b>	<b>555</b>

Investigation Area	Type	Vegetation	Area (ha) by Habitat Score				Total Area (ha)	Habitat Hectares	
			No Native Vegetation 0	Low 0.01 - 0.30	Medium 0.31 - 0.60	High 0.61 - 1			
Melbourne North (Sunbury)	Farming Zone	Grassy Eucalypt Woodland		2	1		3	1	
		Natural Temperate Grassland			1		1	0	
		No native vegetation	150				150	0	
	Existing Quarry	Grassy Eucalypt Woodland			3	7		10	3
		Other native vegetation			1	9		10	4
		No native vegetation	243				243	0	
	Rural Conservation Zone	Grassy Eucalypt Woodland			67	53		121	35
		Natural Temperate Grassland			0	4		4	1
		Other native vegetation			18	36		54	18
		No native vegetation	1,007				1,007	0	
	Public Conservation Resource Zone	Grassy Eucalypt Woodland			1	2		3	1
		Natural Temperate Grassland			0	0		1	0
		Other native vegetation			3	16		19	7
		No native vegetation	74				74	0	
	Urban Floodway Zone	Grassy Eucalypt Woodland			1	2		3	1
		Natural Temperate Grassland			0	1		2	1
		Other native vegetation			1	1		1	0
	Other parks	No native vegetation	72				72	0	
No native vegetation		9				9	0		
<b>Melbourne North (Sunbury) Total</b>			<b>1,556</b>	<b>97</b>	<b>133</b>		<b>1,786</b>	<b>72</b>	
Melbourne South-East	Farming Zone	Other native vegetation		29	147		176	65	
		No native vegetation	406				406	0	
	Quarry	Other native vegetation			2	41		43	17
		No native vegetation	61				61	0	
	Rural Conservation Zone	Other native vegetation			17	7		24	6
		No native vegetation	17				17	0	
	Public Conservation Resource Zone	Other native vegetation			0	2		2	1
		No native vegetation	0				0	0	
	Urban Floodway Zone	Other native vegetation			78	11		89	24
		No native vegetation	175				175	0	
Other parks	Other native vegetation				0		0	0	
	No native vegetation	17				17	0		
<b>Melbourne South-East Total</b>			<b>675</b>	<b>126</b>	<b>208</b>		<b>1,009</b>	<b>112</b>	

Investigation Area	Type	Vegetation	Area (ha) by Habitat Score				Total Area (ha)	Habitat Hectares
			No Native Vegetation 0	Low 0.01 - 0.30	Medium 0.31 - 0.60	High 0.61 - 1		
Melbourne West	Farming Zone	Grassy Eucalypt Woodland		0			0	0
		Natural Temperate Grassland		57	284	30	371	159
		Other native vegetation		2			2	0
		No native vegetation	625				625	0
	Existing Quarry	Natural Temperate Grassland		3	714	6	724	406
		Plains Grassy Wetland			4		4	2
		No native vegetation	548				548	0
	Rural Conservation Zone	Grassy Eucalypt Woodland		0	0		0	0
		Natural Temperate Grassland		32	555	56	642	291
		Plains Grassy Wetland			4		4	2
		Other native vegetation		52	67	4	124	42
		No native vegetation	920				920	0
	Urban Floodway Zone	Grassy Eucalypt Woodland		1			1	0
		Natural Temperate Grassland		22	96		118	46
		Plains Grassy Wetland		0	4		4	1
		Other native vegetation		1	3	0	4	1
		No native vegetation	632				632	0
	Other parks	Natural Temperate Grassland		3	1		5	1
		Other native vegetation		2	1		3	1
		No native vegetation	28				28	0
	Public Use Zone 7	Natural Temperate Grassland		0	33	62	95	57
		No native vegetation	21				21	0
	<b>Melbourne West Total</b>			<b>2,775</b>	<b>176</b>	<b>1,766</b>	<b>158</b>	<b>4,874</b>
<b>Grand Total</b>			<b>9,911</b>	<b>1,054</b>	<b>3,040</b>	<b>177</b>	<b>14,182</b>	<b>1,749</b>

## APPENDIX 2: SPECIES DISTRIBUTION MODELLING: OVERVIEW OF METHODOLOGY AND ASSUMPTIONS

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### INTRODUCTION

Species distribution modelling (SDM) has become a fundamental tool for ecological and biogeographical research and an increasingly important tool for biodiversity management and conservation. Species distribution models are used to predict the geographic range of a species from occurrence (presence; or presence/absence) records for particular taxa (dependent variable) and relevant environmental data (independent variables) recorded from the same sites. Two types of model output are common: binary results where sites are classified as either part of the distribution of the species or outside their distribution; and continuous results where sites are given a ‘probability’ of being part of a species’ distribution. Species distribution modelling is essentially a binary classification problem with two training classes, presence and absence.

The species modelling framework that has been adopted by Department of Sustainability and Environment is the consequence of extensive trialling and evaluation of many current SDM modelling methods/algorithms, training data selection methods and pseudo-absence generation, selection and allocation methods.

### METHODS

#### EXEMPLARS – TEST AND TRAINING DATA

Two species modelling processes were developed – one to train models with reliable presence and absence data and another to train models for which there is only reliable presence data. The former was used to build models from vetted data from the Victorian Flora Information System – a database of largely vascular plant records and the latter process was employed to build models from vetted data extracted from the Victorian Wildlife Atlas – a database of vertebrate animal records. Where there are sufficient records of a species models are routinely built with a training dataset of 70 per cent of both presence and absence (or pseudo-absences – see below) records and the remaining data is used to test model accuracy.

#### PLANT SPECIES

Real data – both presence and absence – were used to build vascular plant SDMs. Plant species distribution data were extracted from the Victorian Department of Sustainability and Environment’s vegetation and plant species database – the Flora Information System (FIS). The FIS is a large repository of both:

1. Vegetation sample plots or quadrats that have been collected from across the Australian State of Victoria – an area of approximately 22 million hectares. These samples have been collected by some 100’s of botanically competent field workers over the last 30 years in both a systematic and ad-hoc fashion. “Homogeneous” areas of vegetation were sampled employing a range of

quadrat sizes depending on the plant community being sampled. Quadrat sizes varied in accordance with the concept of minimal area. Generally quadrats in grassland and shrublands are 100m<sup>2</sup> in size and quadrats in mallee, forest and woodland are typically 900m<sup>2</sup> in size. All vascular plants growing in or extending over the sample space were recorded as present. Species absence from the quadrat site may be inferred for prominent perennial plant species, from their lack of detection; and

2. Additional 'incidental' observations of plant species with or without a voucher lodged at the National Herbarium of Victoria.

The following modelling protocols have been adopted for all vascular plants following a detailed investigation of the response of model accuracy to prevalence (the ratio of presence records to absence records):

- > If the number of presence records for a particular species is >10 but ≤100 the number of absence records randomly selected was five times the number presence records.
- > If the number of presence records for a particular species is >100 but ≤200 the number of absence records randomly selected was four times the number presence records.
- > If the number of presence records for a particular species is >200 but ≤500 the number of absence records randomly selected was three times the number presence records.
- > If the number of presence records for a particular species is >500 but ≤1000 the number of absence records randomly selected was two times the number presence records.
- > If the number of presence records for a particular species is >1000 the number of absence records randomly selected was equal to the number presence records.

Two plant species listed under the EPBC Act were selected for analysis.

1. Matted Flax-lily *Dianella amoena*
2. Spiny Rice-flower *Pimelea spinescens* subsp. *spinescens*

## FAUNA SPECIES

Real and pseudo-absence data were used to build fauna SDMs. Animal distribution data were extracted from the Victorian Department of Sustainability and Environment's fauna species database – the Victorian Fauna Display (VFD). The VFD is a large repository of site records for fauna species. Records have been collected from across

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the Australian State of Victoria and in some cases adjacent areas of neighbouring states. These samples have been collected by some 1000's of scientists and naturalists over many years using a range of survey techniques although most contributions used for modelling are from the last 50 years.

Training fauna SDMs using site observations is different to modelling vascular plant data using site inventories as a consequence of universal but species specific detection uncertainties for most if not all animals (vertebrates and invertebrates). As such constructing binary models for fauna species rather than distance measures for presence only models for fauna involved the derivation of 'pseudo-absence' records. Exhaustive testing was carried out on representative animal taxa to establish robust techniques for allocating pseudo-absences across the State. A one-class Mahalanobis distance method (MD) was used to exclude the allocation of pseudo-absences from sites environmentally similar to the presence sites. Outside this MDS defined envelope (thresholded to contain 90 per cent of presence sites), 50 per cent of the pseudo-absences were randomly allocated to urban areas and 50 per cent of pseudo-absences were randomly allocated to the remainder of the State of Victoria. The following modelling protocols have been adopted for all vertebrates following a detailed investigation of the response of model accuracy to prevalence (the ratio of presence records to pseudo-absences):

- > If the number of presence records for a particular species is >20 but ≤100, the number of random pseudo-absence records generated was 3 times the number presence records.
- > If the number of presence records for a particular species is >100, the number of random pseudo-absence records generated was 5 times the number presence records.

## SITE DATA VETTING AND ENVIRONMENTAL VARIABLES USED

All data used for modelling is from a single extraction of point data from the VFD and the Victorian FIS from early 2009. The geographic co-ordinates of all sites used in the modelling is known with some certainty (reported spatial error is +/- 100 m) and as such, many environmental (climatic, radiometric, topographic) and spectral variables from the same locations have been extracted from a 'stack' of data themes stored in a Geographic Information System (see Appendix 1). Principal Components Analysis was used to transform the number of correlated variables into a smaller number of uncorrelated variables called principal components. Six Principal Components were extracted from the combined climate, radiometric and terrain variables and a further four Principal Components were extracted from the combined vegetation models and satellite imagery.

Five animal species listed under the EPBC Act were selected for analysis.

1. Growling Grass Frog *Litoria raniformis*
2. Plains-wanderer *Pedionomus torquatus*
3. Southern Brown Bandicoot *Isodon obesulus obesulus*
4. Striped Legless Lizard *Delmar impar*
5. Golden Sun-moth *Synemon plana*

## MODELLING

The MD method (Clark et al. 1993) was used to assist in the allocation of pseudo-absences for the fauna models. MD uses an algorithm to define the ecological niche of a species on the basis of site records and coincident ancillary environmental data. MD ranks all potential sites (characterised by the same environmental variables) by their Mahalanobis distance from a vector that is the expression of the mean environmental conditions at the sites where the species was recorded (Tsoar et al. 2007). It is a particularly useful method to quantitatively determine the difference between sites with known attributes and sites with unknown attributes using covariate data. It is a widely employed statistical tool in ecology and remote sensing, particularly for classification, similarity analyses and species modelling particularly where presence only data is available (Townsend Peterson et al. 2003). The usefulness of modelling of this nature is related to the degree to which sample records (from herbaria, museums and other curated Government datasets) reflect the environmental 'preferences' of the species concerned. MD establishes a signature state by interrogating the environmental values (predictor variables) at the location of each site record. Mahalanobis distances were based on the mean and variance of these predictor variables and the covariant mix of all the variables and therefore take advantage of the covariance among variables. The region of constant Mahalanobis distance around the mean forms a hyper-ellipsoid in a multi-dimensional space commensurate with the number of predictor variables. Mahalanobis distance is calculated as:

$$D^2 = (x-m)^T C^{-1} (x-m)$$

Where:

D<sup>2</sup> = Mahalanobis distance

x = vector of data

m = vector of the mean values of independent (or predictor) variables

C<sup>-1</sup> = the inverse covariance matrix of independent variables

T = transposition of the vector

Random Forest (RF) was used to create SDMs. RF is a new ensemble technique in data mining. It was designed to produce accurate predictions while limiting overfitting of the data (Breiman 2001). In RF, bootstrap samples are drawn to construct multiple trees, each tree is grown with a randomized subset of predictors, a large number of

trees (500 to 2000) are grown, the trees are grown to maximum size without pruning, and aggregation is produced by averaging the trees (Prasad, Iverson & Liaw 2006). The R Package randomForest (version 4.5–22) was used to build the model in this study, which was developed by Andy Liaw and Matthew Wiener, based on original Fortran code written by Leo Breiman and Adele Cutler. Exploratory analysis shows that the default values for the parameters worked well for our problems. That is, 500 trees were grown in each forest (i.e. model) and 3 (the closest integer to the square root of 10 – the number of independent variables used) environmental variables were randomly chosen at each node to split. But we used different weights for the two classes —  $n_1$  for absence and  $n_0$  for presence — to make the total weight balanced for the two classes, where  $n_0$  and  $n_1$  are the number of training sites for the two classes: absence and presence, although exploratory analysis shows that this parameter does not matter much.

When the best SDM is applied to the stack of the relevant environmental variables the result is a map or surface that reflects the probability that a given pixel is part of the respective species' distribution. Models were thresholded to produce a binary view such that at least 95 per cent of the presence records were included within the resulting environmental envelope. While the resultant maps are useful great care must be taken when using these maps for planning purposes. Models reflect – often in perverse ways – the vagaries and biases in the input or site data. By and large these data are dated, spatially crude and highly biased.

## POST PROCESSING

As the models are a general view of habitat suitability on a pixel by pixel basis, one cannot interpret the results in terms of species persistence. This requires detailed knowledge of a range of species specific parameter distributions – for example carrying capacity of sites, dispersal capacity, fecundity, susceptibility to (genetic, epidemiological, natural) catastrophes and the interplay of these.

In the absence of these data the Department of Sustainability and Environment has taken several of the EPBC listed species:

- > Growling Grass Frog *Litoria raniformis*
- > Plains-wanderer *Pedionomus torquatus*
- > Southern Brown Bandicoot *Isodon obesulus obesulus*
- > Striped Legless Lizard *Delmar impar*
- > Golden Sun-moth *Synemon plana*
- > Matted Flax-lily *Dianella amoena*
- > Spiny Rice-flower *Pimelea spinescens* subsp. *spinescens*



and has sought to further process the models to further (albeit) discriminate sites in terms of their temporal and spatial context.

## **INDIVIDUAL SPECIES ASSUMPTIONS**

This section briefly summarises the known or estimated parameters relevant to spatial and temporal population dynamics for each of the seven species selected.

### **STRIPED LEGLESS LIZARD *Delmar impar***

The habitat for this species is primarily grasslands and open woodlands – it shelters in tussocks, under rocks, soil cracks and in the burrows of other small animals (Smith & Roberson 1999).

Home range requirements of Striped Legless Lizard: conservatively 0.5ha per animal (Smith and Robertson 1999) based on movement estimates determined by Kutt (1993) (overlap of home range between sexes not described).

Dispersal: Reluctant to cross open areas without grass tussock cover (Dorrough 1995). Assume sealed road is a more or less absolute barrier to Striped Legless Lizard dispersal in the medium term. Obviously water and urban fabric is a barrier. Have also assumed that regions excluded from the thresholded model are unsuitable for dispersal.

### **PLAINS-WANDERER *Pedionomus torquatus***

The habitat for Plains-wanderer is primarily grasslands sparse, lowland native grasslands from which they obtain all of their annual life cycle needs from (Baker-Gabb 1988). Plains-wanderer has been rarely seen in the Melbourne region in recent decades. However, it is widely accepted that grassland habitat for Plains-wanderer can be maintained and in many cases improved with site management – usually via stock exclusion in drought and strict grazing control in wet years to maintain suitable grassland structure (NSW NPWS 2002).

Range of population densities encountered approximately 18ha shared per pair (Baker-Gabb *et al.* 1990).

Birds are rarely found within 200m of woodland or tree areas – presumably due to predation (NSW NPWS 2002).

Birds can fly long distances – but this is rarely recorded – tends to be sedentary. As such, connectivity does not equate to physical contiguity of habitat except for areas less than 20ha (notional minimal breeding habitat area). Small areas of habitat proximal to larger regions may be useful as temporary foraging or resting areas.

Foxes are an important and effective predator in more productive areas (Baker-Gabb 1995). Fox predation as a threat is diminished in core Plains-wanderer habitat – extensive

and 'droughty' clay plains without surface water and of limited suitability to rabbits and other rodents. Elevated fox predation is expected to extend two kilometres from edge of Urban and Irrigated areas.

### GOLDEN SUN MOTH *Synemon plana*

Generally lowland grasslands and open woodlands exceedingly widespread but rarely observed or more accurately limited reliable records. Historically, the distribution of the Golden Sun Moth corresponded with native temperate grasslands and woodlands across South-eastern Australia. Feeds on *Austrodanthonia* spp and possibly other grass taxa. See also Braby & Dunford 2006; Gilmore et al. 2008.

Home range requirements: Unknown – many thousands of individuals can be supported in very small areas. One population estimate of 10,000 individuals was made at a site of 400m<sup>2</sup> area (DEC 2007). Department of the Environment, Water, Heritage and the Arts (2009) suggests habitat areas less than 0.25ha are “unlikely to contribute to the ecological health of the species” – this was the threshold used to exclude small areas from the model.

Dispersal: Males can fly and winds will disperse some males. Females sedentary and virtually flightless. As a consequence – despite the gift of flight – Golden Sun Moth is a very poor disperser to new or unoccupied disjunct habitat. Prior to settlement temperate woodlands were more or less continuous across South Eastern Australia on plains and foothills and this may explain why long distance dispersal was not really an acute selection pressure on this species. Areas surrounded by barriers of up to 200m are effectively isolated (Clarke & O'Dwyer 2000).

### SOUTHERN BROWN BANDICOOT *Isodon obesulus obesulus*

Range of lowland moist temperate habitats with high veg cover at or near the ground.

Home range area is highly variable 0.5–9ha per individual recorded in a range of studies in varying habitats (DEC 2006). We have adopted a home range area per individual of 0.5 hectare and have therefore assumed optimal habitat is universal.

Dispersal: No absolute barriers. Succumbs to predation in open country – mainly foxes, but also cats and domestic animals. Dispersal through suburbs is **highly unlikely** and dispersal through rural residential is considered *unlikely*. In the absence of human assisted dispersal, good dispersal habitat (which is rare and discontinuous in the Melbourne area) is as least as important as remaining prime habitat areas in the medium to long term for this species' local persistence.

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### SPINY RICE-FLOWER *Pimelea spinescens* subsp. *spinescens*

Lowland grassland plant species, specialising in low rainfall regions. Most remaining populations are to be found on roadsides, cemeteries and rail reserves. Several populations on freehold are known in the study area and additional populations will be located as urban expansion brings more surveys to freehold grasslands.

Unknown to what extent inbreeding depression and population dynamics is particularly important consideration in the medium term for the conservation of long-lived plant species such as *Pimelea spinescens*. It is more likely that site management or the absence of useful commensal organisms are more critical immediate concerns. Most populations will benefit from improved site security and site management.

Dispersal: Dispersal is by passive fall and pollination is effected by insects. As a consequence this species may maintain genetic contact sufficient to genetically enrich small isolated populations but is unlikely to spread readily across unsuitable habitat types such as roads and urban areas. Such areas represent real barriers to dispersal. Frequent burning provides recruitment opportunities for the Spiny Rice-flower. This species probably germinates in autumn or spring. Plants also re-sprout after fire. The species has been observed to regenerate from seed readily following appropriate fire events, even in severe drought. The species is thought to be extirpated by cropping, herbicide application (boom spraying) and intensive grazing but persist in relatively weed infested areas provided inter tussock space is maintained.

As such, the key to selecting the best places for reservation for this species is a detailed knowledge of the occurrence of the species. While many populations are known, no systematic survey of the species has been conducted across its range or in the Melbourne area. As the species continues to be recorded in grasslands subject to planning permit applications in the Melbourne area it may be reasonable to suppose populations additional to those that are known may yet be found. The model identifies areas suitable for *Pimelea spinescens* on the basis of climate, soils, terrain and satellite imagery. It cannot identify regions that have been subjected to once off cropping, boom spraying of herbicide or severe grazing. These are some of the caveats on the interpretation of the modelling. Given that we do not know the intimate details on land use (so important to plant conservation) if we assume all parcels with “habitat” to have at least a small population – persistence is simply improved with area retained and controlled.

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### MATTED FLAX-LILY *Dianella amoena*

Widespread lowland species typically found in woodlands and open forests on a range of substrates.

Dispersal: Dispersal is largely carried out by frugiverous birds (possibly some reptile dispersal) and pollination is largely effected by native bees. Whether fruit is regularly taken and effectively dispersed by birds in peri-urban areas is not known. As seed is bird dispersed we can assume some connectivity over non-habitat. Therefore we have selected an arbitrary figure of 200m (a distance within which a large proportion of seed is voided by birds) and have removed all areas that are not connected to 'habitat regions' of more than 1,000ha.

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## **APPENDIX 3: MAPPING THE SPECTRUM OF CONTRIBUTION TO SPECIES PERSISTENCE FOR GOLDEN SUN MOTH *Synemon plana* AS PART OF THE STRATEGIC IMPACT ASSESSMENT REPORT FOR MELBOURNE'S FUTURE GROWTH.**

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Biodiversity and Ecosystem Services Division, Department of Sustainability and Environment.

### **SPECIES DISTRIBUTION MODELLING: OVERVIEW OF METHODOLOGY**

#### **SALIENT INFORMATION FOR SPATIAL TEMPORAL DYNAMICS**

Climatic range is restricted to South East Australia. Generally found in native grasslands and open wood-lands, particularly corresponding to *Austrodanthonia* spp. With soils ranging from sandy loams and clays with a pH between 5.3 and 7 (O'Dwyer and Attiwill 1998).

Home range requirements are unknown as thousands of individuals may be supported in very small areas (i.e. observed 10000 individuals in 400m<sup>2</sup>). DEWHA (2009) suggests that habitat <0.25ha “unlikely to contribute to the ecological health of the species” (White, 2009).

*Synemon plana* life cycle is poorly known. Adults live 1–4 days and do not feed. Females are largely stationary, and males will not fly >100m from areas of suitable habitat. Therefore habitat separated by distances >200m is assumed distinct. Genetic distance strongly correlates to geographic distance, and may be a measure of habitat fragmentation (Clarke and O'Dwyer 2000).

In terms of habitat maintenance and subsequent contribution to species persistence, it was considered that management of native vegetation is more likely to contribute to longer-term habitat maintenance and improvement than management of non-native vegetation habitat (i.e. habitat consisting mostly of weeds) where the management outcomes are less certain and the risks of unregulated “habitat loss” greater. Habitat dominated by weeds also poses some conflicts under legislation where land owners may be required to control or remove ‘listed noxious weeds’ that may otherwise provide habitat for Golden Sun Moth. As such, a minimum site condition score (sensu. Parkes et al. 2003, DSE 2004) was used to threshold sites of poor condition but dominated by native grass cover from sites dominated by introduced weeds.

#### **SOURCE DATA**

- > Modelled habitat probability from Department of Sustainability and Environment Arthur Rylah Institute (White 2009)
- > Department of Sustainability and Environment Native Vegetation Extent 2005
- > Department of Sustainability and Environment Native Vegetation Modelled Site Condition 2005
- > VicMap Roads dataset
- > VicMap urban extents dataset



## LINEAGE

1. Thresholded the habitat probability model to 0.35 to create a statewide binary model that contains 95 per cent of the recorded samples of *Synemon plana*.
2. Removed all habitat from the model with <0.25ha contiguous area.
3. Removed all areas from the map intersecting with urban areas and roads.
4. Grouped habitat into distinct regions. Regions are considered the same if there is <200m between potential habitat areas.
5. Ranked habitat pixels (25 x 25m) into classes based on whether the pixel is within a region (as defined in [4]) that contains the following hectares of potential habitat:

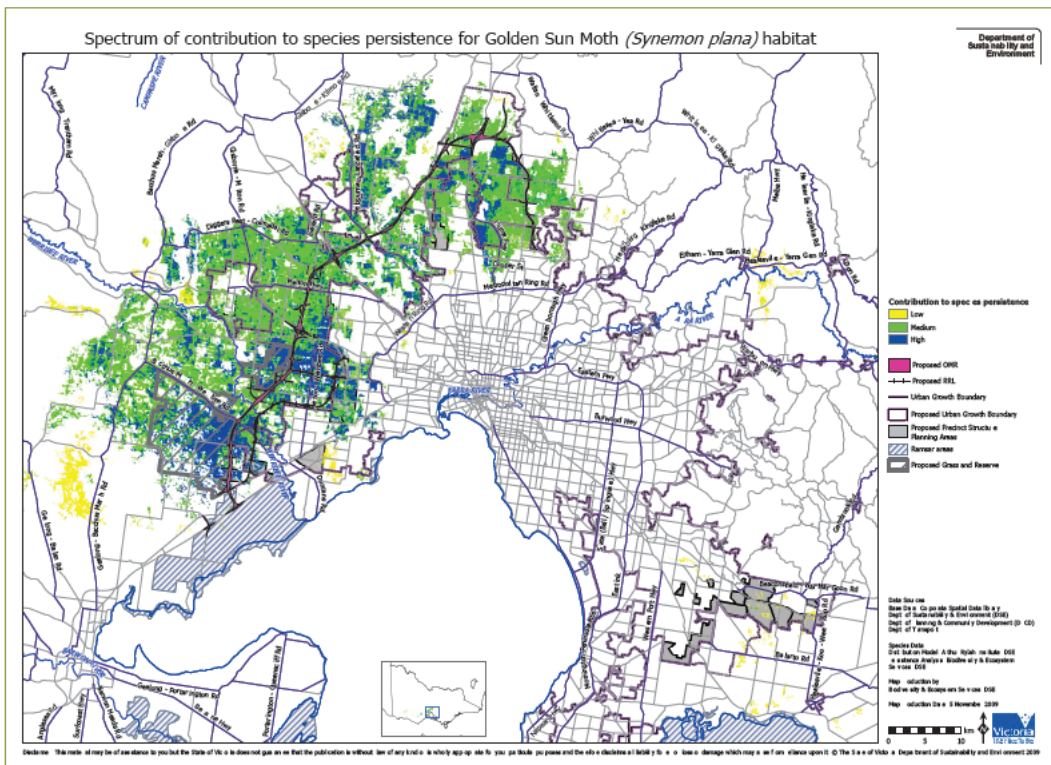
Area (ha) of potential habitat	Ranking
>100,000	4
10,000 – 100,000	3
1,000 – 10,000	2
100 – 1,000	1
<100	0

6. Compared this ranked habitat to the native vegetation extent and modelled site condition where the modelled site condition is  $\geq 0.2$ . The model was divided into three classes of “contribution to species persistence” shown in the following table:

Habitat within native vegetation with modelled site condition $\geq 0.2$ ?	No	Yes
Habitat Region Ranking		
4	Medium	High
3	Medium	High
2	Low	Low
1	Low	Low
0	Does not contribute to species persistence	

## OUTPUT MAP

The map of the modelled habitat of *Synemon plana* in the Melbourne region of Victoria divided into three classes of “contribution to species persistence”: Low; Medium; and High.



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## **APPENDIX 4:**

# **MAPPING THE SPECTRUM OF CONTRIBUTION TO SPECIES PERSISTENCE FOR MATTED FLAX-LILY *Dianella amoena* AS PART OF THE STRATEGIC IMPACT ASSESSMENT REPORT FOR MELBOURNE'S FUTURE GROWTH.**

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Biodiversity and Ecosystem Services Division, Department of Sustainability and Environment

### **SPECIES DISTRIBUTION MODELLING: OVERVIEW OF METHODOLOGY**

Refer to Appendix 1 – Delivering Melbourne's Newest Sustainable Communities – Strategic Impact Assessment Report for EPBC Act 1999. The State of Victoria, DSE, East Melbourne 2009.

### **SALIENT INFORMATION FOR SPATIAL TEMPORAL DYNAMICS**

Widespread lowland species typically found in woodlands and open forests on a range of substrates.

#### **DISPERSAL**

Dispersal is largely carried out by frugivorous birds (possibly some reptile dispersal) and pollination is largely effected by native bees. Whether fruit is regularly taken and effectively dispersed by birds in peri-urban areas is not known.

As seed is bird dispersed we can assume some connectivity over non-habitat. Therefore we have selected an arbitrary figure of 200m (a distance within which a large proportion of seed is likely voided by birds) and have removed all areas that are not connected to 'habitat regions' of more than 1,000ha.

In terms of habitat maintenance and subsequent contribution to species persistence, it was considered that management of higher quality native vegetation is more likely to contribute to longer-term habitat maintenance and improvement than management of lower quality vegetation or areas dominated by weeds where the management outcomes are less certain and the risks of unregulated "habitat loss" greater. Habitat dominated by weeds also poses some conflicts under legislation where land owners may be required to control or remove 'listed noxious weeds' that may otherwise provide habitat for Matted Flax-lily. As such, areas of habitat were further ranked according to their modelled site condition score (sensu. Parkes et al. 2003, DSE 2004).

#### **SOURCE DATA**

Modelled habitat probability from Department of Sustainability and Environment Arthur Rylah Institute (White 2009)

- > Department of Sustainability and Environment Native Vegetation Extent 2005
- > Department of Sustainability and Environment Native Vegetation Modelled Site Condition 2005
- > VicMap Roads dataset
- > VicMap urban extents dataset

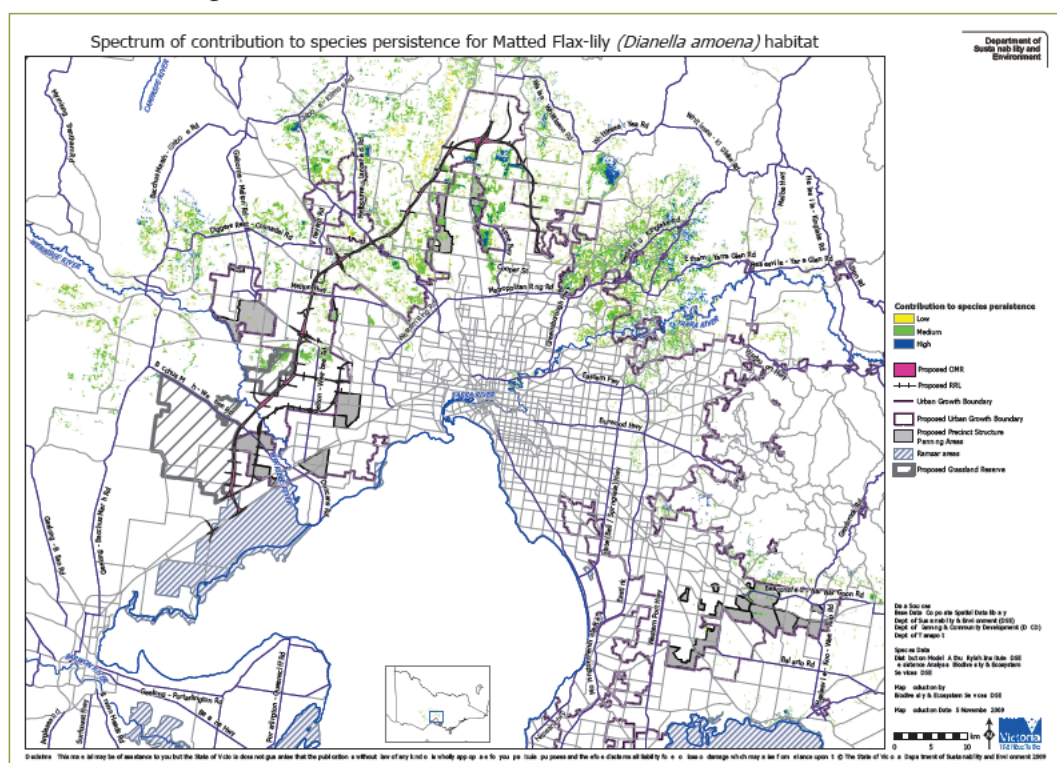
## LINEAGE

1. Threshold the habitat probability model to 0.38 to create a binary model that contains 95 per cent of the recorded samples of *Dianella amoena*.
2. All habitat less than 200m apart considered contiguous.
3. Identify contiguous habitat of 1,000ha or more.
4. Removed all areas less than one hectare in size outside 1,000ha contiguous habitat areas identified in "3" above.
5. For the all remaining habitat, assign the following ranking based on modelled native vegetation site condition:

Modelled Site Condition	Contribution to species persistence class
≥0.4	High
0.20-0.39	Medium
<0.20	Low

## OUTPUT MAP

A map of the modelled habitat of *Dianella amoena* in the Melbourne region of Victoria. The map is divided into three classes of "contribution to species persistence": Low; Medium; and High.



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## REFERENCES

Department of Sustainability and Environment (2004). *Vegetation Quality Assessment Manual – Guidelines for applying the Habitat Hectares Scoring method*. Version 1.3. DSE, East Melbourne.

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## **APPENDIX 5: MAPPING THE SPECTRUM OF CONTRIBUTION TO SPECIES PERSISTENCE FOR SPINY RICE-FLOWER *Pimelea spinescens* ssp. *spinescens* AS PART OF THE STRATEGIC IMPACT ASSESSMENT REPORT FOR MELBOURNE'S FUTURE GROWTH.**

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Biodiversity and Ecosystem Services Division, Department of Sustainability and Environment

### **SPECIES DISTRIBUTION MODELLING: OVERVIEW OF METHODOLOGY**

Refer to Appendix 1 – Delivering Melbourne's Newest Sustainable Communities – Strategic Impact Assessment Report for EPBC Act 1999. The State of Victoria, Department of Sustainability and Environment, East Melbourne 2009.

### **SALIENT INFORMATION FOR SPATIAL TEMPORAL DYNAMICS**

Lowland grassland plant species, specialising in low rainfall regions. Most remaining populations are to be found on roadsides, cemeteries and rail reserves. Several populations on freehold are known from the study area and additional populations will be located as urban expansion brings more surveys to free-hold grasslands.

Not sure that inbreeding depression and population dynamics is particularly important consideration in the medium term for the conservation of long-lived plant species such as *Pimelea spinescens*. It is more likely that site management or the absence of useful commensal organisms are more critical immediate concerns. Most populations will benefit from improved site security and site management.

### **DISPERSAL**

Dispersal is by passive fall and pollination is effected by insects. As a consequence this species may maintain genetic contact sufficient to genetically enrich small isolated populations but is unlikely to spread readily across unsuitable habitat types such as roads and urban areas. Such areas represent real barriers to dispersal. Frequent burning provides recruitment opportunities for the Spiny Rice-flower. This species probably germinates in autumn or spring. Plants also re-sprout after fire. The species has been observed to regenerate from seed readily following appropriate fire events, even in severe drought. The species is thought to be destroyed by cropping, herbicide application (boom spraying) and intensive grazing but it may persist in relatively weed infested areas provided inter tussock space is maintained.

As such, the key to selecting the best places for reservation for this species is a detailed knowledge of the occurrence of the species. While many populations are known no systematic survey of the species has been conducted across its range or in the Melbourne area. As the species is often recorded in grasslands subject to approval for destruction in the Melbourne area it may be reasonable to suppose populations additional to those that are known may yet be found. The model identifies areas suitable for *Pimelea spinescens* on the basis of climate, soils, terrain and satellite imagery. It

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cannot identify regions that have been subjected to once off cropping, boom spraying of herbicide or severe grazing. These are some of the caveats on the interpretation of the modelling. Given that we do not know the intimate details on land use (so important to plant conservation) if we assume all parcels with “habitat” to have at least a small population – persistence is simply improved with area retained and controlled.

In terms of habitat maintenance and subsequent contribution to species persistence, it was considered that management of higher quality native vegetation is more likely to contribute to longer-term habitat maintenance and improvement than management of lower quality vegetation or areas dominated by weeds where the management outcomes are less certain and the risks of unregulated “habitat loss” greater. Habitat dominated by weeds also poses some conflicts under legislation where land owners may be required to control or remove ‘listed noxious weeds’ that may otherwise provide habitat for Spiny Rice-flower. As such, areas of habitat were further ranked according to their modelled site condition score (sensu Parkes et al. 2003, DSE 2004).

## SOURCE DATA

- > Modelled habitat probability from DSE Arthur Rylah Institute (White 2009)
- > Department of Sustainability and Environment Native Vegetation Extent 2005
- > Department of Sustainability and Environment Native Vegetation Modelled Site Condition 2005
- > VicMap Roads dataset
- > VicMap urban extents dataset

## LINEAGE

1. Thresholded the habitat probability model to 0.376 to create a binary model that contains 95 per cent of the recorded samples of *Pimelea spinescens* subsp. *spinescens*.
2. Removed all areas from the map intersecting with urban areas and sealed roads.
3. Grouped habitat according to contiguity (i.e. no breaks in habitat cover).
4. Ranked contiguous habitat into the following categories based on area:



Area [ha] of contiguous habitat	Ranking
>1000	6
500-1000	5
100-500	4
50-100	3
25-50	2
1-25	1

5. Ranked modelled native vegetation site condition into the following categories:

Modelled Site Condition	Ranking
$\geq 0.35$	3
0.20-0.34	2
$< 0.20$	1

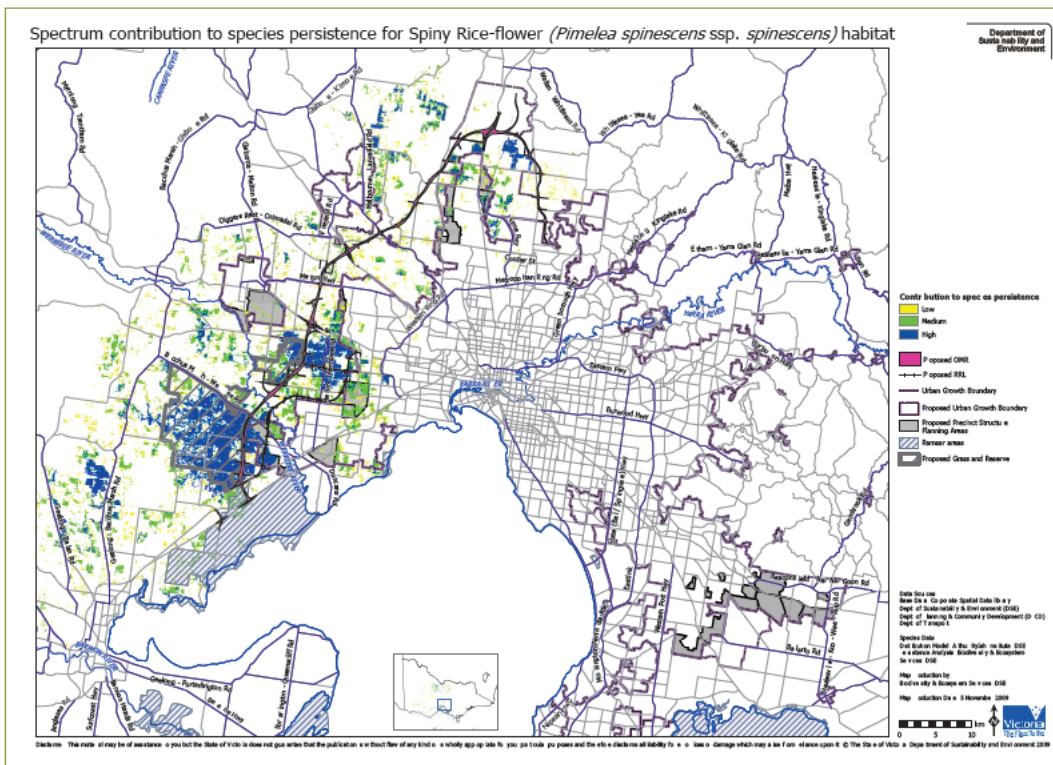
6. Combined habitat area classes with site condition classes and classified species persistence into three classes, as follows:

Site Condition Rank	3	2	1
Habitat Area Rank			
6	High	High	Medium
5	High	High	Medium
4	High	Medium	Medium
3	High	Medium	Medium
2	Medium	Medium	Low
1	Medium	Low	Low

7. As a result habitat in the high category constitutes close to 25 per cent of suitable habitat area, medium is about 50 per cent and low makes up the other 25 per cent.

## OUTPUT MAP

A map of the modelled habitat of *Pimelea spinescens* in the Melbourne region of Victoria. The map is divided into three classes of “contribution to species persistence”: Low; Medium; and High.



## REFERENCES

Department of Sustainability and Environment (2004). *Vegetation Quality Assessment Manual – Guidelines for applying the Habitat Hectares Scoring method*. Version 1.3. DSE, East Melbourne.

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## APPENDIX 6: SUMMARY OF NATIVE GRASSLAND RESERVE PRIORITISATION APPROACH

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This note summarises the spatial prioritisation approach used to strategically locate native grassland reserve(s) to the immediate west of Melbourne. Refer to Figure 1 for the final solution used by the Department of Sustainability and Environment to inform the reserve design process.

### INPUT DATA

The following spatial datasets were used to inform the prioritisation processes.

- > *Grassland extent and condition* – calibrated from the modelled Department of Sustainability and Environment’s state vegetation condition layer (NV2005\_QUAL1) using site data collected in the target area during 2008/09 (i.e. vegetation type, extent, condition), including those collected by the Victorian Growth Areas Authority and Department of Sustainability and Environment.
- > *Planning Unit layer* – Cadastral property boundaries. Used to potentially inform implementation decisions regarding the prioritising of individual properties. A threshold was set to only include properties greater than five hectares.
- > *Natural water resources layer* – layer showing combined spatial information on wetlands, streams and 1 in 100 year flood prone areas. Used for the purposes of incorporating “refugia” into the reserve design.
- > *Land use layers* – urban (including residential, industrial, roads, rail) and agricultural (consisting on irrigated agriculture and dry land agriculture). A range of urban layers were used to explore the effect of different current and possible future urban land use scenarios on the reserve design.
- > *Existing conservation areas* – areas currently managed primarily for nature conservation including public reserves, local government reserves and private land offset areas. Used to ensure that the final reserve design was well integrated with existing reserves.
- > *Public land* – areas of crown land not managed primarily for nature conservation or “non-developable” easements such as unused road reserves, transmission lines etc. This information is used to generate a preference layer for the spatial prioritisation (see below).

All input data derived from ESRI grid format with a 50m pixel resolution.

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## APPROACH

### ZONATION

The Zonation conservation planning tool (Moilanen and Kujala, 2006) was used to assign each pixel in the study area a prioritised value between 0 and 1, with 1 representing highest conservation value. The algorithm used by Zonation to prioritise pixels is a reverse stepwise heuristic which iteratively removes cells from the landscape in an order that minimises marginal loss of (Moilanen et al. 2005) while maintaining connectivity. The algorithm is based on the principle that minimizing the loss of conservation value while cells are removed, results in the greatest conservation value in the remaining areas. Priority areas of any given size can be determined by selecting pixels in the Zonation solution above a given threshold value.

### AGGREGATION

Extra aggregation was obtained in the solution using the boundary quality penalty (BQP) feature built into Zonation (Moilanen and Wintle 2007). When using the BQP, the conservation value of a given pixel of grassland is adjusted based on the amount and quality of grassland in a surrounding square area with a radius of 500m. The conservation value of pixels surrounded by a high proportion of grassland is increased, while conversely, the pixel value will be reduced if surrounded by a low proportion of grassland. This results in increased aggregation of the Zonation solution around the areas with highest quality grassland.

### LAND USE IMPACT

The impact of surrounding land use on pixel conservation value was applied in the context of these land uses being a source of weeds with a risk of spread. Land use layers showing the locations of urban and agricultural areas (consisting on irrigated agriculture and dry land agriculture) were used for this purpose.

Regardless of the mode of seed dispersal, seeds of terrestrial plants usually fall in a continuous leptokurtic distribution (normal with high peak) with the mode under or near the parent plant and decline with distance (Howe 1989). The impact is high at or near the interface and approaching a negligible value at the edge of the distribution. However, occasional long distance dispersal of invasive species has potentially important ramifications for weed management (Trakhtenbrot et al. 2005).

To account for the impact of weeds near urban and agricultural areas, kernel smoothing of the landuse maps was used to generate a “halo” of influence where weeds could potentially impact the condition of grassland. The shape of the kernel was defined using a high kurtosis / Super Gaussian (Pearson type IV) function with the standard deviation (SD) set such that  $3 \times SD = 500m$ .

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## PREFERENCE LAYER

Zonation allows a cost or preference layer to be used, when calculating the marginal loss value of a given cell. In simple terms, the preference layer can be thought of as providing information on where preferences would lie in the landscape with **grassland conservation value (and other factors) being equal**.

The preference layer was generated by combining the following layers:

1. The weed influence of urban and agricultural areas combined into a single weed source layer (urban areas were given twice the weed impact as agricultural areas). Areas away from these landuses are preferred to those that are closer.
2. The natural water resources layer: areas overlapping or close to wetlands / streams / flood prone areas are preferred to those that are more distant.
3. The public land layer: areas overlapping or close to unused road reserves or transmission lines are preferred to those that are more distant.

## EXISTING CONSERVATION AREAS

Zonation allows a mask layer to be used where existing conservation areas can be specified. These areas are then taken into account during the prioritisation process, along with the other factors such as aggregation and land use impact. The current approach used an existing conservation areas layer (see above) to account for these locations in study area.

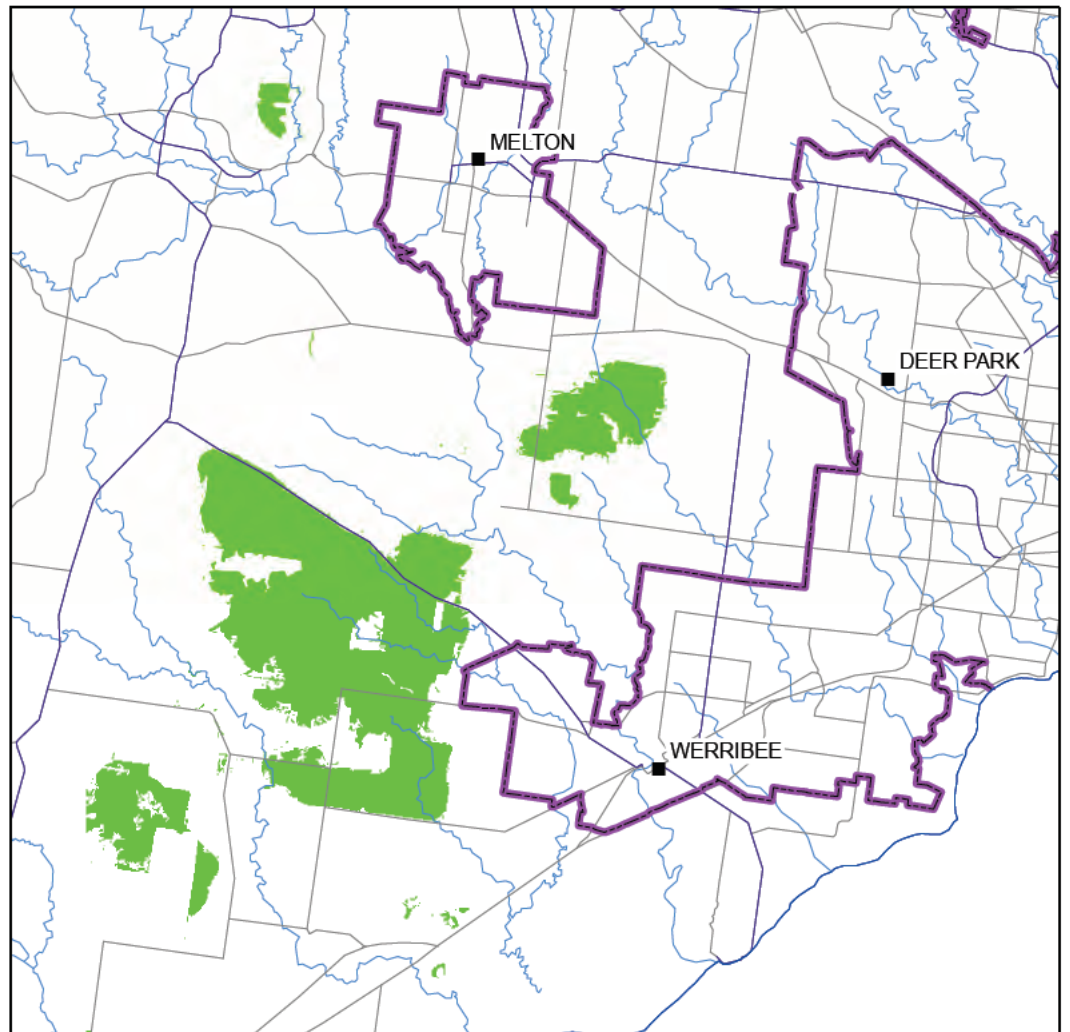
## PLANNING UNITS

Zonation can also run prioritising whole land parcels instead of pixels. This can be useful when considering properties for purchase, though it does not use the BQP aggregation and is not as biologically relevant. For the current project, both parcel and pixel prioritisations were made and after consultation with Department of Sustainability and Environment, it was decided to proceed with the final solution based on the pixel prioritisation.

## RESULTS

Zonation was run with all the settings described above and, on advice from the Department of Sustainability and Environment, a target area threshold of 12,000ha was applied and priority areas of these sizes were determined from the Zonation pixel solution illustrated in Figure 1.

FIGURE 1. FINAL ZONATION SOLUTION – OPTIMISED LOCATION FOR A 12,000HA GRASSLAND RESERVE TO THE WEST OF MELBOURNE



## ACKNOWLEDGMENTS

Research presented here was undertaken with support from the Australian Research Council through the Linkage Projects scheme and through the Commonwealth Environment Research Facility (Applied Environmental Decision Analysis).

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## APPENDIX 7: PROJECTIONS OF FUTURE GRASSLAND EXTENT-CONDITION CHANGE IN THE WEST OF MELBOURNE

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The aim of the investigation was to model the future extent and condition of native grasslands in the west of Melbourne under a number of possible scenarios. The approach aims to quantify and illustrate the net benefit (if any) of a strategic grassland reserve to the west of Melbourne to offset likely clearing of native grasslands within proposed Melbourne development areas.

For this study we modelled 24 years into the future using 12 time steps of two years duration. This approximates the period during which proposed development is likely to occur.

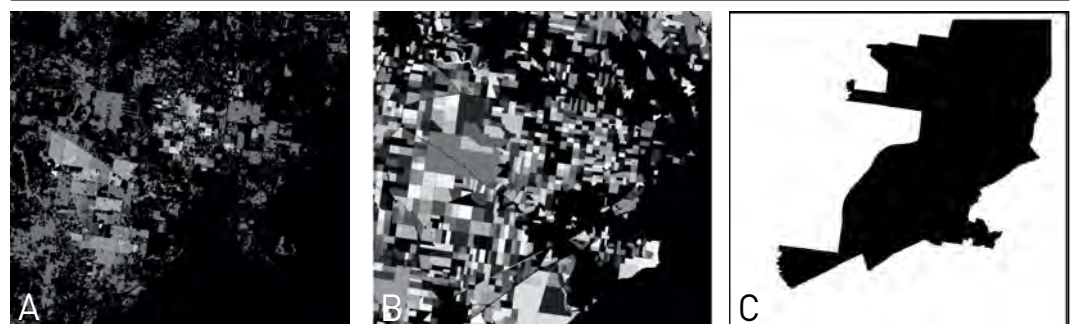
### MODELLING GRASSLAND CONDITION CHANGE

#### STARTING CONDITION (2009)

The relative starting condition of grasslands across the study area is illustrated in Figure 1. Each cell represents grassland condition within a 50x50m pixel. This condition model was calibrated from the modelled Department of Sustainability and Environment state vegetation condition layer (NV2005\_QUAL1) using site data collected in the target area during 2008/09 (i.e. vegetation type, extent, condition) including those collected by the Victorian Growth Areas Authority and the Department of Sustainability and Environment.

Figure 1(a) shows the grassland extent and quality in the study area (lighter colours are higher quality and black areas contain no grassland). Figure 1(b) shows land parcels in study area (only land parcels greater than 20ha were used (due to issues with the processing time associated with large numbers of very small parcels)). Figure 1(c) shows the mask depicting the development and offset scenario used, where development areas are shown black and offset areas (non-developable areas that overlap with any grassland) are shown white.

**FIG 1 (A) SHOWS THE GRASSLAND EXTENT AND QUALITY IN THE STUDY AREA (LIGHTER COLOURS ARE HIGHER QUALITY AND BLACK AREAS CONTAIN NO GRASSLAND). (B) SHOWS LAND PARCELS IN STUDY AREA (C) SHOWS THE MASK DEPICTING POTENTIAL DEVELOPMENT AREAS (BLACK) AND POTENTIAL OFFSET AREAS (NON-DEVELOPABLE WHITE AREAS THAT OVERLAP WITH ANY GRASSLAND).**

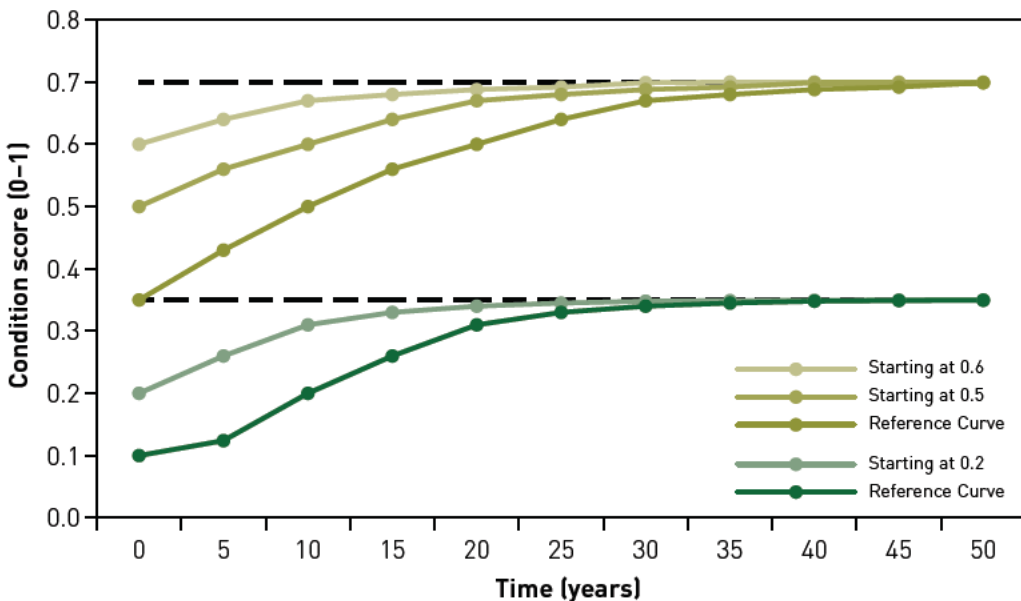


## MODELLING FUTURE CONDITION

All grassland was assumed to be either “actively managed” (permanently protected offset within or outside a “public reserve”); “not actively managed” (remaining grassland on private land subject to entitled uses and uncontrolled threats); or “developed” (no longer grassland).

Future grassland condition was calculated using the curves shown in Figures 2 and 3. The two reference curves in Figure 2 show how the condition of an actively managed grassland pixel will change over a given time period depending on its initial condition. If its score is below 0.35 (against a benchmark condition state of 0.7), then it will asymptote towards a condition value of 0.35. If it starts above 0.35 it will asymptote towards a value of 0.7. This rule was designed to capture the fact that once a patch of grassland falls below a certain condition it is likely to be very difficult to fully restore it and aligns with observations made by the Department of Sustainability and Environment grassland ecologists in sites around Melbourne over the past 10–15 years. It should be noted that some variance has been factored in that allows for some sites <0.35 to “jump” to the higher recoverability curve, particularly where surrounded by higher condition pixels.

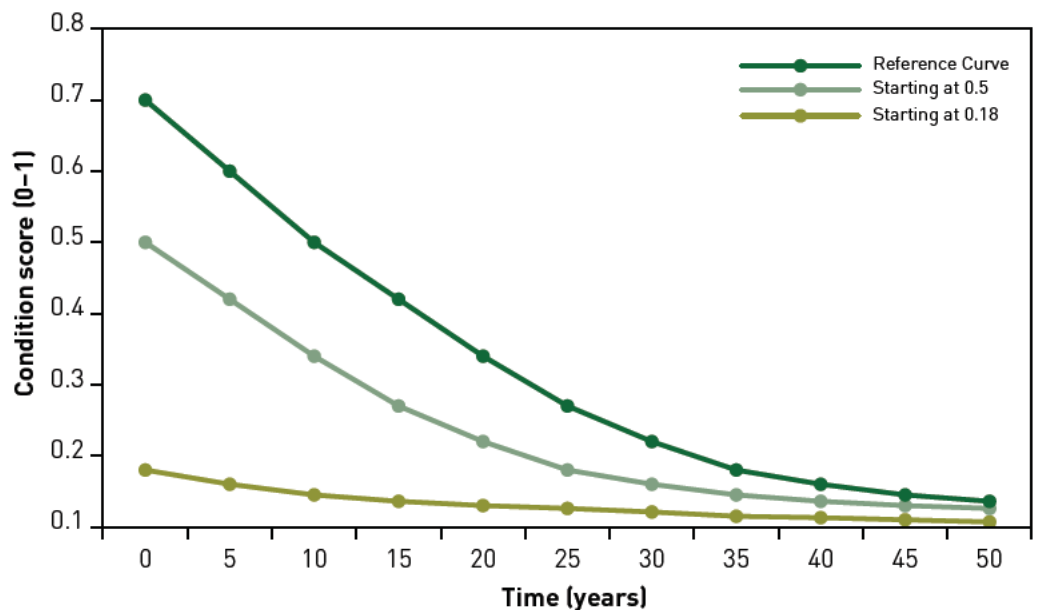
**FIG. 2** CONDITION CHANGE OVER TIME FOR ACTIVELY MANAGED GRASSLANDS.



The reference curves in Figure 3 show how the condition of a given pixel of grassland will degrade over time if it is not actively managed. This assumes a range of entitled uses such as grazing but also factors in the spread of various environmental weeds that landholders are not required to manage under existing legislation. In both actively managed and unmanaged cases the reference curves define how the condition will

change for any given starting value and the other curves show this same trajectory for different starting conditions.

**FIG. 3** CONDITION CHANGE OVER TIME FOR NOT ACTIVELY MANAGED GRASSLANDS.



For each time step, the condition of all pixels of grassland was evolved using the curves in Figures 2 and 3. After this the condition score or each pixel was randomly fluctuated by five per cent of its value to model stochasticity of the condition change process. Finally smoothing was applied to give some spatial autocorrelation to the condition change to ensure that adjacent grassland pixels did not vary greatly from each other due the random variation approach applied. This assumes that most co-located pixels within a parcel will be affected similarly under a future land use-management scenario.

### SCENARIOS MODELLED

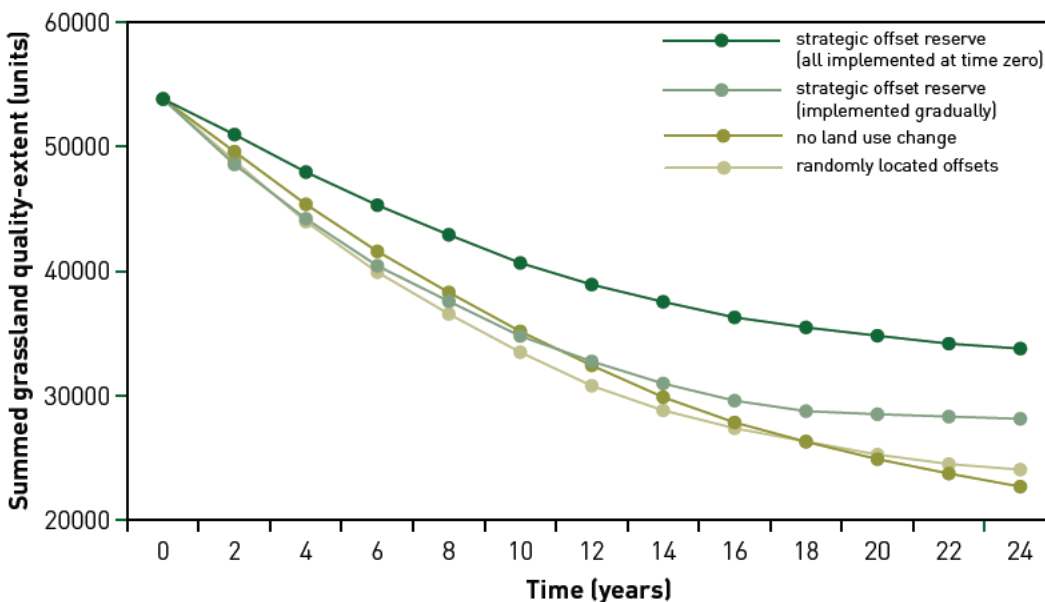
- > *No land use change* – in this scenario there is no development and no grassland is actively managed. Thus all grassland in the study area declines in condition over time due to unmanaged threats.
- > *Randomly located offsets* – here development occurs gradually over the 24 years at a rate such that all parcels are developed within 24 years. Parcels are selected for development by randomly choosing parcels within development area (Figure 1(c)). As each parcel is developed an offset is implemented for that parcel. The offset is chosen using the following procedure:
  - make a list of all the land parcels in the potential offset area that have a summed grassland condition score equal or greater than the summed grassland condition of the parcel being developed.

- select one of these parcels randomly.
  - if the summed condition off the offset is greater then the summed condition of the developed parcel, the offset quantity left over is stored and can be used to further offset another parcel.
  - it is assumed that all offsets are located within the study area (Figure 1(a)).
- > *Strategic offset reserve (implemented gradually)* – here strategic offsets (informed by the Zonation reserve prioritisation output – see Appendix 2) are implemented gradually over time such that the complete strategic offset reserve is in place after approximately 20 years. Development occurs in the same way as *the randomly located offsets* scenario. Offsets are chosen for each parcel developed in the same way as with the *randomly located offsets* scenario, but the list of land parcels available for offset is constrained to an area specified by the Zonation prioritisation. The total area for the locations of strategic offsets is set to approximately 11,000ha.
- > *Strategic offset reserve (all implemented at time zero)* – here strategic offsets (informed by the Zonation prioritisation) are all set in place at “time zero”. Development occurs in the same way as *the randomly located offsets* scenario. The total area of the offsets is set to be approximately 11,000ha.

## RESULTS

Results are shown by plotting the grassland condition summed over each pixel in landscape as a function of time – see Figure 4. Curves are shown for each of the 4 scenarios above.

FIG. 4 MODELLED NATIVE GRASSLAND QUALITY – EXTENT UNDER VARIOUS FUTURE SCENARIOS



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The results illustrate the difference between the four approaches. The results support the use of offsets to achieve net benefits over time (see – *no land use change* and *random offset* curves) and show the added benefit of a strategic grassland offset reserve. The greatest benefit occurs when creating the offset reserve as early as possible in the process, as shown in the *strategic reserve (all implemented at time zero)* curve.

### **ACKNOWLEDGMENTS**

Research presented here was undertaken with support from the Australian Research Council through the Linkage Projects scheme and through the Commonwealth Environment Research Facility (Applied Environmental Decision Analysis).





