SouthmetroConnect

OEPA Correspondence 20 November 2012

Appendix B

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Government of **Western Australia**
Office of the **Environmental Protection Authority**

Mr Reece Waldock
Commissioner
Main Roads
PO Box 6202
EAST PERTH WA 6892

Our Ref: *A563814:OEPA2010/000330*
Enquiries: *Gerard O'Brien, 6467 5459*
Email: *gerard.obrien @epa.wa.gov.au*

Dear Mr Waldock

ROE HIGHWAY EXTENSION RESPONSE TO SUBMISSIONS DOCUMENT

Southmetro Connect has provided the Office of the Environmental Protection Authority (OEPA) with an initial copy of the response to submissions document for the Roe Highway Extension Public Environmental Review (PER).

The OEPA has reviewed the document, and consulted with the Department of Water (DoW), the Department of Environment and Conservation (DEC) and the Department of Sustainability, Environment, Water, Population and Communities (DSEWPAC).

The OEPA has developed a consolidated list of issues/questions for you to consider when finalising the response to submissions document (Attachment 1). Please also find attached comments from DoW, DEC and DSEWPAC (Attachments 2-4).

Please note the Environmental Protection Authority (EPA) will only progress the assessment and preparation of the EPA Report once it is satisfied with the proponent's response to submissions document.

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XOEPAL002

I recommend that you contact Gerard O'Brien on (08) 6467 5459 should you have any further queries.

Yours sincerely

Kim Taylor
GENERAL MANAGER

20 November 2012

cc: Terry Pearce – Southmetro Connect
John Braid – AECOM, C/o 3 Forrest Place, PERTH WA 6000

Attachments

1. Consolidated questions/issues
2. Comments from the Department of Water
3. Comments from the Department of Environment and Conservation
4. Comments from the Department of Sustainability, Environment, Water, Population and Communities

Attachment 1

1. Groundwater Dependent Ecosystems – Construction Impacts

- The Department of Water (DoW) has advised that based on the drawdown estimates presented in the Water Management Strategy (WMS), no abstraction bores should be located within 1.5 kilometres (km) of North Lake or Bibra Lake. The 'recommended groundwater abstraction areas' within this distance are not appropriate.

  The OEPA requests that you modify the WMS to incorporate the requirement that bores will not be located within 1.5 km of the two lakes, as this will potentially be required as a condition on the WMS.

  The DoW has also advised that the groundwater levels at groundwater dependent ecosystems, other than North Lake and Bibra Lake, will need to be determined. While groundwater levels were identified in the PER using the *MIKE SHE surface and groundwater modelling*, this model cannot be used to assess the local impacts on wetlands as a result of post-development activities. This includes the infilling of Murdoch Drain, the construction of retaining walls and any local abstraction. The DoW considers that to determine the potential impacts to groundwater dependent ecosystems outside of the 1.5 km area around North Lake and Bibra Lake, the groundwater levels at groundwater dependent ecosystems should be provided.

  The OEPA requests that you liaise directly with the DoW to confirm which groundwater dependent ecosystems need groundwater levels determined and provide this information to inform the assessment of this factor.

2. Drainage

- The DoW has suggested the following changes to the WMS:

  1. All bioretention areas to be sized at 2% of the constructed, directly connected impervious area to ensure effective water quality treatment of the 1:1 ARI rainfall event;
  2. All drainage areas to receive stormwater in the 1:1 ARI rainfall event to be bioretention areas to protect the water quality of groundwater and connected wetlands;
  3. Future Water Management Plan (WMP) to investigate further opportunity for treatment of the 1:1 ARI rainfall close to source and discharge of larger rain events to wetlands; and
  4. Proponent to consult with the DoW during preparation of the WMP.

  The OEPA considers that these changes are important for maintaining groundwater quality and quantity for wetlands, and will potentially become conditions on the WMS. Please modify the WMS to incorporate these changes.

3. Wetlands

- OEPA considers that it has sufficient information on the direct impacts on wetlands from the construction of the highway extension. However, there is insufficient information on the likely extent of indirect impacts to wetlands.

  Section 6.6.2.4 of the PER contains a conceptual model to show indirect impacts on distal vegetation, and alterations in surface water and groundwater in the wetland zone. Indirect impacts to the wetlands are also discussed in Section 6.2.3.2.

  Based on existing information, the OEPA considers that further detail and mapping (including spatial data) should be provided regarding predictions of indirect impacts to the wetlands, specifically the zone of indirect impacts on Bibra Lake and Roe Swamp. This further detail should include which threatening processes were used to determine the zone of indirect impact.

4. Flora and Vegetation

- DEC identified that the *Caesia* species of taxonomic uncertainty will require further investigations to determine whether it exists in areas that will not be impacted, and its status. DEC also considers that further investigations should be carried out on the known priority flora taxa in the area to determine their local distribution, which may include monitoring remnant vegetation sites over the long term.

  The OEPA needs to have an understanding of the impacts of the highway extension to these species, and considers that the proponent should deal directly with DEC for a resolution regarding these details.

5. Fauna

- *Millipede*

  DEC has identified that further work is required to determine the identity and distribution of the unidentified sucking millipede, *Siphonotidae* sp.

  The OEPA considers that the Western Australian Museum should be consulted regarding the millipede and whether the species is likely to be restricted in habitat.

6. Aboriginal Heritage

Aboriginal Heritage is likely to be considered as a key environmental factor. Please provide an update regarding any further work and consultation on Aboriginal Heritage to inform the assessment of the factor.

7. General

- The OEPA requests the following spatial data:
    - Project area.
    - Construction Envelope, including details regarding:
        - All vegetation to be cleared.
        - Areas to be rehabilitated.
        - Drainage basin locations and area.
        - Zone of indirect impacts (based on the comments above).
    - Area to be covered by bridges.

ATTACHMENT 2

Government of **Western Australia**
Department of **Water**

looking after all our water needs

Your ref: A543000:OEPA2010/00330
Our ref: RF6144
Enquiries: Patrick Ridley, 9550 4237

5 October 2012

Office of the Environmental Protection Authority
Locked bag 33, Cloisters Square
PERTH WA 6850

Attn: Gerard O'Brian

Dear Gerard,

RE: ROE HIGHWAY EXTENSION RESPONSE TO SUBMISSIONS DOCUMENT

Thank you for the *Roe Highway Response to Submissions* (AECOM, 12 July 2012) and associated documents received with correspondence dated 7 September 2012. The Department of Water (DoW) wishes to provide the following advice with specific reference to questions raised by the Office of the Environmental Protection Authority (OEPA) in the aforementioned letter.

1. Groundwater Dependant Ecosystems – Construction Impacts

Can the temporary impacts of the proposal on groundwater dependent ecosystems be managed by the DoW under the Rights and Water Irrigation Act 1914?

Yes, the impacts of a proposed abstraction of up to 140,000 kL over a 1 to 2 year period for construction phase water supplies can be managed by the DoW under the *Rights and Water Irrigation Act 1914*. The technique used to estimate drawdown is considered acceptable. The following advice is provided with regards to the proposed bore locations and predicted drawdown:

- Drawdown from abstraction bores must have no impact on water levels at North Lake and Bibra Lake as the water levels at these sites are already in breach of water level criteria set in Ministerial statement 688.
- Based on the drawdown estimates presented by the proponent (Figure 19 in Appendix C – Water Management Strategy), no abstraction bores should be located within 1.5 kms of North Lake or Bibra Lake. The 'recommended groundwater abstraction areas' within this distance (as shown in Figure 20 in Appendix C – Water Management Strategy) are not appropriate.
- For other GDEs within the area, the predicted level of drawdown associated with abstraction must be within the low impact category as per table 1 (see next page). To assess these impacts, the depth to groundwater at GDEs in the area needs be determined.
- Abstraction should be spread between a number of bores to limit localised drawdown and should be apportioned more to the west (down gradient in terms of groundwater flow direction) of North Lake and Bibra Lake where the drawdown is likely to be less due to the occurrence of Tamala Limestone.

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SDCTMADX

Table 1 The potential impact to groundwater-dependent ecosystems measured as the predicted drawdown over a five year period from pre-drawdown summer/ autumn minimum water levels (adapted from Froend et al. 2004).

Groundwater-dependent ecosystems type	Predicted level of drawdown (m) at groundwater-dependent ecosystems[1]		
Wetland vegetation	<0.25	0.25– 0.50	>0.50
Riparian (baseflow river/ stream) vegetation perennial (flows permanently)	<0.25	0.25– 0.50	>0.50
ephemeral (flows seasonally/occasionally)	<0.75	0.75–1.25	>1.25
Terrestrial vegetation 0–3 m depth to groundwater	<0.75	0.75– 1.25	>1.25
3–6 m depth to groundwater	<1.00	1.00–1.50	>1.50
6–10 m depth to groundwater	<1.25	1.25– 2.00	>2.00
Impact	**Low**	**Moderate**	**High**

2. Drainage

Please advise if the Water Management Strategy adequately address the potential impacts and management measures for ground and surface water for both the construction and operational phases of the proposal?

Amendments are recommended to the Water Management Strategy (WMS) prior to the Department confirming satisfaction with the document. The WMS commits the proponent to prepare a number of plans for the management of various issues, including a Water Management Plan (WMP). Further assessment of the aforementioned plans by relevant agencies will be required to ensure the strategies outlined in the WMS are appropriately adhered to. The WMS is required to demonstrate that all potential risks are accounted for and managed to appropriately inform the future detailed plans.

Risks with regard to drainage impacting on water quantity are considered manageable. The wetlands are a groundwater flow-through system, thus the proposed placement of infiltration areas will have little impact the groundwater levels or on the wetlands. Stormwater will be infiltrated to the superficial aquifer, which in turn will recharge the wetland.

The Department is not satisfied with the strategies stipulated in the WMS to manage water quality. In accordance with DoWs publication *Water Sensitive Urban Design: Biofilters* (DoW, 2011), bioretention should be a minimum 2% of the constructed, directly connected impervious area to ensure effective water quality treatment. The proponent has provided MUSIC modelling to justify departure from the design specification (range of 0.97% - 1.25%), however this model does not calibrate reliably to the conditions of the Swan Coastal Plain, thus its output is not appropriate. Also bioretention is not proposed for drainage areas located up gradient of wetland areas. Given the proximity to sensitive receptors best practice stormwater management should be employed for this project to mitigate potential for detrimental impacts to water quality. Therefore, the DoW considers the WMS satisfactory subject to the following amendments:

1. All bioretention areas to be sized at 2% of the constructed, directly connected impervious area to ensure effective water quality treatment of the 1:1 ARI rainfall event;
2. All drainage areas to receive stormwater in the 1:1 ARI rainfall event to be bioretention areas to protect the water quality of groundwater and connected wetlands;
3. Future Water Management Plan (WMP) to investigate further opportunity for treatment of the 1:1 ARI rainfall close to source and discharge of larger rain events to wetland; and
4. Proponent to consult with the DoW for preparation of the WMP.

3. Wetland Interactions

Can the DoW advise whether the proposal will maintain surface, subsurface and groundwater connection between Bibra Lake and North Lake, and between Roe Swamp and North Lake?

Modelled Impacts

Consideration of the MIKE SHE model to quantify the hydrological connections of the lakes and wetland system was not possible. Ideally, modeling should inform the assessment to compare pre and post development conditions, with water-balances for each wetland reported. However, the MIKE SHE model cannot be used to assess the local impacts on wetlands as a result of post-development activities. This includes:

- The infilling of Murdoch Drain
- The construction of retaining walls.
- Any local abstraction

The PER alludes to the fact that the model supports the post-development assessment of these activities, however this is not the case, as no post-development scenarios were completed. In addition, the pre-development scenario and model calibration data were not provided by the proponent as requested in the DoW's correspondence dated 31 August 2011. The proponents response to this requested data (provided in Section 3.3-4 of the response to submissions report) is "*The calibration statistics, required by the Murray-Darling Basin Commission guidelines were omitted to simplify the report for the general public. It was felt that the calibration statistics would add a layer of complexity to the report that would make it difficult for the public to understand*". This response is insufficient for the Department to assess whether the model is fit-for-purpose, thus it must be assumed it is of limited accuracy.. The model can be used as a guide to assist with AECOM's understanding of the hydrological system, however the Department cannot consider any results of the model in its assessment of the project. The DoW will provide further information relating to the assessment of the MIKE SHE model if requested.

Risk Management

Though modelling presented within the PER is limited accuracy, the Department has undertaken a risk based approach to the consideration of hydrological impacts to the wetlands systems.

Bibra Lake, North Lake and Roe Swamp are "through-flow" systems, maintained by the flow of groundwater from the east, and exiting to the west. Given the parallel east-west alignment of the Roe Highway extension, it is expected the movement of groundwater east to west will continue to maintain the predominate hydrological function of the lakes.

The road will present a barrier to the connection of surface water north and south of the alignment. These impacts are considered manageable by engineering solutions proposed through the bridge structure and balancing culverts under the road to maintain the exchange of surface water.

Compaction associated with road construction will reduce porosity of the soil to a depth of approximately 2 to 3 metres. However, as previously stated, the flow of groundwater east to west maintains the hydrological function of the lake/wetland systems, thus the impact is likely to be negligible.

If you have any further queries, please contact Patrick Ridley at the Mandurah Office on (08) 9550 4237.

Yours Sincerely,

Leon Brouwer
Region Manager Peel Region

O'Brien, Gerard ATTACHMENT 3

From: Caporn, Norm
Sent: Thursday, 11 October 2012 10:46 AM
To: O'Brien, Gerard
Cc: Coffey, Daniel
Subject: FW: DEC Response to public submissions for the Roe Highway PER
Attachments: 20120914110024076.pdf; DEC Response to Submissions.docx

Department of
Environment and Conservation
Our environment, our future

Your Ref: A544641; OEPA2010/000330
Our Ref: CEO 759/11 2007/001350-2
Enquiries: Advice Coordinator

17 Dick Perry Drive, Technology Park, Western Precinct, KENSINGTON WA 6151
Postal Address: Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983
Tel: (08) 9334 0365 Fax: (08) 9334 0140
Email: advice.coordinator@dec.wa.gov.au

To: **Director, Assessment and Compliance Division - Office of EPA (Att: Gerard O'Brien)**

From: **Manager, Environmental Management Branch - DEC (Att: Dan Coffey)**

Date: **12 October 2012**

Subject: **ROE HIGHWAY EXTENSION – ASSESSMENT 1787 – RESPONSE TO SUBMISSIONS DOCUMENT**

Thank you for the opportunity to provide comment on the above proposal.

The attached (Attachment 1) comments are provided in relation to DEC's Conservation and Land Management Act 1984 and Wildlife Conservation Act 1950 related responsibilities. DEC is satisfied that the CEMP and its supporting ASSIDMP satisfy the requirements of Condition 7-1 of Statement 714, for the initial phase of construction.

No comments are provided in relation to DEC's *Environmental Protection Act 1986* and *Contaminated Sites Act 2003* related responsibilities.

Please contact Dan Coffey (Environmental Management Branch) on 9334 8102 if you have any queries in relation to this advice.

Norm Caporn
Manager
Environmental Management Branch

for Keiran McNamara
Director General

COMMENTS ON OEPA QUESTIONS ON ROE HIGHWAY PER - RESPONSE TO PUBLIC SUBMISSIONS

1. Vegetation and flora

OEPA question
'Based on the survey work in the Public Environmental Review (PER) and the additional information provided by the proponent (Attachment 2), is the proposal likely to impact on the conservation status of this species {Drakea elastica}?'

Advice: *The proposal is unlikely to impact on the conservation status of this species.*

Discussion: The additional information provided satisfies the survey requirements for this species. The botanist involved in the survey is known to be competent for undertaking such surveys, and the clarification of the timing of the surveys demonstrates that they were undertaken at the appropriate time of the year.

OEPA question
'Based on the additional information provided by the proponent, is there now sufficient information to determine the impacts of the proposal on the above mentioned {Lepidosperma and Caesia species} flora species.'

Caesia species
Recommendation: *The information provided suggests the potential impact on this taxon will be significant, risking its extinction. This would be unlikely, however, based on the balance of probabilities, but needs to be confirmed through further investigation.*

Discussion: The information provided for the *Caesia* species, only confirms that more investigation is required for this species, but no commitment to this investigation is provided. The information provided demonstrates that all known plants of this taxon will be taken in the footprint. Further survey is required to identify the taxon in areas that will not be impacted, and a commitment to taxonomic investigation to determine its status is required. Collection of propagating material is a minimum requirement to ensure the taxon is not lost should it be determined to be a rare and new variant.

Lepidosperma species
Recommendation: *Further taxonomic investigation is being undertaken, and if it is determined to be a novel taxon, then investigations in nearby bushland should be undertaken to identify viable populations of this taxon*

Discussion: Information provided for the *Lepidosperma* species shows that only a low impact is proposed on these taxa. In the case of the *L. pubisquameum*, no plants will be directly taken, but the plants will be retained in very narrow vegetation remnants, sometimes between the construction footprint and noise barriers, that may not be sustainable in the long term. .

Recommendation: *Further investigations are required to identify this taxon, if proved to be novel, in areas of bushland with greater viability.*

Summary Discussion: In the case of *L. squamatum*, only one plant of 24 is proposed to be taken. In interpreting the information and identifying the quadrats in which they were found (from the original appendice) it is apparent that the plants are not common and will mainly be retained in small isolated remnants. .

Thus, the identified direct impact on the *Caesia* species is significant, while the direct impact on the *Lepidosperma* species is stated as being low, but the indirect and longer term impacts may be significant based on the information available.

OEPA question
'Are the management plans and management measures acceptable for managing the indirect and ongoing impacts of the proposal on flora and on-site rehabilitation'.

Appendix D – Flora Vegetation and Fauna Management Plan
Recommendation: *Further investigations should be carried out on the known priority flora taxa in the area to determine their local distribution. Monitoring sites should then be monitored over the longer term to determine the capacity of these residual population to persist in the narrow remnant vegetation areas.*

Outcome targets should be provided that are evaluated following monitoring events to determine if the management actions are being effective in achieving the maintenance of the values at the site

Discussion: The objective of the Plan is to maintain abundance and diversity of flora and fauna at species level. This is unachievable, and impractical, as there will be vegetation clearance which will reduce abundance.

All of the known priority flora plants in the project area for *Tetraria* sp. Chandala and *Dodonaea hackettiana*, and most of the *Dampiera triloba* will be taken by the project. This will reduce the abundance and diversity of the flora in the area. As stated above, unless further investigations are done into the *Caesia* species, the diversity may also be reduced through the total loss of this taxon.

The objective should be practical and related to the project, or specify that it is only in relation to the objectives post-construction (ie in relation to the residual flora and fauna).

Table 10 provides broad guidance areas for managing the values at the site, but does not provide detail on the methodology. .

Items 5 and 6, Flora and Vegetation, refer to surveying for priority flora and marking these plants. However, there is no statement about what is intended to be done with these plants other than collection of seed (and topsoil), and protect outside development area. The purpose of marking plants within the development area only appears to be to facilitate seed collection, and possibly topsoil handling.

It is suggested that monitoring sites could be established at priority flora locations outside the development zone to monitor the effect of the development on the flora and associated habitat.

Specific reference is made to survey for, and collection of propagation material from, priority flora. This targeted action should also extend to the unknown *Lepidosperma* and *Caesia* species.

Appendix E – Rehabilitation Strategy
Advice: *The Rehabilitation Strategy appears adequate for this project.*

Discussion: 5.2.2 – the topsoil map should also show occurrence of priority flora species to facilitate the re-establishment of these species in appropriate areas.
Details of rehabilitation actions will be developed in specific rehabilitation plans, but the overall strategic approach is sound.

2. Black cockatoo

OEPA question
'Is the additional work undertaken sufficient to determine the regional and local significance of the loss of foraging habitat?'

Recommendation: *Rather that reporting that 'there may be some reduction in viability of these nine roosts' (page 86 of the public response document), it would be more accurate to say that 'there is likely to be some reduction in viability of these nine roosts'. Main Roads to investigate the options of providing funds for further research as suggested below.*

Discussion: In this assessment, it is noted that some of the Carnaby's roost sites have less forage habitat available (750 to 883ha) resulting in the relatively higher percentage impact, compared to others that have over 1000ha available. Current studies into the forage requirements of Carnaby's cockatoo will help to answer the question as to what is the cut-off area for effective forage to support a roost site, but at present we cannot say if the proposed reduction for these smaller areas will be critical to the maintenance of these roost sites. While we can say that the continued, incremental loss of foraging habitat within 6km of a black cockatoo roost site will eventually result in the loss of that roost site, there is insufficient information to assess exactly when this is likely to occur.

To assess this potential reduction in roost viability, Main Roads could provide funds for research into the impacts of habitat loss on Carnaby's Cockatoos. For example, a modeling analysis that quantifies the relationship between the number of roosting cockatoos and the area of potential foraging habitat within 6km. Understanding this relationship will allow an informed estimate of the number of roosting birds likely to be lost from each roost site and allow an assessment of the incremental loss of cockatoos as a consequence of gradual habitat loss. Also, research into the use of foraging habitat by roosting birds, to address DEC's concerns about the loss of local foraging habitat having a greater impact on roost viability, than the loss of habitat 6km away (for example research by Teagan Johnstone and Christine Groom from DEC).

It is also noted that RT1 is located next to the development, and most of the close forage will be lost. While other forage is present within the 6km, the impact of the loss of closer forage is also unknown.

OEPA question
'Does DEC consider this to be consistent with the DEC data?'

Advice: *The estimate of 9,133ha of potential Carnaby's Cockatoo foraging habitat within 15km of the project site is consistent with the DEC data. No further action required.*

OEPA question
'Are further surveys still necessary to determine Black Cockatoo breeding activity?'

Advice: *The black cockatoo breeding survey work appears to have been adequate. No further surveys are deemed necessary.*

OEPA question
'Are the proposed measures in the Rehabilitation Strategy adequate?'

Recommendation: *Further mitigation measures should be put in place to reduce the risk of bird strike by employing a range of measures as discussed below.*

Discussion: The Rehabilitation Strategy (Appendix E) identifies a single strategy for minimizing road strike for black cockatoos, which is to avoid planting Carnaby's food trees and shrub within 10m of the roadside. The risk of bird strike will reduce with the distance such plants are planted from the road. However, it is unknown what the level of reduction will be.

An additional measure would be to fence between the road and revegetated areas, to encourage cockatoos to fly over the height of traffic. It is also a factor that if there is suitable vegetation on both sides of the road (even at distance, the birds will most likely fly at low level between these. This has been observed at Baldivis where strikes occurred. Thus the planting configuration also needs to take into account the likely movement patterns across the road.

3. Millipede

OEPA question
'Is further work still required to determine the occurrence and distribution of the millipede species outside the footprint area?'

Recommendation: *Further work is still required to determine the identity and distribution of the unidentified millipede outside the footprint area*

Discussion: The information provided is hypothetical, and does not adequately cater for the potential that this millipede is indeed a SRE that is rare and only locally present.

4. Southern Brown Bandicoot

OEPA question
'Are the new proposed measures adequate in regards to the bandicoot?'

Recommendation: *Further investigations into potential translocation sites are required Main Roads could provide for a coordinated study that addresses the requirements of animals from this site as discussed below.*

Discussion: Item 12 in Table 10 of the Flora Vegetation and Fauna Management Plan, refers to translocation of Southern Brown Bandicoot. Investigations into potential translocation sites will need to occur well in advance to enable site assessment and consultation with recipient land managers. DEC has started to make such investigations, and support from Main Roads could provide for a coordinated study that addresses the requirements of animals from this site.

This could include identification of potential recipient sites, the refining of protocols for translocating the quenda, monitoring to assess the impacts of the quenda after translocation and monitoring the survival of the translocated animals. The timing of translocations also needs to be planned to ensure animals are moved under suitable seasonal conditions.

5. Wetland interactions

General discussion
DEC's Wetlands Section does not have "in-house" technical hydrological expertise and a detailed technical hydrological review of the Roe Highway extension proposal with respect to potential impacts on wetlands was not undertaken. It is understood that the Department of Water (DoW) is providing a technical review of the hydrological reports. The Wetlands Section advice below should be considered in the context of the technical review of the hydrological studies provided by DoW.

Given current resource and time pressures, Wetlands Section was not able to undertake a detailed review of the appendices to the *Response to submissions*, and the below comments focus on the information required to respond to the OEPA's questions posed to DEC in the correspondence of 14 September 2012. In particular, it should be noted that a detailed review of the Wetland Buffer Study was not able to be undertaken within the requested response time.

OEPA question
'Can reasonable judgments be made about the proposal's potential long-term impacts on the hydrological regime and connectivity between wetlands, based on information provided by the proponent and also the current understanding of the subsurface connections and flow regime in the project area?'

OEPA question
Will there be no change to the wetland water regimes and water quality as a result of the proposed drainage management outlined in the new Water Management Strategy?

Discussion: The information provided in the PER and the *Response to submissions*, including the Water Management Strategy (Appendix C, WMS), provides insufficient information to assess the potential impacts of changes to hydrology from the development on wetlands and insufficient detail with respect to monitoring, management and mitigation measures to be able to confirm whether there will be long-term impacts from potential changes to the wetland water regimes and connectivity between wetlands. Based on the information provided, it appears that wetlands may potentially be impacted by drawdown of the superficial aquifer for construction water, compaction and "cut and fill" of soils potentially resulting in altered hydrological regimes, groundwater mounding beneath drainage basins and changes to surface water flow, which may impact high conservation value wetlands in high rainfall events. Insufficient information has been provided to determine whether these impacts will be adequately managed by the proponent.

With respect to the matter of drawdown of the superficial aquifer for construction water, this was not addressed in the PER and the potential impacts on wetland and groundwater dependent ecosystems (GDEs) are not adequately addressed in the *Response to submissions*, including the WMS. Furthermore, the proponent does not provide any commitments with respect to an appropriate monitoring and management program for wetlands and GDEs, which would include collection of baseline data, and development of appropriate management action triggers and proposed management responses in the event that monitoring shows that triggers have been exceeded. The introduction of this new component to the proposal, subsequent to the PER, that will result in drawdown on the superficial aquifer, and the limited assessment of the potential impacts of this drawdown on wetlands and other GDEs, is of specific concern.

There still appears to be some uncertainties around the potential impacts of soil compaction and "cut and fill" of soil on the wetlands. Appendix D notes the sedimentary and stratigraphic complexity of the North and Bibra Lakes area and the increased importance of small scale localised and seasonal hydrological processes (p. 62). It also states that "cut and fill" may permanently change the hydrological properties of the shallow stratigraphic layers that either perch or retard vadose percolation (p. 63, Appendix D). Furthermore, compaction may alter the soil hydraulic conductivities which may potentially alter the hydrological regime in these areas (p. 68, Appendix G). The matter of "cut and fill" altering the stratigraphic complexity and localised and seasonal hydrological properties does not appear to be adequately addressed. Although there is some discussion of the potential impacts of compaction of soils in the *Response to public submissions* and WMS, the calculation presented was based on the compaction and reduction in porosity of "clean sand" (p. 52, WMS) rather than the complex soils of the North and Bibra Lakes area.
Uncertainty remains regarding the potential impacts of the compaction and "cut and fill" of the complex soils the North and Bibra Lakes area on wetland hydrology.

The WMS contains few commitments with respect to the proposed drainage management and repeatedly states that the details of the stormwater system will not be addressed until further planning stages of the proposal. Without the details of the stormwater system, or at least clear commitments from the proponent with respect to

minimizing and mitigating impacts of the stormwater system on wetlands, there is insufficient information to determine whether the proposal is likely to have a significant impact on wetland water regimes. Location and design of the retention basins and culverts are critical with respect to determining the potential impacts of groundwater mounding and the potential impacts of changes to surface water flow regimes on the wetlands within the project area.

Further details with respect to the matters raised above and associated recommendations are included below.

Response to public submissions – Section 3.2 - General
Discussion: Many of the proponent's responses in Section 3.2 simply refer to the WMS, Wetland Buffer Study (Appendix B, WBS) or other supporting documentation, rather than providing a direct response to the submission. The documents cited do not always provide adequate information to address the matters raised in the public submissions. Some specific examples are detailed below.

Response to public submissions - Wetland buffers requirements (p. 19 and p. 22)
Recommendation: *That the proponent commits to appropriate buffers to protect high conservation value wetlands from potential hydrological changes resulting from the implementation of the Roe Highway extension or, alternatively, details appropriate mitigation, monitoring (including collection of appropriate spatial and temporal baseline data), management triggers and management measures for wetlands prior to implementation of the proposal. This could be implemented through the development of the proposed Wetland Management Plan, which should be developed in consultation with DEC's Wetlands Section and on the approval of the OEPA.*

Recommendation: *That the proponent commits to appropriate mitigation, monitoring (including collection of appropriate spatial and temporal baseline data), management triggers and management measures for other GDEs prior to implementation of the proposal.*

Discussion: The WBS appears to have been developed to retrospectively fit the proposal and does not always address the matters raised in the public submissions. In particular, in the WBS the proponent dismisses buffers with respect to managing hydrological impacts on the basis that buffers are not suitable for managing catchment scale wetland and water regimes. However, potential hydrological impacts on wetlands from the proposal were detailed in Appendices D and G of the PER and this information could be used to recommend suitable buffers to be applied in relation to specific potential hydrological impacts resulting from the implementation of the Roe Highway extension. Simply referring to the WBS study does not address the public submissions with respect to buffers in this regard, in particular Submissions 2.1-1 (p. 19), 2.1-2 (p. 19) and 2.2-5 (p. 22).

If the potential hydrological impacts of the proposal are not going to be addressed through provision of appropriate buffers, then the Wetland Management Plan proposed to be developed needs to detail appropriate mitigation, monitoring (including collection of baseline data), development of management triggers and management responses prior to implementation of the project. The details of the Wetland Management Plan should be developed in consultation with DEC's Wetlands Section and on the approval of the OEPA.

The response to submission 2.2-12 (p. 20) states that there are no "*Limits of Acceptable Change*" proposed for the project. It also states that "*During construction and operation of the project, impacts on the hydrological regime will be monitored and managed through the WMS (Appendix C) and impacts on vegetation will be monitored and managed through the FVFMP* [Flora, Vegetation and Fauna Management Plan] *(Appendix D)*" (p. 20). Neither the WMS nor the FVFMP provide for adequate monitoring and management of GDEs, including wetlands and vegetation communities, in relation to potential impacts from groundwater or surface water changes potentially cause by the proposal. No commitment to collect baseline data prior to construction has been made in any of the documents and without adequate spatial and temporal baseline data, the impacts of the proposal will remain unclear. Furthermore, no management triggers or limits of acceptable change have been provided for in the WMS or are proposed for inclusion in the Wetland Management Plan. Therefore, although a change may be monitored, without baseline data, the significance of the change would be unknown, and without management triggers, no corrective action would be implemented.

Drawdown on the superficial aquifer was not addressed in the documents associated with the PER as it was not being considered at the time the PER was prepared. Groundwater mounding beneath the retention basins may also impact on wetlands and other GDEs from both a water quantity and quality perspective. There is the potential for the road to create a sheet flow "shadow" effect in high rainfall events. Compaction of soils may also potentially impact wetland hydrology and other GDEs. The Roe Highway extension MIKE SHE model, as presented in the PER (Appendix G), cannot be used to assess the post-development impacts on wetlands as a result of these factors, as no post-development scenarios were run. Wetland and vegetation monitoring programs need to be developed addressing all these potential impacts from the proposal and to demonstrate the effectiveness of any proposed groundwater and surface water management (in particular retention basins and culverts).

Response to public submissions – Impacts to wetlands (pp. 19-20)
Recommendation: *That the proponent confirms that the modeling undertaken to demonstrate the potential impacts of groundwater mounding beneath retention basins is appropriate and that the model is adequate to assess the impacts of groundwater mounding beneath the retention basin proposed to be located adjacent to Horse Paddock Swamp (Basin I), given the significant difference in design/size to the other retention basins and its proximity to wetlands.*

Recommendation: *That, in light of the modeling presented which shows a potential impact from groundwater mounding beneath retention Basin I on Horse Paddock Swamp, the proponent clarifies how it proposes that the* "hydrological values of Horse Paddock Swamp will be maintained" *(p. 19).*

Discussion: The WMS states that "*The results show that the magnitude of mounding expected in areas surrounding the conceptual basin locations is expected to be limited; negligible groundwater level rises (<0.1m) are expected beyond 50 -100m of basin perimeters*" (p. 52). Based on the graphs presented in Figures 24 and 25, this statement is not correct. For Bassendean Sands the groundwater mounding is greater than 0.1 m at 50 m distance from the basin in all scenarios modeled and greater than 0.1 m at 100 m distance from the basin for three of the four scenarios modeled.

The response to submission 2.2-1 (p. 19) states that the hydrological values of Horse Paddock Swamp will be maintained and that there will be "*little to no impact*" to on groundwater hydrology, citing Appendix G of the PER and the WMS. These documents do not clearly demonstrate that there will be "*little to no impact*" to the hydrology of Horse Paddock Swamp. Horse Paddock Swamp is less than 70 m from Basin I (1.7 hectares in size, in Bassendean Sand). Based on the model for a basin of 70 m radius provided in Figure 24, it may experience groundwater mounding of approximately 2 m in a 1 in 5 year event and 3 m in a 100 year event. The proposed design of the retention basin adjacent to Horse Paddock Swamp is significantly different to the other retention basins and it is unclear whether the model used is appropriate given that the size of this retention basin is larger than the largest sized basin modeled (being radius 70 m).

Recommendation: *That the proponent ensures that the bores for construction water, not previously assessed in the PER, are located such that drawdown from the superficial aquifer does not impact on conservation significant wetlands.*

Recommendation: *That the proponent ensures that the proposed "turkey's nests", not previously assessed in the PER, are located such that native vegetation is not cleared and wetlands are not impacted.*

Recommendation: *That the proponent finalises the locations of the groundwater abstraction areas and undertakes modeling of the drawdown extent in consultation with DoW and then overlays the drawdown extent on sensitive receptors, including wetlands and susceptible vegetation communities based on the GDE indicator species listed in Table 5.8-9 of the PER and the susceptibility of these species as listed in Table 17 of Appendix D.*

Response to public submissions – Groundwater abstraction assessment (pp. 24-25)

Recommendation: *That the proponent uses the information from the above analysis to revise the impact assessment, in particular Table 6.6-6 Proportionate Extent of GDEs Represented Within 50 m Zone of Potential Effect from Alterations in Surface Water and Groundwater (PER). The models provided in the Response to public submissions shows potentially a significantly larger area of impact than that which was assessed in the PER documentation.*

Discussion: The Groundwater abstraction assessment (pp. 24-25) provided in response to submission 3.3-2 states that impacts on wetlands will be low "*Provided any bores for groundwater abstraction are located at least 150m from any wetland*". Figure 20 of the WMS shows the "*Recommended Groundwater Abstraction Areas*", but a final decision on the groundwater abstraction areas is yet to be made.

The wetlands in proximity to the project area, in particular North Lake, are already under stress (widespread death of fringing vegetation) and the location and timing of groundwater drawdown due to abstraction must be adequately assessed. Without a final decision on the location of the bores and an overlay of the groundwater drawdown extent with respect to the wetlands, it is difficult to determine the potential impacts of the groundwater abstraction on wetlands.

In the WMS, Section 3.2.4 *Wetlands and Hydrologic Regime* states that "*Groundwater and lake levels show seasonal fluctuations of 0.5 – 1-5 m, and in the past decade exhibit a slight declining trend. Absolute minimum trigger levels appear to have been breached a number of times*" (p. 40). It then goes on to say that "*Based on the assessments above, the proposed abstraction of up to 140,000 kL over a 1-2 year period for construction phase water supplies is considered feasible from the Superficial Aquifer present within the project area without causing any significant adverse environmental impacts*" (p. 42). If the absolute minimum trigger levels have already been breached prior to the implementation of this project, then any additional drawdown on the superficial aquifer for this proposal would potentially exacerbate the stress that these wetlands are currently experiencing. No clear justification is provided in the WMS that justifies why the drawdown on the superficial aquifer for this proposal would not contribute to and exacerbate the stress that these wetlands are experiencing. Furthermore, Appendix D clearly states that "*If dewatering for dust suppression is required* Banksia ilicifolia *and shallow rooted species within the 200m hydrological buffer will be impacted, particularly if it occurs during late summer – autumn*" (p. 176, Appendix D). This matter was not assessed as part of the original PER and the *Response to submissions* and WMS do not adequately address the potential impacts of the drawdown in relation to impacts on wetlands or other GDEs.

As noted above, it appears that groundwater abstraction for the purposes of construction from the superficial aquifer may have the potential to impact on shallow rooted GDE species and the associated vegetation communities. Table 17 (Appendix D) indicates that the maximum drawdown limit for many of the GDE indicator species is 0.1 m / year and the current models (Figure 2, *Response to submissions*) show drawdown of between 0.1 m and 0.5 m potentially occurring within up to 600 m from the bores. This is potentially a significantly larger area of impact that was assessed in the PER documentation and it may impact more flora species, and therefore vegetation communities, than was originally considered in the PER. After confirming with DoW that the model used for estimating drawdown of superficial aquifer is fit-for-purpose, the proponent should present the drawdown contours to 0.1 m with an overlay of vegetation communities containing susceptible indicator species as per Appendix D (i.e. any flora that may be impacted by a drop in the water table of 0.1 m or greater within a 1 year period) and assess the impacts to shallow rooted GDE species and the associated vegetation communities. As discussed previously, the proponent should also commit to monitoring these GDEs, collecting baseline data and developing appropriate management triggers / actions.

Furthermore, the bore proposal includes provision for "turkey's nests" and limited information is included with respect to any clearing required for this purpose or any potential impact on wetlands from the "turkey's nests". The proponent should avoid clearing of native vegetation for "turkey's nests" and they should be located such that there are no impacts to wetlands.

Response to public submissions – Management of impacts to wetlands (p. 27 and p. 29)

Recommendation: *That the proponent designs the final stormwater system to minimize impacts on wetlands and native vegetation communities. The final stormwater system should be designed to mimic natural sheet flow in high rainfall events, as far as possible, by ensuring that the number of culverts and their design is appropriate. Drainage basins*

should be appropriately located to avoid impacts from groundwater mounding on wetlands.

Recommendation: *That the final stormwater system design be endorsed by DoW and consider the advice of DEC's Wetlands Section with respect to potential impacts on high conservation value wetlands.*

Discussion: The *Response to public submissions* states that "*It is not expected that culverts will affect sheet flow. The culverts may cause heightened flow rates and volumes, potentially causing scours and sedimentation*" (p. 27). These two sentences appear conflicting, as heightened flow rates and volumes are a change to the natural sheet flow. This also suggests, that while "*heightened flow rates and volumes*" will occur at the culverts, other sections without culverts will experience a sheet flow "shadow" effect. Again, the proponent's response defers these matters to be addressed at the final design phase and refers to the WMS, which does not adequately address monitoring or management in relation to this matter.

Based on the information provided by the proponent, it appears that natural sheet flow will be impacted in heavy rain events. The proponent has not adequately considered the significance of these heavy rain events and the associated sheet flow for the wetlands and their connectivity, as well for other vegetation communities. These sheet flow events may be significant in sustaining some flora species and the "shadow" effect caused by the road should be addressed through the implementation of appropriate stormwater management. Culvert designs which spread the surface water flow and mimic natural sheet flow in high rainfall events, as far as possible, should be implemented.

The *Response to submissions* states that "*It is envisaged that oil / water separators and gross pollutant traps will be installed as part of the final design*" (p. 29). The WMS states that "*Later phases of project design may identify the need for subsoil drainage, and potential impacts on local groundwater should be considered and addressed*" (p. 53). Although many such statements about various stormwater management measures are made throughout the *Response to submissions* and WMS, it is repeatedly stated that these matters will be addressed at further planning stages. A full assessment of the potential impacts of the proposal on wetlands cannot be made without this level of detail. The final stormwater design needs to be reviewed in detail by DoW, in consultation with DEC with respect to wetlands and other vegetation communities potentially impacted.

Water Management Strategy - 4.1.2.2 Compaction effects (p. 52)
Recommendation: *That, in consultation with DoW, the proponent clarifies whether the compaction effects modeled on the basis of "clean sand" can be equated to the compaction effects that would apply on the complex soils within the project area, and subsequently clarifies the impacts on wetlands from soil compaction potentially causing changes to the hydrology.*

Discussion: The WMS states that "*Clean sands typically have porosities in the range 30-45%. If the upper bound of modeled porosity reduction (3%) is applied, then the resultant porosity would be approximately 29-43.5%. This level of change, applied across only the upper few metres of an aquifer unit that this typically 35-40m thick in the project area, would have no discernable impact on aquifer permeability or subsequent groundwater levels and flows (at a local or regional scale)*" (p. 52). Appendix G states

that "*The combined effects of limestone lenses, diatomite fills, kaolin clays, buried wetland sediments, interlayered very coarse, coarse, and medium to fine sands, and diagenesis have increased the sedimentary and stratigraphic complexity of the North and Bibra Lakes area*" (p. 62). Given that the compaction effects were considered in relation to "clean sand" and not the complex soils of the North and Bibra Lakes area, it is unclear how this would be applied in the context of the complex soils in the project area and what the implications are for the wetlands adjacent to the project area.

Appendix D also states that "*Cuts-and-fills will permanently change the hydrological properties of the shallow stratigraphic layers that either perch or retard vadose percolation*" (p. 63). This matter also does not appear to be adequately addressed in the proposal documents.

Water Management Strategy – Table 5.3.4 Roles and Responsibilities (p. 61)
Recommendation: *That, in the absence of any consultation by the proponent with DEC with respect to the monitoring program, the proponent removes all reference to DEC in Table 5.3.4 Roles and Responsibilities (p. 61).*

Discussion: Table 5.3.4 *Roles and Responsibilities* (p. 61) states that "*Monitoring of potential impacts on surface water and groundwater will be the responsibility of Main Roads for an initial post construction period, after which any ongoing responsibilities will be reverted to DEC.*" DEC has not been consulted with respect to this monitoring program, nor is it currently resourced to undertake this work. This statement should be removed from the WMS.

Environmental Management Branch
Department of Environment and Conservation
October 2012

ATTACHMENT 4

Comments on Response to public submissions for Roe Highway Extension (EPBC 2009/5031)

Prepared by: Mick Welsh
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Date: 18 September 2012

Please see the department's comments below on the response to public submissions for the Roe Highway extension, and appendices, that were provided to the department by post from Mr Gerard Obrien (WA EPA) in August 2012.

Document	Page / part of document	Issue	Comment
Response to Public Submissions	Response to Submission 7.2-6:	Discussion of 'non-viable' GSM habitat.	The text should be changed to: The term 'non-viable' will be removed from this statement in Table 6.7-6 of the PER.
Revegetation Strategy	6.6.1	The list of species that won't be planted near roads only lists 5 plant species	This list should include all known primary foraging species for CBC and FRTBC. Appendix B has such plant species. Appendix A includes species that are foraging habitat for black cockatoos.
	Naming of Appendixes within this document	Confusing because this document is in itself an 'Appendix'	Suggest using the term 'attachment' for things attached to this document.
	6.7	Mentions revegetation program away from Roe Highway.	Will black cockatoo habitat be planted here, or anywhere else? How much?
	Section 8.0	Discusses completion criteria	Must include specific commitment to actions relating to completion criteria.
Offset Policy	4.2 (Page 9)	Discussion of offset ratios required by the department for the clearing of black cockatoo habitat	This is old advice from the department (ie 2010 or before), does not necessarily reflect the current views of the department, and may not be relevant under the new offset policy. This section and should either removed or modified and expressed as: "previous proposals involving the clearing of black cockatoo habitat were approved provided that offsets of the following ratios were provided..."
	4.2 (Page 9)	Discussion on offset policies under the EPBC Act	The new policy (which is likely to be approved very shortly) will include an offset calculating tool. This tool will have to be used to determine the adequacy of offsets for EPBC listed threatened species.
	Offset proposal 1 and 3	Offset for black cockatoos	Offset likely to be roughly acceptable under the new offset policy, although the quantum may need to be slightly greater, include revegetation or their may need to be funding for management of the land to improve the habitat value gain.
	Offset proposal 2 and 5	Offset for water birds (including migratory species)	Offset seems adequate for EPBC migratory species

	Offset proposal 4	GSM offset	Offset may not be adequate under new offset policy because much of the offset is 'indirect' (ie research and surveys). The plan does not state how much GSM habitat will be managed or improve, and it is unclear if GSM habitat occurs on the offset site proposed (offset proposal 1) so the adequacy of the offset cannot be determined at this time. The Response to public submissions mentions on page 79, that the GSM population on site may be made unviable because it will be reduced in size. There appears here an opportunity for a positive environmental outcome by better managing the existing (albeit smaller) population, which may be unviable if not properly managed. Has there been any discussion with DEC about how this could be managed, or any chance this GSM habitat could be ceded to the DEC for conservation?

Note. CBC = Carnaby's Black Cockatoo, FRTBC = Forest Red-tailed Black Cockatoo, GSM = Graceful Sun Moth, EPBC = *Environment Protection and Biodiversity Conservation Act 1999*.

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Amendments

Appendix C

Amendments

Appendix C Amendments

Appendix C – Amendments to previous draft response to submissions document for Roe Highway Extension

Changes, amendments and additions to this draft of the SMC Roe Highway Extension Response to Submission document since the 13 July 2012 draft are described in Table C-1.

Section/Submission	Changes
1.2.2 OEPA	This section has been added to explain OEPA's request for additional information
1.3	The description of the document structure has been amended to describe the new section and appendices included
2.2 – Table 1	Key characteristics table amended to include 1.5km buffer on groundwater abstraction around Bibra Lake and North Lake
Submission 2.2-9	Amended to include 1.5km buffer on groundwater abstraction around Bibra Lake and North Lake
Submission 3.1-8	Amended to include 1.5km buffer on groundwater abstraction around Bibra Lake and North Lake
Submission 3.2-5	Amended to include commitment for 2% bioretention component in infiltration basins
Submission 4.0-3	Amended to include bioretention component in all infiltration basins
Submission 6.2-3 & 6.2-6	Amended following advice from DEC
3.7	Responses regarding GSM amended to reflect revised conservation status
3.12	Responses to offset submissions amended following changes to offset policies
Figure 6	Amended following November 2012 targeted flora surveys
5.	Section added to address OEPA's request for additional information
Appendix B	Added to provide context for amendments to previous draft of response to submissions
Appendix C	Added appendix to list changes between the 13 July 2012 draft and this document
Appendix D-G	Appendix number amended due to the inclusion of Appendices B & C
Appendix E	Water Management Strategy has been amended to reflect the requests of OEPA in Appendix B
Appendix H	2012 targeted survey for sucking millipedes has been included
Appendix I	The Offset Strategy has been amended following changes to offset policies and consultation with the OEPA and DSEWPaC
Appendices I & J	Appendix number amended due to included appendices
Appendix K-O	Appendices added to provide additional information to support the response to the OEPA's comments and questions

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Wetland Buffer Study

Appendix D

Wetland Buffer Study

Appendix D Wetland Buffer Study

Roe Highway Extension
Main Roads Western Australia
15 June 2012

Wetland Buffer Study

Roe Highway Extension



Wetland Buffer Study

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Quality Information

Document Wetland Buffer Study

Ref 60100953

Date 15 June 2012

Prepared by John Braid and Gaby Martinez

Reviewed by Jane Latchford

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
A	18-May-2012	Draft for Internal Review	Jane Latchford Associate Director - Environment	
0	15-Jun-2012	Final	Jane Latchford Associate Director - Environment	

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Guideline for the Determination of Wetland Buffer Requirements A

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Executive Summary

Main Roads Western Australia proposes to extend the Roe Highway from its current terminus at the Kwinana Freeway in Jandakot to Stock Road in Coolbellup (Roe Highway Extension). The Roe Highway Extension will complete a strategic link in Perth's road network, and will also provide a southern access to the Murdoch Activity Centre including the soon to be constructed Fiona Stanley Hospital.

Roe Highway Extension was referred to the Environmental Protection Authority (EPA) under the *Environmental Protection Act 1986* (EP Act) and to the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) under the Federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in 2009. The project is being assessed as a Public Environmental Review (PER) under the Bilateral Agreement between the State and Commonwealth.

The PER document was submitted to the EPA on 20 June 2011 for public comment. This wetland buffer study is in response to a number of submissions and comments questioning the size of the wetland buffer used in the assessment of impacts upon wetlands in the PER. A buffer of 50m was used to determine the extent of impacts on wetlands and their buffers in the PER (SMC, 2011). This is the minimum accepted buffer to protect wetlands of conservation significance (EPA, 2008). However, a 200m buffer was recommended in one of the supporting studies to the PER, to protect the hydrology of the wetlands (Syrinx & VCSRG, 2011). SMC does not support this 200m buffer, as a buffer is not an appropriate mechanism for managing water levels and hydrology (WAPC, 2005).

This study aims to determine the existing buffer for each wetland within the project area, based on the functions, values and attributes of each wetland and the ability of the surrounding land use to provide a buffer function. The methodology used follows the draft "Guideline for the Determination of Wetland Buffer Requirement" prepared by the West Australian Planning Commission (WAPC) in 2005 (Appendix A). This guideline provides a seven step process for determining a wetland buffer for all wetland types. This guideline has not been finalised but as it is the most current document for wetland buffer determination it has been used for this study.

The PER stated there would be a direct impact of 5.8 ha to CCWs as well as a 5.4 ha to the assigned CCW buffers (SMC, 2011). However, by using a value based approach study recommended by WAPC, which recognises key threatening processes and key attributes which are critical to the preservation of each wetland's management category objective; this study has identified there will only be a direct impact of approximately 2.0ha of CCW and 1.6ha of RE assigned wetland buffers. This is a reduction of 3.4 ha of direct impact on the 50m CCW buffers, as assessed in the PER. The reduction is mainly attributed to the fact that two wetlands within the Roe Highway Extension project area do not have an existing or assigned buffer in place due to adjacent land uses and pre-existing development. The overall impact on CCWs remains unchanged at 5.8 ha as delineation of wetland boundaries as mapped in DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset has not changed since publication of the PER.

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1.0 Introduction

1.1 Background

Main Roads Western Australia proposes to extend the Roe Highway from its current terminus at the Kwinana Freeway in Jandakot to Stock Road in Coolbellup (Roe Highway Extension). The Roe Highway Extension will complete a strategic link in Perth's road network, and will also provide a southern access to the Murdoch Activity Centre including the soon to be constructed Fiona Stanley Hospital.

The Roe Highway Extension is justified within the context of Perth's forecast urban and industrial growth to 2031 and within the overarching strategic plan for accommodating this growth. Perth's transport needs highlight the importance of transport infrastructure in facilitating continued growth.

Roe Highway Extension was referred to the Environmental Protection Authority (EPA) under the *Environmental Protection Act 1986* (EP Act) and to the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) under the Federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in 2009. The project is being assessed as a Public Environmental Review (PER) under the Bilateral Agreement between the State and Commonwealth.

In August 2009, Main Roads Western Australia and industry partners, AECOM Australia, formed the South Metro Connect (SMC) alliance. The team was created for the development phase of the Roe Highway Extension project. Its primary objective is to work collaboratively with specialist consultants, stakeholders and regulatory authorities to develop an environmentally, socially and economically acceptable project design in order to obtain relevant statutory approvals.

This wetland buffer study is in response to a number of submissions and comments questioning the size of the wetland buffer used in the assessment of impacts upon wetlands in the PER. This study aims to determine the existing buffer for each wetland within the project area, based on the functions, values and attributes of each wetland and the ability of the surrounding land use to provide a buffer function.

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2.0 Objectives

The objective of this study is to determine the existing buffer area of each of the wetlands within the Roe Highway Extension project area using a systematic, logical approach, in order to determine the total impact of Roe Highway Extension on wetlands and wetland buffers. The buffers will be calculated based on current management and land use to determine the extent of the existing buffer.

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3.0 Existing Wetlands

3.1 Eastern Chain of Beeliar Wetlands

The alignment of the proposed Roe Highway Extension intersects the eastern chain of the Beeliar Wetlands within Beeliar Regional Park. The eastern chain of Beeliar Wetlands encompasses North Lake, Bibra Lake, South Lake, Little Rush Lake, Yangebup Lake, Kogolup Lake, Thomsons Lake and Banganup Lake (within the City of Cockburn), Blue Gum Lake, Booragoon Lake and Piney Lakes (within the City of Melville), and the Spectacles (within the Town of Kwinana) (Dooley *et al*., 2006). The wetlands that will be impacted by the proposed Roe Highway Extension are as follows:

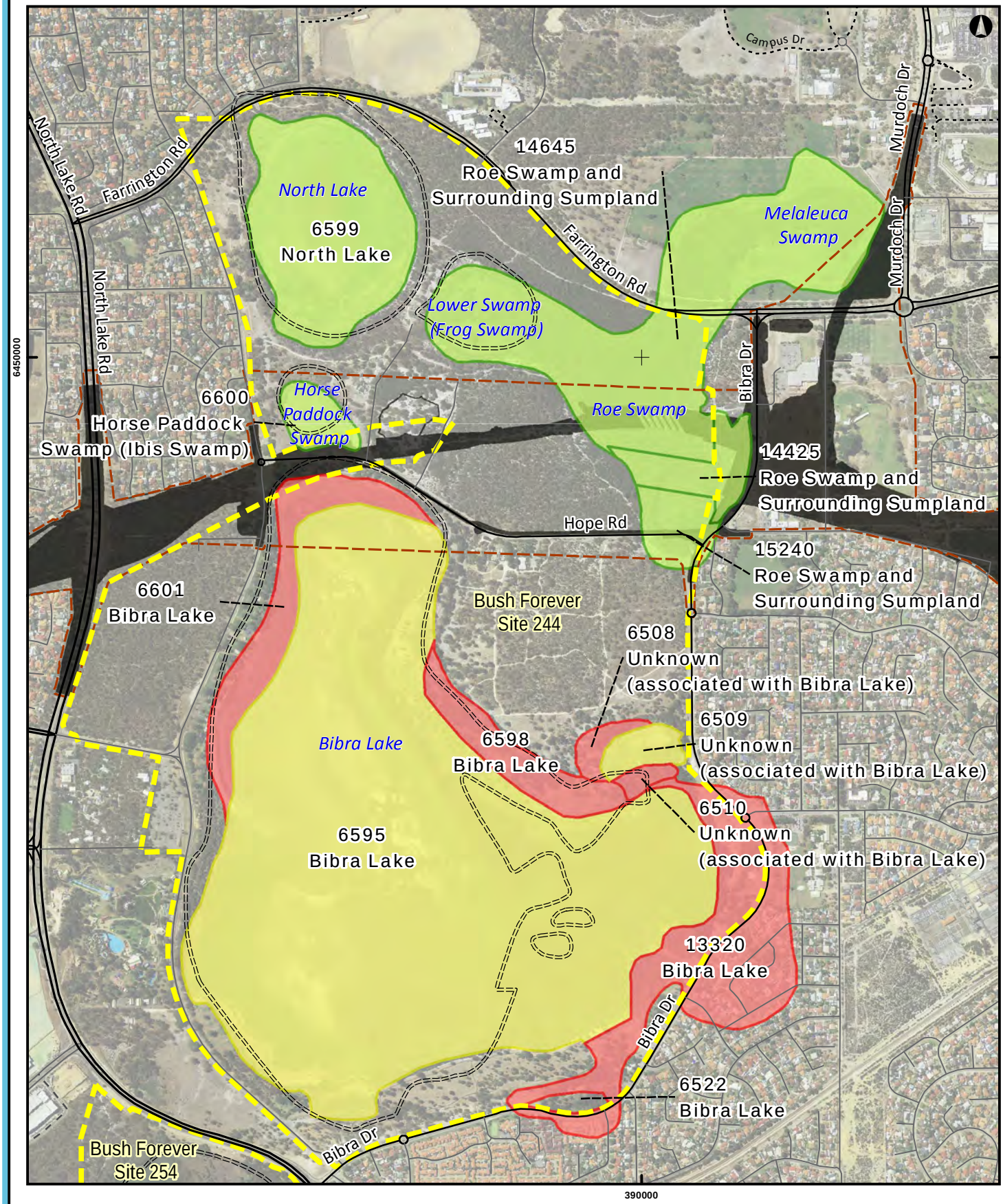
- Bibra Lake (UFIs 6595 and 6601)
- Roe Swamp and surrounding sumplands (UFIs 15240, 14425 and 14645); and
- Horse Paddock swamp (UFI 6600).

The alignment of the proposed Roe Highway Extension runs between North Lake and Bibra Lake (Figure 1). This area is located in a depression at the interface of two major dune systems, the Bassendean and Spearwood system. In addition to the two large lakes, the area also supports several smaller, ephemeral wetlands (EPA, 2003). The wetlands mapped in the *Geomorphic Wetlands of the Swan Coastal Plain* dataset that occur within the project area and in the immediate vicinity are listed in Table 1.

Table 1 Geomorphic Wetlands within and in the immediate vicinity of the proposed Roe Highway Extension

UFI	Wetland Name	Classification	Evaluation	Location
6595	Bibra Lake	Lake	Resource Enhancement	Northern most portion of this wetland is within proposed alignment
6522	Bibra Lake	Lake	Resource Enhancement	Approximately 1.5 km South of alignment
6601	Bibra Lake	Lake	Multiple Use	Within alignment
6598	Bibra Lake	Lake	Multiple Use	Approximately 340m South of alignment
13320	Bibra Lake	Lake	Multiple Use	Approximately 760m South of alignment
6508	Unknown (associated with Bibra Lake)	Sumpland	Multiple Use	Approximately 450m South of alignment
6509	Unknown (associated with Bibra Lake)	Sumpland	Resource Enhancement	Approximately 475 m South of alignment
6510	Unknown (associated with Bibra Lake)	Sumpland	Multiple Use	Approximately 600m South of alignment
6600	Horse Paddock Swamp	Lake	Conservation	Within alignment
15240	Roe Swamp and surrounding sumplands	Sumpland	Conservation	Within alignment
14425	Roe Swamp and surrounding sumplands	Sumpland	Conservation	Within alignment
14645	Lower Swamp (Frog Swamp) and Melaleuca Swamp	Sumpland	Conservation	Partially within alignment
6599	North Lake	Lake	Conservation	Approximately 80m North of alignment

NB: It must be noted that the DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset identifies wetlands (UFIs 6508, 6509 & 6510) as Roe Swamp and Surrounding sumplands. However all of the literature reviewed to date refers to wetlands (UFIs 15240, 14425 & 14645) as being Roe Swamp and Surrounding sumplands. For the purposes of this document wetlands (UFIs 15240, 14425 & 14645) will be referred to as Roe Swamp and Surrounding sumplands.



Locality

SouthMetro Connect

Figure 1

Coordinate System: GDA 1994 MGA Zone 50

0 100 200 300 400 500

Metres

1:15,000 (A4)

LEGEND

- Project Area
- Construction Footprint
- Bush Forever Sites
- EPP Lakes

Geomorphic Wetlands

- Conservation Category Wetland
- Resource Enhancement Wetland
- Multiple Use Wetland

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SouthmetroConnect

3.1.1 North Lake

The Department of Environment and Conservation's (DEC) *Geomorphic Wetlands of the Swan Coastal Plain* dataset classifies North Lake (UFI 6599) as a Lake (permanently inundated basin) with a management category of Conservation Category Wetland (CCW). CCW are the highest priority wetlands for conservation as they support a high level of ecological attributes and functions.

North Lake is a large lake with steep sides. At its deepest point it is 12.4m AHD on the eastern side. The Lake is a groundwater expression of the western Jandakot groundwater mound, with groundwater flow entering the lake through the sandy eastern shore. A drain connects North Lake to Roe Swamp (EPA, 2003). Fringing wetland vegetation surrounds the lake.

The wetland vegetation is described as being part of the Herdsman Complex (DCE, 1980). The fringing vegetation is described as *Eucalyptus rudis* and *Melaleuca rhaphiophylla* open forest or open woodland (Syrinx & VCSRG, 2011).

North Lake lies within Bush Forever Site 244 and is also protected under the *Environmental Protection (Swan Coastal Plain Lakes) Policy* 1992 (EPP Lakes) (Figure 1). This policy prohibits the filling, mining, pollution or changing of drainage into or out of wetlands without assessment and approval by the Environmental Protection Authority (EPA) and approved by the Minister for the Environment.

3.1.2 Roe Swamp and Surrounding Sumplands

Roe Swamp and Surrounding Sumplands (UFIs 15240, 14425 & 14645) are ephemeral CCW sumplands (seasonally inundated basins), located to the east of North Lake and within the boundaries of Bush Forever Site 244 (Figure 1). The western portion of Frog Swamp is also protected under the EPP Lakes. Sections of Roe Swamp and Surrounding Sumplands are known by a variety of names, including Melaleuca Swamp, Lower Swamp (Frog Swamp) and Roe Swamp. For the purposes of this report, the names used for the various parts of Roe Swamp and Surrounding Sumplands are as follows:

- Melaleuca Swamp – part of UFI 14645 north of Farrington Road
- Lower Swamp (Frog Swamp) – part of UFI 14645 south of Farrington Road
- Roe Swamp UFI 14425 – UFI 14425
- Roe Swamp UFI 15240 – UFI 15240

Despite the surrounding urban development, these sumplands have remained relatively unaltered in terms of its hydrological regime and vegetation cover with the exception of Murdoch Drain (EPA, 2003). Murdoch Drain is an anthropogenic (man made) feature which runs from Melaleuca Swamp into Lower Swamp (Frog Swamp) and ultimately into North Lake. The drain has intercepted the water table at some points and carries a baseline flow of groundwater for much of the year (SMC, 2011).

Vegetation in Lower Swamp (Frog Swamp) and Roe Swamp is generally *Eucalyptus rudis/ Melaleuca rhaphiophylla/ M. preissiana* closed forest, with *Typha orientalis* closed sedgeland in areas of once open water. The vegetation in Melaleuca Swamp has a smaller component of *E. rudis,* with woodlands of *Melaleuca rhaphiophylla* and *M. preissiana* (SMC, 2011).

3.1.3 Bibra Lake

Bibra Lake is one of the largest lakes in the Beeliar system and it is mostly open water and an expression of groundwater levels on the western side of the Jandakot Mound. It is located within Bush Forever Site No. 244 and is protected under the EPP Lakes Policy. Bibra Lake has been broken up into a number of management categories in the DECs *Geomorphic Wetlands of the Swan Coastal Plain* dataset (Figure 1). The dataset classifies Bibra Lake (UFIs 6595 & 6522) as Lakes (permanently inundated basins) with a management category of Resource Enhancement Wetlands (REW). REWs are priority wetlands which have been partially modified but still support substantial ecological attributes and functions with the ultimate objective being for management, restoration and protection towards improving their conservation value.

Bibra Lake UFIs 6601, 6598 & 13320 are classified as lakes and have a management category of Multiple Use Wetlands (MUW). MUW usually have only a few wetland attributes and functions remaining. Their use, development and management should be considered in the context of ecologically sustainable development and best management practice catchment planning through landcare. There are an additional three sumpland wetlands (UFIs 6508, 6510 & 6509) adjoining Bibra Lake which are unnamed, two of which are classified as MUWs (UFIs 6508 & 6510) and one which is classified as a REW (UFI 6509) (Table 1).

The various management categories within Bibra Lake reflect its history of disturbance by human activities. Up until recent times Bibra Lake had been used as a landfill at several sites around the shore (Cockburn Wetlands Study, 1976). Anecdotal evidence suggests that a channel for navigation was dredged along the western shore at some point in the past, possibly breaching the semi-impermeable lake deposits and altering hydrology. Currently the western shore of Bibra Lake is grassed and used for picnicking, walking, running, cycling, bird watching and other forms of passive recreation.

Vegetation types and composition varies greatly around the extremity of Bibra Lake. In the vicinity of the Roe Highway Extension project area, (northern end of Bibra Lake) vegetation consists of *Typha orientalis* Sedgeland, with *Juncus pallidus* and occasional trees of *Melaleuca rhaphiophylla, M. teretifolia, Eucalyptus camaldulensis* and *Corymbia calophylla*. Vegetation condition is described as Completely Degraded to Degraded – Completely Degraded.

3.1.4 Horse Paddock Swamp

Horse Paddock Swamp (UFI 6600) is a degraded, cleared, ephemeral lake located between Bibra Lake and North Lake. The wetland is aptly named as it resembles a horse paddock. However this wetland is a CCW, which affords it the highest level of protection for wetlands on the Swan Coastal Plain. It is also protected under EPP SCP Lakes Policy and is within Bush Forever Site 244 (Figure 1).There is no remnant vegetation within the designated wetland area, except for occasional *Eucalyptus rudis* and *Melaleuca rhaphiophylla* on the fringes. The vegetation condition is described as Completely Degraded (SMC, 2011).

Horse Paddock Swamp has unusual hydrology when compared to other wetlands in the Bibra/North Lake area. Most of these wetlands are surface expressions of groundwater and water levels are almost entirely reliant on groundwater. Horse Paddock Swamp is not connected to groundwater and is filled through surface flows. There has been limited surface water in Horse Paddock Swamp in recent years, primarily due to the drying climate in Perth resulting in lower overland flows. Also stormwater drainage into Horse Paddock Swamp has been modified in the suburbs to its west, resulting in lower flows into the wetland.

4.0 Wetland Buffers

A wetland buffer is the area that surrounds a wetland and reduces the adverse impacts on wetland functions and values from adjacent land uses (Castelle *et al.*, 1992). Balla (1994) defined a wetland buffer as:

"A surface catchment buffer is a zone of vegetation which begins at the transition from wetland vegetation to upland vegetation and extends radially outward from a wetland" (Balla, 1994). In other words, buffer distances are measured from the outside extent of the wetland dependent vegetation to the outside edge of any proposed development or activity.

Buffers are designed to protect wetlands from potential deleterious impacts while helping safe guard and maintain ecological processes and functions within the wetland and, wherever possible, in the buffer. Buffer composition should comprise of under-storey vegetation (grasses, reeds and sedges), over-storey (tall shrubs, trees) and carbon rich litter matching the density and diversity of undisturbed local native vegetation (DoW, 2006). A wetland buffer provides protection to the attributes, functions and values of a wetland through:

- maintaining water quality
- flood control
- protection from erosion
- providing wildlife habitat
- protection from weed invasion
- allowing a wetland to adjust to changing water levels via the expansion and contraction of plant communities.

Wetland buffers are also used to protect the community from the potential impacts such as nuisance midge or mosquito problems.

The size of the buffer will be dependent on the values of the wetland and the threatening processes that may affect the wetland (Castelle *et al.*, 1992). In Western Australia the DEC's policy of a wetland buffer is for a minimum 50m buffer (WRC, 2001 & EPA, 2008). Alternatively a site specific buffer requirement may be determined. Buffer widths vary based on several factors including: existing wetland functions, values and attributes; buffer characteristics and land use, but generally buffer effectiveness increases with size. The buffer width does not need to be uniform around the entire wetland as adjacent land uses may reduce the buffer width in some locations (Castelle *et al.*, 1992).

Open spaces such as parks and ovals or pasture are not considered to be effective buffers (Balla, 1994). Grass can have a contaminant and nutrient stripping function, however it is unable to provide functional habitat for wildlife, prevent significant erosion due to its shallow root systems, slow or stop weed invasion and is also likely to actually contribute nutrients to the wetland through fertilisers (DoW, 2006).

Furthermore, catchment management plays a significant role in the management of wetland water levels. A buffer cannot protect a wetland from all threatening processes, in particular changes in water quantity in urban catchments (Castelle *et al.*, 1992). Clearing in the catchment often results in more water within a wetland. Urban catchments often cause a higher than natural volume of water to enter wetlands, due to the increase in impervious surfaces in the catchment and lack of groundwater infiltration (Balla, 1994).

A 200m hydrological buffer as suggested by Syrinx & VCSRG (2011) to protect the hydrology of the North Lake/Bibra Lake/Roe Swamp wetlands is not supported. Buffering is not an appropriate management measure to influence wetland water regimes, from either surface water or groundwater (WAPC, 2005). The impacts of changes to the water regime on a wetland are better managed at catchment level (Balla, 1994). There are many factors within a catchment that affect the water regime of a wetland including land clearing, water use, drainage and changes in land use (EPA, 2007, Froend *et al.*, 1993). The quantity of water entering a wetland is dependent on the entire catchment, its surface flows and groundwater inputs. A buffer of 50-200m around a wetland is useful for preserving ecological processes in the wetland and buffering the wetland from local impacts, but it can not significantly affect the quantity of water entering the wetland from the groundwater catchment (WRC, 2000 & Balla, 1994).

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5.0 Methodology

Currently in Western Australia, there is no formal guideline specifically for the determination of a wetland buffer, although DEC and the Department of Planning (DoP) are currently in the process of preparing one. EPA (2008) and WRC (2001) recommend a minimum buffer distance of 50m for those wetlands that are going to be protected, however they also suggest a site specific wetland buffer can be determined.

The West Australian Planning Commission (WAPC) prepared a draft "Guideline for the Determination of Wetland Buffer Requirement" for public comment in 2005 (WAPC 2005; **Error! Reference source not found.**). This guideline provides a seven step process to determining a wetland buffer for all wetland types. This guideline has not been finalised but as it is the most current document for wetland buffer determination it has been used for this study.

The wetland buffers in the project area of the proposed Roe Highway Extension will be determined using the seven step methodology in WAPC (2005). The WAPC (2005) seven step process is summarised below:

- Step 1: Acknowledge that a wetland exists
- Step 2: Identify wetland attributes, management category and establish management objective
- Step 3: Define wetland function area
- Step 4: Identify threatening processes
- Step 5: Identify role of separation
- Step 6: Establish separation requirement
- Step 7: Apply separation requirement to proposal and assess ability of separation to achieve management objectives.

The buffer assessment process will follow the seven step method in WAPC (2005), with the following constraints:

1) The wetland management categories used will be in accordance with the DEC's *Geomorphic Wetland of the Swan Coastal Plain* dataset. This buffer assessment does not attempt to challenge DEC's wetland management category or boundary classifications.

2) Wetland function area (Step 3) will be the wetland boundary as described in DEC's *Geomorphic Wetland of the Swan Coastal Plain* dataset. Lakes defined under EPP Lakes Policy do not fall under the definition of wetland function area for this study.

3) Altered water regime is not considered as a threatening process in order to determine buffer size. WAPC (2005) describes "altered water regime" as a threatening process that can be mitigated by buffering. However it then states that catchment management is the only way to manage water regime and does not recommend a buffer size to manage for "altered water regimes".

4) The maximum proposed buffer size will be 100m. This is due to the fact that the area has already been disturbed in the past and is already being impacted by edge effects and weed infestation. WAPC (2005) recommends a buffer of 100m for weed infestation, up to 100m for avifauna habitat and greater than or equal to 100m for edge effects for conservation category wetlands. Given that there is disturbance inside the 100m buffer for all wetlands in the area; greater buffer distances to prevent edge effects are not considered appropriate.

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6.0 Wetland Buffer Assessment

An assessment of the total area of wetlands to be impacted within the project area was conducted in the PER (SMC, 2011). This study determined that the proposed Roe Highway Extension will directly impact 5.8 ha of CCW entity as mapped in DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset as well as 5.4 ha of CCW buffer. The PER states that there will be no direct impact on REW or MUW category wetlands, however, there will be indirect impacts on their wetland buffers (Table 2). Not all the wetlands listed in Table 1 will be directly impacted by the project, but as they are all in close proximity to the project area their buffer may be impacted by the proposal.

The wetlands listed in Table 2 have been amended from those listed in Table 1. Only wetlands or wetland buffers that will actually be impacted by the Roe Highway Extension have been included in this buffer assessment. Roe Swamp and Surrounding Sumplands (Lower Swamp (Frog Swamp) and Melaleuca Swamp) as described in section 3.1.2 have been assessed as four separate wetland areas for the purpose of determining a buffer. The Roe Swamp and Surrounding Sumplands have already been classified as three separate wetlands in DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset (Figure 1). In this study, wetland (UFI 14645) has been broken into Lower Swamp (Frog Swamp) which is located on the western part of Roe Swamp, nearest to North Lake and Melaleuca Swamp (north of Farrington Road) for assessment of wetland buffers, due to the different land use and management surrounding the wetlands on either side of Farrington Road.

Table 2 Roe Highway Extension Wetlands – classification, evaluation and predicted area of impact within wetland mapped area in accordance with DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset (SMC, 2011)

Wetland Name	UFI	Classification	Evaluation	Area of Impact within DECs wetland mapped area in PER (ha)
Bibra Lake	6595	Lake	REW	0
Bibra Lake	6601	Lake	MUW	0
Horse Paddock Swamp	6600	Lake	CCW	0.2
North Lake	6599	Lake	CCW	0
Roe Swamp	15240	Sumpland	CCW	5.4
Roe Swamp	14425	Sumpland	CCW	0
Lower Swamp (Frog Swamp)	14645 (part)	Sumpland	CCW	0
Melaleuca Swamp	14645 (part)	Sumpland	CCW	0.2
TOTAL				**5.8**

An assessment of the buffer size for all the wetlands listed in Table 2 is conducted in the following sections of this report.

6.1 Bibra Lake (UFI 6595)

6.1.1 Step 1 - Acknowledge Existence of Wetland

Bibra Lake is located in the eastern chain of the Beeliar wetlands and is classified in DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset as a lake with unique feature identifier (UFI) number 6595. The existence of the wetland is acknowledged in SMC (2011).

Bibra Lake UFI 6595 is the main water body of Bibra Lake and is one of the largest lakes in the eastern Beeliar wetland system. The lacturine deposits of Bibra Lake are fairly impermeable, except for sandy shores on the western edge and a dredged channel. Surface water remains in the lake in most summers, although it does occasionally dry out. Bibra Lake is primarily fed by groundwater, although it does receive surface flows from stormwater drains.

6.1.2 Step 2 - Identify Wetland Attributes, Management Category and Establish Management Objective

6.1.2.1 Has a wetland management category been assigned?

Bibra Lake (UFI 6595) is a Resource Enhancement wetland and the objective for this category is to restore wetlands through maintenance and enhancement of wetland functions and attributes. It is also classed as an EPP Lake, is protected under the EPP Lakes Policy and forms part of Bush Forever Site 244 (Figure 1).

6.1.2.2 Are existing wetland values, processes, functions and attributes consistent with the assigned management category?

Bibra Lake (UFI 6595) is recognised as a significant and important lake within the southern suburbs of Perth. It has both natural functions and recreational values that are important to the community. Whilst there are significant natural functions and values, it is the recreational use of the lake that dictates that the management category of Resource Enhancement is appropriate.

Bibra Lake (UFI 6595) is located within the Beeliar Regional Park and is managed for Parks and Recreation.

The review of the justification for the Resource Enhancement management category identified the following key values, processes and attributes for Bibra Lake (UFI 6595):

a) Bibra Lake constitutes part of a linked natural system and its destruction would disturb adjacent wetlands or fauna using the system;

b) Supports high habitat diversity;

c) Important for maintaining species and/or ecological diversity;

d) Important regional wildlife sanctuary even if flora/fauna are not rare or endangered;

e) Seasonal or temporary habitat or breeding ground for large numbers of migratory or nomadic animals;

f) Supports extensive areas of emergent and fringing vegetation;

g) Water quantity and quality;

h) Drainage and presence of nutrient sources;

i) Australian heritage commission criteria for natural or cultural history – listed on the (non-statutory) Register of the National Estate;

j) Aesthetics;

k) Visual amenity of open water;

l) Historical, archaeological or cultural significance;

m) Passive recreation

n) Educational significance.

6.1.3 Step 3 - Define Wetland Function Area

Where practicable, the wetland function area is the area required to support the attributes of the wetland (Table 3). In the case of Bibra Lake (UFI 6595) the wetland function area should incorporate all of the fringing wetland vegetation to ensure maintenance of its REW management category and all ecological communities associated with the wetland. The presence of developed residential and industrial land immediately outside of the boundaries of Bush Forever site 244, (west of Progress Drive and east Bibra Drive), means the wetland function area is restricted by pre-existing development.

The vegetation condition surrounding Bibra Lake (UFI 6595) is considered to range from Degraded to Completely Degraded in the vicinity of Hope Road. Remnant vegetation areas within the Bush Forever site separated from the wetland vegetation by degraded areas have been excluded from the wetland function area as they are effectively isolated from the wetland and also are not part of a wetland-upland continuum associated with the wetland. The wetland function area therefore corresponds to the Bibra Lake (UFI 6601) wetland mapped boundary as shown in the *Geomorphic Wetlands of the Swan Coastal Plain* dataset and Figure 2.

6.1.4 Step 4 - Identify Threatening Processes

The key threatening processes for each attribute of Bibra Lake has been examined in Table 3 in accordance with WAPC (2005). Processes that could potentially threaten the significant attributes of this wetland were identified based on consideration of the environmental risks from the surrounding urban land. Based on this assessment the threatening processes requiring a buffer and/or management for Bibra Lake (UFI 6595) are:

- habitat modification
- inappropriate recreational use
- diminished water quality.

Table 3 Key threatening processes for the wetland attributes of Bibra Lake (UFI 6595)

Attribute	Requirement to support attribute	Key Threatening Processes	Role of Buffer	Required Buffer Size
Bibra Lake constitutes part of a linked natural system ,the destruction of which would disturb adjacent wetlands or fauna using the system - *Bibra Lake is part of the Beeliar Wetland chain*	Maintain wetland area	Habitat modification Inappropriate recreational use Diminished water quality	Can link Bibra Lake to buffer areas of Horse Paddock Swamp and Roe Swamp Provides protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m to maintain linkages to Horse Paddock Swamp
Supports high habitat diversity	Maintain representation of all identified ecological communities associated with wetland, to include upland communities abutting wetland vegetation zone	Habitat modification	Protect Bibra Lake from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m fringing vegetation beyond wetland function area
Important for maintaining species and/or ecological diversity	Maintain representation of all identified ecological communities associated with wetland, to include upland communities abutting wetland vegetation zone	Habitat modification	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m fringing vegetation beyond wetland function area
Important regional wildlife sanctuary even if flora/fauna are not rare or endangered – part of Beeliar Regional Park	Support attributes consistent with management objectives	Habitat modification Inappropriate recreational use Diminished water quality	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m fringing vegetation beyond wetland function area
Seasonal or temporary habitat or breeding ground of large numbers of migratory or nomadic animals	Maintain areas of open water, seasonally inundated areas used for breeding and other areas of vegetation likely to be used by species	Habitat modification	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m fringing vegetation beyond wetland function area

Attribute	Requirement to support attribute	Key Threatening Processes	Role of Buffer	Required Buffer Size
Supports extensive areas of emergent and fringing vegetation	Maintain areas containing emergent wetland species and fringing vegetation	Habitat modification Diminished water quality	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m fringing vegetation beyond wetland function area
Water quantity and quality	Maintain or improve accepted water quality	Diminished water quality	Vegetation interception and use of water and/or use of nutrients in surface and subsurface water flows Role highly dependent on hydrogeology and catchment characteristics	Not possible from buffer management
Drainage and presence of nutrient sources	Nutrients leaching into lake by a variety of means including landfill leakage, bird excrement and nutrient loads from surface drainage	Diminished water quality	Seepage from landfill and drainage from urban areas such as stormwater pipes and car park runoff, reduces the efficiency of the buffer to protect from nutrient inputs Role highly dependent of hydrology and catchment characteristics	Not possible from buffer management
Australian heritage commission criteria for natural or cultural history – Bibra Lake (UFI 6595) is listed on the (non- statutory) Register of the National Estate	Maintain natural state of wetland, particularly area of inundation	Habitat modification	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m buffer
Aesthetics	Maintain accepted water levels and fringing vegetation	Habitat modification	A vegetated buffer will add to as well as maintain aesthetic qualities Protection from direct disturbance	50m
Visual amenity of open water - The southern section of Bibra Lake is generally open with expansive views over the water	Maintain accepted water levels	Alteration to the water regime	Can add to as well as maintain aesthetics of wetland function area Protection from direct disturbance or other change/impact to the wetland function area	50m
Historical, archaeological or cultural significance Bibra Lake has cultural significance to indigenous people -	Maintain natural state of wetland, particularly area of inundation	Habitat modification	Protection of wetland features and function integral to cultural values	50m

Attribute	Requirement to support attribute	Key Threatening Processes	Role of Buffer	Required Buffer Size
Archaeological investigations have recorded various materials in the ground between North and Bibra lakes, indicating that these areas were historically used as camping areas (sites 3293, 3709, 4107)		Inappropriate recreational use	Protection from direct disturbance	
Passive recreation - activities include walking, walking the dog, riding bikes and bird watching/observing wildlife	Maintain wetland area Maintain waterbird habitat Maintain of enhance fringing vegetation	Habitat modification	Protection of wetland values and function integral to passive recreation needs	None required Manage through track access
Educational significance - The Bibra Lake area and surrounds are used to study a variety of science topics, relating to the natural environment	Maintain natural state of wetland	Habitat modification	Protection from direct disturbance	50m fringing vegetation beyond wetland function area

6.1.5 Step 5 - Identify Role of Separation

The required buffer size for each attribute was identified based on consideration of key threatening processes identified in Table 3. To summarise, the role of a buffer for Bibra Lake UFI (6595) is to:

- protect from direct disturbance
- provide a linkage to other wetlands or wetland buffers in the area
- indirect benefit of maintaining hydrological and terrestrial processes
- add to aesthetic qualities
- protection of wetland features and functions integral to cultural values and passive recreation needs
- prevent adverse effects on nearby residents aesthetics
- interception and use of water and/or nutrients in surface and subsurface flow.

6.1.6 Step 6 - Establish Buffer Requirement

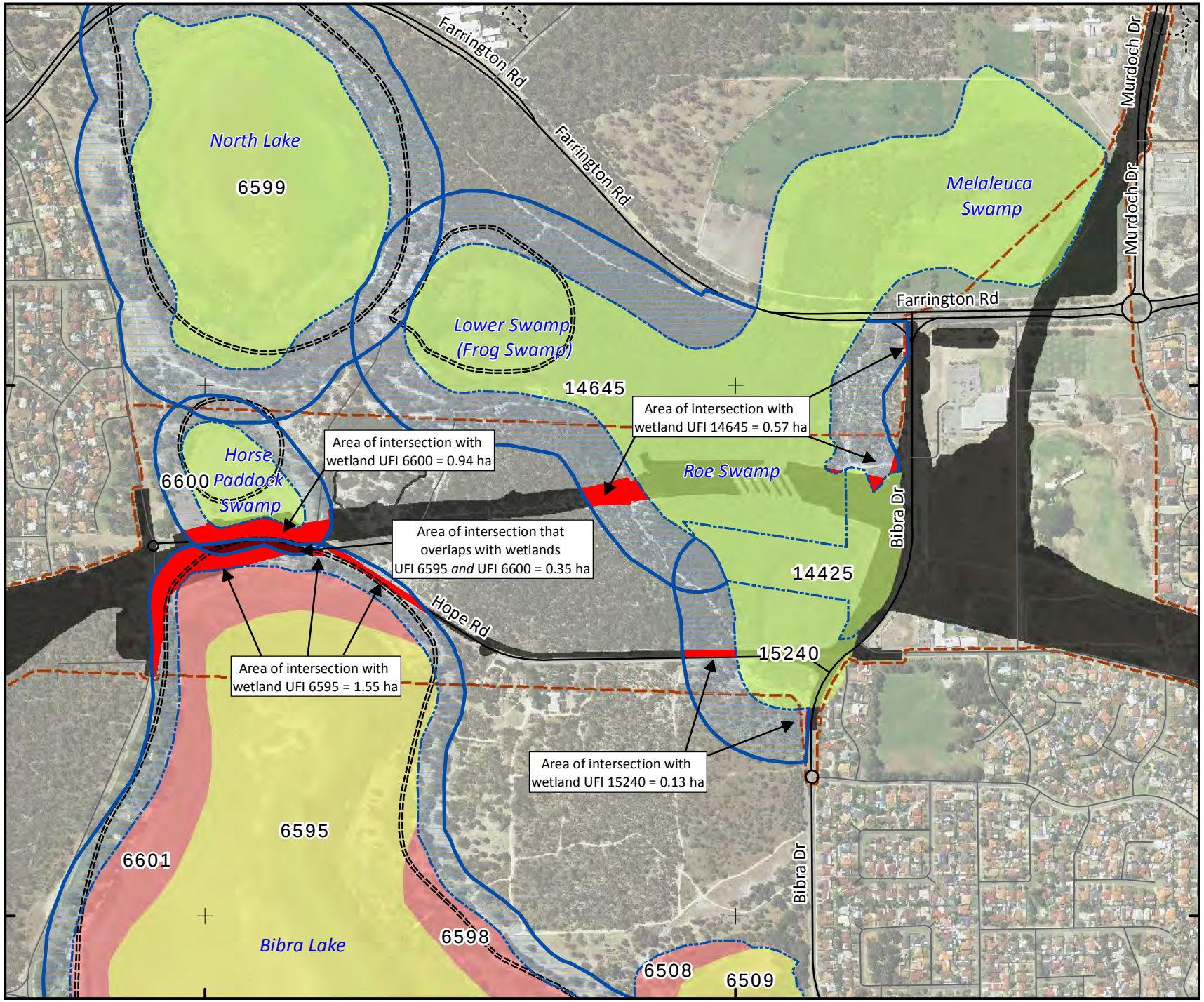
The following buffer distances, in accordance with WAPC (2005) recommended buffer requirements, should be implemented for Bibra Lake (UFI 6595) to maintain a condition consistent with its REW management objective:

- 50m to prevent weed infestation
- 50m to protect bird habitat
- 6 m for firebreak
- 10-50m as a barrier and to improve aesthetics
- water quality to be managed as part of catchment management.

A buffer of 50m is recommended in order to meet Bibra Lake's (UFI 6595) management objective for a REW and to minimise impacts on the wetland associated largely with urban and recreational land uses.

6.1.7 Step 7 - Apply Separation Requirement to Proposal and Assess Ability of Separation to Achieve Management Objective

A 50m buffer is achievable and proposed around Bibra Lake UFI 6595. There is an overlap of approximately 1.55 ha of the proposed buffer and the construction footprint. Additionally, there is an overlap of approximately 0.35 ha between Bibra Lake (UFI 6595) and Horse Paddock Swamp (UFI 6600) assigned wetland buffers (Figure 2).



Assessed Wetland Buffers

SouthMetro Connect

Figure 2

0 100 200 300

Metres

1:10,000 (A4)

Coordinate System: GDA 1994 MGA Zone 50

LEGEND

- Project Area
- Construction Footprint
- EPP Lakes

Geomorphic Wetlands

- Conservation Category Wetland
- Resource Enhancement Wetland
- Multiple Use Wetland
- Wetland Function Area
- Assessed Wetland Buffers
- Wetland Buffer that Intersects Construction Footprint
- Area of Overlap where two Wetland Buffers Intersect Construction Footprint

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SouthmetroConnect

6.2 Bibra Lake (UFI 6601)

6.2.1 Step 1 - Acknowledge Existence of Wetland

Bibra Lake (UFI 6601) is located in the eastern chain of the Beeliar wetlands and is classified in DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset as a lake with a management category of MUW. The existence of the wetland is acknowledged in SMC (2011).

6.2.2 Step 2 - Identify Wetland Attributes, Management Category and Establish Management Objective

6.2.2.1 Has a wetland management category been assigned?

Bibra Lake (UFI 6601) is a MUW. The objective for this category is to use, develop and manage wetlands in the context of water, town and environmental planning. Bibra Lake (UFI 6601) abuts the main body of Bibra Lake (UFI 6595) to the north and west. It has been identified as a separate management category to (UFI 6595) as the area has been substantially modified to support passive recreation (picnic area, park land and bicycle paths) in the area. It is also classed as an EPP Lake and forms part of Bush Forever Site 244 (Figure 1).

6.2.2.2 Are existing wetland values, processes, functions and attributes consistent with the assigned management category?

The review of the justification for the MUW management category identified the following key values, processes and attributes for Bibra Lake (UFI 6601):

a) Drainage and presence of nutrient sources

b) Aesthetics

c) Passive recreation

These values and attributes are consistent with the wetland MUW management category. The western shore of Bibra Lake, adjacent to wetland UFI (6601), has been heavily modified to allow passive recreation. This area is reserved for parks and recreation and consists of cleared parkland comprising of, but not limited to, *Melaleuca preissiana, Eucalyptus camaldulensis, Corymbia calophylla* and *Xanthorrhoea preissii* over introduced grasses of *Pennisetum clandestinum, Cynodon dactylon* and *Eragrostis curvula*. This area is used as a parkland and picnic area that allows the public to access Bibra Lake. It is not currently managed for natural wetland functions and the vegetation condition is described as Degraded to Completely Degraded.

6.2.3 Step 3 - Define Wetland Function Area

Where practicable, the wetland function area is the area required to support the attributes of the wetland (Table 4). Due to the existing residential and industrial development outside of the boundaries of Bush Forever site 244, (west of Progress Drive and east of Bibra Drive) near Bibra Lake (UFI 6601) and the construction of Hope Road; the wetland function area has been restricted by pre-existing development. Bibra Lake (UFI 6601) is adjacent to grassed parklands and as such has been given a classification of MUW by DEC, where the most important wetland value is to support an area of open water for recreation and aesthetic purposes. The wetland function area therefore corresponds to the wetland entity as mapped and described in DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset and as shown in Figure 2.

6.2.4 Step 4 - Identify Threatening Processes

The key threatening processes for each attribute of Bibra Lake (UFI 6601) has been examined in Table 4. Processes that potentially could threaten the significant attributes of this wetland were identified based on consideration of the environmental risks from the surrounding urban land. Based on this assessment the threatening processes requiring a buffer and/or management for Bibra Lake (UFI 6601) is:

- Diminished water quality

Table 4 Key threatening processes for the wetland attributes of Bibra Lake (UFI 6601)

Attribute	Requirement to support attribute	Key Threatening Processes	Role of Buffer	Required Buffer Size
Drainage and presence of nutrient sources	Nutrients leaching into lake by a variety of means	Diminished water quality	Drainage from urban areas such as stormwater pipes and car park runoff reduces the efficiency of the buffer to protect from nutrient inputs	Not possible to buffer
Aesthetics	Maintain accepted water levels and maintain or improve water quality	Diminished water quality	Strip nutrients from water entering wetland	Not possible to buffer
Passive recreation	Maintain water levels and maintain or improve water quality	Diminished water quality	Protection of wetland values and function integral to passive recreation needs	Not possible to buffer

6.2.5 Step 5 - Identify Role of Separation

The role of the buffer is to protect those wetland values and function integral to passive recreation needs and to strip nutrients. In this case the only wetland value or function that a buffer could protect is the water quality of Bibra Lake. Water quality is the fundamental wetland value that needs to be preserved to manage (UFI 6601) in terms of importance for aesthetics and passive recreation (Table 4).

6.2.6 Step 6 - Establish Separation Requirement

No buffer is currently in place to manage impacts from passive recreation within Bibra Lake (UFI 6601) in the adjacent parkland. There is currently no separation from threatening processes at the lake's shore due to pre-existing developments such as Hope Road and as a result, no separation area beyond the wetland function area is required. The proposed development outside the wetland function area of the wetland meets the management objective for a multiple use wetland.

Although there is currently no buffer present or proposed for Bibra Lake (UFI 6601), water quality can be improved by educating the public to pick up after their dogs and refrain from feeding birds. Additionally, the storm water drains can be upgraded to increase the efficiency of pollutant removal.

6.2.7 Step 7 - Apply Separation Requirement to Proposal and Assess Ability of Separation to Achieve Management Objective

No buffer is required to maintain the wetland's MUW management objective (Figure 2).

6.3 Horse Paddock Swamp (UFI 6600)

6.3.1 Step 1 - Acknowledge Existence of Wetland

Horse Paddock Swamp is located between Bibra Lake and North Lake. It is classified in DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset as a lake with UFI 6600 and a management category of CCW (Figure 1). The existence of the wetland is acknowledged in SMC (2011).

6.3.2 Step 2 - Identify Wetland Attributes, Management Category and Establish Management Objective

6.3.2.1 Has a wetland management category been assigned?

Horse Paddock Swamp (UFI 6600) is a CCW with the objective of preserving the wetland's (natural) attributes and functions. It is also classed as an EPP Lake and forms part of Bush Forever Site 244 (Figure 1).

6.3.2.2 Are existing wetland values, processes, functions and attributes consistent with the assigned management category?

The existing wetland values, processes, functions and attributes are not consistent with the CCW management category of Horse Paddock Swamp (UFI 6600). Horse Paddock Swamp (UFI 6600) has been significantly modified and is predominantly devoid of native vegetation. It currently supports vegetation that is dominated by introduced grasses and weeds such as *Carpobrotus edulis*, *Zantedeschia aethiopica* and *Oxalis pes-caprae*.

The following key values, processes and attributes have been identified for Horse Paddock Swamp (UFI 6600):

a) constitute part of a linked natural system between North Lake and Bibra Lake and disturbance would affect adjacent wetlands or fauna using the system

b) water quantity and quality

c) drainage and presence of nutrient sources

d) historical, archaeological or cultural significance.

6.3.3 Step 3 - Define Wetland Function Area

Based on field investigations conducted by SMC, it was identified that Horse Paddock Swamp (UFI 6600) is unlikely to meet the criteria for CCW and would more appropriately be categorised as a REW. Due to the highly disturbed nature of Horse Paddock Swamp (UFI 6600), the wetland function area used for this assessment corresponds to the wetland boundary for UFI 6600 as described in DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset (Figure 2).

6.3.4 Step 4 - Identify Threatening Processes

Processes that potentially could threaten the attributes of this wetland were identified based on consideration of the environmental risks from the surrounding urban land. The key threatening processes, as described in WAPC (2005), for Horse Paddock Swamp (UFI 6600) have been identified in Table 5 and are:

- diminished water quality
- habitat modification

Table 5 Key threatening processes for the wetland attributes of Horse Paddock Swamp (UFI 6600)

Attribute	Requirement to support attribute	Key Threatening Processes	Role of Buffer	Required Buffer Size
Constitute part of a linked natural system between North Lake and Bibra Lake and disturbance would affect adjacent wetlands or fauna using the system	Maintain wetland area	Diminished water quality Habitat modification	Can link adjacent wetland buffer areas Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m to maintain linkages to other wetlands
Water quantity and quality	Maintain accepted water levels	Diminished water quality	Interception and use of water and/or nutrients in surface and sub surface flows Can suppress water tables locally and reduce salinisation of surface soils	50m nominal buffer to limit nutrient input from overland flows
Drainage and presence of nutrient sources	Maintain water levels	Diminished water quality	Interception of water in surface and subsurface flow can suppress water tables locally Role highly dependent on hydrogeology and catchment characteristics	50m nominal buffer to limit nutrient input from overland flows
Historical, archaeological or cultural significance - *Archaeological investigations have recorded various materials in the ground between North and Bibra lakes, indicating that these areas were historically used as camping areas (site 3709)*	Maintain natural state of wetland, particularly area of inundation	Habitat modification	Protection of cultural values from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m

6.3.5 Step 5 - Identify Role of Separation

The required buffer size for each attribute was identified based on consideration of key threatening processes identified in Table 5. To summarise, the role of a buffer for Horse Paddock Swamp (UFI 6600) is to:

- link adjacent wetland buffer areas
- intercept and use water and/or nutrients in surface and subsurface flow
- protect cultural values from direct disturbance
- provide indirect benefits through the maintenance of hydrological and terrestrial processes.

6.3.6 Step 6 - Establish Separation Requirement

Horse Paddock Swamp (UFI 6600) is extremely degraded and is more typical of a REW or MUW. However, given its management category of CCW, to prevent any further degradation, a buffer of 50m is recommended. This is the minimum recommended buffer for a conservation category wetland (EPA, 2008).

6.3.7 Step 7 - Apply Separation Requirement to Proposal and Assess Ability of Separation to Achieve Management Objective

A buffer of 50m can be achieved around the entire mapped wetland boundary of Horse Paddock Swamp (UFI 6600). The buffer achieves its primary aim of linking buffer areas of adjacent wetlands. To the south, the 50m buffer links into the EPP Lakes boundary and buffer for Bibra Lake. To the north it links with the buffer of North Lake (UFI 6599). There is an overlap of approximately 0.94 ha of the assigned buffer and the construction footprint. Additionally, there is an overlap of approximately 0.35 ha between Horse Paddock Swamp (UFI 6600) and Bibra Lake (UFI 6595) proposed wetland buffer (Figure 2).

6.4 North Lake (UFI 6599)

6.4.1 Step 1 - Acknowledge Existence of Wetland

North Lake is located in the eastern chain of the Beeliar wetlands to the north of Bibra Lake and south of Farrington Road (Figure 1). It is classified as a lake in DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset with UFI 6599. The existence of the wetland is acknowledged in SMC (2011).

6.4.2 Step 2 - Identify Wetland Attributes, Management Category and Establish Management Objective

6.4.2.1 Has a wetland management category been assigned?

North Lake (UFI 6599) is a CCW with the objective to preserve wetland (natural) attributes and functions. It is also classed as an EPP Lake and forms part of Bush Forever Site 244 (Figure 1).

6.4.2.2 Are existing wetland values, processes, functions and attributes consistent with the assigned management category?

North Lake has a number of attributes and functions that justifies its listing as a CCW. The following key values, processes and attributes were identified for North Lake (UFI 6599):

a) Constitutes part of a linked natural system such as destruction would disturb adjacent wetlands or fauna using the system;

b) Supports high habitat diversity;

c) Habitat of plants or animals at critical stage of biological cycle or vulnerable stage of their life cycle;

d) Important for maintaining species and/or ecological diversity;

e) Important regional wildlife sanctuary even if flora/fauna not rare or endangered as it is part of Beeliar Regional Park and Bush Forever Site 244;

f) Seasonal or temporary habitat or breeding ground for migratory waterbirds;

g) Supports areas of emergent and fringing vegetation;

h) Water quantity and quality;

i) Drainage and presence of nutrient sources;

j) Aesthetics;

k) Historical, archaeological or cultural significance;

l) Passive recreation;

m) Effect on land values;

n) Research, scientific importance; and

o) Educational significance

6.4.3 Step 3 - Define Wetland Function Area

Where practicable, the wetland function area is the area required to support the attributes of the wetland (Table 6). In the case of North Lake (UFI 6599), the wetland function area should contain at least the entirety of wetland vegetation to ensure maintenance of its CCW management category and all ecological communities associated with the wetland.

The definition of wetland function area boundary to assess setbacks from North Lake (UFI 6599) is relevant to only the north, south and east of the lake. The presence of developed residential and public purpose land immediately outside of the boundaries of Bush Forever site 244, (west of Progress Drive, north of Farrington road and east Bibra Drive), means the wetland function area is restricted by pre-existing development. Therefore, the wetland function area in this case corresponds to the wetland entity as mapped by DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset (Figure 2).

6.4.4 Step 4 - Identify Threatening Processes

The key threatening processes for each attribute of North Lake (UFI 6599) has been examined in Table 6. Processes that could potentially threaten the attributes of North Lake (UFI 6599) were considered in light of the urban development to the west of North Lake (UFI 6599) and the existing wetland system. Based on this assessment, the threatening processes requiring a buffer and/or management for North Lake (UFI 6599) are:

- habitat modification
- inappropriate recreational use
- diminished water quality.

Table 6 Key threatening processes for the wetland attributes of North Lake

Attribute	Requirement to support attribute	Key Threatening Processes	Role of Buffer	Required Buffer Size
Constitute part of a linked natural system such as destruction would disturb adjacent wetlands or fauna using the system North Lake is adjacent to Frog Swamp (Roe Swamp and surrounds) and is in close proximity to Horse Paddock Swamp and Bibra Lake	Maintain wetland area	Habitat modification Inappropriate recreational use Diminished water quality	Can link adjacent wetland separation areas Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m to maintain linkages to other wetlands
Supports high habitat diversity with areas of open water, sedgelands and fringing woodlands	Maintain representation of all identified ecological communities associated with wetland, to include upland communities abutting wetland vegetation zone	Habitat modification	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	100m to protect all fringing vegetation
Habitat of plants or animals at critical stage of biological cycle or vulnerable stage of their life cycle	Maintain areas of open water, seasonally inundated areas used for breeding and other areas of vegetation likely to be used by species	Habitat modification Inappropriate recreational use	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	100m to encompass all habitat east of Progress Drive
Important for maintaining species and/or ecological diversity	Maintain representation of all identified ecological communities associated with wetland, to include upland communities abutting wetland vegetation zone	Habitat modification	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m fringing vegetation beyond wetland function area
Important regional wildlife sanctuary even if flora/fauna not rare or endangered as part of Beeliar Regional Park and Bush Forever Site 244	Support attributes consistent with management objectives	Habitat modification Inappropriate recreational use Diminished water quality	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m buffer as minimum requirement
Seasonal or temporary habitat or breeding ground for migratory waterbirds - - Glossy Ibis were recorded at North Lake	Maintain wetland area Maintain water quality	Habitat modification Inappropriate recreational use Diminished water quality	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	100m to encompass all habitat east of Progress Drive

Attribute	Requirement to support attribute	Key Threatening Processes	Role of Buffer	Required Buffer Size
Supports areas of emergent and fringing vegetation	Maintain areas containing emergent wetland species	Habitat modification Diminished water quality	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m to protect fringing vegetation
Water quantity and quality	Maintain accepted water levels and maintain or improve water quality	Diminished water quality Habitat modification	Vegetation interception and use of water and/or nutrients in surface and subsurface water flows Can suppress water tables locally and reduce salinisation Role highly dependent on hydrological and catchment characteristics	Not possible to buffer due to other influences
Drainage and presence of nutrient sources	Maintain wetland area and maintain or improve water quality	Habitat modification Diminished water quality	Vegetation interception and use of water and /or nutrients in surface and subsurface water flows Can suppress water tables locally Role highly dependent on hydrological and catchment characteristics	Not possible to buffer due to other influences
Aesthetics	Maintain accepted water quality and fringing vegetation	Habitat modification Diminished water quality	Can add to as well as maintain aesthetic qualities Protection from direct disturbance	50m vegetated buffer for aesthetics
Historical, archaeological or cultural significance - Archaeological investigations have recorded various materials in the ground between North and Bibra lakes, indicating that these areas were historically used as camping areas (sites 3293, 3294,3295, 3709, 4106)	Maintain natural state of wetland, particularly area of inundation	Habitat modification	Protection of wetland features and function integral to cultural values Protection from direct disturbance Can add to as well as maintain features of wetland function area	50m to protect from disturbance
Passive recreation - activities include walking, walking the dog, riding bikes and bird watching/observing wildlife	Management of access Maintain natural wetland attributes	Habitat modification	Protection of wetland values and function integral to passive recreation needs Protect from direct disturbance	Not possible to buffer Manage through track access

Attribute	Requirement to support attribute	Key Threatening Processes	Role of Buffer	Required Buffer Size
Effect on land values	Aesthetics	Habitat modification	Prevent adverse effects on nearby residents from poor aesthetics Protect from direct disturbance	Not possible to buffer
Research, scientific importance	Maintain natural wetland functions and attributes	Habitat modification Diminished water quality Inappropriate recreational use	May be of research interest Protection from direct disturbance	50m to protect from disturbance
Educational significance - Murdoch University utilizes North and Bibra lakes on a yearly basis for field work for students enrolled in environmental science, management, biology and restoration degrees	Maintain natural wetland functions and attributes	Habitat modification Diminished water quality Inappropriate recreational use	May be of educational interest Protection from direct disturbance	50m to protect from disturbance

6.4.5 Step 5 - Identify Role of Separation

The required buffer size for each attribute was identified based on consideration of key threatening processes identified in Table 6. In summary the role of the buffer for North Lake (UFI 6599) is to:

- link adjacent wetland areas
- protect North Lake (UFI 6599) from direct disturbance
- provide indirect benefits through the maintenance of hydrological and terrestrial processes
- interception of water and/or use of nutrients in surface and subsurface water flow by vegetation
- protection of wetland features and function integral to cultural values
- add to as well as maintain features of wetland function area
- protect wetland values and function integral to passive recreation needs
- provide research or educational value.

6.4.6 Step 6 - Establish Separation Requirement

The recommended buffer distance as per WAPC (2005) for a CCW is:

- 100m to prevent weed infestation
- Up to 100m to protect bird habitat
- 6-50m for firebreak
- 100m to minimise edge effects
- 50m as a barrier and to improve aesthetics
- water quality and water regime to be managed as part of catchment management.

A buffer of 100m is recommended to protect the values and functions of North Lake (UFI 6599).

6.4.7 Step 7 - Apply Separation Requirement to Proposal and Assess Ability of Separation to Achieve Management Objective

A buffer of 100m can be achieved most of the way around North Lake (UFI 6599), with the exception of the western side of the lake. On the west side of North Lake (UFI 6599), Progress Drive is only approximately 90m from the edge of the CCW boundary. Where Progress Drive is less than 100m from North Lake's CCW boundary, Progress Drive marks the extent of the buffer. This 100m buffer will also link North Lake (UFI 6599) to adjacent wetlands in the area (Figure 2).

6.5 Roe Swamp (UFI 15240)

6.5.1 Step 1 - Acknowledge Existence of Wetland

Roe Swamp (UFI 15240) is located within the eastern chain of Beeliar wetlands to the north-east of Bibra Lake and east of North Lake. Roe Swamp (UFI 15240) is the southern-most section of the Roe Swamp and Surrounding Sumplands contiguous wetlands and it is crossed by Hope Road and Bibra Drive (Figure 1). It is classified in DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset as a CCW sumpland (seasonally inundated basin). It is part of a series of sumplands (Roe Swamp, Lower (Frog) Swamp and Melaleuca Swamp) that are essentially one continuous wetland function area. The northern boundary of Roe Swamp (UFI 15240) is not a wetland boundary, but an administrative boundary to wetland (UFI 14425). The existence of the wetland is acknowledged in SMC (2011).

6.5.2 Step 2 - Identify Wetland Attributes, Management Category and Establish Management Objective

6.5.2.1 Has a wetland management category been assigned?

Roe Swamp (UFI 15240) is a CCW, with the objective to preserve wetland (natural) attributes. It also forms part of Bush Forever Site 244.

6.5.2.2 Are existing wetland values, processes, functions and attributes consistent with the assigned management category?

Some of the existing values, processes, functions and attributes are consistent with the wetland CCW management category. Some areas of the wetland are degraded and destroyed through residential development and previous road construction of Bibra Drive and Hope Road. The wetland mapped boundary as mapped in DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset overlaps with Bibra Lake and Hope Road and extends further in some cases (Figure 2). The vegetation condition within this wetland was found to range from Degraded to Completely Degraded south of Hope Road; Degraded condition in the corner of Bibra Drive and Hope Road and the rest was found to be in Degraded to Good condition.

The review of the justification for the CCW management category identified the following key values, processes and attributes for Roe Swamp (UFI 15240):

a) constitute part of a linked natural system such as destruction would disturb adjacent wetlands or fauna using the system

b) support high habitat diversity

c) important for maintaining species and/or ecological diversity

   iImportant regional wildlife sanctuary even if flora/fauna not rare or endangered as it is part of Bush Forever 244

d) supports areas of emergent and fringing vegetation

e) water quantity and quality

f) aesthetics

g) research, scientific importance

h) educational significance.

6.5.3 Step 3 - Define Wetland Function Area

Where practicable, the wetland function area is the area required to support the attributes of the wetland (Table 7). In the case of Roe Swamp (UFI 15240), the wetland function area should contain at least the entirety of wetland vegetation to ensure maintenance of its CCW management category and all ecological communities associated with the wetland.

The definition of wetland function area boundary to assess setbacks from Roe Swamp (UFI 15240) is relevant to only the south and west of the wetland. The presence of developed residential land immediately outside of the boundaries of Bush Forever site 244 (east of Bibra Drive), means the wetland function area is restricted by existing development. The majority of the wetland is located within the Primary Regional Road reserve boundary of the Metropolitan Region Scheme (MRS). Therefore, the wetland function area in this case is considered to correspond to the wetland boundary as mapped in DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset (Figure 2).

6.5.4 Step 4 - Identify Threatening Processes

The key threatening processes for each attribute of Roe Swamp (UFI 15240) has been examined in Table 7. Processes that could potentially threaten the attributes of Roe Swamp (UFI 15240) were considered in light of the urban development to the east of the wetland and the adjoining wetland system. Based on this assessment the threatening processes requiring a buffer and/or management for Roe Swamp (UFI 15240) are:

- habitat modification
- inappropriate recreational use
- diminished water quality.

Table 7 Key threatening processes for the wetland attributes of Roe Swamp UFI 15240

Attribute	Requirement to support attribute	Key Threatening Processes	Role of Buffer	Recommended Buffer Size
Constitute part of a linked natural system such as destruction would disturb adjacent wetlands or fauna using the system	Maintain wetland area	Habitat modification Inappropriate recreational use Diminished water quality	Can link adjacent wetland separation areas Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m to maintain connection to other wetlands
Support high habitat diversity - The south-east portion of the larger Roe Swamp is known to have good quality black cockatoo foraging habitat	Maintain representation of all identified ecological communities associated with wetland, to include upland communities abutting wetland vegetation zone	Habitat modification	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	100m vegetated buffer protect from weed infestation
Important for maintaining species and/or ecological diversity	Maintain representation of all identified ecological communities associated with wetland, to include upland communities abutting wetland vegetation zone	Habitat modification	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	100m vegetated buffer to protect from weed infestation
Important regional wildlife sanctuary even if flora/fauna not rare or endangered, as part of Beeliar Regional Park and Bush Forever Site 244	Support attributes consistent with management objectives	Habitat modification Inappropriate Recreational use Diminished water quality	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m buffer as minimum requirement
Supports areas of emergent and fringing vegetation	Maintain areas containing emergent wetland species	Habitat modification Diminished water quality	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	100m vegetated buffer to prevent weed infestation and allow for changes in fringing vegetation
Water quantity and quality	Maintain accepted water quality	Diminished water quality	Vegetation interception of water and/or use of nutrients in surface	50m to allow vegetation to strip nutrients from surface flows

Attribute	Requirement to support attribute	Key Threatening Processes	Role of Buffer	Recommended Buffer Size
			and subsurface water flows Can suppress water tables locally and reduce salinisation of surface soils Role highly dependent on hydrogeology and catchment characteristics	
Aesthetics	Maintain accepted water quality Maintain wetland vegetation	Diminished water quality Habitat modification	Can add to as well as maintain aesthetic qualities Protection from direct disturbance	50m vegetation to maintain aesthetic qualities
Research, scientific importance	Maintain natural wetland functions and attributes	Habitat modification Diminished water quality Inappropriate recreational use	May be of research interest Protection from direct disturbance	50m to protect from disturbance
Educational significance	Maintain natural wetland functions and attributes	Habitat modification Diminished water quality Inappropriate recreational use	May be of educational interest Protection from direct disturbance	50m to protect from disturbance

6.5.5 Step 5 - Identify Role of Separation

The required buffer size for each attribute was identified based on consideration of key threatening processes identified in Table 7. In summary the role of the buffer for Roe Swamp (UFI 15240) is to:

- link adjacent wetland areas
- protect the wetland body from direct disturbance
- provide indirect benefits through the maintenance of hydrological and terrestrial processes
- interception of water and/or use of nutrients in surface and subsurface water flow by vegetation
- add to as well as maintain aesthetic qualities
- the buffer may be of research or educational value itself.

6.5.6 Step 6 - Establish Separation Requirement

The recommended buffer distance as per WAPC (2005) for a CCW is:

- 100m to prevent weed infestation
- Up to 100m to protect bird habitat
- 6-50m for firebreak
- 100m to minimise edge effects
- 50m as a barrier and to improve aesthetics
- water quality and water regime to be managed as part of catchment management.

A buffer of 100m is recommended to protect the values and functions of Roe Swamp (UFI 15240).

6.5.7 Step 7 - Apply Separation Requirement to Proposal and Assess Ability of Separation to Achieve Management Objective

A 100m buffer cannot be achieved around the entirety of Roe Swamp (UFI 15240). To the north it directly abuts another wetland – Roe Swamp (UFI 14425) and no buffer is in effect. To the east, residential development and construction of Bibra Drive has already encroached into the wetland boundary as mapped in DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset and therefore no buffer exists or is proposed. The only areas where the 100m buffer can be implemented are to the south and west. This buffer will also link Roe Swamp (UFI 15240) to adjacent wetland buffer of (UFI 144425) (Figure 2).

6.6 Roe Swamp (UFI 14425)

6.6.1 Step 1 - Acknowledge Existence of Wetland

Roe Swamp (UFI 14425) is part of a series of sumplands located to the north-east of Bibra Lake and south-east of North Lake. There are a number of wetland UFI's identifying what is essentially one continuous wetland (Figure 1). The existence of Roe Swamp (UFI 14425) is acknowledged in SMC (2011).

The boundaries of Roe Swamp (UFI 14424) to the north and south have been designated by the MRS, as this is the part of Roe Swamp (UFI 14425) that was zoned for primary regional roads usage in order to build the proposed Roe Highway extension. Until recently the management category of this wetland had been MUW, however, it has recently been re-classified as CCW in DEC's Geomorphic *Wetlands of the Swan Coastal Plain* dataset.

6.6.2 Step 2 - Identify Wetland Attributes, Management Category and Establish Management Objective

6.6.2.1 Has a wetland management category been assigned?

Roe Swamp (UFI 14425) is a CCW with the objective to preserve wetland (natural) attributes. It also forms part of Bush Forever Site 244.

6.6.2.2 Are existing wetland values, processes, functions and attributes consistent with the assigned management category?

The existing wetland values, processes, functions and attributes are consistent with the CCW management category. The vegetation condition within Roe Swamp (UFI 14425) ranges from Very Good to Very Good - Excellent for the majority of the wetland with the exception of the eastern boundaries where vegetation structure has been significantly modified due to past and present land uses. Here the vegetation condition ranges from Degraded to Degraded – Completely Degraded.

The review of the justification for the CCW management category identified that the following key values, processes and attributes for Roe Swamp (UFI 14425) are:

a) constitute part of a linked natural system such as destruction would disturb adjacent wetlands or fauna using the system

b) support high habitat diversity

c) important for maintaining species and/or ecological diversity

d) important regional wildlife sanctuary even if flora/fauna not rare or endangered

e) supports extensive areas of emergent and fringing vegetation

f) water quantity and quality

g) drainage and presence of nutrient sources

h) aesthetics

i) research, scientific importance

j) educational significance.

6.6.3 Step 3 - Define Wetland Function Area

Where practicable, the wetland function area is the area required to support the attributes of the wetland (Table 8). In the case of Roe Swamp (UFI 14425), the wetland function area should contain at least the entirety of wetland vegetation to ensure maintenance of its CCW management category and all ecological communities associated with the wetland.

The definition of wetland function area boundary to assess setbacks from Roe Swamp (UFI 14425) is relevant to only the north and west of the wetland. The presence of developed residential land immediately outside of the boundaries of Bush Forever site 244 (east of Bibra Drive), and Bibra Drive itself, means the wetland function area is restricted by pre-existing development. The majority of the wetland is located within the Primary Regional Road reserve boundary of the MRS. Therefore, the wetland function area in this case corresponds to the CCW boundaries as mapped by DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset for UFI 14425 (Figure 2).

6.6.4 Step 4 - Identify Threatening Processes

The key threatening processes for each attribute of Roe Swamp (UFI 14425) has been assessed in Table 8. Processes that could potentially threaten the attributes of Roe Swamp (UFI 14425) were considered in light of the urban development to the east of the wetland and the adjoining wetland system.

The threatening processes requiring buffering and management of Roe Swamp (UFI 14425) are:

- habitat modification
- inappropriate recreational use
- diminished water quality

Table 8 Key threatening processes for the wetland attributes of Roe Swamp (UFI 14425)

Attribute	Requirement to support attribute	Key Threatening Processes	Role of Buffer	Required Buffer Size
Constitute part of a linked natural system such as destruction would disturb adjacent wetlands or fauna using the system	Maintain wetland area	Habitat modification Inappropriate recreational use Diminished water quality	Can link adjacent wetland separation areas Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m to maintain linkages
Support high habitat diversity	Maintain representation of all identified ecological communities associated with wetland, to include upland communities abutting wetland vegetation zone	Habitat modification	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	100m to protect from weed infestation
Important for maintaining species and/or ecological diversity	Maintain representation of all identified ecological communities associated with wetland, to include upland communities abutting wetland vegetation zone	Habitat modification	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	100m vegetated buffer to protect from weed infestation
Important regional wildlife sanctuary even if flora/fauna not rare or endangered - *Roe Swamp is part of Beeliar wetland chain and Bush Forever site 244*	Support attributes consistent with management objectives	Habitat modification Inappropriate recreational use Diminished water quality	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m buffer as minimum requirement
Supports extensive areas of emergent and fringing vegetation	Maintain areas containing emergent wetland species	Habitat modification Diminished water quality	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	100m vegetated buffer to protect from weed infestation
Water quantity and quality	Maintain accepted water quality	Diminished water quality	Vegetation interception of water and/or use of nutrients in surface	50m to allow vegetation to strip

Attribute	Requirement to support attribute	Key Threatening Processes	Role of Buffer	Required Buffer Size
			and subsurface water flows Can suppress water tables locally and reduce salinisation Role highly dependent on catchment characteristics	nutrients from surface flows
Drainage and presence of nutrient sources	Maintain accepted water quality	Diminished water quality	Vegetation interception of water and/or use of nutrients in surface and subsurface water flow Can suppress water tables locally Role highly dependent on catchment characteristics Role redundant where piped discharge into wetland occurs	50m to allow vegetation to strip nutrients from surface flows
Aesthetics	Maintain accepted water levels and fringing vegetation	Habitat modification	Can add to as well as maintain aesthetic qualities Protection from direct disturbance	50m vegetated buffer
Research, scientific importance	Maintain wetland function area	Habitat modification	May be of research interest Protection from direct disturbance	50m vegetated buffer
Educational significance	Maintain wetland function area	Habitat modification	May be of educational interest Protection from direct disturbance	50m vegetated buffer

6.6.5 Step 5 - Identify Role of Separation

The required buffer size for each attribute was identified based on consideration of key threatening processes identified in Table 8. In summary the role of the buffer for Roe Swamp (UFI 14425) is to:

- link adjacent wetland areas
- protect the wetland body from direct disturbance
- provide indirect benefits through the maintenance of hydrological and terrestrial processes
- interception of water and/or use of nutrients in surface and subsurface water flow by vegetation provide research or educational value.

6.6.6 Step 6 - Establish Separation Requirement

The recommended buffer distance as per WAPC (2005) for a CCW is:

- 100m to prevent weed infestation
- Up to 100m to protect bird habitat
- 6-50m for firebreak
- 100m to minimise edge effects
- 50m as a barrier and to improve aesthetics
- water quality and water regime to be managed as part of catchment management.

A buffer of 100m is recommended to protect the values and functions of Roe Swamp (UFI 14425).

6.6.7 Step 7 - Apply Separation Requirement to Proposal and Assess Ability of Separation to Achieve Management Objective

A buffer of 100m can only be achieved to the west and the north east of Roe Swamp (UFI 14425). This wetland abuts other CCWs to the north and south and therefore a buffer is not required or proposed in these areas. The eastern boundary of Roe Swamp (UFI 14425) is Bibra Drive. On the eastern side of Bibra Drive, there is cleared land which has been identified to be in Completely Degraded condition and as such can not act as a buffer to Roe Swamp (UFI 14425) (Figure 2). Although this land is zoned as parks and recreation under the MRS, it has not been managed as a buffer for the Roe Swamp suite of wetlands in the past and is most likely impacting the wetlands through eutrophication, sedimentation, channelising of water flows and providing a source of weed infestation.

6.7 Lower Swamp (Frog Swamp) (part UFI 14645)

6.7.1 Step 1 Acknowledge Existence of Wetland

Lower Swamp (Frog Swamp) (part UFI 14645) is part of a series of sumplands classified in DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset as a CCW. It is located to the north-east of Bibra Lake and south-east of North Lake. There are a number of wetland UFI's identifying what is essentially one continuous wetland (Figure 1). The existence of the wetland is acknowledged in SMC (2011).

Lower Swamp (Frog Swamp) (part UFI 14645) is assessed in this document as the section of wetland UFI 14645 which is located south of Farrington Road. The section of UFI 14645, which is located north of Farrington Road, is considered for this assessment as Melaleuca Swamp (Figure 1).

6.7.2 Step 2 Identify Wetland Attributes, Management Category and Establish Management Objective

6.7.2.1 Has a wetland management category been assigned?

Lower Swamp (Frog Swamp) part (UFI 14645) is a CCW with the objective to preserve wetland (natural) attributes. The western most section of this wetland is also classified as an EPP Lake in DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset and it also forms part of Bush Forever Site 244.

6.7.2.2 Are existing wetland values, processes, functions and attributes consistent with the assigned management category?

The existing wetland values, processes, functions and attributes are consistent with the CCW management category. The key values, processes and attributes for Lower Swamp (Frog Swamp) part (UFI 14645) are:

a) constitute part of a linked natural system such as destruction would disturb adjacent wetlands or fauna using the system

b) support high habitat diversity

c) important for maintaining species and/or ecological diversity

d) important regional wildlife sanctuary even if flora/fauna not rare or endangered

e) supports extensive areas of emergent and fringing vegetation

f) water quantity and quality

g) drainage and presence of nutrient sources

h) aesthetics

i) historical, archaeological or cultural significance

j) research, scientific importance

k) educational significance.

6.7.3 Step 3 Define Wetland Function Area

Where practicable, the wetland function area is the area required to support the attributes of the wetland (Table 9). In the case of Lower Swamp (Frog Swamp) (part UFI 14645) the wetland function area should incorporate all of the wetland vegetation to ensure maintenance of its CCW management category and all ecological communities associated with the wetland. The definition of wetland function area boundary to assess setbacks from Lower Swamp (Frog Swamp) (part UFI 14645) is relevant to only the section of wetland which is located south of Farrington Road. Required setbacks for Melaleuca Swamp (part UFI 14645) are assessed separately in section 6.8 below. Previous construction of Farrington Road to the north of the wetland means the wetland function area is restricted by development. The wetland function area therefore corresponds to the Lower Swamp (Frog Swamp) (UFI 14645) wetland mapped boundary as shown in the *Geomorphic Wetlands of the Swan Coastal Plain* dataset and Figure 2.

6.7.4 Step 4 Identify Threatening Processes

The key threatening processes for each attribute of Lower Swamp (Frog Swamp) (part UFI 14645) were considered and assessed in Table 9. Processes that potentially could threaten the significant attributes of this wetland were identified based on consideration of the environmental risks from the surrounding urban land. The threatening processes requiring buffering and management of Lower Swamp (part UFI 14645) are:

- habitat modification
- inappropriate recreational use
- diminished water quality

Table 9 Key threatening processes for the wetland attributes of Lower Swamp (Frog Swamp) (part UFI 14645)

Attribute	Requirement to support attribute	Key Threatening Processes	Role of Buffer	Required Buffer Size
Constitute part of a linked natural system such as destruction would disturb adjacent wetlands or fauna using the system	Maintain wetland area	Habitat modification Inappropriate recreational use Diminished water quality	Can link adjacent wetland separation areas. Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m to link buffer to other wetlands and wetland buffers
Support high habitat diversity	Maintain representation of all identified ecological communities associated with wetland, to include upland communities abutting wetland vegetation zone.	Habitat modification	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	100m vegetated buffer to prevent direct disturbance and weed incursion
Important for maintaining species and/or ecological diversity	Maintain representation of all identified ecological communities associated with wetland, to include upland communities abutting wetland vegetation zone.	Habitat modification	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	100m vegetated buffer to prevent direct disturbance and weed incursion
Important regional wildlife sanctuary even if flora/fauna not rare or endangered - *Roe Swamp is part of Beeliar wetland chain and Bush Forever site 244*	Support attributes consistent with management objectives.	Habitat modification Inappropriate recreational use Diminished water quality	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m buffer as minimum requirement
Supports extensive areas of emergent and fringing vegetation	Maintain areas containing emergent wetland species	Habitat modification Diminished water quality	Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	100m vegetated buffer to prevent direct disturbance and weed incursion
Water quantity and quality	Maintain accepted water quality	Diminished water quality	Vegetation interception and use of water and/or nutrients in surface and subsurface water flows	50m vegetated buffer to strip nutrients from surface flows

Attribute	Requirement to support attribute	Key Threatening Processes	Role of Buffer	Required Buffer Size
			Can suppress water tables locally and reduce salinisation Role highly dependent on hydrogeology and catchment characteristics	
Drainage and presence of nutrient sources	Maintain accepted water quality	Diminished water quality	Vegetation interception and use of water and/or nutrients in surface and subsurface water flows Can suppress water tables locally Role highly dependent on hydrogeology and catchment characteristics Role redundant where piped discharge into wetland occurs.	Not able to be buffered – linked to Melaleuca Swamp by Murdoch Drain
Aesthetics	Maintain accepted water levels and fringing vegetation	Habitat modification	Can add to as well as maintain aesthetic qualities Protection from direct disturbance	50m vegetated buffer
Historical, archaeological or cultural significance - This area consisted of a sparse scatter of 53 artefacts consisting of adzes, bipolar pieces, flakes and chips scattered over an area on an open sandy rise adjacent to a permanent lake (site 3295)	Maintain natural state of wetland, particularly area of inundation	Habitat modification	Can add to wetland features Protection of wetland features and function integral to cultural values Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m buffer to prevent disturbance
Research, scientific importance	Maintain wetland function area	Habitat modification	May be of research interest Protection from direct disturbance	50m vegetated buffer
Educational significance	Maintain wetland function area	Habitat modification	May be of educational interest Protection from direct disturbance	50m vegetated buffer

6.7.5 Step 5 Identify Role of Separation

The required buffer size for each attribute was identified based on consideration of key threatening processes identified in Table 9. In summary the role of the buffer for Lower Swamp (Frog Swamp) (part UFI 14645) is to:

- link adjacent wetland areas
- protect the wetland body from direct disturbance
- provide indirect benefits through the maintenance of hydrological and terrestrial processes
- interception of water and/or use of nutrients in surface and subsurface water flow by vegetation add to as well as maintain aesthetic qualities.
- protection of wetland values and function integral to cultural values.
- provide research or educational value.

6.7.6 Step 6 Establish Separation Requirement

The recommended buffer distance as per WAPC (2005) for a CCW is:

- 100m to prevent weed infestation
- Up to 100m to protect bird habitat
- 6-50m for firebreak
- 100m to minimise edge effects
- 50m as a barrier and to improve aesthetics
- water quality and water regime to be managed as part of catchment management.

A buffer of 100m is recommended to protect the values and functions of Lower Swamp (Frog Swamp) (part UFI 14645).

6.7.7 Step 7 Apply Separation Requirement to Proposal and Assess Ability of Separation to Achieve Management Objective

A 100m buffer can be applied to the perimeter of Lower Swamp (Frog Swamp) (part UFI 14645), except to the south where it abuts wetland (UFI 14425) and to the north as it crosses Farrington Road. The buffer areas of North Lake (UFI 6599) and Lower Swamp (Frog Swamp) (part UFI 14645) overlap (Figure 2).

6.8 Melaleuca Swamp (part UFI 14645)

6.8.1 Step 1 Acknowledge Existence of Wetland

Melaleuca Swamp (part UFI 14645) is part of a series of sumplands classified in DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset as CCWs. This wetland is located to the north east of Bibra Lake and east of North Lake. Melaleuca Swamp (part UFI 14645) is defined as that part of UFI 14645 north of Farrington Road for the purposes of this buffer assessment only (Figure 1). The existence of the wetland is acknowledged in SMC (2011).

6.8.2 Step 2 Identify Wetland Attributes, Management Category and Establish Management Objective

6.8.2.1 Has a wetland management category been assigned?

Melaleuca Swamp (part UFI14645) is a CCW with the objective to preserve wetland (natural) attributes.

6.8.2.2 Are existing wetland values, processes, functions and attributes consistent with the assigned management category?

Existing wetland values, processes, functions and attributes are not consistent with the CCW management category of Melaleuca Swamp (part UFI 14645). This is due to the surrounding land use, where pasture is adjacent to and within the CCW boundary on all sides. CCWs require buffers of natural vegetation to prevent impacts from inappropriate land use affecting the wetland values. Additionally, the land where Melaleuca Swamp (part UFI 14645) is located is currently zoned for Public Purposes (University) and as such has not been managed in the past with the intention of enhancing or maintaining the wetlands values, functions and attributes. Its current land use is most likely impacting the wetland through eutrophication, weed infestation and grazing. Melaleuca Swamp (part UFI 14645) is located outside the boundaries of Bush Forever Site 244 (Figure 1).

The key values, processes and attributes for Melaleuca Swamp (part UFI 14645) are:

a) Constitute part of a linked natural system such as destruction would disturb adjacent wetlands or fauna using the system

b) Water quantity and quality

c) Aesthetics

d) Research, scientific importance

e) Educational significance.

6.8.3 Step 3 Define Wetland Function Area

Based on brief field investigations conducted by AECOM it was identified that Melaleuca Swamp (part UFI 14645) does not meet the criteria for identification under the conservation management category due to its highly modified nature and past and present land uses. The wetland buffer for this wetland is already included in the CCW boundary as per DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset. Aerial imagery indicates that delineation of DEC's wetland boundary is not consistent with the actual vegetated boundary of the wetland. The wetland function area used for this assessment corresponds to the CCW boundary described in DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset (Figure 2).

6.8.4 Step 4 Identify Threatening Processes

The key threatening processes for each attribute of Melaleuca Swamp (part UFI 14645) has been considered and assessed in Table 9. Processes that potentially could threaten the significant attributes of Melaleuca Swamp (part UFI 14645) were identified based on consideration of the environmental risks from the surrounding rural land use. Murdoch University manages this area as paddocks for their veterinary studies and these paddocks extend into the wetland function area as described above. Native vegetation only remains in the centre of the mapped CCW area.

The threatening processes requiring buffering and management of Melaleuca Swamp (part UFI 14645) are:

- habitat modification
- diminished water quality

These threats could be mitigated by an appropriate buffer. However, no buffer exists to prevent these threats from impacting the wetland (Table 10).

Table 10 Key threatening processes for the wetland attributes of Melaleuca Swamp

Attribute	Requirement to support attribute	Key Threatening Processes	Role of Buffer	Required Buffer Size
Constitute part of a linked natural system such as destruction would disturb adjacent wetlands or fauna using the system	Maintain wetland area	Habitat modification Inappropriate recreational use Diminished water quality	Can link adjacent wetland separation areas Protection from direct disturbance Can provide indirect benefits through the maintenance of hydrological and terrestrial processes	50m to link buffer to other wetlands and wetland buffers
Water quantity and quality	Maintain accepted water quality	Diminished water quality	Vegetation interception and use of nutrients in surface and subsurface water flows Can suppress water tables locally and reduce salinisation Role highly dependent on hydrogeology and catchment characteristics	Cannot be buffered Management of veterinary paddocks required to manage water quality
Aesthetics	Maintain wetland vegetation	Habitat modification	Can add to as well as maintain aesthetic qualities Protection from direct disturbance	Requires at least 50m vegetated buffer No vegetation currently exists in this buffer area
Research, scientific importance	Maintain wetland function area	Habitat modification	May be of research interest Protection from direct disturbance	50m vegetated buffer required
Educational significance – used by Murdoch University for environmental studies	Maintain wetland function area	Habitat modification	May be of educational interest Protection from direct disturbance	50m vegetated buffer required

6.8.5 Step 5 Identify Role of Separation

The required buffer size for each attribute was identified based on consideration of key threatening processes identified in Table 10. The role of a buffer for each attribute is listed in Table 10 above. In summary the role of a buffer for Melaleuca Swamp (part UFI 14645) is to:

- link adjacent wetland separation areas.
- protect the wetland body from direct disturbance
- provide indirect benefits through the maintenance of hydrological and terrestrial processes
- interception of water and/or use of nutrients in surface and subsurface water flow by vegetation add to as well as maintain aesthetic qualities
- provide educational value.

6.8.6 Step 6 Establish Separation Requirement

A vegetated buffer of at least 50m is required to protect Melaleuca Swamp (part UFI 14645) from threatening processes. No vegetation remains within this proposed buffer zone (Figure 2).

6.8.7 Step 7 Apply Separation Requirement to Proposal and Assess Ability of Separation to Achieve Management Objective

There is no surrounding buffer of natural vegetation to protect the Melaleuca Swamp's values, functions and attributes from threatening processes. Pasture extends to and within the CCW area; hence the surrounding land cannot protect the wetland from weed infestation and other threats. Whilst a buffer of at least 50m would be ideal to protect the values of Melaleuca Swamp, it does not currently exist. No buffer is proposed to be applied to Melaleuca Swamp (Figure 2).

7.0 Summary of Wetland Buffers

The assessment process in Section 6.0 has demonstrated that buffer sizes for the wetlands impacted by the Roe Highway Extension vary between 0-100m, depending on the wetland's functions, values, attributes and management category. Of the CCWs within or in close proximity to the project area, two have buffers of less than 100m. Additionally, two wetlands in the vicinity of the project area, (Bibra Lake UFI 6601 and Melaleuca Swamp part UFI 14645), which are classified as a MUW and CCWs respectively, do not have an assigned or existing buffer in place due to adjacent land uses of parkland for recreation purposes, rural land use and pre-existing development such as Hope Road and Farrington Road (Table 11).

Bibra Lake (UFI 6595) is a REW which is assigned a 50m buffer of which 1.55 ha will be directly impacted by the project (Figure 2).

Melaleuca Swamp (part UFI 14645) is located north of Farrington Road and consists of a patch of wetland vegetation (comprising mainly *Melaleuca* forest) within a sumpland (seasonally inundated basin) which is surrounded by Murdoch University's veterinary paddocks. The wetland boundary assigned to this wetland in DEC's *Geomorphic Wetlands of the Swan Coastal Plan* dataset is considerably larger than the actual area of vegetation. Therefore, delineation of DEC's wetland mapped boundary is not consistent with the actual boundary of the wetland. Given that the CCW is surrounded by open paddock and has been highly modified due to past and present land uses; the surrounding land outside of the CCW mapped boundary provides no buffering ability and hence no buffer is assigned to this wetland (Table 11).

Horse Paddock Swamp (UFI 6600) has been assigned a buffer of 50m. This wetland has also been highly modified by past and present land uses and is predominantly devoid of native vegetation. The swamp has been completely cleared, with only scattered trees remaining on its gently sloping shores. It currently supports vegetation that has been mapped as being in Completely Degraded condition and is dominated by introduced grasses and weeds. The 50m buffer provides a linkage to the wetland buffers of North Lake (UFI 6599) and Bibra Lake (UFI 6595). There is an overlap of approximately 1.29ha* of the assigned buffer and the construction footprint (Figure 2).

The reason Horse Paddock Swamp warrants a buffer, when other CCW wetlands (Melaleuca Swamp and Roe Swamp east of Bibra Drive) do not have a buffer is due to the existing land use within the desired buffer distances for each of these wetlands. The 50m buffer around Horse Paddock Swamp is almost devoid of vegetation, however it is within Beeliar Regional Park and is being managed for conservation. East of Bibra Drive there is no native vegetation and the land use is vacant land, which is not being managed. Around Melaleuca Swamp the land is also cleared and is being used as a veterinary paddock. This land is not currently being managed as a wetland buffer and the existing land use is actually a significant threat to the health of wetland.

A buffer of 100m has been assigned for North Lake (UFI 6599). This distance was determined by the proximity of residential development to the west and north of the lake. No further increase in the size of the buffer is possible due to existing development and the change in land use.

The suite of Roe Swamp wetlands (assessed here as Roe Swamp UFI 15240 & 14425 and (Lower Swamp-Frog Swamp part UFI 14645) has an assigned buffer of 100m where there is native vegetation abutting the wetland boundary. A buffer of greater than 100m is not considered appropriate as a number of tracks already run parallel to the CCW boundaries to the west and north of the wetlands within this buffer. These tracks should delineate the wetland buffer boundaries, as weed incursion and disturbance from edge effects is likely to occur due to these tracks. However, due to the good quality vegetation abutting these tracks and the condition of the CCW itself, a 100m buffer has been assigned. There is an overlap of approximately 0.57 ha and 0.13 ha of the assigned buffers for Lower Swamp (part UFI 14645) and Roe Swamp (part UFI 15240) and the construction footprint respectively (Figure 2).

However, where Roe Swamp (UFI 15240 & 14425) is bounded by Bibra Drive to the east, no wetland buffer exists. The area east of Bibra Drive is not suitable as a buffer to a CCW and the vegetation condition is Completely Degraded. Although this area is zoned as parks and recreation under the MRS, it has not been managed as a buffer for the Roe Swamp suite of wetlands in the past and is most likely impacting the wetlands through eutrophication, sedimentation, channelizing of water flows and providing a source of weed infestation.

Table 11 Summary of Wetland Buffer Sizes for wetlands impacted by Roe Highway Extension.

Wetland Name	UFI	Management Category	Buffer Size	Area of Impact to CCW buffer (ha)	Area of impact to REW buffer (ha)
Bibra Lake	6595	REW	50m	0	1.6
Bibra Lake	6601	MUW	0	0	0
Horse Paddock Swamp	6600	CCW	50m	1.3*	0
North Lake	6599	CCW	100m	0	0
Roe Swamp	15240	CCW	100m	0.1	0
Roe Swamp	14425	CCW	100m	0	0
Lower Swamp (Frog Swamp)	14645 (part)	CCW	100m	0.6	0
Melaleuca Swamp	14645 (part)	CCW	0	0	0
TOTAL				**2.0**	**1.6**

* Includes 0.35 ha wetland buffer area overlap between Bibra Lake (UFI 6595) and Horse Paddock Swamp (UFI 6600)

8.0 Conclusion

The current system of determining wetland buffers by applying DEC's non-statutory policy of a minimum 50m from the edge of the wetland was used in the PER. This is the minimum accepted buffer to protect wetlands of conservation significance (EPA, 2008). However, a 200m buffer was recommended in one of the supporting studies to the PER to protect the hydrology of the wetlands (Syrinx & VCSRG, 2011). As stated previously, this 200m buffer is not supported as buffering is not an appropriate management measure to influence wetland water regimes, from either surface water or groundwater (WAPC, 2005). The impacts of changes to the water regime on a wetland are better managed at catchment level (Balla, 1994). Additionally, Syrinx & VCSRG (2011) did not provide any science in quantifying the 200m separation distances required (i.e. buffer.

This wetland buffer study was primarily undertaken as a result of discrepancies between buffer requirements in the PER and supporting studies. This study aims to determine the existing buffer area of each wetland within the Roe Highway Extension project area using a systematic logical approach, in order to determine the total impact of the Roe Highway Extension on wetland and wetland buffers.

The PER stated there would be a direct impact of 5.8 ha to CCWs as well as a 5.4 ha to the assigned CCW buffers (SMC, 2011). However, by using a value based approach study which recognises key threatening processes and key attributes which are critical to the preservation of each wetland's management category objective, this study has identified there will only be a direct impact of approximately 2.0ha of CCW and 1.6ha of REW wetland buffers. This is a reduction of 3.4 ha of direct impact to assigned CCW buffers which can be mainly attributed to the fact that two wetlands within the Roe Highway Extension project area do not have an existing buffer in place due to adjacent land uses and pre-existing development. The overall impact to CCWs remains unchanged at 5.8 ha as delineation of wetland boundaries as mapped in DEC's *Geomorphic Wetlands of the Swan Coastal Plain* dataset has not changed since publication of the PER.

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Appendix A

Guideline for the Determination of Wetland Buffer Requirements

Appendix A Guideline for the Determination of Wetland Buffer Requirements



Guideline for the Determination of Wetland Buffer Requirements

for public comment
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by Essential Environmental Services

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The technical basis for the Guideline was established previously through work undertaken by Welker Environmental Consultancy in the DPI commissioned study Buffering between wetlands and other land uses. This study resulted in two unpublished reports: Study into Buffering Between Wetlands and Other Land Uses: A Management Framework for Wetland Buffering (2002) and Buffering Between Wetlands and Other Land Uses: A Guideline for the Determination of Wetland Buffering Requirements (2003). Text from these reports has been used directly in large parts of this guideline, where explanation of terms and concepts is provided.

Essential Environmental Services acknowledges the significant work of Welker Environmental Consultancy in defining the concepts of buffers, wetland function area, separation distance and separation requirements, including supporting information, diagrams and tables. This information has been used directly to formulate the approach outlined in this Guideline. Essential Environmental Services claims no responsibility for the technical basis of the approach.



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Introduction

This guideline has been developed to assist landowners, developers, planners and architects to identify an appropriate buffer between wetlands and land uses that will enhance or maintain the significant attributes and values of the wetland.

It should be used where a change in land use or development is proposed in the immediate vicinity of a wetland (ie within a lot containing a wetland or adjacent to a wetland) where the future use or development is likely to conflict with the established wetland management objective. This may include urban, some public purposes, intensive rural, commercial or industrial uses and development.

The appropriate separation distance should be identified at an early stage in the planning process so that the proposed plan achieves an acceptable environmental outcome, in the context of planning for sustainability.

This guideline recognises that the planning process must consider other relevant factors, together with environmental factors, in decision-making. Importantly, planning is guided by sustainability principles, as established in the Western Australian State Sustainability Strategy, 2003, that guide strategic actions to meet the 'needs of current and future generations through the integration of environmental protection, social advancement and economic prosperity'.

These guidelines do not apply where landowners are continuing existing activities. However, the principles and approach are supported to establish buffers from existing activities to improve the environmental health and conservation status of a wetland, consistent with its identified management objective.

Buffering of a wetland is recognised as essential for the achievement and maintenance of the wetland's management objective. However, buffering should be considered as only one component of an integrated approach to wetland protection and management. Buffering is proposed as a tool to be employed where separation is appropriate and able to achieve the desired wetland outcomes.

The role that catchment management plays in dealing with wetland issues such as pollution, particularly groundwater pollution, must also be recognised. Groundwater pollution and its impact on wetlands, water regime issues, the terrestrial habitat requirements of many fauna species that inhabit wetlands and the management of mosquitoes and midges extend beyond the influence of wetland buffering. These aspects need to be considered as land planning and management issues in their own right and therefore are beyond the scope of this guideline.

The guideline is structured in seven stages to establish an appropriate buffer between wetlands and existing or proposed development.

Additional information is contained in application notes, which cover the individual stages of the process and help the user complete each step. Guideline application examples, a list of resource documents and a glossary are included as appendices.

The concept of wetland buffers

Buffering provides an important tool in achieving and maintaining the desired values, processes, functions and attributes of wetlands. It involves separating a wetland from the adjacent land use(s) that might threaten its desired values and ensuring wetland activities do not have undue impact on the land use(s), through either spatial separation or the use of physical barriers.

Figure 1 shows the proposed buffering concept in terms of the three basic areas requiring definition to provide separation for the wetland:

- the wetland water body;
- the wetland function area; and
- the separation requirement.

Only permanently inundated wetlands will have a visible area of open water - the wetland water body, all year round. Some wetlands, such as waterlogged areas, never have an open expression of water. Additional information on wetland types is contained in application note 1.

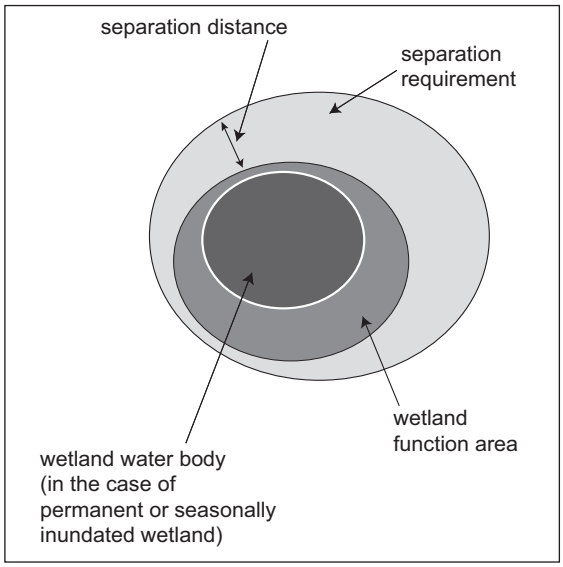


Figure 1 - Generalised wetland buffering concept (Welker Environmental Consultancy, 2002)

The wetland function area is the area which needs to be protected to ensure the important functions and values of the wetland can be maintained. The wetland function area is the spatial boundary of the wetland. It normally would include the wetland itself and the wetland vegetation. The wetland function area is discussed in greater detail in application note 3.

The wetland function area often will require additional separation from surrounding land use(s) to ensure its protection and compatibility with the land use. Separation can involve two general forms: a physical barrier (fence, wall), or a separation distance. These forms are not mutually exclusive, and in some cases, a combination can provide a solution. Key considerations in defining separation needs are values, functions and attributes of the wetland to be protected, the characteristics of the surrounding land use and the threats associated with the land use(s).

A separation distance is generally measured from the boundary of the wetland function area; however, they may be measured from the boundary of the water body in cases of a permanent or seasonally inundated wetland without significant ecological values outside the inundated area.

The separation requirement effectively is the furthest extent of the separation distance required to deal with all separation issues (eg habitat protection, fire management, water quality management) specific to each proposed or existing adjacent land use. Activities compatible with the surrounding land use and the management objective of the wetland can be permitted in all or part of the separation area (eg passive recreation) in accordance with the respective wetland management plan.

Process for determination of wetland buffer

The process to determine an appropriate buffer between a wetland and an existing or proposed land use requires the systematic consideration of wetland attributes (existing or desired), threatening processes associated with adjacent land use, and the role of the buffer in mitigating these threats so the wetland values, functions and attributes are protected to the extent that separation measures can achieve this practically. An individual approach is required to determine buffer requirements, rather than a “one size fits all” approach.

The approach requires completion of a seven step process (figure 2):

- Step 1 Acknowledge existence of wetland
- Step 2 Identify wetland attributes, wetland management category and establish management objective
- Step 3 Define wetland function area
- Step 4 Identify threatening processes
- Step 5 Identify role of separation
- Step 6 Establish separation requirement
- Step 7 Apply separation requirement to proposal and assess its ability to achieve management objective.

The process is depicted in figure 2 and described briefly below. The majority of information is contained in individual application notes at the back of this document, which should be used as necessary to complete each step.

Step 1 Acknowledge existence of wetland

Acknowledgment of the existence of a wetland is the first step in the determination of a wetland buffer. This step does not require any specific definition of the wetland area. The outcome is simply agreement that a wetland of some form exists at a particular location.

Information regarding types of wetlands and existing wetland mapping and identification is contained in application note 1.

Step 2 Identify wetland attributes, wetland management category and establish management objective

A critical step in determining buffering requirements is the identification and definition of the management objective of the wetland.

Wetland evaluation requires an assessment of the values, functions and attributes of the wetland which are used to establish an appropriate management category (application note 2). The information used to establish the management category will aid in the determination of the wetland function area and separation distance, steps 3 and 4 respectively.

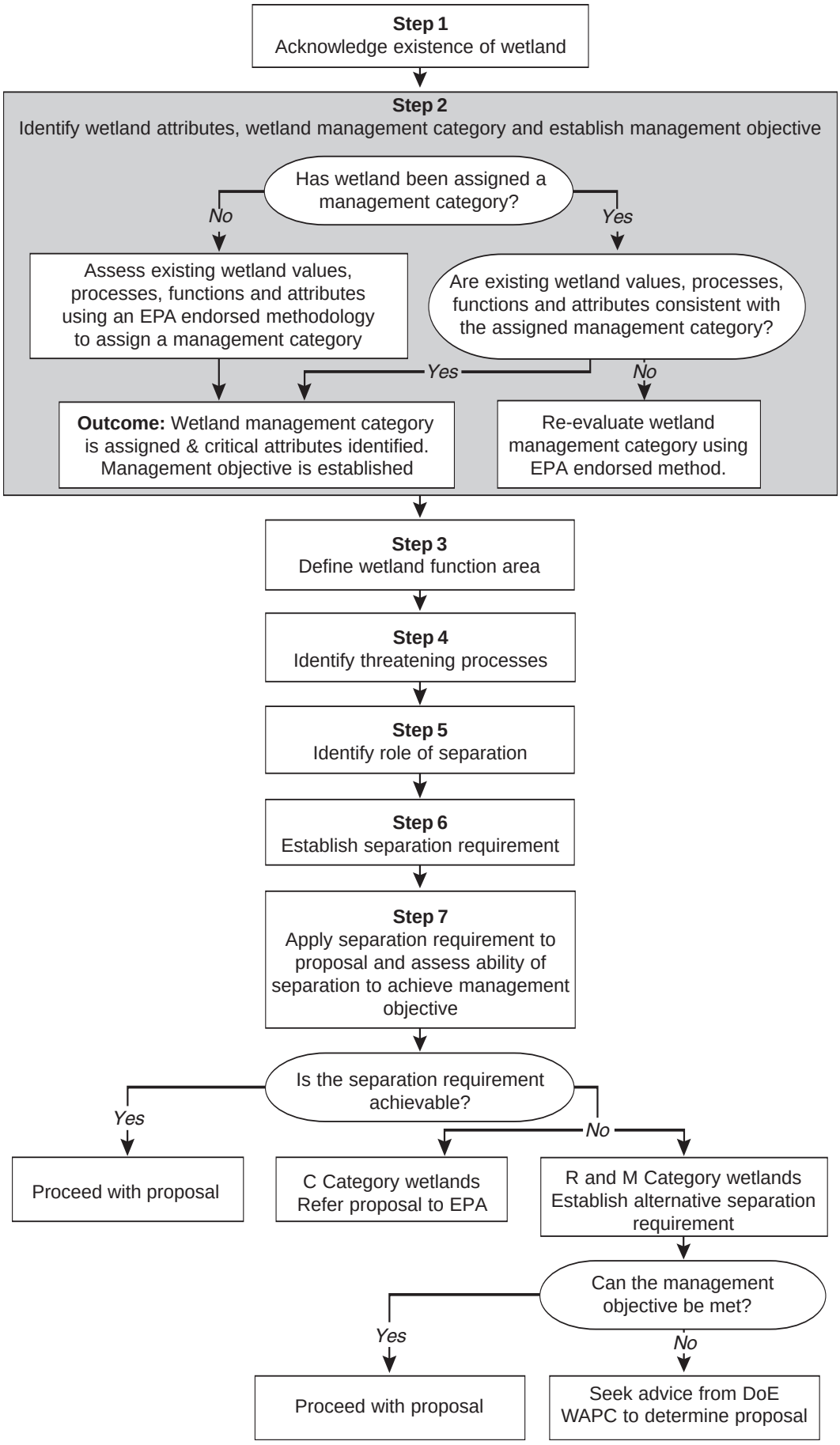


Figure 2 - Proposed process for determination of wetland buffer requirements

Current Swan Coastal Plain evaluation methodologies are used to assign wetlands to one of three management categories:

- C category (conservation): wetlands with high conservation value for both natural or human use;
- R category (resource enhancement): wetlands with moderate natural and human use attributes that can be restored or enhanced; and
- M category (multiple use): wetlands that score poorly on both natural and human use attributes.

Each category has management objective that will ensure retention of the values, functions and attributes associated with the wetland (table 1).

Management objectives have been identified for all wetlands on the Swan Coastal Plain, from Gingin to Dunsborough, through evaluation work completed by the Department of Environment (DoE) (formerly the Water and Rivers Commission) (The Geomorphic Wetlands Swan Coastal Plain dataset can be accessed at www.walis.wa.gov.au). If the wetland in question has already been assigned a management category, the features that have formed the basis for that assignment should be re-evaluated to confirm the management category is appropriate.

If the management category for the wetland is appropriate, the attribute(s) used as the basis for categorisation should be examined to identify the attribute(s) relevant to establishment of the buffer. Table 4 should be used to help determine the key attribute(s) of the wetland and the required function of the buffer. It is important to consider not only the importance of the attribute to achievement of the management objective, but also the degree to which a buffer is able to ensure retention of the attribute.

If the management category is inconsistent with the current state (ie the wetland may be in an improved or more degraded state), the wetland should be re-evaluated using a DoE endorsed protocol and submitted to the DoE for endorsement and update. For further information, see the DoE website http://www.environment.wa.gov.au or contact the Wetlands Program, DoE.

Wetlands yet to be mapped by the DoE will require evaluation with an endorsed protocol, to establish an appropriate management category and objective. Contact the Wetlands Program, DoE for further information and advice or see the above DoE website.

Once a management category has been assigned and the critical wetland attributes – those considered essential to the achievement of the management objective and the effectiveness of the buffer - are identified, proceed to step 3.

Table 1: Wetland management category objectives

Category	Objective
Conservation (C category) wetlands	to preserve wetland (natural) attributes and functions
Resource Enhancement (R category) wetlands	to restore wetlands through maintenance and enhancement of wetland functions and attributes
Multiple Use (M category) wetlands	to use, develop and manage wetlands in the context of water, town and environmental planning

(Source: Hill et al, 1996).

Step 3
Define wetland function area

The wetland function area is the area which needs to be protected to ensure the important functions and values of the wetland can be maintained. It normally would include the wetland, the wetland vegetation and any directly associated dependent terrestrial habitat. If the wetland function area is determined, after a site assessment, to be less than the mapped boundaries, the wetland should be re-evaluated and the results submitted to the DoE so the mapping can be updated.

Information to help define the wetland function area is contained in application note 3. Once the wetland function area has been defined, proceed to Step 4.

Step 4
Identify threatening processes

The key threatening process(es) for the wetland attributes identified in Step 2 should be identified based on consideration of the environmental risks of the various surrounding existing and proposed land uses.

There are many anthropogenic threats to wetlands; however, not all of them may be managed through separation or provision of a buffer. Those that can be mitigated (at least in part) by buffering are:

- alteration to the water regime;
- habitat modification (grazing in wetlands, invasion of exotic species, clearing);
- inappropriate recreational use; and
- diminished water quality (nutrients, organic compounds, suspended solids, toxic compounds and salinity).

Table 6 provides a guideline for the identification of relevant threatening processes associated with the various categories of land use. Once these have been identified relevant to the critical wetland attributes, proceed to Step 5.

Step 5
Identify role of separation

The wetland function area often will require additional separation from surrounding land use to ensure its protection and compatibility with the surrounding land use. Key considerations in defining separation needs are the values, functions and attributes of the wetland and the threats associated with the surrounding land use.

The separation requirement effectively is the furthest extent of separation distances required to deal with all separation issues (eg, habitat protection, fire management, water quality management) specific to each proposed or existing adjacent land use.

It is important to identify the role of the separation requirement for each wetland attribute. This will help to assess the ability of the achievable separation requirement to meet the management objective of the wetland (step 7) and provide the context for any additional separation area management recommendations.

Table 7 should be used to identify the role of the separation requirement in mitigating threatening processes associated with adjacent land use. When the role of the separation with regard to wetland attributes and adjacent land use has been determined, proceed to Step 6.



Step 6
Establish separation requirement

The recommended separation requirements in this guideline are based on consideration of the associated threats and are a factor of the wetland's management category. Different separation measures are required to achieve the different management objectives associated with each management category.

Tables 8, 9 and 10 set out by wetland category, the separation requirement recommended to mitigate the key threatening processes associated with the critical wetland attributes. When the appropriate separation requirement is established, proceed to step 7.

Step 7
Apply separation requirement to proposal and assess ability of separation to achieve management objective

This step involves the overlay of the required separation on the proposal to assess whether it can be achieved. If so, proceed with the proposal.

If the required separation is unachievable, i.e. the recommended separation distance cannot be achieved around the whole wetland function area or the recommended management measures are unable to be implemented, an assessment of what is achievable is required. If it can be demonstrated clearly that the achievable separation (ie separation distance, management measures or a combination of both) will ensure that the appropriate wetland management objective is met, proceed with the proposal.

A reduction in the wetland boundary, the required separation distance or recommended management measures for C category wetlands is unlikely to meet the identified management objective. In such cases the proposal should be referred to the EPA.

A reduction in the recommended separation requirement for R category wetlands, provided it is not associated directly with the critical wetland attributes and additional management measures are proposed to address the reduction, may meet the management objective.

M category wetlands generally are quite degraded and may be weed infested due to their existing use and/or lack of management. The likelihood of having any attributes that require protection through imposition of a buffer is therefore low. Accordingly, it is anticipated that the majority of proposals affecting M category wetlands can be designed and managed to meet the management objective.

Notwithstanding this, the wetland function area or separation distance determined through this process may, in some cases, not be achievable because of existing or planned development within the theoretical buffer area and/or the inability to avoid or adequately manage impacts from adjacent land use. However, modification to either the proposal or the proposed management of the buffer to result in an improved outcome may still meet the wetland's management objective.

The critical wetland attributes and the assigned management category provide the context for decisions on the necessary separation distance and management.

Accordingly, these must be addressed in any argument for reduction of separation requirement. Current technical information should be used in any justification for modified buffering needs.

If, after addressing the management of likely impacts from the proposal, it can be demonstrated that the wetland's management objective can be met, proceed with the proposal.

Where the proposed separation may result in an impact on wetland values, functions or attributes, appropriate approvals may be required to implement the proposal. In these instances, the DoE should be consulted so that an outcome that is acceptable in terms of environmental benefits can be achieved. If it cannot be demonstrated that the wetland values and attributes will be enhanced or maintained, and the proposal cannot be modified to ensure this outcome, particularly where conservation category wetlands are involved, the proposal should be referred to the EPA.



Using the Guideline

The guideline's application notes are designed to facilitate ease of use, as they give the user only the information necessary to complete the appropriate step.

The information obtained from completing each step should be tabulated in a form similar to Table 2, which allows easy identification of critical elements. It establishes a clear process for determining an appropriate separation requirement and allows individual consideration of attributes.

For example, an attribute of a wetland may be the existence of waterbird breeding habitat (step 2). The requirement to maintain this attribute is to retain and protect all areas used by the waterbirds for breeding. This should include areas of open water and seasonal inundation or dampness containing vegetation used by such birds for nesting and shelter.

This requirement can be translated into a boundary requirement (step 3) as, to incorporate this attribute, the wetland function area should extend from the wetland core to include all areas of wetland vegetation possibly utilised by waterbirds. The limit of wetland vegetation therefore defines this boundary. The final wetland function area is determined by incorporating the requirements to maintain all relevant attributes.

The table also can be useful to list the potential threatening processes facing each attribute (step 4) and identify the role of the separation (step 5) using tables 6 and 7.

Table 2: Recommended format for completing steps 3 to 5

Step 2 Attribute	**Requirement to support attribute, for the purpose of defining wetland function area**	**Step 3 Definable boundary/extent**	**Step 4 Threatening processes**	**Step 5 Role of separation**
Migratory bird habitat/breeding ground (protected under JAMBA/CAMBA)	Maintain areas of open water, seasonally inundated areas used for breeding and other areas of vegetation likely to be used by species	Boundary of wetland as mapped by Geomorphic Wetland Database plus surrounding vegetated areas known to be used by birds	• Alteration to the water regime • Habitat modification • Inappropriate recreational use	• Protection from direct disturbance or otherchange/ impact to the wetland function area • Can provide indirect support for wetland function area) through hydrological and terrestrial processes (eg external origin of resources)

(Source: adapted from Welker Environmental Consultancy, 2002).

The appropriate separation requirement then can be established from tables 8, 9 and 10, depending on the management category of the wetland.

It is also useful to summarise the critical points on the summary sheet provided. This form is designed to provide a clear picture of the key stages to help guide the user through the process. It enables the critical information required under one step to be identified and summarised before moving on to the next step.

Unless a significant amount of up-to-date information relating to the wetland is available, the services of a suitably qualified environmental professional are likely to be required to complete this guideline. Assistance may be required to define the wetland function area, particularly the identification of the area/feature required to support and maintain the critical attributes of the wetland. The success of the wetland buffer hinges on the accurate definition of the wetland's boundary.

A field trip should be made to view and take photographs of the wetland itself. The photographs should show clearly the condition of the wetland, all open water, any existing vegetation and evidence of use of the wetland (active or passive recreation or any industrial or rural activities that may impact on the wetland).

The examples in appendices 3, 4 and 5 were completed using desktop information only. This shows that it is possible to determine a buffer with existing information, particularly in the metropolitan region of the Swan Coastal Plain; however it is recommended that a field trip is undertaken to update the field work. This allows confirmation of the management category based on up-to-date information, especially if limited or no management of the wetland has occurred to date.



Wetland Buffer Definition Summary Sheet

Step 1 Location of wetland .....

Step 2 Management category .....

Management objective .....

Critical attributes – high relevance of attribute and high importance to buffering (see Table 4)	Area required to support attribute
.....	.....
.....	.....
.....	.....
.....	.....

Step 3 Greatest extent of wetland function area .....

Step 4 Adjacent land use(s) .....

.....

.....

.....

Threatening processes .....

.....

.....

.....

Step 5 Critical role of separation .....

Step 6 Separation requirement Minimum distance from WFA .....

Management measures .....

Step 7 Is separation requirement achievable? ☐ Yes ☐ No

Application note 1: Acknowledge existence of wetland

1.1 Step 1

Acknowledgment of the existence of a wetland is the first step in the determination of a wetland buffer. This step does not require any specific definition of the wetland area. The outcome is agreement that a wetland of some form exists at a particular location.

1.2 Definition of wetlands

Wetlands are defined as:

> "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres". (UNESCO, 1971)

This definition is from the RAMSAR Convention on Wetlands of International Importance (to which Australia is a signatory) and which has been adopted in the Wetlands Conservation Policy for Western Australia (Government of Western Australia, 1997).

Although rivers, creeks, estuaries, caves, and shallow marine areas fall within this definition, their special attributes, values, protection and management requirements fall outside the scope of this guideline and will be addressed primarily through other guidelines or policies.

Wetland types in Western Australia generally are categorised according to Semeniuk (1987), who proposed that wetlands could be classified according to landform (basin, channel, flat, slope, highland) and the longevity with which water is contained (permanently inundated, seasonally inundated, intermittently inundated and seasonally waterlogged). Wetlands may be classified as the following types, as outlined in Table 3. This guideline is not proposed to apply to intermittently inundated wetlands and channel wetlands (as noted above).

The catchment of a wetland can be defined as the area within which any activities undertaken have the potential to affect the water quality or water levels in the wetland function area. However, surface and groundwater catchments should be excluded from specific consideration in determining separation distances.

Table 3: Wetland types (after Semeniuk, 1987)

Water Longevity			**Landform**		
	Basin	**Channel**	**Flat**	**Slope**	**Highland**
Permanently inundated	lake	river	-	-	-
Seasonally inundated	sumpland	creek	floodplain	-	-
Intermittently inundated	playa	wadi	barlkarra	-	-
Seasonally waterlogged	dampland	trough	palusplain	paluslope	palusmont



Information on the presence of wetlands on the Swan Coastal Plain may be obtained from the Geomorphic Wetlands Swan Coastal Plain dataset (DoE). The dataset can be accessed at www.walis.wa.gov.au (the DoE has A Guide to Viewing Wetland Information on the WALIS website), or alternatively, contact the Wetlands Program at the DoE. For information regarding wetlands outside the Swan Coastal Plain, contact the relevant regional office of the DoE.

If it is possible to modify the proposal to exclude the wetland at this stage, it should be done. This action is consistent with the current EPA position which states that "the EPA places great importance on the protection of the remaining wetlands and expects that in the first instance, proponents will conduct a thorough appraisal of all development options, including proper consideration of site selection, that would avoid direct or indirect impacts on wetlands" (EPA, 2001).

Application note 2: Identify wetland attributes, wetland management category and establish management objective

Wetland evaluation is a process used to describe and weigh a wetland's existing and potential values (Hill et al, 1996). It is helpful to be precise in the description of wetland values, characteristics, functions and attributes, so that they are more readily understood and communicated.

2.1 Wetland values, functions and attributes

Wetland characteristics and attributes give rise to environmental values or functions, which in turn may support or protect the beneficial uses of wetlands (EPA, 1999). The following definitions are taken from Claridge (1991) as outlined in Hill et al (1996) with the exception of 'wetland functions' which was adapted from the definition provided in DoE's internet site glossary.

Wetland **values** are a measure or expression of worth placed by society on a particular function, use or attribute.

The **characteristics** are those properties of a wetland which describe the area in the simplest and most objective possible terms (eg wetland size, species present, soil type, water quality). Characteristics, singly or in combination, give rise to benefits (existing or future) which may be functions, uses or attributes of a wetland.

Wetland **functions** are the physical, chemical and biological processes occurring within a wetland.

A **use** is some direct utilisation of one or more of the characteristics of a wetland.

An **attribute** of a wetland is some characteristic or combination of characteristics which is valued by a group within society, but which does not necessarily provide a function or support a use.

Attributes include:

- richness or diversity of flora or fauna;
- landscape/aesthetic qualities;
- value as a cultural, symbolic or spiritual place by a defined group within the community; and
- presence of rare, endangered or uncommon flora, fauna, communities, ecosystems, natural landscapes, processes or wetland types.

For a comprehensive list of characteristics, functions, uses and attributes, see Hill et al, (1996). More attributes are listed in table 4.

Wetland values can be categorised as:

- uniqueness
- naturalness
- habitat or collective attributes
- scientific attributes
- recreational attributes

- aboriginal
- cultural/heritage
- educational

The first three values are natural attributes. The functions of wetlands reflected in those values are considerable and include supporting numerous species of flora and fauna through the provision of breeding and nursery areas, refuge and feeding areas. Representativeness is an additional value that needs to be considered as having importance (Bowen, Froend & O'Neil, 2002).

Human uses of wetlands include the functions of stormwater retention or retardation, numerous forms of recreation, enhancement of urban development through the provision of 'green' corridors. Aboriginal and European heritage uses of wetlands are extensive, including use as a food source and watering points. Educational and scientific study functions also are important human uses.

The Revised Draft Environmental Protection (Swan Coastal Plain Wetlands) Policy and regulations 2004, (EPA, 2004) proposes that wetlands with at least one significant natural attribute or at least two environmental values listed in the regulations are worthy of registration for protection under the draft Environmental Protection Policy.

2.2 Wetland management categories

A wetland management category system was established by the EPA (1993b) in Bulletin 686. This is the system currently endorsed by the EPA; however, current practices tend to use the system outlined in Hill et al (1996). Accordingly, Bulletin 686 is under review.

Hill et al proposes three wetland management categories:

- C category (conservation): wetlands with high conservation value for both natural or human use;
- R category (resource enhancement): wetlands with moderate natural and human use attributes that can be restored or enhanced; and
- M category (multiple use): wetlands that score poorly on both natural and human use attributes.

The review of Bulletin 686 is not expected to result in any change to the current management categories as it is purported to result in the amalgamation into one document of the range of methodologies already used.

Wetlands are scored against a suite of attributes (currently under revision by DoE) to determine their management category. Given the current revision of the attributes to be used and the scoring process, the information contained in this guideline is based on an expectation of the general outcome of the revised categorisation system.

A management objective has been identified for all wetlands on the Swan Coastal Plain through evaluation work completed by the DoE. For further information regarding wetland classification, evaluation and mapping see the DoE website http://www.environmental.wa.gov.au or consult the DoE Wetlands Program.

2.3 Step 2

In this step, the outcome is the assignment of a management category to the wetland with its associated management objective. This step also requires the identification of attributes considered to be critical to the wetland, the assignment of a management category and the effectiveness of the buffer.

2.3.1 Determination of management category and objective

If the management category for the wetland has been previously determined (as is the case for all wetlands on the Swan Coastal Plain from Gingin to Dunsborough), the attributes used as the basis for categorisation should be re-examined to ensure that they remain consistent with the assigned management category. The Geomorphic Wetlands Swan Coastal Plain dataset can be accessed at www.walis.wa.gov.au.

If there is any inconsistency between the management category and the current state of the wetland, a re-evaluation by the landowner is necessary. Application to the DoE Wetlands Program should be made to obtain the current re-evaluation protocol. As this guideline uses management categories as a basis for the final recommendations, the re-evaluation of the wetland should be completed by the land owner and endorsed by the DoE before progressing to step 3.

Further information is available on the DoE website http://www.environment.wa.gov.au.

If the management category has not been determined, there is a need for the landowner to assess the existing wetland values, processes, functions and attributes and assign a management category for the purpose of establishing the buffer measures. To categorise an unassessed wetland, an evaluation should be made by an appropriately qualified person using an EPA endorsed methodology. This step could involve either the two-tier method of evaluation described in chapter 5 of Hill et al (1996) or the Semeniuk evaluation method. These two methods currently are being combined into one evaluation methodology, which will form an update to Bulletin 686 (EPA, 1993b).

Each management category has an objective for management that will ensure retention of the attributes associated with the wetland (table 1).

Once the management category has been assigned, the appropriate objective can be allocated.

2.3.2 Identification of critical wetland attributes

Once the management category for the wetland has been established, the attributes used as the basis for categorisation should be examined to understand those relevant to buffering. Not

Table 1: Wetland management category objectives (repeated)

Category	Objective
Conservation (C category) wetlands	to preserve wetland (natural) attributes and functions
Resource Enhancement (R category) wetlands	to restore wetlands through maintenance and enhancement of wetland functions and attributes
Multiple Use (M category) wetlands	to use, develop and manage wetlands in the context of water, town and environmental planning

(Source: Hill et al, 1996).



all attributes can be protected through wetland buffers. Therefore, those most relevant to buffers and to the establishment of the management category should be identified – the critical attributes.

Table 4 sets out the relative importance of wetland attributes to achievement and protection of the management objective for the wetland category and provides a general description of the role of the wetland function area and the separation area. As with a buffer distance, a degree of individual judgment is involved in determining relative importance and table 4 is intended as a guide only. Additionally, the table is not comprehensive, as it would be impossible to list all the attributes that may be ascribed to wetlands in WA. Accordingly, case-specific considerations are necessary and may result in some modification to the outcomes.

Additional considerations:

- If already categorised, determine the features that have given the wetland its management category. Some information is provided in Hill et al (1996); however, some of this information is now out of date and therefore mapping in the Geomorphic Wetlands Swan Coastal Plain Dataset also should be referred to. If the wetland is recognised in System 6, the Directory of Important Wetlands in Australia, the Register of the National Estate, the Perth - Bunbury Water Resources Allocation Plan or Busselton – Walpole water resources studies, the values will be discussed in these reports.
- If applicable, determine the justification for the wetland being protected by policy, such as listing under an environmental protection policy or Bush Forever, or convention such as RAMSAR. The justification for the listing of the wetland would provide information on the most significant ecological values previously identified for that wetland.
- If the wetland is contained within an area under conservation management such as in a CALM-managed conservation reserve and/or regional park, values and attributes of the wetland may be listed in the management objectives for such areas. Management plans often exist for these areas, particularly in the case of regional parks, and should be reviewed for information relating to the values of the wetland in question in addition to listed wetlands ecological processes that the park or reserve is intended to maintain.

Additionally, the wetland values and functions could be assessed by reviewing existing studies or conducting new studies on the wetland to investigate the presence of attributes (table 4).

Studies that would contribute important information include those investigating:

- vegetation and flora within and surrounding the wetland to determine the presence (attribute) of significant conservation (value) species or communities (maintenance of these would be functions of the wetland);
- fauna, in or associated with the wetland, to determine the presence (attribute) of fauna, their conservation significance (value) and how the wetland is used by this species ie habitat, food resource (these would be functions of the wetland);
- vegetative and surface hydrological linkage to other wetlands and areas of remnant vegetation;
- water quality of wetland and comparison with Australian and New Zealand Environment and Conservation Commission guidelines for the maintenance of aquatic ecosystems (2000);

- its relationship to groundwater hydrology (ie recharge, discharge) and surface hydrology (eg filtering zone before river/estuary), which would be specific functions of the wetland;
- Aboriginal heritage / ethnographic value;
- its social significance through surveys of recreational and commercial use, perception in community, and determination of proximity to various land uses, particularly residential areas; and
- other key attributes in the evaluation methods.

It is acknowledged that unless a significant amount of up-to-date information relating to the wetland in question is available, it is likely that the services of a suitably qualified environmental professional will be required to complete this step. Assistance may be required to undertake the above studies. These studies are important, as they provide current information to accurately identify wetland attributes and corresponding wetland boundaries. The information also would ensure the attributes identified were specific to the particular wetland, rather than being identified generally from a table or book.



Table 4: Relative importance of wetland attributes to achievement of management aims

	Attribute	Relevance of attribute[1] (H, M, L)[2]			IOB[3] (H, M, L)	Role of wetland function area	Role of separation
		C[4]	R[5]	M[6]			
Ecological	Presence of rare, endangered, restricted, endemic or vulnerable species and/or communities	H	M	L	H	• Provides the habitat and ecological context for the species and maintains ecological processes and biodiversity essential for wetland integrity and resilience	• Protection from direct disturbance or other change/impact to the wetland function areas • Can provide indirect support for wetland function areas through hydrological and terrestrial processes (eg external origin of resources)
	Ecological or geological features of national or international significance	M	M	M	M	• Provides a context for the ecological or geological feature and maintains ecological processes and biodiversity essential for integrity and resilience • Provides a geological context for the formation and/or resource	• Protection from direct disturbance or other change/impact to the wetland function areas • Can provide indirect support for wetland function areas through hydrological and terrestrial processes (eg external origin of resources)
	Constitute part of a linked natural system such as destruction would disturb adjacent wetlands or fauna using the system	M	M	M	H	• Can link adjacent wetland function areas • Provides an ecological context for the species, habitat and/or resource, and maintains ecological processes and biodiversity essential for integrity and resilience	• Can link adjacent wetland Separation Areas. Protection from direct disturbance or other change/impact to the WFA. Can provide indirect support for WFA) through hydrological and terrestrial processes (e.g. external origin of resources)
	Supports high habitat diversity	H	M	L	H	• Provides an ecological context for the habitat and maintains ecological processes and biodiversity essential for integrity and resilience	• Protection from direct disturbance or other change/impact to the wetland function areas • Can provide indirect support for wetland function areas through hydrological and terrestrial processes (eg external origin of resources)
	Habitat of plants or animals at critical stage of biological cycle or vulnerable stage of their life cycle	M	M	L	H	• Provides an ecological context for the habitat and maintains ecological processes and biodiversity essential for integrity and resilience	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area through hydrological and terrestrial processes (eg external origin of resources)

[1] Relative importance of attribute relative to achievement of management category aims
[2] H, M, L: high, medium, low relative importance
[3] IOB: importance of buffering - Relative importance of buffering to achieving/protecting the attribute
[4] management category C: High conservation value
[5] management category R: Resource enhancement
[6] management category M: Multiple use

Table 4: Relative importance of wetland attributes to achievement of management aims (continued)

	Attribute	Relevance of attribute[1] (H, M, L)[2]			IOB[3] (H, M, L)	Role of wetland function area	Role of separation
		C[4]	R[5]	M[6]			
Ecological	Important for maintaining species and/or ecological diversity	H	M	L	H	• Provides an ecological context for diversity and maintains ecological processes and biodiversity essential for maintaining that diversity	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area through hydrological and terrestrial processes (eg external origin of resources)
	Important regional wildlife sanctuary even if flora/ fauna are not rare or endangered	M	H	L	H	• Provides an ecological context for the species, habitat and/or resource, and maintains ecological processes and biodiversity essential for integrity and resilience	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area through hydrological and terrestrial processes (eg external origin of resources)
	Supports large numbers of fauna/flora or 1% of national population	M	M	L	M	• Provides an ecological context for the species, habitat and/or resource, and maintains ecological processes and biodiversity essential for integrity and resilience	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area through hydrological and terrestrial processes (eg external origin of resources)
	Seasonal or temporary habitat or breeding ground of large numbers of migratory birds or nomadic animals	M	M	L	M	• Provides an ecological context for the species, habitat and/or resource, and maintains ecological processes and biodiversity essential for integrity and resilience	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area through hydrological and terrestrial processes (eg external origin of resources)
	Supports extensive areas of emergent and fringing wetland vegetation	H	M	L	M	• Provides an ecological context for the species, habitat and/or resource, and maintains ecological processes and biodiversity essential for integrity and resilience	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area through hydrological and terrestrial processes (eg external origin of resources)

[1] Relative importance of attribute relative to achievement of management category aims
[2] H, M, L: high, medium, low relative importance
[3] IOB: importance of buffering - Relative importance of buffering to achieving/protecting the attribute
[4] management category C: High conservation value
[5] management category R: Resource enhancement
[6] management category M: Multiple use

Table 4: Relative importance of wetland attributes to achievement of management aims (continued)

	Attribute	Relevance of attribute[1] (H, M, L)[2]			IOB[3] (H, M, L)	Role of wetland function area	Role of separation
		C[4]	R[5]	M[6]			
Ecological	Water quantity and quality	H	M	H-L	M	• Provides an ecological context for the physicochemical processes that occur within it • Maintenance of biological and physical processes critical to wetland water quality	• Vegetation interception and use of nutrients in surface and subsurface flow • Can suppress water tables locally and reduce salinisation of surface soils • Role highly dependent on hydrogeology and catchment characteristics
	Drainage (to and from) and presence of nutrient sources	H	M	L	M	• Acts as a discharge site during wet periods and possibly as a recharge site during dry periods • Provides an ecological context for the physicochemical processes that occur within it • Maintenance of biological and physical processes critical to wetland water quality	• Vegetation interception and use of water in surface and subsurface flow • Can suppress water tables locally • Role highly dependent on hydrogeology and catchment characteristics • Role redundant where channelised (piped) discharge into wetland occurs
	Supports significant proportion of indigenous fish, food source, spawning ground, nursery or migration path	M	M	L	M	• Provides an ecological context for the species, habitat and/or resource and maintains ecological processes and biodiversity essential for integrity and resilience	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area through hydrological and terrestrial processes (eg external origin of resources)
Other criteria*	Representative example of wetland type, biogeographical region, function/ role in river or coastal system or major wetland system/ complex	M	M	L	M	• Maintenance of unique/representative character and/or function • Provides an ecological context for the attributes and maintains ecological processes and biodiversity essential for wetland integrity and resilience	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area through hydrological and terrestrial processes (eg external origin of resources)
	Rare or unusual wetland within a region	H	M	L	M	• Maintenance of unique/representative character and/or function • Provides an ecological context for the attributes and maintains ecological processes and biodiversity essential for wetland integrity and resilience	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area through hydrological and terrestrial processes (eg external origin of resources)

Table 4: Relative importance of wetland attributes to achievement of management aims (continued)

	Attribute	Relevance of attribute[1] (H, M, L)[2]			IOB[3] (H, M, L)	Role of wetland function area	Role of separation
		C[4]	R[5]	M[6]			
Other criteria*	Australian heritage commission criteria – important for natural or cultural history (4 separate criteria)	H	M	L	M	• Maintenance of unique/representative character and/or function • Provides an ecological context for the attributes and maintains ecological processes and biodiversity essential for wetland integrity and resilience	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area through hydrological and terrestrial processes (eg external origin of resources)
	Unaltered or unusual wetland vegetation, fauna or processes	H	M	L	H	• Maintenance of pristine condition • Provides an ecological context for the condition and maintains ecological processes and biodiversity essential for wetland integrity and resilience	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area through hydrological and terrestrial processes (eg external origin of resources)
	Important to maintain the quality of human or animal and plant life eg vegetation to arrest soil erosion	M	H	H	M	• Maintenance of unique/representative character and/or function • Provides an ecological context for the attributes and maintains ecological processes and biodiversity essential for wetland integrity and resilience	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area through hydrological and terrestrial processes (eg external origin of resources)
Human use	Aesthetics	H	H	M	H-M	• Maintenance of aesthetic qualities • Provides an ecological context for the qualities and maintains ecological processes and biodiversity essential for wetland aesthetics	• Can add to as well as maintain aesthetics of wetland function area • Protection from direct disturbance or other change/impact to the wetland function area
	Wilderness function	H	L	L	H	• Maintenance of wilderness features, function (as for pristine) and social/cultural importance • Provides an ecological context for attributes and maintains ecological processes and biodiversity essential for maintaining wilderness condition	• For maintenance of wilderness function, separation should extend to wetland catchment boundary • Is an integral part of the surrounding wilderness • Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area through hydrological and terrestrial processes (eg external origin of resources)

Table 4: Relative importance of wetland attributes to achievement of management aims (continued)

	Attribute	Relevance of attribute[1] (H, M, L)[2]			IOB[3] (H, M, L)	Role of wetland function area	Role of separation
		C[4]	R[5]	M[6]			
Human use	Historical, archaeological or cultural significance	H-L	H-L	M-L	M	• Provides an environmental context for the features and cultural values and maintains ecological processes and biodiversity essential for maintaining wetland condition	• Can add to as well as maintain features of wetland function area • Protection from direct disturbance or other change/impact to the wetland function area • Protection of wetland features and function integral to cultural values • Protection from direct disturbance or other change/impact to the wetland function area
	Passive recreation	M	H	H-L	M	• Provides a focus for passive recreation. Maintenance of recreation features • Provides an environmental context for recreation attributes and maintains ecological processes and biodiversity essential for maintaining wetland condition	• May be a focus for passive recreation. Protection of wetland features and function integral to recreation values. Protection from direct disturbance or other change/impact to the WFA
	Active recreation	L	M-L	H-L	L	• Provides a focus for passive recreation • Maintenance of recreation features • Provides an environmental context for recreation attributes and maintains ecological processes and biodiversity essential for maintaining wetland condition	• May be a focus for passive recreation • Protection of wetland features and function integral to recreation values. Protection from direct disturbance or other change/impact to the wetland function area
	Effect on land values	L	M	H-L	M-L	• Maintenance of aesthetic qualities • Provides an ecological context for the qualities and maintains ecological processes and biodiversity essential for wetland aesthetics	• Can add to as well as maintain aesthetics of wetland function area • Protection from direct disturbance or other change/impact to the wetland function area

[1] Relative importance of attribute relative to achievement of management category aims
[2] H, M, L: high, medium, low relative importance
[3] IOB: importance of buffering - Relative importance of buffering to achieving/protecting the attribute
[4] management category C: High conservation value
[5] management category R: Resource enhancement
[6] management category M: Multiple use

Table 4: Relative importance of wetland attributes to achievement of management aims (continued)

	Attribute	Relevance of attribute[1] (H, M, L)[2]			IOB[3] (H, M, L)	Role of wetland function area	Role of separation
		C[4]	R[5]	M[6]			
Human use	Research resource/scientific importance	H	H	H	M	• Maintenance of unique/representative character and/or function of research interest	• May be of research interest • Protection from direct disturbance or other change/impact to the wetland function area
	Educational significance	H	H	H	M-L	• Maintenance of unique/representative character and/or function of educational interest	• May be of educational interest • Protection from direct disturbance or other change/impact to the wetland function area
	Important productive area for commercial endeavours, eg fisheries	L	M	H	H-M	• Maintenance of wetland features, function and commercial (direct or indirect) importance • Provides an ecological context for attributes and maintains ecological processes and biodiversity essential for maintaining production values	• Protection from direct disturbance or other change/impact to the wetland function area

Cannot be defined by one attribute

(Source: Welker Environmental Consultancy, 2002)

[1] Relative importance of attribute relative to achievement of management category aims
[2] H, M, L: high, medium, low relative importance
[3] IOB: importance of buffering - Relative importance of buffering to achieving/protecting the attribute
[4] management category C: High conservation value
[5] management category R: Resource enhancement
[6] management category M: Multiple use

Application note 3: Define wetland function area

The wetland function area means the area required to be protected to ensure the important values, processes, functions and attributes of the wetland can be maintained. The wetland function area normally would include the wetland itself, the wetland vegetation and any directly associated dependent terrestrial habitat.

The wetland function area often will require additional separation from surrounding land use to ensure its protection and to ensure compatibility with the surrounding land use. Separation can be achieved via a physical barrier (fence, wall, etc.) or by a separation distance. These forms of separation are not mutually exclusive, and in some cases, a combination can provide a solution.

The wetland function area will typically include, in addition to any open water, all wetland vegetation unless the management objective is such that the peripheral wetland vegetation need not be retained or considered.

For example, a small lake within grassed parkland may be classified for multiple use, where the only important wetland value is to support an area of open water. In this case, the wetland function area could be restricted to the high-water mark and would not extend to the grassed parkland.

Definition of the high-water mark is somewhat problematic and such boundaries should be considered on a case-by-case basis. Use of the highest historical water level is not a specifically defined level as it may depend on several factors, not the least being the amount of recorded water level data available.

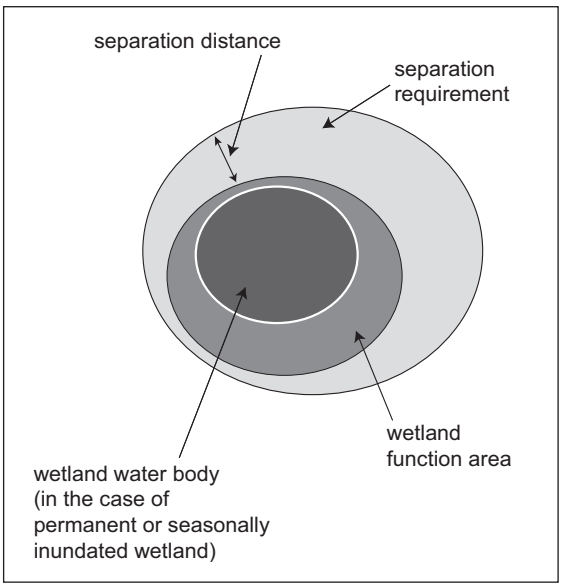


Figure 1 - Generalised wetland buffering concept (Welker Environmental Consultancy, 2002) (repeated)

However, use of historical data is recommended to ensure that the current environmental conditions, such as lack of rainfall, have not led to an uncharacteristic wetland state.

It is proposed that the wetland function area be defined by the outer boundary of the wetland vegetation or the geomorphologic boundary, whichever is the larger, unless a specific case can justify extension beyond that boundary. Extension of the wetland function area to surrounding upland vegetation areas would not normally occur unless those areas served a specific role in maintaining wetland processes and contain or serve attributes associated with the wetland, consistent with the management objective. The issue of protection of terrestrial fauna habitat that is remote from the wetland (even when the primary habitat is within the wetland function area) extends beyond the capacity of wetland buffers.

There is therefore a need to consider those species and their habitat needs through a separate environmental assessment process.

This is consistent with the mapping of wetlands undertaken to date by the DoE contained in the Geomorphic Wetland swan Coastal Plain Databset and should be used where available. All wetlands of the Swan Coastal Plain from Moore River to Dunsborough have been mapped, evaluated and classified and a framework is being developed for wetlands in the remainder of the State. If a wetland has not been mapped and included on the dataset, advice should be sought from the DoE Wetlands Program on the approach to be used to determine the wetland boundary. The Geomorphic Wetlands Swan Coastal Plain dataset can be accessed at www.walis.wa.gov.au.

The issue of protection of upland habitat needs to be considered as a separate (although associated) matter beyond the scope of wetland buffering. Notwithstanding this, separation can be expected, at least in part, to provide some protection for upland habitat.

3.1 Step 3

This step initially involves the assessment of the material used to evaluate the wetland in terms of its management category to define the boundary of the wetland function area. The wetland function area is the area required to be protected to ensure the important values, processes, functions and attributes of the wetland can be maintained.

For each attribute, the requirement to maintain or retain that attribute should be identified and then, where possible, related to a definable boundary centred on the wetland. It can be useful to tabulate the requirements to support significant attributes to determine the wetland function area (table 5).

The use of a table at this stage of the process allows the identification of the requirements to support the listed attributes of the wetland, together with an estimation of the area applicable to this requirement. The latter is defined by a boundary around the wetland, which differs in its extent away from the wetland core according to the attribute being maintained by it.

It is possible that some of these boundaries will be defined by the interface between an area of bushland and another land use that serves no role in supporting the particular attribute of the wetland, such as a residential or industrial area containing no native vegetation. This is highly likely in the case of wetlands in well-established urban areas, such as Yangebup Lake, where residential and industrial areas have been established close to conservation wetlands. It should be noted, however, that small roads (two lanes) separating bushland are considered by the DoE not to interrupt the wetland function area.

Where practicable, the wetland function area is defined as the area within the maximum extent of these boundaries. That is, if all boundaries were to be presented as an overlay on an aerial photograph of the wetland (the approach that is recommended in practice), the wetland function area is the envelope incorporating all the boundaries. For example, an important attribute of a wetland may be the existence of waterbird breeding habitat. A requirement to maintain this attribute is to retain and protect all areas used by the waterbirds for breeding, which would include areas of open water and seasonal inundation or dampness containing vegetation utilised by such birds for nesting

and shelter. This requirement can be translated into a boundary definition as, to incorporate this attribute, the wetland function area should extend from the wetland core to include all areas of wetland vegetation possibly used by waterbirds. The limit of wetland vegetation therefore defines this boundary. The final wetland function area identified is the result of incorporating the requirements to maintain all relevant attributes.

It should be noted that if the final wetland function area boundary is less than that mapped in the geomorphic wetlands datatset, DoE will not alter the dataset unless it is demonstrated that the mapped boundary is not consistent with the true wetland boundary. For more information see the Draft Protocol for proposing modifications to geomorphic wetlands datatset.

Once the wetland function area has been identified, proceed to Step 4.

Note: A table can be useful in listing the potential threatening processes facing each attribute and identifying the role of a separation requirement using tables 6 and 7 as a guide. A table of the attributes of the Coogee Springs wetland is presented as an example in Table 5.

Table 5: Defining the wetland function area for each attribute

Attribute	Requirement to support attribute, for the purpose of defining wetland function area	Definable boundary/extent	Key threatening processes	Role of separation
Part of significant regional wetland system	Maintain wetland area	Boundary of wetland as mapped in the Geomorphic Wetland Swan Coastal Plain Dataset held by DoE	• Alteration to the water regime • Habitat modification	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area) through hydrological and terrestrial processes (eg external origin of resources)
Remnant wetland fringing vegetation	Maintain areas containing emergent wetland species	Boundary of wetland as mapped in the Geomorphic Wetland Swan Coastal Plain Dataset held by DoE	• Alteration to the water regime • Habitat modification • Diminished water quality	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area) through hydrological and terrestrial processes (eg external origin of resources)

Table 5 continued next page

Table 5: Defining the wetland function area for each attribute (continued)

Attribute	Requirement to support attribute, for the purpose of defining wetland function area	Definable boundary/extent	Key threatening processes	Role of separation
Supports large range of macroinverte-brate fauna	Maintain natural water levels. Protect fringing Melaleucas that are within seasonally inundated zone	Areas permanently or seasonally inundated	• Alteration to the water regime • Habitat modification • Diminished water quality	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area) through hydrological and terrestrial processes (eg external origin of resources)
Waterbird breeding habitat	Maintain natural water levels. Protect fringing wetland vegetation	Areas permanently or seasonally inundated and containing wetland vegetation	• Alteration to the water regime • Habitat modification	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area) through hydrological and terrestrial processes (eg external origin of resources)
Potentially provides habitat and/or refuge for a range of frogs, reptiles, birds, and mammals, not otherwise present (associated fauna)	Maintain all areas on which associated fauna are dependent, such that local representation is not affected	Extending from wetland to average known extent of foraging/ use of associated fauna	• Alteration to the water regime • Habitat modification • Inappropriate recreational use • Diminished water quality	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area) through hydrological and terrestrial processes (eg external origin of resources)
Visual amenity of open water	Maintain seasonal water levels	Areas seasonally inundated	• Alteration to the water regime	• Can add to as well as maintain aesthetics of wetland function area • Protection from direct disturbance or other change/impact to wetland function area

(Source: Welker Environmental Consultancy, 2002)

Application note 4: Identify threatening processes

The key threatening process(s) should be identified, based on consideration of the environmental risks of the various surrounding land uses. These threatening processes should also be associated with the wetland attributes identified in Step 2.

4.1 Threats to wetlands

There are many anthropogenic threats to wetlands; however, not all of them may be managed through separation or provision of a buffer. Those that can be mitigated (at least in part) by buffering are:

- alteration to the water regime;
- habitat modification (eg grazing in wetlands, invasion of exotic species, clearing);
- inappropriate recreational use; and
- diminished water quality (nutrients, organic compounds, suspended solids, toxic compounds and salinity).

These threats are discussed in more detail in the following sections and summarised in table 6. For a comprehensive list of anthropogenic threats to wetlands, see Bowen, Froend & O'Neil (2002).

4.1.1 Alterations to the water regime

All wetland processes are maintained by the associated water regimes and any alteration to the regime will result in changes to the flora and fauna.

Water regimes can be changed through several means. Those relevant to wetland buffering include:

- removal of vegetation (affects the water balance through reduced interception and transpiration);
- development of impervious surfaces (increases water interception, but may increase groundwater recharge if concentrated and directed to sumps); and
- directing drains or diverting natural creeks into or away from wetlands.

Wildlife impacts of changing water levels include loss of nesting sites and food sources, lowered biodiversity and emergence of exotic predators.

Groundwater pumping clearly can influence wetland water-level regimes but is not dealt with here as buffering is an inappropriate management response to deal with this effect.

Rises in water level cause deaths to fringing vegetation (which may relocate to a higher elevation if it occurs slowly) and an increase in habitat suitable to aquatic flora and fauna. This impact usually is caused by activities in the catchment and buffering again is an inappropriate management measure to control this. Removal of large areas of vegetation close to the wetland can be managed, at least in part, through inclusion of susceptible areas in a buffering space.

Buffering can assist management of these impacts through constraints on removal or damage to vegetation close to the wetland function area, control of land development close to the wetland function area that will

have a significant influence on vertical water fluxes, and management or elimination of drains discharging into wetlands. Provision of a separation with appropriate controls is the primary buffering mechanism.

4.1.2 Habitat modification

The primary modification of wetland habitat occurs through the removal of vegetation. This includes wetland and upland vegetation. Removal can be direct, through clearing, or indirect, through means such as fire, which also may result in loss of native seeders and sprouters.

Grazing in wetlands and associated upland vegetation creates a threat when, for example, certain native species are excluded or inappropriate native species are introduced, or when feral animals or stock graze in wetlands. The impacts are loss of habitat (eg, preferred food species, shelter, roosting areas), competition with native animal food sources, and physical damage to vegetation.

Management measures include:

- fencing to prevent stock and feral animals entering the wetland;
- providing alternative watering points;
- controlling stock densities; and
- culling feral animal populations.

The invasion of wetlands by exotic species typically occurs after wetlands and associated upland vegetation are disturbed or degraded. Exotic plant species can smother or inhibit native vegetation, alter organic matter fluxes, inhibit light penetration (shading out benthic plants), interfere with water movement, change evapotranspiration, alter water quality and create fire hazards. Nearby residential and agricultural areas are a particular source of weeds and exotic plants that can create a risk of invasion of wetland areas.

Exotic animals can compete with and prey on native species. Species such as carp can increase turbidity, reduce invertebrate numbers and cause declines in numbers of fish and wetland plants.

Buffering can help manage these impacts though constraints on removal or damage to vegetation, fencing, and controlling exotic animal populations.

4.1.3 Inappropriate recreational use

The ability to use wetlands is considered one of the most important attributes of wetlands by the general community. Recreational use may be active, such as water skiing, swimming or horse riding, or passive, such as bird watching, picnicking or research. Use of wetlands by the community, however, sometimes results in impacts on the wetland that are detrimental to its values.

Recreation impacts on wetlands and associated upland vegetation include trampling of vegetation, bank erosion, pollution and disturbance of wildlife. Buffers, particularly physical barriers, are an effective way of managing many impacts from inappropriate use in urban and rural areas. Appropriate management of recreational usage such as through fencing, regulation, signage (education) and provision of vegetated areas which enhance degraded wetlands and encourage people to use them instead of high conservation wetland areas, are relatively simple ways of minimising or eliminating this type of impact on wetlands.

The appropriateness of use of wetlands largely is a function of the management

category of the wetland. It is unlikely that active recreational pursuits are appropriate in C category wetlands, where they may be acceptable in R and M category wetlands. For guidance on appropriate use of wetlands, refer to the relevant wetland management plan, CALM or the DoE Wetlands Program.

4.1.4 Water quality

Pollution affects the full range of wetland ecosystem processes. Bunn et al (1997) categorised pollutants as:

1. Nutrients – nutrient enrichment is a widespread occurrence in wetlands resulting in algal blooms that affect productivity, create odours, spoil water taste and appearance and can produce toxins (that can affect wetland biota or drinking water supply quality). Effects on wetland biota can result in a change in species structure and diversity (both flora and fauna).

2. Suspended solids and sedimentation – excessive amounts of sediment entering wetlands can cause detrimental effects on plant and animal (vertebrate and invertebrate) communities through a gradual infilling of the wetland, smothering of flora and fauna and reduction of light transmission through the water column. This may occur as a result of land clearing adjacent to wetlands that leaves areas of bare soil that are transferred to the wetland by wind and surface water flow.

3. Organic compounds – organic wastes from household effluent, animal wastes and urban runoff can foul water, build up in the food chain, cause odours and increase biological oxygen demand. Many organic compounds (eg hydrocarbons, detergents) can be irritants or toxic to fish and possibly to invertebrates.

4. Toxic compounds – wetlands act as sinks for many pesticides and other chemicals used in wetland catchments. Pesticides and heavy metals form the main toxic materials of concern. Degradation of wetlands can affect water chemistry (pH, chelating agents, etc) and enhance the toxicity of heavy metals. The presence of toxic material in wetlands is likely to be long term and chronic and where the material may not directly kill flora and fauna, it can make it more susceptible to other environmental stresses such as salinity. High concentrations of toxicants may also induce acute toxic effects, including flora and fauna death. Metal poisoning can cause large algal growths though removal of algal grazers and competitive algae.

5. Salinity – secondary salinisation where a wetland becomes unnaturally saline, primarily due to vegetation clearing. Salinisation may also occur from mining or industry discharges. Most biota have limits to the salinity they can tolerate and salinity impacts on wetlands usually involve a change to more salt tolerant species.

The phenomenon of acidification of wetland water bodies through occasional drying and oxidation of sediments has been observed recently in several locations. Lake Gnangara is a recent example. Land clearing and artificial lowering of water tables in susceptible areas also may induce acidification of surface and groundwater entering wetlands. For further information, refer to Planning Bulletin 64 Acid Sulfate Soils (WAPC, 2003) or the DoE Acid Sulfate Soils Guidelines Series at www.environment.wa.gov.au/contaminatedsites

The primary role of buffering in managing water quality is through management or elimination of drains carrying pollutants discharging directly into wetlands or their buffers. It also is important to eliminate treatment basins which may contaminate the groundwater of the wetland or overflow into the wetland.

Buffering incorporating the use of biological filters should be considered; however, this can be expected to play a significant role only with surface water inflows. Groundwater inflows are more problematic, particularly in areas such as the Swan Coastal Plain where the ability of wetland fringing vegetation to take up nutrients before they enter wetlands via the groundwater through-flow will be limited.

Apart from minimising drainage discharges directly into wetlands, the most effective means of managing wetland water quality is through catchment management processes rather than buffering.

4.2 Environmental risk of various land uses

Different land uses generate different threats to wetlands. While specific land use development proposals need to be evaluated on a case-by-case basis, the following general risks apply to the various major land use categories.

4.2.1 Rural land uses

Rural land uses fall into two broad categories: broad acre farming and intensive agricultural industries. Both constitute risks to wetlands.

Land clearing is the primary threat common to both categories. Broadacre farming introduces exotic animals and plants and presents risks from predation and overgrazing. Use of pesticides and fertilisers are risks common to most agricultural uses, independent of intensity.

Intensive agricultural industries such as horticulture and animal feedlots present these risks in a substantial form. Piggeries are a particular intensive agricultural pursuit unsuited to being close to wetlands because of the high nutrient outputs. Stock trampling and overgrazing of understorey are common occurrences.

Salinity effects on wetland areas are the result of land clearing to support broadacre farming. Land clearing also causes rises in groundwater and associated wetland water levels, resulting in drowning of fringing vegetation.

Special rural land use zonings create some risks as a range of activities can be carried out on rural lifestyle properties, many of which may in effect be light industrial rather than agricultural. Activities such as vehicle and machinery maintenance create similar risks to light industrial activities through input of organic and inorganic pollutants and nutrients. The proximity of rural lifestyle properties can generate opportunities for inappropriate recreation, including horse-riding trails.

Groundwater abstractions to supply irrigation water for intensive horticulture can be a major influence on wetland water levels. Buffering is an inappropriate measure to control groundwater abstractions, however, bores should not be permitted within the wetland function area or separation area if likely to affect wetland water levels. This issue is best addressed by controlling groundwater abstractions to

ensure drawdown impacts on wetlands are within appropriate limits.

Artificial maintenance of wetland levels through the addition of water to the water body is undertaken for several wetlands on the Swan Coastal Plain and is an effective management measure in specific circumstances.

4.2.2 Urban land uses

Urban land uses include residential, special residential, and light and heavy industry.

Apart from clearing pressures resulting from commercial opportunities from all forms of land development in urban areas, residential land uses generate pressure on wetlands through the potential for inappropriate recreation, traffic noise, weed infestation, drainage and stormwater run-off, pollutant discharges and groundwater impacts of contamination and abstractions.

There are numerous examples of development of residential land increasing groundwater recharge and permanently raising water levels, resulting in drowned fringing vegetation. This occurs through the combined effect of clearing native vegetation and the creation of impervious areas that direct stormwater to sumps which increases the overall infiltration rate to groundwater from storm events. Examples of wetlands with drowned vegetation in the Perth metropolitan area are Lake Claremont and Blue Gum Lake.

Eutrophication of wetlands occurs through drainage carrying lawn and garden fertilisers into the water bodies. Organic material in lawn clippings is a particular issue with residential areas.

Industrial areas carry the risks of noise and water quality impacts through drainage discharges and groundwater contamination.

The aesthetic aspects of urban wetlands create pressures on water managers to maintain permanent water in ephemeral wetlands. Periodic drying of wetlands is recognised as being necessary to maintain wetland health and reductions in the range of water variation can cause water quality problems and other problems.

As in rural areas, groundwater abstractions in urban areas create risks to wetlands and again are better managed through controls on abstractions rather than buffering.

4.2.3 Other land uses

Other more specific land uses create a variety of risks. Clearly, reserves that prevent land clearing and intensive activities are generally of low risk to wetlands, and can provide good protection. However, silvicultural activities can significantly affect groundwater recharge rates and impact on wetland water levels. The State Forest 65 pine plantations at Gnangara are attributed with causing a significant reduction in recharge below natural levels in areas not subjected to periodic thinning to meet target basal densities set to achieve groundwater management objectives.

4.3 Step 4

Table 6 provides a guideline for the identification of threatening processes associated with different land use categories. Relevant threatening processes should be identified through the assessment of possible impacts from applicable land uses. Once these have been identified for each wetland attribute, proceed to step 5.

Table 6: Summary of lands uses and associated threats Land Use

	Key Threatening Process			
Land use	**Alteration to the water regime**	**Habitat modification**	**Inappropriate recreational use**	**Diminished water quality**
Broadacre rural	• Land clearing and watertable rise with drowning of vegetation • Drainage to minimise flooding	• Loss of vegetation • Introduction of exotic flora and fauna • Overgrazing • Loss of fringing vegetation and erosion from stock trampling	• Power boating on larger water bodies in remote areas	• Pesticides and fertilisers • Salinisation
Intensive rural	• Land clearing and watertable rise with drowning of vegetation • Drainage to minimise flooding • Groundwater abstraction lowering water levels • Drainage into wetland	• Loss of vegetation • Introduction of exotic flora and fauna • Loss of fringing vegetation and erosion from stock trampling	• Horse riding trails associated with rural lifestyle living	• Pesticides and fertilisers • Nutrients from intensive animal industries • Some risk of organic and inorganic contamination form rural lifestyle living
Urban/ Residential	• Watertable rise through reduced rainfall interception and higher induced recharge • Use as drainage compensating basis • Groundwater abstraction lowering water levels • Reduced drying because of loss of aesthetic value of water body	• Loss of fringing vegetation to provide aesthetic views • Encroachment to achieve maximum commercial returns • Uncontrolled access trails affect vegetation • Traffic noise • Weed infestation • Feral and domestic animals	• High population pressures • Rubbish disposal	• Stormwater and drainage discharges carrying nutrients and inorganic and organic pollutants
Industrial	• Watertable rise through reduced rainfall interception and higher induced recharge • Groundwater abstraction lowering groundwater levels • Drainage into wetland	• Encroachment to achieve maximum commercial returns • Noise impacts		• Stormwater and drainage discharges carrying nutrients and inorganic and organic pollutants • Industrial pollutants
Other	Silvicultural activities affect rainfall recharge to groundwater		• Bank erosion • Noise and other disturbances • Water pollution • Vegetation trampling • Introduction of feral animals	

(Source: Welker Environmental Consultancy, 2002)

Application note 5: Identify role of separation

The wetland function area often will require additional separation from surrounding land use to ensure its protection and compatibility with the surrounding land use. Separation can involve two general forms: a physical barrier (fence, wall), or a spatial, along-the-ground separation distance or area. These forms are not mutually exclusive, and in some cases, a combination can provide a solution. Key considerations in defining separation needs are the attributes of the wetland and the threats associated with the surrounding land uses.

5.1 Separation

Separation (spatial separation and barrier separation) has a broad role in achieving and protecting the range of values associated with the management category and objective of any particular wetland.

Separation provides the following functions: (Bowen, Froend & O'Neil, 2002)

- reduces unchannelised accelerated water runoff from surrounding land;
- provides a physical barrier to slow surface flows and mechanically trap sediment and debris and chemically trap nutrients, salt and other contaminants;
- provides shelter in wind erosion prone areas;
- provides a native fauna corridor;
- provides screening between conflicting landscapes and/or disruptive movement and/or noise and/or approaching visitors;
- reduces the impacts of browsing animals;
- reduces the effects of nuisance insects; and
- prevents invasion of unwanted plants; and provide aesthetic value.

A vegetated separation area performs the following tasks in addition to those above:

- maintains water quality by filtering nutrients and trapping sediments;
- provides food, shelter and breeding habitat for terrestrial and aquatic fauna;
- provides shade to lower water temperature and increase oxygen holding capability of water body;
- provides shade to reduce nuisance aquatic plants and algae;
- provides energy source from debris from overhanging vegetation;
- provides food source for larger organisms where invertebrates living in vegetation are blown into the water and;
- reduces flood and salinity risk by increasing evapotranspiration;
- stabilises banks against erosion; and
- contributes to the tannin content of the water body reducing light penetration and consequently reducing incidence and severity of algal blooms. Colouring of water also can assist aquatic animals to hide from predators.

Areas of vegetation and grass also are recommended to be used where overland flow is the predominant medium for water input to wetlands[7]. This is because:

- vegetated areas can significantly slow overland flow into wetlands, and thereby prevent polluted water, sediment and nutrients from reaching the wetland and reducing erosive capacity; and
- grassed areas are very effective in reducing overland flow and mechanically trapping sediments and debris as well as nutrients (5 m wide grassed areas have been shown to remove about 70 per cent of sediment and 90 per cent of nutrients from run-off while an 8 m wide area removed up to 80 per cent of sediments and a 9.1 m wide strip removed from 96 per cent to 99.9 per cent of nutrients)[8]. However grassed areas run the risk of causing weed invasion into the wetland or adding nutrients if excessive fertilisers are applied or lawn clippings escape into the wetland. Consideration should be given to using appropriate non-seeding grass species to reduce the risk of seed flowing into the wetland.

There is increasing recognition that disease vector and nuisance insects such as midges and mosquitoes can affect urban residential areas close to wetlands. It is acknowledged that risk of impacts from disease vector and nuisance insects needs to be considered in certain land planning decisions. Midges and mosquitoes generally are controlled by chemicals, the use of water sensitive design and/or the use of buffers. Memorials on Title also are used to raise the awareness of the issue with potential homebuyers in areas affected severely by mosquitoes.

This issue is beyond the scope of this guideline, as it is a whole-of-government issue that requires a consistent approach across the State. The issue of disease vector and nuisance insects is addressed in greater detail from a planning perspective in Development of a Planning Policy for Mosquitoes and Development (DPI, 2001).

5.1.1 Separation distance and separation area

A separation distance is generally measured from the boundary of the wetland function area; however, may be measured from the boundary of the water body in cases of a permanent or seasonally inundated wetland with low ecological values.

The spatial form of separation can be considered as being a required setback or separation distance. The terms separation distance and separation area (figure 1) are used in this guideline as the term setback carries specific connotations that do not fit

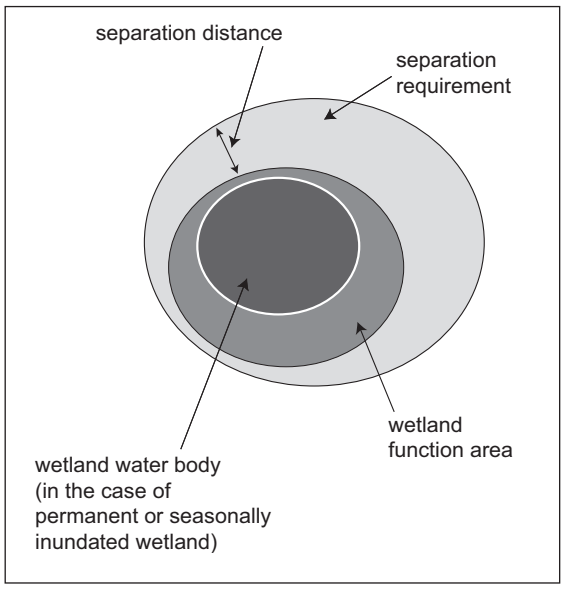


Figure 1 - Generalised wetland buffering concept (Welker Environmental Consultancy, 2002) (repeated)

[7] Overland flow is a minor contributor to wetland water in areas such as the Swan Coastal Plain where sandy or other permeable soils allow high levels of infiltration and natural water input to wetlands predominantly is through the underlying groundwater.

[8] Grassed areas must be grown without the use of excess fertilisers that can increase nutrient input to wetlands.

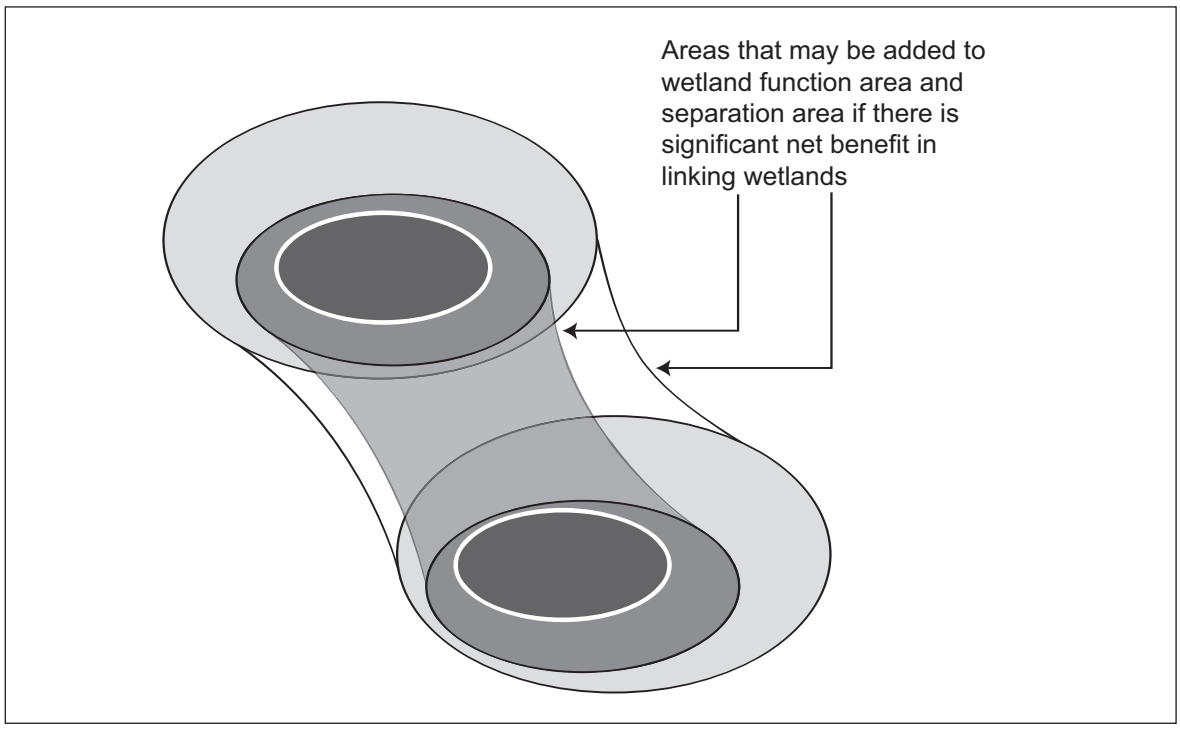


Figure 3 - Linking wetlands (Welker Environmental Consultancy, 2002)

with allowing and managing activities in separation areas. Additionally, use of the word zone also is avoided due to its specific planning meaning.

Figure 3 shows how the approach might be applied where two wetland function areas are in proximity and the wetlands can be linked. In this example, the wetland function area and separation distance for each wetland has been dealt with individually. Where the two wetlands are separate and in proximity (as shown) or where wetland function ares overlap, there may be an overall benefit in linking them, at least in terms of the separation distances, and in some cases, the wetland function areas, to provide a wetland corridor.

This approach would be appropriate in the situation of wetland suites and regional parks, where the benefit of linking the wetlands is determined, on balance, to outweigh the disadvantages of prohibiting activities within the increased separation area and wetland function areas.

5.1.2 Physical barriers

In some circumstances, physical barriers may provide an alternative to large separation area in certain circumstances, eg the use of a fence to keep domestic animals from nearby residences out of the wetland function area, or use of a path to help prevent spread of seed. To achieve the above through a separation distance would require a considerably larger separation area. In addition, more intensive management arrangements may be required.

5.2 Separation requirement

The separation requirement effectively is the envelope of the separation distance and management required to deal with all separation issues (eg habitat protection, fire management, water quality management) specific to each proposed or existing adjacent land use.

Activities compatible with the surrounding land use and the management objective of the wetland may be permitted in all or part of the separation area (eg passive recreation) in accordance with the wetland management plan.

The separation of wetlands from incompatible land uses helps to manage activities that cannot be controlled or managed by regulatory agencies. However, wetland buffers should also be supplemented by catchment management activities, especially where they provide a more practical means of achieving the desired aim than spatial separation.

5.3 Step 5

It is important to identify the role of separation as it relates to the individual wetland attributes to reduce the impacts of the adjacent land uses on the wetland (and vice versa). This will help to assess the ability of the achievable separation requirement to meet the wetland's management objective (Step 7) and provide the context for recommendations for management of the separation area.

For example, if one of the critical wetland attributes is that it is a migratory bird habitat and breeding ground protected under JAMBA and CAMBA, the role of the separation requirement is to protect the wetland function area from direct disturbance or other changes/impacts. This role is vital to the maintenance of the wetland's values and functions and must be assured through determination of the final separation requirement.

Table 7 sets out the role of separation in the mitigation of threatening process(es) relevant to associated adjacent land use. This table should be used to identify the role of separation in accordance with the threatening process(es) that would be expected to apply.

When the role of the separation measures in mitigation of potential impacts (threatening processes) with regard to adjacent land use(s) for each wetland attribute has been determined, proceed to Step 6.



Table 7: Role of separation to address threatening processes

Threatening process	Role of separation
Alteration to the water regime	• Reduces rates of surface (unchannelised) and subsurface inflow and therefore reduces potential for elevated levels and prolonged flooding • Resists channelisation, thus decreasing erosion and rate of water flow • Increases interception and evapotranspiration, reducing excessive flooding • Assists in adjustments to changing water levels via the expansion and contraction of plant communities • Vegetated wetland fringes may affect the water regime through increasing evapotranspiration losses from the groundwater system supporting the wetland
Habitat modification	• Vegetated buffers are valuable in minimising disturbance to the wetland and reducing potential for colonisation by exotic species • Fencing the perimeter of the buffer is effective in preventing access to the wetland by exotic terrestrial vertebrate fauna • Adds to and maintains wildlife habitat of a wetland • Firebreaks reduce potential for increased frequency of fire
Inappropriate recreational use	• Vegetated buffers can be used to enhance the aesthetics of a wetland, encouraging people to use that wetland rather than those of high conservation value • Provides barrier to visual and noise pollution • Minimises public access and activities in certain areas and/or wetlands
Diminished water quality	• Vegetated buffers assist in the reduction of nutrient inputs to wetlands through increased uptake and assimilation of surface and subsurface water-borne nutrients • Reduces un-channelised surface water flow rates, allowing suspended material to settle prior to wetland entry • Provides for management of drainage inputs (see Alteration to the water regime) • Avoids eutrophic conditions in a wetland and reduces the dispersal and impact of midges on surrounding areas • Hydrogeology within the catchment and immediately around and beneath the wetland has a significant influence on the effectiveness of a buffer with respect to water quality. The intensity of production of contaminants by the source is a major factor to be considered and managed

(Welker Environmental Consultancy 2002)

Application note 6: Establish separation requirement

The recommended separation requirements outlined in this guideline are determined by the likely impacts of adjacent land uses on the wetland and its values. Requirements are different for each management category because different separation measures are required to achieve the different objectives associated with each management category. The critical wetland attributes provide additional context for decisions on separation and management measures.

Recommended separation distances are given as ranges for several measures, in particular for firebreaks, aesthetic improvements, and nutrient and sediment control. In a case-by-case assessment, the distance should be determined by taking into account the physical characteristics relevant to the wetland, including wetland values and attributes, the surrounding land use and the feature being mitigated for or against (threatening process).

The rationale for selection of a separation distance should be justified in terms of the wetland's site-specific characteristics. For example, with firebreaks, the distance is dependent largely upon the vegetation (height, flammability), susceptibility of the wetland to fire effects, and the risk posed by and/or to surrounding land use. Aesthetic improvements and barrier controls are dependent on the characteristics of the surrounding land use. Noise control is governed by the characteristics of the potential noise generator. In the case of control of sediment and nutrient inputs through overland flow, the influential parameters are soil characteristics, slope of the land, vegetation cover (particularly in terms of its ability to retard flow and trap or take up containments), and potential contamination concentrations.

The buffering requirements in this guideline have been determined generally on the basis of management objective. Achievement of the management objective may require more than the proposed distance, or may be able to be achieved with less. Variation from the suggested distances needs to be considered on the merits of each case.

The recommended separation and management to mitigate potential impacts (threatening processes) for category C, R and M wetlands is shown in tables 8, 9 and 10 respectively. To help identify attributes that have high importance relative to the achievement of the aims of each management category, attributes shown in table 7 are listed.

6.1 Category C wetlands

Attributes identified as having high importance relative to achievement of the aims of the conservation (C category) management category are:

Ecological

- presence of rare, endangered, restricted, endemic or vulnerable species and/or communities;
- supports high habitat diversity;
- important for maintaining species and/or ecological diversity;

	• supports extensive areas of emergent and fringing wetland vegetation; • water quantity and quality; and • drainage (to and from the wetland) and presence of nutrient sources.
Other criteria	• rare or unusual wetland within a region; • Australian heritage commission criteria – important for natural or cultural history (4 separate criteria); and • unaltered or unusual wetland vegetation, fauna or processes.
Human use	• aesthetics; • wilderness function; • research resource/scientific importance; and • educational significance.

Recommended separation and management to mitigate potential impacts (threatening processes) for category C wetlands is shown in table 8.

6.2 Category R wetlands

Attributes identified as having high importance to achieve the aims of the resource enhancement (R category) management category are:

Ecological	• important regional wildlife sanctuary even if flora/ fauna are not rare or endangered
Other criteria	• important to maintain the quality of human or animal and plant life eg vegetation to arrest soil erosion

Table 8: Category C wetlands: Separation and management

Key threatening process	Recommended Separation and/or management	Separation area management
Alteration to the water regime	Regulation of groundwater abstraction as catchment management measure	• Area to be vegetated with deep-rooted perennial vegetation • Preferably native plant communities • 6m firebreak minimum, inside of fence • Fence to limit vehicle, stock, exotic fauna access • Clear perimeter outside of fence (path, firebreak, road. • Fire control to maintain habitat and species diversity • Minimise track access/clearing, maximise native vegetation • Management for water quality outcomes as required
Habitat modification	• 100 m weed infestation • Up to 100 m for bird habitat dependent on extent of use • 6-50 m firebreak • Fence for controlling exotic fauna access • ≥100 m to minimise edge effects	
Inappropriate recreational use	• ≥ 50 m to improve aesthetics • ≥ 50 m for barrier • Fence, paths for controlling access	
Diminished water quality	• Drainage inflows eliminated or managed • Where a proposal may affect wetland water quality, particularly through un-channelised flow, detailed site specific work should be undertaken to determine the specific separation measures required, including management measures	

(Source: Welker Environmental Consultancy, 2002)

Human use
- aesthetics
- passive recreation
- research resource/ scientific importance
- educational significance

R category wetlands can possess similar attributes to C category wetlands but the wetland may not be in as good condition or possess as many attributes. The attributes of C category wetlands therefore should be used as a guide.

Recommended separation and management to mitigate potential impacts (threatening processes) for Category R wetlands are shown in table 9.

6.3 Category M wetlands

Attributes identified as having high importance relative to achievement of the aims of the multiple use (M category) management category are:

Other Criteria
- important to maintain the quality of human or animal and plant life eg vegetation to arrest soil erosion, management of water quantity and water quality

Human Use
- passive recreation research resource/scientific importance
- educational significance
- important productive area for commercial endeavours eg fisheries

Recommended separation distances and management to mitigate potential impacts (threatening processes) for M category wetlands are shown in table 10.

Table 9: Category R wetlands: Separation and management

Key threatening process	Recommended Separation and/or management	Separation area management
Alteration to the water regime	Regulation of groundwater abstraction as catchment management measure	• Area to be vegetated with deep-rooted perennial vegetation. Limited open areas of grass • Controlled access to wetland (paths) • 6 m firebreak minimum, inside fence (if required) • Fence to limit vehicle, stock access • Clear perimeter outside fence (path, road) • Fire control to minimise hazards and maintain habitat diversity • Management for water quality outcomes as required
Habitat modification	• 50 m weed infestation • 50 m avifauna habitat • 6 m firebreak	
Inappropriate recreational use	• 10 m - 50 m for improving aesthetics • 10 m - 50 m for barrier • Fence, paths for controlling access	
Diminished water quality	• Drainage inflows eliminated or managed • Where a proposal may affect wetland water quality, particularity through un-channelised flow, detailed site-specific work should be undertaken to determine the specific separation measures required, including management measures	

(Source: Welker Environmental Consultancy, 2002)

It is acknowledged that M category wetlands generally are quite degraded, containing limited or no upland vegetation not infested with weeds, most likely resulting from uncontrolled access by humans or animals. There often is limited acknowledgement of the existence of the wetland and therefore inadequate management has occurred. Accordingly, it is not anticipated that many M category wetlands will require provision of a buffer between the wetland and the surrounding land use. The objective in these instances is restoration of the wetland and enhancement of wetland values where possible.

6.4 Step 6

Tables 8, 9 and 10 set out, by wetland management category, the separation and management recommended to mitigate the key threatening processes associated with the critical wetland attributes. These tables should be used to identify an appropriate separation distance and recommend management based on the key threatening processes identified in step 4 and the management category of the wetland.

The rationale for determination of a separation distance should be justified in terms of the site-specific characteristics. The separation requirement should be relevant to the critical wetland attributes as they relate to the key threatening processes and the individual characteristics of the wetland.

Separation distances and management measures are recommended on the basis of potential threats in order to mitigate likely impacts of the surrounding land use. Separation measures are required to mitigate only those threats that are present. For example, if there is no potential for loss of vegetation (habitat modification), there is no need for a separation requirement to manage this impact. Similarly, if the only threat identified is the potential for alteration to the water regime, no separation distance is required.

Table 10: Category M wetlands: Separation and management

Key threatening process	Recommended Separation and/or management	Separation area management
Alteration to the water regime	Regulation of groundwater abstraction as catchment management measure	• Area to be vegetated with deep-rooted perennial vegetation. Limited open areas of grass • Controlled access to wetland (paths) • 6 m firebreak minimum, inside fence (if required) • Fence to limit vehicle, stock access • Clear perimeter outside fence (path, road) • Fire control to minimise hazards and maintain habitat diversity • Management for water quality outcomes as required
Habitat modification	• 50 m weed infestation • 50 m avifauna habitat • 6 m firebreak	
Inappropriate recreational use	• 10 m - 50 m for improving aesthetics • 10 m - 50 m for barrier	
Diminished water quality	• Drainage inflows eliminated or managed • Where a proposal may affect wetland water quality, particularity through un-channelised flow, detailed site-specific work should be undertaken to determine the specific separation measures required, including management measures	

(Source: Welker Environmental Consultancy, 2002)

Generic separation measures are recommended in the tables. It is therefore necessary to ensure that the separation identified is relevant to the attribute associated with the threat.

The identification of an accurate separation distance for firebreaks, aesthetic improvements, and nutrient and sediment control, which are recommended as ranges in the tables, also is necessary. These distances should be determined by taking into account the physical characteristics relevant to the values and attributes of the wetland, the surrounding land use and the feature being mitigated for or against. This assessment is likely to require the services of a suitably qualified environmental professional.

When the appropriate separation requirement is established, proceed to step 7.



Application note 7: Apply separation requirement to proposal and assess ability of separation to achieve management objective

7.1 Step 7

This step involves the overlay of the separation requirement on the proposal to assess whether the recommended separation measures can be achieved. An aerial photograph should be used for this step. An overlay of clear film, which shows the proposal, cadastral boundaries, contours to identify ridgelines and extrapolate areas of wetland vegetation, and other land use planning information, may be more useful than marking the photograph. The wetland function area also should be drawn on the overlay. The required separation distance then can be measured from the boundary of the wetland function area.

7.2 Separation measures achievable

If the required separation measures are achievable, ie the separation distance can be achieved and recommended management measures implemented, proceed with the proposal.

7.3 Separation measures unachievable

In a practical situation, existing land planning decisions often make securing required buffering distances or necessary associated management regimes impractical. Effectively this means the wetland management category objective is not practically achievable without modification of existing decisions or the proposal of arrangements to ensure retention and maintenance of wetland values and attributes.

A simple example is where significant residential development has already been allowed to develop within the recommended separation distance. The residential land use is likely to compromise the function of the wetland and thus the achievement of the management objectives of the wetland.[9]

Figure 4 provides an indicative example of where previous land planning decisions have reduced the separation to an extent that is not adequate to provide the necessary separation. Within the area to the top of the diagram, the separation distance can be applied to its desired extent, but it is inhibited throughout the lower part of the diagram because of previous land planning decisions allowing encroachment of incompatible land uses.

[9] If development exists within the wetland function area, this should have been identified in step 2 and a wetland re-evaluation undertaken at that stage.

Because the desired separation area has been compromised by existing development, this may mean the values of the wetland function area potentially are compromised unless proved otherwise. However, as the desired separation is still able to be achieved around a significant part of the wetland function area, additional work could be done that may demonstrate that the wetland will still be able to maintain its management category objective.

In figure 4, the area at the top of the diagram also contains land with high conservation value that extends beyond what is necessary for separation. This area would be dealt with, in terms of setting it aside or putting a managed land use in place, on its merits. It should not be dealt with in the context of wetland buffering as it lies outside the area that by definition is required for achievement of the wetland's management objective.

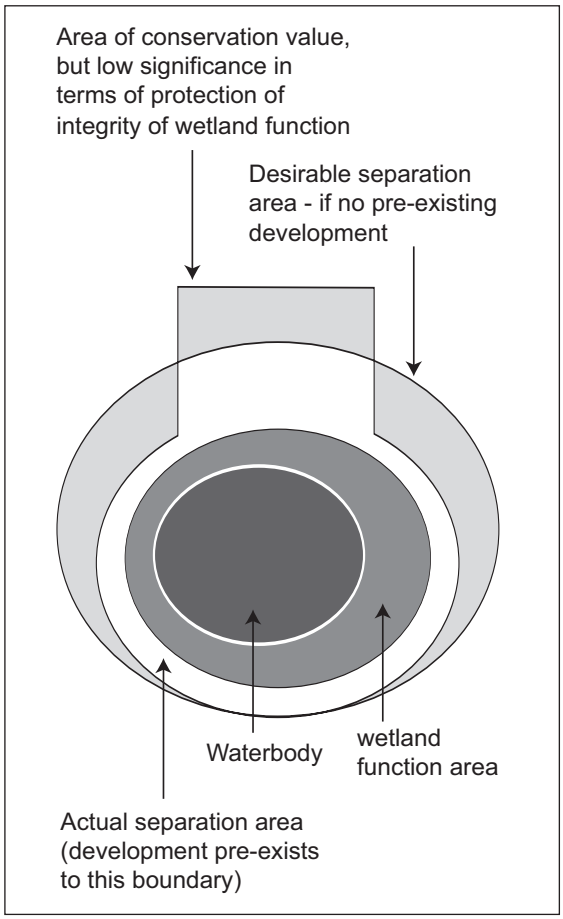


Figure 4 - Separation distance not able to be achieved (Welker Environmental Consultancy, 2002) (repeated)

If the required separation is unachievable, ie the recommended separation distance cannot be achieved around the whole wetland function area or the recommended management measures are unable to be implemented, an assessment of what is achievable is required.

7.3.1 C category wetlands

In the case of C category wetlands, a reduction in the required separation distance or management is unlikely to meet the conservation category management objective. If the boundary of the wetland could be compromised, the proposal should be referred to the EPA.

A case may still be made for reducing the recommended separation for a C category wetland. The argument should be substantiated by up-to-date technical information and evidence. Consultation with the DoE Wetlands Program is required.

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Every effort should be made to maximise the achievable buffer and implement improved management measures. This may include modification of the proposal where possible. If a proposal is unable to achieve the recommended separation, referral to the EPA is required.

7.3.2 R and M category wetlands

Small reductions in the recommended separation for R and M category wetlands, provided the reduction is not associated directly with the critical wetland attributes and additional management measures are proposed to address the reduction, may meet the appropriate wetland management objective.



7.4 Establishing an alternative separation requirement

In certain circumstances, it may be desired to create an outcome for the wetland that is significantly different from the current state of the wetland. Possible reasons for wishing to modify the current state include:

- inability to avoid or adequately manage impacts from adjacent land use as a result of the inability to achieve the required separation that protects current values;
- inability to maintain the current wetland function area which would result in an impact on current values;
- desire to enable development to encroach on the wetland function area or its separation because the overall net benefit of the development is extremely high and impacts cannot be avoided or adequately managed; and
- desire to improve the current values of the wetland by enhancing its features.

A landowner might have defined the required separation to maintain current attributes consistent with the management category but found the distance to be unachievable. An alternative separation then should be proposed, together with additional management measures that maximise the potential for the buffer to achieve the management objectives of the wetland. If there is scope to modify the proposal to achieve this, it should be done.

The alternative separation then should be evaluated for its ability to achieve the wetland's management objective.

7.5 Does the alternative separation meet the wetland's management objective?

The wetland management category and corresponding objective provides an obvious context for management. The difficulty is in understanding what the management objective means.

In the majority of cases for C category wetlands, current values should be maintained and therefore proposals that reduce the separation requirement are unlikely to be acceptable.

In the case of R and M category wetlands, current values should be maintained or enhanced where possible. The proposal must ensure the future outcome for the wetland is equal to, or preferably better than, what exists. It must be demonstrated that the potential impacts from the proposal will not result in a reduction in the existing values, attributes or condition of the wetland. If the separation is unachievable, additional management must be proposed to reduce the impacts from the proposal to the point where the existing condition of the wetland is enhanced, or at least, preserved. Table 11 outlines the management priorities for the three categories of wetlands. This provides the context for the desired future outcome of the wetland.

7.6 Making a case for an alternative separation requirement

Consultation with the DoE Wetlands Program and the DPI Environment and Natural Resource Management Branch should occur at this time.

The proposed separation should be justified in terms of the wetland attributes it is desired to achieve and protect, and by implication, its actual or expected future state as defined by its objective. The identification of attributes associated with the wetland management category, and whether the protection of those current attributes can be achieved, forms the basis for justification of an alternative separation requirement. The case must be substantiated with up-to-date technical information, presented in a logical format.

The argument for reducing the separation requirement should be based on consideration of the overall balance of social, environmental and economic aspects associated with the various parameters that may affect the future of a wetland. The original wetland evaluation will provide information regarding some of the social considerations affecting the wetland. Economic considerations also are relevant, including the cost of ongoing management and maintenance and who is responsible for this funding.

Stakeholder involvement in the decision-making process is a requirement on public land, where the role of various regulators and responsibility for decision-making also needs to be considered. Community consultation should occur where it is known that there is a community interest in the current use and future outcome of the wetland.

Table 11: Wetland management categories, objectives and management priorities

Category	Description	Objective	Management priorities
Conservation (C category) wetlands	Wetlands which support high levels of attributes and functions	to preserve wetland (natural) attributes and functions	Preserve wetland attributes and functions through reservation in national parks, Crown land and protection under environmental protection policies
Resource Enhancement (R category) wetlands	Wetlands which have been partly modified but still support substantial functions and attributes	to restore wetlands through maintenance and enhancement of wetland functions and attributes	Restore wetlands through maintenance and enhancement of wetland functions and attributes by protection in Crown reserves, State or local government land and by environmental protection policies, or in private property by sustainable management
Multiple Use (M category) wetlands	Wetlands with few attributes which still provide important wetland functions	to use, develop and manage wetlands in the context of water, town and environmental planning	Consider use, development and management in the context of water (catchment/strategic drainage planning), town (land use) and environmental planning through landcare

(Source: Hill et al, 1996).



If, after addressing the management of likely impacts from the proposal, it can be demonstrated that the wetland's management objective is able to be met, proceed with the proposal.

Where the proposed separation and management, if implemented, may result in a change to the wetland values or attributes, appropriate environmental approvals may be required to enable such an impact on the wetland. In these instances, it is recommended that consultation occur with the DoE, to identify an approach that will result in acceptable environmental outcomes. The WAPC may be unlikely to approve a proposal that is not supported by the DoE. For R and M category wetlands, a negotiated outcome will need to be achieved in consultation with the DoE. For C category wetlands, if it cannot be demonstrated that the wetland values and attributes will be enhanced or maintained, and the proposal cannot be modified to ensure this outcome, the proposal should be referred to the EPA.

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Websites:
www.environment.wa.gov.au
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Appendix 2: Definitions

AHD	Australian Height Datum.
anthropogenic	affected by or related to humans.
benthic	relating to or living in or on the bed of a body of water including the silt or mud that lies there.
bio-diversity	variety of life forms: different plants, animals and micro-organisms, genes they contain, ecological functions they perform and ecosystems they form. It is usually considered at three levels: ecosystem diversity, species diversity, and genetic diversity.
buffer	separation of a wetland from adjacent land use through either spatial separation or the use of physical barriers to reduce the threats to desired values and attributes and ensure wetland activities do not have undue impact on the land use.
CALM	Department for Conservation and Land Management.
conservation	management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations, while maintaining its potential to meet the needs and aspirations of future generations. Thus conservation is the positive, embracing, preservation, maintenance, sustainable utilisation, restoration and enhancement of the natural environment.
creek	type of wetland, a seasonally inundated channel (Semeniuk, 1987).
dampland	type of wetland, a seasonally waterlogged (damp) basin of variable size and shape (Semeniuk, 1987).
directly associated dependent terrestrial vegetation	vegetation that occurs in association with a particular wetland. Also referred to as wetland vegetation.
DoE	Department of Environment.
DPI	Department for Planning and Infrastructure.
ecosystem	defined community of organisms, their interaction, and their physical surroundings (Department of Environment, Sport & Territories (1994). State of the Environment reporting: Framework for Australia. 42pp, Canberra, ACT).
environmental value	beneficial use or an ecosystem health condition (ie, a condition of the ecosystem relevant to the maintenance of ecological structure, ecological function or ecological process).
ecological integrity	physical, chemical and biological components of an ecosystem and the interactions between those components, being in a sound, undiminished and unimpaired state.
EPA	Environmental Protection Authority.

EPP	environmental protection policy.
evapotranspiration	the transfer of water into the atmosphere through evaporation from the land and transpiration from plants and animals and can be calculated from the difference between precipitation and the amount of run-off.
floodplain	type of wetland, a seasonally inundated flat (Semeniuk, 1987).
inter-generational equity	principle that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.
lake	type of wetland, a permanently inundated basin of variable size and shape (Semeniuk, 1987).
palusplain	type of wetland, a seasonally waterlogged flat (Semeniuk, 1987).
paluslope	type of wetland, a seasonally waterlogged slope (Hill et al, 1996).
river	type of wetland, a permanently inundated channel (Semeniuk, 1987).
separation area	area between the boundary of the wetland function area and the outer limit of the separation requirement that extends as far as the separation distance.
separation requirement	furthest extent of the separation distances required to deal with all separation issues (eg, habitat protection, fire management, water quality management) specific to each particular proposed or existing adjacent land use.
silviculture	the science and economics of the establishment, management, composition and growth of forests.
sumpland	type of wetland, a seasonally inundated basin of variable size and shape (Semeniuk, 1987).
upland vegetation	vegetation that exists outside the wetland function area.
WALIS	Western Australian Land Information Service.
WAPC	Western Australian Planning Commission.
wetland attribute	characteristic or combination of characteristics which is valued by a group within society, but which does not necessarily provide a function or support a use.
wetland characteristic	properties of a wetland which describe the area in the simplest and most objective possible terms (e.g. wetland size, species present, soil type, water quality). Characteristics, singly or in combination, give rise to benefits (existing or future) which may be functions, uses, or attributes of a wetland.
wetland function area	area required to be protected to ensure the important functions and values of the wetland can be maintained.

wetland function	aspect of a wetland that, potentially or actually, supports or protects a human activity or human property without being used directly.
wetland value	measure or expression of worth placed by society on a particular function, use or attribute.
wetland vegetation	vegetation which is adapted to inundated or waterlogged conditions that often forms overlapping zones along an elevational gradient from the deepest part of a wetland. Wetland vegetation is essential to the ecological functioning of a wetland (and includes fringing and riparian vegetation) (Balla, 1994)
wetland water body	part of a wetland where there is an expression of open water.
WRC	Water and Rivers Commission (now the DoE).

Appendix 3: Example of application of the guideline - Lake Yangebup

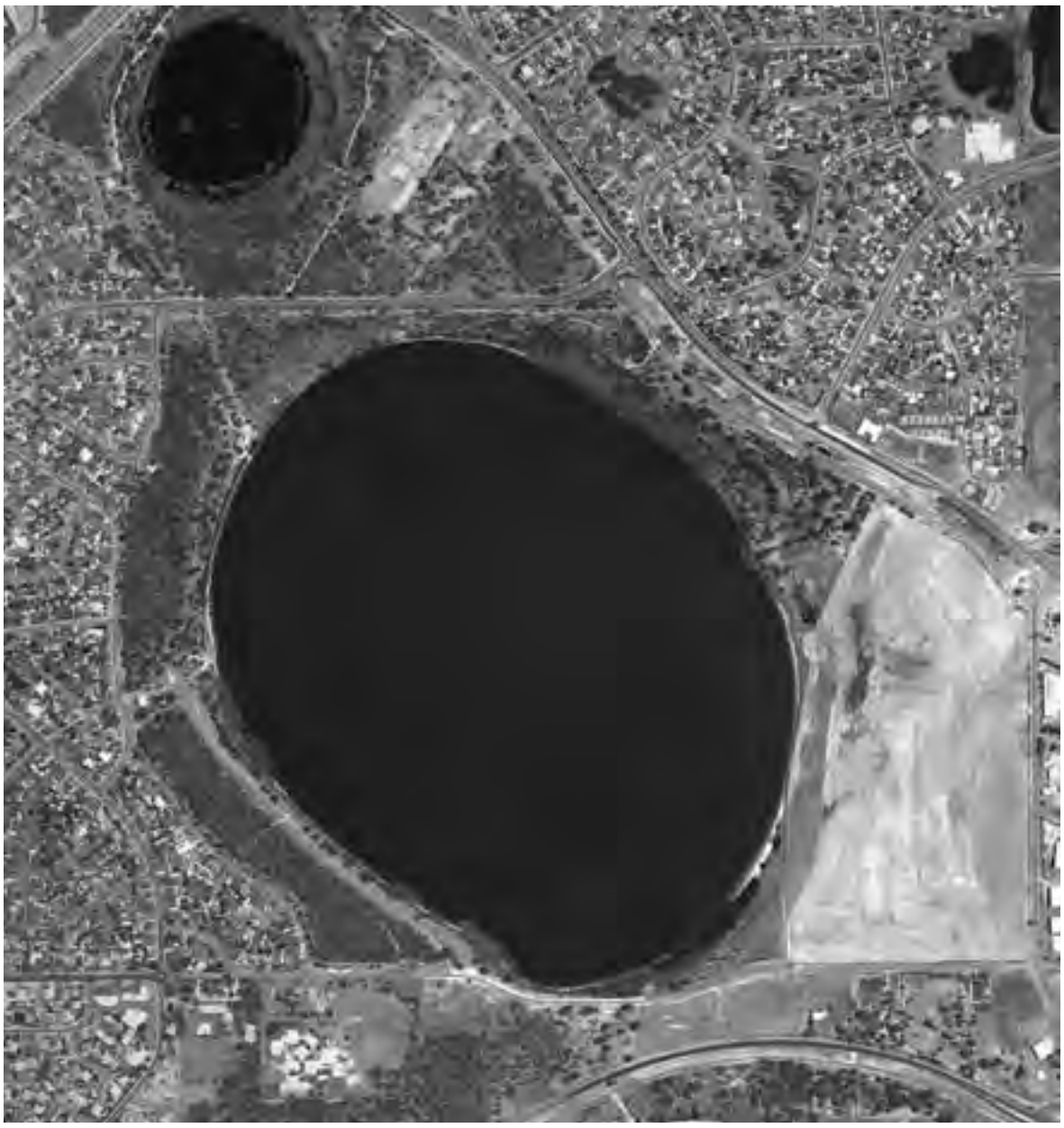


Figure 5: Yangebup Lake (Source: Former Department of Land Administration StreetExpress Directory, 2000)

Step 1 Acknowledge existence of wetland

Yangebup Lake is located on North Lake Road and can be identified on the Geomorphic Wetlands Swan Coastal Plain dataset (DoE) as unique feature identifier number 6602.

Step 2 Identify wetland attributes, wetland management category and establish management objectives

Has a wetland management category been assigned?

Yes. Yangebup Lake is a conservation category wetland.

Are existing wetland values, processes, functions and attributes consistent with the assigned management category?

Yes. Yangebup Lake is a first-tier recognised wetland. It is on the Interim List of the Register of the National Estate, protected by the *Environment Protection Biodiversity Conservation Act 1999* as it provides a location for JAMBA/CAMBA species. It is protected under the Swan Coastal Plain Lakes EPP (EPA 1992) and located within Bush Forever Site 256) (Government of WA, 2000b). It also is reserved for Parks and Recreation and managed by the Department of Conservation and Land Management (CALM) as part of Beeliar Regional Park.

The review of the justification for the high management category identified the following key values, processes and attributes for Yangebup Lake:

(a) high habitat diversity and wide representation of ecological communities (including upland communities);

(b) part of regional conservation/wildlife park;

(c) part of significant regional wetland system;

(d) part of regionally significant contiguous bushland/wetland linkage and wildlife corridor (Greenways 78 and 81);

(e) supports wetland fringing vegetation;

(f) recognised migratory bird (as protected under JAMBA/CAMBA) habitat/breeding ground;

(g) important permanent water body for ducks (second highest recording of some species of 300 wetlands surveyed);

(h) supports a wide range of macroinvertebrate fauna;

(i) provides habitat and/or refuge for a range of frogs, reptiles (including the long-necked tortoise), birds and mammals that would not be there if a wetland was not present;

(j) significance to Aboriginal culture;

(k) entered on the Interim List of the Register of the National Estate;

(l) visual amenity of open water; and

(m) maintaining processes essential for retaining wilderness condition, which contributes to its landscape value.

The key attributes critical to the conservation category management objective of "to preserve wetland (natural) attributes and functions" are points (a), (e), (f), (g), (i) and (j). These are the attributes that are critical to the determination of the extent of the boundary of the wetland function area and the appropriate separation requirement.

The lake also retains nutrients from a nearby wool-scouring settling pond, performing a filtration function for local groundwater. This attribute is in conflict with the wetland's high conservation status and the CALM management objective.

The information sources used to identify the above attributes include the justification for protection of the area as a Bush Forever Site and the draft Beeliar Regional Park Management Plan (CALM, 2001) which identifies important attributes to be protected.

Step 3 Define wetland function area

Where practicable, the wetland function area is the area required to support the attributes of the wetland (see table 12). In the case of Yangebup Lake, the wetland function area should contain at least the entirety of wetland vegetation plus all remnant upland vegetation communities abutting the wetland vegetation in Bush Forever site 256, to ensure the maintenance of all ecological communities associated with the wetland. Remnant vegetation areas within the Bush Forever site separated from the wetland vegetation by completely degraded areas (>50 m wide) containing no native species are excluded from the wetland function area as they are effectively isolated from the wetland and also are not part of a wetland-upland continuum associated with the wetland.

As Yangebup Lake is part of a regional wetland system and due to the close proximity of a wetland both to the north and south of the lake, the wetland function area practically extends to link with wetland function areas of these two wetlands, Little Rush Lake and The Kogalups (North and South Kogalup Lake). The definition of the wetland function area boundary to assess setbacks from Yangebup Lake is relevant to only the west and east of the lake. The presence of developed residential and industrial land immediately west and east of the Bush Forever site boundary means the wetland function area does not extend further in these directions outside that boundary.

If the areas to the west and east of the lake were not developed, the wetland function area would extend to a limit defined by the average range of dependent fauna associated with the wetland (attribute (i)). The lake is inhabited by long-necked tortoises, which are known to move from the wetland to lay eggs. Typically they roam between 50 and 200 m, but have been known to move as far as 500 m, from water bodies (WRC 2000, Bamford pers. comm. 2002).

The wetland function area therefore should extend at least 200 m from the wetland vegetation around Yangebup Lake, as this is an ecological requirement of a species dependent on the lake. This would be the case for any conservation category wetland that supports long-necked tortoises under this framework. However, because of the existing residential and industrial development around Lake Yangebup, the wetland function area

cannot be realised. The wetland function area reaches its optimum extent in some areas, but for the most part, is restricted by pre-existing development. The wetland function area therefore corresponds to the wetland entity as mapped by Hill et al. 1996 (see Figure 5).

Table 12: Requirements to support significant attributes of Yangebup Lake

Attribute	Requirement to support attribute, for the purpose of defining the wetland function area	Definable boundary/extent	Key threatening processes	Role of separation
High habitat diversity and wide representation of ecological communities (including upland communities)	Maintain representation of all identified ecological communities associated with wetland, to include upland communities abutting wetland vegetation zone	All remnant vegetation within Bush Forever site boundary abutting wetland vegetation in continuum. (excludes completely degraded areas and vegetation beyond them)	• Habitat modification	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area) through hydrological and terrestrial processes (eg external origin of resources)
Part of regional conservation/ wildlife park	Support attributes consistent with management objectives	N/A	• Alteration to the water regime • Habitat modification • Inappropriate recreational use • Diminished water quality	As above
Part of significant regional wetland system	Maintain wetland area	Boundary of wetland as mapped Geomorphic Wetland Swan Coastal Plain Dataset (DoE)	• Alteration to the water regime • Habitat modification	• Can link adjacent wetland separation areas • Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area) through hydrological and terrestrial processes (eg external origin of resources)
Part of regionally significant contiguous bushland/ wetland linkage and wildlife corridor (Greenways 78 and 81)	Maintain bushland links north, south and east of wetland	Providing connection with bushland to north, south, and east	• Habitat modification	As above

Table 12: Requirements to support significant attributes of Yangebup Lake (continued)

Attribute	Requirement to support attribute, for the purpose of defining the wetland function area	Definable boundary/extent	Key threatening processes	Role of separation
Supports wetland fringing vegetation	Maintain areas containing emergent wetland species	Boundary of wetland as mapped Geomorphic Wetland Swan Coastal Plain Dataset (DoE)	• Alteration to the water regime • Habitat modification • Diminished water quality	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area) through hydrological and terrestrial processes (eg. external origin of resources)
Recognised migratory bird (protected under JAMBA/ CAMBA) habitat/ breeding ground	Maintain areas of open water, seasonally inundated areas used for breeding and other areas of vegetation likely to be used by species	Boundary of wetland as mapped by Hill et al (1996) plus surrounding vegetated areas known to be used by birds	• Alteration to the water regime • Habitat modification • Inappropriate recreational use	As above
Important permanent water body for ducks (second highest recording of some species of 300 wetlands surveyed)	Maintain areas of open water, seasonally inundated areas used for breeding and other areas of vegetation likely to be used by species	Boundary of wetland as mapped by Geomorphic Wetland Swan Coastal Plain Dataset (DoE) plus surrounding vegetated areas known to be used by birds	• Alteration to the water regime • Habitat modification • Inappropriate recreational use	As above
Supports a wide range of macroinverteb-rate fauna	Maintain natural water level	Areas permanently or seasonally inundated	• Alteration to the water regime • Habitat modification • Diminished water quality	As above
Potentially provides habitat and/or refuge for a range of frogs, reptiles (including tortoise), birds, and mammals, that would not otherwise be there if a wetland was not present (associated fauna)	Maintain all areas on which associated fauna are dependent, such that local representation is not affected. Long-necked tortoise is assumed to require greatest distance from wetland (200 m) (see text)	Extending from wetland to average known extent of foraging/ use of associated fauna	• Alteration to the water regime • Habitat modification • Inappropriate recreational use • Diminished water quality	As above

Table 12: Requirements to support significant attributes of Yangebup Lake (continued)

Attribute	Requirement to support attribute, for the purpose of defining the wetland function area	Definable boundary/extent	Key threatening processes	Role of separation
Significance to Aboriginal culture	Maintain natural state of wetland, particularly area of inundation	Boundary of wetland as mapped by Geomorphic Wetland Swan Coastal Plain Dataset (DoE)	• Alteration to the water regime • Habitat modification	• Can add to as well as maintain features of wetland function area • Protection from direct disturbance or other change/impact to the wetland function area • Protection of wetland features and function integral to cultural values • Protection from direct disturbance or other change/impact to the wetland function area
Entered on the interim list of the Register of National estate	All of above	Bush Forever site boundary	• Alteration to the water regime • Habitat modification • Inappropriate recreational use • Diminished water quality	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area through hydrological and terrestrial processes (eg external origin of resources)
Visual amenity of open water	Maintain accepted water levels	Areas permanently or seasonally inundated	• Alteration to the water regime	• Can add to as well as maintain aesthetics of wetland function area • Protection from direct disturbance or other change/impact to the wetland function area
Maintaining processes essential to retain wilderness condition, which contributes to its landscape value	All of above	Wetland function area (as defined from amassing areas described above)	• Alteration to the water regime • Habitat modification • Inappropriate recreational use • Diminished water quality	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area through hydrological and terrestrial processes (eg external origin of resources)
Filtering for wool-scouring settling pond effluent moving into groundwater – lake serves to retain nutrients and buffer effect on local groundwater	Ensure rate of effluent flow to wetland does not exceed ability of wetland to filter out contaminants from groundwater (filtering function of wetland will decrease water quality and is likely to affect natural other natural attributes)	Area within groundwater catchment zone of wool-scouring settling ponds	• Alteration to the water regime • Diminished water quality	• Vegetation interception and use of water in surface and subsurface flow • Can suppress watertables locally • Role highly dependent on hydrogeology and catchment characteristics • Role redundant where piped discharge into wetland occurs

(Source: Welker Environmental Consultancy, 2002).

Step 4 Identify threatening processes

The threatening processes for each attribute were considered and are listed in table 12 above. Processes that potentially could threaten the significant attributes of this wetland were identified based on consideration of the environmental risks of the surrounding parks and recreation reserve and residential and industrial land uses. Table 6 was used to aid this assessment. The presence of three drains discharging directly into the wetland is a key consideration in managing wetland water quality.

The threatening processes requiring separation and/or management for Yangebup Lake are:

- alteration to the water regime;
- habitat modification;
- inappropriate recreational use; and
- diminished water quality.

Step 5 Identify role of separation

The role of separation (ie distance and management) for each attribute was identified based on consideration of tables 4 and 7. The role of separation for each attribute is listed in table 12.

Step 6 Establish separation requirement

The recommended separation distances for this management category are outlined in table 8.

The following separation measures (ie. distance and management) should be implemented for Yangebup Lake to maintain condition consistent with its management objective:

- 100 m from wetland function area to urban and park areas to prevent weed infestation;
- Provision of 6 m to 50 m firebreak at and within separation requirement. (Note: DoE is unlikely to support firebreaks that need to be placed within the separation area if it requires significant clearing of native vegetation);
- ≥100 m from wetland function area to urban area to minimise edge effects;
- ≥ 50 m from wetland function area to urban area to improve aesthetics and barrier from inappropriate recreational activities;
- 20 m to 100 m to prevent surface flow of suspended solids; and
- drainage inflows eliminated or managed.

A separation distance of at least 100 m from the wetland function area would be recommended to meet the wetland's management objective, together with elimination or management of drainage inputs.

Other wetlands are located close to Lake Yangebup and the linking of separation areas and wetland functions also could be considered.



Step 7 Apply separation requirement to proposal and assess ability of separation to achieve management objective

Existing development, which has prevented the desired wetland function area being realised, will prevent a suitable separation distance and management measures from being implemented to support the management category objective. Both the wetland function area and the separation distance are inconsistent with the management category objective and the consequence of this lack of adequate buffering has been long term degradation of the lake and loss of conservation value. Any proposal for development within the separation requirement is unlikely to be acceptable and should be referred to the EPA.

Appendix 4: Example of application of the guideline - South Lake



Figure 6: South Lake (Source: Former Department of Land Administration StreetExpress Directory, 2000)

Step 1 Acknowledge existence of wetland

South Lake is located south and west of North Lake Road, Bibra Lake, in the City of Cockburn and can be identified on the Geomorphic Wetlands Swan Coastal Plain dataset (DoE) as unique feature identifier numbers 6603 and 6605.

Step 2 Identify wetland attributes, wetland management category and establish management objectives

Has a Wetland Management Category been assigned?

Yes. South Lake is a resource enhancement category wetland.

Are existing wetland values, processes, functions and attributes consistent with the assigned management category?

The lake is located in Beeliar Regional Park, manged by CALM and is identified as Bush Forever site 254. South Lake is an EPP lake and is part of System 6 area M93. It is entered in the Interim List of the Register of the National Estate and therefore subject to protection under the *Federal Environment Protection and Biodiversity Conservation Act 1999*.

South Lake is a small, shallow, permanent lake covered extensively by reed beds. It is surrounded by a diversity of dense vegetation which provides a habitat for a wide variety of birds. In the open water, aquatic plants attract large wading birds. The lake is a popular bird feeding area and is used by large numbers of migratory waterbirds. The lake is likely to serve a role as a breeding habitat for waterbirds because of the presence of fringing vegetation such as rushes, sedges and paperbarks.

The area is reserved for parks and recreation. The lake is surrounded by paperbark/ banksia woodland and is in good to very good condition, although there are some areas of severe localised disturbance.

Step 3 Define the wetland function area

Where practicable, the wetland function area is the area required to support the attributes of the wetland (table 13).

The South Lake wetland function area should incorporate all wetland vegetation plus all remnant upland vegetation bordering the wetland vegetation, to ensure the maintenance of all ecological communities associated with the wetland. Remnant vegetation areas separated from the wetland vegetation by degraded areas (>50 m wide) are excluded from the wetland function area as they are effectively isolated from the wetland and are not part of a wetland-upland continuum associated with the wetland.

At its furthest point, the wetland function area extends over 300 m from the water body on the eastern side of the lake. The vegetation on the western side is more disturbed and degraded, leaving a wetland function area of about 40 m from the water body. Although upland vegetation in good condition adjoins the degraded area to the south-west, the wetland function area does not continue into this area as it is separate from the functioning of the wetland. This does not mean the vegetation does not possess conservation values in its own right; however.

It could be argued that the wetland function area be extended to connect with a smaller wetland directly north. This wetland; however, is separated from South Lake by North Lake Road, which comprises a road and cleared road reserve of 50m wide. This distance is considered enough of a separation that the wetland function areas would not be contiguous; however, the buffer areas of the wetlands would overlap.

Table 13: Requirements to support significant attributes of South Lake

Attribute	Requirement to support attribute, for the purpose of defining the wetland function area	Definable boundary/extent	Key threatening processes	Role of separation
High habitat diversity and representation of ecological communities (including upland communities)	Maintain representation of all identified ecological communities associated with wetland, to include upland communities abutting wetland vegetation zone	All remnant vegetation within Bush Forever site boundary abutting wetland vegetation in continuum. (excludes completely degraded areas and vegetation beyond them)	• Habitat modification	• Protection from direct disturbance or other change/impact to the wetland function area • Reduces potential for colonisation by exotic species and introduction of exotic terrestrial fauna
Part of regional conservation/ wildlife park	Support attributes consistent with management objectives	N/A	• All	• Protection from direct disturbance or other change/impact to the wetland function area • Reduces potential for colonisation by exotic species and introduction of exotic terrestrial fauna
Part of significant regional wetland system	Maintain wetland area	Boundary of wetland as mapped in the Geomorphic Wetland Swan Coastal Plain Dataset (DoE)	• Alteration to the water regime • Habitat modification	• Can link adjacent wetland separation areas • Protection from direct disturbance or other change/impact to the wetland function area • Reduces potential for colonisation by exotic species and introduction of exotic terrestrial fauna
Supports wetland fringing vegetation	Maintain areas containing emergent wetland species	Boundary of wetland as mapped in the Geomorphic Wetland Swan Coastal Plain Dataset (DoE)	• Alteration to the water regime • Habitat modification • Diminished water quality	• Protection from direct disturbance or other change/impact to the wetland function area • Reduces potential for colonisation by exotic species and introduction of exotic terrestrial fauna
Waterbird habitat/breeding ground	Maintain areas of open water, seasonally inundated areas used for breeding and other areas of vegetation likely to be used by species	Boundary of wetland as mapped in the Geomorphic Wetland Swan Coastal Plain Dataset (DoE) plus surrounding vegetated areas known to be used by birds	• Habitat modification • Alteration to the water regime • Inappropriate recreational use	• Protection from direct disturbance or other change/impact to the wetland function area • Reduces potential for colonisation by exotic species and introduction of exotic terrestrial fauna
Supports a wide range of macroinvertebrate fauna	Maintain natural water level	Areas permanently or seasonally inundated	• Alteration to the water regime • Habitat modification • Diminished water quality	• Protection from direct disturbance or other change/impact to the wetland function area • Reduces potential for colonisation by exotic species and introduction of exotic terrestrial fauna

Table 13: Requirements to support significant attributes of South Lake (repeated)

Attribute	Requirement to support attribute, for the purpose of defining the wetland function area	Definable boundary/extent	Key threatening processes	Role of separation
Provides habitat and/or refuge for a range of frogs, reptiles, birds, and mammals, that would not otherwise be there if a wetland was not present (Associated fauna)	Maintain all areas on which associated fauna are dependent, such that local representation is not affected. This is assumed to include contiguous upland vegetation	Extending out from wetland to average known extent of foraging/utilisation of associated fauna	• All	• Protection from direct disturbance or other change/impact to the wetland function area • Reduces potential for colonisation by exotic species and introduction of exotic terrestrial fauna
Significance to Aboriginal culture	Maintain natural state of wetland, particularly area of inundation	Boundary of wetland as mapped in the Geomorphic Wetland Swan Coastal Plain Dataset (DoE)	• Alteration to the water regime • Habitat modification	• Can add to as well as maintain features of wetland function area • Protection from direct disturbance or other change/impact to the wetland function area • Protection of wetland features and function integral to cultural values
Entered on the Interim List of the Register of the National Estate	All of above	Bush Forever site boundary	• All	• Protection from direct disturbance or other change/impact to the wetland function area • Reduces potential for colonisation by exotic species and introduction of exotic terrestrial fauna
Visual amenity of open water	Maintain accepted water levels	Areas permanently or seasonally inundated	• Alteration to the water regime	• Can add to as well as maintain aesthetics of wetland function area • Protection from direct disturbance or other change/impact to the wetland function area

Step 4 Identify threatening processes

The threatening processes for each attribute were considered and are listed in table 13. Processes that could potentially threaten the significant attributes of this wetland were identified based on consideration of the environmental risks of the industrial zoned land to the south and west, the urban land to the east and the surrounding parks and recreation reserve which is separated by the other regional roads reserve. Table 6 was used to aid this assessment.

The threatening processes requiring separation and management for South Lake are:

- alteration to the water regime;
- habitat modification;
- inappropriate recreational use; and
- diminished water quality.

Step 5 Identify role of separation

The role of separation (distance and/or management) for each attribute was identified based on consideration of tables 4 and 7. The role of separation for each attribute is also listed in table 13.

Step 6 Establish separation requirement

The recommended separation for this management category is outlined in Table 9.

The following separation measures (distance and/or management) should be implemented for South Lake to maintain a condition consistent with its management objective:

- regulation of groundwater abstraction as catchment management measure;
- 50 m from wetland function area to industrial and urban areas to prevent weed infestation;
- 50 m in addition to the wetland function area to protect bird habitat; provision of 6 m to 50 m firebreak at edge of separation requirement;
- ≥ 50 m from wetland function area to industrial and urban areas to minimise edge effects;
- ≥ 50 m from wetland function area to urban area to improve aesthetics and barrier from inappropriate recreational activities;
- 20 m to 100 m to prevent surface flow of suspended solids; and
- ensuring no drainage inflows from nearby industrial or residential areas.

A maximum separation distance of 100 m from the wetland function area is required to meet the wetland's management objective and to minimse impacts on the wetland associated largely with the proposed industrial area to the south.

Other wetlands are located close to South Lake and the linking of separation areas and wetland functions should be considered in the context of any further development in the area.

Step 7 Apply separation requirement to proposal and assess ability of separation to achieve management objective

A buffer of 100 m from the boundary of the wetland function area can be achieved to the south and east of South Lake, as the land is part of Bush Forever site 254 and reserved for parks and recreation. Although the wetland water body directly abuts industrial zoned land to the west, the proposed subdivision of this land (Lot 502) by LandCorp intends to include a buffer of at least 150 m from the water body. As the vegetation on this side is less than 50 m wide, this proposed buffer should be sufficient to retain wetland function.

The only questionable area is to the north, where a section of the buffer contains North Lake Road. As the area adjacent is reserved for parks and recreation, it is considered that although the road may be a barrier to large fauna movement, this is not seen as critical to the maintenance of the significant functions of the wetland. Accordingly, the imposition of a 100 m buffer around South Lake can be achieved and will meet the management objective of the wetland.

Appendix 5 Example of application of the guideline - Stillwater Gardens Lake



Figure 7: Stillwater Gardens Lake Source: Former Department of Land Administration StreetExpress 2000)

Step 1 Acknowledge existence of wetland

Stillwater Gardens Lake is located on Berrigan and South Lake Drives and can be identified on the Geomorphic Wetlands Swan Coastal Plain dataset (DoE) as unique feature identifier number 6523.

Step 2 Identify wetland attributes, wetland management category and establish management objective

Has a Wetland Management Category been assigned?

Yes. Stillwater Gardens Lake is a multiple use category wetland.

Are existing wetland values, processes, functions and attributes consistent with the assigned management category?

Yes. The lake is located in open parkland in the suburb of South Lake and categorised for multiple use as described by Hill et al (1996). It is under the management of the City of Cockburn and is not considered to possess any significant conservation values (City of Cockburn, pers. comm. 2002). It is zoned urban and is not protected. The lake is surrounded by reticulated grassed parkland used for recreational activities such as walking, jogging, picnics etc.

The lake represents a surface expression of the groundwater table in a low lying area and is likely to act as a local discharge area and help to maintain low groundwater levels in surrounding residential areas. Some stormwater drainage from surrounding roads is diverted to the lake and hence the lake has some function for local drainage.

As the lake is a permanent open body of water, however small, it is likely that some duck species frequent the lake. The lake is unlikely to serve any role as breeding habitat for waterbirds because of the absence of fringing vegetation such as rushes/sedges/ paperbarks. The lake is not considered to support any significant flora or fauna values.

Step 3 Define the wetland function area

The wetland function area of Stillwater Gardens Lake is defined by the area within the high water level mark for the wetland as determined from the requirements for significant attributes (table 14).

Step 4 Identify threatening processes

Processes that potentially could threaten the attributes of this wetland were identified based on consideration of the environmental risks of the surrounding urban zoning and near by parks and recreation reserve. Table 6 was used to aid this assessment.

The threatening processes for each attribute were considered (table 13). The relevant attributes identified are:

- alteration to the water regime
- diminished water quality

Table 14: Requirements to support significant attributes of Stillwater Gardens Lake

Attribute	Requirement to support attribute, for the purpose of defining the wetland function area	Definable boundary/extent	Key threatening processes	Role of separation
Frequented by duck and possibly other waterbird species	Maintain natural water level	Areas permanently or seasonally inundated	• Alteration to the water regime	• Protection from direct disturbance or other change/impact to the wetland function area • Can provide indirect support for wetland function area through hydrological and terrestrial processes (eg external origin of resources)
Visual amenity of open water	Maintain seasonal water level	Areas seasonally inundated	• Alteration to the water regime	• Can add to as well as maintain aesthetics of wetland function area • Protection from direct disturbance or other change/impact to the wetland function area
Local drainage	Access and sufficient basin size to prevent flooding of surrounding area	Dependent on amount of water to be received	• Alteration to the water regime	• No role

Step 5 Identify role of separation

The role of separation for each attribute was identified based on consideration of tables 6 and 7. The role of separation for each attribute is listed in table 14.

Step 6 Establish separation requirement

The recommended separation (distances and/or management) for this management category are outlined in table 10.

However, as no separation is required to manage the potential for alteration to the water regime, no separation area beyond the wetland function area is required. Proposals for appropriate development outside the wetland function area of the wetland should meet the management objective for a multiple use wetland.

Water quality and groundwater abstractions in the catchment will still need to be managed; however, to ensure no impact on the values, functions and attributes of the wetland.

Other wetlands are located close to Stillwater Gardens Lake. The potential to link the separation areas and wetland function areas could be considered.

Public submissions for the draft Guideline for the Determination of Wetland Buffer Requirements

This has been released to seek public comment on the information in the draft guideline. All aspects of the guideline will be re-assessed prior to being finalised.

Every submission received will be acknowledged in writing and will be considered in the review process. All submissions will be treated in the strictest confidence.

When making a submission, it is very helpful to:

- clearly state your opinion and the reasons for your opinion
- if possible, outline possible alternatives or solutions to your area of interest
- if possible, include the section or page number which relates to your area of interest
- provide any additional information to support your comments.

A public submission form is included overleaf for your convenience, which can be posted free of charge. If you prefer to make a comment in an alternative format, please remember to include the relevant details as outlined on the submission form.

The closing date for submissions is Friday 14 April 2006

You can send your submissions free of charge to:

Guideline for the Determination of Wetland Buffer Requirements
Western Australian Planning Commission
Albert Facey House
469 Wellington Street
Reply Paid 80014
PERTH WA 6000

If you would like more information on making a submission, please contact:

Manager environmental planning,
Tel: (08) 9264 7777
Fax (08) 9264 7566
email: corporate@wapc.wa.gov.au

We look forward to receiving your submission.

Public submission form

Draft Guideline for the Determination of Wetland Buffer Requirements

1 Name: .....

.....

2 Organisation (if relevant): .....

3 Address: .....

.....

.....

4. Interest: .....

.....

.....

(eg local resident, business operator)

I/we would like to make the following comments on the draft Guideline for the Determination of Wetland Buffer Requirements and would like them to be considered in the preparation of the final document

Comments: .....

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SouthmetroConnect

Water Management Strategy

Appendix E

Water Management Strategy

Appendix E Water Management Strategy

South Metro Connect

Main Roads Western Australia

16 Jan 2013

Document Number: 601100953-413D-EN-REP-0003

Water Management Strategy

Roe Highway Extension



Water Management Strategy

Roe Highway Extension

Prepared for

Main Roads Western Australia

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South Metro Connect

16 Jan 2013

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Quality Information

Document Water Management Strategy

Ref 60100953

Date 16 Jan 2013

Prepared by Ross Perrigo and Tim Smith

Reviewed by Todd Hodgkin

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
0	29-Jun-2012	Response to PER Submissions	Francoise Kercheval Principal Engineer – Drainage and Waterways	
1	17-Jan-2013	Response to OPEA Submissions	John Braid Principal Environmental Scientist	

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Executive Summary

The Roe Highway Extension Water Management Strategy has been prepared to outline the guiding principles and designs to minimise impacts on the total water cycle in the project area. The report addresses both the construction and operational phases of the highway extension, potential impacts and management proposals for both groundwater and surface water.

The PER provides significant details of the environmental context for the project. These have been summarised in the Water Management Strategy, with emphasis given to features that relate to the total water cycle. The key features that require consideration in developing management strategies include conservation category wetlands, remnant native vegetation, complex groundwater and surface water interactions, shallow groundwater table near the wetlands and the potential for Acid Sulfate Soils.

The project was identified as having the potential for causing a decline in local groundwater levels from altering surface water flow paths, increasing in surface water runoff by vegetation clearing, changes to the local groundwater level from drawdown of aquifers and an increase of pollutants and contaminants entering the wetland systems from road runoff and construction practises.

The Water Management Strategy provides a summary of the management measures developed to avoid, minimise and mitigate impacts on the water cycle from this project. In some instances, analysis indicated that no direct management measures were required. Modelling of the effect of compaction on groundwater levels demonstrated minimal impacts on porosity or groundwater flows. Similarly, modelling indicated that the localised changes to the groundwater levels by recharge from infiltration basins were minimal. A summary of these analyses is presented in this document.

The Water Management Strategy also examines the impacts of abstraction of groundwater for construction purposes and the filling of a portion of Murdoch Drain. Abstraction of groundwater for construction is considered viable, as allocations are available within the Superficial Aquifer and conservative estimates of drawdown indicated that appropriate location of bores would result in minimal impacts on the environment. Backfilling of a section of Murdoch Drain was identified as insignificant to the local and regional hydrological regime.

The guiding principles for water management for this project are based on the Department of Water's Stormwater Management Manual (2004-2007), Better Urban Water Management (2008), Decision Process for Stormwater Management (2009) and EPA's Guidance Statement No 33 Environmental Guidance for Planning and Development. Site specific documents including the Beeliar Regional Park Management Plan (CALM, 2006) and Cockburn Groundwater Area Management Plan (DoW, 2007) also provided a basis for this strategy.

The approach to Water Management throughout this project involves the follow hierarchy:

- **Planning** to avoid impacts
- **Design** of structural and non-structural controls where possible to mitigate impacts that cannot be avoided
- **Monitoring** of the water regime during construction and operations
- **Adaptive Management** based on monitoring outcomes and improved understanding.

Strategies to minimise the impacts on the hydrological regime are developed initially at the conceptual level and are continued through all phases of the project. To maintain the hydrological regime, the Water Management Strategy commits to:

- Infiltration at source outside of wetland areas (where possible)
- No subsoil drainage
- No dewatering for construction
- Installation of bridges and culverts to maintain existing surface flow paths
- Installation of infiltration basins, sized for either a 5 yr or 20 yr ari event.

Management strategies to maintain or improve water quality from road runoff, prior to entering wetlands include:

- Construction of bio-retention systems, sized to 2% of the constructed, directly connected impervious area, to treat the 1yr ARI rainfall event.
- Kerbed roads in wetland areas to direct runoff into the bio-retention system.
- Installation of gross pollutant traps and oil separators in sensitive areas.

As described above, the Water Management Strategy has been prepared to guide the further water management measures during subsequent phases of the project. These further measures will be reported in a Water Management Plan which will include the final configuration of the stormwater system, the locations, frequency and parameters for monitoring, and refined calculations for abstraction based on the final project water requirements. Site specific measures during construction, including sediment control and spill response, will be outlined in the Construction and Environmental Management Plans prior to construction works.

1.0 Introduction

Main Roads Western Australia (Main Roads) is proposing to extend Roe Highway approximately 5 km from its current terminus at Kwinana Freeway in Jandakot to Stock Road in Coolbellup. This will complete a strategic link in Perth's road network and provide southern access to the forthcoming Murdoch Activity Centre, which includes the Fiona Stanley Hospital. The Roe Highway Extension project (the project) will consist of a dual carriageway with two lanes in each direction; separated by a concrete barrier in place of a median strip.

The project (Figure 1) is located approximately 14 km south of Perth within the Swan Coastal Plain Bioregion. The project area is contained within the City of Cockburn; however, parts of the design extend northward into the City of Melville along Murdoch Drive and Kwinana Freeway. The proposed project is generally orientated east-west and sits largely within a road reserve that was set aside within the Metropolitan Region Scheme (MRS) in 1963. It aligns between North and Bibra lakes, which are part of the Eastern Chain of the Beeliar Wetlands.

The Water Management Strategy has been prepared to outline the guiding principles and strategies for managing the total water cycle throughout the project area.

1.1 Environmental Assessment Process

In 2009 the project was referred to the Environmental Protection Authority (EPA) under the *Environmental Protection Act 1986* (EP Act), and to the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act). The project was set a level of assessment of Public Environmental Review (PER) and the bilateral agreement between the State and Commonwealth governments was enacted. South Metro Connect submitted the PER to the Office of the Environmental Protection Authority (OEPA) on 20 June 2011.

Following a 12 week public review period the EPA received 449 submissions to the PER. Of these, 29 were from government and non-government organisations, and 420 from the public, including one submission consisting of a petition with 189 signatures.

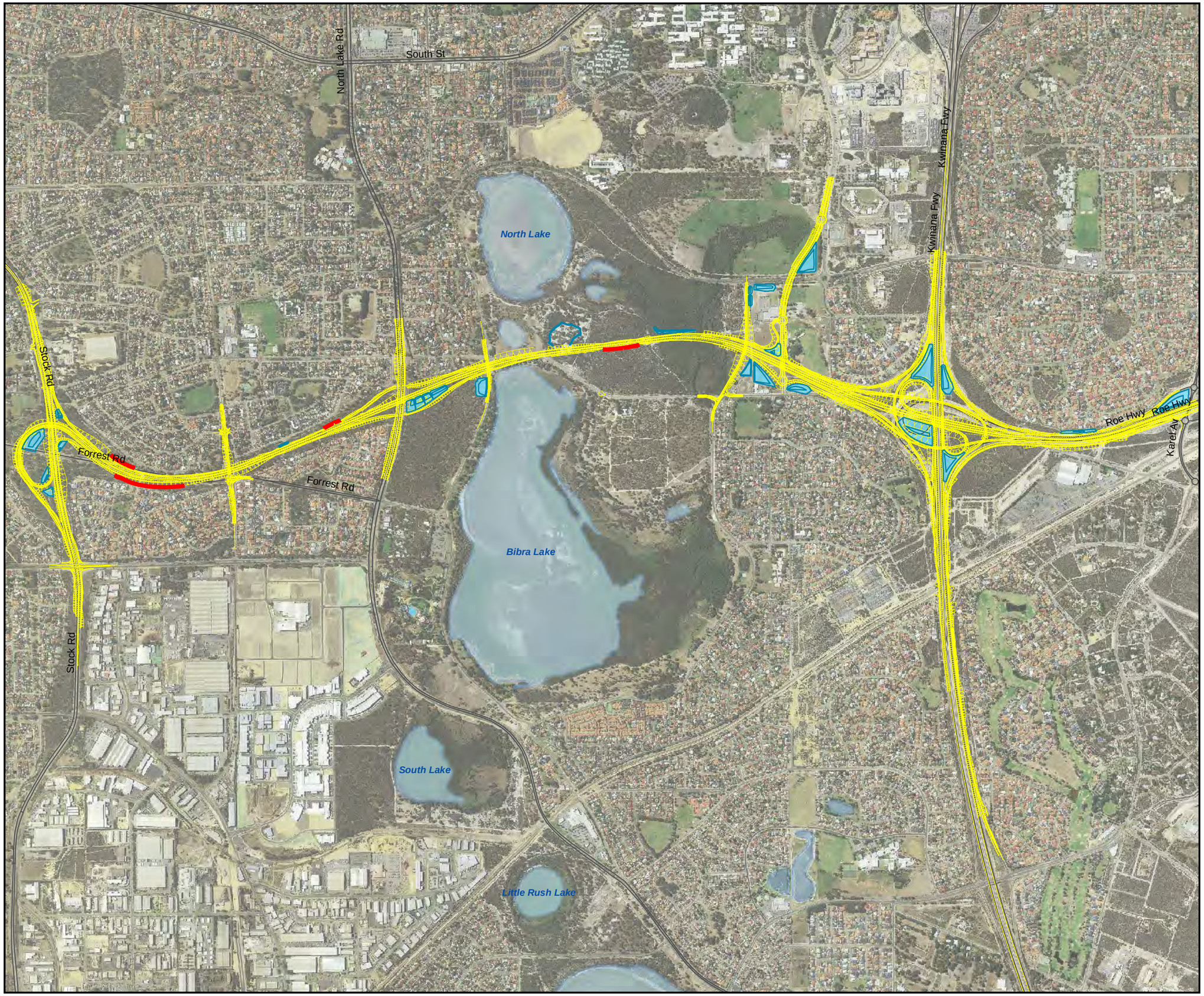
This Water Management Strategy (WMS) has been produced in response to the Department of Water's (DoW) comments on the PER, which requested a Water Management document to specifically address both the construction and operational phases of the highway extension, potential impacts and management proposals for both groundwater and surface water. This WMS should be read in conjunction with the PER and forms part of the response to submissions for the Roe Highway Extension PER.

1.2 Guiding Documents

This Water Management Strategy has been prepared with consideration for the following guidelines and policy documents:

- State Planning Policy 2.9 Water Resources (WAPC, 2006)
- Stormwater Management Manual for Western Australia (DoW, 2004-2007)
- Decision Process for Stormwater Management in WA (DoW, 2009)
- Better Urban Water Management (DoW, 2008)
- Environmental Guidance for Planning and Development, Guidance Statement No. 33 (EPA, 2008)
- Beeliar Regional Park Management Plan (CALM, 2006)
- Cockburn Groundwater Area Management Plan (DoW, 2007).

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Proposed Development

South Metro Connect

Figure 1

0 250 500 750 1,000

Metres

1:20,000 (A3)

Coordinate System: GDA 1994 MGA Zone 50

LEGEND

- Road Formation (yellow)
- Catch Drain
- Drainage Areas

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Last Printed: 21/05/12

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1.3 Project Description

Main Roads is proposing to extend Roe Highway from its current end point at Kwinana Freeway in Jandakot to Stock Road in Coolbellup (Figure 1). The proposed road will be constructed entirely within government-owned land; however a short section will be constructed outside the MRS Primary Regional Roads boundary in order to accommodate an alignment that minimises environmental impacts. There will be no acquisition of privately owned residential land.

The proposed project is being developed to accommodate Perth's forecast urban and industrial growth to 2031 and is within the overarching strategic plan for accommodating this growth. The project area is located within a region identified for key growth over the next 20 years. In the short term, the proposed project will support a growing number of freight vehicles utilising the Fremantle Inner Harbour and other local industrial areas. In the long term, it will provide the necessary infrastructure for businesses to operate effectively, which is crucial for stimulating and supporting economic growth of the Perth southern metropolitan region.

Construction of the proposed project will require the following key activities:

- Construction footprint of 148ha
- Construction of road formation, road drainage basins, principal shared paths (pedestrian and cycle paths), retaining walls; fauna underpasses, culverts, bridges, overpasses and noise attenuation walls
- Installation of street and PSP lighting
- Rehabilitation of areas disturbed for construction.

Operation of the proposed project will result in the following key activities:

- Freight transport
- Private and commercial vehicle movements
- Operation of street lighting and other electrical infrastructure
- Maintenance.

The key characteristics of the proposed project are outlined in Table 1.

Table 1 Elements of Roe Highway Extension

Elements	Description
Length of highway extension between Kwinana Freeway and Stock Road	Approximately 6.8 km
Murdoch Drive Extension	Full access via an extended Murdoch Drive into and out of the Murdoch Activity Centre from both directions of travel on Roe Highway.
Bridge at Roe Swamp	A bridge will span the topographic low point at Roe Swamp.
Bridge located between North and Bibra lakes	A bridge will be constructed between North and Bibra Lakes
Rehabilitation of Forrest Road	Approximately 1.0 ha of redundant sections of Forrest Road will be rehabilitated.
Cut and fill areas (subject to final design)	~1,123,000 m^3 of fill ~1,172,000 m^3 of cut
Retaining walls (subject to final design)	~1,360 m full height ~420 m half height
Water quantity (approximate)	140,000kL of water will be needed for the highway construction, including dust suppression.
Stormwater basins	Basins will be located adjacent to the proposed project; Presently, the proposed basins are as follows: - Stormwater retention basins to be located at Stock Road Interchange, Kwinana Freeway Interchange, North Lake Road Interchange; Progress Drive Overpass, Murdoch Drive Extension Interchange and various locations along the proposed highway. - Bio-retention basins within all stormwater retention basins to treat the 1yr ARI rainfall event. - A dedicated stormwater bio-retention basin to be located east of Horse Paddock Swamp and south-west of Lower Swamp.
Access/haul roads	Haulage and access will be via the construction corridor, Hope Road, Forrest Road and other existing infrastructure or existing cleared areas. No additional clearing will be required.

*values are not exclusive of each other and do not include wetland buffers

1.4 Water Management

The proposed development will influence the total water cycle as a result of infrastructure construction, temporary groundwater abstraction, cut and fill, changes to existing stormwater drainage and clearing of native vegetation and wetlands.

The key features of the proposed development that relate to water management are the drainage basins and wetland buffers. Figure 1 shows the indicative location of basins that will be used through the project area. The function of these features and the guiding management principles are discussed in Section 4.0, in the context of the surrounding environment.

2.0 Existing Environment

The pre-development environmental conditions of the project area provide an important context for the water management strategy. A summary of the conditions is presented in this section, based on the PER.

2.1 Topography

The project area is located along an east–west transect that crosses from low to moderately sloping Bassendean Sands near Kwinana Freeway, down into relatively flat topography and minimal slopes in the Beeliar Wetlands and then up into the moderate topography and slope of the Spearwood Dunes in the western portion of the project area (Figure 2). Slopes within the project area are generally low to moderate, and elevation ranges approximately 16 to 60 metres Australian Height Datum (AHD). Within the broader landscape context, the eastern chain of the Beeliar wetlands are separated from their western counterparts by a prominent ridge of the Spearwood Dunes, around the Hamilton Hill and Samson suburbs.

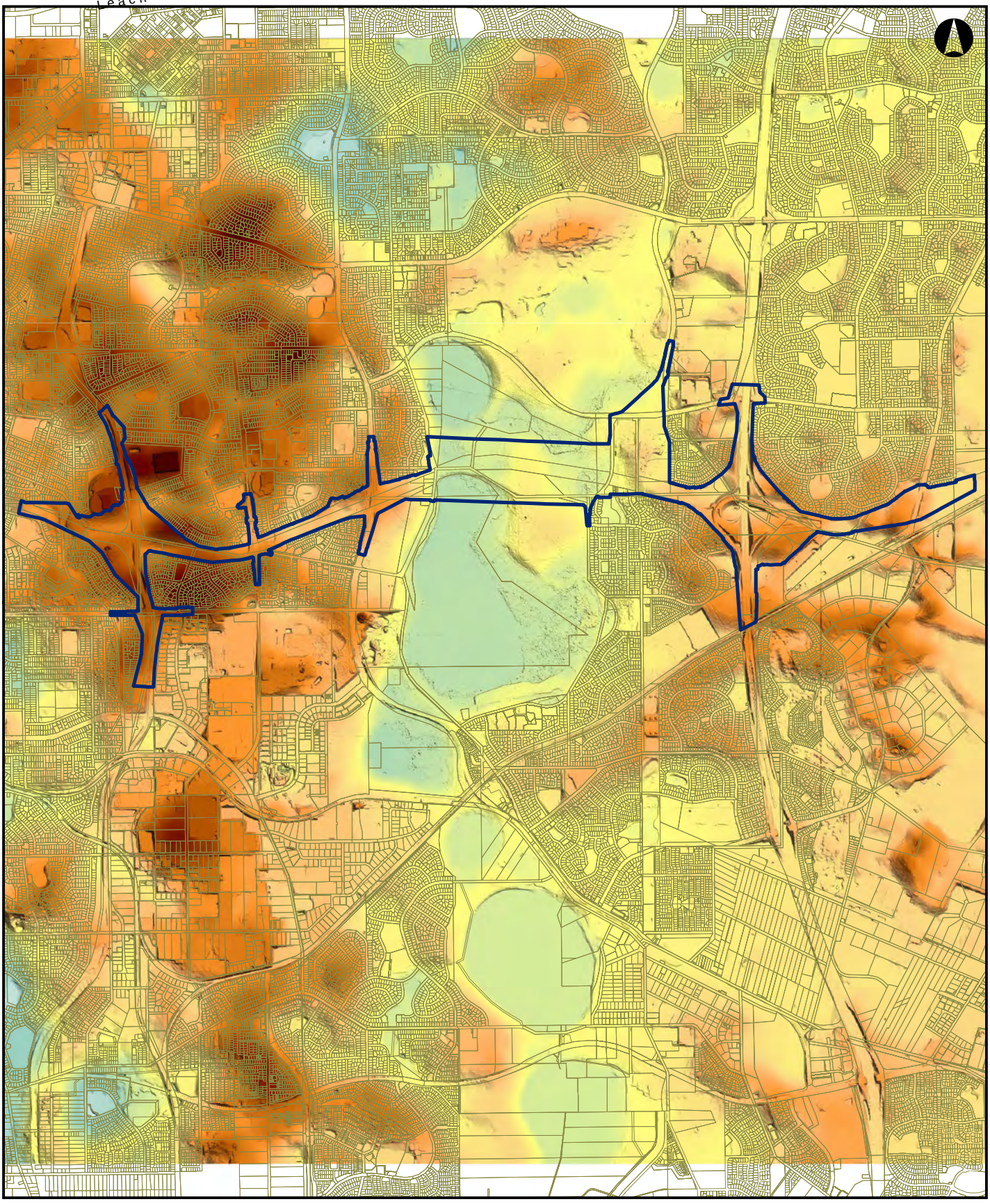
2.2 Climate

The climate of the south-western region of Western Australia is characterised by the Bureau of Meteorology as being Subtropical with warm, distinctly dry summers and cold, wet winters. The closest operating rainfall gauge to the project, Jandakot Aero Weather Station (Station 009172), is located 3.5 km away and has a dataset with a length of 40 years, but there are a number of gaps in the data. The weather station at Perth Airport (Station 009021), approximately 20 km northeast of the project area, has been recording continuously since 1944 and provides a better historical record.

Perth Airport, as demonstrated by Figure 3, experiences some variation in total annual rainfall. Between 1945 and 2011, annual rainfall totals ranged between 480 mm and 1165 mm, with a long term mean of 775 mm. This average has decreased since 1969, to an average annual rainfall of 726 mm, reflecting a 6% reduction compared to the long term mean (Figure 3).

Mean and median monthly rainfall totals for Perth Airport, for the period 1944 to 2011, are shown on Figure 4. The majority of rain falls between May and September, with very little falling between December and March. The small difference between the mean and median monthly data indicates that rainfall in the region is not highly variable. The dominant rainfall mechanisms are frontal systems caused by cold fronts associated with low pressure systems that extend across southern Australia between May and October. These winter time cold fronts are associated with colder south westerly winds and showery conditions.

Evaporation, as shown on Figure 4, is highest between November and March. A comparison of the mean monthly rainfall and evaporation totals demonstrates that the region is water limited between September and April, as evaporation is significantly higher than rainfall. Between May and August, rainfall is higher than evaporation.



Topography

South Metro Connect

Figure 2

0 0.5 1 1.5

Kilometres

1:42,000 (A4)

Datum: GDA94 Projection: MGA z50

Project Area

Cadastre

0m 10m 20m 30m 40m 50m 60m 65m

AHD

(Map Note : Slope derived from 1m Bare Earth LIDAR

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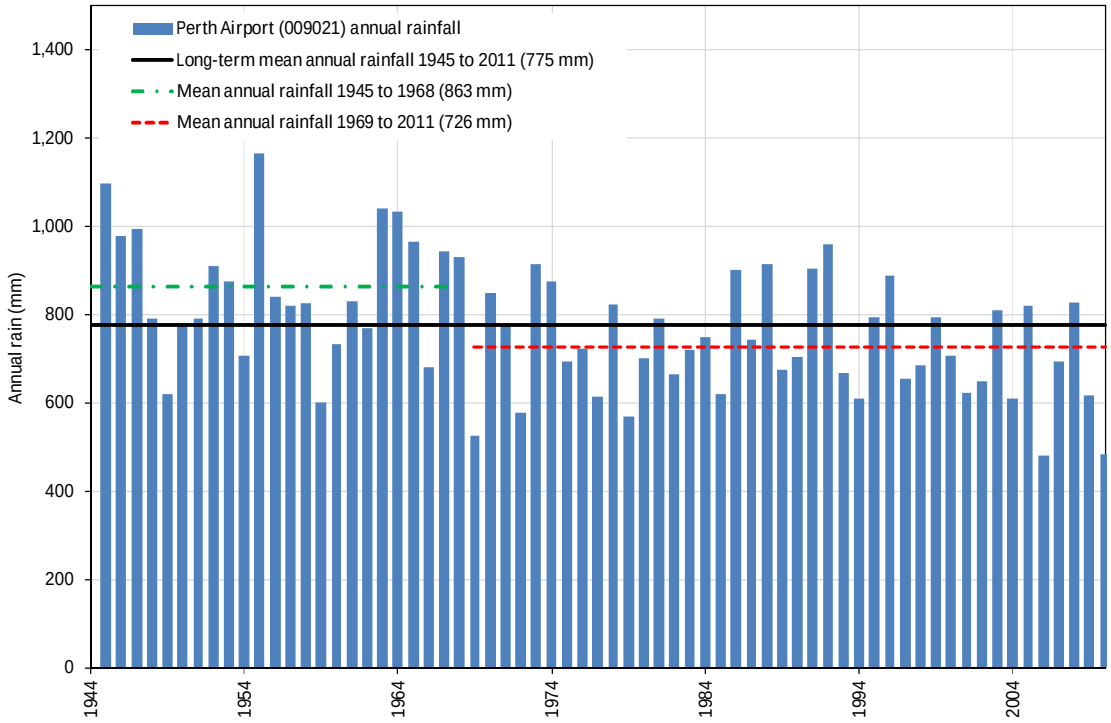


Figure 3 **Annual rainfall recorded at Perth Airport (009021) from 1945 to 2011**

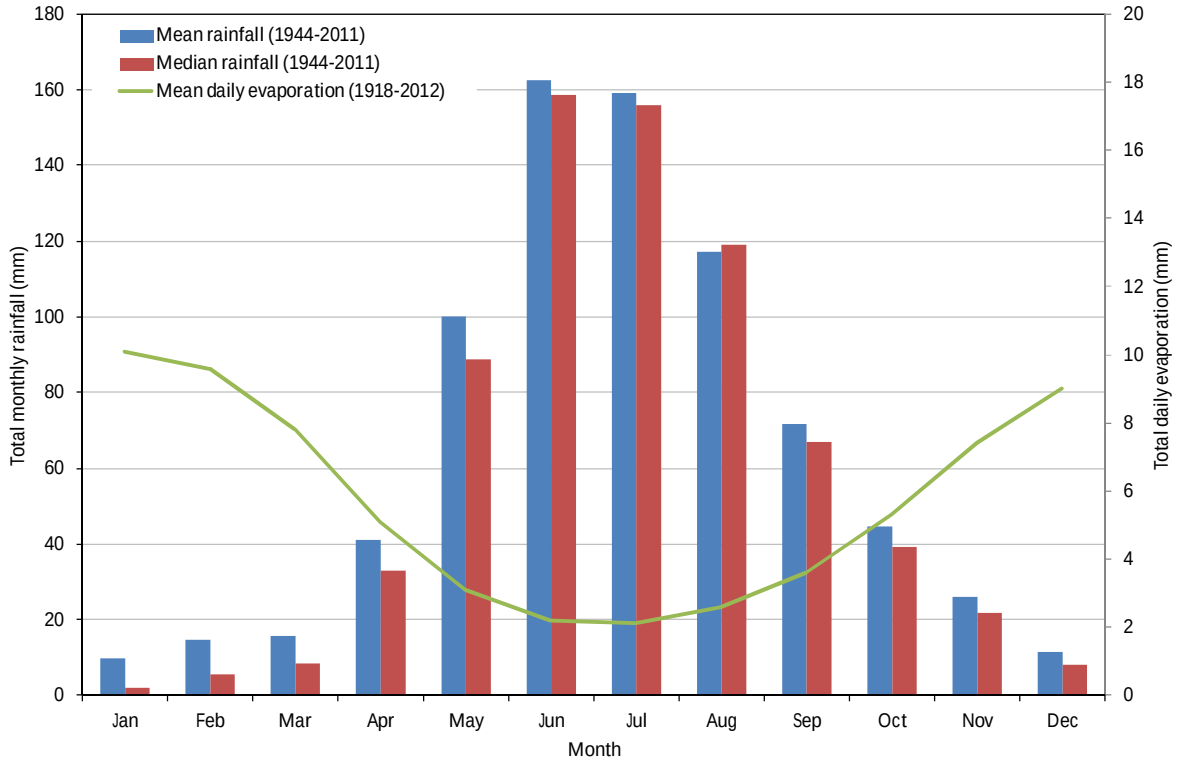


Figure 4 **Mean and median total monthly rainfall for Perth Airport (1944-2011)**

2.3 Biophysical Environment

The road alignment for the project passes through an important wetland chain and some of the last remaining remnant vegetation in the area. In urban areas around Perth, often the last land to be developed is the road reserve set aside within the MRS for primary regional roads. The Roe Highway Extension project will impact upon several key environmental factors including:

- Wetlands
- State and Commonwealth listed fauna species and species habitat
- Remnant vegetation including populations of State listed priority flora
- Conservation land (Bush Forever and Beeliar Regional Park)
- Noise and
- Aboriginal Heritage.

2.3.1 Wetlands

The project will have an impact on Conservation Category Wetlands (CCW) and on lakes protected under the *Environment Protection Policy Swan Coastal Plain Lakes* (Lakes EPP). The areas of wetland affected by the proposal are:

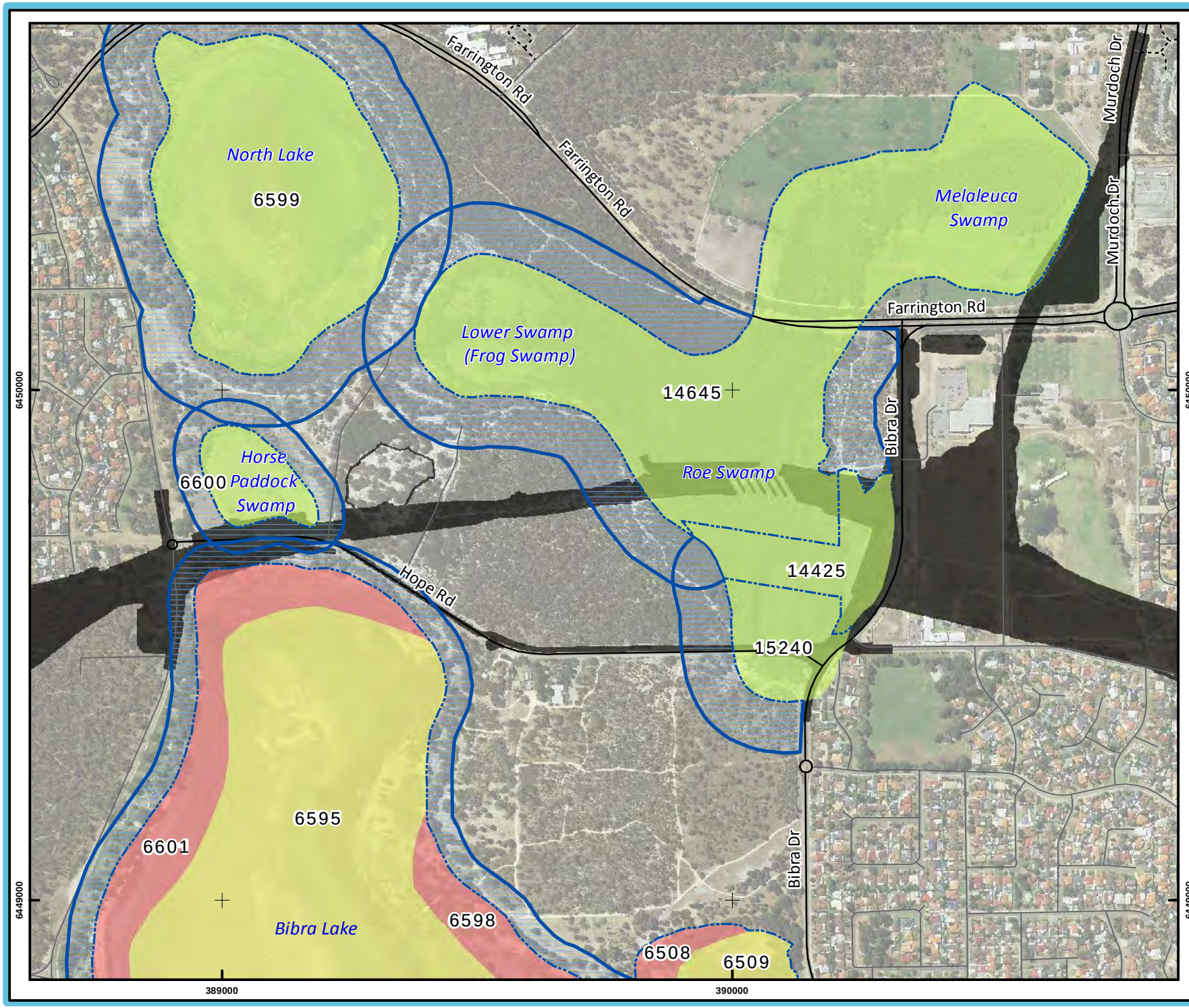
- Bibra Lake –1.0ha Lakes EPP wetland
- Horse Paddock Swamp – 0.2ha CCW
- Melaleuca Swamp – 0.2 ha CCW
- Roe Swamp – 5.6ha CCW.

These wetlands and their buffers are shown in Figure 5.

2.3.2 Flora and Vegetation

Project construction will require the clearing of up to 79.3ha of remnant native vegetation. Much of the project area has been subject to historical disturbance from agriculture and recreational activities in the past. Most of the Perth Metropolitan Area has been subjected to large scale disturbance and clearing of native vegetation and hence many of the vegetation complexes occurring have less than 30% of their pre-European extent remaining. Of the four complexes occurring within the project area, two have less than 30% of their pre-European extent remaining (Table 2). None of the vegetation complexes occurring within the project area will be reduced to below the 10% threshold value where they would be considered a “critical asset” by the EPA.

A total of 8 species in 15 sub-populations of Priority Flora, consisting of approximately 7,000 individuals will be impacted by the project. Most of the recorded Priority Flora within the proposed clearing footprint is *Dampiera triloba* (Priority 1) a small herb that is locally abundant (Table 3).



Assessed Wetland Buffers

SouthMetro Connect

Figure 5

0 100 200 300

Metres

1:10,000 (A4)

Coordinate System: GDA 1994 MGA Zone 50

LEGEND

- Assessed Wetland Buffers
- Construction Footprint

Geomorphic Wetlands

- Conservation Category Wetland
- Resource Enhancement Wetland
- Multiple Use Wetland

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Table 2 Heddle vegetation complexes occurring within the project area and the extent remaining prior to this project (SMC 2011)

Heddle Vegetation Complex	Description	Pre-European Extent (ha)	Current Remaining Area (ha)	% of Pre-European Extent Remaining (ha)	Area to be cleared for construction (ha)
Bassendean Complex – Central and South (44)	Woodland of Jarrah-Marri with well defined second storey of Pink Summer Calytrix (*Calytrix fraseriana*) and Bull Banksia (*Banksia grandis*) on the deeper soils and a closed scrub on the moister sites. The understorey species reflect similarities with the adjacent vegetation complexes.	46,220	10,919	24	35.9
Herdsman Complex (53)	Sedgelands and fringing woodland of Flooded Gum (*Eucalyptus rudis*) and *Melaleuca* species.	6,509	2,017	31	3.0
Karrakatta Complex – Central and South (49)	Predominantly open forest of Tuart-Jarrah-Marri and woodland of Jarrah and *Banksia* species.	34,532	6,275	18	21.2
Cottesloe Complex – Central and South (52)	Mosaic woodland of Tuart and open forest of Tuart-Jarrah and Marri, closed heath of the limestone outcrops.	34,439	12,362	36	19.1

Table 3 Priority Flora species impacted by the project (SMC 2011)

Species	Conservation Code	Total Number of Known Populations	Number of Populations Known Within the Study Area	Number of Populations to be Impacted Within Project Footprint	Percentage of Populations to be Impacted	Total Minimum Number of Known Individuals	Number of Individuals Within Study Area	Number of Known Individuals to be Impacted Within Project Footprint	Percentage of Known Individuals Within Study Area to be Impacted
Dampiera triloba	P1	21	14	4	19.1	7,132	66,17	5,404	75. 8
Tetraria sp. Chandala (G.J. Keighery 17055)	P2	3	1	1	0	3	1	1	0.0
Cyathochaeta teretifolia	P3	56	5	3	5.4	582	482+	38	6.5
Jacksonia gracillima	P3	20	3	2	10.0	200	173	15	7.5
Eryngium pinnatifidum subsp. palustre	P3	20	4	4	20.0	63	45	16	25.4
Dodonaea hackettiana	P3	56	1	1	1.8	205	1	1	0.5
Calothamnus rupestris	P4	48	2	0	0.0	8,394	2	0	0.0
Eucalyptus caesia	P4	42	1	0	0.0	741	1	0	0.0

2.3.3 Fauna

Road construction will result in impacts on up to 112ha of fauna habitat. This includes 40ha of *Eucalyptus*/*Banksia* woodland, 26ha of *Eucalyptus*/*Xanthorrhoea* woodland and 13ha of other native remnant vegetation. The fauna habitat includes 20ha of non-native vegetation including: rehabilitated vegetation, parklands and roadside verges that provide fauna habitat. The remaining fauna habitat (13 ha) is of little habitat value for fauna.

Habitat for a number of species listed under the EPBC Act, *Wildlife Conservation Act 1950* (WC Act) and DEC's priority fauna list potentially occurs within the project area (Table 4)

One unidentified invertebrate species was recorded in the project area, an unidentified sucking millipede (*Siphonotidae sp*.). Further taxonomic review and survey work of this species is required. A single specimen was collected from *Eucalyptus*/*Banksia* habitat in the north-east quadrant of the Stock Road/Forrest Road intersection.

2.3.4 Conservation Land (Bush Forever and Beeliar Regional Park)

The project will impact upon Bush Forever sites and Beeliar Regional Park. A total of 7ha of Bush Forever will be cleared during construction of the project. Beeliar Regional Park will be impacted by the resumption of 5.4ha of the park for road reserve, due to the realignment of the road to minimise impacts on native vegetation and CCW.

2.3.5 Noise

Construction noise and traffic noise during operation will have a significant impact on sensitive receivers adjacent to the project. Significant noise impacts during construction include: operation and movement of machinery, out of regular working hours construction noise, reversing alarms and piling. During operation, excessive noise from traffic can result in a loss of amenity for residents, and possible health impacts.

2.3.6 Aboriginal Heritage

The Bibra Lake/North Lake area is significant to Aboriginal people. In the past the area was used as a semi-permanent camp site due to the proximity to food and water year round. The project area will impact upon a number of mythological and archaeological sites in the vicinity of Bibra Lake and North Lake registered under the *Aboriginal Heritage Act 1972* (Table 5)

Table 4 Fauna listed under EPBC Act, WC Act or DEC's priority fauna list that occur within the project area and the impact of the project on their habitat (SMC 2011)

Species	Conservation Status	Habitat Loss in Project Area
Carnaby Cockatoo (*Calyptorhynchus latirostris*)	Endangered – EPBC Act Schedule 1 – WC Act	78.3ha
		249 potential nesting trees (DBH >500mm. i.e. potentially able to form nesting hollows)
		Loss of 2.5ha of potential nesting habitat (based on 100m^2 radius around each significant tree to be cleared)
Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*)	Vulnerable – EPBC Act Schedule 1 – WC Act	73.2ha
		249 significant trees (DBH >500mm. i.e. potentially able to form nesting hollows)
		Loss of 2.5ha of potential nesting habitat (based on 100m^2 radius around each significant tree to be cleared)
Australasian Bittern (*Botaurus poiciloptilus*)	Endangered – EPBC Act Schedule 1 – WC Act	0.3ha
Australian Little Bittern (*Ixobrychus dubius*)	Priority 3 - DEC	0.3ha
Peregrine Falcon (*Falco peregrinus*)	Schedule 4 – WC Act	111.8ha
Western Brush Wallaby (*Macropus irma*)	Priority 4 – DEC	72.7ha
Southern Brown Bandicoot (Isoodon obesulus fusciventer)	Priority 5 - DEC	72.5ha
Perth Lined Lerista (*Lerista lineata*)	Priority 3 - DEC	91.4ha
Black-striped Snake (*Neelaps calonotus*)	Priority 3 - DEC	72.7ha
Jewelled Sandplain Ctenotus (*Ctenotus gemmula*)	Priority 3 - DEC	34ha
Rainbow Bee-eater (*Merops ornatus*)	Migratory – EPBC Act	89.9ha
Migratory Wetland Birds	Migratory – EPBC Act	3.7ha
Graceful Sun-moth (*Synemon gratiosa*)	Endangered – EPBC Act Schedule 1 – WC Act	5.6ha

Table 5 Aboriginal Heritage sites, registered under the *Aboriginal Heritage Act 1972*, within the project area (SMC 2011)

Site Number	Site Name	Status	Recorder /Year	Access	Restriction	Archaeological/Ethnographic
3196	Lake Bibra: Forrest Road	Stored Data	Chapman 1977	Open	Not Restricted	Quarry
3293	Bibra Lake	Insufficient Information	Hallam, S 1974	Open	Not Restricted	Archaeological
3709	North Lake and Bibra Lake	Permanent Register	O'Connor, Bodney & Little 1985	Open	Not Restricted	Ethnographic
4107	Bibra Lake North	Permanent Register	Stranger, R 1973	Open	Not Restricted	Archaeological
4106	North Lake SW	Permanent Register	Hallam, S Smith, M & Stranger, R 1972	Open	Not Restricted	Archaeological
3294	North Lake N	Permanent Register	Stranger, R 1974	Open	Not Restricted	Archaeological
3295	North Lake Coolbellup	Permanent Register	Hallam, S Smith, M & Stranger, R 1972	Open	Not Restricted	Archaeological
3296	Hope Rd Swamp/Bibra Lake	Stored Data	Stranger, R 1974	Open	Not Restricted	Archaeological

2.4 Current Land Use

There are three distinct zones of the project area, each characterised by their environmental and social values. The two outer portions of the project area (east of Bibra Drive and west of Progress Drive) are situated in areas of urban development. The central portion (between Progress Drive and Bibra Drive) consists of parklands, wetlands and vegetated areas. These different land uses can be seen on aerial photography of the project area (Figure 1). The Kwinana Freeway and existing Roe Highway are located to the east of the project area, while North Lake Road and Stock Road are located to the west of Bibra Lake and North Lake.

Land adjacent to the MRS road reserve is predominantly zoned for urban uses. Other areas, notably around Bibra Lake are reserved for parks and recreation. Approximately 5.4 ha of Beeliar Regional Park will be acquired for incorporation into the road reserve.

2.5 Historical Land Use

Land use within the project area has changed significantly over time (Table 6). From the 1830s to the 1970s and 1980s, the land use had primarily been agricultural. More recently suburban development has encroached into the area. Parts of Bibra Lake have been used as a landfill for many years and the landfill may be a source of contamination for Bibra Lake.

Table 6 Historical Land Uses

Date	Land Use(s)	Source
Prior to 1820s (pre-European)	Locality of site used by Aboriginal people for camping and hunting.	Strategen 2009
1800s	Early pastoral leases (George Robb and Benedict Von Bibra).	Strategen 2009
1890s	Market gardens and dairy enterprise on land near Bibra Lake, oats/pastures on higher ground.	Strategen 2009
1920s	Establishment of schools, extension of North Lake Road and a decline of dairy and market gardens.	Strategen 2009
1970s and 1980s	Encroachment of suburban development.	Strategen 2009
1975	Establishment of Murdoch Veterinary School and animal handling facilities.	Clark and Grandage 2005
1940s to 1960s	Sanitary landfill at the southern end of Bibra Lake.	Riggert 1983

2.6 Geology

Understanding the underlying geology is significant to water management owing to the proposed use of infiltration basins and abstraction of groundwater during the construction phase of the project.

2.6.1 Regional Geology

The project area falls within the Swan Coastal Plain, which comprises sand, limestone and fluvial deposits that form a coastal strip of between approximately 5 m and 90 m in height above sea level, between the Darling Scarp and the Indian Ocean. The eastern margin of the Swan Coastal Plain is dominated by silts and clays (muds), while the central area is predominantly sandy. To the west, the sandy materials pass laterally into limestone, which borders the coastal strip (V&CSRG 2009). These formations include the Bassendean Sand and Tamala Limestone.

Several major dune systems, oriented in a north-south direction, transect the Swan Coastal Plain. The Quindalup and Spearwood dune systems lie closest to the coast, with the Bassendean dune system further to the east. The Bassendean Dunes (Bassendean Sand Formation) are the oldest and most leached of the series, and comprise fine to coarse sand and ferruginous sand. These occur in the eastern portion of the project area. A depression exists where the interface between the two dune systems occur.

2.6.2 Local Shallow Geology

The superficial geology of the project area is illustrated in Figure 6. North and Bibra Lakes form part of a chain of lakes that occupies interdunal depressions in the Spearwood dune system at the contact with the Bassendean dune system. Beneath the lakes are lacustrine sediments comprising unlithified silt and clay-sized clastic and organic sediments (Davidson 1983).

The site is typically underlain by up to four different geological units of Quaternary and Tertiary aged formations to depths of 40-60m, which are described below. Deeper and older formations are not discussed.

2.6.2.1 Bassendean Sands

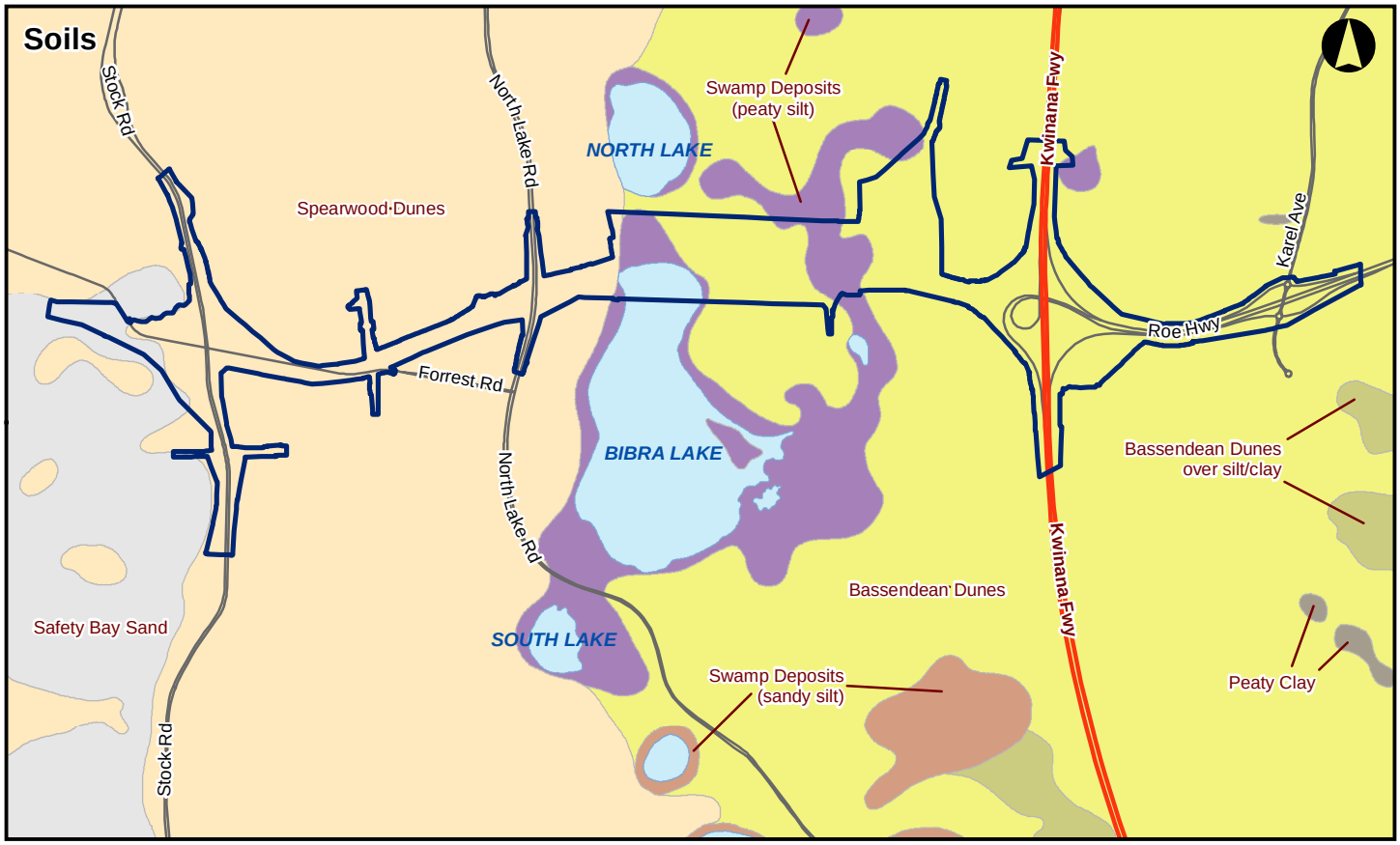
The eastern portion of the project area is defined by the Bassendean Sands geologic unit, which is present over much of the central Perth region and has a maximum thickness of about 80 m. It is pale grey to white and includes fine to coarse sand that is predominantly medium grained. It comprises moderately sorted, sub-rounded to rounded quartz sand and commonly exhibits fining upward textures. A layer of friable, limonite-cemented sand, commonly known as ‘coffee rock’, occurs throughout some of the area near the water table (AECOM 2010). Bassendean Dunes (located in the eastern portion of the project area) tend to be acidic, highly leached and nutrient poor (Bolland 1999).

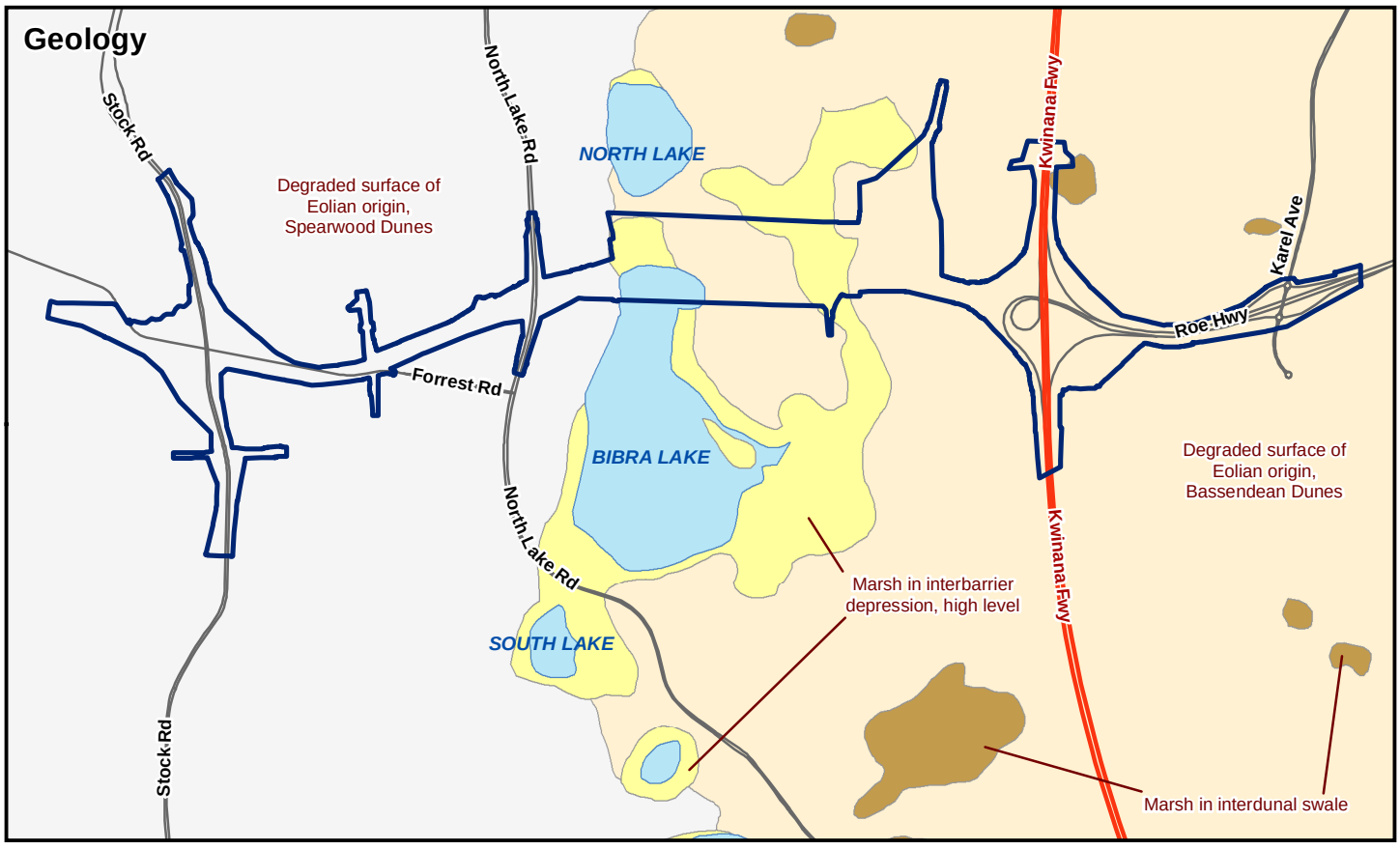
2.6.2.2 Swamp Deposits and Organic Sediments

The areas surrounding Bibra Lake, North Lake and the swamp areas adjacent to and west of Bibra Drive are underlain by swamp deposits comprising peaty silt. Organic sediments of Swan Coastal Plain wetlands range from fine silty oozes of deeper lakes derived from phytoplankton production settling out on the lake bottom, to sediments formed by coarser organic matter, usually called peat. Peat is derived from decaying vascular plant material that accumulates in shallow swamps or in stands of sedges fringing open lakes (Pinder 2005).

2.6.2.3 Spearwood Dunes

The western portion of the project area is predominantly underlain by sand derived from Tamala Limestone. The exception to this is at the western end of the proposed road corridor at Stock Road, which is underlain by Tamala Limestone. The sand derived from Tamala Limestone forms part of the Spearwood dune system and is described as a pale yellowish brown, medium to coarse grained, sub-angular quartz sand that is moderately sorted and of residual origin (AECOM 2010).





Geology & Soils

South Metro Connect

Figure 6

0 0.5 1 1.5

Kilometres

1:42,500 (A4)

Datum: GDA94 Projection: MGA z50

Soils

- Peaty Clay
- Safety Bay Sand
- Swamp Deposits (peaty silt)
- Swamp Deposits (sandy silt)
- Spearwood Dunes
- Bassendean Dunes
- Bassendean Dunes over silt/clay
- Water

Geology

- Degraded surface of Eolian origin, Spearwood Dunes
- Degraded surface of Eolian origin, Bassendean Dunes
- Marsh in interbarrier depression, high level
- Marsh in interdunal swale
- Water
- Project Area

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Source: Geology of the 1:50 000 mapsheet FREMANTLE (2033-IV) , Geological Survey of Western Australia

Last Modified 22/05/2012 at 09:10 AM by jonesk4

\\auper2fp001\roehwy\60100953 - Roe Hwy Ext\4 Tech work area\4.4 Environment\4.4.3 EIA\4.1.3.D Responses\Figures\GIS\Workspaces\2012_04_26_Ross_Perrigo_WMP\Figure7_Geology and Soil Types.mxd

The Spearwood dune system is leached limestone and comprises fine to very coarse, very slightly calcareous, sand. Limestone features occur within thick sections of yellow quartz sand at various scales of up to 10 m thick and 20–150 m wide. The soils of the Spearwood Dunes comprise yellow sands known as Karrakatta Sands, located on the upper slopes of the dunes, and red/brown sands called Cottesloe Sands, nearer to the coast that are believed to have been formed about 40,000 years ago (Bolland 1999). West of the Spearwood Dunes are yellow phase Karrakatta Sands derived from Tamala Limestone. The proposed project terminates in yellow phase Karrakatta Sands at Stock Road.

2.6.2.4 Tamala Limestone

The Tamala Limestone forms part of the Spearwood dune system and is an Aeolian, or wind derived, deposit. It is typically described as a pale yellowish brown, fine to coarse grained calcarenite, comprising sub-angular to well-rounded quartz with a trace of feldspar and shell debris. The Tamala Limestone is variably lithified and ranges from a limestone to calcarenite to uncemented sand. The limestone is characterised by solution cavities, which are commonly developed at the current or historic water table locations. Its surface is covered by yellow sand which also extends along its unconformities, and underlies it. The Tamala Limestone outcrops sporadically (as evidenced at the coast and in road cuttings) and its surface ranges from convex, horizontal and sloping to pinnacled, depending on the degree of weathering.

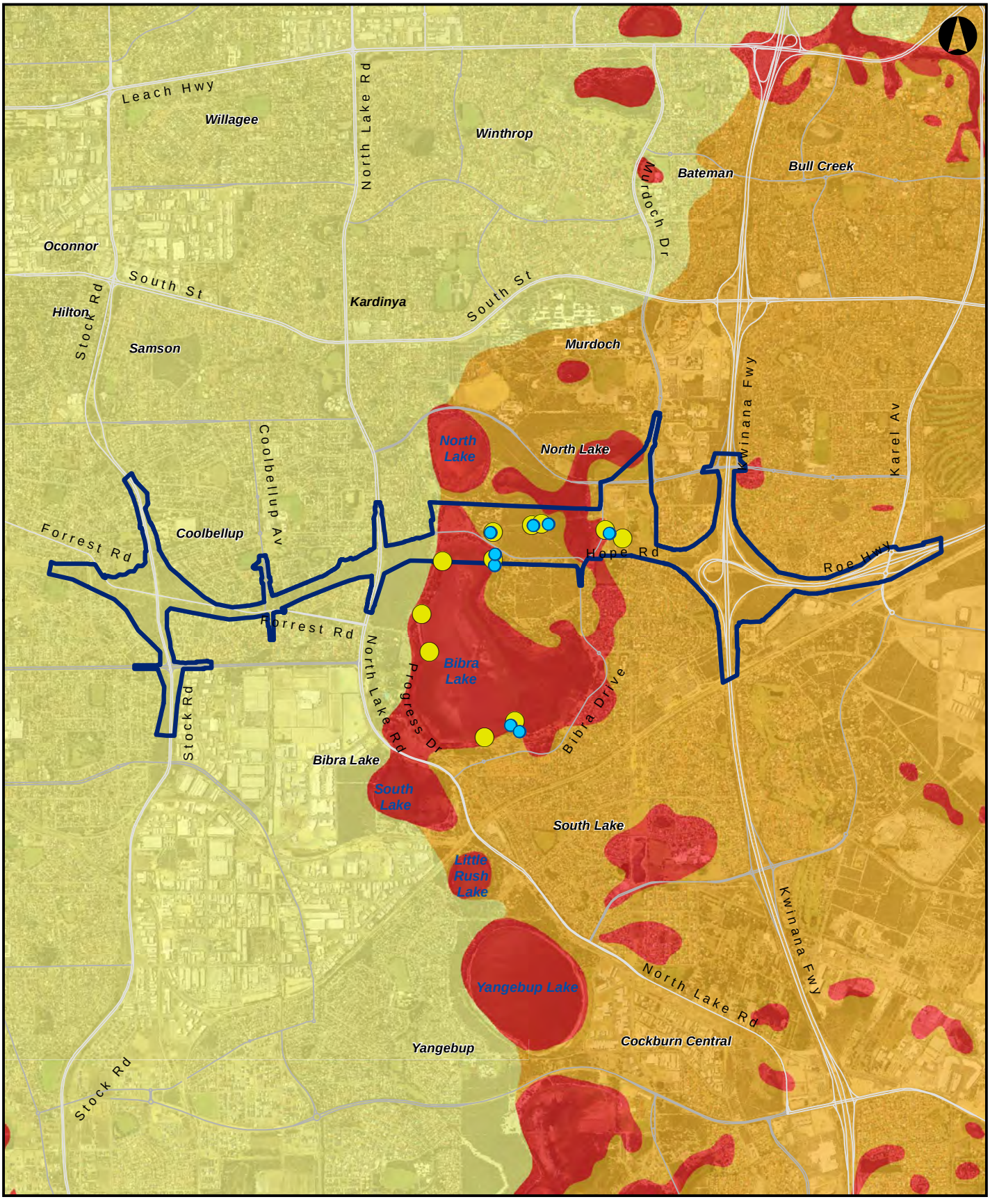
2.7 Acid Sulfate Soils (ASS)

The WAPC *Acid Sulfate Soils – Planning Bulletin No.64* identifies portions of the project area falling within one of the following three risk classifications (for Potential ASS (PASS) occurring within three metres of the natural soil surface):

- Class 1 — high to moderate risk;
- Class 2 — moderate to low risk; or
- Class 3 — no known risk.

A soil sampling programme was conducted as part of the preliminary ASS assessment. This preliminary sampling program is consistent with the ASS risk mapping for the area (Figure 7).

A summary of the ASS laboratory test results is presented in Table 7. Based on these results, it is considered unlikely that the sampled soils are AASS or PASS, but some indicators of PASS within coffee rock horizons were recorded at about 3 mbgl. There was a moderate indication of PASS in all sediment samples taken from BLSB2 and BSLN2, which means that the sediment has the potential to oxidise further and produce sulfuric acid if exposed. There was no clear indication of AASS or PASS in all other samples.



Acid Sulphate Soils

South Metro Connect

Figure 7

0 0.5 1 1.5

Kilometres

1:45,000 (A4)

Datum: GDA94 Projection: MGA z50

- Sample showing evidence of ASS
- Test Locations
- Class 1 - High to Moderate Risk
- Class 2 - Moderate to Low Risk
- Class 3 - No Known Risk
- Project Area

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Table 7 Summary of ASS Laboratory Test Results

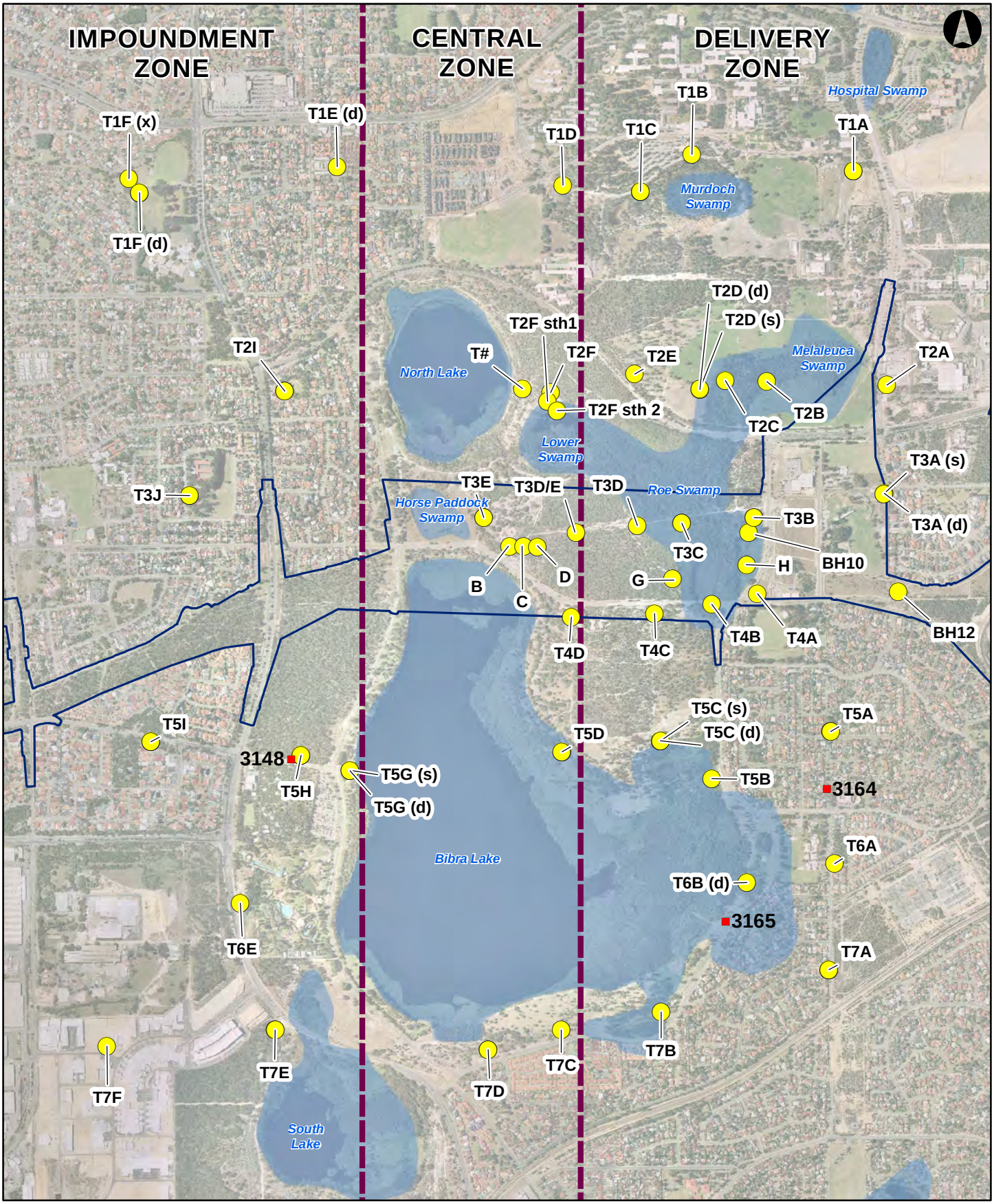
Field Observations			Field Test (Laboratory)		Action Criteria	
Sample ID		Soil Description	pH_F	pH_{FOX}	$pH_F - pH_{FOX}$	Net Acidity (SPOCAS)
Sample Name	Sample Details (Depth in mgbl) / Interval of Soil Type		pH Units	pH Units	pH Units	mol H^+/t
Soil Samples						
TP13/2.6	2.6 m	SAND (SP): dark brown fine to coarse grained with coffee rock	5.5	3.1	2.4	64
TP14A/2.0	2.0 m	SAND (SP): orange brown fine to coarse grained	5.7	4.8	0.9	26
TP15/2.7	2.7 m	SILTY SAND (SM): dark brown fine to coarse grained with coffee rock	4.6	4.0	0.6	82
TP16/3.0	3.0 m	SAND (SP): grey fine to coarse grained. Some coffee Rock	6.0	4.6	1.4	33
TP17/2.0	2.0 m	SAND (SP): orange brown fine to coarse grained	5.9	4.7	1.2	<10
Sediment Samples						
BLS2	0.1–0.3m	Sediment	6.3–6.6	2.0–2.7	3.6–4.6	59–65
BLN2	0.1–0.3m	Sediment	4.8– 4.9	3.2–3.3	1.5–1.7	643–763

2.8 Groundwater

The underlying aquifer's quality of groundwater and depth of water below the surface are significant groundwater hydrology components that require consideration. The groundwater monitoring bores in the area are shown in Figure 8.

2.8.1 Aquifers

The Jandakot Groundwater System is comprised of a superficial aquifer, the confined Leederville Aquifer and the confined Yarragadee Aquifer (Water Corporation 2008). The superficial aquifer is known as the Jandakot Mound. At the centre of the Jandakot Groundwater System, the saturated thickness of the superficial aquifer formation is approximately 40m (Water Corporation 2008). It comprises shallow sands and is unconfined, although ferricrete and coffee rock layers can locally impede groundwater or surface water, resulting in areas of ponding and perched aquifers. Generally, the thickness of the unconfined aquifer decreases to the west, towards the coast.



Groundwater Monitoring Locations

South Metro Connect

Figure 8

0 250 500

Metres

1:20,000 (A4)

- WIN Groundwater Bores
- Groundwater Monitoring Bores
- Zone Boundary
- Wetlands
- Project Area

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Recharge to the superficial aquifer occurs through direct vertical infiltration of rainfall, which migrates downward to the water table or less permeable layers, at which point groundwater primarily flows laterally through the aquifer.

North and Bibra lakes are considered to be hydraulically connected with the Jandakot Mound. The elevation of the water table on the eastern side of the lakes is higher than that of the lake, indicating discharge of groundwater into the lakes. On the western side of the lakes, the water table is lower than the lake level; indicating outflow from the lakes to groundwater (Townley et al. 1993). This is also evident from regional east-west groundwater movement descriptions (Figure 9 to Figure 11). The Beeliar wetlands in the western portion of the Jandakot Mound (including North and Bibra lakes) are through-flow lakes and expressions of groundwater (CyMod 2009).

The water table is shallow in many parts of the project area, resulting in significant losses of water via evapotranspiration. In other areas, depth to groundwater is substantially deeper: for example, west of Bibra Lake (near Coolbellup Avenue), the water table is approximately 30 to 50 mbgl.

2.8.2 Groundwater Levels

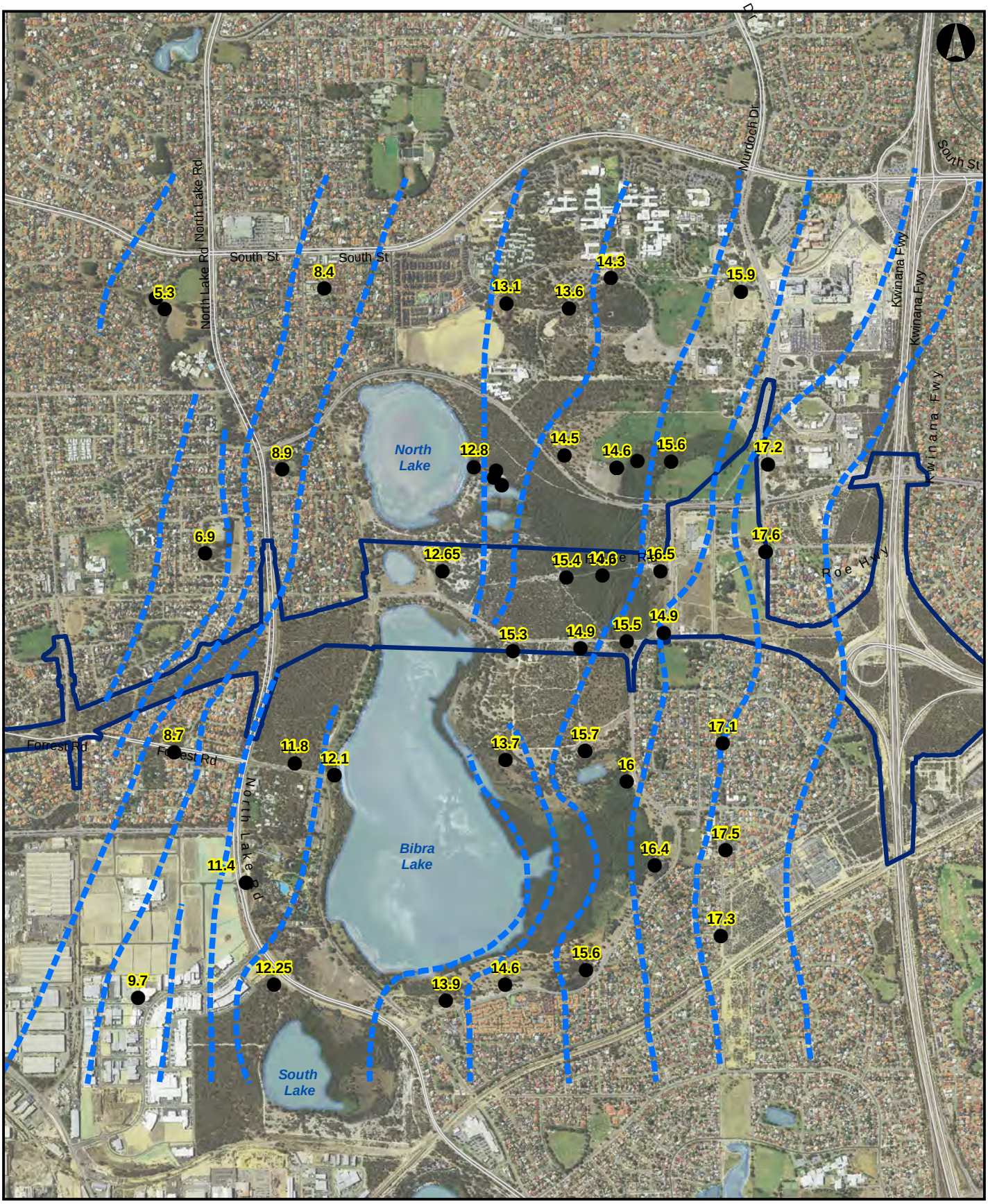
Groundwater levels within the study area fluctuate seasonally by approximately one metre and are generally highest during September and October (after winter rainfall recharge) and lowest during April and May (after summer) (Davidson 1983). Inspection of groundwater contour maps indicates that groundwater generally flows in a westerly direction from the Jandakot Mound to discharge in the near-shore marine environment of Cockburn Sound.

Groundwater contours indicate that the wetlands influence regional groundwater levels and flow direction beneath and surrounding wetland basins. Lake sediments, groundwater levels and flows are likely to produce local variations to regional patterns. In the wetland basins, the sediment fill exhibits various thicknesses of mud, consequently forming an impedance to lateral groundwater flow into the wetlands and to vertical groundwater migration.

Monthly groundwater measurements were conducted for the PER throughout 2010. The measured groundwater contours of the area for 2010 are presented in Figure 9 (March 2010), Figure 10 (April 2010) and Figure 11 (August 2010) and show the regional west to north-westerly groundwater flow direction. On the eastern side in the delivery zone the increased number of monitoring bores indicates some local small scale mounding effects near Roe Swamp and North Lake. In the same area, there were two local small mounds: one centred on Melaleuca Swamp and the other located between sites T4-C and T4-D on Hope Road.

Groundwater level monitoring was continued along Transect 3 (the proposed road alignment corridor), throughout 2011 and the first half of 2012. Significant differences in seasonal water level maximums and minimums were observed. At bores T2F and T3D, the difference in seasonal maximum water levels was 2.09 m and 1.28 m respectively, between October 2010 and 2011, which highlights the effects of rainfall and recharge variations between wet and dry years, notably in areas adjacent to wetlands.

Department of Water WIN database bores 3164, 3165, 3148 and 3151 show that the 2010/2011 period is indicative of a historical minimum, last observed in the early 1980s (see Figure 12).



Regional Groundwater Contours Plotted from Lowest Bore Water Levels in March 2010

South Metro Connect

Figure 9

0 0.25 0.5

Kilometres

1:25,000 (A4)

Datum: GDA94 Projection: MGA z50

15.5 Height of Water Table in metres above AHD

Drill Site

Ground Water Contours in metres above AHD

Project Area

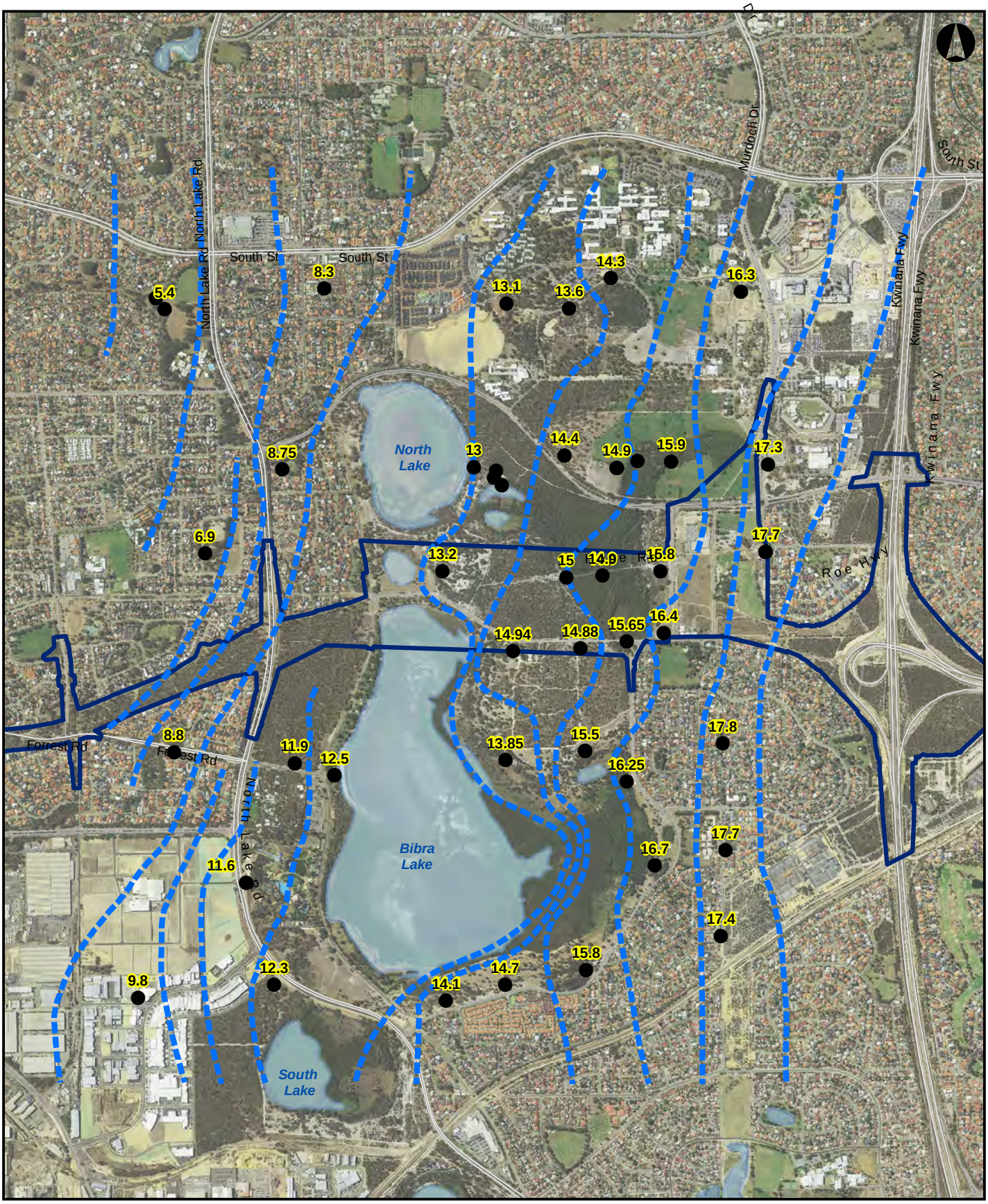
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Regional Groundwater Contours Plotted from Recharged Water Levels in April 2010

South Metro Connect

Figure 10

0 0.25 0.5

Kilometres

1:25,000 (A4)

Datum: GDA94 Projection: MGA z50

15.5 Height of Water Table in metres above AHD

Drill Site

Ground Water Contours in metres above AHD

Project Area

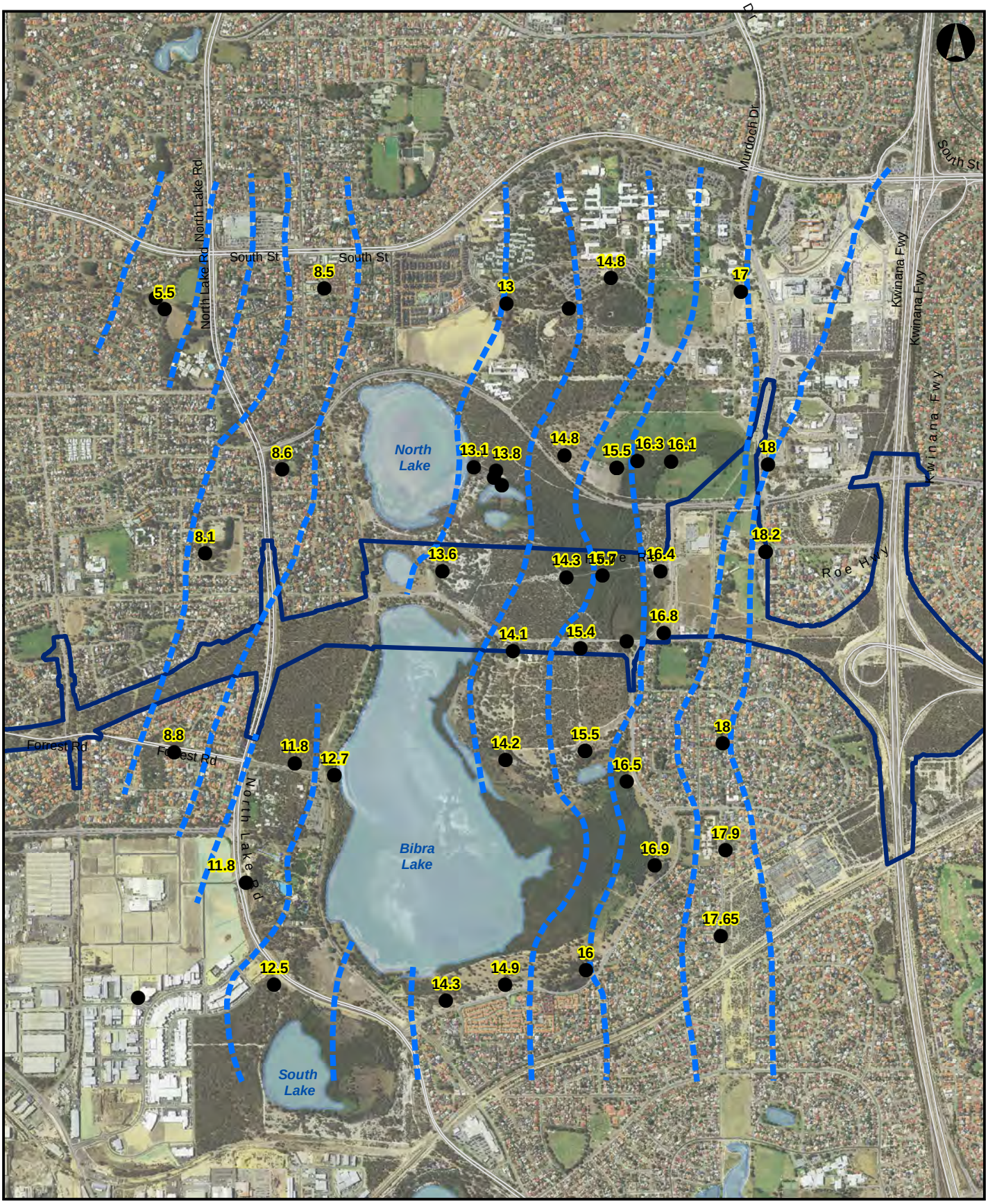
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Regional Groundwater Contours from Highest Water Levels

South Metro Connect

Figure 11

0 0.25 0.5

Kilometres

1:25,000 (A4)

Datum: GDA94 Projection: MGA z50

15.5 Height of Water Table in metres above AHD

Drill Site

Ground Water Contours in metres above AHD

Project Area

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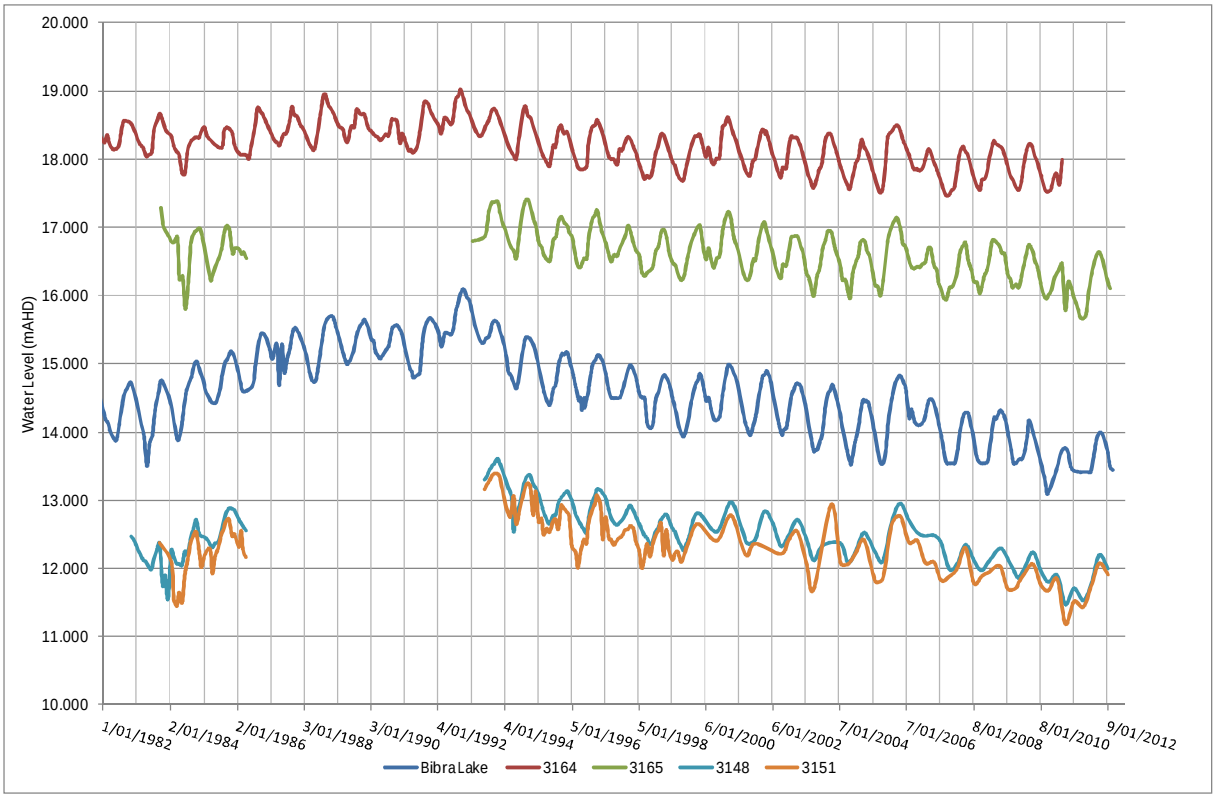


Figure 12 Selected WIN Data Bores in Bibra Lake area

2.8.3 Groundwater Quality Data

Groundwater quality within the study area was monitored by South Metro Connect through 2010 to record pre development site conditions and help further understand the mechanics of the wetland system.

Table 8 provides a summary of selected groundwater bore quality data for significant areas within and around the project area. The detailed assessment of water quality within the study area can be found in the main body and Appendix H of the PER.

Table 8 Selected Groundwater Bore Water Quality Data

Bore ID	Description	2010 Data		
		pH	Total Dissolved Solids (mg/L)	TKN (mg/L)
T1A	Delivery Zone North of site, Bassendean Sands	6.5 – 6.9	220 – 340	<0.1 – 0.6
T2D (deep) T2D (shallow)	Delivery Zone Roe Swamp/ West of North Lake Bassendean Sands	6.6 – 7.2 6.2 – 6.9	355 – 565 445 – 900	
T2F	Central Zone Frog Swamp/West of North Lake Bassendean Sands	6.4 – 6.8	270 – 310	0.2 -0.9
T3C	Delivery Zone Horse Paddock Swamp / Bibra Drive Bassendean Sands	5.2 – 5.9	130 – 145	<0.1 – 0.5
T3E	Central Zone Adjacent to North and Bibra Lakes, Bassendean Sands	5.7 – 6.4	290 – 360	0.5 – 1.5
T5A	Upgradient of wetland area	5.6 – 6.2	110 – 130	<0.1 – 0.5
T5D	Central Zone Upgradient of Bibra Lake Bassendean Sands	6.4 – 6.7	280 – 340	1.5 – 2.0
T5G (deep) T5G (shallow)	Impoundment Zone Downgradient of Bibra Lake Bassendean Sands	6.6 – 6.9 7.0 – 7.4	975 – 1050 950 – 985	
T7A	Delivery Zone Upgradient of Site Bassendean Sands	5.5 – 6.3	200 – 235	<0.1 – 0.4
T7D	Central Zone Adjacent to Bibra Lake Bassendean Sands	6.0 – 6.7	135 – 165	<0.1 – 1.8
T7E	Down Gradient of Wetland area – Tamala Limestone	6.6 – 6.8	1480 – 1960	16 – 21
BH10	Delivery Zone Roe Swamp Bassendean Sands	5.5 – 5.9	130 – 155	<0.1 – 1.6
BH12	Deliver Zone Upgradient of area Bassendean Sands	6.2 – 6.5	90 – 145	<0.1 – 0.1

2.9 Surface Water

The pre-development surface water hydrology consists of existing drainage infrastructure and natural features.

2.9.1 Surface Water Features

Surface water within the wetland systems is a combination of groundwater expression and surface water runoff. Site investigations and historical aerial photography have identified surface water at the following locations:

- Bibra Lake
- North Lake
- Horse Paddock Swamp
- Roe Swamp
- Murdoch Drain.

The project area intersects a catchment that contributes surface water to each of these wetlands. The catchment has an area of approximately 730 ha (Figure 13). Parts of the Roe Highway road reserve to the east and west of this catchment are generally self-contained with respect to surface water (i.e. surface water does not enter or leave the road reserve in these areas). These areas to the east and west of the catchment are referred to in terms of their proximity to existing local government drainage infrastructure.

The catchment surface area was calculated using a combination of topographic contours and City of Cockburn drainage information. The catchment does not include areas that may contribute to the wetland system through groundwater recharge. The surface water catchment for the project wetland system includes:

- Areas generating surface water flow that discharge directly into the project wetland system.
- Areas generating surface water flow from road drainage infrastructure.
- Areas generating surface water flow within residential areas that would contribute to road drainage infrastructure or overflow into the project wetland system during larger storm events.
- The area of water bodies receiving direct rainfall.
- Areas generating surface water flow to existing City of Cockburn basins that overflow into the project wetland system during larger storm events.

The Beeliar Regional Park Management Plan (CALM, 2006) states that in the longer term, existing stormwater outfalls will be reviewed to assess the viability of improving water quality entering the Park.

2.9.2 Hydrological Data

Water levels at Bibra Lake and North Lake have been monitored since 1963 and 1971 (Figure 14). Inspection of the historical data shows water levels fluctuate seasonally. During the summer period, parts of the lakes experience drying out, which are then refilled during the winter period.

Water levels in Bibra Lake and North Lake were monitored from the end of 2009 through 2010 for the PER. During this period, water levels in North Lake were at or near minimum water levels during late 2009, with a maximum water depth around 0.3 m. North Lake dried up in early 2010, however, was replenished during the winter months and reached a depth of around 1.0 m in August 2010 (Figure 14).

Long term observations at Bibra Lake and North Lake suggest a potential 20 year sinusoidal pattern; however there are not enough years of data to conclude this is a consistent pattern. The observed variations in Bibra Lake, North Lake and the peripheral water systems such as Horse Paddock Swamp and Roe Swamp indicate a shallow surface water system, sensitive to groundwater expression and surface water contributions. Lake levels since 2001 and groundwater levels for two Superficial Aquifer monitoring bores east (upgradient) and west (down gradient) of Bibra Lake are shown on Figure 15. The connection of lake levels to groundwater levels in the Superficial Aquifer can be seen clearly.

2.9.3 Surface Water Quality

Water quality at North and Bibra Lakes has been monitored intermittently by various groups since as early as 1970. A summary of the monitored periods is provided in Table 9 and a summary of the water quality is provided in Table 10.

At Bibra Lake, pH levels have ranged from 5.8 to 11.3 over the monitored periods. The most recent sampling events through 2009 and 2010 show that Bibra Lake is currently alkaline, with pH increasing during the summer months.

At North Lake, pH levels ranged from 4.4 to 10.4 over the monitored periods. As observed in Bibra Lake, the more alkaline readings are generally recorded in the summer months. Monitoring since 2007 has shown slightly acidic to near neutral conditions. Increasing pH levels during the summer months is a trend observed through the historical data.

It is likely that increased algal photosynthesis activity is a factor. Increased photosynthetic activity is associated with the consumption of dissolved carbon dioxide, which leads to the production of hydroxyl ions (from chemical disassociation of water), which in turn leads to an increase in pH (Kinnear et al. 1997). This explains the slightly elevated pH results in February 2010 and is supported by the higher chlorophyll a levels observed in Bibra Lake in February 2010 (which serves as an indicator of algal biomass).

Water salinity in Bibra Lake is generally fresh to brackish, as indicated by electrical conductivity (EC) measurements, which ranged from 330 to 8,125 µS/cm over the monitored periods. EC increases during the summer months due to increased temperatures and evaporation. Water salinity is also directly and indirectly influenced by rainfall, through surface runoff from the catchment and also via increased/reduced recharge to groundwater affecting groundwater levels and groundwater flux through the lake.

Over the observed periods, water salinity in North Lake has ranged from fresh to brackish. Since 2007, water salinity has been slightly brackish to brackish, potentially due to a decline in surface water and groundwater inflows. Dissolution of surface salt may be another factor (SMC, 2011) that the readings were higher than during previous studies which indicated that North Lake water stayed fresh throughout the year (Davis and Roll 1987).

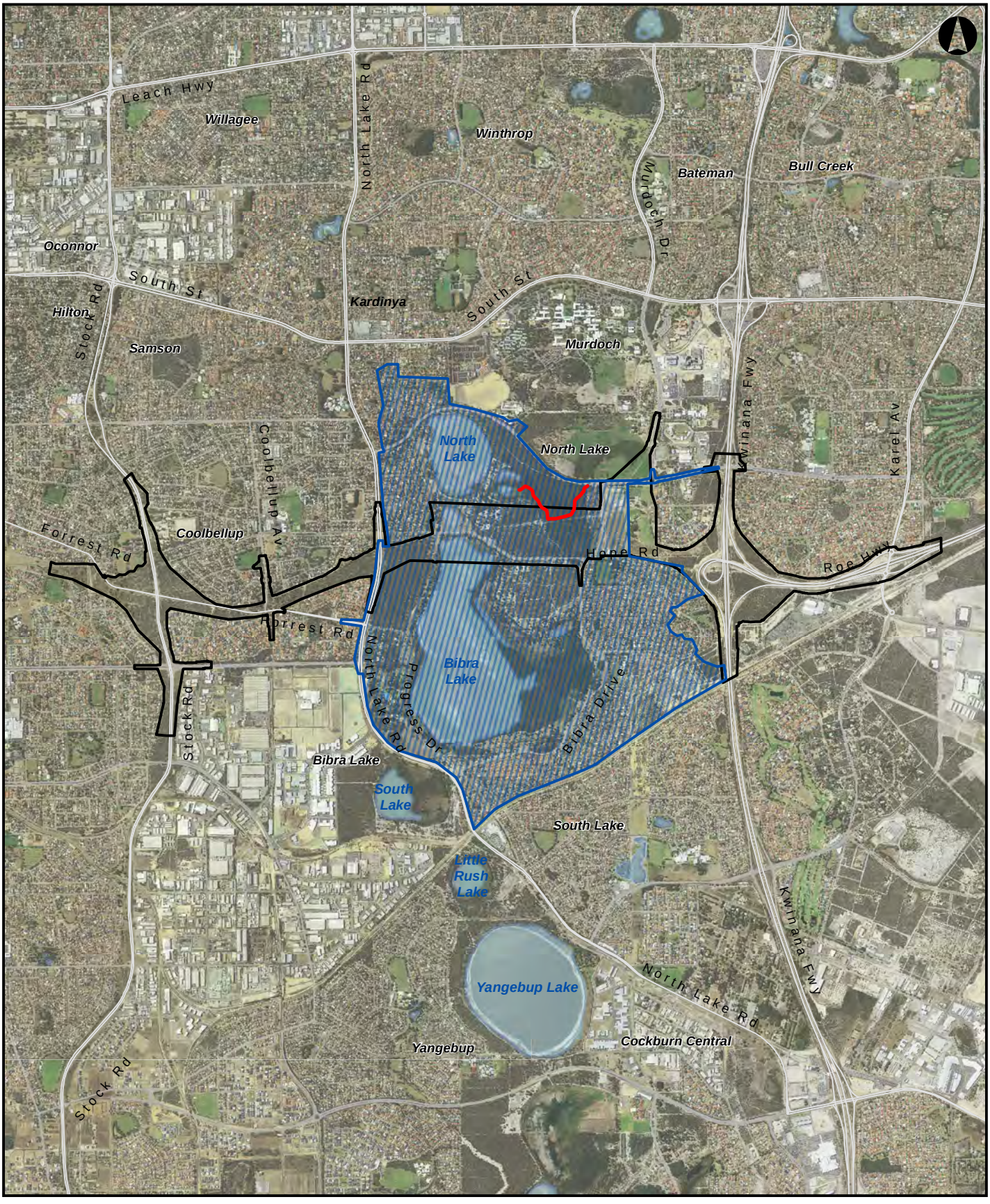
During the most recent water quality assessment (2009 to 2010), the water in Bibra Lake and North Lake appeared to be well oxygenated, with dissolved oxygen (DO) levels above 5 mg/L during the monitoring period (Figure 16 and Figure 17). The highest DO level was recorded in February 2010, likely due to the increased algal activity in the lake at this time. Diurnal sampling was not undertaken. However, as algal activity was high in February 2010, it is likely that the dissolved oxygen was much lower at night when photosynthetic activity ceased and only respiration occurred.

Total Kjeldahl Nitrogen (TKN) increased by a factor of 10 in Bibra Lake from spring 2009 to summer 2010. Observations of TKN results from the City of Cockburn water quality monitoring, undertaken from 1994 to 2001, showed a similar trend, with concentrations fluctuating and generally being higher at the end of summer / beginning of the autumn period.

Biological oxygen demand (BOD), a surrogate measure of organic content in waters, was also measured to assist in understanding how much oxygen was available in the water column. In February 2010, BOD concentrations were 61 mg/L and 69 mg/L. The BOD suggests that bacteria that break down the organic material will readily consume all of the oxygen in the water column. Lack of oxygen can have a number of effects on the system. The most obvious is the direct impact on the respiring biota beneath the lake's surface waters. Another is that the oxygen availability can influence the binding and releasing of contaminants and nutrients generally stored in lake sediments (Burkett 2005). This in turn can affect the amount and toxicity of contaminants in the water column. For instance, zinc is an essential element for plant metabolism, but can be toxic to algae and zinc's toxicity is increased by low dissolved oxygen concentration (Clarke et al. 1990).

Aluminium, arsenic, chromium, copper, lead and zinc concentrations were noted to be higher than guideline levels. These elements, in addition to hydrocarbons, were detected at their highest concentrations at sites close to a nearby car park. The presence of arsenic and zinc in the water suggests that pesticides and fertilisers used in the surrounding area may be transported into Bibra Lake (George et al. 1996).

Consistent with the study undertaken by Davis and Rolls (1987), North Lake's water was coloured during August 2010. The study suggested that this colouration (and slightly acidic pH levels) may be due to humic and fulvic acids, which are released during the decomposition of organic material.



Wetland System Surface Water Catchment

South Metro Connect

Figure 13

0 0.5 1 1.5

Kilometres

1:45,000 (A4)

Datum: GDA94 Projection: MGA z50

Wetland System Surface Water Catchment

Approximate Murdoch Drain Location

Project Area

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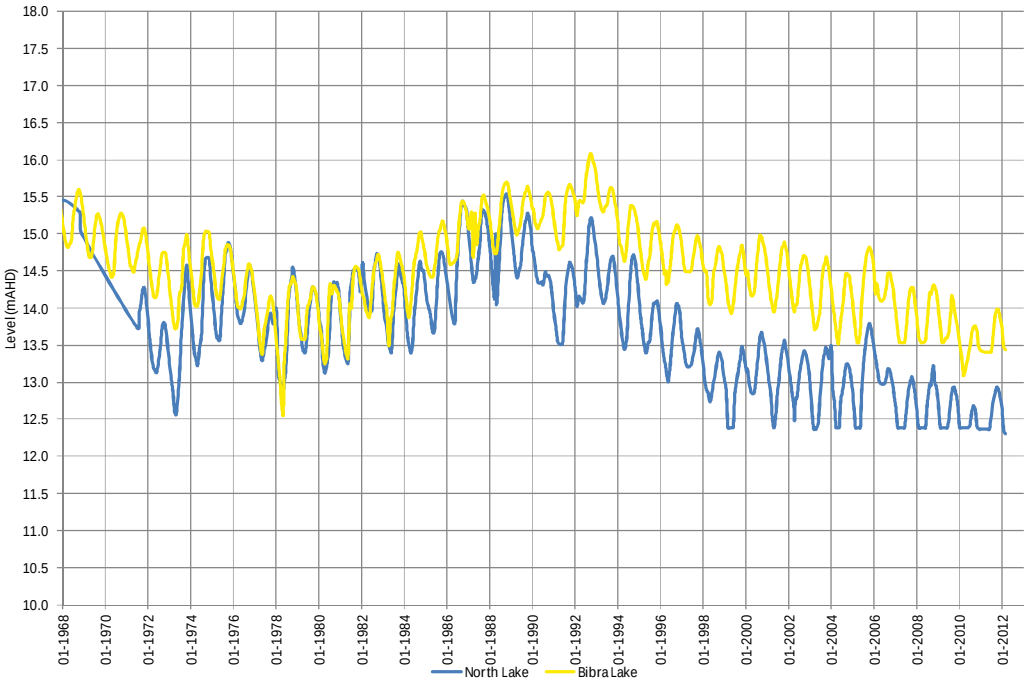


Figure 14 WIN Surface Water Level data for Bibra Lake and North Lake

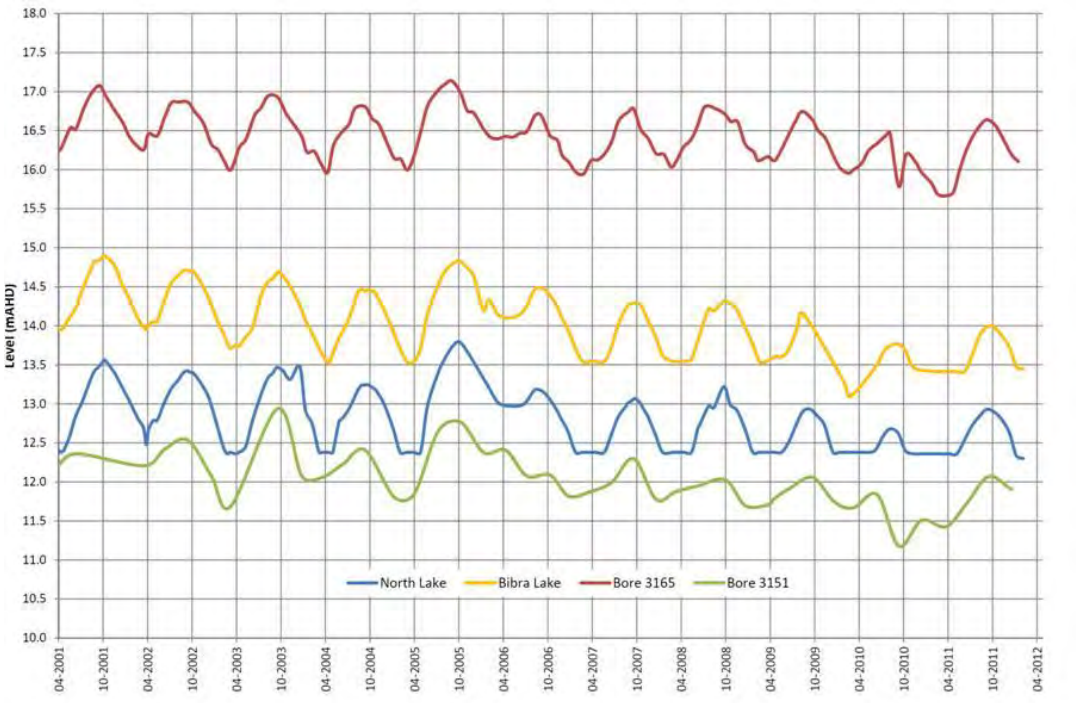


Figure 15 Lake and Groundwater Levels since 2001

Table 9 Lake Water Sample Periods

Data Source	Bibra Lake		North Lake	
	From	To	From	To
Department of Water WIN Database	1970	1986	1970 2007	1986 2009
City of Cockburn	1994	2009	-	-
AECOM	2009	2010	2009	2010

Table 10 North Lake and Bibra Lake Water Quality

Location	Sample Period	pH	EC (µS/cm)	TKN (mg/L)
Bibra Lake	1970 – 1986	7.3 – 10.8	980 – 2,000	-
	1994 – 2009	5.8 – 11.3	330 – 8,125	1.5 – 14.9
	2009 – 2010	8.2 – 8.7	1,295 – 6,230	2.0 – 13.0
North Lake	1970 – 1986	6.9 – 10.4	580 – 1,100	-
	2007 – 2008	4.4 – 6.2	1,300 – 3,720	1.6 – 2.9
	2009 – 2010	6.9 – 7.4	1,720 – 4,800	1.1 – 2.6

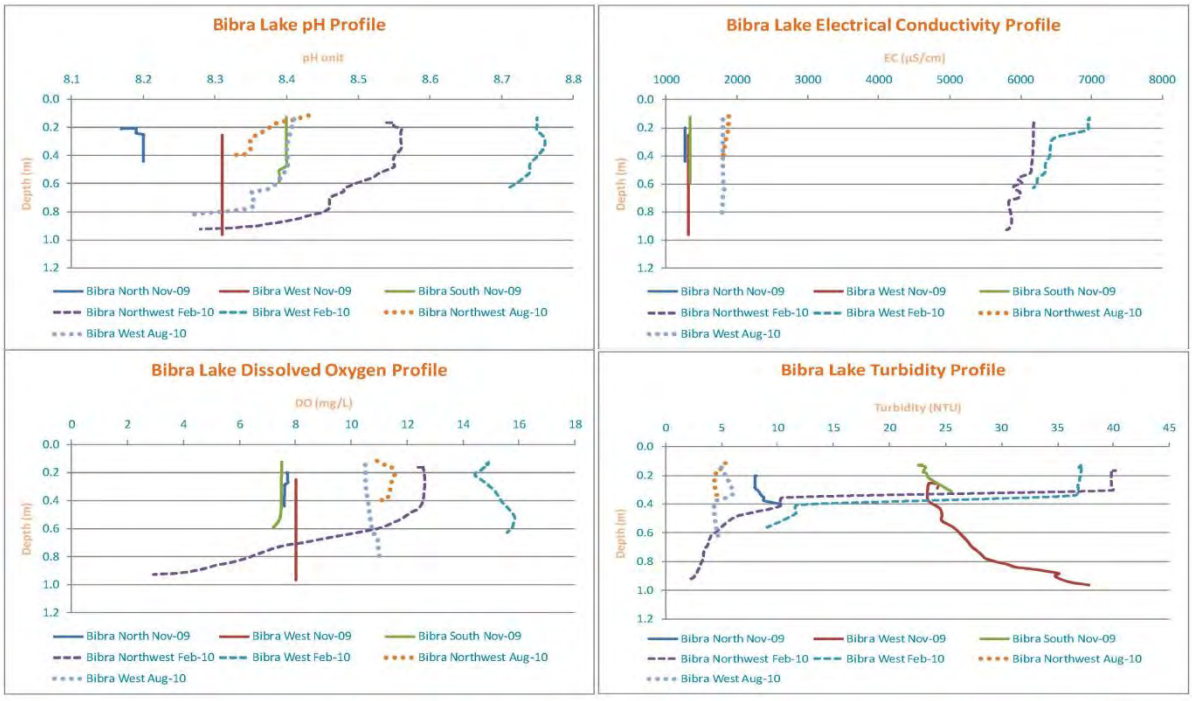


Figure 16 Water Profiles for Bibra Lake (late 2009 to mid 2010)

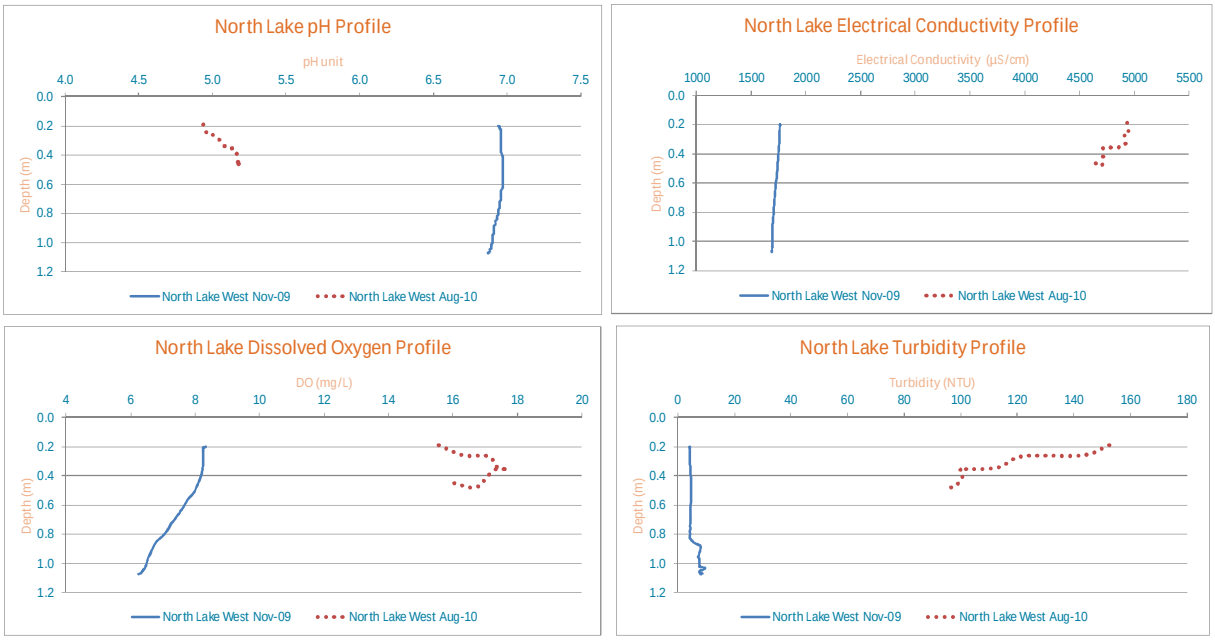


Figure 17 Water Profiles for North Lake (late 2009 to mid 2010)

2.10 Water Resources

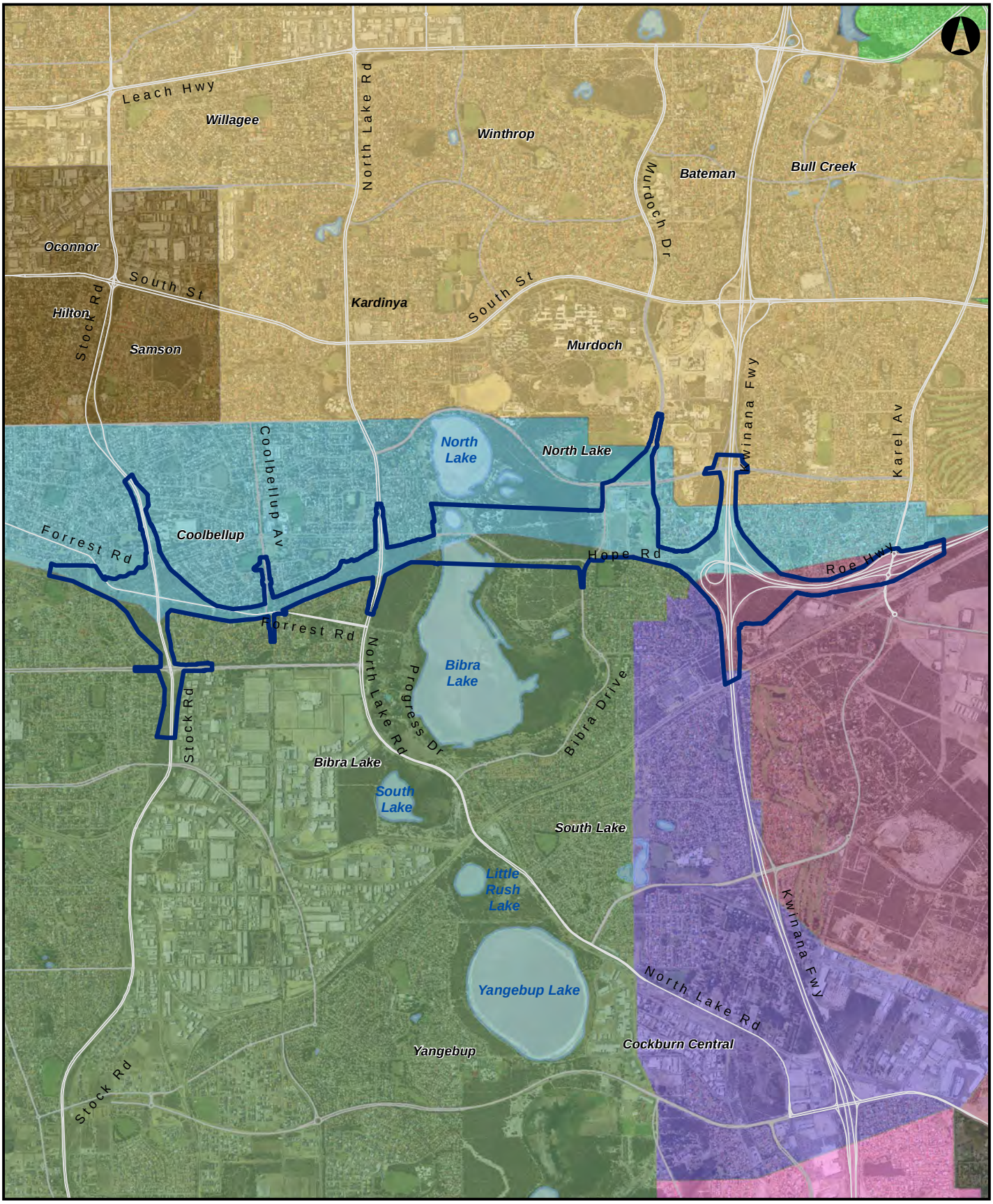
The project area is underlain by three regionally extensive aquifer systems; The Superficial, Leederville and Yarragadee. In the project area and wider metropolitan region the Department of Water (DoW) manages groundwater resources under the *Rights in Water and Irrigation Act 1914* via a system of licensing and allocation plans. The Superficial Aquifer represents the most suitable resource for project supplies based on available allocations and likely lack of adverse impacts. The deeper aquifer systems are fully or over-allocated but can possibly be accessed for temporary periods. Figure 18 shows the DoW Groundwater Management Subareas in the project region for the Superficial Aquifer, whilst Table 11 summarises the water allocation status of the various aquifer resources in these management areas.

The project area occurs near the boundaries of several Groundwater Management Areas; Cockburn, Jandakot and Airport. Whilst all areas have a system of groundwater allocation planning and licensing, only the Cockburn area has a current Groundwater Management Allocation/Plan (released by the DoW in 2007). In the four management subareas within and adjacent to the project area, there is collectively about 3,300,000kL of annual allocation available from the Superficial Aquifer.

Table 11 Department of Water Groundwater Resource Allocation Report (March 2012)

Groundwater Area	Groundwater Subarea	Aquifer	Allocation Limit (kL)	Licensed Allocation (kL)	Total Allocated[2] (kL)	Total Available (kL)
Cockburn	***Kogalup***	***Superficial Swan***	***11,393,390***	***9,838,950***	***9,986,578***	***1,406,812***
Jandakot	***Airport***	***Superficial Swan***	***1,741,232***	***951,225***	***1,060,725***	***680,507***
Jandakot	***South Lakes***	***Superficial Swan***	***1,120,210***	***457,050***	***457,050***	***663,160***
Perth	City of Canning	Superficial Swan	3,494,750	2,249,549	2,316,549	1,178,201
Perth	***City of Cockburn***	***Superficial Swan***	***998,500***	***459,360***	***461,535***	***536,965***
Perth	City of Melville	Superficial Swan	5,498,725	4,190,386	4,190,386	1,308,339
Cockburn	Cockburn Confined	Leederville.	1,350,000	1,500,000	1,500,000	0
Perth	Perth South Confined	Leederville.	4,500,000	5,867,130	5,877,330	0

1. Sub-areas highlighted in bold italic font are those which occur within or immediately adjacent to the project area.
2. Total allocated incorporates licensed allocations plus allocation amounts currently committed or requested.



DOW Groundwater Management Areas

South Metro Connect

Figure 18

0 0.5 1 1.5

Kilometres

1:45,000 (A4)

Datum: GDA94 Projection: MGA z50

Project Area

Groundwater Areas

- Airport
- Banjup
- City of Canning
- City of Cockburn
- City of Fremantle South
- City of Melville
- Kogalup
- South Lakes
- Success

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3.0 Groundwater Abstraction

A total water demand of 140,000 kL has been estimated for construction purposes. Most of the construction water will be sourced from on-site bores, with only a limited component of scheme water being used. The feasibility and potential impacts of the abstraction of groundwater for construction has been assessed and included as a key component of the Water Management Strategy. The following aspects of water demand have been assumed in conducting this groundwater assessment:

- Water is required for road compaction/construction and dust suppression only and not for any uses that may require fresh water, such as drinking water or concrete manufacture. Consequently, water of up to 3,000 mg/L salinity is considered acceptable. Whilst higher salinities may be acceptable for dust suppression, the 3,000 mg/L upper limit represents the limit of low risk for water use in pavement construction, as described by Main Roads WA standards (2007).
- The demand for water is uniform over a period of about 24 - 30 months and that pumping rates would also be uniform on a 24/7 type basis, with any peak rates effectively managed by a water transfer/storage system of tanks or 'turkeys nest' type dams.

3.1 Water Sources

As discussed in Section 3.7, there is sufficient allocation within the Superficial Aquifer for supply of water for the project. In broad terms, groundwater flow occurs in an east-west direction. The north-south trending series of lakes in the project area act as 'groundwater flow-through' lakes within the Superficial Aquifer, whereby groundwater discharges into the lake from the eastern side and then discharges from the lake on the western side.

Groundwater salinity is fresh to brackish, being typically less than 500 mg/L to the east of the lakes and 400 – 1,000 mg/L west of the lakes. Significant amounts of water are discharged as evapotranspiration from the lake surfaces and wetland areas, which results in an increased groundwater salinity (up to 1,500 mg/L) in the down-gradient 'shadow' to the west of the lakes (Davidson, 1995).

Groundwater in the upper sections of the Superficial Aquifer can be acidic within Bassendean Sands, but is less so at depth, and is typically neutral to slightly alkaline in the Tamala Limestone to the west of Bibra and North lakes.

Based on the regional groundwater assessments of Davidson (1995), the Superficial Aquifer in the project area has the following typical hydraulic properties:

- Specific yields of between 0.2 (Bassendean Sands) and 0.3 (Tamala Limestone).
- Saturated thickness of between 35 – 40 m.
- Aquifer transmissivities of between 600 – 800 m^2/day.

These values of transmissivity and thickness equate to hydraulic conductivities in the range from 15 – 23 m/day.

3.2 Potential Abstraction Impacts

The PER stated that no abstraction would take place within the project area. However there is a good groundwater source that is easily available, so to reduce haulage and impacts upon the reticulated water supply, construction water will be sourced from bores within or adjacent to the project area. The following sections examine the potential impacts from the changed approach to sourcing water for construction. The project occurs in a setting where the groundwater of the Superficial Aquifer has multiple high value beneficial uses. However, given the relatively limited quantum and duration of proposed abstraction, the potential for adverse impacts on existing beneficial uses is considered to be limited. The basis for this assertion is explained in the following sub-sections, which represent preliminary impact assessments. Refinement or extension of these assessments will be addressed during the abstraction licensing process and will include consultation with Department of Water's Regional Hydrogeologist (Peel Region) to determine appropriate pre-development monitoring..

3.2.1 Estimation of Drawdown

Estimates of the potential drawdown of groundwater levels in the Superficial Aquifer have been made for a range of aquifer properties and abstraction rates and durations. The Theis Equation, which was originally developed for

predicting drawdown in confined aquifers under transient conditions, has been used as it is applicable for approximating drawdown in unconfined aquifers as well.

The Department of Water consider that for Wetland Vegetation in a Groundwater Dependent Ecosystem, a low impact is a drawdown of less than 0.25m, moderate impact is a drawdown between 0.25 and 0.50m and high impact is drawdown greater than 0.5m.

The Theis Equation is only strictly valid under a set of aquifer conditions that are rarely observed in the real world; these conditions include:

- The aquifer is infinite in extent.
- The aquifer is isotropic and homogeneous.
- The water table is flat and no recharge to aquifer occurs during the abstraction period.

Whilst the conceptual hydrogeology of the project area is considered to be sufficiently or reasonably uniform to apply the Theis equation, the assumption that no recharge occurs to the aquifer in the time frames involved (1 – 2 years) is not valid. Significant recharge from direct infiltration of rainfall as well as groundwater through-flow from east to west will occur in the project construction time frame. The consequence of this is that the Theis equation is likely to significantly over-estimate actual drawdowns in the project area and is thus quite a conservative tool. This aspect is revisited in the discussion section below.

Figure 19 displays predicted drawdowns as cross-sectional plots of drawdown versus radial distance from the source/centre of abstraction for the following criteria:

- Specific yield (S_y) = 0.2 and 0.3
- Transmissivity (T) = 600 and 800 m^2/day
- Abstraction schedule of 384 kL/day for 1 year and 192 kL/day for 2 years (note these equate to the same total volume of ~140,000 kL). The estimates for a pumping period of 1 year represent a conservative case for drawdown estimation, as the likely project construction period is of the order of 24 – 30 months.

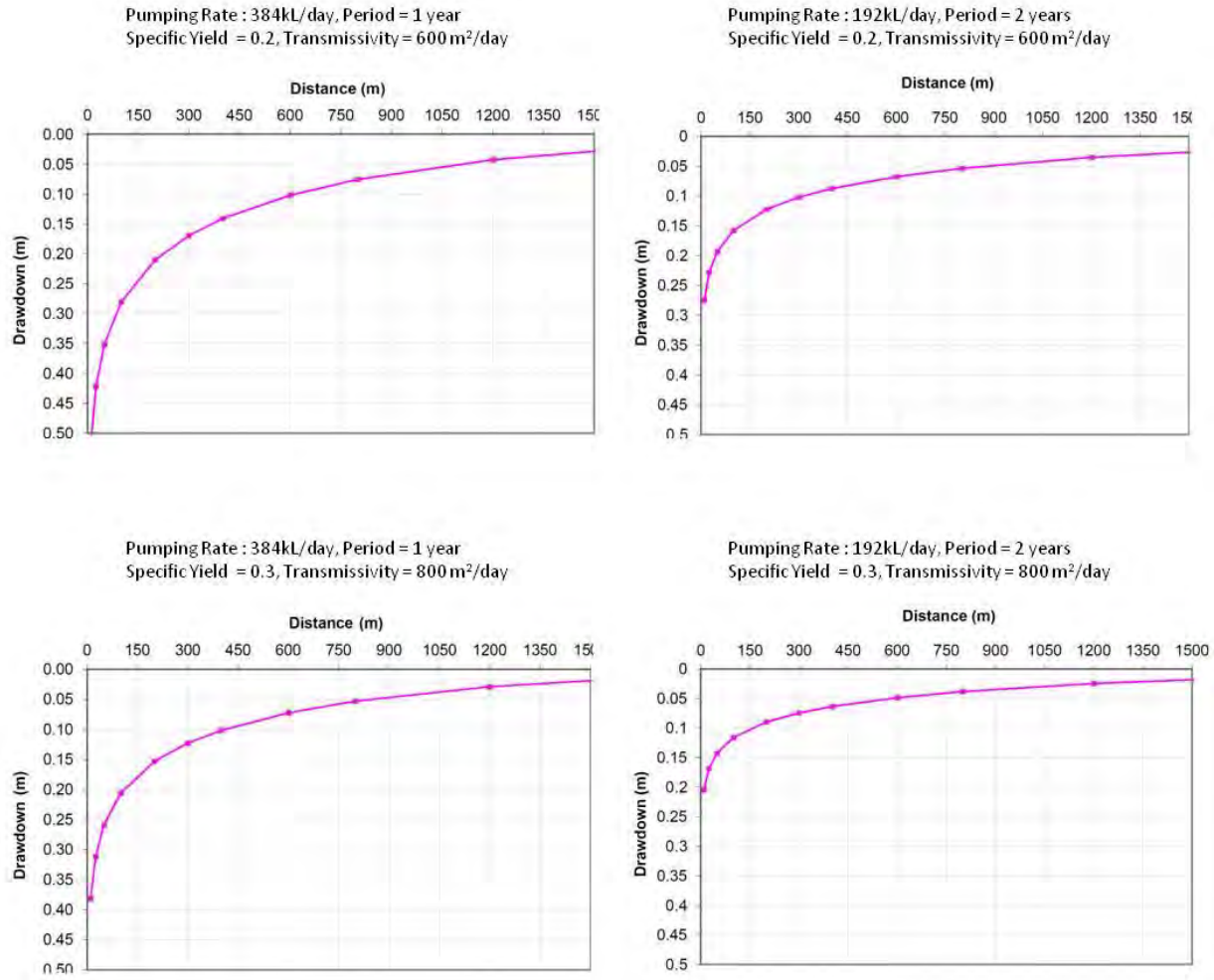


Figure 19 Predicted Drawdowns

The higher S_y and T 'scenario' is likely to be more representative of abstraction west of Bibra Lake where the Tamala Limestone occurs, although aquifer properties can be quite variable. In these higher S_y and T such settings, the predicted drawdowns are small; at 100 m from the abstraction source (bore), predicted drawdowns are of the order of 0.1 – 0.2 m (low impact) and only about 0.05 m (low impact) at 1,000 m from the abstraction source. The lower abstraction rate solution shows that there is less localised drawdown near the bore, however, the drawdowns at greater distances from the bore are similar (which is due to the equivalence in net total abstraction).

For the lesser S_y and T values, predicted drawdowns are still minor but slightly higher. Predicted drawdowns at 100 m from the abstraction source are between 0.15 – 0.3 (low to moderate impacts) depending on the abstraction schedule. These solutions may be more typical of the Bassendean Sands areas.

A conservatively lower bound estimate of drawdowns was also done for values of S_y = 0.10 and T = 400 m^2/day. For this scenario, drawdown at 100 m from the bore is predicted to be between 0.25 – 0.45 (moderate impact) depending on the abstraction schedule. At 1,000 m, the estimates are between 0.07 – 0.10 m (low impact).

3.2.2 Other Groundwater Users

The water licensing and management process effectively works in a manner such that any new proponents of groundwater abstraction are required to not adversely affect the 'draw' of water by existing groundwater users. In the project region, there are numerous shallow bores screened within the Superficial Aquifer that provide an unlicensed water use for domestic use (mainly lawn and garden irrigation). Groundwater use > 1,500 kL/year is typically licensed and the DoW maintains a publicly available website licence database (the "Water Register") which provides details of existing licences.

A search of the Water Register was undertaken for Superficial Aquifer water licences within and immediately surrounding the project area; these results are shown in Table 12.

The Water Register data has some limitations. Whilst licensed draw points are shown on the website interface, the spatial data for these abstraction bore locations cannot be exported or downloaded. The DoW WIN database can be used to obtain spatial and other data for individual bores, but this dataset is not cross-referenced to licensing data and is often unreliable as not all bores may be captured in the database, and for those bores in the database, the purpose and status of the bore may be unknown or uncertain. Consequently, it can be important for new proponents to undertake field surveys (with land/bore owner permissions) of bores within a certain distance to ascertain the true location, purpose and status of existing abstraction bores.

Many of the licensed abstraction bores in the project region are operated by the City of Cockburn for irrigation of parks and reserves.

3.2.3 Subterranean Fauna

The potential impacts of proposed groundwater abstraction on stygofauna are considered to be insignificant. Based on original project reviews of boreholes, the site is not considered to have favourable lithologies for hosting stygofauna as much of the area is underlain by non-carbonate sands of the Bassendean Sands. Within the Tamala Limestone to the west of Bibra Lake, no direct evidence of karsts, voids or cavities (which provide suitable macro-sized pore spaces) was found in available borehole logs.

3.2.4 Wetlands and Hydrologic Regime

Maintenance of groundwater dependant ecosystems in the project region have been considered as part of regional groundwater management by the DoW, as outlined in the Cockburn Groundwater Area Water Management Plan (CGA WMP 2007). Environmental water requirements (EWR's) were established for Bibra Lake in the 1990's as part of assessment of public water supplies from the Jandakot (groundwater) Mound to the east of the project area. This assessment defined an EWR for Bibra Lake in terms of maintenance of 'preferred' minimum lake levels in the range from 13.6 – 14.2 mAHD, with the lower level of 13.6 mAHD being considered a 'trigger' level (CGA WMP, 2007).

Ministerial Statement 883 *Jandakot Mound Groundwater Resources and Schedule 1 Proponent's Environmental Management Commitments* (WRC, 2004), defines the absolute summer minimum water level for North Lake as 12.68 mAHD, with a preferred water level criterion of 13.29 mAHD.

Lake levels since 2001 and groundwater levels for two Superficial Aquifer monitoring bores east (up gradient) and west (down gradient) of Bibra Lake are shown on Figure 15. Groundwater and lake levels show seasonal fluctuations of the order of 0.5 – 1.5 m, and in the past decade exhibit a slight declining trend. Absolute minimum trigger levels appear to have been breached a number of times.

Table 12 Groundwater Licence Details (as at May 2012)

Licence Number	Parties	Allocation	Issue Date	Expiry Date	Groundwater Area	Groundwater Subarea
49535	City of Cockburn	1,490,140	05-May-10	30-Jun-18	Cockburn	Kogalup
49545	City of Cockburn	351,100	05-May-10	30-Jun-18	Perth	City of Cockburn
49938	Wooldumpers Australia Pty Ltd	6,000	09-Dec-04	09-Dec-14	Cockburn	Kogalup
57611	Adventure World (WA) Pty Ltd	70,050	17-Apr-07	17-Apr-17	Cockburn	Kogalup
59403	Water Corporation	950,000	21-Dec-11	30-Jun-12	Jandakot	Airport
61182	St John of God Health Care Inc	41,250	03-Aug-11	03-Aug-21	Perth	City of Melville
62672	City of Cockburn	211,650	05-May-10	30-Jun-18	Jandakot	South Lakes
64664	Electricity Networks Corporation T/A Western Power	10,000	19-Mar-09	19-Mar-19	Jandakot	Airport
69366	Winthrop Baptist College	7,500	20-Oct-09	20-Oct-19	Perth	City of Melville
110551	Murdoch University	439,500	11-Apr-11	11-Apr-21	Perth	City of Melville
111214	CSBP Limited	6,300	12-Jan-06	12-Jan-15	Cockburn	Kogalup

Licence Number	Parties	Allocation	Issue Date	Expiry Date	Groundwater Area	Groundwater Subarea
153822	International Golf Investments Pty Ltd	30,000	20-May-10	30-Jun-13	Perth	City of Canning
155080	Challenger Institute of Technology	52,300	08-Jul-10	11-Feb-14	Perth	City of Melville
155453	Department of Education	108,000	15-Feb-12	28-Feb-22	Perth	City of Cockburn
158722	Dept Justice Rangeview Remand Centre	12,000	09-Apr-10	01-Jul-15	Perth	City of Melville
161540	The Waldorf School.	3,625	13-May-10	12-Sep-16	Cockburn	Kogalup
165057	Ensign Services (Aust.) Pty. Ltd.	6,750	21-Oct-09	21-Oct-19	Perth	City of Melville
166359	Primewest (381 Pheonix Road) Pty Ltd	5,250	16-Jul-10	16-Jul-20	Cockburn	Kogalup
167031	Department of Health of WA	69,300	23-Apr-10	02-Mar-12	Perth	City of Melville
167047	Department of Health of WA	80,000	19-May-11	09-Sep-15	Perth	City of Melville
168069	Electricity Networks Corporation	3,750	15-Jan-09	15-Jan-19	Jandakot	Airport
168188	Cockburn Wetlands Education Centre Incorporated	260	30-Jun-10	30-Jun-20	Perth	City of Cockburn
173650	Highway Construction Pty Ltd	20,000	15-Dec-11	30-Jun-12	Jandakot	Airport

3.2.5 Acid Sulfate Soils

Sourcing groundwater from the Superficial Aquifer within the project area should consider the risk of acid Sulfate soils (ASS) and ensure bore abstraction rates and locations do not cause any significant drawdown in the areas classed as high risk of ASS. In addition to potential ASS impacts, the locations of any proposed groundwater bores should consider the presence of known or likely groundwater contamination from previous land-use activities.

3.3 Abstraction Locations

Based on the assessments above, the proposed abstraction of up to 140,000 kL over a 1 – 2 year period for construction phase water supplies is considered feasible from the Superficial Aquifer present within the project area without causing any potentially significant adverse environmental impacts.

Based on the drawdown predictions, Department of Water has advised that no abstraction bores should be located within 1.5km of the Bibra Lake or North Lake, and any abstraction bores located near Groundwater Dependent Ecosystems must be within the low category (less than 0.25m of drawdown).

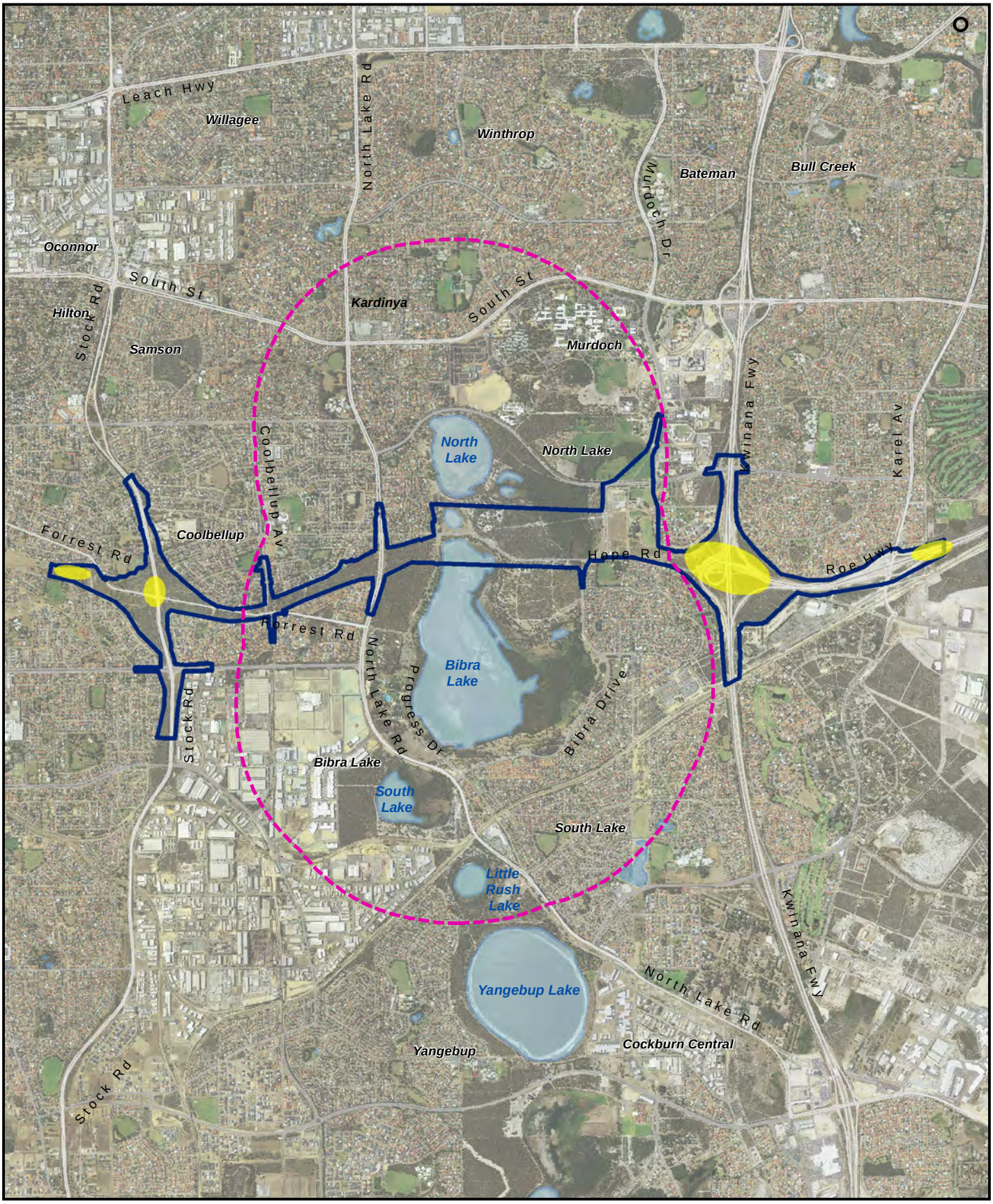
Preferred areas for groundwater abstraction to prevent or minimise potential impacts are highlighted on Figure 20. These areas occur within the Airport, City of Canning and Kogalup Groundwater Management Sub-areas, which all have sufficient available allocations for the proposed water supply.

Should consideration of groundwater abstraction within the project area be progressed further, the following will be considered:

- Revision of this assessment if the required water demand increases significantly and/or if the duration of pumping decreases significantly.
- Multiple (two or three) groundwater abstraction bores should be considered for installation and use; this would help reduce local drawdown effects and would probably benefit construction work efficiencies.
- New abstraction bores should be located not closer than 250 m from known existing groundwater abstraction bores, wetland and lake boundaries and high ASS potential areas. The areas shown in Figure 20 are based on a high level assessment of proximity to currently licensed abstraction bore and

environmental conditions. Other locations may be possible through further investigation in subsequent phases of the project.

- Department of Water's Regional Hydrogeologist (Peel Region) should be consulted to determine and clarify their expectations and requirements for securing the water allocation for project water supplies. A monitoring programme will form a key component of the licence sought.



Recommended Groundwater Abstraction Areas

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Figure 20

0 0.5 1 1.5

Kilometres

1:45,000 (A4)

Datum: GDA94 Projection: MGA z50

- Project Area
- Recommended Groundwater Abstraction Areas
- 1.5km buffer of Bibra & North Lakes

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M:\60100953 - Roe Hwy Ext\4 Tech work area\4.4 Environment\4.4.3 EIA\4.1.3.D Responses\Figures\GIS\Workspaces\2013_01_11_Ross_WMP\Figure20_Recommended_GW_Abstraction_Areas.mxd

4.0 Water Management Strategy

The proposed Water Management Strategy for the project is outlined in this chapter. It includes the key elements of groundwater, surface water and water quality management with respect to demonstrated best management practice in water sensitive urban design.

4.1 Conceptual Stormwater Management System

Management of the water following development involves maintaining the hydrological regime and mitigating the impacts from construction and flooding through the design of a suitable stormwater system. The conceptual stormwater system has been prepared to provide a proof of concept for drainage infrastructure within the proposed project design. It may be subject to change following detailed design of the road layout, however the principles and concepts outlined in this section will guide the detailed design of stormwater infrastructure. It has been prepared based on the documents listed in Section 1.2.

4.1.1 Stormwater Management

The proposed stormwater management systems involve the use of pits, pipes, infiltration basins, bio-retention basins and culverts to minimise impacts on the hydrological regime by the proposed road alignment. Development of the road will convert 10.4ha of the catchment to an impervious area, equating to a 1.4% change in the overall catchment.

The pit and pipe network will be designed to convey flows from the impervious road areas. The network will be designed to convey the 10yr ARI event and conform with MRWA minimum grade, cover and relevant design requirements. Minimum grades will be incorporated to ensure pipes are self-cleansing, as well as allowances for provision of scour protection and access for maintenance.

Both bio-retention and infiltration basins are proposed for the road development. The infiltration basins have generally been sized for a 20yr ARI event unless an overflow route was available to mimic natural drainage paths. In these cases, the basins were sized for the 5yr ARI event. Further detail is provided in Section 4.1.1.2. All basins will incorporate smaller a bio-retention basin in the wider infiltration basin to treat frequent rainfall events up to the 1 year 1 hr ARI event. Further details of the bio-retention systems are presented in Section 4.1.1.3. A large bio-retention basin (1.7 ha) is proposed east of Horse Paddock Swamp at Dixon Road to treat stormwater before it enters the wetland system.

Limiting the clearing of vegetation was a significant factor in the basin design. Care has been taken to limit clearing and excavation to areas of less significant vegetation communities, with significant trees and other vegetation being avoided.

The location of the basins will be such that stormwater is infiltrated close to the source. To provide further protection against accidental spills and road pollutants, flows within the wetland area will be directed through gross pollutant traps and oil separator systems. With the current road configuration, this involves having a kerbing along the road alignment near the wetland and directing flows to the system. The use of kerbing may be subject to change during detailed design; however, gross pollutant traps and oil separator systems will be used in the wetland areas. Geometric and road safety designs measures to limit the risks and effects of potential transport accidents will also be incorporated into the design.

The stormwater management systems will mimic natural drainage processes where possible. The proposed road alignment coincides with two existing areas of ephemeral surface water ponding at Roe Swamp and north-east of Bibra Lake. The proposed road alignment has been selected, with consideration of other priorities, such as fauna habitat, vegetation quality and social values, to have minimal impact on the surface water. This included locating the road alignment north of Roe Swamp and having a bridge structure over the lowest point in the terrain. Culverts are also proposed to retain local drainage beneath the road formation and will feature protective armouring to prevent scouring.

4.1.1.1 Flooding Protection

The majority of the road vertical profile is greater than 2 m higher than the annual maximum groundwater level, as published in the Perth Groundwater Atlas (DoW, 2011). By maintaining this vertical separation, waterlogging is avoided. There are two locations where this separation is not achieved; along Roe Highway between Murdoch Drive and Progress Drive, and along Murdoch Drive for 200m north of Farrington Road. At these locations, the

geometry of the existing road alignment prevented vertical separation, as the proposed road needs to tie into the existing network at these points.

The serviceability of the proposed roads and intersections for different ARI storm events will be confirmed through the detailed design process. Given the importance of the road in the local and regional network, the design will cater for a high level of serviceability.

4.1.1.2 Infiltration Basin Design

A summary of the conceptual-level basin designs is provided in Table 13, with locations shown in Appendix A.

Table 13 Summary of Proposed Basins

Basin Reference	Design Event	Storage Required (m^3)	Calculated Basin Storage (m^3)	Water Depth (m)	Side Slope	Basin RL (mAHD)	GW Level (mAHD)	Impervious Catchment Area (ha)	Bio-Retenion Basin Area (ha)
Basin A	20 yr	2,918	3,025	1.2	1:3	24.5	23	1.19	0.024
Basin B	20 yr	10,060	10,113	1.2	1:4	25.4	23	6.08	0.122
Basin C	20 yr	3,410	4,041	1.2	1:4	28.3	23	2.47	0.049
Basin D	20 yr	3,907	3,936	1.2	1:4	26	23	1.74	0.034
Basin E	20 yr	1,545	1,854	1.2	1:3	20.5	18.3	0.75	0.015
Basin F	5 yr	6,044	6,118	1.2	1:4	17.9	17.75	4.48	0.090
Basin G	5 yr	1,891	1,978	0.85	1:4	17.65	17.6	1.36	0.027
Basin H	5 yr	330	379	1.2	1:3	18.7	17.9	0.14	0.002
Basin I	5 yr	3,365	3,387	0.225	1:3	~17 (varies)	15	3.06	0.061
Basin J (1-4 combined)	20 yr	6,030	5,624	1.2	1:4 Roe side 1:3 Off ramp	28 (av)	13 (av)	3.21	0.064
Basin K	20 yr	2,832	4,159	1.2	1:03	15.1	13.8	1.61	0.032
Basin L	20 yr	6,883	7,300	1.2	1:6	18.3	18.15	3.17	0.063
Basin M1	20 yr	2,375	2,525	2.4	1:5	31.4	24.5	2.38	0.048
Basin M2	20 yr	4,821	4,821	1.2	1:3	26.4	24.5	2.55	0.051
Basin M3	20 yr	1,734	1,743	1.22	1:15	32	24.5	1.47	0.029
Basin N	20 yr	2,036	2,096	1.2	1:3	18	17.65	1.02	0.020
Basin O (combined)	5 yr	490	536	0.7	1:3	18.5	17.4	2.48	0.050
Basin P	20 yr	3,415	3,465	1.2	1:3	37	3.5	3.10	0.062
Basin Q	20 yr	254	285	1.2	1:13	47.8	3.5	0.16	0.003
Basin R	20 yr	457	522	1.1	1:11	47	3.5	0.55	0.011
Basin S	20 yr	1,248	1,371	2.4	1:8	46.6	3.5	1.26	0.025
Basin T	20 yr	577	577	1.2	1:3	42.4	3.5	0.69	0.013

The key features of the basin design include the following:

- All basins are designed as infiltration systems, with a bio-retention component.
- Most basins are located within sands of the Bassendean Sands, whilst those near the western margins of the project area are likely to be within the Tamala Limestone.
- Basin area size is variable, but typically ranges from about 2,000 – 15,000 m^2.
- The storage capacity of most basins has been designed to accommodate the critical 1 in 20 year ARI event for a basin water height of 1.2 m.
- Review of available literature and mapping, as well as geotechnical investigations and limited permeability testing has been used to derive sub-surface permeabilities for different project areas; these range from 8 – 30 m/day (see Table 5-1 of PER Appendix H).
- Basin base RL's have been set at or above maximum groundwater levels as defined by the Department of Water (DoW) Groundwater Atlas and published maximum contours (2001). The depth to (maximum) water table heights in the likely basin areas is variable and ranges from negligible (0.1) in low-lying areas, to typically 40 m (in the area west of Stock Road).

4.1.1.3 Bio-retention Basin Design

Bio-retention basins are proposed to be included within all retention basins to reduce the impacts from road runoff nutrients and pollutants (Table 13). These basins consist of filtration media and their use in capturing the more frequent storm events is consistent with DoW Principles.

The configuration of a larger bio-retention system, The Dixon Road basin proposed in the sensitive wetland areas, is provided in Figure 21 to Figure 23; the depth of filtration media is 600 mm and the extended detention depth is 350 mm. Impermeable barriers prevent the horizontal flow of pollutants from the system, and a weir allows overflow into the infiltration basins to prevent choking.

Performance of the larger bio-retention systems was assessed using MUSIC modelling. Previous work suggests that this model may not accurately model the nutrient removal ability of Perth's sandy soils, nor the runoff generated by the pervious catchment. To address these issues, only the impervious catchment area was modelled, and the filtration media was assumed to be amended soil. The bio-retention areas were sized to achieve the following nutrient removal rates:

- 85% of Total Suspended Solids (TSS)
- 65% of Total Phosphorus (TP)
- 45% of Total Nitrogen (TN).

The Dixon Road basin (Figure 21) will be planted with indigenous wetland species. *Baumea juncea* and *Kunzea ericifolia*, both of which are found within the project area, are listed as potential plants to be used in the bio-retention features. Additional indigenous species will be selected during future design stages of the project. These can include, but are not limited to local native wetland species such as *Astartea fascicularis*, *Adenanthos cygnorum*, *Banksia littoralis*, *Kunzea glabrescens*, *Daviesia physodes* and *Hovea pungens*.

Along with the vegetation, a natural filter medium will filter the water prior to its entry into the subsurface. Although localised water mounding will occur below the basins, it is not expected to adversely affect regional groundwater regimes, relative to inter-annual and typical seasonal effects. This conclusion is based on the mounding assessments described in Section 4.1.2.1. The bio-retention basin will ultimately take the form of a natural wetland system functioning to improve water quality and provide wetland habitat. These basins are presented as part of the mitigation package for impacts on wetland values.



N

*Final location of piping subject to existing vegetation and to be confirmed during detail design

Dixon Road Bioretention Basin Concept Plan

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Figure 21

- New bund wall
- Pipe
- Bioretention areas
- Gross Pollutant Trap/oil separator manifold combined with flow splitter and energy dissipation structure
- Proposed road

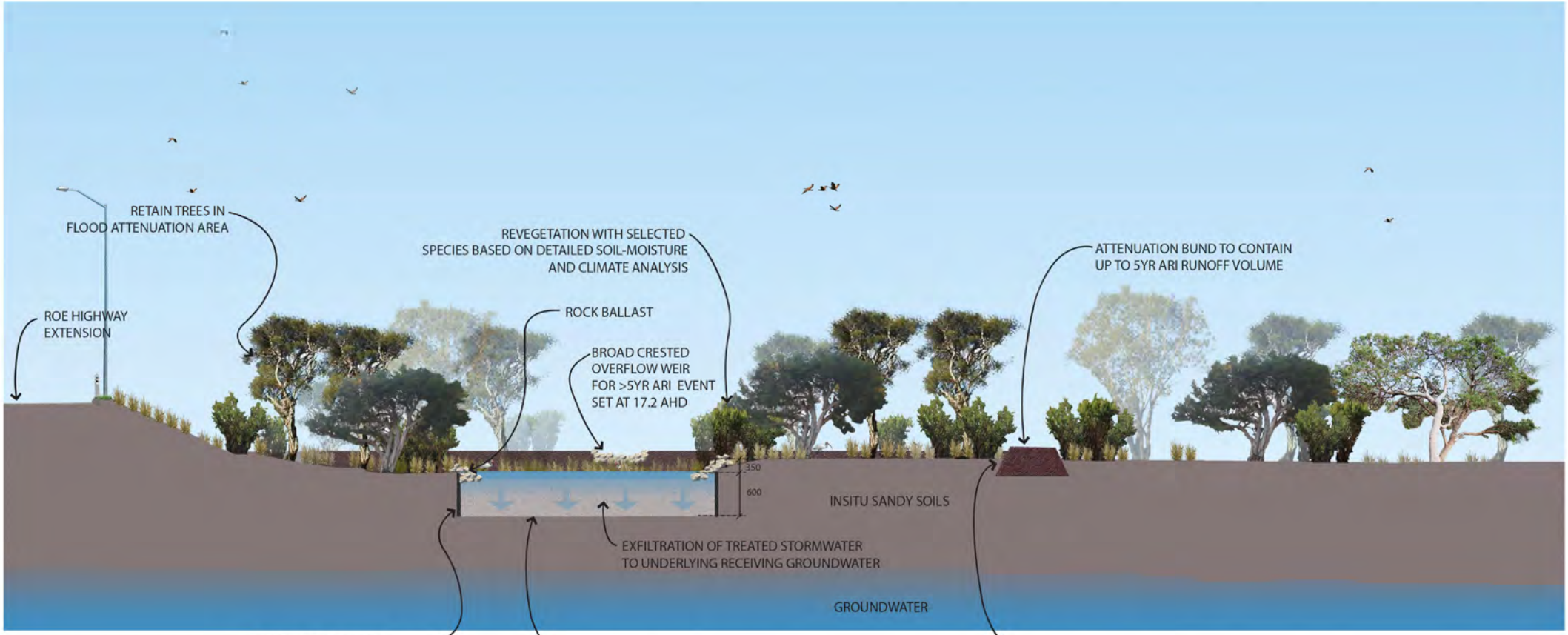
A — A: Cross Section illustrated in Fig 36

B — B: Longitudinal Section illustrated in Fig 37

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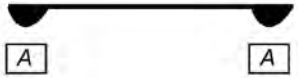
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Bioretention Cross Section

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Figure 22



Cross Section illustrated in *Fig 35*

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Bioretention Longitudinal Section

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Figure 23

B B

Longitudinal Section illustrated in *Fig 35*

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4.1.2 Groundwater Management

Groundwater Management will be required during the construction phase of the project to address potential issues around abstraction for water supplies, as discussed in Section 3.0. Other construction phase issues are discussed in Section 4.3. For the ongoing operational phase, groundwater management within the project area will focus on mitigating the impacts on the natural regime from project infrastructure. Analysis of localised changes in the groundwater levels from infiltration basins and compaction is presented in Sections 4.1.2.1 and 4.1.2.2, with respective management measures implemented where required. The use of subsoil drainage is outlined in Section 4.1.2.3.

In order to minimise modification of the hydrological regime, and to minimise the transport of pollutants, infiltration at source is promoted in the drainage design. This is principle is achieved through use of infiltration and bio-retention basins connected to smaller road catchments, and no kerbs along the road. Opportunities for drainage to be connected to soakwells will be examined in further detail during detailed design.

4.1.2.1 Effects of mounding beneath basins

Localised changes to groundwater levels due to mounding beneath infiltration and bio-retention basins have been assessed by basic analytical modelling. The results of this modelling are constrained by several assumptions and simplifications, but nevertheless provide a semi-quantitative set of results in a site-wide context (i.e. not basin specific) that can be used to better address queries around potential impacts of stormwater basins.

Analytical solutions have been adopted from Walton (1997) and *AQTESOLV for Windows software Ver.4.5*, both of which are based on earlier work by Hantush (1967), for estimating the rise and decay of water table mounds beneath areas of vertically uniform recharge. The application of the analytical solutions is underpinned by various assumptions that include:

- The aquifer is homogeneous, isotropic and effectively present over a very wide area.
- The solution is not applicable for settings where the mounding 'reaches' the ground surface.
- Recharge to the watertable is assumed to occur 'instantly' at the water table such that the solution does not consider the complexities of flow through the unsaturated zone and associated time lag effects.

Based on the conceptual drainage designs, site investigations and regional groundwater studies, the following inputs and assumptions have been adopted for the estimation of mounding:

- Hydraulic conductivity range of 8 – 30 m/day; lower values considered representative of the Bassendean Sands whilst the higher values are adopted for the Tamala Limestone.
- Specific yield range of 0.1 – 0.3.
- Individual basin areas of 2,000 – 15,000 m^2; equivalent to circle radii of approximately 25 to 70 m.
- Typical design water heights in basins of 1.0 m for 1 in 5 year, 1.2 m for 1 in 20 year and 1.6 m for 1 in 100 year critical events.
- Infiltration rates assumed to be 10% of hydraulic conductivity. This parameter is a key transient variable and depends on the unsaturated hydraulic conductivity of the subsurface, the nature of the basin floor and the depth to the water table amongst other things. The adopted value also considers the 'water balance' of the drainage basins; for the lower permeability substrate of 8 m/day, 1.6 m of water in the drainage basin equates to a period of 2 days for the stored water to reach the water table at the adopted infiltration rate. For a substrate permeability of 30 m/day and a water height of 1.2 m, this corresponds to full infiltration in less than12 hours. The adopted infiltration rates are thus likely to represent a conservative (maximum) estimate of the volume of water that reaches the water table and consequently a conservatively high level of mounding.

The estimates of peak groundwater levels from mounding beneath basins (as 'cross-sections' from the centre of the basin) are provided in Figure 24 for the Bassendean Sands and in Figure 25 for the Tamala Limestone.

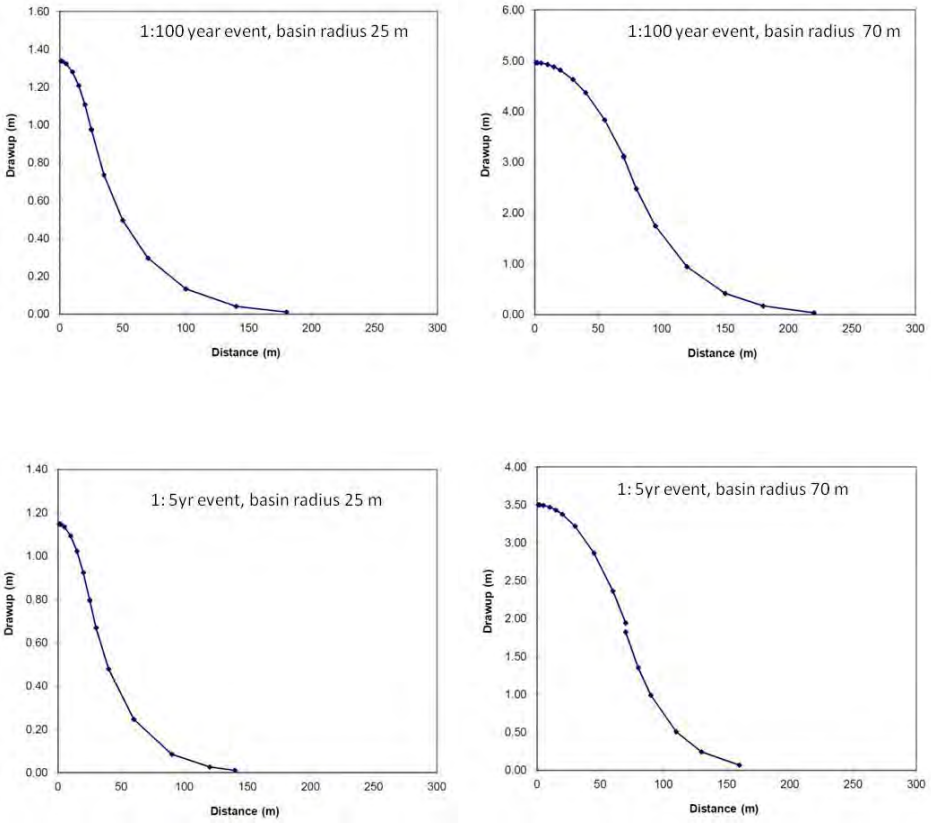


Figure 24 Mounding estimates beneath infiltration basins – Bassendean Sands

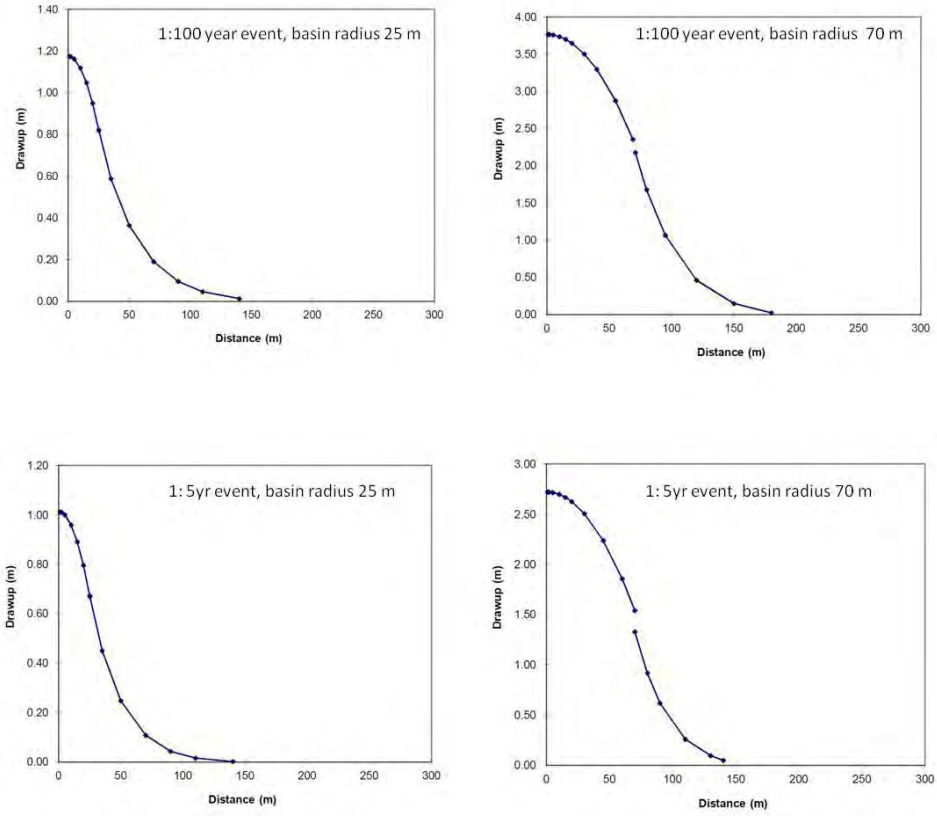


Figure 25 Mounding estimates beneath infiltration basins – Tamala Limestone

The results show that the magnitude of mounding expected in areas surrounding the conceptual basin locations is expected to be limited; negligible groundwater level rises (<0.1 m) are expected beyond 50 – 100 m of basin perimeters. These rises are also relatively 'short-lived' in response to individual rainfall runoff events; the 'decay' of mounds is quite rapid and groundwater levels would be expected to return to pre-mounding levels within a few days or weeks.

In areas where the floor of the infiltration basin is very close (<1.0 m) to the water table, mounding heights will be limited as the shallow depths to groundwater provide a constraint to the mounding height that can develop. This is applicable to the central project area, as some of the conceptual basin locations indicate that the depth to (seasonal) maximum groundwater levels is less than 1.0 m. The time for all stored basin water to infiltrate and dissipate in these areas is likely to increase, but the loss of stored water to evaporation and evapotranspiration is likely to be much greater.

In broad terms, significant changes to groundwater levels or fluxes are not expected in the project area due to the relatively high specific yields and hydraulic conductivities of the aquifers present. To limit the potential for adverse impacts on the water table and or wetland areas in a localised sense, the following principles should be applied to drainage basin design:

- Ensure basins are constructed at least 50 – 100 m from wetland boundaries (depending on basin size).
- If infiltration capacity is to be optimised, locate basins away from any areas containing lower permeability / finer grained surficial deposits associated with wetlands.
- In relative terms, utilise more basins at smaller sizes in comparison to fewer basins of larger size to limit the potential for increased localised mounding in any sensitive areas.

4.1.2.2 Compaction Effects

The potential impacts on the groundwater regime and flows in wetland areas as a result of compaction of the natural sub surface material from proposed embankment constructions associated with the road alignment have been considered. The susceptibility of Groundwater Dependent Ecosystems adverse impacts from future water regime change is directly influenced by historic water levels changes and current groundwater levels (Froend & Loomes 2004). It is assumed that any ecosystem that develops in the presence of groundwater will have some reliance on it and if the groundwater level is reduced, the ecosystem will respond.

The proposed road alignment may require embankments with fill above the natural ground surface. Estimates of compaction of the natural underlying material were made using a finite element model (PLAXIS 2D and 3D) to predict the effect from embankments of varying heights (3 m, 4.25 m, 4.5 m, 6 m, 7.5 m, 8.5 m and 9 m). The modelling was based on the properties of unconsolidated sand material typical of the Bassendean Sands as determined by site investigations.

The model estimates the change in porosity (as volumetric strain) for a 9 m embankment as shown in Table 14. The change in volumetric strain is very minor and limited to effectively the upper 3 m of the subsurface.

Table 14 PLAXIS Modelling Outputs

Depth (mbgl)	Volumetric Strain
0 to 1	1.9% - 2.0%
1 to 2	1.3% - 1.9%
2 to 3	0.6% - 1.2%
Greater than 3m	No significant change

In sandy materials, even where a shallow (less than a few metres) unconfined water table aquifer is present, the effects of any compaction on groundwater levels or flow (either locally or more regionally) are expected to be insignificant. Clean sands typically have porosities in the range of 30 – 45%. If the upper bound of modelled porosity reduction (3%) is applied, then the resultant porosity would be approximately 29 – 43.5%.

PER submissions have implied that compaction issues and effects may be significant in wetland areas and lake margins where shallow groundwater levels can occur within a surficial sequence of finer grained lacustrine sediments. Surficial geology mapping (Figure 6) shows the presence of peaty soils. This regional mapping was compared against lithological logs from monitoring bores installed as part of the wetland assessment by Syrinx

(2011). Bore logs from near Roe Swamp are summarised in Table 15 below. The data confirms that sand with some finer grained sediment and organic material are present in the upper few metres, however, this material is not necessarily thick, extensive or impermeable at these bore locations.

Table 15 Summary of shallow subsurface lithology near Roe Swamp

Bore ID	T3B	T3C	T4A	T4B	H
Depth (mbgl) and Lithological Description	0 – 1 m Humic, very coarse, coarse and medium grained sands	0 – 1 m Buff coarse sands	0 – 1 m Buff, coarse, mostly medium and fine quartz sands	0 – 1 m Fill	0 – 2.5 m Brown, muddy sand (fine grained opaline silica hash) and quartz sand
	1 – 2 m Buff, very coarse, coarse and medium quartz sand	1 – 2 m Very coarse and mainly quartz sand	1 – 3 m Grey, buff, coarse mostly medium and fine quartz sand	1 – 2 m Grey muddy sand	2.5 – 3 m Buff, mainly medium quartz sand
				2 – 2.5 m Grey, coarse, medium and fine quartz sand	

In areas containing finer grained sediments, little change is expected in local or more regional groundwater flows, as these surficial sediments represent only a minor portion of the (vertical) aquifer sequence. The top few metres of the water table aquifer could therefore accommodate a larger reduction in porosity and permeability without significantly changing aquifer flows or levels given the aquifer is of the order of 35 – 40 m thick and high permeability (10 – 20 m/day).

The alignment of the main highway is largely parallel to the overall east-west groundwater flow direction, and thus any potential compaction induced changes to the groundwater system should be minimised. Based on the information above, it is considered that any compaction is unlikely to have adverse impact on the groundwater flows and hydrological function of Groundwater Dependent Ecosystems. This conclusion is supported by the Department of Water following discussions in January 2013.

4.1.2.3 Subsoil Drainage

Subsoil drainage is not considered to be a requirement for the conceptual stormwater system design. Existing road drainage arrangements within the project area do not require subsoil drainage. Later phases of project design may identify the need for subsoil drainage, and potential impacts on local groundwater should be considered and addressed.

4.2 Ecological Management

Along with measures to maintain the hydrological regime and improve stormwater quality outlined in Section 4.1, other measures are proposed to ensure protection of the wetlands in the area. These measures are discussed in Section 4.2.1. The protection of existing vegetation surrounding the Murdoch Drain is discussed in Section 4.2.2.

4.2.1 Wetlands

Roe Swamp is an integral part of the linked hydrological, geomorphic and ecological systems within the eastern low hollows of the Bassendean Dunes that drains towards North and Bibra lakes. Roe Swamp has demonstrated resilience to existing pressures as evidenced by the ongoing functionality of the swamp despite fragmentation caused by Farrington Road, Hope Road and the power transmission line. As it is a prerequisite for development of an east-west corridor, the proposal is to cross a section of the wetland. However, the proposed project avoids the main swampland of Roe Swamp, which is located in the south-east portion of the larger Roe Swamp and, in doing so, also avoids intersection of known good quality black cockatoo foraging habitat.

The maintenance of the water cycle is essential to the continued long-term function of Roe Swamp. This will be achieved by the provision of a bridge that spans a significant extent of very good condition vegetation within Roe

Swamp to avoid the impedance of surface and near surface water conveyance along the topographic low point of the catchment. There is no anticipated loss or reduction in current wetland value or function of Horse Paddock Swamp due to the proposed project.

4.2.2 Murdoch Drain

The section of Murdoch Drain proposed to be filled by development of the road is shown on Figure 26 against an aerial image from 2011. Two options for Murdoch Drain were assessed: either realigning the drain, or filling the drain where it intersects the road footprint. The latter option requires no additional clearing of native vegetation, beyond the road construction footprint, where realigning the drain involves clearing of vegetation and potential disturbance of ASS. Both options will have a similar negligible impact on local hydrology.

It is presumed that Murdoch Drain was formed in an attempt to drain the area of surface water to facilitate agricultural or urban development, such as road or residential construction activities.

Current survey information indicates that it does not function as a conveyance system; the open drain does not have a positive grade falling in either direction. The open channel receives surface water contributions from Farrington Road piped drainage, but it appears to require a considerable amount of flow from this contribution before it develops enough hydraulic grade to move in a westerly direction and discharge into North Lake. In addition to the absence of grade, there is an obstruction in the form of a 1.5m high earth blockage within the drain, which appears to dam flows from moving further west without significant hydraulic head. There does not appear to be a culvert connecting either side; however, this possibility cannot be ruled out and if one exists, it is likely blocked. The purpose of the blockage is unclear, but it forms a makeshift bridge allowing pedestrian access from one side of the drain to the other.

Water is often present in Murdoch Drain as an expression of the groundwater water table, notably in the months following recharge of the aquifer from winter rainfall. The drain invert level is about 15 mAHD and historical maximum groundwater levels in this area vary between 16 to 17 mAHD.

The proposed filling of a section of Murdoch Drain is not considered likely to have a significant impact locally or upon the hydrology of Horse Paddock Swamp or North Lake located further west and north-west of the relevant section of Murdoch Drain. Filling would preclude the loss of water from the open drain by evaporation but this magnitude of water is very minor (< 1,000 kL/year) and insignificant compared to other major components of the local system. The effect of filling the drain on surface water flows is also likely to be minor.

Owing to the limited hydrological performance of the current drain, realignment is not considered necessary to maintain the local or regional hydrological regime. Therefore no additional works within the wetland would be undertaken and further clearing of vegetation can be avoided.

4.3 Water Management During Construction

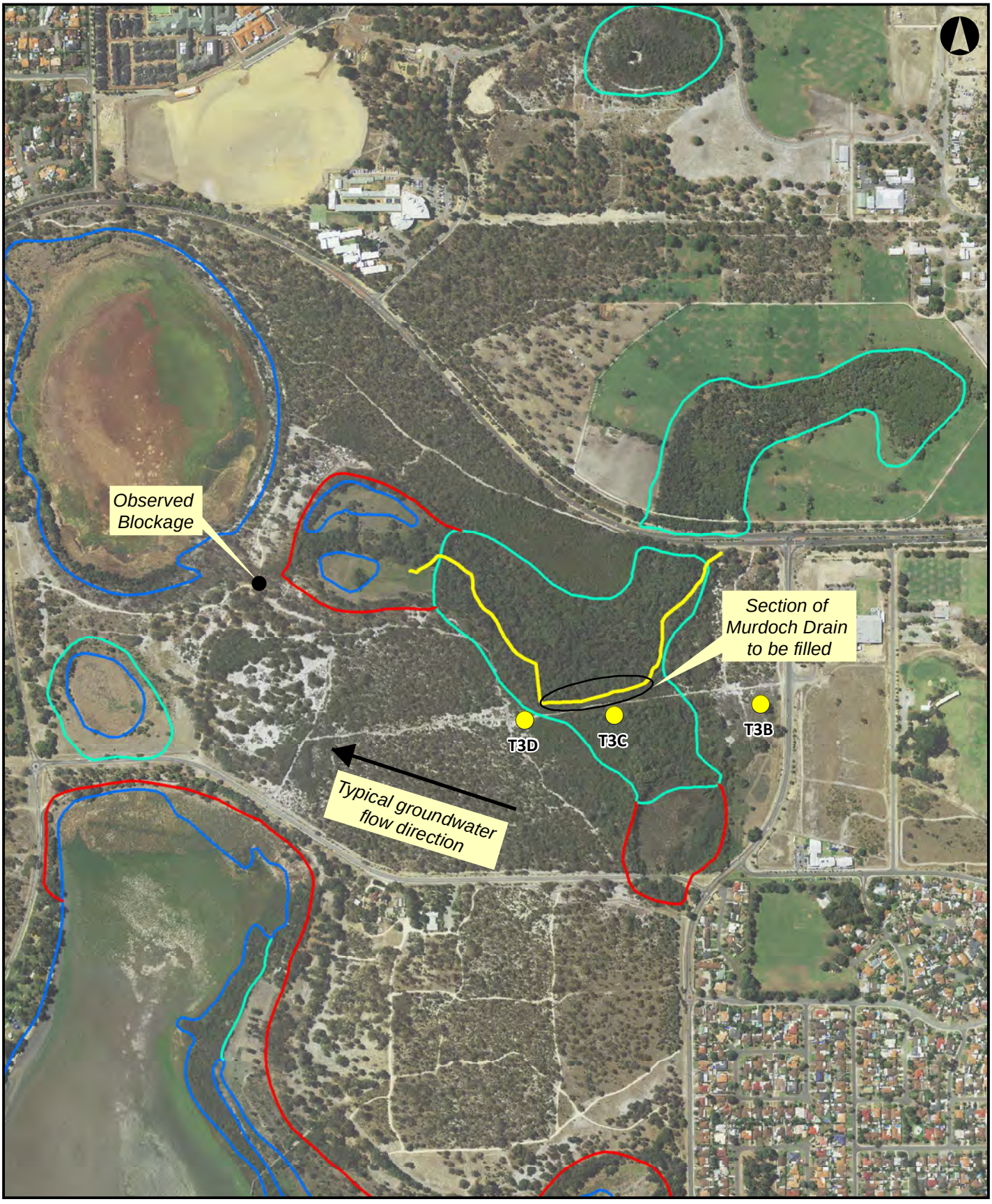
A Construction Environmental Management Plan (CEMP) will be developed and implemented in order to manage impacts of construction on the environment. The CEMP will detail management measures for wetlands, potentially acid sulfate soils and proposed groundwater abstraction for construction water supplies during construction of the project. The CEMP will include:

4.3.1 Dewatering

No dewatering activities will be conducted during construction of this project. This includes within and outside of wetland areas.

4.3.2 ASS

As shown in Figure 7, the area between North Lake Road and the Kwinana Freeway is the most vulnerable area to ASS exposure. Prior to excavations during construction, a Detailed Site Investigations (DSI) will be undertaken for the excavation sites. Outcomes of this investigation will be used to develop appropriate ASS management procedures in accordance with DEC guidelines. Prior to construction, these procedures will be documented in an ASS management plan, which will include a monitoring programme, reporting requirements and contingency measures. The management plan will include an assessment of earthwork quantities, potential environmental impacts, contingency measures and other DEC guidelines for management of ASS. The risk of environmental harm from exposed ASS on groundwater will be avoided with the commitment that no dewatering will be undertaken during project construction.



Murdoch Drain

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Figure 26

0 100 200 300

Metres

1:10,000 (A4)

Datum: GDA94 Projection: MGA z50

- Groundwater Monitoring Bores
- Murdoch Drain (approximate)
- Area Subject to Inundation
- Lake
- Swamp

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4.3.3 Wetlands

The risk of water quality of wetlands adjacent to construction activities being impacted by sediment erosion and spills will be minimised through the implementation of a CEMP. These management measures will include:

- Staging of works by scheduling and sequencing to minimise the risk of sediment mobilisation as a result of mechanical disturbance during high rainfall events.
- Develop construction management plans with water quality management controls such as waste disposal, chemical use and management, material handling and storage, vehicle movement and workforce awareness.
- Sediment containment and erosion management measures to limit mobilisation during rainfall events, including bunding, filter strips and stockpile stabilisation.
- Installation of appropriate temporary fencing, bunding and hoarding to limit litter, gross pollutants and windblown sediment entering the wetlands.
- Servicing, refuelling and wash downs to be performed within designated maintenance areas situated outside of wetland buffer areas.
- Spill response, clean-up and reporting procedures.
- Appropriate procedures for corrective actions and remediation requirements for salvage of chemical spills.
- Maintenance regime for high risk items, such as hydraulic lines, with particular focus on plant and machinery being used between Progress Drive and Bibra Drive.

4.4 Water Management and Design Concepts

Table 16 provides an overall summary of key elements of the proposed water management strategy for the project in relation to Water Sensitive Urban Design (WSUD) principles and design concepts.

Table 16 Water Management Principles and Design Features

Key WSUD Principle		
- Manage the Urban Water Cycle as a single system, integrating water supply, groundwater and stormwater - Integrate water planning and land use planning - Manage the water regime to protect the natural environment and built environment - Maintain, and where possible, enhance water-related environmental values - Enhance water related cultural and recreational values - Recognise the need for site specific solutions - Utilise monitoring outcomes from the site to adapt management strategies - Minimise risk to public safety.		
Category	**Principle**	**Design Criteria**
Water Use	- Minimise the import and use of scheme water. - Minimise the potential impacts on existing water users.	- Abstraction of groundwater from unallocated superficial aquifers, but not within 1.5km of Bibra Lake and North Lake and low impact (less than 0,25m drawdown) on other GDEs.
Stormwater	- Maintain natural surface water characteristics including natural drainage paths. - Prevent flood damage and waterlogging damaging infrastructure.	- Pits, pipes, infiltrations basins and bio-retention form the stormwater system to maintain the hydrological regime. - Bridge over part of Roe Swamp and culverts in the road profile to maintain drainage paths. - Non-kerbed roads to promote infiltration.

Key WSUD Principle		
Groundwater Levels	- Maintain appropriate aquifer levels and recharge characteristics.	- Infiltration at source, where possible in the stormwater system. - No use of subsoil drainage in the project. - Location of drainage basins outside of wetlands and buffer areas. - Abstraction in suitable locations, away from wetlands and existing bores.
Water Quality	- Maintain and, where possible, enhance water quality. - Prevent groundwater acidification processes. - Where possible, promote infiltration of groundwater at source. - Where infiltration at source is not possible, use a treatment train approach to water quality.	- Infiltrate the 1yr ARI event on site in bio-retention basins, sized at 2% of the directly connected impervious areas. - Structural controls, such as gross pollutant traps and oil separators near the wetland areas. - Compared to areas that do not actively manage stormwater quality; • At least 80% reduction of TSS • At least 60% reduction of TP • At least 45% reduction of TN..
Protection of Receiving Environments	- Minimise impacts to the hydrological regime of the wetlands. - Minimise the transport of pollutants, including nutrients, suspended solids, oils and other hydrocarbons. - Minimise cut and fill.	- Use of buffers to maintain the integrity of the wetlands. - Minimise the project footprint through the use of retaining walls. - No works to realign Murdoch Drain to retain native vegetation.
Public Health and Risk	- Prevent risk from flooding.	- The road vertical profile is at least 2m above maximum groundwater levels.
Social Values	- Consider the visual and aesthetic values.	- The Dixon Road bio-retention basin will take the form and appearance of a natural wetland.
Construction	- Minimise impacts on the hydrological regime by construction activities.	- No dewatering for construction. - Detailed ASS site investigation prior to construction. - Site specific Construction and Environment Management Plans to be developed. - Sediment control measures during construction. - Location of vehicle maintenance areas outside of wetland and buffer areas. - Monitoring of groundwater and surface water during construction.
Operation	- Develop long term economically viable stormwater solutions. - Ensure regular maintenance of drainage infrastructure.	- Ongoing monitoring of groundwater and surface water following construction. - Maintenance of the stormwater system.

5.0 Implementation Strategy

Implementation of the Water Management Strategy involves defining the roles and responsibilities of stakeholders, outlining further documentation required to support the project and defining operation, monitoring and maintenance of the stormwater system.

5.1 Detailed Design Phase

The proposed road design is subject to further change during detailed design. During this design phase, the stormwater system and abstraction requirements will be refined.

5.1.1 Water Management Plan

A Water Management Plan (WMP) will be developed during the detailed design phase. The WMP will incorporate all aspects of the WMS, including final design, construction and operation and considering the points listed below and in Table 16. It will be prepared in consultation with Department of Water.

5.1.2 Stormwater System Design

The final configuration of the stormwater system will be confirmed during the detailed design phase of the project. The stormwater system described in Section 4.1 is based on a preliminary road alignment and presented for proof of concept. The final location and sizing of infiltration basins, bio-retention basins, pit and pipe network, culverts and pollutant controls will be determine from the final road alignment. Further opportunities for treatment of the 1yr ARI rainfall close to source will also be examined. The system will be developed based on the guiding principles outlined in Table 16. Detailed designs will be presented in the Water Management Plan.

5.1.3 Abstraction Licensing

Prior to abstraction of groundwater for construction water supplies, the construction contractor will apply for and obtain from Department of Water a “Licence to Take Water”. All abstraction will be carried out in accordance with the conditions of this licence. A separate abstraction management plan may be required depending on the advice from Department of Water. It is likely that further monitoring will be required to prior to construction activities to establish baseline groundwater levels in any GDE that may be impacted by abstraction.

Abstraction calculations presented in Section 3.0 are based on estimates from previous Main Roads projects. The license allocation sought should reflect any further information related to construction water needs that become available during detailed design.

5.2 Construction Phase

During construction of the project, ongoing monitoring and further site specific investigations are required to ensure impacts on the surrounding environment are avoided or suitably mitigated.

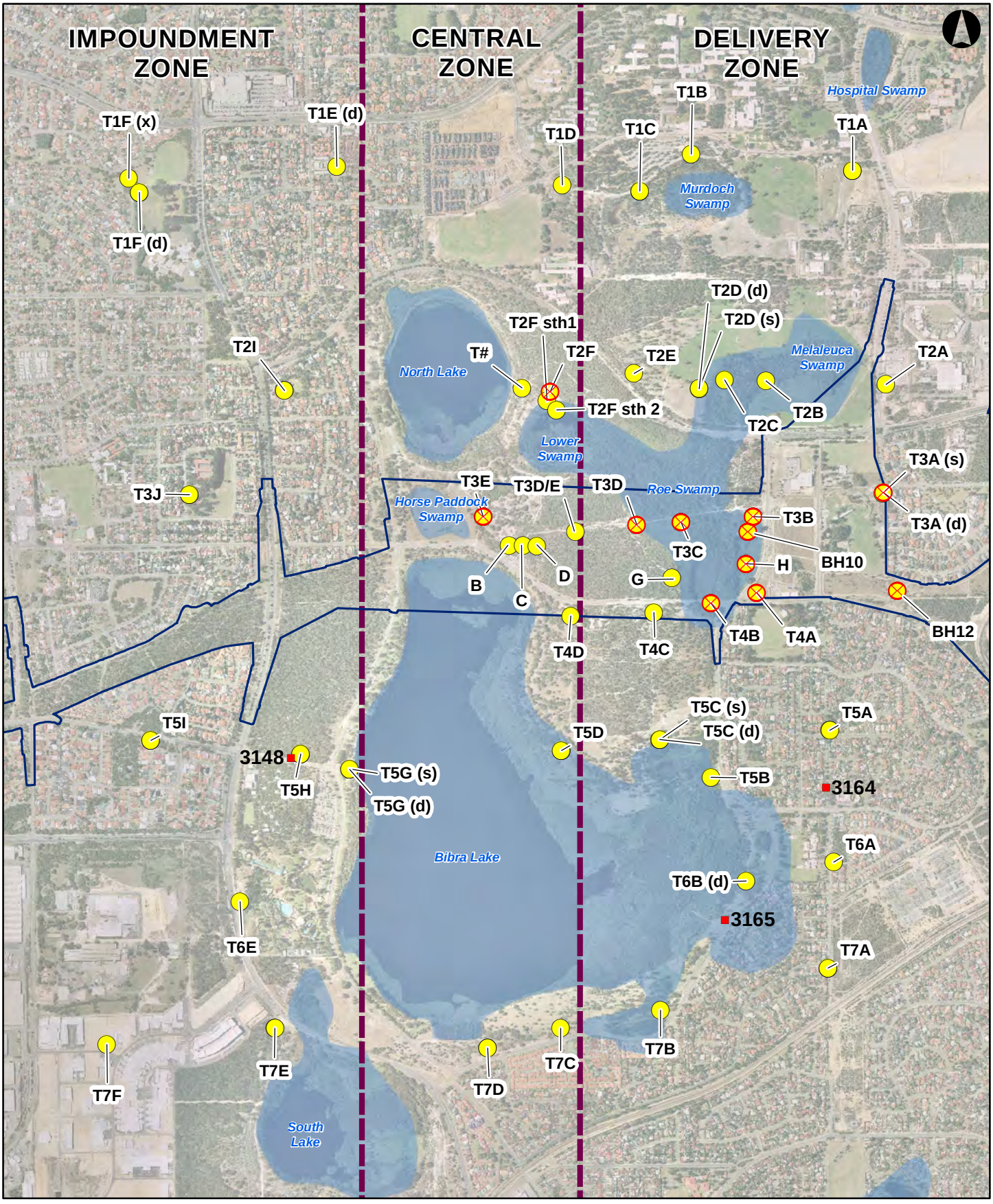
5.2.1 Monitoring

Monitoring of groundwater and surface water will be undertaken to enable assessment of potential impacts and design outcomes. Prior to commencement of construction, a monitoring program will be established. The locations of any monitoring sites or bores will be determined by the final road alignment. Efforts should be made to avoid the destruction of existing piezometers, as much as is practical. However, if this is unachievable, then a commitment to the reinstallation of piezometers as close to the original location should be made.

There are particular areas of concern that should be monitored regardless of final road alignment. Groundwater monitoring bores BH12, BH10, T3B, T3C, T3D, T3E and T3F should continue to be monitored throughout construction to ensure that any groundwater impacts can be detected. Monitoring bores T4A and H should also be monitored to assess any impacts on Roe Swamp down gradient of construction of a large embankment section along Bibra Drive. Selected locations are shown on Figure 27. The monitoring program will also outline the frequency of monitoring.

If the proposed design were to change location significantly, then the bores listed above may be unsuitable for monitoring the impacts to groundwater adjacent to a road alignment construction.

WIN Groundwater Monitoring bores 23023913, 3148, 3164 and 3165 are currently monitored monthly by the Department of Water and should continue at this frequency.



Potential Groundwater Monitoring Locations

South Metro Connect

Figure 27

0 250 500

Metres

1:20,000 (A4)

- Potential Groundwater Monitoring Locations
- WIN Groundwater Bores
- Groundwater Monitoring Bores
- Zone Boundary
- Wetlands
- Project Area

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Monitoring of groundwater and surface water levels and quality will be undertaken at a suitable frequency for relevant parameters to ensure potentially adverse impacts of construction activities can be detected and assessed.

If abstraction is undertaken within the project area for construction water supplies, monitoring of the superficial aquifer will be undertaken to the satisfaction of the DoW. Monitoring would be undertaken prior to abstraction, as well as further assessment of historical data, to gain further understanding of the pre-development conditions.

5.2.2 ASS

As outlined in Section 4.3.2, an Acid Sulfate Soil Management Plan will be prepared prior to excavation and construction activities. The Plan will be based on detailed site investigations and DEC Guidelines.

5.2.3 Contingency and Emergency Response

The WMP is to include measures for contingency and emergency response.

5.2.4 Roles and Responsibilities

Table 17 details the roles and responsibilities for water management during construction and operation of the project. Construction of the stormwater system will be the responsibility of Main Roads and the Contractor. Monitoring of potential impacts on surface water and groundwater will be the responsibility of Main Roads; DEC and DoW may also choose to contribute to ongoing monitoring in the area. The Contractor and Main Roads will be responsible for the actions required to mitigate any adverse impacts to surface water and groundwater.

Table 17 Construction Phase Implementation Responsibilities

Action	Responsibility				
	Contractor	Main Roads	DoW	Local Government	DEC
Preparation of Water Management Plan	✓	✓			
Construction of stormwater system	✓	✓			
Monitoring of Surface Water and Groundwater		✓	✓		✓
Response to impacts on Surface Water and Groundwater	✓	✓			

5.3 Operational Phase

The operation phase of the project requires maintenance of the stormwater systems and assessment of their performance in relation to potentially adverse impacts on the surface water and groundwater regimes of the project area, to determine whether additional water management measures are required.

5.3.1 Monitoring

Groundwater monitoring post construction will be conducted for two years, or longer if this period is not representative of average or typical rainfall patterns. Monitoring will focus on sensitive areas, such as the area between North Lake and Bibra Lake, the Roe Swamp area down gradient of the Bibra Drive embankment and other areas where the shallow groundwater table is vital to maintaining the existence to certain wetland species.

5.3.2 Maintenance

Operation and maintenance of the drainage system will be the responsibility of Main Roads. The surface drainage system will require routine maintenance to ensure its efficient operation. It is considered the following operating and maintenance practices will be implemented periodically:

- Removal of debris to prevent blockages.
- Street sweeping to reduce particulate build up on road surfaces and gutters.
- Cleaning of sediment build up and litter layer on the bottom of bio-retention areas.
- Assessment of the health of vegetation in bio-retention areas and removal and replacement of dead plants where necessary.

The maintenance of the Dixon Road bio-retention basin will be the responsibility of Main Roads.

5.3.3 Contingency and Emergency Response

An emergency response plan is to be developed by Main Roads in consultation with other authorities including DEC and Fire and Emergency Services Authority of Western Australia (FESA).

5.3.4 Roles and Responsibilities

Table 18 details the roles and responsibilities to be undertaken during the operational phase.

Monitoring of potential impacts on surface water and groundwater will be the responsibility of Main Roads for an initial post construction period, after which any ongoing monitoring responsibilities will be reverted to DEC. As the operator of the road, Main Roads will be responsible for the stormwater system maintenance. The response to adverse environmental impacts will be the responsibility of Main Roads, overseen by DEC.

Table 18 Operational Phase Implementation Responsibilities

Action	Responsibility				
	Contractor	Main Roads	DoW	Local Government	DEC
Monitoring of Surface Water and Groundwater		✓	✓		✓
Maintenance of the stormwater system		✓			
Response to impacts on Surface Water and Groundwater		✓		✓	✓

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Appendix A

Conceptual Basin Locations

Appendix A Conceptual Basin Locations

App A1 Roe Highway Extension Catchment Plan

App A2 Karel Ave/Roe Hwy Interchange Catchment Plan

App A3 Kwinana/Roe Hwy Interchange Catchment Plan

App A4 Murdoch Dr/Roe Hwy Interchange Catchment Plan

App A5 Murdoch Drive Extension Catchment Plan

App A6 Bibra Drive to Progress Drive Catchment Plan

App A7 North Lake Rd/Roe Hwy Interchange Catchment Plan

App A8 North Lake Rd/Roe Hwy Interchange Basin Plan

App A9 Stock Rd/Roe Hwy Interchange Catchment Plan

App A10 Malvolio Rd Basin Plan

Roe Highway Extension Catchment Plan

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Figure A1

0 250 500 750 1,000

Metres

1:22,500 (A3)

Coordinate System: GDA 1994 MGA Zone 50

LEGEND

- Indicative Catchment Locations
- Road Formation (yellow)
- Drainage Areas
- Project Area

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Karel Ave/Roe Hwy Interchange Catchment Plan

Figure A2

0 50 100 150 200 250

Metres

1:5,000 (A3)

Kwinana Freeway

Karel Avenue

Roe Highw

Basin M3

Basin M2

Basin M1

- Bio-Retention Area
- Basin M3 Catchment
- Basin M1 Catchment
- Basin M2 Catchment
- Basin
- Indicative Drainage Network
- Design Concept

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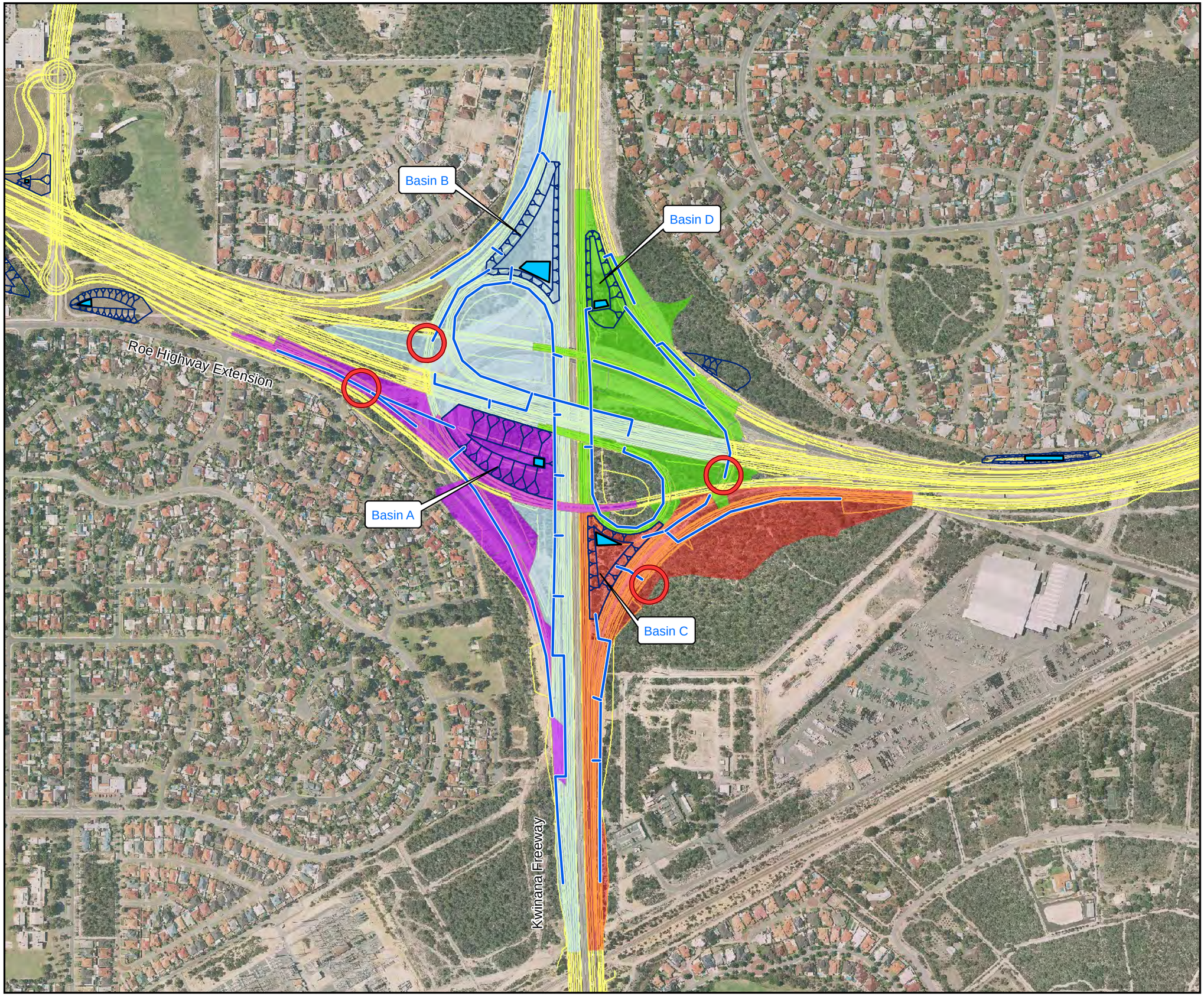
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Kwinana/Roe Hwy Interchange Catchment Plan

Figure A3



0 100 200 300

Metres

1:6,000 (A3)

- Bio-Retention Area
- Trapped Low Points
- Basin A Catchment
- Basin B Catchment
- Basin D Catchment
- Basin C Catchment
- Basin
- Indicative Drainage Network
- Design Concept

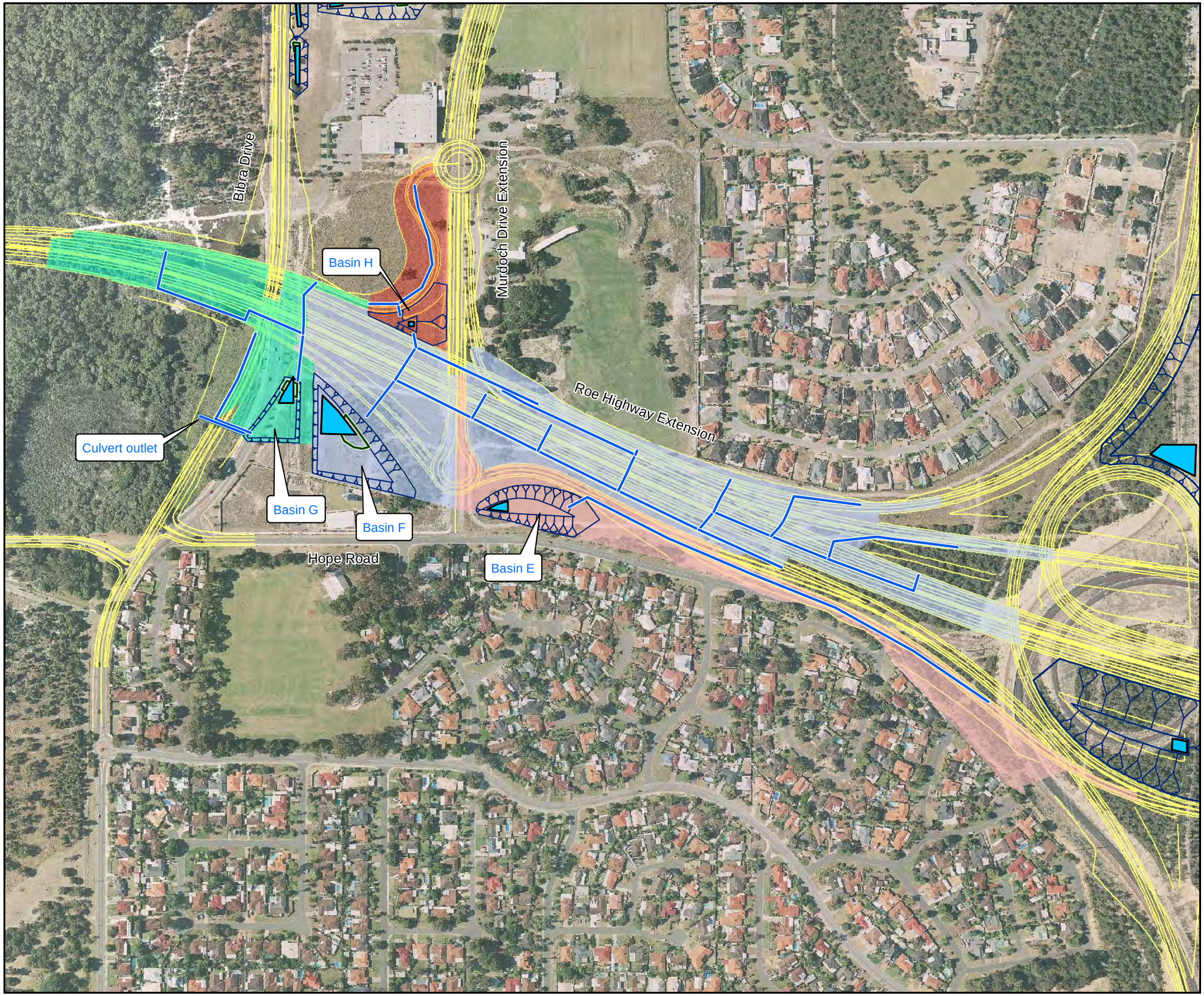
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Murdoch Dr/Roe Hwy Interchange Catchment Plan

Figure A4

0 100 200

Metres

1:4,000 (A3)

- Bio-Retention Area
- Basin E Catchment
- Basin F Catchment
- Basin G Catchment
- Basin H Catchment
- Culvert
- Basin
- Indicative Drainage Network
- Design Concept

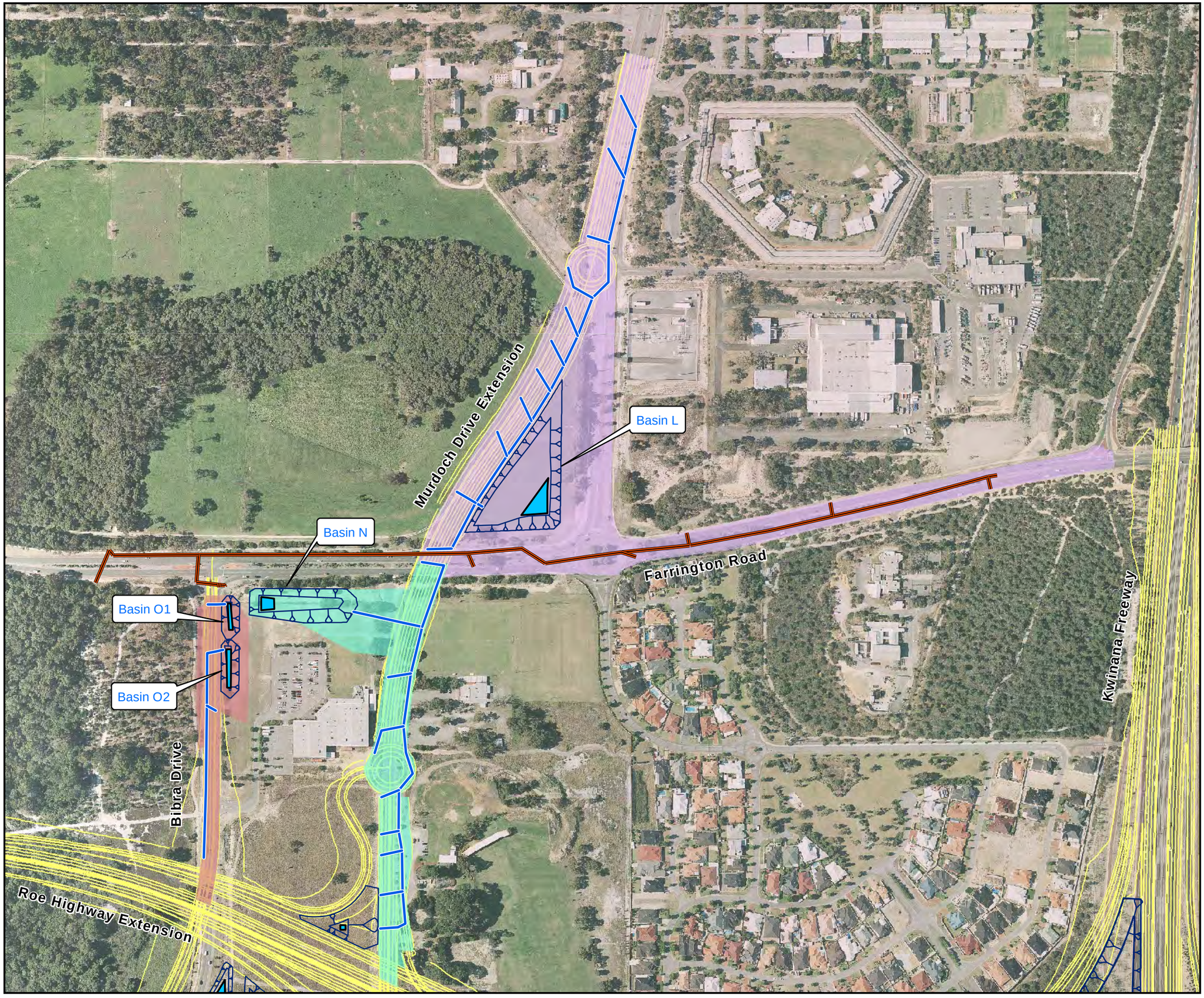
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Murdoch Drive Extension Catchment Plan

Figure A5

0 100 200

Metres

1:4,000 (A3)

- Bio-Retention Area
- Basin L Catchment
- Basin N Catchment
- Basin O1 and O2 Catchment
- Indicative Drainage Network
- Design Concept
- Existing Drainage Network

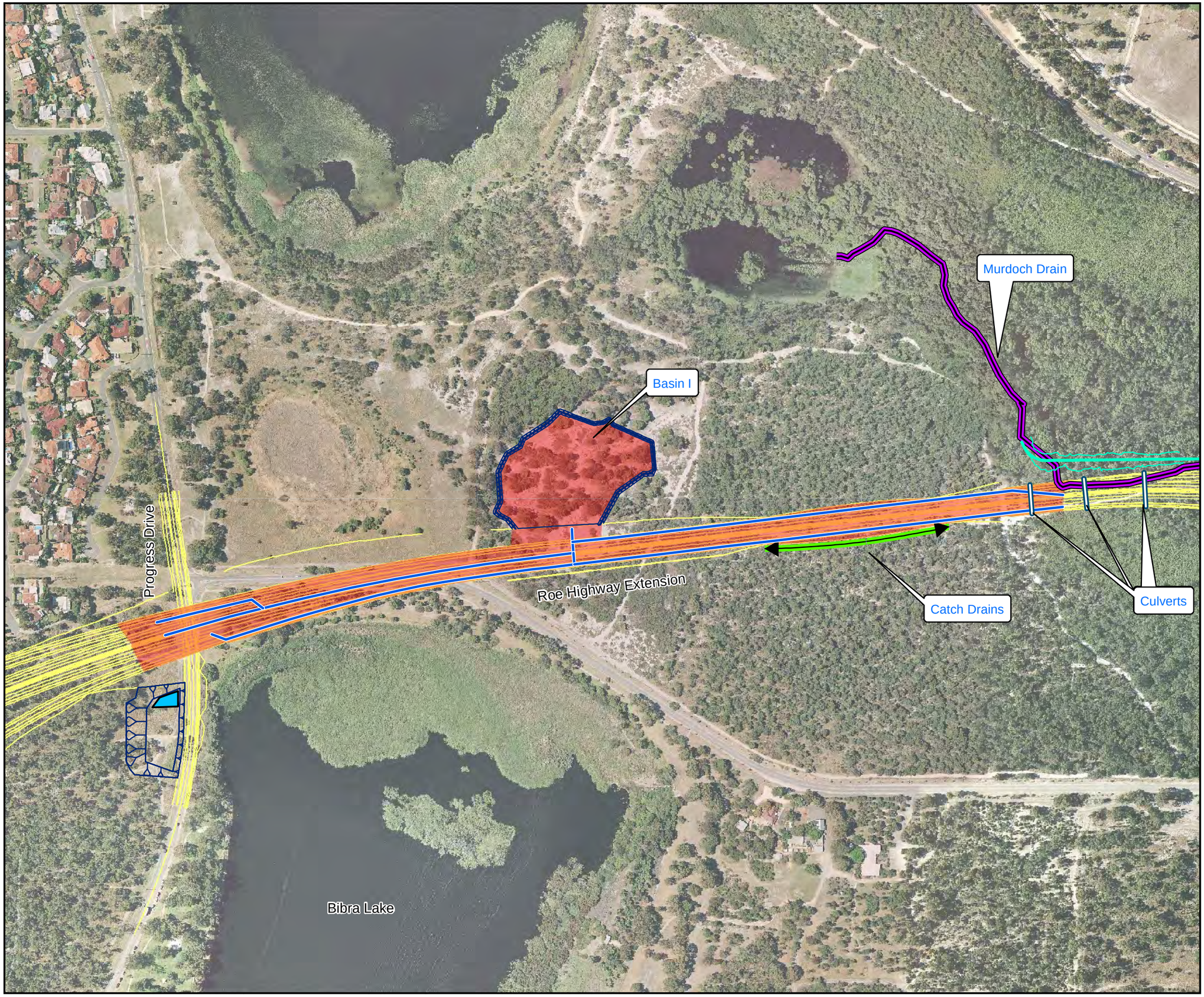
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Bibra Drive to Progress Drive Catchment Plan

Figure A6

0 100 200

Metres

1:4,000 (A3)

- Bio-Retention Area
- Basin I Catchment
- Basin
- Indicative Drainage Network
- Design Concept
- Catch Drain
- Culverts
- Approximate Murdoch Drain Location
- Murdoch Drain Realignment

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North Lake Rd/Roe Hwy Interchange Catchment Plan

Figure A7

0 100 200 300 400

Metres

1:8,000 (A3)

- Bio-Retention Area
- Basin J1-J4 Catchment
- Basin K Catchment
- Indicative Drainage Network
- Design Concept
- Basin
- Catch Drain

Catch Drains
Basin K
Basin J4
Basin J3
Basin J2
Basin J1
Basin U
Malvolio Road
Coolbellup Avenue
North Lake Road
Progress Drive
Forrest Road
Sudlow Road
Stock Road
Phoenix Road

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North Lake Rd/Roe Hwy Interchange Basin Plan

Figure A8

0 100

Metres

1:2,000 (A3)

Roe Highway Extension

Basin J4

Basin K

Basin J3

Basin J2

Basin J1

North Lake Road

Progress Drive

- Bio-Retention Area
- Basin J1-J4 Catchment
- Basin K Catchment
- Basin
- Indicative Drainage Network
- Design Concept

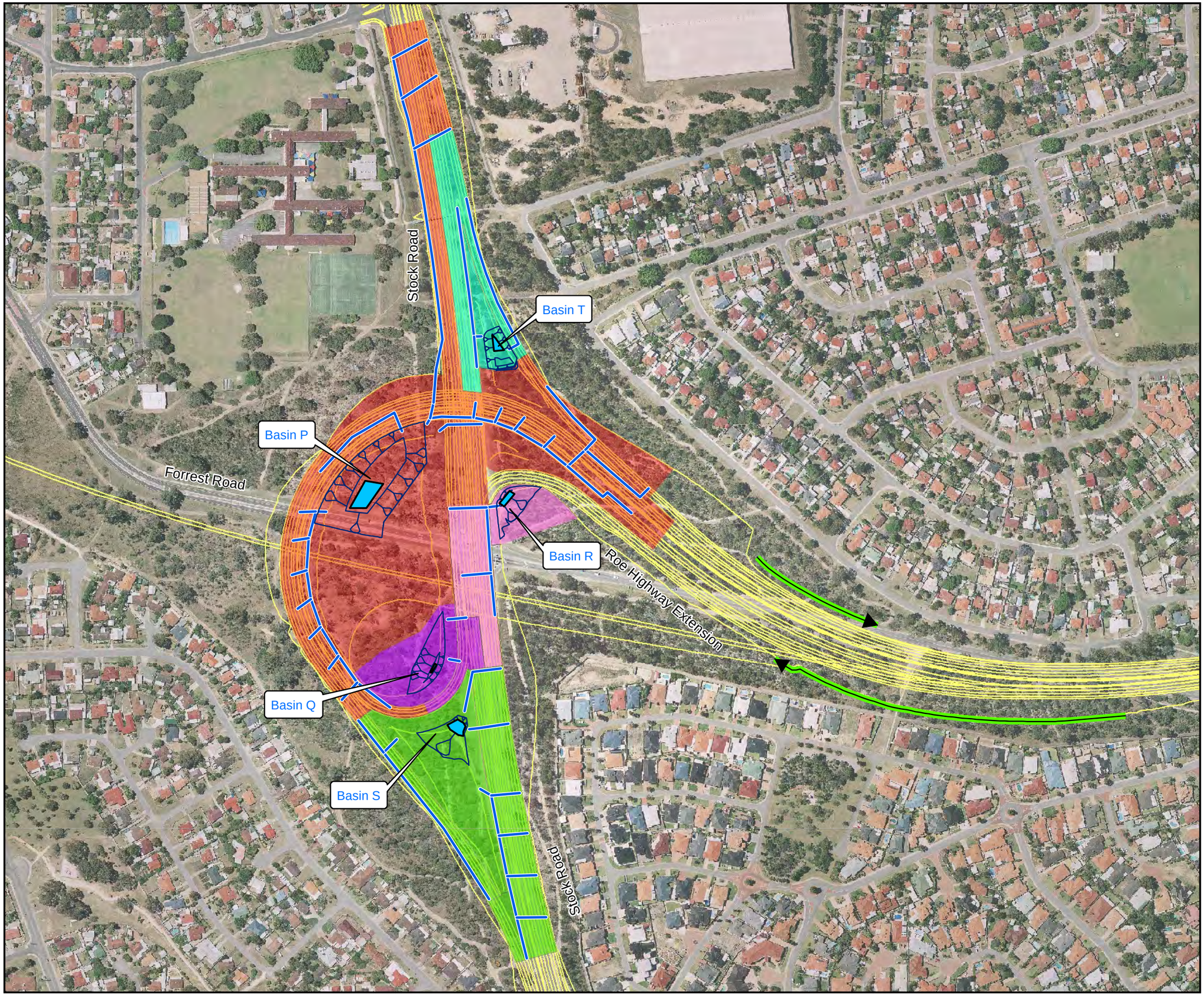
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Stock Rd/Roe Hwy Interchange Catchment Plan

Figure A9

0 100 200

Metres

1:4,000 (A3)

- Bio-Retention Area
- Basin P Catchment
- Basin Q Catchment
- Basin R Catchment
- Basin S Catchment
- Basin T Catchment
- Basin
- Indicative Drainage Network
- Design Concept
- Catch Drain

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Malvolio Rd
Basin Plan

Figure A10

0 10 20 30 40 50

Metres

1:1,000 (A3)

Malvolio Road

Basin U

Roe Highway Extension

- Basin
- Indicative Drainage Network
- Design Concept

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Flora, Vegetation and Fauna Management Plan

Appendix F

Flora, Vegetation and Fauna Management Plan

Appendix F Flora, Vegetation and Fauna Management Plan

12 July 2012

Flora Vegetation and Fauna Management Plan

Roe Highway Extension



Flora Vegetation and Fauna Management Plan

Prepared for

Main Roads

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12 July 2012

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Quality Information

Document Flora Vegetation and Fauna Management Plan

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Date 12 July 2012

Prepared by Vanessa Yeomans and Conor O'Neill

Reviewed by Andrew Batty and Karen Crews

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			Name/Position	Signature
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B	11-Jul-2012	For Issue	Jamie Shaw Associate Director	
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1.0 Introduction

This Flora, Vegetation and Fauna Management Plan (FVFMP) outlines the approach and level of commitment of Main Roads Western Australia (Main Roads) to mitigate the impacts on flora, vegetation and fauna from the construction and operation of the Roe Highway Extension project in Perth, Western Australia (WA).

1.1 Project Background

Main Roads proposes to construct the Roe Highway Extension ("the project") by extending Roe Highway approximately five kilometres from its current terminus at the Kwinana Freeway in Jandakot to Stock Road in Coolbellup (Figure 1). In August 2009, Main Roads and industry partner, AECOM Australia, formed the South Metro Connect (SMC) alliance. SMC was created for the development phase of the project. Its primary objective is to work collaboratively with stakeholders and regulatory authorities to develop an environmentally, socially and economically acceptable project design and obtain relevant statutory environmental and heritage approvals.

The project is located approximately 14 kilometres south of Perth within the Swan Coastal Plain Bioregion. The project area is largely contained within the City of Cockburn, however, parts of the design extend northward in to the City of Melville along Murdoch Drive and Kwinana Freeway (Figure 1). Generally, the project is oriented east-west, within a road reserve that was set aside in the Metropolitan Region Scheme (MRS) in 1963. The alignment is between North and Bibra Lakes, which are part of the Eastern Chain of the Beeliar Wetlands.

The project will consist of a dual carriageway with two lanes in each direction, separated by a concrete barrier in place of a median strip. The preferred design was selected following an extensive options analysis and consultative process. Once selected, the preferred design was optimised to avoid and minimise environmental impacts to the maximum extent possible.

1.2 Public Environmental Review and Response to Submissions

In 2009 the project was referred to the Environmental Protection Authority (EPA) under the *Environmental Protection Act 1986* (EP Act), and to the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act). The project was set a level of assessment of Public Environmental Review (PER) and the bilateral agreement between the State and Commonwealth governments was enacted. SMC submitted the PER to the Office of the Environmental Protection Authority (OEPA) on 20 June 2011.

Following a 12 week public review period the EPA received 449 submissions to the PER. Of these, 29 were from government and non-government organisations, and 420 from the public, including one submission consisting of a petition with 189 signatures. On 7 June 2012 the OEPA provided Main Roads with a spreadsheet with an additional 2834 comments from the Conservation Council of Western Australia's (CCWA) website.

1.3 Project Description

Main Roads proposes to extend Roe Highway from its current terminus at Kwinana Freeway in Jandakot to Stock Road in Coolbellup, located approximately 14km south of Perth (Figure 1). The project will consist of a dual carriageway with two lanes in each direction; separated by a concrete barrier in place of a median strip.

The road will be constructed entirely within government-owned land; however a short section will be constructed outside the Metropolitan Region Scheme (MRS) Primary Regional Roads boundary in order to accommodate an alignment that minimises environmental impacts. There will be no resumption of privately owned land. Construction of the project will require the following key activities:

- Clearing of vegetation;
- Removal and stockpiling of topsoil;
- Construction of:
  - Road formation;
  - Earthworks, pavement and bituminous surfacing;
  - Drainage pipes and stormwater basins;
  - Principal Shared Paths (PSPs) and other pedestrian and cycle paths;
  - Retaining walls;
  - Bridges, underpasses and overpasses;
  - Fencing;
  - Fauna underpasses, pedestrian underpasses and culverts; and
  - Noise attenuation barriers.
- Relocation of powerlines and other services;
- Installation of street and PSP lighting;
- Installation of electrical infrastructure including but not limited to: traffic signals, variable message signs and cameras;
- Standard road signs; and
- Rehabilitation of areas disturbed for construction.

The operation of the project will include the following key activities:

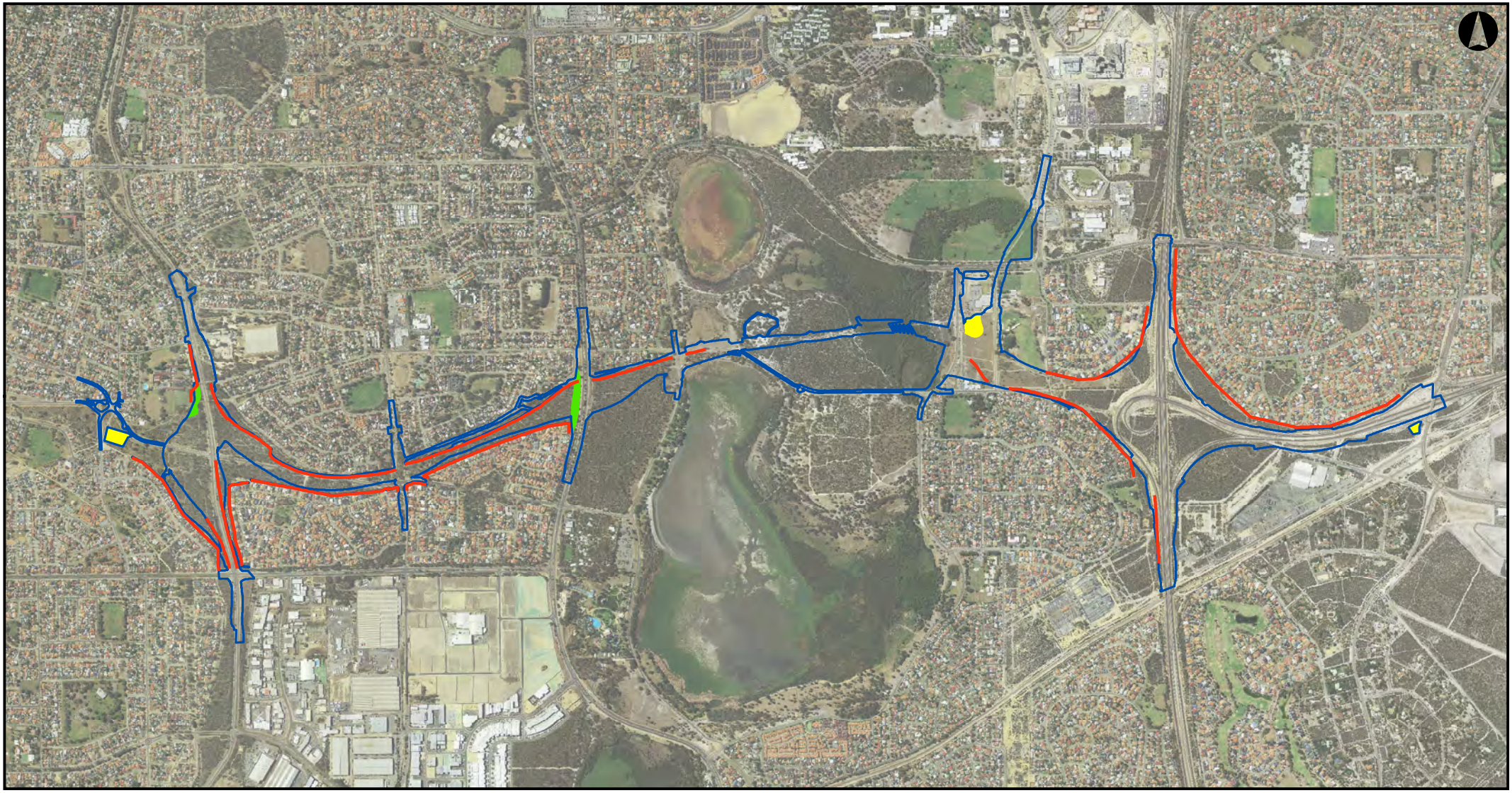
- Freight transport;
- Private and commercial vehicle movements;
- Stormwater management;
- Operation of street lighting and other electrical infrastructure; and
- Maintenance.

A summary of key details of the project is provided in the key characteristics table below (Table 1).

Table 1 Key Characteristics Table

Element	Description
Murdoch Drive Extension	Full access via an extended Murdoch Drive into and out of the Murdoch Activity Centre from both directions of travel on Roe Highway
Bridge at Roe Swamp	A bridge from east to west will span the topographic low point at Roe Swamp
Bridge located north of Bibra Lake	Final length to be determined, subject to more detailed site investigations once Aboriginal heritage approval to access site is obtained
Water supply (source and requirement during construction)	An estimated 140,000kL of water will be needed for highway construction, including dust suppression, to be sourced from bores

Element	Description
Dewatering	No dewatering will be undertaken
Stormwater basins	Where possible road run off will be infiltrated in swales as close as possible to the source In and adjacent to wetlands, all road run off will be detained in basins prior to infiltration
Access/haul roads	Haulage and access will be via the construction corridor, Hope Road, Forrest Road and other existing infrastructure or existing cleared areas No additional clearing will be required outside of the project footprint
Construction envelope	148ha
Disturbance to fauna habitat	112ha within the construction envelope
Disturbance of Black Cockatoo habitat	- Black Cockatoo refers to both Carnaby's Cockatoo and the Forest Red-tailed Black Cockatoo - Not more than 78.3 ha of Black Cockatoo foraging habitat to be cleared within the construction envelope - Not more than 249 potential nesting trees with DBH >500mm to be cleared within the construction envelope
Disturbance of Graceful sun moth habitat	Not more than 5.6ha of Graceful sun moth habitat to be cleared with the construction envelope
Vegetation disturbance	Not more than 79.3ha of intact remnant vegetation is to be cleared within the construction envelope
Construction contingency	Up to 15ha of previously cleared land outside the current construction envelope to facilitate construction requirements where necessary.
Vegetation rehabilitation	All disturbed areas not forming part of the road surface or drainage will be rehabilitated
Total clearing of wetland areas	Impacts on wetlands will not exceed: - 5.80ha of Conservation Category Wetland (CCW) - 0.95ha of Environmental Protection Policy Lakes These areas are included in the total clearing footprint
Maximum height of noise attenuation walls	- 4.4m on residential boundary - 5.0m on roadside



Roe Highway Extension Construction Envelope

South Metro Connect

0 250 500 750 1,000

Metres

1:27,500 (A4)

- Construction Envelope
- Noise Barriers
- Laydown Areas
- Temporary Bypasses

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2.0 FVFMP Objectives

The primary objective of the FVFMP is to set management objectives and actions for the project in order to minimise and manage impacts on flora, vegetation and fauna. The FVFMP is intended to provide guidance on the development of the Construction Environmental Management Plan (CEMP) for the project, with respect to management of flora, vegetation and fauna. The CEMP is to address all aspects of the FVFMP.

Successful implementation of the FVFMP is intended to result in the project meeting the EPA's objectives for flora and fauna:

> *To maintain abundance, diversity, geographic distribution and productivity of flora and fauna at species and ecosystems levels through the management of adverse impacts and improvement in knowledge.*

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3.0 Legal and other requirements

3.1 Relevant legislation, guidelines and policies

There are a number of legislative requirements, guidelines and policies that inform the FVFMP (Table 2 and Table 3). The agencies responsible for administering this legislation and providing guidance to such plans include: the Commonwealth Government (DSEWPaC), State Government (DEC, OEPA), and local government (City of Cockburn). Other departments administering legislation relevant to the FVFMP include the Department of Agriculture and Food (DoAF), Fire and Emergency Services Authority (FESA) and the Western Australian Planning Commission (WAPC).

Table 2 Relevant Legislation

Legislation	Purpose	Requirement
Western Australia		
Wildlife Conservation Act 1950	Provides for the conservation and protection of Western Australia's wildlife.	License to take protected flora and fauna, consent to take rare or endangered flora.
Aboriginal Heritage Act 1972	Preservation of places and objects customarily used by the original inhabitants of Australia.	Consent to disturb Aboriginal sites.
Environmental Protection Act 1986	Preventing, controlling and abating environmental harm and conserving, preserving, protecting, enhancing and managing the environment.	Approval to undertake an assessed proposal. Permit to clear native vegetation.
Conservation and Land Management Act 1984	Provides for the use, protection and management of certain public lands and waters and the establishment of responsible authorities.	License/permit to undertake activities impacting on DEC managed properties and compliance with management plans
Heritage of Western Australia Act 1990	Conservation of places having significance to Western Australia's cultural heritage.	Permit to disturb, damage or demolish heritage sites.
Rights in Water and Irrigation Act 1914	Provides for regulation, management, use and protection of water resources and irrigation schemes.	Rights and licenses to take water; permit to obstruct or interfere with a watercourse or wetland including its bed or banks.
Agriculture and Related Resources Protection Act 1976	Protects agriculture from threatening influences, including weeds. Provides a list of declared plants (weeds) that require controlling.	Control of declared plants.
Contaminated Sites Act 2003	Identification, recording, management and remediation of contaminated sites.	Ensure that development complies with site classification and any restrictions that may apply.
Metropolitan Water Supply, Sewerage and Drainage Act 1909	Defines the metropolitan water, sewerage and drainage control area and establishes method of control.	Ensure that development does endanger water supply areas.
Commonwealth of Australia		
Environment Protection and Biodiversity Conservation Act 1999	Provides for the protection of the environment and the conservation of biodiversity.	Approval required for activities likely to have a significant impact on any matter of national environmental significance.

Table 3 Relevant Guidelines and Policies

Relevant Guidelines and Policies
Flora and Vegetation
State Planning Policy 2.8: Draft Bushland Policy for the Perth Metropolitan Region, July 2004
CALM Draft Policy Statement No. 9: Conserving Threatened Species and Ecological Communities
EPA Position Statement No. 2: Environmental Protection of Native Vegetation in Western Australia
Bush Forever: Volume 1: Polices, Principles and Processes Perth, W.A., Western Australian Planning Commission
Environmental Weed Strategy for WA (1999)
State Weed Strategy for WA (2001)
Phytophthora cinnamomi and diseases caused by it, Volume 1 – Management Guidelines (CALM, 2000)
Managing *Phytophthora* dieback, Guidelines for Local Government (Dieback Working Group, 2000)
Fauna
EPA Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection
EPA Guidance Statement No. 20: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia
EPA Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia

4.0 Key Environmental Factors

The proposed alignment traverses through an important wetland chain and some of the last remaining remnant vegetation in the area. In urban areas around Perth, often the last land to be developed is the road reserve set aside within the MRS for primary regional roads. The Roe Highway Extension project will impact upon several key environmental factors including:

- Wetlands;
- State and Federally listed fauna species and species habitat;
- Remnant vegetation including populations of State listed priority flora;
- Conservation land (Bush Forever and Beeliar Regional Park);
- Noise; and
- Aboriginal Heritage.

4.1 Wetlands

The project will have a direct impact on Conservation Category Wetlands (CCW) and on lakes protected under the *Environment Protection Policy Swan Coastal Plain Lakes* (Lakes EPP). The areas of wetland affected by the proposal are:

- Bibra Lake –1.0ha Lakes EPP wetland;
- Horse Paddock Swamp – 0.2ha CCW;
- Melaleuca Swamp – 0.2 ha CCW, and
- Roe Swamp – 5.6ha CCW.

4.2 Flora and vegetation

Project construction will require the clearing of up to 79.3ha of remnant native vegetation. Much of the project area has been subject to historical disturbance from agriculture and recreational activities in the past. Most of the Perth Metropolitan Area has been subjected to large scale disturbance and clearing of native vegetation and many of the vegetation complexes occurring in Perth have less than 30% of their pre-European extent remaining. Of the four complexes occurring within the project area, two have less than 30% of their pre-European extent remaining (Table 4). None of the vegetation complexes occurring within the project area will be reduced to below the 10% threshold for the retention of vegetation communities in constrained urban areas.

A total of eight species in 15 sub-populations of Priority Flora, consisting of approximately 7,000 individuals, will be impacted by the project. Most of the recorded Priority Flora within the proposed clearing footprint is *Dampiera triloba* (Priority 1) a small herb that is locally abundant (Table 5).

Table 4 Heddle Vegetation Complexes occurring within the Project Area (SMC 2011).

Heddle Vegetation Complex	Description	Pre-European Extent (ha)	Current Remaining Area (ha)	% of Pre-European Extent Remaining (ha)	Area to be Cleared for Construction (ha)
Bassendean Complex – Central and South (44)	Woodland of Jarrah-Marri with well defined second storey of Pink Summer Calytrix (*Calytrix fraseriana*) and Bull Banksia (*Banksia grandis*) on the deeper soils and a closed scrub on the moister sites. The understorey species reflect similarities with the adjacent vegetation complexes	46,220	10,919	24	35.9
Herdsman Complex (53)	Sedgelands and fringing woodland of Flooded Gum (*Eucalyptus rudis*) and *Melaleuca* species	6,509	2,017	31	3.0
Karrakatta Complex – Central and South (49)	Predominantly open forest of Tuart-Jarrah-Marri and woodland of Jarrah and *Banksia* species	34,532	6,275	18	21.2
Cottesloe Complex – Central and South (52)	Mosaic woodland of Tuart and open forest of Tuart-Jarrah and Marri, closed heath of the limestone outcrops	34,439	12,362	36	19.1

Table 5 Priority Flora species that will be impacted by the project (SMC 2011).

Species	Conservation Code	Total Number of Known Populations	Number of Populations Known Within the Study Area	Number of Populations to be Impacted Within Project Footprint	Percentage of Populations to be Impacted	Total Minimum Number of Known Individuals	Number of Individuals Within Study Area	Number of Known Individuals to be Impacted Within Project Footprint	Percentage of Known Individuals Within Study Area to be Impacted
Dampiera triloba	Priority 1	21	14	4	19.1	7,132	6,617	5,404	75. 8
Tetraria sp. Chandala (G.J. Keighery 17055)	Priority 2	3	1	1	0	3	1	1	0.0
Cyathochaeta teretifolia	Priority 3	56	5	3	5.4	582	482+	38	6.5
Jacksonia gracillima	Priority 3	20	3	2	10.0	200	173	15	7.5
Eryngium pinnatifidum subsp. palustre	Priority 3	20	4	4	20.0	63	45	16	25.4
Dodonaea hackettiana	Priority 3	56	1	1	1.8	205	1	1	0.5
Calothamnus rupestris	Priority 4	48	2	0	0	8,394	2	0	0.0
Eucalyptus caesia	Priority 4	42	1	0	0	741	1	0	0.0

4.3 Fauna

Road construction will result in impacts on up to 112ha of fauna habitat. This includes 40ha of *Eucalyptus*/*Banksia* woodland, 26ha of *Eucalyptus*/*Xanthorrhoea* woodland and 10.2ha of other native remnant vegetation. The fauna habitat includes 21.9ha of non-native vegetation including: rehabilitated vegetation, parklands and roadside verges that provide fauna habitat. The remaining fauna habitat (13ha) is of little value for fauna.

Habitat for a number of species listed under the EPBC Act, *Wildlife Conservation Act 1950* (WC Act) and DEC's priority fauna list occurs within the project area (Table 6).

One unidentified invertebrate species was recorded in the project area, an unidentified sucking millipede (Siphonotidae sp.). Further taxonomic review and survey work of this species is required. A single specimen was collected from *Eucalyptus*/*Banksia* habitat in the north-east quadrant of the Stock Road/Forrest Road intersection.

4.4 Conservation Land (Bush Forever and Beeliar Regional Park)

The project will impact upon Bush Forever sites and Beeliar Regional Park. A total of 7ha of Bush Forever will be cleared during construction of the project. Beeliar Regional Park will be impacted by the resumption of 5.4ha of the park for road reserve, due to the realignment of the road to minimise impacts on native vegetation and CCW.

4.5 Noise

Construction noise and traffic noise during operation will have a significant impact on sensitive receivers adjacent to the project. Significant noise impacts during construction include: operation and movement of machinery, out of regular working hours construction noise, reversing alarms and piling. During operation, excessive noise from traffic can result in a loss of amenity for residents and possible health impacts.

4.6 Aboriginal Heritage

The Bibra Lake/North Lake area is significant to Aboriginal people. In the past the project area was used as a semi-permanent camp site due to the proximity to food and water year round. The project area will impact upon a number of mythological and archaeological sites in the vicinity of Bibra Lake and North Lake registered under the *Aboriginal Heritage Act 1972* (Table 7)

Table 6 Fauna listed under EPBC Act, WC Act or DEC's Priority Fauna List within the Project Area (SMC 2011).

Species	Conservation Status	Habitat Loss in Project Area
Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*)	Endangered – EPBC Act Schedule 1 – WC Act	- 78.3ha - 249 potential nesting trees - Loss of 2.5ha of potential nesting habitat
Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*)	Vulnerable – EPBC Act Schedule 1 – WC Act	- 73.2ha - 249 potential nesting trees - Loss of 2.5ha of potential nesting habitat
Australasian Bitten (*Botaurus poiciloptilus*)	Endangered – EPBC Act Schedule 1 – WC Act	0.3ha
Australian Little Bittern (*Ixobrychus dubius*)	Priority 3 - DEC	0.3ha
Peregrine Falcon (*Falco peregrinus*)	Schedule 4 – WC Act	111.8ha
Western Brush Wallaby (*Macropus irma*)	Priority 4 – DEC	72.7ha
Southern Brown Bandicoot (Isoodon obesulus fusciventer)	Priority 5 - DEC	72.5ha
Perth Lined Lerista (*Lerista lineata*)	Priority 3 - DEC	91.4ha
Black-striped Snake (*Neelaps calonotus*)	Priority 3 - DEC	72.7ha
Jewelled Sandplain Ctenotus (*Ctenotus gemmula*)	Priority 3 - DEC	34ha
Rainbow Bee-eater (*Merops ornatus*)	Migratory – EPBC Act	89.9ha
Wetland Birds		3.7ha
Graceful Sun-Moth (*Synemon gratiosa*)	Endangered – EPBC Act Schedule 1 – WC Act	5.6ha

Table 7 Aboriginal Heritage sites, registered under the *Aboriginal Heritage Act 1972*, within the project area (SMC 2011)

Site Number	Site Name	Status	Archaeological/Ethnographic
3196	Lake Bibra: Forrest Road	Stored Data	Quarry
3293	Bibra Lake	Insufficient Information	Archaeological
3709	North Lake and Bibra Lake	Permanent Register	Ethnographic
4107	Bibra Lake North	Permanent Register	Archaeological
4106	North Lake SW	Permanent Register	Archaeological
3294	North Lake N	Permanent Register	Archaeological
3295	North Lake Coolbellup	Permanent Register	Archaeological
3296	Hope Rd Swamp/Bibra Lake	Stored Data	Archaeological

4.7 Matters of National Environmental Significance

Significant impacts on Matters of National Environmental Significance will occur for three species listed as threatened under the EPBC Act (Table 8). Whilst there will be an impact on migratory birds and migratory waterbirds, this impact is not expected to be significant (Table 9).

Table 8 EPBC listed threatened species that will be significantly impacted by the project (SMC 2011).

Threatened Species	EPBC Status	Extent of Impact
Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*)	Endangered – EPBC Act Schedule 1 – WC Act	- 78.3ha of foraging habitat - 249 potential breeding trees (2.5 ha of potential breeding habitat)
Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*)	Vulnerable – EPBC Act Schedule 1 – WC Act	- 73.2ha of foraging habitat - 249 potential breeding trees (2.5 ha of potential breeding habitat)
Graceful sun moth(*Synemon gratiosa*)	Endangered – EPBC Act Schedule 1 – WC Act	5.6ha

Table 9 EPBC listed migratory birds that may be impacted by the project (SMC 2011).

Migratory Species	EPBC Status	Extent of Impact
Rainbow Bee-eater (*Merops ornatus*)	Migratory	89.9ha of foraging and breeding habitat.
Glossy Ibis *(Plegadis falcinellus*)	Migratory	Little to no habitat loss May be impacted by lighting, noise and road traffic
Eastern Great Egret *(Ardea modesta*)	Migratory	Little to no habitat loss May be impacted by lighting, noise and road traffic

5.0 Potential Impacts

The potential impacts of the project on flora, vegetation and fauna have been assessed in the PER document and are summarised below (SMC 2011). The potential impacts of the construction and operation of Roe Highway Extension include:

- Clearing of up to 79.3ha of native vegetation;
- Potential spread or introduction of weeds;
- Potential introduction or spread of dieback (*Phytophthora cinnamomi*);
- Overclearing outside of the designated clearing footprint;
- Loss of priority flora;
- Loss of ecological linkages and connectivity between habitats;
- Increase in edge effects and fragmentation;
- Ineffective rehabilitation;
- Loss of up to 112ha of fauna habitat including:
    - 78.3ha of Black Cockatoo foraging habitat;
    - 249 potential nesting trees for Black Cockatoos;
    - 5.6ha of Graceful Sun Moth habitat;
- Fauna death or injury due to vehicle strike or construction activities;
- Accidental chemical spill during construction or operation;
- Impacts on vegetation from dust;
- Impacts on fauna from light during construction and operation;
- Impacts on fauna from noise during construction and operation; and
- Fire.

Management actions to avoid, minimise, reduce and rectify these impacts are addressed in Section 6.0. Residual impacts following these mitigation measures are addressed by a series of offsets as described in the Offset Strategy.

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6.0 Management Actions

The management actions, targets and reporting requirements listed in Table 10 are to be incorporated into the CEMP and implemented during construction and operation of the project.

Table 10 Management actions, targets and reporting required to manage impacts to flora, vegetation and fauna during the construction and operation of Roe Highway Extension

Item No	Aspect		Management Action	Target/Indicator	Reporting/Evidence
1.	EMS	Management Plans	- Develop and implement a CEMP in accordance with the FVFMP - Audits will be conducted in accordance with the audit schedule (Section 10) to assess compliance with this FVFMP and corrective actions implemented where non-compliance is identified. .	- 100% compliance and suitability of CEMP with FVFMP - 100% of non-compliances and non-conformances identified in audits are corrected	- Annual Compliance Report (ACR) - Audits
2.	EMS	Inductions	- All employees and contractors will undergo site specific environmental awareness training during inductions. The training will include: • Significant flora, vegetation and fauna of the project area and relevant management information • Staff responsibilities regarding environmental compliance requirements and commitments in the FVFMP • Actions on encountering fauna on site - Review of training by site personnel will be an annual requirement. - Toolbox meetings are to discuss FVFMP issues at least monthly	- 100% inductions - Flora, vegetation and fauna issues raised in toolbox meetings at least monthly	- ACR - Audits - Contractor monthly reports
3.	EMS	Incident Reporting	- All incidents involving flora, vegetation and fauna will be reported to a supervisor - A formal incident report is to be raised for significant incidents (significance to be determined in CEMP) - Supervisors will take appropriate measures as described in the CEMP to report and manage any incidents - If injured fauna are encountered the Environmental Manager will contact DEC's Wild Care 24 hour hotline on (08) 9474 9055	- All incidents are reported - Incident reporting occurs within the allotted time - All incidents are closed out	- ACR - Audits - Contractor monthly reports - Incident register
4.	Design	Design	- All road design drawings will be reviewed by the Environmental Manager - Any changes to the road design drawings will be reviewed and approved by the Environmental Manager -	- All design drawings reviewed by the Environmental Manager prior to construction - All changes to road design drawings are reviewed and approved by the Environmental Manager prior to construction	- Audits - Design review documentation
5.	Flora and Vegetation	Vegetation Surveys	Prior to clearing operations, a targeted flora survey will be conducted to: - Confirm and mark mapped locations of priority flora - Map weed distribution and topsoil suitability - Identify and mark individual trees, plants or shrubs that are suitable for translocation	- Priority flora, topsoil and weed mapping completed prior to clearing	- Audits - ACR
6.	Flora and Vegetation	Priority Flora	- All populations of priority flora within or adjacent to the project area will be clearly marked, whether or not they are to be cleared - Propagation material will be obtained from all populations of priority flora within the project area for use in rehabilitation and further research	- No impact on priority flora outside of the clearing footprint of the project - Propagation material from priority flora is used in rehabilitation	- Audits - Monitoring - ACR - Seed collected, species and quantity recorded
7.	Flora and Vegetation	Topsoil, mulch and habitat salvage	A Topsoil Management Plan will be developed in accordance with the Rehabilitation Strategy and incorporated into the CEMP. The plan will: - Identify areas of topsoil to be retained and areas to be disposed of - Require all weed free vegetative material to be mulched for reuse in rehabilitation - Require salvaging of fallen logs for respread as fauna habitat in rehabilitation - Identify locations of stockpiles for topsoil, mulch and habitat log salvage	- All non-weedy topsoil is stripped, stockpiled and reused in rehabilitation - All non-weedy vegetation is mulched, stockpiled and reused in rehabilitation - Habitat logs are salvaged prior to clearing, stockpiled and respread during rehabilitation	- Audits - Monitoring - ACR
8.	Flora and Vegetation	Seed Collection	- Prior to clearing, propagation material (seeds and cuttings) will be collected from vegetation within the project area - Propagation material will be used as part of the project rehabilitation	- Seed and other propagation material is collected prior to clearing - Collected seed is used in rehabilitation	- Audits - Monitoring - ACR - Seed collected, species and quantity recorded

Item No	Aspect		Management Action	Target/Indicator	Reporting/Evidence
9.	Flora, Vegetation and Fauna	Clearing Controls	- A system of permits is to be established for clearing operations. Permits are to be authorised by the Environmental Manager and Construction Manager - Prior to clearing operations, the clearing line is to be marked - Prior to clearing, any trees, plants or shrubs identified for translocation will be removed • The Construction Manager and the Environmental Manager will ensure that there is sufficient lead time to allow this to occur - No vehicle or plant movement will be permitted outside the clearing line, except on existing approved tracks - The Environmental Manager (or their delegate as specified in the CEMP) is to be on site during clearing operations - The Environmental Manager is to inspect the clearing line weekly and report any incidents of clearing or vehicle movement outside the clearing line As constructed drawings of clearing are to be produced and updated monthly throughout construction	- No clearing of native vegetation beyond the clearing footprint - Environmental Manager (or delegate) on site at all time during clearing operations -	- Inspection of clearing line - Clearing permits - Monthly Reports - Incident Register - ACR - Surveyed cleared edges
10.	Flora and Vegetation	Weed Control	A Weed Control Plan will be developed in accordance with the Rehabilitation Strategy and the Offset Strategy and incorporated into the CEMP. The plan will: - Identify areas of weed infestation prior to clearing - Specify actions that prevent the introduction or spread of declared plants and environmental weeds - Target the three known weed species in the project area listed as Declared Plants: • Arum Lily (*Zantedeschia aethiopica); • Bridal Creeper (*_Asparagus asparagoides_); and • One-leaf Cape Tulip (*_Moraea flaccida_). - Outline appropriate weed control techniques and herbicides - Incorporates the weed control requirements of the Offset Strategy and Rehabilitation Strategy - Require appropriately qualified herbicide operators - Include a monitoring and auditing program	- No introduction or spread of declared plants or environmental weeds - A reduction in the population of Declared Plants in the project area and in offset areas within Beeliar Regional Park -	- Audits - Monitoring - ACR
11.	Flora and Vegetation	Hygiene Management Plan	A Hygiene Management Plan will be developed and incorporated into the CEMP that includes: - Vehicle and plant hygiene protocols - Protocols to minimise risk of Dieback spread - Demarcation of Dieback control and weed infested areas - Wash down locations	- No introduction or spread of declared plants or environmental weeds - No introduction or spread of dieback -	- Audits - ACR - Site logs for vehicles entering/leaving
12.	Fauna	Trapping and Translocation Programs	- A trapping and translocation program for Southern Brown Bandicoot will be developed in consultation with DEC and in accordance with CALM Policy Statement No 29 Translocation of Threatened Flora and Fauna. The trapping and translocation program will: • Be developed and undertaken by suitably qualified zoologists • Be submitted to the DEC for endorsement at least 3 months prior to the planned commencement of the program • Specify trapping and translocation methodologies, based on relevant and current industry practice and understanding of species biology and ecology • Identify translocation sites • Include post-release monitoring requirements - If Carnaby's Black Cockatoo or Forest Red-tailed Black Cockatoo are found to be breeding within the clearing footprint, a translocation plan will be developed in consultation with DEC - Translocation of the Graceful sun-moth will be in accordance with the Graceful sun-moth Management Plan (to be developed and implemented as part of the Offset Strategy)	- No conservation significant vertebrate fauna killed or injured during construction - Trapping and translocation program is implemented to the satisfaction of DEC	- Audits - Monitoring - ACR
13.	Fauna	Fauna Fencing	- Fauna fencing is to be prior to construction commencing to exclude terrestrial vertebrate fauna from the construction footprint and the operational highway - Temporary fauna fencing installed can be used during construction, but must conform to the standards required for permanent fencing - Fencing specifications (height, mesh dimensions and dig in depth) are to be designed to exclude the Southern Brown Bandicoot from the project area - Escape gates will be incorporated into the fauna fencing design to allow fauna trapped in the road reserve an exit route	- Fauna fencing is installed to prevent vertebrate fauna from entering the construction area	- Audits - Monitoring - ACR

Item No	Aspect		Management Action	Target/Indicator	Reporting/Evidence
14.	Fauna	Fauna Handling	- During clearing operations, a suitably qualified fauna handler will conduct daily pre-clearing surveillance and fauna relocation to: • Minimise vertebrate fauna injuries and fatalities as far as practicable • Ensure trees are bumped or shaken prior to clearing • Inspect all trees removed for fauna too young or unable to leave tree • Relocate any conservation significant fauna encountered during clearing into adjacent areas of remnant vegetation. - A fauna handler is to be on site at all times during clearing operations - At all other times during construction, a fauna handler is to be on call, but not necessarily present on site - Clearing will also be conducted in stages and on one front where possible, to allow for local migration of fauna into adjacent areas - If native fauna is encountered during construction it will be allowed to make its own way from the work area - Where fauna has not made its way from the construction footprint, fauna will be moved to nearby bushland by a qualified fauna handler - Trenches required for the project will be open for the shortest period possible and inspected and cleared of any fauna each morning and evening, and prior to backfilling. - Trenches left open overnight will have a method of egress for trapped fauna	- All vertebrate fauna encountered during clearing or construction operations are safely removed from site without harm to the fauna or personnel	- Audits - Monitoring - ACR
15.	Fauna	Vehicle Strike	- Visual barriers will be installed at critical locations to encourage birds to fly over the height of traffic in consultation with DEC - Replacement power lines will be fitted with high visibility reflectors - Revegetation immediately adjacent (no closer than 10m) to roadsides will not include black cockatoo foraging and nesting species - The CEMP will consider the following: • Appropriate speed limits will be set, signposted and adhered to on all access roads to avoid fauna strike • All vehicles will yield right-of-way to fauna • Speed restrictions will apply in areas between dusk and dawn where there is a high risk of fauna/vehicle collisions • These areas and restrictions will be routinely revised based on records of physical encounters/near misses	- Minimise fauna death and injury due to construction vehicles - Minimise fauna death and injury due to vehicle strike during operation	- Audits - Monitoring - ACR
16.	Fauna	Habitat connectivity and condition	- Dual use underpasses (fauna and pedestrian) and dedicated fauna underpasses will be installed to maintain fauna connectivity between habitat areas across the highway during operation in accordance the guidelines in *Fauna Sensitive Road Design Volume 2* (Queensland Government 2010) - Use of underpasses by fauna post-construction will be monitored - Artificial nesting boxes will be installed to replace lost nesting habitat for wetland birds prior to clearing, with locations determined by a specialist - The Rehabilitation Strategy will incorporate consider the recreation of fauna habitat and movement corridors for fauna where possible	- Connectivity between habitat areas for ground dwelling vertebrates is maintained - Artificial nesting boxes constructed for waterbirds - Fauna underpasses are utilised by ground-dwelling fauna	- Audits - Monitoring - ACR
17.	Fauna	Feral Pest Control	A pest control program will be developed in consultation with DEC that includes: - Waste management. - No domestic pets shall be allowed on site. - Feeding or interacting with feral or native fauna will be prohibited, identified in the induction and regularly repeated in site HSE meetings - A rabbit baiting and/or trapping program to reduce damage to rehabilitation	- No introduction of feral animals or increase in numbers of sightings of feral animal species	- ACR - Audits
18.	Flora, Vegetation and Fauna	Fire	- Consult with FESA regarding the development of a fire management plan - Monitor and adhere to fire bans - Construction machinery fitted with spark arresters - Vehicles fitted with fire fighting equipment and Personnel trained in their use - Hot work permits required for all “hot works” (works that have the potential to create a source of ignition) - Fire fighting equipment is to be available on site	- No ignition of fires from project activities	- ACR - Audits
19.	Flora, Vegetation and Fauna	Dust	- A dust management plan is to be developed and incorporated into the CEMP - The dust management plan is to consider the impacts of dust on flora, vegetation and fauna	- Dust causes no adverse impact on flora or fauna	- ACR - Audits

Item No	Aspect		Management Action	Target/Indicator	Reporting/Evidence
20.	Fauna	Noise	- Minimise the impact of noise from construction and operation on fauna	- No adverse effect on fauna from noise	- ACR - Audits
21.	Fauna	Light	Consideration will be given to using lighting innovations to reduce the impact of light spill on fauna. Options may include: - Low level lighting aimed directly at the road surface - Directional lighting that avoid s light spill into adjacent habitats - Sensor lights - Screening (artificial or vegetative) There is to be no reduction in road safety standards in minimising the effects of light spill on fauna	- Minimise the impact of light spill on fauna habitat - No reduction in road safety standards	- ACR - Audits
22.	Flora, Vegetation and Fauna	Chemical Spills	- Chemicals on-site will be stored appropriately, in secure, bunded locations as per the chemical and hazardous substances guidelines of the CEMP - Accidental spill response actions - Spill will be reported and remediated as quickly as possible to minimise disturbance of the natural environment	- Comply with spill management procedures within CEMP	- ACR - Audits

7.0 Roles and Responsibilities

The responsibilities for each role for the project during construction and operation have been outlined in Table 11 and Table 12. These roles and responsibilities will be incorporated into the CEMP that is developed for the project.

Table 11 Roles and responsibilities during construction under the FVFMP

Construction	
Role	**Responsibility**
Main Roads	- Main Roads has the overall responsibility for the implementation of this FVFMP - The roles below may be delegated to a contractor by Main Roads - If the roles are delegated, Main Roads has the responsibility to audit compliance with the FVFMP
Project Manager	- Overall responsibility for the management of flora, vegetation and fauna
Environmental Manager	- Overall accountability for auditing and compliance assessment with this FVFMP to ensure it is maintained and meets objectives and targets - Provide technical support to all Project personnel to ensure this FVFMP is implemented correctly and complied with - Implement and maintain this FVFMP, review its effectiveness and review the implementation as required - Obtain relevant approvals for fauna disturbance as required - Liaise with stakeholders and technical advisors for advice and resolution of management aspects/objectives as required - Review and close out any corrective actions listed in the Incident Register - Participate in hazard studies, risk workshops and design reviews to ensure fauna risks and opportunities are identified and managed - Report as required to regulating authorities - May delegate all or part responsibility to an appropriately qualified person - May be the on-site fauna handler - Must be on-site during clearing operations
Construction Manager	- Overall accountability to ensure this FVFMP is implemented, reported and maintained on-site. - Ensure personnel attend inductions, have sufficient resources and training to meet the requirements of this FVFMP
Project Engineer	- Ensuring design of Project minimises the impact on significant flora, vegetation and fauna
Fauna Handler	- Must be on-site at all times during clearing operations - Pre-clearing inspections to locate and remove fauna - Daily inspection of pits and trenches - Must be on-call during construction activities other than clearing
Site Supervisor	- Ensure the requirements of the FVFMP is implemented within their area of responsibility as designated by the Construction Manager - Conduct audits, inspections and raise corrective actions where required with input from the Site Environmental Coordinator or as directed by Environment Manager - Provide leadership and training in managing flora, vegetation and fauna
Contractors	- Support the proponent's flora, vegetation and fauna management initiative and culture - Comply with all legal requirements and the requirements of this FVFMP - Ensure staff employed are adequately trained in flora, vegetation and fauna management - Ensure all personnel involved in the project will adhere to FVFMP requirements - Seek advice from proponent when in doubt about requirements
All Personnel	- Must receive induction prior to commencement of work on site - Comply with all legal requirements and the requirements of this FVFMP - Report flora, vegetation and fauna incidents to their Supervisor or Site Environmental Coordinator - Attend environmental inductions and any other training required on fauna management - Participate in toolbox meetings and suggest improvements to flora, vegetation and fauna management

The operational responsibilities for the project have been are outlined in Table 12. The roles and/or responsibilities outlined for operation in this draft FVFMP will be determined during the final audit and review phase after completion of construction. They may also be reiterated within a CEMP in the future management section.

Table 12 Roles and responsibilities during operation

Operational	
Role	**Responsibility**
Main Roads Asset Manager	- Maintain the asset to minimise impact on flora, vegetation and fauna as described in this FVFMP for the duration of the life of the asset - Fully comply with all environmental legislation, government policy and specific conditions associated with the management of flora, vegetation and fauna as described within this management plan. - Implement, maintain and continually improve on the objectives and actions of this FVFMP - Listen and be responsive to community and stakeholder views on flora, vegetation and fauna management and issues - Review and revise FVFMP objectives and targets relating to key FVFMP activities, measure and report progress in achieving these targets.
Main Roads Environment Officer	- Responsible for overseeing implementation of the FVFMP and monitoring the activities of work contractors employed by Main Roads to achieve its objectives - Assesses and audits compliance with this FVFMP - Coordinate Main Roads environmental supervision of key activities/actions listed in this management plan

8.0 Contingency Plan

Non-compliance with management actions outlined in the FVFMP will trigger contingency procedures (formalised within the CEMP) that will address further actions to be taken. These contingency procedures will include specific management measures (and responsible parties) to address any non-compliance that has the potential to impact on flora, vegetation or fauna, deemed an Environmental Incident.

Environmental incidents are events or occurrences that result in, or have the potential to result in, impacts on the environment.

At a minimum the management measures detailed in the CEMP will include:

- Any non-compliance shall be reported as an incident on an Environmental Incident Report form and registered in an electronic database;
- Each incident will be reported and investigated as a minimum as per Main Road's Corporate Procedure 6707/042 Environmental Guideline – Environmental Incident Reporting and Investigation or as specified within the CEMP;
- Causes of incidents will be determined, management procedures will be modified and measures taken (as required) to prevent re-occurrence of incidents;
- All incidents will be reviewed immediately to determine if they require reporting to the appropriate authority. If reporting is required, this will be carried out in writing to the appropriate authority in accordance with Main Roads Corporate Procedure 6707/042;
- Incidents will be tracked to ensure that the appropriate corrective actions and measures are taken to prevent the incident from reoccurring;
- Environmental incidents will be reviewed on a monthly and annual basis to determine incident trends. This will enable targeting of areas that require further adaptive management and will assist in preventing future incidents; and
- An emergency response plan will be implemented to deal with any major environmental incidents.

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9.0 Reporting

Performance reporting will be implemented to produce regular, comprehensive and informative reports on the environmental management and monitoring activities of the project. Monitoring data will be collected as per the management actions of this FVFMP during the audit and review process and Main Roads will undertake internal management review to ensure monitoring commitments are being met.

Internal auditing of activities associated with this FVFMP will be carried out in accordance with the internal audit schedule in Section 10.0 of this FVFMP and outlined by the CEMP and its associated procedures.

Where auditing finds environmental management actions are not being effective, the audits may recommend changes to management actions in this FVFMP and their procedures as highlighted in the CEMP.

Where non-conformance issues or opportunities for improvement are identified, these will be documented and tracked via the review process formally described in the CEMP.

Environmental records are evidence of the ongoing environmental performance of the project and demonstrate conformance with legal and other requirements. Environmental records to be maintained by Main Roads and/or its contractors will include:

- A register of legal and other regulatory requirements including licences and permits;
- A register of environmental aspects and impacts;
- Reports generated as a result of further surveys or investigations;
- Incident reports;
- Training records;
- Inspection, calibration and maintenance records;
- Monitoring data;
- A register of non-conformances;
- Public complaints and responses to these; and
- Internal and external audits and reviews.

9.1 External reporting

Auditing, monitoring and other reporting requirements will be used to provide a report on the management of flora, vegetation and fauna for this project as part of the Annual Compliance Report (ACR). The ACR will report on the compliance of the project to ministerial conditions, and will be submitted to environmental regulators.

9.2 Flora reporting

Reports, databases and registers that are specific to flora and will be generated as a result of the management actions of FVFMP include:

- Flora population constraint maps;
- Register of clearing permits;
- Pre-disturbance flora mapping survey report;
- Conservation Significant Flora database;
- Vegetation Monitoring Program reports;
- Rehabilitation Management Strategy and Rehabilitation Management Plan reports;
- Section of the broader Annual Compliance Report ;
- Flora particulars entered into the Annual Environmental Register;
- Assessment and mapping of weeds and dieback report; and
- Weed Register.

9.3 Fauna reporting

Reports, databases and registers that are specific to fauna and will be generated as a result of the management actions of FVFMP include:

- Significant Fauna Habitat constraint maps;
- Register of Ground Disturbance Permits;
- Pre-disturbance fauna clearance survey report ;
- Fauna Relocation Plan report ;
- Fauna injury or death register;
- Feral Animals Register;
- Feral animal control program report; and
- Section of the broader Annual Compliance Report.

10.0 Audit and review

10.1 Auditing of the FVFMP

Auditing of the FVFMP shall be conducted in accordance with Main Roads Corporate Procedure 6707/044 Environmental Auditing. The type and frequency of auditing shall be in accordance with the schedule in Table 13.

Table 13 Auditing schedule for FVFMP

Audit Type	Timing/Frequency	Scope
Suitability Audit	Prior to ground disturbing activities, after development of CEMP	Ensure the CEMP complies with the FVFMP
Internal Audit of CEMP	At least 6 monthly	Ensure project activities are conducted in accordance with the CEMP
Compliance Audit (FVFMP)	Annually, or whenever CEMP is revised	Ensure CEMP complies with FVMP
Compliance Audit (Ministerial Conditions)	Annually or as required	Audit compliance of project to FVFMP

10.2 Nonconformity, Corrective Actions and Opportunities for Improvement

The CEMP will document and implement a procedure to deal with nonconformities, corrective actions and opportunities for improvement found from project audits against the FVFMP. As a minimum the procedure is required to:

- Maintain a non-conformance register;
- Provide a mechanism to investigate non-conformances;
- Implement corrective actions; and
- Instigate a review of the CEMP and/or FVFMP.

10.3 Review of the FVFMP

It is important that plans and procedures are frequently reviewed and revised as the project undergoes construction and the operation phase begins, and at key points such as when there is a need to improve performance, following incidents and changes in impact frequency or scale; when opportunities for improved management practices are identified; audits are completed; and when the project construction is completed and the operations phase begins.

The FVFMP will be reviewed annually or more frequently if an audit or incident investigation has produced significant additional information that prompts an amendment.

Upon review, the FVFMP will be revised where appropriate and the revision status will be updated in accordance with Main Road's document control procedures.

This review will address the following:

- Any changes in project design or operation that require modifications to the environmental management actions outlined in this FVFMP;
- Any issues identified as a result of internal and external audits, and Main Roads management review of the audit outcomes, in relation to the suitability, adequacy and effectiveness of this FVFMP in meeting the agreed objectives; and
- Corrective or preventative actions developed in response to environmental incidents and non-conformances

After the initial review, the FVFMP will be revised and updated:

- Annually, following feedback on annual environmental reports from relevant stakeholders;
- Prior to the implementation of any significant changes to the key characteristics of the FVFMP;
- If monitoring results indicate that performance objectives are not being met; and
- In the event that new information becomes available regarding improvements in flora, vegetation or fauna management, where relevant to the FVFMP.

11.0 References

Queensland Government (2010). *Fauna Sensitive Road Design. Volume 2.* Retrieved 29 June 2012 from http://www.tmr.qld.gov.au/Business-industry/Technical-standards-publications/Fauna-Sensitive-Road-Design-Volume-2.aspx

SMC (2011). *Roe Highway Extension. Public Environmental Review. 20 June 2011.* Report prepared by South Metro Connect for Main Roads Western Australia.

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Rehabilitation Strategy

Appendix G

Rehabilitation Strategy

Appendix G Rehabilitation Strategy

AECOM

11 July 2012
60100953-413D-EN-REP-0006

Rehabilitation Strategy

Roe Highway Extension



Rehabilitation Strategy

Prepared for

Prepared by

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60100953

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Quality Information

Document Rehabilitation Strategy

Ref 60100953

Date 11 July 2012

Prepared by Nicola Kingdon

Reviewed by John Braid

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
F	20-Mar-2012	Internal Review	Jamie Shaw Associate Director	
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Executive summary

Main Roads Western Australia (Main Roads) proposes to extend Roe Highway approximately five kilometres from its current terminus of Kwinana Freeway in Jandakot to Stock Road in Coolbellup. The extension will consist of a dual carriageway with two lanes in each direction; separated by a concrete barrier in place of a median strip and various interchanges. A preferred design was selected following extensive options analysis and consultative process. Once selected, the design was modified to avoid, minimise and mitigate impacts on vegetation, significant flora, fauna and wetlands in accordance with EPA guidance.

This Rehabilitation Strategy provides an overarching framework to guide the development of a detailed Rehabilitation Plan to be developed and implemented during final design and construction. For rehabilitation treatment types, the project area has been split into four vegetation complexes (Bassendean, Herdsman, Karrakatta and Cottesloe) and six structural treatment types. There are 14 rehabilitation types across the project area:

- Bassendean – Roadsides
- Herdsman – Roadsides
- Karrakatta – Roadsides
- Cottesloe – Roadsides
- Bassendean – Redundant Roads
- Herdsman - Redundant Roads
- Karrakatta – Redundant Roads
- Cottesloe – Redundant Roads
- Bassendean – Interchanges
- Karrakatta – Interchanges
- Cottesloe – Interchanges
- Herdsman - Drainage Basins
- Horse Paddock Swamp
- Arum Lily Control Program.

This Rehabilitation Strategy provides guidance on:

- Species selection for rehabilitation
- Use of Priority flora
- The salvage of fauna habitat material to be utilised in the rehabilitation
- Translocation of mature plants
- Minimising the impact on Carnaby's Cockatoo
- Key rehabilitation tasks
- Completion Criteria
- Schedule of works.

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1.0 Introduction

1.1 Project description

Main Roads Western Australia (Main Roads) proposes to construct the Roe Highway Extension (the project) by extending Roe Highway approximately five kilometres from its current terminus at the Kwinana Freeway in Jandakot to Stock Road in Coolbellup. In August 2009, Main Roads and industry partner, AECOM Australia, formed the South Metro Connect (SMC) alliance. The team was created for the development phase of the project. Its primary objective is to work collaboratively with stakeholders and regulatory authorities to develop an environmentally, socially and economically acceptable project design and obtain relevant statutory environmental and heritage approvals.

The project is located approximately 14 kilometres south of Perth within the Swan Coastal Plain Bioregion (Figure 1). The project area is largely contained within the City of Cockburn, however, parts of the design extend northward in to the City of Melville along Murdoch Drive and Kwinana Freeway. Generally, the proposed project is oriented east-west, within a road reserve that was set aside in the Metropolitan Region Scheme (MRS) in 1963. The alignment is between North and Bibra Lakes, which are part of the Eastern Chain of the Beeliar Wetlands.

The project will consist of a dual carriageway with two lanes in each direction; separated by a concrete barrier in place of a median strip. The preferred design was selected following an extensive options analysis and consultative process. Once selected, the preferred design was optimised to avoid and minimise environmental impacts to the maximum extent possible.

1.2 Purpose of document

Main Roads has committed to the implementation of this Rehabilitation Strategy. It provides a framework to guide the development of a detailed Rehabilitation Plan to be implemented during construction of the Roe Highway Extension Project.

This Rehabilitation Strategy has been prepared by SMC to guide and describe the overarching approach to the rehabilitation of the project area. All areas disturbed during project activities and not part of the paved surface, or required for operational maintenance are to be rehabilitated. Areas to be rehabilitated include roadsides, redundant roads, drainage basins, interchanges and Horse Paddock Swamp.

This Rehabilitation Strategy has been developed in conjunction with the Flora, Vegetation and Fauna Management Plan (FVFMP). It aims to maintain the abundance of species diversity, geographic distribution and productivity of vegetation habitat by:

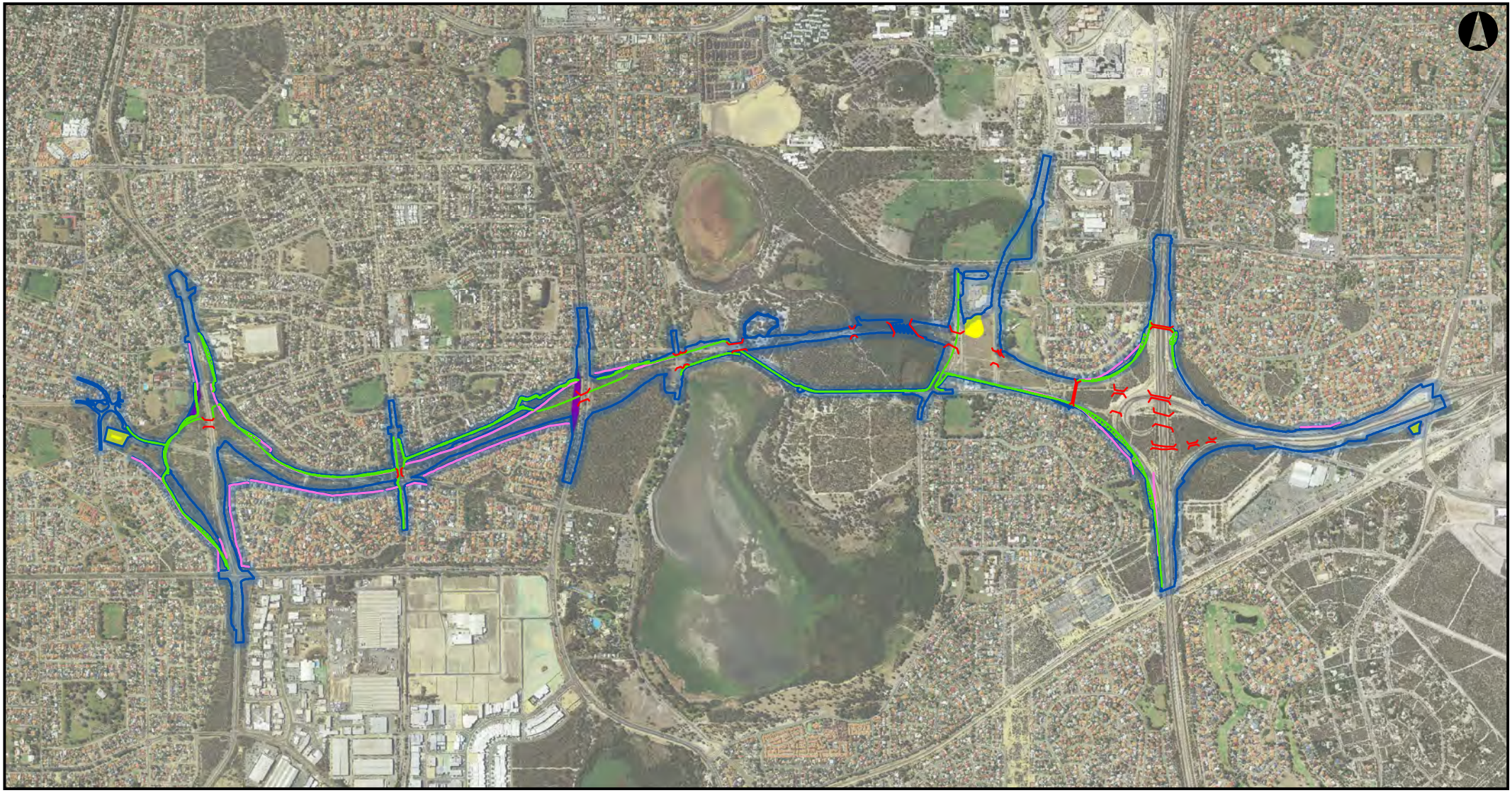
- rehabilitating all areas disturbed during the project, except those areas that form part of the final paved surfaces or required for operational maintenance
- rehabilitating redundant roads
- returning a level of species and structural diversity to disturbed areas
- maintaining biodiversity by controlling weeds in rehabilitated areas.

1.3 Rehabilitation objectives

The objectives of rehabilitation within the project area include:

- vegetation is established to maintain roadside and road formation stability
- creation of fauna habitat within rehabilitated areas through species and structural diversity of the rehabilitation
- rehabilitation works improve the visual amenity
- rehabilitation is comprised of species that will survive and perpetuate with minimal ongoing maintenance in the form of watering and weed control
- species selection is suitable at a regional and local scales
- roadside revegetation meets community expectations related to amenity and aesthetics

- appropriate salvage operations are conducted during clearing operations to provide topsoil, mulch and habitat logs for rehabilitation
- weed control of areas outside of the project footprint in accordance with the Offset Strategy
- restoration of Horse Paddock Swamp, in accordance with the Offset Strategy
- enhance the wetland areas within the project area as much as possible.



Roe Highway Extension Construction Envelope

South Metro Connect

0 250 500 750 1,000

Metres

1:27,500 (A4)

- Road Formation
- Bridge Abutment
- Principal Shared Paths
- Indicative Noise Walls Design
- Construction Envelope
- Temporary Bypasses
- Laydown Areas

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2.0 Objectives and relevant legislation

The relevant legislation pertaining to vegetation protection, management and rehabilitation within the Roe Highway Extension Project are detailed below (Table 1 and Table 2).

2.1 Relevant legislation

Table 1 Relevant legislation and the area to which it applies

Legislation	Application Area
Soils and Land Conservation Act 1945	Prevention of soil and land degradation within the project area
Wildlife Conservation Act 1950	Protection of rare flora and fauna in the project area
Environmental Protection Act 1986	Minimising environmental impacts within the project area
Environment Protection and Biodiversity Conservation Act 1999	Nationally significant species within the project area
Environmental Protection Amendment Act 2003 (Environmental Protection, Clearing Permits)	Control vegetation clearing within the project area

2.2 Relevant guidelines and policies

Table 2 Relevant guidelines and policies and the areas in which it applies

Guidelines and Policies	Application areas
EPA Position Statement No.2 – Environmental Protection of Native Vegetation in Western Australia	Clearing of vegetation within the project area
CALM Draft Policy, Statement No. 9 – Conserving Threatened Species and Ecological Communities	Threatened species within the project area
Environmental Weed Strategy for WA (1999)	Weeds of environmental concern within the project area
State Weed Strategy for WA (1999)	Weeds species found in the project area
Phytophthora cinnamomi and diseases caused by it, Volume 1 – Management Guidelines (CALM, 2000)	Dieback management in the project area
Managing Phytophthora dieback, Guidelines for Local Government (Dieback Working Group, 2000)	Dieback management in the project area
Main Roads Environmental Guideline 6707/022 – Vegetation Placement	Placement of vegetation on roadsides

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3.0 Environmental Management Plan commitments

Rehabilitation and weed management commitments for the proposed project are summarised in Table 3 as written in the PER. These commitments are to be carried forward into the Rehabilitation Plan.

Table 3 Rehabilitation, weed and reporting management commitments

Aspect	Commitment	Commitment Reference
Rehabilitation	- Main Roads will implement a progressive rehabilitation program for areas within the final Roe Highway road reserve that are cleared for construction purposes or currently degraded and are not required for operational purposes such as access and maintenance	PER Section 9.2.6.1
	- Main Roads will utilise local provenance species aimed primarily at increasing available black-cockatoo foraging, potential future nesting and roosting habitat.	PER Section 9.2.6.1
	- The rehabilitation and restoration program will also focus on enhancing local biodiversity and improving visual aesthetics within the road reserve	PER Section 9.2.6.1
	- Restoration of 8.4ha of Horse Paddock Swamp - Main Roads will implement a wetland restoration and rehabilitation program (WRP) within the Beeliar Regional Park. Direct offsets will incorporate both site led restoration activities and species led weed control that, when combined, achieve improvements over an area of approximately 13.4ha. - The wetland restoration plan will be finalised prior to the commencement of any ground disturbing activities within the Roe Swamp CCW to enable the inclusion of an investigation into the viability of translocating wetland vegetation to Horse Paddock Swamp. If it can be proved viable, the rehabilitation program will also include translocation to Horse Paddock Swamp of wetland vegetation sourced from within the construction envelope at Roe Swamp. - Main Roads will monitor and implement remedial measures until the criteria outlined in the WRP have been met, or the OEPA agrees that work is complete (whichever is sooner).	Offset Strategy
Weed Management	- Main Roads will ensure that no new species of weed (including Declared Plants and environmental weeds) are introduced into the final amended road reserve as a result of the proposed project, for 3 years following completion of construction	PER Section 9.2.5.1
	- Weed control and rehabilitation of approximately 5ha of degraded wetland fringes of North Lake	Offset Strategy
	- Prior to commencement of construction, Main Roads will prepare, in consultation with DEC an Arum Lily (*Zantedeschia aethiopica*) Control Program (ALCP) with the objective of controlling Arum Lily within the MRS road reserve. Main Roads will implement the ALCP prior to transfer of the MRS road reserve to the DEC	Offset Strategy
Reporting	- Monitoring results will be complied in a report and provided to the EPA as part of the Annual Compliance Report. The ACR will highlight the results of the monitoring program, discuss performance and specify any corrective actions recommended.	PER Section 9.2.6.4
Completion Criteria	- Main Roads will agree completion criteria with DEC prior to completion of construction activities. It is proposed that completion criteria will be based on the following measurements: 1) Average native stems per hectare; 2) Native foliage cover; 3) Species diversity; 4) A ratio of weeds to natives, based on projected foliage cover of; and 5) Extent of erosion on roadside batters.	PER Section 9.2.6.2

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4.0 Existing environment

A brief summary of the project's existing environment is included below. For a more detailed description of the existing environment see the Roe Highway Extension Public Environmental Review (PER) (SMC 2011).

The project area is made up predominantly of *Banksia* woodland and areas of wetland vegetation, all with varying levels of disturbance and integrity. The construction envelope spans an area of approximately 148 hectares and is made up of four vegetation complexes with a total of 40 different vegetation communities. The vegetation complexes found in the project area are described in Table 4.

Table 4 Vegetation Complexes present within the project area as described in the PER and the areas of vegetation to be removed through construction

Vegetation Complex	Description	Area of proposed clearing (ha)
Bassendean Complex Central and South	Woodland of Jarrah-Marri with well defined second storey of Pink Summer Calytrix (*Calytrix fraseri*) and Bull Banksia (*Banksia grandis*) on the deeper soils and a closed scrub on the moister soils. The understorey species reflect similarities with the adjacent vegetation complexes.	35.9
Herdsman Complex	Sedgelands and fringing woodland of Flooded Gum (*Eucalyptus rudis*) and *Melaleuca* species.	3.0
Karrakatta Complex Central and South	Predominantly open forest of Tuart-Jarrah-Marri and woodland of Jarrah and *Banksia* species.	21.2
Cottesloe Complex Central and South	Mosaic woodland of tuart and open forest of Tuart-Jarrah and Marri, closed heath on the limestone outcrops	19.1

Six Priority species were recorded in the project area and are described in Table 5. These species were also found within the project footprint. A total of 15 sub-populations of Priority Flora, consisting of approximately 7,000 individual plants are likely to be impacted by the proposed clearing.

The construction of the project will see the clearing of 79.3 hectares of bushland with approximately 38 hectares able to be rehabilitated following the construction phase. 45.36 hectares (57.2%) of the bushland is described as being in 'Degraded to Good or better' vegetation condition. Seven hectares of Bush Forever Site 244 will be within the construction footprint.

Table 5 Priority species occurring within the project area

Species	Conservation Status	Description
Dampiera triloba	Priority 1	Erect perennial, herb or shrub to 0.5 metres high. Flowers blue from August to December
Tetraria sp. Chandala (G.J. Keighery 17055)	Priority 2	Slender sedge up to 1.5 metres high and 0.3 metres wide. Flowers brown
Cyathochaeta teretifolia	Priority 3	Rhizomatous, clumped, robust perennial, grass-like or herb (sedge) to 2 metres high to 1 metre wide. Flowers brown
Jacksonia gracillima	Priority 3	Low spreading shrub up to 1.5 metres high and 1 metre wide. Flowers orange, orange-yellow.
Eryngium pinnatifidum subsp. *palustre* (ms)	Priority 3	Erect, perennial, herb, 0.15 to 0.5 metres high. Flowers white/blue from October to November.
Dodonaea hackettiana	Priority 4	Erect shrub or tree 1 to 5 metres high. Flowers yellow-green/red, mainly July to October.

129 introduced or non-endemic species were identified within the project area including three listed as Declared Plants (Table 6).

Table 6 Declared Plant species found within the project area

Species	Description	Control Measures
Arum Lily (*Zantedeschia aethiopica*)	Robust, dark green succulent herb found in creeks, irrigation ditches and areas of summer-moist land. Forms large dense clumps	Herbicides from June to October
Bridal Creeper (*Asparagus asparagoides*)	Climbing herb or vine to three metres. Frost tolerant and can also survive summer drought	Herbicides from mid June to late August
One Leaf Cape Tulip (*Moraea flaccida*)	Perennial herb to 0.7 metres high, distinguished by fibrous sheathed corm at the base of the plant	Herbicides from August to September

Five conservation significant fauna species (excluding wetland and shore birds) were found to occur in the project area (Table 7). The habitat for three recorded Commonwealth and State conservation significant fauna species will be removed during construction. These three species are:

- Carnaby's Cockatoo
- Forest Red-tailed Black Cockatoo
- Graceful Sun Moth.

Table 7 Conservation significant fauna species (excluding wetland and shore birds) found within the project area

Species	Status	Habitat description
Carnaby's Cockatoo	Endangered	*Eucalyptus* woodlands especially Salmon Gum and Wandoo, or shrubland or kwongan heath
Graceful Sun Moth	Endangered	*Banksia* woodland. Dependant on two known host plant species *Lomandra hermaphrodita* and *Lomandra maritima*
Forest Red-tailed Black Cockatoo	Vulnerable	Dense Jarrah, Karri or Marri forests
Perth Lined Lerista	P3	*Banksia* woodlands, sandy coastal heath and low shrubland in soils containing a low percentage of clay
Southern Brown Bandicoot	P5	Densely covered, scrubby, often swampy vegetation up to one metre high

The project will have a direct impact on Conservation Category Wetlands (CCW) and on lakes protected under the *Environment Protection Policy Swan Coastal Plain Lakes* (Lakes EPP). The areas of wetland affected by the proposal are:

- Bibra Lake –1.0ha Lakes EPP wetland
- Horse Paddock Swamp – 0.2ha CCW
- Melaleuca Swamp – 0.2 ha CCW
- Roe Swamp – 5.6ha CCW.

5.0 Implementation

All non-paved areas forming part of the project and other areas disturbed during construction that are not required for ongoing operational maintenance access will be rehabilitated. This includes roadside batters, drainage basins, access tracks, laydown areas and redundant roads. In some cases (offsets), areas which will not be disturbed during construction will be rehabilitated.

5.1 Vegetation Placement within the Road Reserve

All planting and seeding is to be conducted in accordance with Main Roads Environmental Guidelines 6707/022 *Vegetation Placement* and 6707/045 *Vegetation Control.*

5.2 Rehabilitation Tasks

The rehabilitation program has been split into several tasks which will generally occur in succession. Listed below are the tasks which will be included in the detailed Rehabilitation Plan which is to be produced prior to commencing any rehabilitation works. Refer to Section 5.0 for the rehabilitation treatment types.

5.2.1 Seed Collection

- ***Site-won Seed***
  - Seed is to be collected from inside the project area prior to clearing and will be used in rehabilitation.
- ***Seed Collection (outside project area):***
  - Seed is to be collected by appropriately trained people or through professional services
  - Seed may be purchased through accredited seed merchants
  - Where required seed storage will be undertaken in accordance with best practice methods.
- ***Pre-treatment:***
  - The pre-treatment of seed will be completed prior to the seeding process.

5.2.2 Topsoil and Mulch Management

- ***Topsoil Management Plan***
  - The Rehabilitation Plan is to include a detailed Topsoil Management Plan that includes:
  - ***Topsoil Mapping***
    - Prior to clearing a topsoil map is to be produced that identifies:

      Presence of Declared Plants, significant grassy weeds and other environmental weeds

      Presence of other weeds

      Vegetation type

      Suitability of topsoil for reuse
    - Topsoil in areas containing Declared Plants (eg Arum Lily), grassy weeds (eg Veldt Grass, African Lovegrass) or other environmental weeds is not to be used in rehabilitation.
  - ***Weed Infested Topsoil***
    - Weed infested topsoil will be disposed of offsite or by burying beneath at least 1 metre of clean fill
    - Weed infested topsoil is not to be used in rehabilitation.
  - ***Stripping and Stockpiling***
    - Topsoil is to be stripped to a depth of 150mm
    - Weed free topsoil shall be stockpiled as close as practicable to where it was stripped
    - Weed free site-won vegetation from the clearing is to be mulched and stockpiled.

- ***Imported Topsoil***
    - Any imported topsoil shall be certified as dieback and weed-free
    - Imported soil is to be in accordance with Australian Standards AS4419, AS4454, and AS3743.
- ***Respreading***
    - Prior to respreading the mulch shall be mixed with the topsoil
    - The topsoil-mulch mix will be respread over all rehabilitation areas to a depth of at least 50mm
    - Topsoil/mulch is to be tracked in using a tracked bobcat, light bulldozer, or equivalent.
- ***Timing***
    - *Stripping and Stockpiling* – Occurs concurrently to clearing.
    - *Respreading* – Occurs in late summer/early autumn in conjunction with Site Preparation.

5.2.3 Site Preparation

- ***Earthworks***
    - Rehabilitation areas are to be contoured (if applicable) prior to topsoil and mulch respread.
    - Areas (in particular roadsides batters) are to be 'roughened' to encourage seed germination, plant establishment and water drainage.
- ***Pest Control***
    - Consult with DEC to consider whether a baiting program for rabbits is appropriate.
- ***Timing***
    - Site preparation should occur in late summer/early autumn.

5.2.4 Weed Control

5.2.4.1 Prior to Planting and Seeding

- Prior to seeding and planting all weeds within rehabilitation areas are to be removed or killed.

5.2.4.2 During Maintenance

- An annual weed control program will be developed during the maintenance period that will include the following:

Herbicides

- Herbicides are only to be applied by accredited contractors.
- Selective herbicides should be considered for the control of grassy weeds in revegetation.
- May be applied using the following methods:
    - Herbicide Wipe
    - Spot Spraying
    - Blanket Spraying
- Consideration should be made for avoiding the use of herbicides within close proximity to wetland areas;
- No herbicide spraying within or in close proximity to areas of significant vegetation or flora populations; and
- No herbicide spraying in windy conditions.

Non-Chemical Weed Control

- Non-chemical forms of weed control such as, but not limited to, mechanical or solarisation, will be investigated.

5.2.4.3 Timing

- Spot spraying of all rehabilitated areas will occur twice a year. Spraying will occur:
  - In late autumn/ early winter.
  - In late winter/early spring prior to seed set.

5.2.5 Seeding

- ***Species Mix***
  - Seed mixes will be prepared in accordance with the different rehabilitation treatment types (see Section 6.0and Appendix A) within the project area;
  - Mixes shall also consider the landscape being revegetated and the condition of the areas; and
  - The seed mixes will incorporate site-won seed (where available).
- ***Seeding***
  - Areas will be seeded to a minimum of 4.5 kg per hectare.
- ***Timing***
  - Seeding is to occur in mid autumn prior to winter rains.

5.2.6 Planting

- ***Tube-Stock***
  - Tube-stock will be utilised for the rehabilitation program
  - All tube-stock will be sourced from accredited nurseries and is to be certified as dieback and disease free
  - Tube-stock will be ordered several months in advance so that they are of an acceptable size for planting activities
  - Tube-stock will be planted at a density of at least one stem per m^2.
- ***Artificial Watering***
  - Native tube-stock and seedlings may be artificially watered in the first summer to increase survival rates, as required
  - If advanced material is translocated to be utilised in rehabilitation a watering program is to be implemented
  - Non-native or non-endemic plants used for landscaping purposes may be artificial watered.
- ***Timing***
  - *Drainage Basins* – Planting will occur in late summer/early autumn.
  - *Other Areas* – Planting will occur in early winter at the break of season.

5.2.7 Translocation of Plants

- Mature plants identified for translocation will be removed from the project area prior to clearing;
- Consideration should be given to translocating as much vegetation as possible from wetland areas to be cleared into the Horse Paddock Swamp restoration works
- Individual plants for translocation will be identified during targeted flora surveys as part of the FVFMP
- Translocation works should include consultation with Botanical Parks and Gardens Authority, to assist in the identification of potential species for translocation
- Translocation is to include: Grasstrees (*Xanthorrhoea preissii*), Western Australian Christmas Tree(*Nuytsia floribunda*) and potentially *Banksia* species
- Not all individuals of species identified for translocation are required to be salvaged.

5.2.8 Monitoring

- ***Assessments***

  - There will be two assessment types undertaken in the monitoring of revegetated areas and are described below.
  - *Monitoring quadrats and transects*
    - The aim of quadrat and transect monitoring is to provide quantifiable data for the assessment of the rehabilitation against the completion criteria
    - Quadrats or transects with an area of 100m^2 are to be used to record:
      a) Native species present
      b) Weed species present
      c) Number of stems of native species
      d) Projected foliage cover of native species
      e) Projected foliage cover of weed species.
    - At least one quadrat/transect is required for each treatment type; and
    - At least one quadrat/transect is required for each hectare of rehabilitation.
  - *Rapid Assessment Areas*
    - The aim of the rapid assessment monitoring technique is to provide information on areas where further rehabilitation works are required
    - Rapid assessment will include a visual assessment of:
      a) Visible health of maturing vegetation (classified as ‘healthy’, ‘slightly stressed’, ‘stressed’, or ‘very stressed’)
      b) Observations of bare areas or erosion scours
      c) Other observations including vandalism and grazing of vegetation
      d) Observations on extent of weeds present, including Declared Weeds and Environmental Weeds
      e) A photo from a designated point that can be compared to previous and/or subsequent photos to assess the maturing vegetation growth and visual aesthetics.
    - The Rapid assessment is to identify areas within the rehabilitation works that require a priority for further works or maintenance activities.

- ***Timing***

  - Monitoring will be conducted over a five year period from the end of the construction phase
  - Quadrats/Transects monitoring shall be carried out annually
  - Rapid assessments will be conducted twice a year.

- ***Remedial Action***

  - Rapid assessment monitoring is to be used to trigger management actions including erosion control, weed control and infill planting.

5.2.9 Maintenance

- ***Weed Control***

  - Weed control will include spot spraying of all rehabilitated areas at least twice per year in accordance with Section 5.2.4.2.
  - Ongoing weed control will be conducted for Horse Paddock Swamp, North Lake and the Arum Lily Control Program.

- ***Infill Planting***
    - Infill planting will be conducted for at least two years following from the original planting.
    - Infill planting will include at least 20% of the numbers of tube-stock of the original planting.
- ***Erosion Control***
- ***Timing***
    - Maintenance of the rehabilitation areas will be conducted as required until the handover to the DEC or other parties.

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6.0 Treatments

Rehabilitation treatments within the project area have been broken up into 14 treatment areas, determined by: pre-existing vegetation type; location of rehabilitation within the road reserve and special interest areas (Table 8). The broad location of the treatment areas is shown in Figure 2.

6.1 Vegetation complexes

Rehabilitation areas have been determined according to their pre-existing vegetation complexes:

- Bassendean
- Karrakatta
- Herdsman
- Cottesloe

6.2 Rehabilitation Location

Each vegetation type contains three different locations that require different rehabilitation treatments. These include:

- Roadside batters
- Redundant roads
- Drainage basins.

6.3 Special Treatments

Three “special” treatment types are also included within the rehabilitation of the project area.

- Interchanges:
- These areas were identified in the Landscape and Urban Design Framework (LUDF) (Appendix X2 of the PER) as significant feature nodes and areas for feature formal tree planting. In particular the Roe Highway/ Kwinana Freeway Interchange presents an opportunity for a major gateway with structured planting of native species and land art to enhance the experience. Refer to Appendix X2 of the PER for more detail.
- Horse Paddock Swamp:
    - Rehabilitation and revegetation of 8.4 hectares of Horse Paddock Swamp as part of Offset Proposal 2 (see Offset Strategy).
- Arum Lily Control Program:
    - Development and implementation of an Arum Lily Control Program as part of Offset Proposal 3 (see Offset Strategy).

6.4 Timeline

A suggested timeline for rehabilitation activities is shown in Figure 3.

6.5 Species Selection

Species selection is to be in accordance with the pre-existing vegetation complex. Appendix A provides a suggest species list for each vegetation complex. These lists are not exhaustive and are intended as a start point for the development of a complete species list for rehabilitation.

Propagation material for any priority flora species impacted by the project shall be incorporated into the rehabilitation works.

6.6 Fauna Habitat

Plant species selection for the rehabilitation works should also maximise the ability of fauna to use the rehabilitation as feeding and breeding habitat. Appendix E contains a list of plant species favoured by fauna.

Logs salvaged during clearing should be placed strategically in the rehabilitation to create fauna habitat.

6.6.1 Carnaby's Cockatoo Foraging Habitat

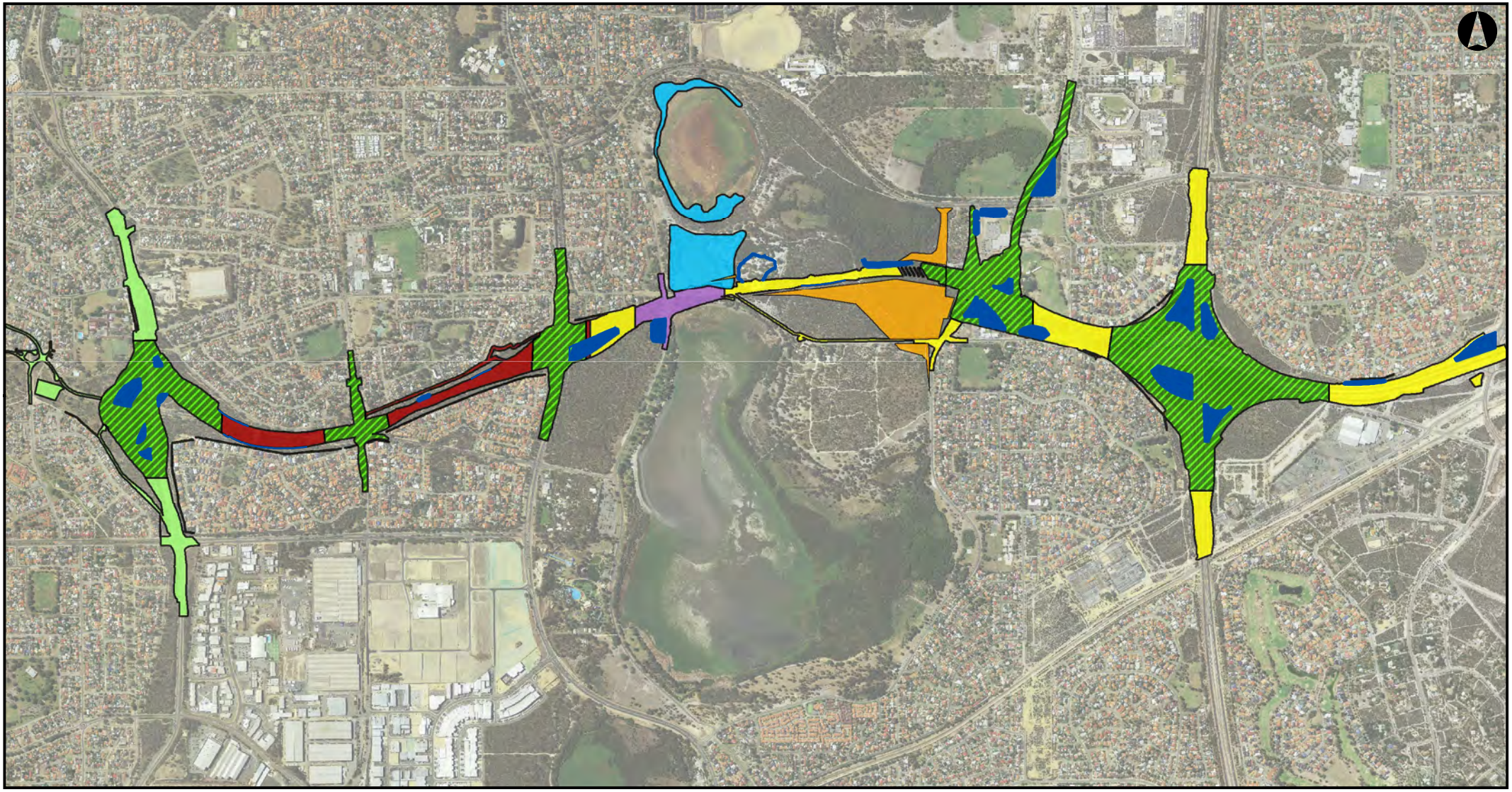
Vehicle strike is a significant risk to Carnaby's Cockatoo. To mitigate the risk of vehicle strike to Carnaby's Cockatoo, plant species that Carnaby's Cockatoo regularly forages upon will not be planted in close proximity to the road. The following species will not be planted within 10m of the road edge:

- *Banksia attenuata*
- *Banksia menziesii*
- *Corymbia calophylla*
- *Eucalyptus marginata*
- *Allocasuarina fraseriana.*

Preferably no Carnaby's Cockatoo foraging species will be planted within 10m of the road edge. Appendix B contains a list of preferred foraging and breeding flora species for a number of fauna species. Further consultation with DEC and the WA Museum is required during the development of the Rehabilitation Plan.

Table 8 Rehabilitation Treatment Types within the Roe Highway Extension project area.

Item	Rehabilitation Treatments	Species Selection	Site Preparation	Seeding Rate	Planting Density
1	Bassendean - Roadsides	- See Appendix A	- See Section 4.2.3	- See Section 4.2.5 - At least 4.5kg per hectare	- See Section 4.2.6 - At least 1 stem per metre^2
2	Herdsman - Roadsides	- See Appendix B			
3	Karrakatta – Roadsides	- See Appendix C			
4	Cottesloe - Roadsides	- See Appendix D			
5	Bassendean – Redundant Roads	- See Appendix A	- See Section 4.2.3 - Prior to topsoil/mulch respread pavements and/or bitumen will need to be removed and the area ripped to the depth of compaction or to at least 1 metre	- See Section 4.2.5 - At least 4.5kg per hectare	- See Section 4.2.6 - At least 1 stem per metre^2
6	Herdsman - Redundant Roads	- See Appendix B			
7	Karrakatta – Redundant Roads	- See Appendix C			
8	Cottesloe – Redundant Roads	- See Appendix D			
9	Bassendean - Interchanges	- Potential for specially landscaped areas/nodes - Where it is decided that the interchanges shall not become a node, it will be rehabilitated as per the Roadside treatment of that vegetation complex (e.g. Cottesloe – Interchanges becomes Cottesloe – Roadsides)			
10	Karrakatta – Interchanges				
11	Cottesloe – Interchanges				
12	Herdsman - Drainage Basins	- See Appendix B	- No topsoil and mulch respread	- No seeding	- See Section 4.2.6 - Planting of at least 1 stem per metre^2 above low water mark only
13	Horse Paddock Swamp	- Development and implementation of a Wetland Restoration Program in accordance with Offset Proposal 2 - Refer to Section 6.7			
14	Arum Lily Control Program	- Development and implementation of an Arum Lily (*Zantedeschia aethiopica*) Control Program as outlined in Offset Proposal 3 - Refer to Section 6.8			



Roe Highway Extension Rehabilitation Treatments

South Metro Connect

0 250 500 750 1,000

Metres

1:25,000 (A4)

Rehabilitation Treatments

- Interchange Treatment
- Bassendean Treatment
- Cottesloe Treatment
- Herdsman Treatment
- Karrakatta Treatment
- Arum Lily Control Program
- Horse Paddock Swamp Rehabilitation
- Drainage Basins

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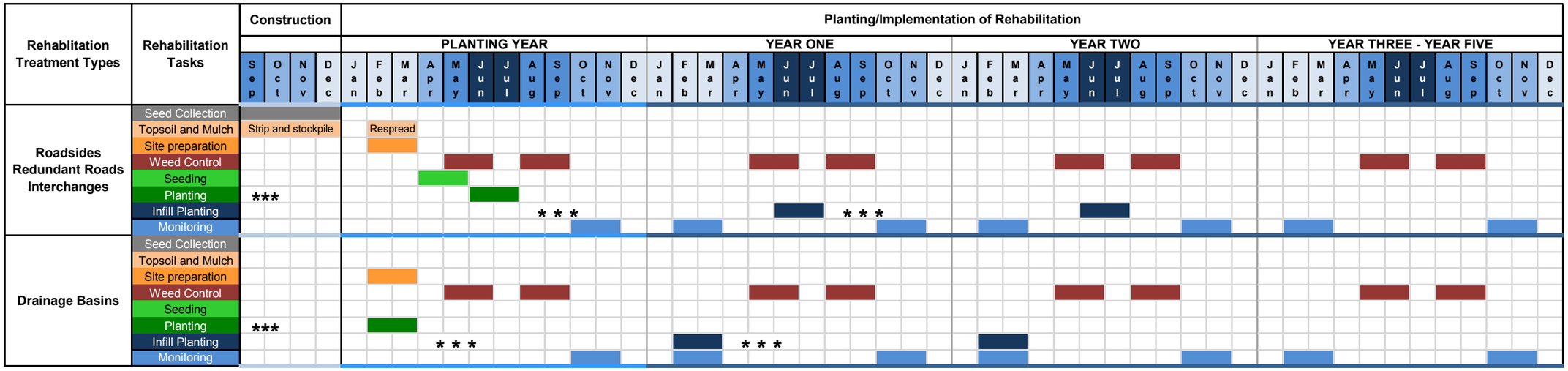
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Last Printed: 29/06/12



* * *	Place seedling orders with nursery. Liase with nursery as to the exact timing of orders
Seed Collection	Collection of seed inside project area. Seed may be purchased from accreditied busninesses
Topsoil and Mulch	Removal of topsoil prior to clearing and stockpiling of topsoil and mulch. Respreading in conjunction with site preparation
Site Preparation	Preparation of the site including earthworks, pest control, and spreading of topsoil and mulch
Weed Control	Eradication of weeds prior and during rehabilitation activities
Seeding	Spreading of seed across rehabilitation areas. Includes pre-treatment as required
Planting	Planting of tube-stock in rehabilitation areas
Infill Planting	Commencement from Year One of Monitoring. Shall occur for at least two years
Monitoring	Annual monitoring for a period of five years from the end of the construction phase. Includes rapid and detailed assessments

Mean Rainfall (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	> 20	> 20	> 20	20-80	80-140	> 140	> 140	80-140	80-140	20-80	20-80	> 20

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6.7 Horse Paddock Swamp

Horse Paddock Swamp is part of an offset proposal that will incorporate the restoration of Horse Paddock Swamp and parts of North Lake (Figure 4). A Wetland Restoration Plan (WRP) will be developed and implemented in accordance with the Offset Strategy and in consultation with DEC. Elements to be included in the WRP are included in Table 9.

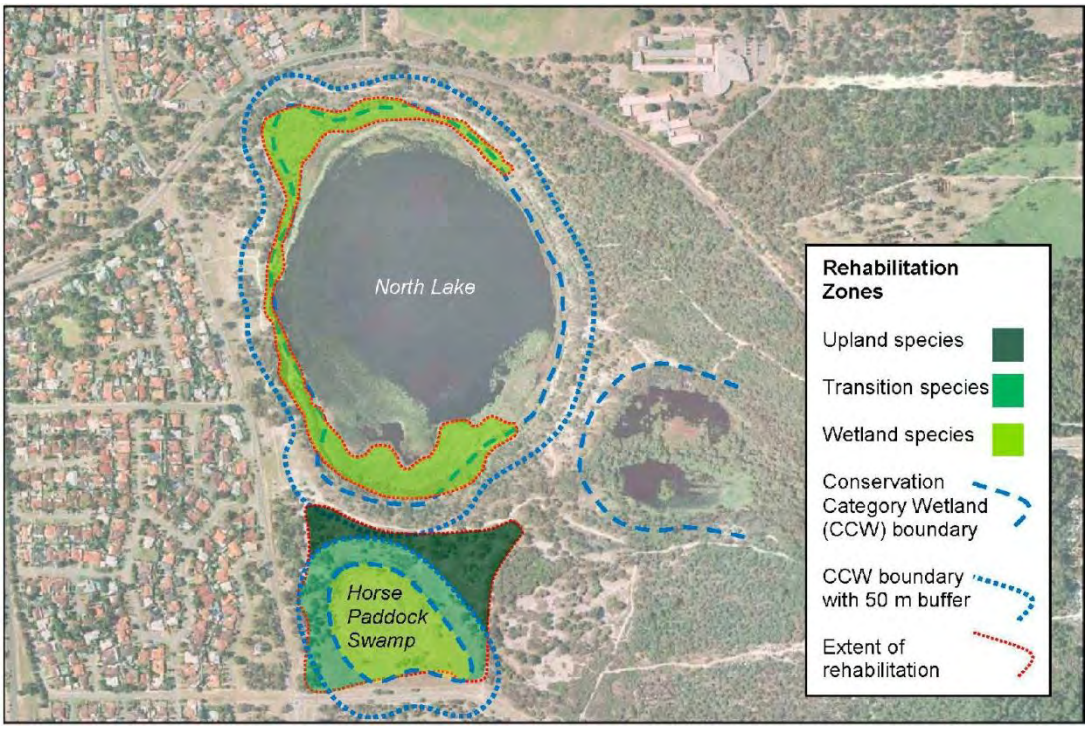


Figure 4 Suggested plan for the restoration of Horse Paddock Swamp and weed control on the fringes of North Lake

Table 9 Elements of the Wetland Restoration Plan

Elements to be incorporated into Wetland Restoration Plan
Weed control within North Lake and the restoration of Horse Paddock Swamp and North Lake wetland fringes is intended to establish historical wetland values through a program of rehabilitation that: - enhances wetland vegetation characteristics (by improving the density and diversity of vegetation) - prepares the site and manages topsoil and microhabitat, salvaging and recycling suitable soil and habitat logs from areas of Roe Swamp designated for clearing - prevents fauna and human access to the rehabilitation area by fencing (fencing may be removed upon successful establishment of planted vegetation) - removes and controls weeds - collects and propagates suitable seed and vegetative material of appropriate provenance in a timely manner to allow seedlings to be planted at a planting density to be agreed with DEC - re-establishes native wetland vegetation by planting seedlings and augmenting with direct seeding (if appropriate) - times the planting of seedlings to make the most beneficial use of natural rainfall and seasonal groundwater conditions by corresponding planting times with position in the landscape - considers limited artificial watering over the first summer to help ensure survival through the initial establishment period

Elements to be incorporated into Wetland Restoration Plan

- where practicable, translocates suitable plants from within the clearing envelope into Horse Paddock
- where practicable, uses provenance species and genetic material
- re-establishes at Horse Paddock Swamp and other locations, species that are relatively uncommon now on the Swan Coastal Plain, e.g. *Banksia littoralis* and *Melaleuca lateritia*
- a detailed monitoring program will be agreed with DEC during the preparation of the WRP. As a minimum, the detailed monitoring program will include:
    - annual spring monitoring surveys every spring for five years following the completion of construction
    - at least one permanently marked 10m x 10m monitoring quadrat or transect will be set up per hectare of rehabilitation for each habitat type (i.e., upland, transition and wetland)
    - monitoring transects of sufficient length to cross transition zones between habitat types, which will be designed to provide data regarding:
        - site stability
        - infiltration; and
        - nutrient cycling.
- assess for completion criteria after 5 years.
- completion criteria, linked to the following parameters:
        - percent foliage cover
        - stem density
        - health of vegetation within restored and rehabilitated areas; and
        - percent weed cover;
- contingency and corrective actions; and
- reporting requirements.

6.8 Arum Lily Control Program

An Arum Lily Control Program (ALCP) will be developed in consultation with DEC, in accordance with the Offset Strategy. The ALCP is to control Arum Lily in the redundant road reserve to be incorporated into Beeliar Regional Park as part of Offset Proposal 3 (Figure 2).

7.0 Roles and Responsibility

The roles and responsibilities for the development and implementation of the Rehabilitation Plan are listed below:

- Main Roads:
  - Overall responsible for the successful implementation of rehabilitation works
  - Handover of rehabilitation areas to the ongoing management authority at the completion of works
  - Can delegate the positions below to the construction contractor.
- Project Manager:
  - Overall responsibility for the rehabilitation.
- Construction Manager
  - Management of topsoil
  - Ensuring the construction schedule includes consideration for the rehabilitation program
  - Site preparation.
- Environmental Manager
  - Develop Rehabilitation Plan, in accordance with this Rehabilitation Strategy
  - Audit compliance of Rehabilitation Plan to this Rehabilitation Strategy
  - Supervision of topsoil stripping and topsoil/mulch stockpiling
  - Supervision of topsoil and mulch respread
  - Ordering plants and seed
  - Supervision and inspection of site preparation, including pre-planting weed control
  - Auditing compliance with Rehabilitation Plan
  - Implementation of seeding and planting activities
  - Implement WRP and ARCP
  - Implementation maintenance program.

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8.0 Completion criteria

To ensure that sites are rehabilitated to a minimum standard, completion criteria have been developed for this project. The completion criteria for this project are based on species diversity and average abundance for a range of site conditions. An outcomes based approach may be considered for the rehabilitation program.

The completion criteria will include the following:

- ***Vegetation Cover***
  - Vegetation cover for all non-paved areas must meet the requirements listed in Table 10. Projected foliage cover is the proportion of the ground covered by the vertical projection of the vegetation and foliage.

Table 10 Vegetation cover requirements

All non-irrigated areas of planting (or direct seeding)	A minimum of 50% projected foliage cover (excluding any weeds) over any treated area of 100 m^2, with no bare soil areas > 10 m^2.
All irrigated planting areas	A minimum of 70% projected foliage cover (excluding any weeds) over any treated area of 100 m^2, with no bare soil areas > 5 m^2

- ***Species Diversity***
  - Species diversity must meet the requirements listed in Table 11.

Table 11 Species diversity requirements

Across the whole site	No less than 25 species occurring throughout the site.
Local scale	No less than ten species within any 100 m^2 area.

- ***Vegetation Condition***
  - Vegetation condition for all planting, seeding or grassing forming part of the rehabilitation works within the site must meet the following requirements:
    - Vegetation is well formed and exhibits signs of healthy growth
    - Vegetation is free of disease symptoms (e.g. yellowing, wilting, etc)
    - Vegetation is free from signs of insect pests.
- ***Weed, Pest and Disease Control***
  - Declared plants and other high control priority species, nominated in the Contractor's control program are eradicated from the site or controlled in accordance with the *Agriculture and Related Resources Protection Act* 1976.
  - The presence of other nuisance species and their effect on new plant growth must be demonstrably manageable with minimum future maintenance requirements as described in the Contractor's control program.

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9.0 References

SMC, 2011. *Roe Highway Extension. Public Environmental Review 20 June 2011*. Report by South Metro Connect for Main Roads Western Australia.

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Appendix A

Suggested Species Lists for Rehabilitation

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Appendix A

The species lists included here are suggested starting lists for each vegetation complex within the project area. The lists are not exhaustive and are intended to include the most commonly occurring species in each vegetation complex, and also those that are able to be propagated. All the species listed are available from commercial nurseries in Perth (Apace 2011).

Table 12 Suggested species list for rehabilitation in Bassendean Vegetation Complex

Scientific Name	Common Name	Height
Acacia pulchella	Prickly Moses	1.5m
Allocasuarina fraseriana	Common Sheoak	9.9m
Allocasuarina humilis	Dwarf Sheoak	1.5m
Anigozanthos humilis	Catspaw	0.2m
Anigozanthos manglesii	Mangles Kangaroo Paw	0.9m
Banksia attenuata	Candle Banksia	7.0m
Banksia dallanneyi	Couch Honeypot	0.8m
Banksia grandis	Bull Banksia	8.0m
Banksia menziesii	Firewood Banksia	6.0m
Beaufortia elegans	Elegant Beaufortia	0.8m
Bossiaea eriocarpa	Common Brown Pea	0.4m
Brachycome iberidifolia	Swan River Daisy	0.3m
Burchardia congesta	Milkmaids	0.5m
Calothamnus sanguineus	Silky Leaved Blood Flower	1.2m
Calytrix angulata	Yellow Starflower	1.0m
Conostylis aculeata	Prickly Conostylis	0.4m
Conostylis candicans	Grey Cottonheads	0.3m
Corymbia calophylla	Marri	9.9m
Dodonaea hackettiana	Perth Hopbush	3.0m
Eucalyptus marginata	Jarrah	9.9m
Eucalyptus todtiana	Prickly Bark	6.0m
Hakea ruscifolia	Candle Hakea	2.0m
Hardenbergia comptoniana	Native Wisteria	0.0m
Hemiandra pungens	Snake Bush	0.2m
Hypocalymma robustum	Swan River Myrtle	1.0m
Jacksonia furcellata	Grey Stinkwood	3.0m
Jacksonia sternbergiana	Green Stinkwood	3.0m
Kennedia prostrata	Running Postman	0.0m
Melaleuca preissiana	"Modong"	8.0m
Melaleuca rhaphiophylla	Swamp Paperbark	7.0m
Patersonia occidentalis	Purple Flag	0.4m

Scientific Name	Common Name	Height
Regelia inops	-	2.0m
Xanthorrhoea preissii	Grass Tree	3.0m

Table 13 Suggested species list for the Herdsman Vegetation Complex

Scientific Name	Common Name	Height
Acacia cyclops	Red Eyed Wattle	3.0m
Acacia pulchella	Prickly Moses	1.5m
Anigozanthos humilis	Catspaw	0.2m
Astartea scoparia	-	1.5m
Banksia littoralis	Swamp Banksia	9.0m
Baumea articulata	Jointed Twig-rush	2.5m
Baumea juncea	Bare Twig-rush	1.0m
Beaufortia elegans	Elegant Beaufortia	0.8m
Bolboschoenus caldwellii	Marsh Club-rush	0.8m
Brachycome iberidifolia	Swan River Daisy	0.3m
Carex appressa	Tall Sedge	1.5m
Carex fascicularis	Tassell Sedge	1.2m
Corymbia calophylla	Marri	9.9m
Dianella revoluta	Flax Lily, Blueberry Lily	0.5m
Dodonaea hackettiana	Perth Hopbush	3.0m
Hakea prostrata	Harsh Hakea	3.0m
Hakea varia	Variable Leaved Hakea	3.0m
Hypocalymma angustifolium	White Myrtle	1.0m
Isolepis cernua	Nodding Club-rush	0.2m
Jacksonia furcellata	Grey Stinkwood	3.0m
Juncus kraussii	Sea Rush	1.0m
Juncus pallidus	Giant Rush	2.0m
Kunzea glabrescens	Spear Wood	3.0m
Lobelia alata	Angled Lobelia	0.3m
Logania vaginalis	White Spray	1.8m
Melaleuca preissiana	"Modong"	8.0m
Melaleuca rhaphiophylla	Swamp Paperbark	7.0m
Melaleuca teretifolia	"Banbar"	4.0m
Melaleuca thymoides	-	1.0m
Myoporum caprarioides	Slender Myoporum	1.2m
Regelia ciliata	-	1.5m
Schoenoplectus validus	Lake Club-rush	2.0m

Scientific Name	Common Name	Height
Viminaria juncea	Swish Bush	4.0m
Xanthorrhoea preissii	Grass Tree	3.0m

Table 14 Suggested species list for the Karrakatta Vegetation Complex

Scientific Name	Common Name	Height
Acacia cyclops	Red Eyed Wattle	3.0m
Acacia pulchella	Prickly Moses	1.5m
Acacia rostellifera	Summer Scented Wattle	3.0m
Allocasuarina fraseriana	Common Sheoak	9.9m
Allocasuarina humilis	Dwarf Sheoak	1.5m
Anigozanthos humilis	Catspaw	0.2m
Anigozanthos manglesii	Mangles Kangaroo Paw	0.9m
Banksia attenuata	Candle Banksia	7.0m
Banksia dallanneyi	Couch Honeypot	0.8m
Banksia grandis	Bull Banksia	8.0m
Banksia menziesii	Firewood Banksia	6.0m
Banksia sessilis	Parrot Bush	4.0m
Calothamnus quadrifidus	One-sided Bottlebrush	2.0m
Calothamnus sanguineus	Silky Leaved Blood Flower	1.2m
Conostylis aculeata	Prickly Conostylis	0.4m
Conostylis candicans	Grey Cottonheads	0.3m
Corymbia calophylla	Marri	9.9m
Dianella revoluta	Flax Lily, Blueberry Lily	0.5m
Dodonaea hackettiana	Perth Hopbush	3.0m
Eremophila glabra	Tar Bush	0.6m
Eucalyptus decipiens	Limestone Marlock, Redheart.	6.0m
Eucalyptus gomphocephala	Tuart	9.9m
Eucalyptus marginata	Jarrah	9.9m
Eucalyptus todtiana	Prickly Bark	6.0m
Grevillea crithmifolia	-	1.5m
Hakea ruscifolia	Candle Hakea	2.0m
Hardenbergia comptoniana	Native Wisteria	0.0m

Scientific Name	Common Name	Height
Hemiandra pungens	Snake Bush	0.2m
Hypocalymma robustum	Swan River Myrtle	1.0m
Isolepis cernua	Nodding Club-rush	0.2m
Jacksonia furcellata	Grey Stinkwood	3.0m
Jacksonia sericea	"Waldjumi"	0.6m
Jacksonia sternbergiana	Green Stinkwood	3.0m
Kennedia prostrata	Running Postman	0.0m
Kunzea glabrescens	Spear Wood	3.0m
Melaleuca preissiana	"Modong"	8.0m
Melaleuca seriata		0.6m
Melaleuca systena	Coastal Honeymyrtle	1.5m
Melaleuca thymoides	-	1.0m
Melaleuca trichophylla	-	0.5m
Patersonia occidentalis	Purple Flag	0.4m
Regelia inops	-	2.0m
Xanthorrhoea preissii	Grass Tree	3.0m

Table 15 Suggested species list for the Cottesloe Vegetation Complex

Scientific Name	Common Name	Height
Acacia cyclops	Red Eyed Wattle	3.0m
Acacia lasiocarpa	Dune Moses, Panjang	0.7m
Acacia pulchella	Prickly Moses	1.5m
Acacia rostellifera	Summer Scented Wattle	3.0m
Acacia truncata	-	1.5m
Acacia xanthina	White Stemmed Wattle	4.0m
Agonis flexuosa	W.A. Peppermint	8.0m
Allocasuarina fraseriana	Common Sheoak	9.9m
Allocasuarina humilis	Dwarf Sheoak	1.5m
Anigozanthos manglesii	Mangles Kangaroo Paw	0.9m
Banksia attenuata	Candle Banksia	7.0m
Banksia dallanneyi	Couch Honeypot	0.8m
Banksia grandis	Bull Banksia	8.0m
Banksia menziesii	Firewood Banksia	6.0m
Banksia sessilis	Parrot Bush	4.0m
Brachycome iberidifolia	Swan River Daisy	0.3m
Burchardia congesta	Milkmaids	0.5m

Scientific Name	Common Name	Height
Calothamnus quadrifidus	One-sided Bottlebrush	2.0m
Conostylis aculeata	Prickly Conostylis	0.4m
Conostylis candicans	Grey Cottonheads	0.3m
Corymbia calophylla	Marri	9.9m
Dianella revoluta	Flax Lily, Blueberry Lily	0.5m
Dodonaea hackettiana	Perth Hopbush	3.0m
Eucalyptus decipiens	Limestone Marlock, Redheart.	6.0m
Eucalyptus gomphocephala	Tuart	9.9m
Eucalyptus marginata	Jarrah	9.9m
Eucalyptus todtiana	Prickly Bark	6.0m
Grevillea crithmifolia	-	1.5m
Hakea costata	Ribbed Hakea	1.0m
Hakea lissocarpha	Honey Bush	1.2m
Hakea prostrata	Harsh Hakea	3.0m
Hakea ruscifolia	Candle Hakea	2.0m
Hakea trifurcata	Two-leaf Hakea	2.0m
Hardenbergia comptoniana	Native Wisteria	0.0m
Hemiandra pungens	Snake Bush	0.2m
Hypocalymma robustum	Swan River Myrtle	1.0m
Jacksonia furcellata	Grey Stinkwood	3.0m
Jacksonia sericea	"Waldjumi"	0.6m
Jacksonia sternbergiana	Green Stinkwood	3.0m
Kennedia prostrata	Running Postman	0.0m
Melaleuca huegelii	Chenille Honeymyrtle	3.0m
Melaleuca trichophylla	-	0.5m
Orthrosanthus laxus	Morning Iris	0.5m
Patersonia occidentalis	Purple Flag	0.4m
Templetonia retusa	Cockies Tongues	1.8m
Xanthorrhoea preissii	Grass Tree	3.0m

References

Apace WA, 2012. "*Online Nursery*". Accessed 14 June 2012, available at: http://www.apacewa.org.au/nursery.

Appendix B

Plant species list for conservation significant fauna

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Appendix B Plant species list for conservation significant fauna

CS = Conservation significance rating. 1 = highest priority fauna, 2 = 2nd priority fauna

Plant species in bold are of highest importance for subject fauna species (e.g. they represent a high proportion of diet, high incidence of foraging records in project area and/or are local species.)

CS	Species	Food	Breeding	Other (e.g. roost), general comments	Sources
1	Carnaby's Black-Cockatoo (Calyptorhynchus latirostris)	Scientific name, Common name, part eaten • *Acacia saligna*, Orange Wattle, bark • *Agonis flexuosa* Peppermint tree bark, grubs • *Allocasuarina fraseriana,* Sheoak, seeds • *Banksia ashbyi* Ashby's Banksia, flowers, seeds • ***Banksia attenuata,* Slender Banksia , flower, seeds** • *Banksia ilicifolia,* Holly Banksia, fruit, cones • *Banksia littoralis,* Swamp Banksia, flower, seed • ***Banksia menziesii* Firewood/Menzies Banksia, flowers, seeds** • *Banksia prionotes,* Acorn Banksia, cones • ***Corymbia calophylla,* Marri, flower, seed** • *Banksia fraseri,* flowers, seeds • *Banksia nivea,* Couch Honeypot, flowers, seeds • *Banksia sessilis,* Parrot Bush flower, seed • *Eremophila glabra* South Coast, flower • *Eucalyptus gomphocephala,* Tuart, flower, seed	Large hollows of: • ***Corymbia calophylla*, Marri** • ***Eucalyptus gomphocephala*, Tuart** • *E. rudis*, Flooded Gum • *E. wandoo,* Wandoo NB – most breeding on SCP in Tuart.	Roost on: • Pines • **Jarrah** • **Marri** • **Tuart** **Apply a planting exclusion buffer along roadsides to minimise risk of road strike from ground feeding.**	Scott & Barton no date Valentine & Stock 2008 Burnham *et al*. 2010

CS	Species	Food	Breeding	Other (e.g. roost), general comments	Sources
		• ***Eucalyptus marginata,* Jarrah, seeds** • *Eucalyptus todtiana,* Coastal Blackbutt, Prickly Bark, seeds • • *Hakea auriculata,* seeds • *Hakea conchifolia,* Shell-leaved hakea, seeds • *Hakea cyclocarpa*, seeds • *Hakea incrassata,* Golfball or marble Hakea, seeds • *Hakea laurina* Pincushion seeds • *Hakea lissocarpha,* Honeybrush, seeds • *Hakea oblique,* Needles & Corks, seeds • *Hakea prostrata,* Harsh Hakea, seeds • *Hakea ruscifolia,* Candle hakea, seeds • *Hakea sulcata,* Furrowed Hakea, seeds • *Hakea trifurcata,* Two leaved Hakea, seeds • *Hakea undulata,* Wavy leaved Hakea, seeds • *Hakea varia,* Variable leaved Hakea, seeds • *Lambertia multiflora,* Many flowered honeysuckle, flower, seed • *Persoonia longifolia*, Snottygobble, seed •			
1	Forest Red-tailed black Cockatoo (*Calyptorhynchus banskii*)	• ***Allocasuarina fraseriana,* Sheoak** • ***Corymbia calophylla*, Marri** • ***Eucalyptus marginata,* Jarrah *(E. marginata and C. calophylla constitute 90% of the diet)*** • *Eucalyptus patens,* Swan River Blackbutt • *Melia azedarach* • *Persoonia longifolia,* Snottygobble	Large hollows of: • ***Corymbia calophylla*, Marri** • ***E. gomphocephala*, Tuart** • ***E. marginata,* Jarrah** • *E. megacarpa*, Bullich	Roost on: • **Marri** • **Jarrah** • Blackbutt **Apply a planting exclusion buffer along**	Johnstone & Storr 1998 DEC 2007

CS	Species	Food	Breeding	Other (e.g. roost), general comments	Sources
			• *E. wandoo,* Wandoo *NB - FRT observed nesting in the cockatube at Fiona Stanley site was in a Salmon Gum??*	**roadsides to minimise risk of road strike from ground feeding.**	
	Southern Brown Bandicoot (*Isoodon obesulus fusciventer*)	Mostly invertebrates and fungal material		**Habitat - densely covered scrubby, heathy and/or swampy vegetation on sandy soil**	
2	Chestnut Teal (*Anas castanea*)	• Aquatic invertebrates • Seeds and plants in general: Cyperaceae, Ruppia sp.	Nest found in rushes and saltbush, also in tree hollows. Fringing vegetation of rushes around wetlands most important for this species in project area		Australian Museum 2012 Norman & Mumford 1982 Johnstone & Storr 1998 Goldingay & Stevens 2009
2	Musk Duck (*Biziura lobata*)	• jilgie (*Cherax quiquecarinatus*) • occasionally ducklings, frogs	• Use rushes and strips of paperbark as nest material. • Nest placed at the base or on the fork of Teatree, Paperbark, Bottlebrush, Spearwood, Casuarina.	Species found in fringing vegetation during the breeding season, with Typhas, Baumea, rushes, Melaleucas.	Johnstone & Storr 1998

CS	Species	Food	Breeding	Other (e.g. roost), general comments	Sources
			Fringing vegetation of rushes around wetlands and Melaleuca paperbark most important for this species in project area		
2	Blue-billed Duck (*Oxyura australis*)	• Aquatic invertebrates • Seed, leaves, plant material	Nest in rushes, sedges, Lignum *Muehlenbeckia cunninghamii*, Paperbarks	-	Garnett & Crowley 2000
2	Shining Bronze-Cuckoo (*Chalcites lucidus*)	Invertebrates	• Parasitic, does not need nest material.	Found in woodlands	Johnstone & Storr 1998
2	Sacred Kingfisher (*Todirhamphus sanctus*)	Aquatic as well as terrestrial vertebrates and invertebrates	• Nest in tree hollows, sometimes burrows into soft soil cliffs, sandbanks.	-	Johnstone & Storr 1998
2	Splendid Fairy-Wren (*Malurus splendens*)	Invertebrates	• Nest usually built in a shrub of Acacia, Hakea, Dryandra or Melaleuca	Found in eucalypt woodland or forest understorey, shrublands, heath, mallee, melaleuca, thickets.	Johnstone & Storr 2004
2	Varied Sittella (*Daphoenositta chrysoptera pileata*)	Invertebrates	• Nest in *Acacia*, *Eucalyptus* (York Gum, Wandoo, Blackbutt, Salmon Gum, Morrel, Mallee), *Corymbia*, and *Banksia*.	Found in forest/woodlands with: • Tuart • Jarrah • Marri • Wandoo • *Acacia acuminuta* (Jam) • Sheoak	Johnstone & Storr 2004

CS	Species	Food	Breeding	Other (e.g. roost), general comments	Sources
				• *Callitris* and *Banksia* scrubs	
	Grey Shrike-Thrush (*Colluricincla harmonica*)	Invertebrates, occasionally vertebrates	Nest built of *Acacia* and *Melaleuca* (bark) in shrubs of: • *Eucalyptus* • *Corymbia* • *Acacia* • *Melaleuca* • *Casuarina* • *Allocasuarina* • *Eremophila* • *Callitris* • *Jacksonia* • Sometimes in clumps of *Amyema*, hollows, caves.	Wooded country with Tuarts *Eucalyptus gomphocephala*	Johnstone & Storr 2004
2	Rufous Whistler (*Pachycephala rufiventris*)	Invertebrates	• Nest built in • *Eucalyptus wandoo* • *Eucalyptus marginata* • *Acacia* • *Allocasuarina* • *Melaleuca* • *Hakea*	Shrubs, thickets, woodlands in general	Johnstone & Storr 2004
2	Spotted Pardalote (*Pardalotus punctatus)*	Invertebrates	Breeds in heavy woodlands with: • *Jarrah* • *Marri* • *Bullish* • *Flooded gum* • *Wandoo* Nest built of various plant materials (bark, stems, and leaves).	Winters in Eucalypt scrubs, dense woodlands	Johnstone & Storr 2004

CS	Species	Food	Breeding	Other (e.g. roost), general comments	Sources
2	Striated Pardalote (*Pardalotus striatus*)	Invertebrates	Eucalypt forest, woodlands, scrubs, nest built in tree hollows, usually in: • *River gum* • *Flooded gum* • *Jarrah* • *Marri* • *Wandoo* • *Yate*	-	Johnstone & Storr 2004
2	Grey Fantail (*Rhipidura albiscapa*)	Invertebrates	Found in woodland, shrublands and well vegetated habitats in general, including with: • *Tuart* • *Jarrah* • *Marri* • *Bullish flooded gum* • *Blackbutt* • *Mallet* • *Wandoo* • *Yate* • *Salmon gum* • *Mallee* • *Melaleuca* • *Acacia* • *Banksia* • *Allocasuarina* • *Casuarina* • *Peppermint thickets and woodlands* Nest built in shrubs of:	-	Johnstone & Storr 2004

CS	Species	Food	Breeding	Other (e.g. roost), general comments	Sources
			• *Acacia* • *Allocasuarina* • *Banksia* • *Eucalyptus* • *Agonis* • *Melaleuca* • *Casuarina* • *Schinus sp.*		
2	Southern Boobook (*Ninox novaeseelandiae).*	Vertebrates and invertebrates	Found in wooded country, nest in hollows of dead trees		

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Targeted Survey for Sucking Millipedes

Appendix H

Targeted Survey for Sucking Millipedes

Appendix H Targeted Survey for Sucking Millipedes

PHOENIX
ENVIRONMENTAL SCIENCES

Targeted survey for sucking millipedes (Siphonotidae) for the Roe Highway Extension Project

Prepared for AECOM

August 2012

Final Report



Targeted survey for sucking millipedes (Siphonotidae) for the Roe Highway Extension Project

Prepared for AECOM

Final Report

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Date: 22 August 2012

Submitted to: John Braid

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1 INTRODUCTION

In February 2012, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by AECOM, on behalf of Main Roads, to undertake targeted surveys for an unidentified sucking millipede (Siphonitidae sp. indet.) collected during previous baseline fauna surveys for the Roe Highway Extension Project ('the Project'). This report describes the surveys undertaken from March to June 2012.

1.1 BACKGROUND

Main Roads proposes to construct the Project by extending Roe Highway approximately 5 km from its current terminus at the Kwinana Freeway in Jandakot to Stock Road in Coolbellup. The Project is located approximately 14 km south of Perth within the Swan Coastal Plain Bioregion.

The project area is largely contained within the City of Cockburn, however, parts of the design extend northward into the City of Melville along Murdoch Drive and Kwinana Freeway (Figure 1-1). Generally, the proposed project is oriented east-west largely, within a road reserve that was set aside in the Metropolitan Region Scheme (MRS) in 1963. The alignment is between North and Bibra Lakes, which are part of the Eastern Chain of the Beeliar Wetlands.

Between November 2009 and November 2010, Phoenix conducted several baseline terrestrial invertebrate surveys to inform the environmental impact assessment for the Project (Phoenix 2010). A single siphonotid (sucking millipede) specimen was collected during the baseline surveys from Karrakatta vegetation complex (*Eucalyptus/Banksia* woodland) in the north-east quadrant of the Stock Road/Forrest Road intersection (SRE (VF) site 3; Figure 1-2). Vegetation clearing will result in the removal of habitat from its only known location within the project area.

Sucking millipedes are very rarely collected in the Perth metropolitan area (PMA); the Western Australian Museum only holds specimens from Woodman Point and two unspecified historical localities in 'Perth'. In Western Australia, these millipedes are generally restricted to the wet western region of the south coast. Australian Siphonotidae species often have highly restricted distributions (Black 1994, 1997).

Accordingly, the siphonotid specimen collected from the project area was designated as having potential conservation significance as it may represent a short-range endemic species.

In the submissions to the Public Environmental Review for the Project, the Department of Environment and Conservation requested a management strategy to either determine the occurrence of the siphonotid outside the project footprint or protect its occurrence within the project footprint.

Phoenix was subsequently engaged to further investigate the occurrence of siphonotid millipedes in the project area in response to this submission. Upon re-examination of the specimen, it was determined to be female (possibly mature based on its large size) and therefore species identification based on morphological features was not possible; only mature male millipedes can be identified to species level. As the specimen was collected in propylene glycol/formalin pitfall traps, it is unlikely that it will yield DNA that is usable for molecular analysis.

Therefore, further fieldwork was required to collect additional specimens outside of the impact area and to test for conspecificity with other siphonotid species collected in the PMA. Collection of mature males was required for morphological identification and comparison with other species. If fresh females or juveniles were collected, identification based on molecular analyses would be necessary. As suitable, fresh material of sucking millipedes from the PMA is not present at the WA

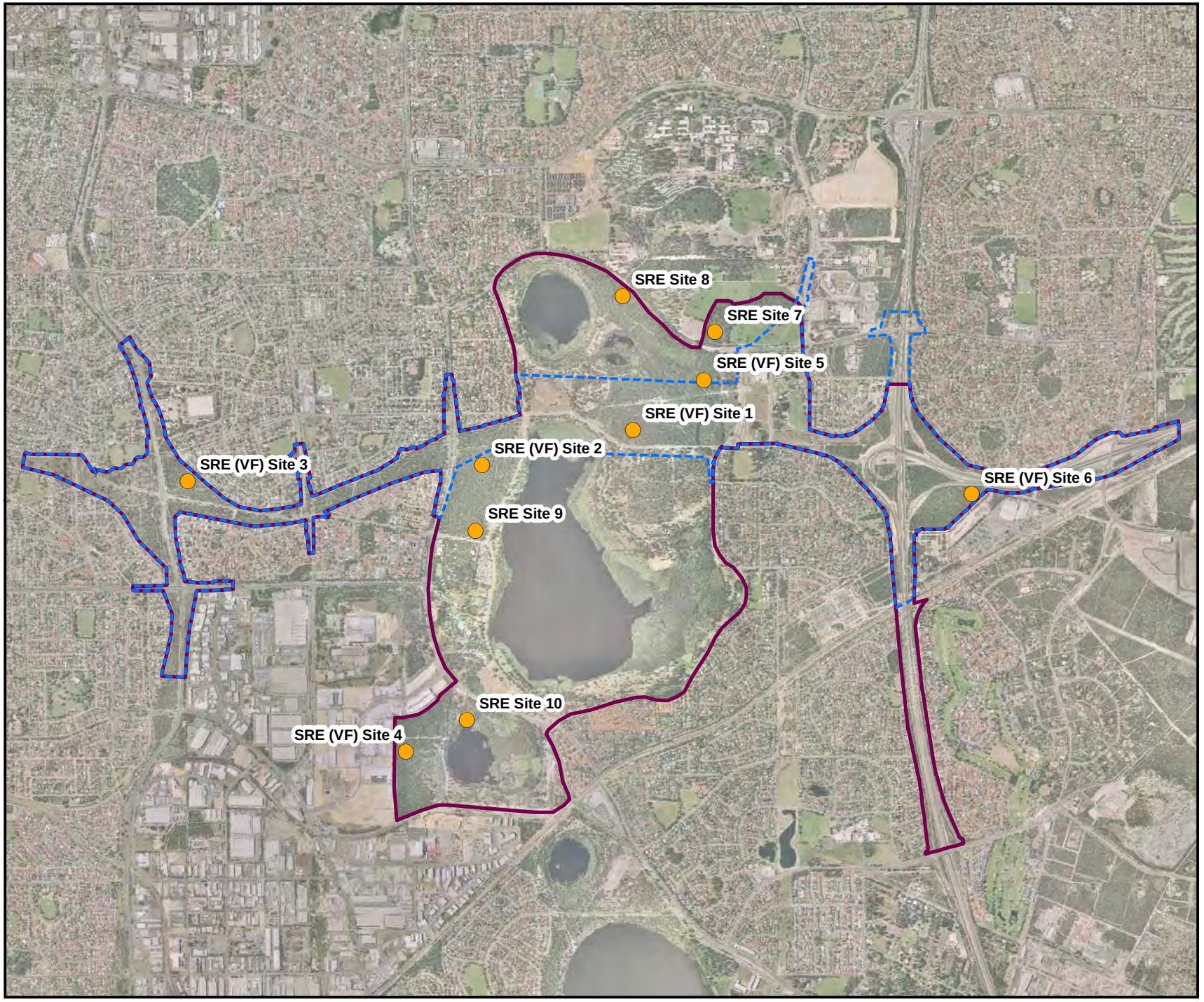
Museum, further fieldwork was also proposed in other known locations, particularly Woodman Point (based on records in WA Museum database).



Figure 1-1
Location of the Roe Highway Extension Project

Project Area

0 1 2 3
Kilometres
Datum: GDA94 Projection: MGA z50



Location of short-range endemic survey trapping sites

Figure 1-2

0 0.25 0.5 0.75 1

Kilometres

1:35,000 (A4)

Datum: GDA94 Projection: MGA z50

- SRE Dry Pitfall Trapping Sites
- Project Area
- Study Area

Modified: 15/02/2011

known J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\#2011\Technical_Reports\SRE and Inverts Baseline Survey\Figure 3-1 - Location of Short-range Endemic Trapping Sites.mxd

1.2 SCOPE OF WORK AND SURVEY OBJECTIVES

The aim of the targeted siphonotid surveys was to obtain additional specimens outside of the proposed impact area for the Project and ideally collect mature males for comparison with the species from other PMA locations, in particular Woodman Point.

The scope of works undertaken to achieve these objectives was as follows:

- undertake targeted field surveys in the project area (inside and outside impact areas) for siphonotid millipedes
- undertake targeted field surveys at Woodman Point for siphonotid millipedes, if only females and juveniles are collected from the project area
- undertake specimen curation, dissection and identification if male specimens are collected
- undertake molecular analyses, if female/juvenile specimens are collected.

This survey adhered to the principles and practices of the Environmental Protection Authority's (EPA) Guidance Statement No. 20: *Sampling of short-range endemic invertebrate fauna for environmental impact assessment (EIA) in Western Australia* (EPA 2009), which outlines preferred methods for the surveying and assessment of SREs in the context of EIA.

The survey has also been designed in accordance with the EPA Guidance Statement No. 56: *Terrestrial fauna surveys for environmental impact assessment in Western Australia* (EPA 2004) and EPA Position Statement No. 3: *Terrestrial biological surveys as an element of biodiversity protection* (EPA 2002).

2 METHODS

From April to June 2012 four targeted surveys were undertaken for the sucking millipede (Siphonotidae) previously found in bushland near the Stock and Farrington Roads intersection. Searches were conducted in and around the site of the original record (SRE (VF) site 3; Table 3-1).

Survey timing was planned to coincide with the time of year when the previous specimen was collected (putative reproductive season; May 2011), allowing for seasonal variation (April to June period) and appropriate weather conditions (surveys were conducted after high rainfall events).

Survey techniques comprised litter sieving and direct searches (foraging). Foraging incorporated the systematic inspection of the underside of logs and rocks.

The collection of leaf litter samples were standardised volumetrically by the diameter and height (310 mm x 50 mm = 1.55 L) of the sieves which were completely filled with compressed litter and the upper layers of underlying soil. Samples were sieved through three stages of decreasing mesh size over a round tray and invertebrates were picked from the sieves and tray with forceps or an aspirator.

In situ collecting and sieving is preferred over transporting litter samples to the laboratory. Small invertebrates are best detected when moving and transport to the laboratory can kill a large proportion of the catch. In addition, if litter sieves in the field contain groups of interest, more extensive searches can be conducted, providing greater flexibility in the sampling protocol.

Table 2-1 Survey dates and effort

Date	Survey location	Collecting techniques[a]	Foraging time (mins)	Litter sifts (No.)
24 April 2012	SRE (VF) site 3 386685E, 6449258N (50H, GDA94)	FO, LS	180	18
10 May 2012	SRE site 3 and surrounding bushland	FO, LS	720	36
18 May 2012	SRE site 3 and surrounding bushland	FO, LS	720	32
8 June 2012	SRE site 3 and surrounding bushland	FO, LS	360	25

a – FO – foraging; LS – litter and soil sieve

2.1 SURVEY PERSONNEL

The personnel involved in the survey are presented (Table 2-2).

Table 2-2 Project team

Name	Qualifications	Role
Dr Volker W. Framenau	M.Sc. (Cons. Biol.), Ph.D. (Zool.)	24 April, 8 June surveys, report review
Mrs Karen Crews	B.Sc. (Env. Biol.) (Hons)	Reporting
Dr Peter Langlands	B.Sc. (Env. Biol.) (Hons) Ph.D. (Zool.)	8 June survey
Mr Conor O'Neill	B.Sc. (Sust. Dev. and Env. Sci.)	24 April survey
Ms Kate Penwarden	B.Sc. (Zool.) (Hons)	10 May, 18 May, 8 June surveys
Ms Leanda Mason	B.Sc. (Cons. Zool.) (Hons)	10 May, 18 May surveys

3 RESULTS

Although the surveys were conducted by experienced invertebrate zoologists, they did not recover any Siphonotidae. Many other millipedes including large numbers of the introduced Portuguese Millipede (*Ommatoiulus moreleti*) were found (Table 3-1).

All millipede species collected during the targeted surveys were previously recorded at SRE site 3 during the baseline surveys (Phoenix 2010).

Table 3-1 Survey results

Date	Survey location	Survey results
24 April 2012	SRE site 3	Portuguese Millipede (*Ommatoiulus moreletii*)
10 May 2012	SRE site 3 and surrounding bushland	Portuguese Millipede (*O. moreletii*); *Podykipus collinus*, Karri Millipede (*Antichiropus variabilis*); *Antichiropus* sp. indet.
18 May 2012	SRE site 3 and surrounding bushland	Portuguese Millipede (*O. moreletii*); Iulomorphidae sp.; Karri Millipede (*Antichiropus variabilis*); *Antichiropus* 'UBS2'; *Antichiropus* sp. indet.
8 June 2012	SRE site 3 and surrounding bushland	Portuguese Millipede (*O. moreletii*); Iulomorphidae sp.

As no siphonotid specimens were recorded from the project area during the four field surveys, no survey work was undertaken at Woodman Point or any other PMA localities where siphonitids have previously been collected.

4 RISK-BASED ASSESSMENT

In light of the survey results, a risk-based assessment was undertaken to provide some indication of the extent of habitat for the siphonotid collected in the project area.

EPA Guidance Statement 20: *Sampling of short-range endemic invertebrate fauna for environmental impact assessment in Western Australia* (EPA 2009) provides a framework for a risk-based approach, i.e. when "the use of habitat as a surrogate for inferring distributional boundaries can […] be considered" (EPA 2009; p. 11–12). The conditions for a risk-based approach following initial surveys are (EPA 2009; p. 11):

- a potential SRE taxon is represented by one or few specimens from only within proposed development areas
- contextual data on the wider distribution and status of the taxon is unavailable from the WA Museum or the DEC
- additional targeted surveys appear unlikely to yield results in a reasonable timeframe.

These conditions are met in relation to an assessment of the impact on the siphonotid millipede collected during the baseline invertebrate surveys, i.e.:

- only one specimen, a female, has been found in the proposed impact area of the Project (SRE (VF) site 3); species identification is not possible
- there is no data available from the WA Museum or DEC in relation to sucking millipedes in the PMA with the exception of two localities (Woodman Point, 6 km south-west of the Project/unspecified records from 'Perth')
- additional targeted surveys were conducted unsuccessfully this year encompassing the putative reproductive season of the millipede (i.e. May, when the previous female specimen was found) and in favourable weather conditions (after periods of intensive rain); it unlikely to find the species until next year around May and possibly only with much higher survey intensity (i.e. pitfall trapping).

Therefore a risk-based approach as recommended by EPA (2009) was conducted taking into consideration the habitat in which the siphonotid was found initially and the extent of this habitat in and around the Perth metropolitan area. It is recognised that it is difficult to infer species-specific habitat preferences based on a single record; however, this extrapolation provides the basis for a risk-based approach as proposed by the EPA (2009).

The siphonotid millipede was found in Karakatta – Central and South vegetation complex characterised predominantly by open forest of *Eucalyptus gomphocephala – Eucalyptus marginata – Corymbia calophylla* and woodland of *Eucalyptus marginata* and *Banksia* species (AECOM 2011; Heddle *et al.* 1980). Pre-European settlement showed more than 34,000 ha of this vegetation complex existing originally, which has been reduced to about 18% (current 6,275 ha) (AECOM 2011). Only 55.33 ha (0.8% of current extent) of the Karrakatta vegetation complex will be impacted by the Project providing considerable refugial areas for invertebrate fauna in the Perth metropolitan area that are unaffected. Almost 2,000 ha of bushland in the Karrakatta vegetation complex are under protection (AECOM 2011).

Two additional factors may be relevant to the risk assessment. Firstly, the species previously collected at Woodman Point has recently been assessed by Australia's leading Siphonotidae specialist, Dr. Dennis Black (LaTrobe University, Albury-Wodonga) and it represents a common species from south-west Western Australia, *Rhinotus michaelseni* (Attems, 1911). It is perceivable that the Roe Highway millipede is conspecific with those from Woodman Point, in which case it

would not be an SRE. Other specimens from near the Perth metropolitan area cannot be taxonomically assessed, as they are immature females (D. Black, email from 29 March 2012).

Secondly, Portuguese Millipedes are found in great numbers in the bushlands of the project area; it was the predominant millipede species collected during the targeted surveys and the baseline surveys (see also Phoenix 2010). It is currently unknown when the invasion of these millipedes in the area began, but it is perceivable that Portuguese Millipedes have largely displaced, or are in the process of displacing, some of the native fauna.

Whilst a displacement of native millipedes by Portuguese Millipedes has not been demonstrated (population-level studies on millipedes are rare world-wide and have not been conducted in Australia) (e.g Griffin & Bull 1995), displacement of native fauna by other invasive invertebrates is very common (Lach & Thomas 2009; McLeod 2004; Odendaal *et al.* 2008). If the Roe Highway siphonotids are displaced by Portuguese Millipedes, further surveys are unlikely to recover the species.

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Offset Strategy

Appendix I

Offset Strategy

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Roe Highway Extension
Main Roads WA
19 March 2013

Offset Strategy

Roe Highway Extension



Offset Strategy

Roe Highway Extension

Prepared for

Main Roads WA

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1.0 Introduction

This Offset Strategy outlines the approach to offset significant residual impacts of the Roe Highway Extension project in Perth, Western Australia. The strategy defines the development of an Environmental Offset Plan that will offset the residual impacts to significant environmental assets in the project area.

The Offset Strategy supersedes Section 10 of the Public Environmental Review (PER) document and has been written following the receipt of public submissions. The overall intent of the offset strategy is the same as Section 10, however some of the offsets have been revised following reassessment of environmental impacts in the response to submissions phase and changes to State and Commonwealth offset policies since the release of the PER.

This document should be read in conjunction with the PER document and the Response to Submissions document for Roe Highway Extension.

1.1 Project background

Main Roads proposes to construct the Roe Highway Extension ("the project") by extending Roe Highway approximately five kilometres from its current terminus at the Kwinana Freeway in Jandakot to Stock Road in Coolbellup. In August 2009, Main Roads and industry partner, AECOM Australia, formed the South Metro Connect (SMC) alliance. The team was created for the development phase of the project. Its primary objective is to work collaboratively with stakeholders and regulatory authorities to develop an environmentally, socially and economically acceptable project design and obtain relevant statutory environmental and heritage approvals.

The project is located approximately 14 kilometres south of Perth within the Swan Coastal Plain Bioregion. The project area is largely contained within the City of Cockburn, however, parts of the design extend northward into the City of Melville along Murdoch Drive and Kwinana Freeway. Generally, the proposed project is oriented east-west, within a road reserve that was set aside in the Metropolitan Region Scheme (MRS) in 1963. The alignment is between North and Bibra Lakes, which are part of the Eastern Chain of the Beeliar Wetlands.

The project will consist of a dual carriageway with two lanes in each direction, separated by a concrete barrier in place of a median strip. The preferred design was selected following an extensive options analysis and consultative process. Once selected, the preferred design was optimised to avoid and minimise environmental impacts on the maximum extent possible.

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2.0 Objectives

The objectives of this offset strategy are to guide the development of an Environmental Offset Plan that:

- provides a net environmental benefit as a result of the project
- provides offsets that are ‘like for like’ or better, where possible
- is targeted at the significant residual impacts of the project
- meets regulatory requirements and is consistent with government policy
- is enforceable and measurable
- is adaptable, if required.

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3.0 Key environmental factors affected by proposal

The road alignment for the project passes through an important wetland chain and some of the last remaining remnant vegetation in the area. In urban areas around Perth, often the last land to be developed is the road reserve set aside within the MRS for primary regional roads. The Roe Highway Extension project will impact upon several key environmental factors including:

- wetlands
- State and Commonwealth listed fauna species and species habitat
- remnant vegetation including populations of State listed priority flora
- conservation land (Bush Forever and Beeliar Regional Park)
- noise and
- Aboriginal Heritage.

3.1 Wetlands

The project will have a direct impact on Conservation Category Wetlands (CCW) and on lakes protected under the *Environment Protection Policy Swan Coastal Plain Lakes* (Lakes EPP). The areas of wetland affected by the proposal are:

- Bibra Lake –1.0ha Lakes EPP wetland
- Horse Paddock Swamp – 0.2ha CCW
- Melaleuca Swamp – 0.2 ha CCW
- Roe Swamp – 5.6ha CCW.

3.2 Flora and vegetation

Project construction will require the clearing of up to 79.3ha of remnant native vegetation. Much of the project area has been subject to historical disturbance from agriculture and recreational activities in the past. Most of the Perth Metropolitan Area has been subjected to large scale disturbance and clearing of native vegetation and hence many of the vegetation complexes occurring have less than 30% of their pre-European extent remaining. Of the four complexes occurring within the project area, two have less than 30% of their pre-European extent remaining. None of the vegetation complexes occurring within the project area will be reduced to below the 10% threshold value where they would be considered a “critical asset” by the EPA.

A total of 8 species in 15 sub-populations of Priority Flora, consisting of approximately 7,000 individuals will be impacted by the project. Most of the recorded Priority Flora within the proposed clearing footprint are *Dampiera triloba* (Priority 1) a small herb that is locally abundant. No *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or *Wildlife Conservation Act 1950* (WC Act) listed threatened flora will be impacted by the proposal.

3.3 Fauna

Construction will impact up to 112ha of fauna habitat. This includes 40ha of *Eucalyptus*/*Banksia* woodland, 26ha of *Eucalyptus*/*Xanthorrhoea* woodland and 13ha of other native remnant vegetation. The fauna habitat includes 20ha of non-native vegetation including: rehabilitated vegetation, parklands and roadside verges that provide fauna habitat. The remaining fauna habitat (13ha) is of little habitat value for fauna.

Habitat for a number of species listed under the EPBC Act, WC Act and DEC’s priority fauna list occurs within the project area. Listed species impacted include: Carnaby’s Cockatoo, Forest Red-tailed Black Cockatoo and the Graceful Sun Moth (Table 1). The term “black cockatoos” where used in this document, refers to both Carnaby’s Cockatoo and the Forest Red-tailed Black Cockatoo.

An unidentified sucking millipede (*Siphonotidae sp*.) was recorded in the project area. Further taxonomic review and survey work of this species is required. A single specimen was collected from *Eucalyptus*/*Banksia* habitat in the north-east quadrant of the Stock Road/Forrest Road intersection.

3.4 Conservation land (Bush Forever and Beeliar Regional Park)

The project will impact upon Bush Forever sites and Beeliar Regional Park. A total of 7ha of Bush Forever will be cleared during construction of the project. Beeliar Regional Park will be impacted by the resumption of 5.4ha of the park for road reserve.

3.5 Noise

Construction noise and traffic noise during operation will have a significant impact on sensitive receivers adjacent to the project. Significant noise impacts during construction include: operation and movement of machinery, out of regular working hours construction noise, reversing alarms and piling. During operation, excessive noise from traffic can result in a loss of amenity for residents, and possible health impacts.

3.6 Aboriginal heritage

The Bibra Lake/North Lake area is significant to Aboriginal people. In the past the area was used as a semi-permanent camp site due to the proximity to food and water year round. The project area will impact upon a number of mythological and archaeological sites registered under the *Aboriginal Heritage Act 1972* in the vicinity of Bibra Lake and North Lake.

3.7 Matters of national environmental significance

Significant impacts on Matters of National Environmental Significance will potentially occur to three species listed as Endangered or Threatened under the EPBC Act (Table 1). Whilst there will be an impact on migratory birds and migratory waterbirds, this impact is not expected to be significant (Table 2).

Table 1 EPBC listed threatened species that will be significantly impacted by the project (SMC 2011).

Threatened Species	Conservation Status	Extent of Impact
Carnaby's Cockatoo (*Calyptorhynchus latirostris*)	Endangered – EPBC Act Schedule 1 – WC Act	78.3 ha of foraging habitat 249 potential breeding trees (2.5ha)
Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*)	Vulnerable – EPBC Act Schedule 1 – WC Act	73.2 ha of foraging habitat 249 potential breeding trees (2.5ha)
Graceful Sun-moth (*Synemon gratiosa*)	Endangered – EPBC Act Priority 4 (DEC)	5.6ha

Table 2 EPBC listed migratory birds that may be impacted by the project (SMC 2011).

Migratory Bird	EPBC Status	Extent of Impact
Rainbow Bee-eater (*Merops ornatus*)	Migratory	89.9ha
Glossy Ibis *(Plegadis falcinellus*)	Migratory	Little to no habitat loss May be impacted by lighting, noise and road traffic
Eastern Great Egret *(Ardea modesta*)	Migratory	Little to no habitat loss May be impacted by lighting, noise and road traffic

4.0 Offset policy and guidance

4.1 State offset policy and guidance

This offset strategy has been developed in accordance with West Australian Government policy and guidance on environmental offsets. Those policies and guidance are listed in (Table 3)

Table 3 Western Australian policy and guidance on environmental offsets.

Policy/Guidance Statement	Date of issue	Description
Government of Western Australia – WA Environmental Offsets Policy.	September 2011	Policy seeks to ensure that environmental offsets are applied in a transparent manner an d serves as an overarching framework for offset assessment and decision making in WA
EPA Position Statement No 9 – Environmental Offsets.	January 2008	Provides EPA's position on the use of offsets
EPA Guidance Statement No 19 – Environmental Offsets – Biodiversity.	September 2008	Provides more specific advice on the technical application of offsets discussed EPA Position Statement No 9
Environmental Protection Bulletin No 1 – Environmental Offsets – Biodiversity.	September 2008	General description of offsets and their use in WA.
Environmental Assessment Guideline for Environmental Offsets (Draft)	October 2012	This document will eventually replace EPA Position Statement No 9; EPA Bulletin 1: Biodiversity Offsets and Guidance Statement 19, once approved and finalised.

4.2 EPBC Act policy and guidance

This offset strategy has been developed with consideration given to the Australian Government offset policy and guidance. The offsets provided in the PER document were consistent with DSEWPaC advice given at the time. However the offsets strategy described in this document has taken into account recent policy changes under the EPBC Act regarding offsets (Table 4)

Table 4 Commonwealth policy and guidance on environmental offsets

Policy/Guidance Document	Date of issue	Description
EPBC Act Environmental Offsets Policy	October 2012	The Australian Government's policy to the use of environmental offsets under the EPBC Act
Offsets Assessment Guide	October 2012	This guide has been developed in order to give effect to the requirements of the EPBC Act Environmental Offsets Policy. Together with the policy these two documents form a framework to normalise the judgement of proposed offsets

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5.0 Mitigation and significance of residual impacts

5.1 Mitigation measures

SMC has attempted to reduce the residual significant environmental impacts of this project on all environmental aspects through the hierarchy of control as described in EPA Position Statement No 9 Environmental Offsets (EPA 2006) (Table 5).

Table 5 Mitigation hierarchy of environmental impacts

Mitigation Hierarchy	Measures undertaken
Avoid	- relocation of the Bibra Drive/Roe Highway interchange from its original location in Roe Swamp to the open cleared ground to the east of Roe Swamp - location of construction laydown areas outside the construction footprint in previously cleared areas - most stormwater basins have been located on previously cleared ground
Minimise	- realignment of the road corridor to the north, to follow an existing power line alignment, in order to reduce the overall footprint of the road on vegetation, wetlands and black cockatoo foraging habitat - innovative road design to reduce the clearing footprint by reducing the median width, using retaining walls and steeper batters to minimise the road footprint - designing a bridge over part of Roe Swamp to reduce the clearing footprint and maintain ecological linkages - designing fauna underpasses to minimise the impact of severing fauna linkages - fauna fencing to minimise fauna road mortality - translocating fauna prior to construction to minimise fauna mortality during construction - no dewatering during construction to reduce the possibility of affecting Acid Sulfate Soils - controlling road runoff so that no stormwater enters a wetland area without treatment - developing a Flora, Vegetation and Fauna Management Plan (FVFMP) and Water Management Strategy for implementation during construction - road traffic noise will be minimised by the installation of noise walls and the use of the quietest available road surfacing material - biophysical impacts on Aboriginal Heritage have been minimised through the reduction of the clearing footprint through Roe Swamp and the inclusion of bridges and underpasses to maintain ecological linkages.
Rectify	- rehabilitation and stabilisation of road verges, medians and embankments immediately following construction - implementation of the SMC Rehabilitation Strategy
Offset	- implement this offset strategy

5.2 Significant residual environmental impacts

Following the implementation of the hierarchy of controls outlined above, a significant residual environmental impact will remain on a number of aspects (Table 6). Impacts from construction and traffic noise have been mitigated to the extent that they are no longer significant impacts, provided they are adequately managed and monitored in accordance with the Noise Management Plan (Appendix J of the Response to Submissions document). Residual impacts on Aboriginal Heritage will be managed under the provisions of the *Aboriginal Heritage Act 1972* and a separate approval process.

Table 6 Significant residual environmental impacts

Aspect	Residual Impact to be Offset	Matter of NES	Proposed Size of Offset	Offset Proposal to mitigate impact
Remnant vegetation	79ha	No	At least 79ha	Offset Proposal 1, 2 & 3
Black Cockatoo foraging habitat	78ha	Yes	In accordance with DSEWPaC's Offset Assessment Guide	Offset Proposal 1 & 3
Black Cockatoo breeding habitat	2.5ha (249 potential breeding trees)	Yes	In accordance with DSEWPaC's Offset Assessment Guide	Offset Proposal 1
CCW and buffers	5.8ha of CCW 2.0ha of CCW buffer	No	At least 15.6ha of wetland rehabilitation and protection	Offset Proposal 1, 2 & 3
Bush Forever	7 ha	No	Protection at least 14ha of Bush Forever sites	Offset Proposal 1, 2 & 3
Beeliar Regional Park	5.4ha	No	5.4ha	Offset Proposal 3
Graceful Sun Moth habitat	5.6ha	Yes	In accordance with DSEWPaC's Offset Assessment Guide (provided GSM remains listed as Threatened under the EPBC Act)	Offset Proposal 1
Migratory Birds	Disruption of migratory birds within project area	Yes	Weed management at Ramsar site	Offset Proposal 4

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6.0 Offset plan and proposed offset packages

6.1 Environmental Offset Plan

Prior to construction commencing, Main Roads Western Australia will develop an Environmental Offset Plan (EOP) based on this Offset Strategy. The EOP is to be to the satisfaction of the Commonwealth Minister for the Environment and the Western Australian Minister for the Environment, or their appointed delegates.

The EOP is to be consistent with Commonwealth and West Australian legislation and policy regarding environmental offsets.

The EOP is to include:

- details of the proposed offset land parcel or land parcels. If a proposed land parcel is only a part of a larger property, then this is to be clearly described (Offset Proposal 1)
- a description of the suitability of each offset parcel to offset the impacts on Matters of National Environmental Significance (Offset Proposal 1)
- a description of the suitability of each offset parcel to offset the impacts on remnant vegetation, wetlands, threatened fauna species, threatened flora species, Bush Forever and Beeliar Regional Park (Offset Proposal 1)
- evidence that each land parcel in the EOP is within 100km of the area of impact (Offset Proposal 1)
- evidence that the size of each offset land parcel is at least 100ha in size (Offset Proposal 1)
- evidence that each land parcel has been acquired or secured to the satisfaction of DSEWPaC and the EPA (Offset Proposal 1)
- management plans for each offset land parcel (Offset Proposal 1)
- evidence that Main Roads and the Department of Environment and Conservation have reached agreement (preferably through a memorandum of understanding) on the funding, management and ultimate vesting of all offset land parcels (Offset Proposal 1)
- maps of the proposed offset land parcels showing vegetation quality and proposed rehabilitation areas
- performance indicators for rehabilitation and restoration works
- details of monitoring, reporting and contingency measures if performance indicators are not met
- timeframes for the completion of the above rehabilitation measures
- roles and responsibilities associated with implementing each of the above measures and funding arrangements
- the restoration of Horse Paddock Swamp (Offset Proposal 2)
- the transfer of redundant road reserve around Roe Swamp to Beeliar Regional Park (Offset Proposal 3)
- the contribution of $300,000 to a Typha control program at Thomsons Lake (Offset Proposal 4).

If the EOP is approved, it is to be implemented prior to the commencement of construction for the Roe Highway Extension project.

6.2 Summary of offset package

Main Roads is proposing a package of four offset proposals to be implemented as part of the EOP to offset the significant residual environmental impacts of the project. These have been described in Table 7. (Note that these proposals have been amended since the PER.)

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Table 7 Offset proposals to be incorporated into the EOP.

	Offset Proposal 1	Offset Proposal 2	Offset Proposal 3	Offset Proposal 4
Description	Acquisition of, or otherwise securing, a land parcel, or series of land parcels, that will meet the offset requirements for Commonwealth and State listed threatened fauna, threatened flora, wetlands, remnant vegetation and conservation estate	- development and implementation of a Wetland Restoration Plan (WRP) in consultation with DEC for a period of up to 5 years to conduct weed control and rehabilitation activities as shown in Figure 1 - the WRP will incorporate all elements in Table 8 - as a minimum the WRP will result in: • rehabilitation of 8.4 ha of degraded wetland areas of Horse Paddock Swamp • weed control of 5 ha of North Lake fringes	Offset Proposal 3 consists of the transfer of 14.5ha of redundant MRS road reserve into Beeliar Regional Park and the development and implementation of an Arum Lily Control Program (ALCP) for 3 years within the redundant road reserve (Figure 2).	Main Roads proposes to provide $300,000 for: - a *Typha* control programme at the Ramsar listed Thomsons Lake over a three year period. The *Typha* control programme will be developed in consultation with DEC.
Type of offset	Direct (land acquisition) Contributing/indirect (management of land)	Direct	Direct	Contributing/indirect
Location	Within 100km of the project area, preferably south of Perth on the Swan Coastal Plain, between Perth and Mandurah.	Horse Paddock Swamp and North Lake	Beeliar Regional Park, Bibra Lake	Thomsons Lake
Size of land parcel	- the size of offset land parcel(s) required will be determined using the *EPBC Act Environmental Offset Policy* and associated *Offset Assessment Guide* - may include more than one land parcel - each individual land parcel is to be greater than 100ha in size - minimum area of land to be acquired or secured will be no less than 450ha	- at least 8.4 ha of Horse Paddock Swamp will be rehabilitated. - at least 5 ha of the surrounding vegetation of North Lake will be subject to weed control - area of rehabilitation is shown in Figure 1	The extent of redundant road reserve to be transferred to Beeliar Regional Park is approximately 14.5ha.	-
Existing threatening processes	- urban development weed incursion - uncontrolled access by people and stock - fire	- weed infestation - feral animals - fire - eutrophication - altered water regimes due to a drying climate and falling groundwater levels across the region.	- current land zoning - public access - weed infestation - feral animals - fire - eutrophication	- Typha infestations at Thomsons Lake are reducing the available area of open water for migratory waterbirds
Relevant environmental issues	- The offset land parcels are to contain: - Black cockatoo foraging habitat - potential black cockatoo breeding habitat - remnant native vegetation of a similar vegetation association as the project area - CCW - GSM habitat or potential habitat (if GSM is still listed under the EPBC Act)	- Horse Paddock Swamp and North Lake are both CCW - Horse Paddock Swamp has no remnant vegetation and is extremely degraded - North Lake has good quality fringing vegetation but has some areas of weed incursion - uncontrolled access	- 8.37ha of CCW (Roe Swamp and surrounding sumplands) - 11.5ha of black cockatoo foraging habitat - 14ha of Bush Forever Site 244 - up to 14ha of intact native vegetation of the Bassendean Central and South complex.	- Migratory waterbird habitat
Objectives	- acquisition of offset land parcels - protection of offset land parcels in perpetuity through the creation of a crown reserve for conservation purposes	- offset impacts on CCW from the project - rehabilitate 8.4 ha of wetland and upland vegetation in Horse Paddock Swamp - control declared and environmental weeds in a 5 ha area around North Lake with the aspirational goal of eradication	- transfer redundant road reserve land within the MRS that is zoned “Primary Regional Roads” into Beeliar Regional Park - mitigate part of the impacts from the project upon CCW, black cockatoo foraging habitat and native vegetation, as a “like for like” offset in the immediate vicinity of the project area - protect this parcel of land in perpetuity by incorporating it into the DEC conservation estate - control Arum Lily within redundant road reserve area - land dealing plans to be submitted to Landgate within 12 months of construction.	- reduce the extent of *Typha orientalis* in Thomsons Lake to increase the area of open water in the lake.

	Offset Proposal 1	Offset Proposal 2	Offset Proposal 3	Offset Proposal 4
Minimum required to meet objectives	- proposed offset land parcels must meet the requirements of the EPBC Act *Offsets Assessment Guide* - land must be protected by creation of crown reserve - ownership of land is to be transferred to the Crown for conservation purposes with the management order created in the name of DEC - Main Roads to develop a Memorandum of Understanding with DEC which agrees on arrangements and funding for the ongoing management of the land	- develop and implement a WRP, in consultation with DEC, in accordance with Table 8.	- land dealing plans developed - land transfers initiated with Landgate - develop and implement ALCP.	- fund the development and implementation of a *Typha orientalis* control programme for Thomsons Lake in consultation with DEC.
Opportunity for like-for-like	- the property may include Threatened or Priority flora species - the offset will protect in perpetuity a greater area of land than that being impacted - may contain areas of CCW	- area of CCW to be restored is to be greater than the area of CCW disturbed by the project - in combination with other offset proposals, will provide an offset for CCW at a greater than 2:1 offset ratio.	- for impacts upon Beeliar Regional Park, there is a greater than 2:1 offset ratio created by Offset Proposal 3 - this land transfer will protect in perpetuity a greater area of CCW than will be impacted by the project - in combination with other offset proposals, it will create a greater than 2:1 offset ratio for impact upon CCW - protecting in perpetuity 14ha of Bush Forever Site 244, through its inclusion into the Beeliar Regional Park and providing a 2:1 offset for clearing within Bush Forever Site 244 - enhancing the condition of remnant vegetation and wetland habitat through the implementation of the ALCP.	- improve the value of existing wetland migratory bird habitat within the Ramsar listed Thomsons Lake. - Since this lake is currently afforded the highest level of international protection under the Ramsar Convention, this offset is considered to represent a net environmental gain for wetland migratory birds.

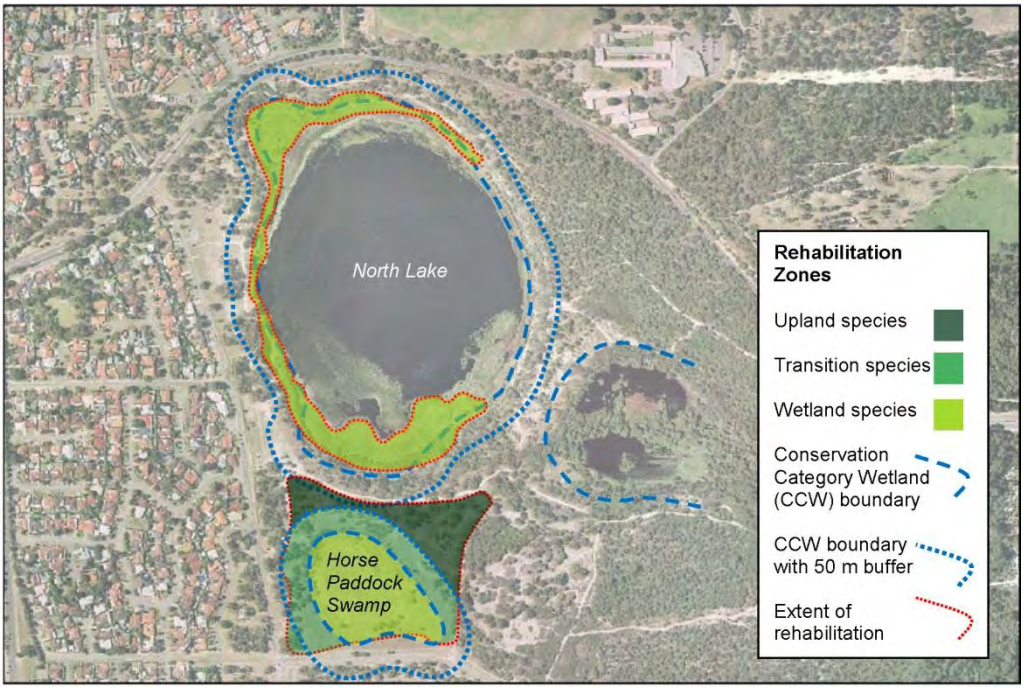


Figure 1 **Proposed North Lake and Horse Paddock Swamp Rehabilitation Areas (SMC 2011)**

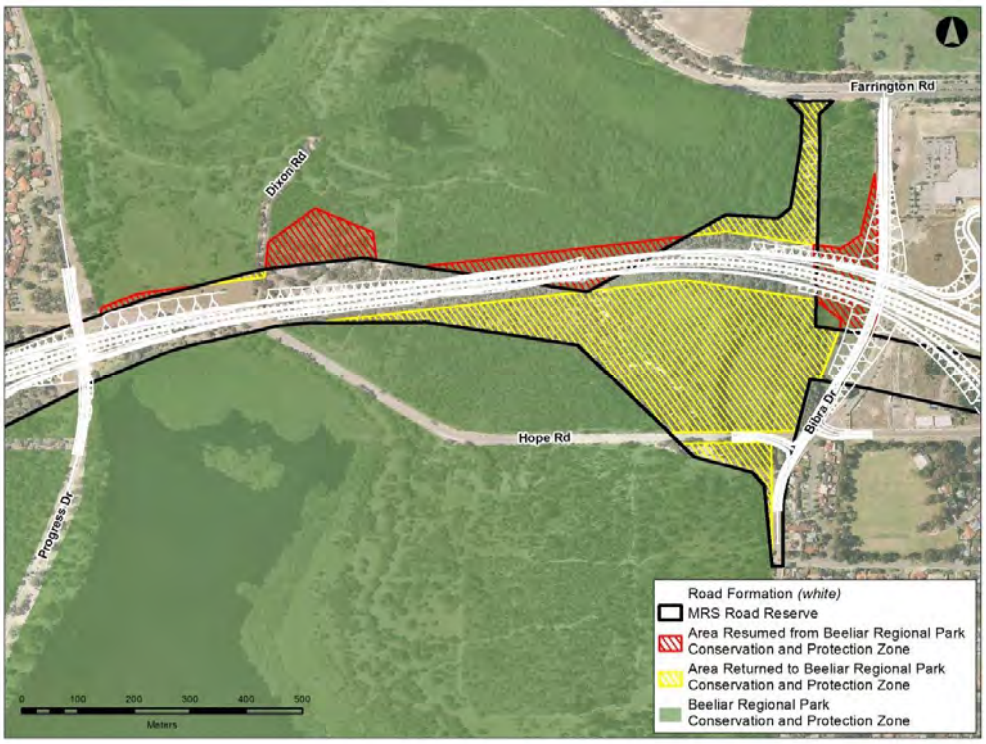


Figure 2 **Proposed Beeliar Regional Park Boundary Amendments (SMC 2011)**

Table 8 Outline of WRP

Elements to be incorporated into Wetland Restoration Plan
Weed control within North Lake and the restoration of Horse Paddock Swamp and North Lake wetland fringes is intended to establish historical wetland values through a programme of rehabilitation that: - enhances wetland vegetation characteristics (by improving the density and diversity of vegetation) - prepares the site and manages topsoil and microhabitat, salvaging and recycling suitable soil and habitat logs from areas of Roe Swamp designated for clearing - prevents fauna and human access to the rehabilitation area by fencing (fencing may be removed upon successful establishment of planted vegetation) - removes and controls weeds - collects and propagates suitable seed and vegetative material of appropriate provenance in a timely manner to allow seedlings to be planted at a planting density to be agreed with DEC - re-establishes native wetland vegetation by planting seedlings and augmenting with direct seeding (if appropriate) - times the planting of seedlings to make the most beneficial use of natural rainfall and seasonal groundwater conditions by corresponding planting times with position in the landscape - considers limited artificial watering over the first summer to help ensure survival through the initial establishment period - where practicable, translocates suitable plants from within the clearing envelope into Horse Paddock - where practicable, uses provenance species and genetic material - re-establishes at Horse Paddock Swamp and other locations, species that are relatively uncommon now on the Swan Coastal Plain, e.g. *Banksia littoralis* and *Melaleuca lateritia* - a detailed monitoring programme will be agreed with DEC during the preparation of the WRP. As a minimum, the detailed monitoring programme will include: • annual spring monitoring surveys for five years following the completion of construction • at least one permanently marked 10m x 10m monitoring quadrat or transect will be set up per hectare of rehabilitation for each habitat type (ie upland, transition and wetland) • monitoring transects of sufficient length to cross transition zones between habitat types, which will be designed to provide data regarding: ▪ site stability ▪ infiltration; and ▪ nutrient cycling. - assess for completion criteria after 5 years - completion criteria, linked to the following parameters: • percent foliage cover • stem density • health of vegetation within restored and rehabilitated areas; and • percent weed cover; - contingency and corrective actions; and - reporting requirements.

7.0 Implementation schedule

Project Phase	Offset Proposal	Activity to be implemented
Prior to construction	Environmental Offset Plan	- develop EOP - MoU between Main Roads and DEC on the ultimate vesting and management of offset proposals and their funding - seek comment and approval from Commonwealth Minister for the Environment and the Western Australian Minister for the Environment, or their appointed delegates - implement approved EOP
	Offset Proposal 1	- identify offset land parcels - acquire offset land parcels
	Offset Proposal 2	- develop WRP
	Offset Proposal 3	- develop ALCP
	Offset Proposal 4	- develop *Typha orientalis* control programme for Thomsons Lake
During Construction	Offset Proposal 1	- complete land transfer and creation of DEC reserve(s)
	Offset Proposal 2	- commence the implementation of the WRP
	Offset Proposal 3	- commence implementation of ALCP - survey redundant road reserve following construction
	Offset Proposal 4	- implement *Typha orientalis* control programme for Thomsons Lake
Post Construction – within 12 months	Offset Proposal 3	- submit land dealing drawings to Landgate
3 years Post Construction	Offset Proposal 4	- finalise *Typha orientalis* control programme
5 years Post Construction	Offset Proposal 2	- complete WRP (may be 6 years if completion criteria are not met)

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8.0 References

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SMC 2012. *Roe Highway Extension. Rehabilitation Strategy.* Report by SMC for Main Roads Western Australia.

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SouthmetroConnect

Noise Management Plan

Appendix J

Noise Management Plan

Appendix J Noise Management Plan

South Metro Connect
11 July 2012

Noise Management Plan

Roe Highway Extension



Noise Management Plan

Roe Highway Extension

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Quality Information

Document Noise Management Plan

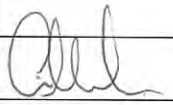
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Reviewed by John Braid

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Appendix A

Roe Highway Extension Revised Noise Mapping A

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1.0 Introduction

South Metro Connect (SMC) have carried out an acoustic assessment study of the concept design for the Roe Highway Extension project. The assessment study undertook road noise modelling to predict noise levels at noise sensitive receivers, as well as the design of noise mitigation measures where reasonable and practicable, to demonstrate that the project could comply with the Western Australian Planning Commision State Planning Policy 5.4 (SPP 5.4).

The acoustic assessment report was issued for Public Environmental Review (PER) in June 2011. This report has been through peer review by Lloyd George Acoustics (LGA) and has been subject to ongoing discussion between SMC, LGA and the Department of Environment and Conservation (DEC), with a focus on the calibration factor used in the modelling. While LGA have acknowledged that the current modelling may provide a realistic outcome, both LGA and the DEC believe the risk of under prediction warrants mitigation design based on a more conservative calibration factor.

As a consequence, SMC have provided additional modelling with a revised calibration factor, in-line with LGA recommendations and SPP5.4 guidance documents. This report presents the results of this revised modelling, including a revised barrier design, and comments on the intent and proposed management of the noise mitigation for the Roe Highway Extension.

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2.0 Noise Assessment

A noise assessment for the Roe Highway Extension project was conducted and a report included in the PER (AECOM 2011). This assessment was subsequently peer reviewed by Lloyd George Acoustics, where the calibration factor used in the SMC noise modelling was challenged. In subsequent liaison between DEC, SMC and the Office of the Environmental Protection Authority (OEPA), SMC has revised the noise assessment using DEC's recommended calibration factor for the Calculation of Road Traffic Noise (CoRTN) of 1.7dB. The revised noise contour mapping is included in Appendix A.

The results of the revised noise contour mapping has been assessed against the criteria applicable to noise emissions from new roads outlined in the SPP 5.4. It should be noted that these criteria do not apply to major transport corridor redevelopments, and are therefore not directly applicable to all aspects of the project area. Areas were the criteria do not apply include existing residential areas along Stock Road and to the north east of the Roe Highway/Kwinana Freeway Interchange.

The noise criteria apply to the emission of road transport noise as received at a noise-sensitive land use such as residential dwellings or non-residential noise sensitive receivers such as schools and child care centres. The criteria are applicable at 1m from the most exposed, habitable façade of the building receiving the noise, at ground floor level only.

2.1 Criteria for New Roads

Outdoor noise criteria for sensitive receivers affected by emissions from new major road proposals are outlined in Table 1 below. The criteria are not applicable to major redevelopment of existing transport infrastructure, which are discussed in Section 2.2.

Table 1 SPP 5.4 Outdoor noise criteria for new major road proposals

Time of day	Noise Target	Noise Limit
Day (6 am–10 pm) - $L_{Aeq,16hr}$	55dB(A)	60dB(A)
Night (10 pm–6 am) – $L_{Aeq,8hr}$	50dB(A)	55dB(A)

The 5 dB(A) difference between the outdoor noise target and the outdoor noise limit, as prescribed in Table 1, represents an acceptable margin for compliance. The policy states that "*In most situations in which either the noise-sensitive land use or the major road or railway already exists, it should be practicable to achieve outdoor noise levels within this acceptable margin*".

Policy guidelines for interpretation and application for new infrastructure proposals state that:

"*If a transport infrastructure project will emit transport noise levels that meet the noise target, no further measures are required under this policy. Otherwise, transport infrastructure providers should design mitigation measures to achieve the noise limit of LAeq(Day) 60dB(A) and LAeq(Night) 55dB(A), when assessed at one metre from the façade at ground floor level. Transport infrastructure providers are also required to consider design measures to meet the noise target of LAeq(Day) 55dB(A) and LAeq(Night) 50dB(A), and to implement these measures where reasonable and practicable.*"

The policy also recognises that in some cases it may not be practicable to achieve the outdoor noise criteria. Where outdoor noise limits cannot be achieved with reasonable and practicable mitigation measures, treatment of individual properties should be considered to achieve acceptable indoor noise levels.

The criteria in Table 1 apply for the majority of the project area, where road traffic noise will impact on noise sensitive receivers.

2.2 Criteria for Redevelopment of Existing Roads

With regard to redevelopment of existing major road infrastructure, SPP 5.4 states that reasonable and practicable noise management and mitigation measures should be considered having regard to:

- the existing transport noise levels
- the likely changes in noise emissions resulting from the proposal; and
- the nature and scale of the works and the potential for noise amelioration.

Guidelines for reasonable and practicable measures are provided within Section 5.8 of the policy.

The criteria in Table 1 do not apply where this project is upgrading existing major road infrastructure. This includes most noise sensitive receivers along Stock Road and to the north east of the existing Roe Highway/Kwinana Freeway Interchange.

2.3 Noise Mitigation

The noise barrier design, as shown in Appendix A, aims to achieve the noise target wherever possible, whilst considering the visual, social and construction limitations of tall noise barriers. From the initial noise modelling in AECOM (2011), noise walls in excess of 6.2m would be required to meet the target. Walls this high are considered to have too many negative impacts. Main Roads and SMC have set caps on noise barrier heights in consultation with DEC and OEPA (Table 2).

The location and heights of noise barriers in Appendix A is based on the concept design developed by SMC. During final design of the road, just prior to construction, further noise modelling will be required to determine the extent and height of noise barriers. The height, extent and materials used for noise wall construction will also be informed by further stakeholder consultation.

Table 2 Maximum noise barrier heights proposed for Roe Highway Extension

Location of noise barrier	Maximum height of noise barrier
Within road reserve (alongside road)	5.0m
Along residential boundary	4.4m

A variety of materials can be used in the construction of noise walls. The most common types used currently in Western Australia by Main Roads are limestone walls or pre-fabricated concrete “panel and post” walls. Provided the surface density exceeds 15kg/m^2, almost any material could be used provided it is acceptable to Main Roads and DEC.

Road surfacing is an important component of noise mitigation. The majority of the alignment will be surfaced using Open Graded Asphalt (OGA). OGA is currently the best performing road surface for noise attenuation – approximately 3dB quieter than Dense Graded Asphalt (DGA). There are limitations to the use of OGA, and it is not suitable for all areas of the project.

Acoustic treatments to individual properties are not proposed under this noise management plan

3.0 Description of Project Noise Mitigation

3.1 General Principles of Noise Mitigation Design

A brief explanation of the noise mitigation for each section of the project is included below. The description highlights the rationale behind the proposed mitigation and any extenuating circumstances.

3.2 Stock Road

Noise sensitive receivers adjacent or near to Stock Road are in an existing noisy environment (see Appendix A 2031 No Build) and as such the criteria in Table 1 do not strictly apply. However noise mitigation as part of this project will see many receivers have a reduction in traffic noise compared to the no build scenario. The target has been achieved at most receivers in this area with the use of maximum wall heights and double walls near Phoenix Road. Only one location (at the corner of Phoenix Road and Stock Road) exceeds the limit.

The double noise barrier on the eastern side of Stock Road is limited to 2.4m in height on the property boundary. This is due to an existing retaining wall in this location, making construction of a taller wall difficult.

A 5m noise barrier is proposed along the eastern boundary of Hamilton High School. This barrier reduces the noise impact on the exposed facade facing Stock Road.

3.3 Stock Road to Coolbellup Ave/Sudlow Road

All noise sensitive receivers in this section meet the limit as per SPP 5.4 and most meet the target. Where the target is not met, this is due to the cap on noise wall height. On the southern side of the project, a 4.4m high noise wall on the northern boundary of residential properties will create significant shading issues.

Roadside barriers to the north of Roe Highway run along the top of the road cutting. The barrier heights vary from 3.4m to 5m, with the smaller barriers located on the top of a significant retaining wall (~10m) where the road is in a cutting. These receivers receive a significant reduction in noise levels relative to the No Build scenario in 2031.

Roe Highway is in significant cutting in this section. While the north side has a large retaining wall, the ground banks steadily toward the southern residences. As a consequence, the proposed barrier along this section is 4.4m high along the residential boundaries.

3.4 Coolbellup Ave/Sudlow Road to North Lake Road

Residences to the north of Roe Highway generally front onto a local road facing the proposed Highway. To preserve the outlook onto bushland and maximise the effectiveness of the barrier, it has been located along the roadside. All noise sensitive receivers are within the limit and most under the target. Several properties on the corner of Roe Highway and North Lake Road are very close to the limit. A “double” wall was investigated in this location, but it was found to be impractical due to the location of the Principal Shared Path (PSP). The “double” wall would have created a choke point for pedestrians and cyclists.

Residences to the south have a 4.4m noise barrier on their residential boundary. While “double” barrier options were considered, with a roadside barrier, these were discarded for social reasons. Having a roadside barrier in this location would have created a trapped corridor between the barrier and the residential fences. Whilst all of the properties in this southern section meet the limit, very few meet the target.

3.5 North Lake Road to Bibra Drive

There are very few nose sensitive receivers in this section of the road, as it passes through Beeliar Regional Park. Barriers to the north of the freeway range from 3m to 5m. Where the highway passes over Progress Drive, the barrier height has been reduced to 3m due to engineering constraints of constructing a large barrier on a bridge.

3.6 Bibra Drive to Kwinana Freeway

Noise sensitive receivers along Hope Road will experience a significant increase in traffic noise due to the project without noise barriers. Noise mitigation of 4-5m walls will ensure that almost all of these receivers will meet the target. Closer the existing Kwinana Freeway, many receivers will receive a reduction in traffic noise from the no build scenario.

An existing 2.4mbarrier along the freeway to the south of the interchange will be relocated and extended. Noise modelling using the 1.7dB calibration factor over predicts the noise impacts in this area, as the dominant source of noise is from the existing Kwinana Freeway.

3.7 North East of Kwinana Freeway

A 2.4m high noise barrier is proposed for residential in the north east quadrant of the Roe Highway/Kwinana Freeway Interchange, and along Roe Highway to Karel Avenue. This section of the Roe Highway Extension is not subject to the criteria in Table 1, as the project would be a redevelopment rather than a new road.

The noise model is expected to over predict in this location. The 1.7 dB calibration factor is normally only applied to new roads. Where there is an existing road (as in this case), the model is calibrated using recorded data. Recorded noise levels show that the model is over predicting by 2-3dB (see AECOM 2011 for recorded data).

Only a 2.4m noise barrier is proposed for the following reasons:

- this conforms to the amenity wall currently under construction as part of the Kwinana Freeway widening works between Leach Highway and Roe Highway
- the area is already experiencing significant road traffic noise
- the noise model is expected to over predict noise in this area as it is not calibrated to the existing noise conditions as per the SPP 5.4 implementation guidelines

Whilst not all noise sensitive receivers will achieve the limit as a result of this noise barrier, it will still provide an improvement over the predicted no build scenario.

4.0 Construction Noise Management

Construction noise will comply with the *Environmental Protection Act* 1986 (WA) and the *Environmental Protection (Noise) Regulations* 1997 (WA).

A Construction Noise and Vibration Management Plan (CVNMP) will be established, implemented and maintained to the satisfaction of the Local Government Authority and the DEC.

The CVNMP will:

- minimise the effects of noise on the occupants of adjacent properties by the use of silenced plant or by operating plant as far away as practicable from those properties;
- limit working hours on those construction activities which generate significant noise (piling); and
- design and construct noise mitigation structures to satisfy the requirements of the *Regulations*.

This page has been left blank intentionally.

5.0 Community Consultation

The final design, height and extent of noise barriers will be determined during the final design phase, just prior to construction. All residents that will be impacted by the construction of noise barriers will be consulted on the design, height and location. As a minimum all affected residents will be contacted by mail.

This page has been left blank intentionally.

6.0 Monitoring

6.1 Construction Noise Monitoring

No noise monitoring is planned during construction, unless specifically required within the CVNMP.

6.2 Traffic Noise Monitoring

Traffic noise monitoring will be conducted immediately post construction and then annually for 3 years to determine the accuracy of the predicted noise emissions and the adequacy of noise mitigation. Monitoring results will be recorded in the annual compliance reports for at least 5 years post construction.

If monitoring indicates that noise mitigation is not sufficient, Main Roads will consider upgrading the noise barriers adjacent to the affected areas.

This page has been left blank intentionally.

7.0 Conclusion

This noise management plan is based on the concept design for Roe Highway Extension. Noise barriers located on residential boundaries have been limited to 4.4m in height and those within the road reserve to 5m in order to best balance noise benefit, cost, feasibility, amenity impacts, community preferences and safety and security.

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8.0 References

AECOM 2011, *Acoustic Assessment Report Roe Highway Extension.* Unpublished report prepared for South Metro Connect. Perth, WA.

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Appendix A

Roe Highway Extension Revised Noise Mapping

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AECOM

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0 95 190 380

metres

Legend - LAeq, 16hr Noise Levels

N/A	57	62	Proposed Roads	Designed Barrier
≤ 53	58	63	No Build Roads	Bridge Barrier
54	59	64	Existing Roads	Retaining Wall
55	60	65		Road Parapet
56	61	≥ 66		Existing Fence

South Metro Connect - Roe Highway Extension Noise Modelling
Revised Calibration - Stock Road to Karel Ave
2031 Build

PROJECT ID 60100953
CREATED BY NB
LAST MODIFIED NB 7 JUNE 2012

Image

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metres

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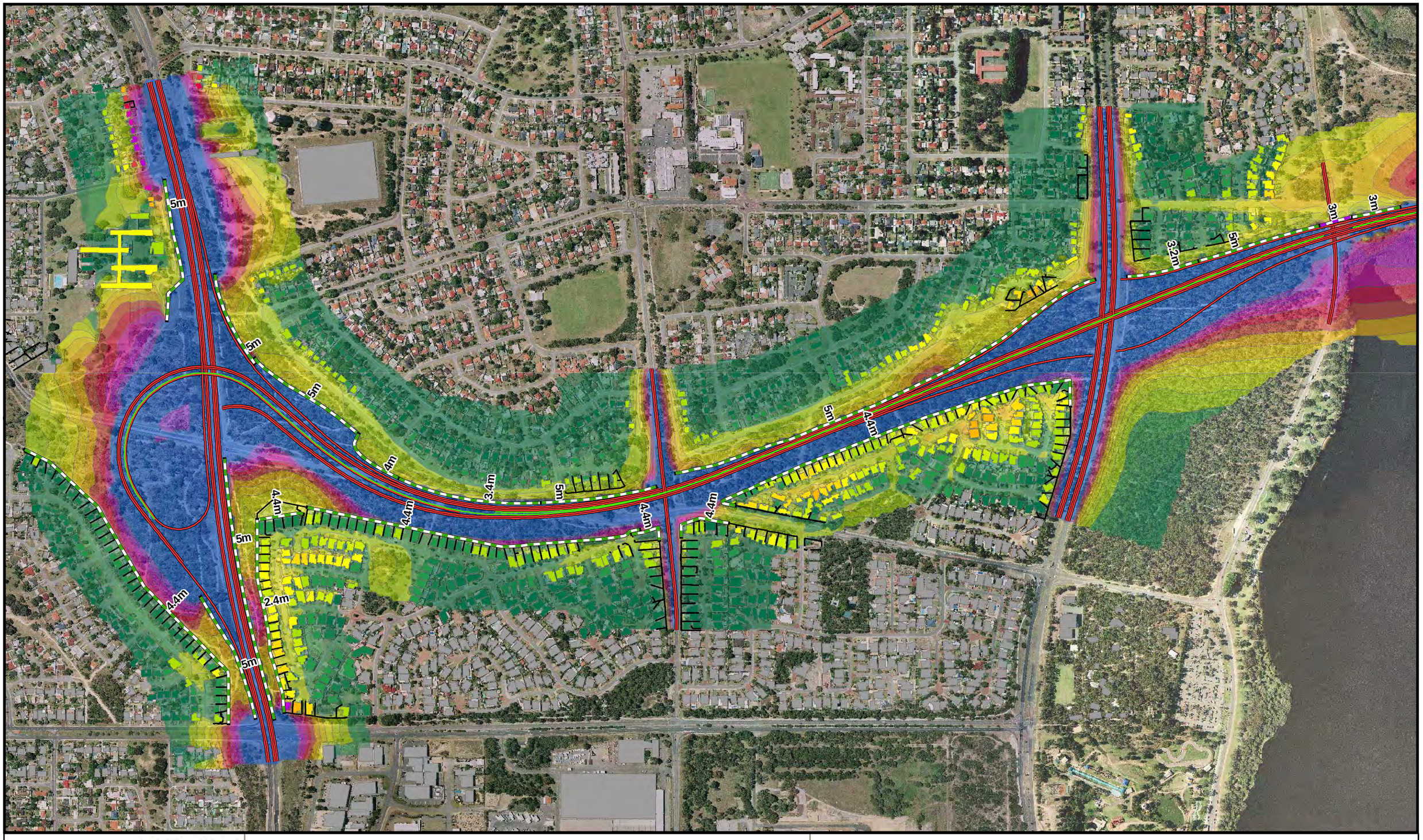
South Metro Connect - Roe Highway Extension Noise Modelling
Revised Calibration - Stock Road to Karel Ave
2031 Build

PROJECT ID	60100953
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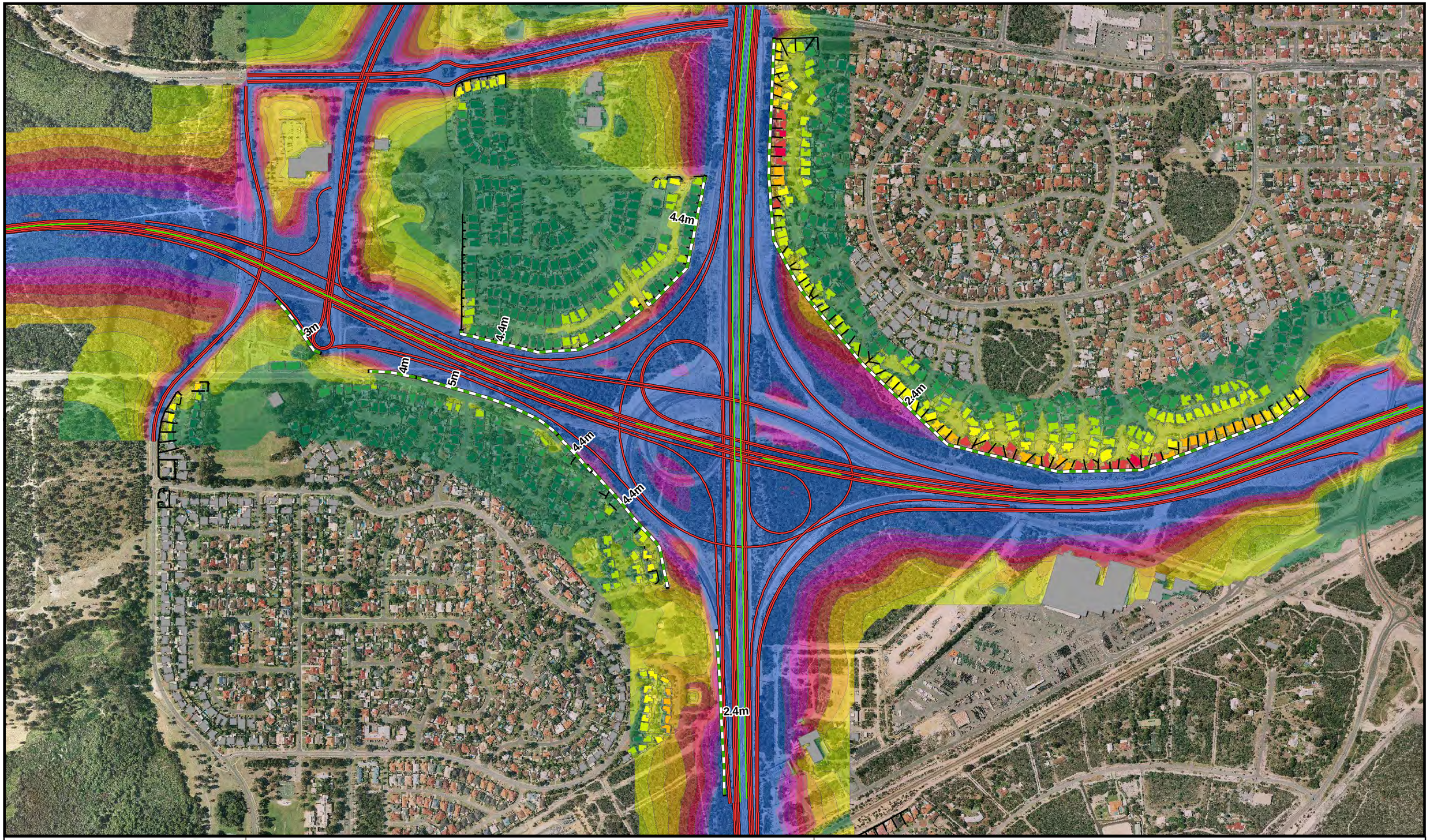
South Metro Connect - Roe Highway Extension Noise Modelling
Revised Calibration - Proposed Final Barriers
Facade Corrected Noise Levels

PROJECT ID	60100953
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South Metro Connect - Roe Highway Extension Noise Modelling
Revised Calibration - Stock Road to Karel Ave
2031 No Build

PROJECT ID	60100953
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PROJECT ID	60100953
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SouthmetroConnect

Consultation with DoW

Appendix K

Consultation with DoW

Appendix K Consultation with DoW

Pilkington, Melinda

From: Perrigo, Ross
Sent: Friday, 11 January 2013 11:50 AM
To: Braid, John; Kercheval, Francoise
Subject: FW: TRIM: FW: Roe Highway Extension - Water Management Strategy

Follow Up Flag: Follow up
Due By: Monday, 14 January 2013 4:00 PM
Flag Status: Flagged

John & Francoise,

Further to our discussions, Department of Water have responded (below) to my previous email. Looks like they are satisfied with what we have proposed. This including no impacts from compaction. Still worth exploring a more detailed response though to cover off OEPA requirements as we discussed in the meeting.

Would be interested on whether you feel contacting the DoW Regional Hydrogeologist regarding monitoring should be done now, as part of the licence application.

Cheers,

Ross Perrigo
Senior Hydrologist
D +61 8 6208 0558
Ross.Perrigo@aecom.com

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Please consider the environment before printing this email.

From: RIDLEY Patrick [mailto:Patrick.Ridley@water.wa.gov.au]
Sent: Friday, 11 January 2013 10:25 AM
To: Perrigo, Ross
Subject: RE: TRIM: FW: Roe Highway Extension - Water Management Strategy

Hi Ross,

Just one more column added...

Please contact me with further queries.

Kind regards,

Patrick Ridley
Natural Resource Management Officer | Peel Region
107 Breakwater Parade | PO Box 332 | MANDURAH WA 6210
Ph (08) 9550 4237 | Email patrick.ridley@water.wa.gov.au
www.water.wa.gov.au

Government of Western Australia
Department of Water

AECOM	DoW	AECOM Approach	DoW comment
1. For which GDEs depth to groundwater needs to be determined	Depth to groundwater needs to be determined for any GDE's considered to be impacted by abstraction other than North Lake and Bibra Lake. Drawdown estimates currently indicate that abstraction needs to occur more than 1.5km from North Lake and Bibra Lake to ensure GW level is not affected. Groundwater levels of other GDE's need to be determined to ensure the impacts of proposed groundwater abstraction are within the low impact category (see DoW's comment in the OPEA response for impact categories). The current modelling information is not considered suitable to determine the groundwater levels across the site.	There will be no abstraction locations within 1.5km of North Lake and Bibra Lake. The only proposed abstraction within 1.5km of other GDEs (i.e. Roe Swamp) is the area near Kwinana Freeway, which is approximately 1km from the GDEs. Modelling conducted for the WMS (relevant pages are attached) demonstrates that at this distance the anticipated drawdown will be ~5cm, which is within the low impact category. It is not considered appropriate to conduct field testing on groundwater levels at this time as construction may not begin for 5-10yrs. It will be recommended that should the abstraction location at Kwinana Freeway be utilised, monitoring of the relevant GDEs be conducted to determine pre-development groundwater levels and any impacts during abstraction.	Noted. Further detail and management should be addressed during the Dewatering Licensing process. It is recommended the proponent contact DoW's Regional Hydrogeologist (Peel Region) for advice on appropriate pre-development monitoring.

2. Any further comments regarding the MIKE SHE results	Attached is a memo from the modellers with additional information regarding the MIKE SHE results.	These comments are useful in understanding the DoW's position. We certainly acknowledge that the model has some short comings. As it has not been requested by OEPA, we will not be performing any revisions or further modelling in support of this project.	Noted.
3. Which indirect impacts to wetlands require further assessment	Given this item appears to be OEPA's comment, I suggest initial clarification should come from the OEPA. DoW will provide advice on specific comments if requested. Please contact DoW early to ensure any water modelling is appropriate.	As discussed on the phone, the three potential indirect hydrological impacts on the wetland are: • Abstraction • Modification of the surface hydrology • Modification of the hydrogeology The first point has been addressed above. Modification of the surface hydrology is considered to be manageable as acknowledge by DoW's comment "these impacts are considered to be manageable by engineering solutions proposed through the bridge structures and balancing culverts under the road to maintain the exchange of surface water". The final point is discussed below.	Noted
4. Compaction and groundwater flows	Ross, you suggested you are keen to clarify the wording in the PER. Would you consider forwarding a draft for DoW's review?	Sorry, there may have been a misunderstanding here. I just wanted to clarify that the DoW are satisfied that there will be no impact from compaction (and reduced soil porosity) as the flow of groundwater is generally parallel to the roadway.	Based on the information provided, DoW agrees that the compaction is likely to have a negligible impact on groundwater flows and hydrological function of the GDE's .

From: Perrigo, Ross [mailto:Ross.Perrigo@aecom.com]
Sent: Wednesday, 9 January 2013 10:05 AM
To: RIDLEY Patrick
Subject: TRIM: FW: Roe Highway Extension - Water Management Strategy

Hi Patrick,

Hope your New Year is off to a good start. I was looking over my previous email to you and realised I had forgotten to attach the pages regarding drawdown impacts. I have attached those now.

Please call should you have any questions.

Regards,

Ross Perrigo
Senior Hydrologist
D +61 8 6208 0558
Ross.Perrigo@aecom.com

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www.aecom.com

Please consider the environment before printing this email.

From: Perrigo, Ross
Sent: Friday, 21 December 2012 11:18 AM
To: patrick.ridley@water.wa.gov.au
Cc: Braid, John
Subject: RE: Roe Highway Extension - Water Management Strategy

Hi Patrick,

Thank you for the email. Your swift response before Christmas is certainly appreciated.

In reply to you email, I have added a column outlining our approach to the outstanding issues. Are you able to confirm whether these are acceptable? Should you wish to discuss, we'd be happy to meet in the new year.

AECOM	DoW	AECOM Approach

5. For which GDEs depth to groundwater needs to be determined	Depth to groundwater needs to be determined for any GDE's considered to be impacted by abstraction other than North Lake and Bibra Lake. Drawdown estimates currently indicate that abstraction needs to occur more than 1.5km from North Lake and Bibra Lake to ensure GW level is not affected. Groundwater levels of other GDE's need to be determined to ensure the impacts of proposed groundwater abstraction are within the low impact category (see DoW's comment in the OPEA response for impact categories). The current modelling information is not considered suitable to determine the groundwater levels across the site.	There will be no abstraction locations within 1.5km of North Lake and Bibra Lake. The only proposed abstraction within 1.5km of other GDEs (i.e. Roe Swamp) is the area near Kwinana Freeway, which is approximately 1km from the GDEs. Modelling conducted for the WMS (relevant pages are attached) demonstrates that at this distance the anticipated drawdown will be ~5cm, which is within the low impact category. It is not considered appropriate to conduct field testing on groundwater levels at this time as construction may not begin for 5-10yrs. It will be recommended that should the abstraction location at Kwinana Freeway be utilised, monitoring of the relevant GDEs be conducted to determine pre-development groundwater levels and any impacts during abstraction.
6. Any further comments regarding the MIKE SHE results	Attached is a memo from the modellers with additional information regarding the MIKE SHE results.	These comments are useful in understanding the DoW's position. We certainly acknowledge that the model has some short comings. As it has not been requested by OEPA, we will not be performing any revisions or further modelling in support of this project.
7. Which indirect impacts to wetlands require further assessment	Given this item appears to be OEPA's comment, I suggest initial clarification should come from the OEPA. DoW will provide advice on specific comments if requested. Please contact DoW early to ensure any water modelling is appropriate.	As discussed on the phone, the three potential indirect hydrological impacts on the wetland are: • Abstraction • Modification of the surface hydrology • Modification of the hydrogeology The first point has been addressed above. Modification of the surface hydrology is considered to be manageable as acknowledge by DoW's comment "these impacts are considered to be manageable by engineering solutions proposed through the bridge structures and balancing culverts under the road to maintain the exchange of

		surface water". The final point is discussed below.
8. Compaction and groundwater flows	Ross, you suggested you are keen to clarify the wording in the PER. Would you consider forwarding a draft for DoW's review?	Sorry, there may have been a misunderstanding here. I just wanted to clarify that the DoW are satisfied that there will be no impact from compaction (and reduced soil porosity) as the flow of groundwater is generally parallel to the roadway.

If you have any immediate questions on the above, please don't hesitate to call me. Our office will close at 2pm today, but I will be back on the 7th of January.

Have a safe and merry Christmas.

Regards,

Ross Perrigo
Senior Hydrologist
D +61 8 6208 0558
Ross.Perrigo@aecom.com

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GPO Box B59 Perth WA 6849
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www.aecom.com

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From: RIDLEY Patrick [mailto:Patrick.Ridley@water.wa.gov.au]
Sent: Thursday, 20 December 2012 3:01 PM
To: Perrigo, Ross
Subject: RE: Roe Highway Extension - Water Management Strategy

Hi Ross,

I would like to try and clarify some information before a meeting is arranged.

AECOM	DoW

1. For which GDEs depth to groundwater needs to be determined	Depth to groundwater needs to be determined for any GDE's considered to be impacted by abstraction other than North Lake and Bibra Lake. Drawdown estimates currently indicate that abstraction needs to occur more than 1.5km from North Lake and Bibra Lake to ensure GW level is not affected. Groundwater levels of other GDE's need to be determined to ensure the impacts of proposed groundwater abstraction are within the low impact category (see DoW's comment in the OPEA response for impact categories). The current modelling information is not considered suitable to determine the groundwater levels across the site.
2. Any further comments regarding the MIKE SHE results	Attached is a memo from the modellers with additional information regarding the MIKE SHE results.
3. Which indirect impacts to wetlands require further assessment	Given this item appears to be OEPA's comment, I suggest initial clarification should come from the OEPA. DoW will provide advice on specific comments if requested. Please contact DoW early to ensure any water modelling is appropriate.
4. Compaction and groundwater flows	Ross, you suggested you are keen to clarify the wording in the PER. Would you consider forwarding a draft for DoW's review?

Contact me if the above is not satisfactory and I will make arrangements for a meeting with the DoW's respective experts. Please specify which items require further clarification.

Please note tomorrow will be my last day and I will return on 7 January.

Regards,

Patrick Ridley
Natural Resource Management Officer | Peel Region
107 Breakwater Parade | PO Box 332 | MANDURAH WA 6210
Ph (08) 9550 4237 | Email patrick.ridley@water.wa.gov.au
www.water.wa.gov.au

Government of Western Australia
Department of Water

From: Perrigo, Ross [mailto:Ross.Perrigo@aecom.com]
Sent: Wednesday, 19 December 2012 12:19 PM
To: RIDLEY Patrick
Subject: TRIM: Roe Highway Extension - Water Management Strategy

Hello Patrick,

I've recently received your comments on the Roe Highway Extension Water Management Strategy (WMS) through the OEPA (attached). I am one of the strategy authors, and I am addressing your comments in order to finalise the document. We'd like to consult with you during the revision of the document to ensure that our responses are satisfactory.

Having reviewed them, I don't see anything too controversial. There is certainly support for increasing the bio-retention treatment across the site, and revising the proposed basin sizing to be consistent with the 2% directly connect impervious area approach. Similarly, abstraction will be prevented within 1.5km of the North and Bibra Lake.

I'm hoping to arrange a meeting with you to discuss some of the other comments in the document. Namely;

- For which GDEs depth to groundwater needs to be determined
- Any further comments regarding the MIKE SHE results
- Which indirect impacts to wetlands require further assessment
- Compaction and groundwater flows

Given it is the week before Christmas, I doubt it's possible to arrange this year. Would you have time to discuss during the week beginning January 7th?

Should you have any questions, please do not hesitate to call.

Regards,

Ross Perrigo
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Technical Note – Potential impacts to groundwater flows from sub-surface compaction from road embankments

Appendix L

Technical Note – Potential impacts to groundwater flows from sub-surface compaction from road embankments

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Technical Note: Potential Impacts to groundwater flows from sub – surface compaction from road embankments

1.0 Introduction

This note has been prepared to assess the potential impacts on the groundwater regime as a result of the proposed embankment constructions associated with the road alignment.

The proposed road alignment will require the construction of a number of embankments with fill to a maximum of approximately 10 m in height above the natural ground surface. . The potential for compaction of the natural sub surface material under these embankments and possible adverse impacts on groundwater levels and flows in wetland areas where groundwater levels are shallow has been raised in the PER submissions, notably along the road alignment between Bibra Drive and the western margin of Bibra Lake.

2.0 Background – Compaction Modelling

Estimation of compaction of the natural underlying material has been described in section 6.3.2.4 of the PER. Estimates were made using a finite element model (PLAXIS 2D and 3D) to predict the effect from embankments of varying heights (3 m, 4.25 m, 4.5 m, 6 m, 7.5 m, 8.5 m and 9 m). The modelling was based on the properties of unconsolidated sand material typical of the Bassendean Sands as determined by site investigations.

Figure 1 shows the model output for a 9 m embankment, which estimates that the change in porosity (as volumetric strain) is very minor and limited to effectively the upper 3 m of the subsurface (1.9 – 2.0% in the interval from 0 – 1 metres below ground (mbgl), 1.3 – 1.9 % from 1 – 2 mbgl and 0.6 – 1.2 % from 2 – 3 mbgl).

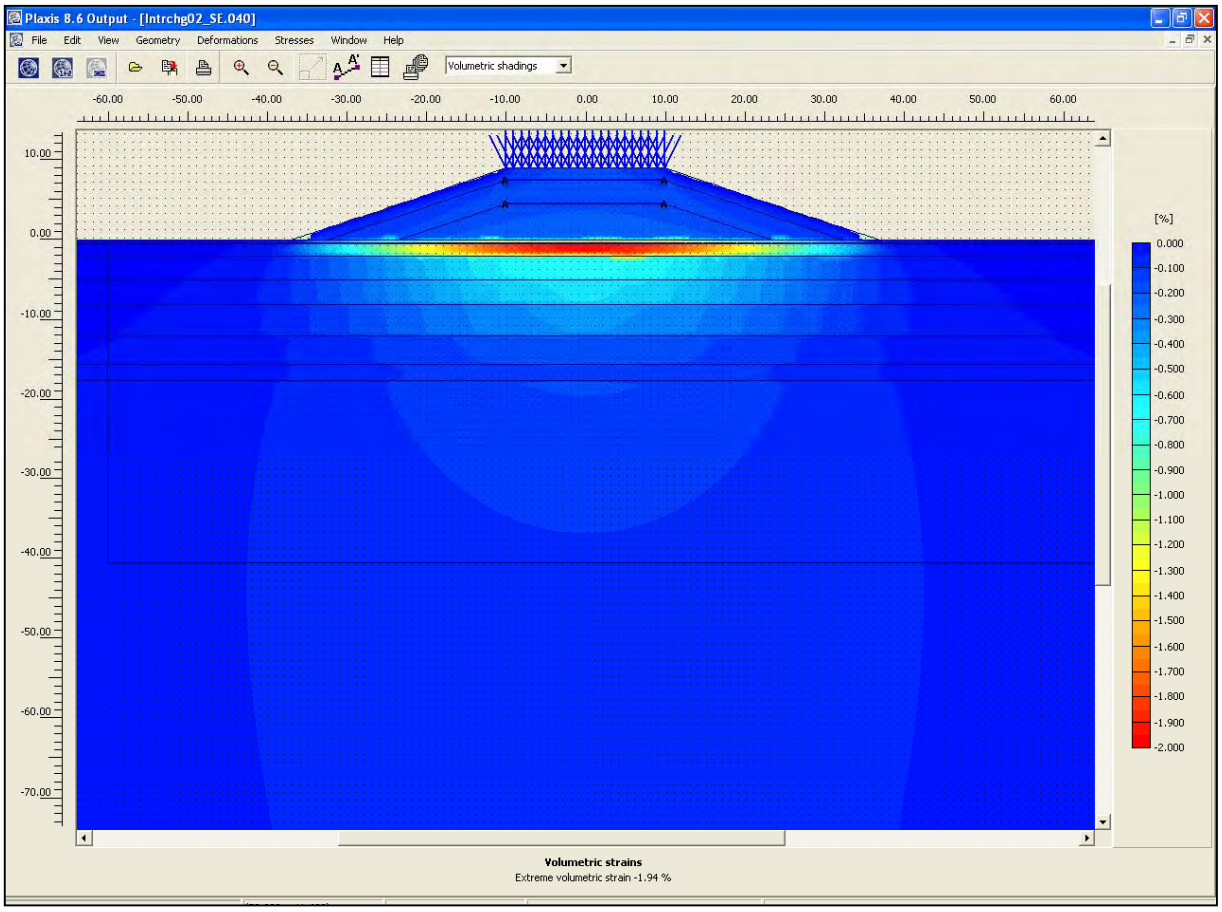


Figure 1 Model estimations of volumetric strain associated with the construction of a 9 m embankment.

The modelling results prove that compaction effects will have no significant effect on groundwater levels or groundwater flow in areas where the subsurface material is comprised of clean sands in which direct sand grain-to-grain contact provides the soil strength and compressibility. In such sandy materials, even where a shallow (less than a few metres) unconfined water table aquifer is present, the effects of any compaction on groundwater levels or flow (either locally or more regionally) are expected to be insignificant. Clean sands typically have porosities in the range from 30 – 45%. If the upper bound of modelled porosity reduction (3%) is applied, then the resultant porosity would be approximately 29 – 43.5%. This level of change, applied across only the upper few metres of an aquifer unit that is typically 35 – 40 m thick in the project area, would have no discernible impact on aquifer permeability or storativity or subsequent groundwater levels and flows (at a local or regional scale).

3.0 Local Geology and Hydrogeology

Whilst the work completed to date provides the basis for stating an absence of significant impacts on the groundwater system from potential compaction, the PER submission(s) imply the compaction issue and effects may be significant in wetland areas and lake margins, where shallow groundwater levels can occur within a surficial sequence of finer grained lacustrine sediments. To consider this issue, we have reviewed the local geology and hydrogeology in the area in the context of the compaction issues raised.

Figure 2 shows groundwater level data (as depth to the watertable) from March and September 2010 for various monitoring bores in the main wetland areas, as well as the proposed road alignment and government-sourced GIS datasets for water bodies and surficial geology. The GIS data on water bodies and surficial geology are not considered to be highly accurate at the local level in question, but provide a reasonable outline.

Bores T3C, T3B and H show that groundwater levels in the area immediately west of Bibra Drive (Roe Swamp) can be shallower than 2 m and potentially within peaty silts of lacustrine origin. Further west of this area along the road alignment, groundwater depths are greater but then would be lower than 2.0 m at peak times near Horse Paddock Swamp. The 2010 groundwater level data collected for the Project represents a 'dry' year, and as such, groundwater levels would be expected to be shallower over a wider area in and near Roe and Horse Paddock swamps.

To reconcile the public-domain surficial geology and soil maps with project data, lithology logs for select monitoring bores installed as part of the wetland assessment by V & C Semenuik Research Group were reviewed. Bore Logs of T3B, T3C, T4A, T4B and H, which are near Roe Swamp, are summarised in Table 1.

Table 1 Summary of shallow subsurface lithology near Bibra Drive

Bore ID	T3B	T3C	T4A	T4B	H
Depth (mbgl) and Lithological Description	0 – 1 m Humic, very coarse, coarse and medium grained sands	0 – 1 m Buff coarse sands	0 – 1 m Buff, coarse, mostly medium and fine quartz sands	0 – 1 m Fill	0 – 2.5 m Brown, muddy sand (fine grained opaline silica hash) and quartz sand
	1 – 2 m Buff, very coarse, coarse and medium quartz sand	1 – 2 m Very coarse and mainly quartz sand	1 – 3 m Grey, buff, coarse mostly medium and fine quartz sand	1 – 2 m Grey muddy sand	2.5 – 3 m Buff, mainly medium quartz sand
				2 – 2.5 m Grey, coarse, medium and fine quartz sand	

The bore data confirms that sands with some finer grained sediments and organic material are present in the upper few metres in and adjacent to the mapped wetland areas, but that this material is not necessarily thick, extensive or impermeable (at least in the locations drilled).

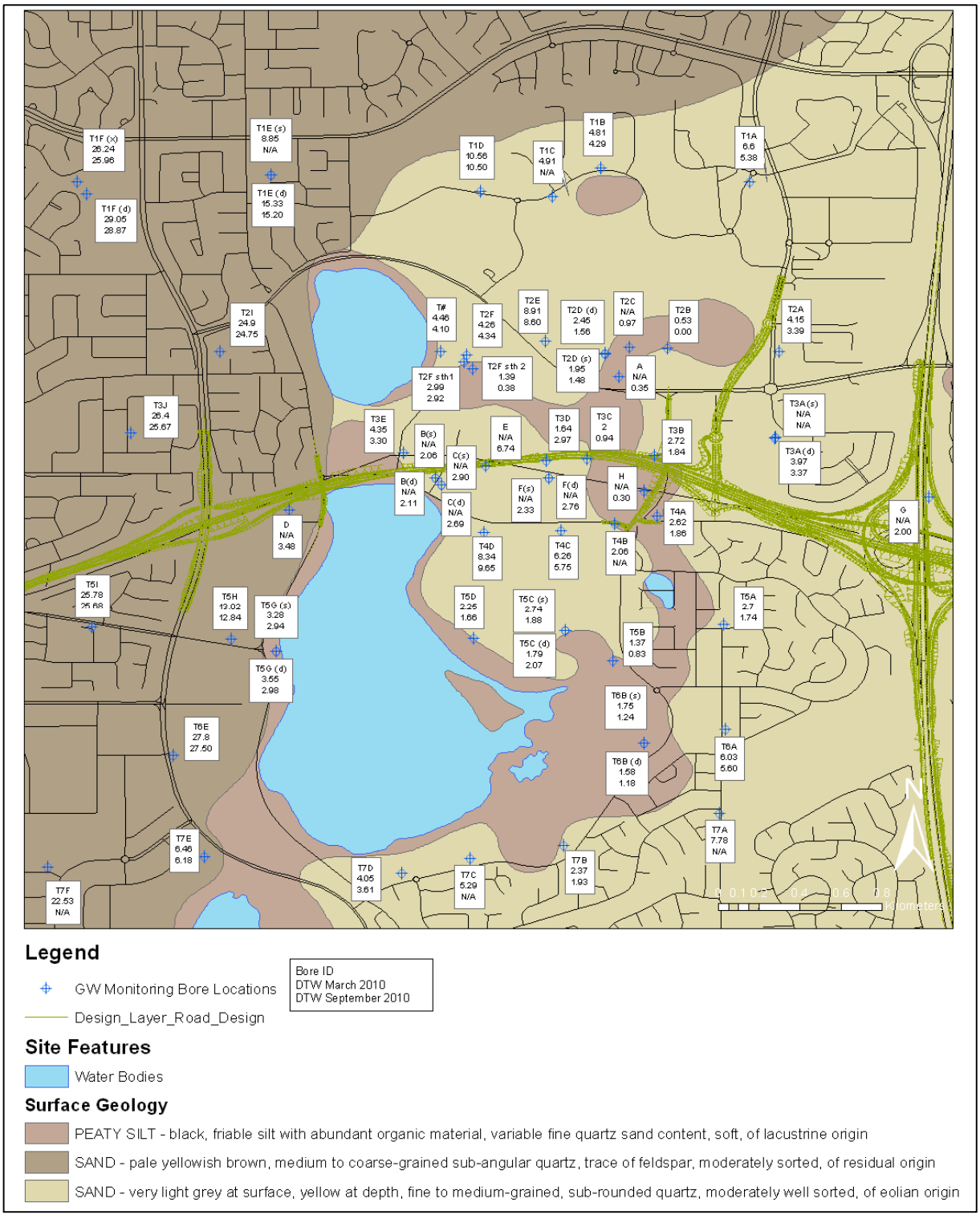


Figure 2 **Depth to groundwater, surficial geology and proposed road alignment.**

4.0 Discussion

Whilst the potential for relatively greater levels of compaction from embankment emplacement exists in areas where surficial finer grained sediments occur within the road alignment near Roe and Horse Paddock swamps, any subsequent potential for adverse impacts on groundwater levels or flow, and the general wetland hydrological regime, is not considered to be significant.

In terms of local or more regional groundwater flow, little change is expected in areas containing finer grained sediments, as these surficial sediments represent only a minor portion of the (vertical) aquifer sequence, which has high porosity and permeability. The top few metres of the water table aquifer could 'accommodate' a massive reduction in porosity and permeability without significantly changing aquifer flows or levels given that the aquifer is of the order of 35 – 40 m thick and highly permeable (10 – 20 m/day typically). In light of this aspect, the alignment of the main highway with respect to the overall groundwater flow direction is not a significant factor in terms of the overall groundwater balance beneath embankment areas.

The most plausible localised effect of embankment and compaction in the shallow water table settings of the project area may be a 'loading' effect if surficial finer grained sediments are present and provide a confining condition to the underlying sandy section of the aquifer (i.e. groundwater levels occur in the shallow finer grained sediments and these are significantly thick and impermeable. A net effect of this is the compression of the finer grained sediments beneath the embankment (new load), reduction of porosity and subsequent 'transmission' of some pore water vertically and laterally away from the zone of compression/loading. If the aquifer was fully confined over a wide area (which it is not considered to be in the project area, even beneath wetlands), the loading would produce a potentially small increase in potentiometric heads away from the embankment areas and potentially alter vertical groundwater flows slightly. However, in the project area, any confining effects from shallow groundwater levels and fine grained sediments are likely to be laterally limited, such that the 'release' of any pore water from beneath embankments would migrate to sandy unconfined aquifer sections where the high porosity and permeability would 'accommodate' the additional water with minimal effect on groundwater levels. Given the sandy nature and limited thickness of the finer grained sediments, even a relatively high percentage of compaction is only likely to 'release' a very small volume/flux of water, such that changes to local groundwater flows are likely to be insignificant.

Based on the insignificant changes to groundwater levels and fluxes predicted above, the consequences to the overall water balance and hydrological regime of wetland areas in the immediate vicinity of the proposed embankments are not considered significant and hence are not discussed further here. The issues associated with transmission of surface and road runoff water near and across embankment areas are described elsewhere as part of drainage designs and management measures to protect and maintain wetland systems.

Flora Consultation

Appendix M

Flora Consultation

Appendix M Flora Consultation

Braid, John

From: Batty, Andrew
Sent: Friday, 1 February 2013 8:04 AM
To: Braid, John
Subject: FW: SMC undescribed and priority species / EPA
Attachments: 60100953-SMC Memo_jan_2013RevB.DOCX

John the email chain relating to memo.

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From: Atkins, Ken [mailto:Ken.Atkins@dec.wa.gov.au]
Sent: Monday, 21 January 2013 2:28 PM
To: Batty, Andrew
Subject: RE: SMC undescribed and priority species / EPA

Comments attached.

I think the Dampiera may be over-stated in significance – I am wondering if the regional population estimates are based on our data, which may not include intensive surveys.

Some clarification of the Eyngium data would also benefit as the data does not match well with the mapped information.

_____
Dr Ken Atkins
Manager, Species and Communities Branch
Department of Environment and Conservation
Locked Bag 104
BENTLEY DELIVERY CENTRE WA 6983

Phone (08) 93340425
Fax (08) 9334 0199

From: Batty, Andrew [mailto:Andrew.Batty@aecom.com]
Sent: Friday, 18 January 2013 11:12 AM
To: Atkins, Ken
Subject: RE: SMC undescribed and priority species / EPA

Hi Ken,

As discussed please find attached the memo for your review.

Thanks

Andrew

Andrew Batty
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From: Atkins, Ken [mailto:Ken.Atkins@dec.wa.gov.au]
Sent: Friday, 14 December 2012 2:50 PM
To: Batty, Andrew
Subject: RE: SMC undescribed and priority species / EPA

Without seeing the OEPA comments, I would assume that information on the new *Lepidosperma* species should also be presented. If the taxonomic work has not identified these as being the same as other more common species, then the location and extent of these taxa should also be clarified.

Otherwise the actions described are appropriate, noting further action will depend on the outcome of the survey work and impact assessment – but at this stage, I assume the OEPA is only trying to get the appropriate information to enable impact assessment.

So, taxonomic studies, survey, and representation of the outcomes of the survey on the construction design are the essential elements of the further study at this stage.

I am not taking leave in near future, so can review outcomes if necessary.

Dr Ken Atkins
Manager, Species and Communities Branch
Department of Environment and Conservation
Locked Bag 104
BENTLEY DELIVERY CENTRE WA 6983

Phone (08) 93340425
Fax (08) 9334 0199

From: Batty, Andrew [mailto:Andrew.Batty@aecom.com]
Sent: Friday, 14 December 2012 10:07 AM
To: Atkins, Ken
Subject: SMC undescribed and priority species / EPA

Hi Ken,

Hope all is good with you.

In relation to the PER submitted for Roe Highway Extension (RHE) the OEPA requires further understanding of the impacts upon Priority species and the unidentified *Caesia* species located within the project footprint and recommends South Metro Connect deal directly with DEC for a resolution. I have detailed our proposed approach for your comment.

Recent actions:
- targeted surveys for *Caesia and Tetraria* in November 2012
- survey of suitable remnant vegetation within and adjacent to the project area
- voucher specimens collected

Actions to be completed:
- determine status of taxonomic review of the unidentified *Caesia* species
- liaise with Russell Barratt and Greg Keighery regarding taxonomy of *Caesia* complex
- locate previously collected specimens to verify species and voucher with WA Herbarium material of:
  - *Caesia micrantha* sans lat
  - *Tetraria* sp Chandala (GJ Keighery 17055)
- liaise with DEC – what to do in relation to OEPA comments?

- map all priority species and *Caesia* on RHE design
- look for areas where population impacts may be minimised
- seek endorsement from DEC that the current design does not represent a significant impact to these species or what other actions are required.

It would be appreciated if you could let me know if you think this approach is suitable and if you are available for a meeting to review the information.

Hope to hear from you soon.

Have a great Christmas.

Andrew

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Memorandum

To	Ken Atkins	Page	13
CC			
Subject	SMC Roe Highway Extension - Significant flora issues raised by the OEPA		
From	Andrew Batty		
File/Ref No.		Date	14-Jan-13

Dear Ken,

Please review the information presented in this memo and document your endorsement or provide advice as to additional actions in the table located at the end of this memo.

1.0 Background

As discussed recently and in response to a request from the OEPA for further information relating to five Priority Flora species and two potentially undescribed taxa to be potentially impacted by the proposed project to extend the Roe Highway from the Kwinana Freeway westward to Stock Road. The specific request from the OEPA is highlighted below.

DEC identified that the *Caesia* species of taxonomic uncertainty will require further investigations to determine whether it exists in areas that will not be impacted, and its status. DEC also considers that further investigations should be carried out on the known priority flora taxa in the area to determine their local distribution, which may include monitoring remnant vegetation sites over the long term.

The OEPA needs to have an understanding of the impacts of the highway extension to these species, and considers that the proponent should deal directly with DEC for a resolution regarding these details.

The OEPA requested that the DEC review and comment on the approach and advice presented in this memo which will be included in MRWA response to the OEPA.

In preparing this memo AECOM have undertaken a desktop review of previous flora surveys (general and targeted) in the Project Area and DEC records relevant to the taxa of concern to the OEPA. This memo details the action taken to address the issues raised by the OEPA in the Roe Highway Extension Response to Submission Document, Section 4. Flora and Vegetation. The OEPA recommended that further investigation into the taxonomic uncertainty around *Caesia micrantha* sens. lat and *Tetraria* sp. Chandala (G.J. Keighery 17055). In addition the OEPA is seeking clarification of potential impacts the five Priority Flora species (Table 2).

2.0 Taxonomy

Consultation with Dr Russell Barrett was undertaken for advice relating to taxonomic resolution of *Tetraria* sp. Chandala (G.J.Keighery 17055) and *Caesia micrantha* sens lat.

A draft manuscript has been written presenting the outcomes of the recent taxonomic revision of the group and resolves current issues for *Tetraria* sp. It is proposed in the manuscript that *Tetraria* sp. Blackwood River (A.R.Annels 3043) and *Tetraria* sp. Chandala (G.J.Keighery 17055) be combined into a single species to be known as ***Netrostylis keigheryana*** R.L.Barrett, J.J.Bruhl & K.L.Wilson, **sp. nov**.

The taxonomy of *Caesia micrantha* sens lat. is yet to be resolved.

3.0 Field Methods

A targeted flora survey was conducted in late Spring (27 November 2012) to investigate the extent of populations of *Tetraria* sp. Chandala (G.J.Keighery 17055) and *Caesia micrantha* sens lat. within the Project Area and in remnant vegetation outside and separate to the Project Area to gain an understanding of the population distribution at a local level. The survey was conducted by three AECOM Botanists (Dr. Andrew Batty, Floora De Wit and Catherine Krens) and one Graduate Ecologist (Tim Moran).

The targeted search within the Project Area involved the field team revisiting two previous collection sites of *Caesia micrantha* sens lat. and a single location for *Tetraria* sp. Chandala. The area was traversed in a spiral transect radiating from the original collection point as determined by a hand held GPS (±5m accuracy).

To gain a better understanding of the local significance of the *Caesia micrantha* sens. lat. two local reserves, Samson Reserve and Bibra Lake Reserve, were visited to determine the local occurrence of these two species thereby quantifying the potential impacts of the proposed project on the long-term survival of the species. The field team traversed the two Reserves until several patches of *Caesia micrantha* sens. lat. had been recorded using a handheld GPS (±5m accuracy).

4.0 Results

Caesia micrantha sens. lat. was recovered at the two known locations in the Project Area. Outside the Project Area this species was recorded within 5 minutes of commencing the survey at both Samson Reserve (one population, five individuals) and Bibra Lake Reserve (one population, 10 individuals) (Figure 1). Approximately 20 minutes (combined survey time) was spent searching at each of the reserves.

The *Tetraria* sp. Chandala was not recovered (including at the original collection site) since its discovery during the survey conducted on 8 June 2010 (Figure 2). There are several potential reasons for this, including:

- Originally miss-identified
- Population death due to unfavourable local environmental conditions

A risk assessment has been completed for the other five Priority flora species identified within the Project Area (see Table 1 extracted from the Public Environmental Review by SouthMetro Connect, 2011). The risk assessment is based on the number of populations present inside and outside the proposed impact area derived from the 2011 Flora and Vegetation report (AECOM 2011). The distribution of these species in the Project Area is presented in Figures 3 to 7. The most affected species by the Roe Highway Extension will be the *Dampiera biloba* (P1) and *Eryngium pinnatifidum* subsp. *palustre* (P3) with these species potentially losing 75.8 % and 25.4 % of known individuals respectively).

5.0 Discussion

Although *Tetraria* sp. Chandala was not relocated during recent surveys potential impacts to this species are unlikely to be significant in light of the recent taxonomic revision. The proposed conservation status of the proposed new species is described below.

Conservation status: Naturally rare and potentially threatened by habitat degradation and urban expansion in some areas. One of the known populations is found in a Nature Reserve. The habitat of some populations of this species is recognised as a Threatened Ecological Community in Western Australia (Species and Communities Branch 2009). Probably more widespread than currently known, but restricted to specific habitat and further surveys are required to ascertain its true conservation status. Department of Environment and Conservation (DEC) Conservation Codes for Western Australian Flora Priority Two. (extracted from the unpublished manuscript from Russell L. Barrett, Jeremy J. Bruhl and Karen L. Wilson).

The *Caesia micrantha* sens. lat. is a common perennial herbaceous species that occurs within five IBRA regions of Western Australia. The term 'sens. lat' was applied to the specimen collected in the Project Area because the collected specimen did not contain suitable material to be matched to one of the recognised varieties. At this present time Greg Keighery is working towards resolving the taxonomic uncertainty of this group. However, advice from Dr Russell Barrett suggests that the form found in banksia woodlands on the Swan Coastal Plain will be relatively common. This is supported by recent field investigations in the vicinity of the Project Area. The time taken to recover populations of this species outside the Project Area (less than five minutes) indicates that the species is locally common and likely to be well represented outside the Project Area.

Potential impacts to the five Priority flora species occurring in the Project Area are unlikely to be significant for four of the species *(Cyathochaeta teretifolia, Jacksonia gracillima, Eryngium pinnatifidum* subsp*. Palustre* and *Dodonaea hackettiana*). However, the potential influence on the long term survival of the population of *Dampiera triloba* dissected by the project footprint is not fully understood. The loss of approximately 75% of the population is considered to be the worst case scenario with design changes in the area associated with Murdoch Drain with result in a reduced impact than the current estimate.

6.0 References

AECOM. 2011. *Roe Highway Extension Kwinana Freeway to Stock Road: Vegetation and Flora Assessment Phase 2*. Unpublished report prepared for MainRoads WA.

Russell L. Barrett, Jeremy J. Bruhl and Karen L. Wilson (unpublished). Taxonomic revision of Netrostylis, a new Australasian genus of Schoeneae (Cyperaceae). *Botanical Journal of the Linnean Society,* 2013, **XX**, XX–XX.

Southmetro Connect. 2011. *Roe Highway Extension– Section Six Potential Impacts and Management.* Public Environmental Review. Available at http://www.southmetroconnect.com.au/environment/approval-process/.

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Principal Ecologist

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Table 1 Impact Assessment of Priority Flora in a Local and Regional Context (Southmetro Connect 2011)

Species	Cons. Code	Total # of known populations	# of populations within Study Area	# of populations to be impacted	% of populations to be impacted	Total minimum # of known individuals	# of individiauls within study area	# of known individuals to be impacted	% of individuals to be impacted
Dampiera triloba	P1	21	14	4	19.1	7,132	6,617	5,404	75.8
Cyathochaeta teretifolia	P3	56	5	3	5.4	582	482+	38	6.5
Jacksonia gracillima	P3	20	3	2	10	200	173	15	7.5
Eryngium pinnatifidum subsp. *palustre*	P3	20	4	4	20	63	45	16	25.4
Dodonaea hackettiana	P3	56	1	1	1.8	205	1	1	0.5

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DEC review and endorsement table

Species	Outcome	Recomendation	DEC Endorsment of recomendation	Notes or additional action required
Taxonomic				
Caesia micrantha sens. lat.	Although taxonomy is not resolved recent advice and results of additional survey effort suggests project impacts are unlikely to be significant	No further action	Endorsed	Taxonomic investigation, and local conservation status, noted. The taxon appears to be relatively common locally, and while subject to further taxonomic investigation, is not deemed to be of conservation concern at this site.
Tetraria sp. Chandala (G.J. Keighery 17055)	Taxonomy resolved and project impacts to the proposed new species unlikely to be significant	No further action	Not endorsed – further investigation warranted	Taxonomic status noted. Confirmation of local conservation status and impact required. *Tetraria* sp. Chandala is currently listed as Priority 2. *Tetraria* sp. Blackwood is not currently listed as a Priority Flora, but is only known from few non-reserved locations, and hence would meet the criteria. When these two taxa are combined it is likely that the new taxon would meet the criteria, and be listed as Priority 3. Further survey investigation recommended for this taxon in the local and regional area.
Priority Species				
Dampiera triloba (P1)	Extent of potential impacts uncertain	Further action may be required in the form management actions and monitoring	Endorsed, plus further regional/ species status investigations warranted	The number of plants recorded and to be impacted appears disproportionate to the number of populations. It is questioned whether the area to be impacted has been intensively surveyed, while the other populations, including the 7 outside the survey area, have not been – thus generating an apparent higher level of impact. Data needs to be clarified, or further intensive survey undertaken to provide equitable data for impact

Species	Outcome	Recomendation	DEC Endorsment of recomendation	Notes or additional action required
Taxonomic				
				assessment. This should be done to enable a more complete impact assessment to be undertaken for the species as a whole, and in the local area.
Cyathochaeta teretifolia (P3)	Impacts unlikely to be significant	No further action	Endorsed	Impact minimal and viable population will remain.
Jacksonia gracillima (P3)	Impacts unlikely to be significant	No further action	Endorsed	Impact minimal and viable population will remain.
Eryngium pinnatifidum subsp. *Palustre* (P3)	Impacts unlikely to be significant	No further action	Qualified endorsement	The data provided does not appear to match the information provided in the associated map. A high proportion of data points appear to overlay the development footprint resulting in either direct or indirect impacts to a high proportion of the local plants. Overall for the species, however, the impact does not appear significant, but the basis for the local impact data should be provided.
Dodonaea hackettiana (P3)	Impacts unlikely to be significant	No further action	Endorsed	Low local and regional impact.

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Correspondence with WA Museum

Appendix N

Correspondence with WA Museum

Appendix N Correspondence with WA Museum

Braid, John

From: Amber Beavis <amber.beavis@museum.wa.gov.au>
Sent: Wednesday, 9 January 2013 10:32 AM
To: Braid, John
Subject: RE: Roe Highway Extension - Sucking Millipedes

Follow Up Flag: Follow up
Flag Status: Completed

Hi John,

Having looked into your request, I can now advise you on the SRE status of the sucking millipedes you were interested in. At present, there is very little known about the taxonomy of the Siphonotidae. It is highly probable that these millipedes are SREs, however, due to the current state of understanding of the group, their official status would be Potential SREs. Below is a table that explains the parameters of the SRE categories we use, which will explain the implications of the group being labelled a potential SRE. If you have any additional queries, please feel free to email me.

All the very best,

Amber

~~~~~~

Dr Amber S. Beavis
Research Scientist
Department of Terrestrial Zoology
The Western Australian Museum
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SRE category	Criteria	Typical representatives
Confirmed	Confirmed or almost certainly SRE; Taxonomy is well known (but not necessarily published) Group is well represented in collections (in particular from the region in question) High levels of endemism exists in documented species of the genus/family Inference is often possible from immature specimens based on locality	*Antichiropus* millipedes (Paradoxosomatidae) *Aops* scorpions (Urodacidae)
Likely	Taxonomically poorly resolved group Unusual morphology related to poor	Opiliones in the genus *Dampetrus*
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	dispersal for that group e.g. troglomorphism Often singletons in surveys Few, if any, regional records	Some pseudoscorpions Schizomids Some slaters (Philosciidae) *Karaops* spiders (Selenopidae)
Potential	Taxonomically poorly resolved group (or specimen cannot be identified to species level) Often common in certain microhabitats in SRE surveys (i.e. litter dwellers) Other species within the genus might be widespread	Many mygalomorph spiders Some centipedes (Cryptopidae; Geophilomorpha) Some pseudoscorpions
Unlikely	Cannot be identified to species level and taxonomy uncertain, but experience suggests the distribution is unlikely to be restricted	*Indolpium* pseudoscorpions
Unknown	So little is known that it does not allow for any suggestion of geographic distribution	Acari
Widespread	Taxonomy well understood Common and known from areas larger than 10,000 km^2	the spider *Gaius villosus* (Idiopidae) The millipede *Austrostrophus stictopygus*

From: Braid, John [mailto:John.Braid@aecom.com]
Sent: Tuesday, 8 January 2013 2:37 PM
To: Amber Beavis
Subject: RE: Roe Highway Extension - Sucking Millipedes

Hi Amber,

One last try – this is a lower resolution version of the same document. I had a look through the report and could not see a WAMT number.

Regards

John Braid
Senior Environmental Scientist
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John.Braid@aecom.com

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Please consider the environment before printing this email.

From: Amber Beavis [mailto:amber.beavis@museum.wa.gov.au]
Sent: Tuesday, 8 January 2013 2:01 PM

To: Braid, John
Subject: RE: Roe Highway Extension - Sucking Millipedes

Hi John,

Many thanks for the email. I'm afraid that the SRE report didn't come through to me. Could I ask whether the specimen in question had a WAMT number? This information should be available in the report.

Many thanks,

Amber

From: Braid, John [mailto:John.Braid@aecom.com]
Sent: Monday, 7 January 2013 10:40 AM
To: Amber Beavis
Subject: FW: Roe Highway Extension - Sucking Millipedes

Hi Amber,

We just spoke on the phone regarding an unidentified sucking millipede found during surveys for the proposed Roe Highway Extension. The email I sent Mark Harvey today is attached below, and I have attached the letter and two of the attachments to the letter I sent to Mark before Christmas. I will send the SRE Report as a separate email in case it doesn't get through.

Thanks for having a look at this for me.

Regards

John Braid
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From: Braid, John
Sent: Monday, 7 January 2013 10:11 AM
To: 'mark.harvey@museum.wa.gov.au'
Subject: Roe Highway Extension - Sucking Millipedes

Dear Dr Harvey,

I wrote to you the week before Christmas requesting a meeting and/or advice from the WA Museum regarding an unidentified sucking millipede found during surveys for the proposed Roe Highway Extension project. This email is a follow up to that letter, to confirm that you received the letter and if you are available for a meeting.

The Office of the Environmental Protection Authority (OEPA) has requested that Main Roads consult with the WA Museum regarding the unidentified sucking millipede and whether the species is likely to be restricted in habitat. The assessment conducted by Phoenix Environmental Services concluded that the millipede was most likely a Short Range Endemic (SRE), and its habitat was inferred to be restricted to the Karrakatta Central and South vegetation complex. A subsequent field survey in 2012 failed to find any further specimens of the sucking millipede.

The advice I am seeking from the WA Museum in order to satisfy the OEPA, is the WA Museum's opinion on:

- The conservation significance of the unidentified sucking millipede found within the footprint of the proposed Roe Highway Extension

- Whether the species is likely to be restricted in habitat

Are you, or one of your colleagues, available this week or next week to meet to discuss this unidentified sucking millipede?

Regards

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18 December 2012

Dr Mark Harvey
Head of Department and Curator - Arachnids and Myriapods
Locked Bag 49
Welshpool DC WA 6986

Dear Dr Harvey

Sucking Millipedes (Siphonotidae) found in proposed Roe Highway Extension footprint

I am writing to you to seek the advice of the WA Museum regarding the distribution of an unidentified sucking millipede (Siphonotidae) found during surveys for the proposed Roe Highway Extension.

Main Roads Western Australia (Main Roads) has been tasked by the State Government to commence development of an extension to Roe Highway, extending Roe Highway from its current terminus at the Kwinana Freeway to Stock Road in Coolbellup. Main Roads created a partnership with AECOM Australia Pty Ltd in 2009 to form Southmetro Connect (SMC). SMC was tasked to commence the design and environmental assessment of the Roe Highway Extension (RHE).

RHE is being assessed at a level of Public Environmental Review (PER) under both the State *Environmental Protection Act 1986* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. The PER report was released for a twelve week public comment period in June 2011 and received over 3,000 public submissions. SMC provided a response to the public submissions to the Office of the Environmental Protection Authority (OEPA) in July 2012. The OEPA reviewed the responses to submissions and asked for additional information on 20 November 2012 (Attachment 1).

The OEPA consulted with the Department of Environment and Conservation (DEC) in its review of SMC's response to submissions. DEC identified that further work is required to determine the identity and distribution of an unidentified sucking millipede (Siphonotidae) found in the initial baseline short range endemic and targeted invertebrate surveys. The OEPA has requested that SMC consult with the WA Museum regarding the millipede and whether the species is likely to be restricted in habitat.

SMC engaged Phoenix Environmental Services Pty Ltd (Phoenix) to conduct a short range endemic (SRE) and targeted invertebrate baseline survey. These surveys were conducted between November 2009 and November 2010 (Attachment 2). Fifteen SRE species were identified in the 2010 surveys, including seven that are considered to be of conservation significance, as they currently only have known distributions confined to the Perth Metropolitan Area. One of those SRE species found was a single specimen of Siphonotidae sp (Polyzoniida), commonly known as sucking millipedes.

The Siphonotidae specimen found in 2010 was unable to be identified. The individual was a large female and therefore morphological identification was not possible. Molecular analysis of the individual was not possible.

A second survey effort was conducted in April-June 2012 to find other specimens of sucking millipedes within the RHE project area, in order to identify the species and its distribution (Attachment 3). If individuals were found, further surveys outside the RHE project area would be conducted to determine if the species is widespread. This survey did not find any further individuals of sucking millipede within the RHE project area and therefore no surveys outside of the project area were conducted.

Sucking millipedes are rarely collected in Perth. On the Swan Coastal Plain, this family is only known from a single population at Woodman Point, 6km to the south west of the project area and several unspecified locations in "Perth". It is possible that the sucking millipede collected within the RHE project area is conspecific with these other populations, but without being able to collect further specimens from the project area this can not be verified.

In accordance with the framework in EPA Guidance Statement 20: *Sampling of short-range endemic invertebrate fauna for environmental impact assessment in Western Australia* Phoenix conducted a risk based assessment of the extent of habitat of the sucking millipede (Attachment 3). The assessment of the sucking millipede met the conditions for a risk based assessment as:

- only one specimen was found in the project area and species identification was not possible

- there is no contextual data available from the WA Museum or DEC in relation to the sucking millipede, with the exception of two localities (Woodman Point and unspecified records from “Perth”)
- additional targeted surveys failed to find any further specimens and are unlikely to yield results in a reasonable timeframe

Phoenix (Attachment 3) stated that whilst it is difficult to infer species habitat from a single record, this does provide the basis for the risk based approach used in EPA Guidance Statement 20. It was inferred that as the sucking millipede was found in the Karrakatta – Central and South vegetation complex, that the species may be restricted to this habitat type. The Karrakatta – Central and South vegetation complex has a current extent of 6,225ha, mainly within the Perth Metropolitan Area, with at least 2,000ha of this vegetation type protected under some type of conservation arrangement. The RHE project will impact 55.33ha of the Karrakatta – Central and South vegetation complex, leaving considerable refuge areas for this sucking millipede within the Perth Metropolitan Area.

Phoenix also highlighted two other factors that may be relevant to the risk assessment:

- the species of sucking millipede previously collected at Woodman Point has been assessed by Dr Dennis Black as representing a common species from the south west of WA, *Rhinotus michaelseni*.
- Portuguese Millipedes (*Ommatoiulus moreleti*) were found in great numbers in the project area. This species is an introduced pest and it may have displaced native fauna.

I am seeking the WA Museum’s advice on whether the sucking millipede found in the invertebrate surveys for RHE is likely to be restricted in habitat. I would like to meet with yourself, or another specialist from the WA Museum, to discuss the distribution of this unidentified sucking millipede in the week of 7 January 2013.

If you have any questions please contact me on 6208 1018 or 0407080035 or email me at john.braid@aecom.com.

Yours faithfully

John Braid
Senior Environmental Scientist

encl: CD containing attachments:
Attachment 1 – OEPA correspondence to Main Roads WA dated 20 November 2012

Attachment 2 – Phoenix Environmental Services 2010. Short range endemics and targeted invertebrates baseline survey for Roe Highway Extension project

Attachment 3 – Phoenix Environmental Services 2012. Targeted survey for sucking millipedes (Siphonotidae) for the Roe Highway Extension project.

cc: Gerard O’Brien (OEPA)

Aboriginal Heritage Surveys

Appendix O

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