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The sole purpose of this report and the associated services performed by Jacobs is to provide advice regarding potential monitoring programs that could be carried out at the Tootgarook Wetlands in accordance with the scope of services set out in the contract between Jacobs and Melbourne Water. That scope of services, as described in this report, was developed by Melbourne Water and the Mornington Peninsula Shire Council.

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1. Introduction

The Tootgarook Wetland is a large, shallow freshwater swamp located on the Mornington Peninsula, near Rosebud. The wetland supports significant biodiversity, cultural and social values and is important for flood mitigation and water quality treatment.

Melbourne Water and the Mornington Peninsula Shire Council (MPSC) are in the process of preparing a strategic management plan for the Tootgarook Wetland. The strategic management plan will look to work with a range of stakeholders to protect the significant wetland and riparian values in the area as well as Port Phillip Bay.

To feed into the strategic management plan and to provide evidence based information about the wetland, Melbourne Water and the MPSC engaged Jacobs to review the ecological and natural values of the wetland and to identify any significant knowledge and information gaps (Ecological Values and Knowledge Gaps Report). That report was informed by the numerous studies and investigations previously completed in the Tootgarook Wetland and the surrounding area and following consultation with a Technical Working Group made up of representatives from Melbourne Water, the MPSC, the Department of Environment and Primary Industries (DEPI) and the Trust for Nature.

Following on from the review of ecological values and knowledge gaps, Jacobs were engaged to design a monitoring program in consultation with Melbourne Water and the MPSC to address the priority knowledge and information gaps and to facilitate the evaluation of future management actions at the wetland. The current report presents this monitoring program.

1.1 Format of this report

This report is divided into a number of sections. In Section 2, a systematic process for determining monitoring questions, by first identifying ecological objectives for the wetland, is described. While the described process is by no means the only way to determine monitoring questions, it does provide a systematic approach which hopefully ensures monitoring questions are targeted and efficient.

The results of the review of the ecological values and knowledge gaps for the Tootgarook Wetland (the Ecological Values and Knowledge Gaps Report) are summarised in Section 3. The results of this report were then used to assist the setting of ecological objectives/priority questions for the wetland. It should be noted that not all of the knowledge gaps identified will be addressed by future monitoring. However, acknowledging areas where understanding of the wetland is incomplete, regardless of the feasibility of conducting monitoring to address the gaps, was considered an important output from this project.

The ecological objectives and priority knowledge gaps for the wetland are identified in Section 4. This includes ecological objectives previously identified for the wetland (for example as part of Melbourne Water’s Healthy Waterways Strategy).

In sections 5 to 8, monitoring questions for each of the four priority areas (Flora, Fauna, Water Quality and Groundwater) are identified. Monitoring programs to provide data to address these questions are then proposed.
2. Monitoring program philosophy

Monitoring programs are powerful tools to aid in the management of natural assets. Well-designed monitoring programs can provide valuable data with which to assess the efficacy of management actions. However, despite their obvious importance, monitoring programs are routinely designed from a “bottom up” perspective, in which the variables being measured (e.g. water quality, vegetation condition etc.) are decided first, with little regard to the questions that this data is going to answer. Sometimes it is only once resources and effort has been invested into collecting data that the questions that are of interest are determined. While some interesting questions can arise once data collection has begun (or completed), it is considerably more efficient to first identify the questions of interest and then to design monitoring programs that can provide sufficient and suitable data for answering these questions.

The following section outlines a systematic process for designing effective and efficient monitoring programs, starting from determining the ecological objectives of the natural asset (in this case the wetland), developing management actions to support these objectives, and finally determining monitoring questions that will allow an evaluation of the management objectives.

As a brief aside, ‘monitoring’ in the context that it will be discussed in this report, can be thought of as a set of measurements taken of a natural system that are repeated over time in such a way as to allow changes over time to be detected. Put simply, monitoring will usually have a standardised methodology that is repeated over a time scale of interest (e.g. monthly). This is in contrast to determining the baseline of a natural system, which is a snapshot of the state of the system at a period in time. As an example, determining the frog species that are supported by a wetland could be considered a baseline survey. Returning to the wetland at the same time each year to determine whether the species composition has changed is a monitoring program. Obviously monitoring requires a baseline with which to compare future change with, but making clear the distinction between monitoring and baselines is important in the context of the current study.

Following the description of the systematic process of setting monitoring questions, we then briefly assess where in the described process we are in terms of the Tootgarook Wetland. This assessment has been directly informed by the review of ecological values and knowledge gaps (Part 1 of the current project) and discussions with Melbourne Water and the MPSC regarding their priorities, goals and the remit and responsibilities of each organisation.

2.1 Steps in determining an effective monitoring program

2.1.1 Determining broad ecological objectives for the wetland

When designing an effective and efficient monitoring program, the first step should be to develop a set of overall ecological objectives for the wetland. An ecological objective can be likened to a statement outlining the vision for the wetland.

An ecological objective might be related to the ongoing health or viability of a particular value, such as an animal group (e.g. birds), species (e.g. Swamp Skink, *Egernia (Lissolepis) coventryi*) or community (e.g. extent of an EVC). For example, an ecological objective for the Tootgarook Wetland might be to increase the diversity of bird species using the wetland.

When dealing with a complex system, such as a wetland, it is important to be as specific as possible with the setting of ecological objectives. A vague objective, such as “to enhance the functioning of the wetland” may be difficult to interpret (what is meant by the functioning of the wetland in this instance?), and to influence.

Ideally, ecological objectives would be determined in consultation with the wider community and the major stakeholders, which in the case of the Tootgarook Wetland would include Melbourne Water, the MPSC, DEPI, South East Water, local landholders and community groups. Different groups may have different visions for the wetland, related to their areas of expertise or interest, or the responsibilities and remit of the relevant organisations.
It is important that a sufficient baseline understanding of the natural system has been established prior to embarking on the setting of ecological objectives. Of course the understanding of the system will not be perfect at this stage, but some understanding of the values that are present is required. For example, if an ecological objective of a wetland is related to its importance as a bird breeding habitat, however the diversity of birds that will benefit is not high compared to nearby areas, then resources may be better deployed elsewhere. In addition to identifying the significant values of a wetland, an understanding of the potential threats will aid in the development of achievable ecological objectives.

In situations where the knowledge of the wetland (or natural system) is not yet sufficient to set a targeted and realistic ecological objective, then there should be a focus on increasing understanding such that ecological objectives will be able to be set in the future. This may involve increasing knowledge of the values of the wetland (e.g. how important is the area for local bird breeding?), the functioning of the wetland (e.g. what is the hydrological regime?) or the impact of particular threats (e.g. what impact does nearby irrigation have on water quality?).

2.1.2 Determining management actions

Once the broad ecological objectives have been determined, management actions that support the ecological objectives can be designed. These management objectives are specific actions that are targeted at achieving or supporting the ecological objectives. These management actions may be targeted at alleviating the impact of particular threats (e.g. reducing fox numbers), or at improving habitat values for a particular species (e.g. increasing the inundation period to support a particular EVC).

It is important that the management actions are realistic and achievable. This means that not only are the management actions logistically possible, but also that they are aligned with the priorities and responsibilities of the management organisations. For example, it would not be feasible to design a management action that required the fencing of a wetland if the ownership structure of the wetland did not permit this action (as may be the case at the Tootgarook Wetland). Further, if an organisation was not responsible for water quality management and had no mechanism for influencing actions, it would be unsuitable for that organisation to determine a management plan chiefly concerned with water quality. Obviously data that helps to build understanding of the wetland may be useful, but it is important that the remit of the organisation is considered when determining management actions.

As outlined above, there may not be a sufficient understanding of the wetland to set ecological objectives that lead directly onto management actions. If this is the case and the focus is instead on understanding some component of the wetland (e.g. value, functioning, threats), it is still important that the areas of interest are targeted to ensure that the monitoring process is efficient and that the data that is collected is going to be useful.

2.1.3 Determining a monitoring program

The next layer down is the monitoring actions/framework. Essentially this is monitoring conducted to provide information or data to determine whether the management actions have been effective at achieving the ecological objectives, or to provide more information to understand a natural process or threat. As outlined above, monitoring (in contrast to determining a baseline) involves a repeated method over time to determine changes in a natural system.

Regardless of whether the monitoring is designed to address the efficacy of management action, the impact of a threat or to increase understanding of the wetland, it is critically important when determining monitoring programs that the question of interest is clear. Frequently time, effort and money is invested in collecting data that is then not useful to answer the questions of interest. The best way to avoid inefficient data collection is to clearly enunciate the monitoring questions and to target data collection as far as practical to only what is required to answer the questions of interest.

Consideration should also be given at this stage to whether any action can be taken in response to the results of the monitoring. For example, if monitoring indicated that inundation in a wetland was not of sufficient duration
to facilitate the growth of a particular vegetation community, but there was no action that could be taken to increase inundation period, it might not be worth monitoring? Obviously it is important to understand at a basic level how a wetland is functioning, but if nothing can be done to influence the situation into the future, potentially the limited resources available for monitoring may be better directed elsewhere.

2.1.4 Flow diagram

Presented below is a flow diagram showing the described process for developing monitoring questions (Figure 2-1). While the flow diagram assumes that the monitoring is being targeted to evaluating a management action, the broad steps hold true if the monitoring questions are designed to evaluate the impact of a threatening process or to test a hypothesis of how the wetland functions.

Highlighted in the flow diagram is the feedback loop should monitoring indicate that the management objectives are ineffective. This could equally apply should the monitoring data indicate that a hypothesis about how the wetland functions is proven false, or that a threat is causing an impact on the wetland. The important thing to note is that the monitoring data is being collected to feedback into something that can be acted upon (e.g. the management actions are changed, hypotheses updated, threats managed).

Figure 2-1 Flow diagram of a systematic approach to determining monitoring questions.
3. Current understanding of the Tootgarook Wetland

From the review of the ecological values conducted as part of this study (Ecological Values and Knowledge Gaps Report – Jacobs 2014), it is clear that some aspects of the ecology of the Tootgarook Wetland are well understood. In other areas however, the baseline information about how the wetland functions and the ecological values that are present is less complete.

Presented below is a brief summary of the Ecological Values and Knowledge Gaps Report (Jacobs 2014), outlining the ecological components of the wetland that are well understood and areas where there are significant knowledge gaps.

3.1 Flora

- The mapping of vegetation communities and assessment of their quality has been undertaken by a number of different people for a variety of reasons and is therefore difficult to align and provide a coherent picture of what values occur within the site.
- With the exception of the Leafy Greenhood (Pterostylis cucullata) population known in the Moonah woodland near Truemans Road (see Piccone and Walker 2003), little is known about the location of threatened species within the wetlands. No systematic targeted surveys have been undertaken in the wetland and therefore it is difficult to truly assess the likelihood of their occurrence.
- Few of the assessments reviewed have been undertaken at a suitable time of year to identify the majority of flora species and there is a significant likelihood that additional species would be detected during spring and summer surveys.

3.2 Fauna

- There is a good baseline understanding of the terrestrial and aquatic species that are likely to be supported by the Tootgarook Wetland. There is no ongoing condition or population health monitoring for terrestrial or aquatic species at the wetland.
- White-footed Dunnart (Sminthopsis leucopus) surveys have been undertaken in most places throughout the wetland area (By Malcolm Legg), except to our understanding, at the McNaught Property.
- There is a very good baseline understanding of the birds that are supported by the Tootgarook Wetland. Ongoing monitoring is being conducted by Birdlife Australia, and is designed to detect changes over time.

3.3 Surface water quality and quantity

- The majority of water quality data for the area (including the long-term water quality monitoring conducted by Melbourne Water at Eastbourne Road) has been collected downstream of the wetland. It is therefore difficult to separate the impacts of industrial, urban, agricultural and natural processes.
- There is limited surface water quantity (flow and level) across the site. A surface water logger has recently been installed (June 2014) in the centre of the site. A site around the outflow would assist with model calibration.
- The nearest rain gauge is at the Rosebud (Country Club) Rainfall Station (Station number 86213).

3.4 Groundwater

- There are four shallow groundwater observation bores on the site (installed in June 2014). Other groundwater monitoring sites are around the swamp monitoring landfill activities, South East Water activities and some of the State Observation Bore Network.
- The installation of the bores improved the conceptual understanding of the site from a groundwater and ecological perspective. Until a consistent period of data is collected from these proposed onsite bores, it is difficult to understand the detailed interaction between groundwater and surface water at the site, seasonal variations in groundwater levels and the impact of groundwater pumping in the area.
- The current lack of regional and on site groundwater quality monitoring makes it difficult to understand the impact on groundwater quality from treated waste water used for irrigation in the Chinaman’s Creek catchment.
4. Ecological objectives for the Tootgarook Wetland

The process outlined in Section 2, where the ecological objectives are determined, followed by the management actions and out of this the monitoring program, relies on there being sufficient understanding of not only the ecological values of the wetland, but also the basic functioning of the wetland (e.g. hydrology) and any major risks or threats (e.g. pollutants). As outlined above, some elements of the ecology and functioning of the Tootgarook Wetland are well understood, while others are still uncertain.

One facet of the wetland's ecology that has been well established is the importance of the area in supporting a diverse variety of wetland and woodland birds. The Tootgarook Wetland has been recognised by Melbourne Water in their Healthy Waterways Strategy as a priority area for birds. The ecological objective for the wetland (defined as the middle and lower reaches of Chinaman’s Creek in the strategy) regarding birds is to “Improve species richness and abundance of streamside and wetland bird populations” (Healthy Waterways Strategy – Melbourne Water 2013, p213).

Another ecological objective that has been formally enunciated for the Tootgarook Wetland also comes from Melbourne Water’s Healthy Waterways Strategy to “maintain the amenity value of lower Chinaman’s Creek” (lower Chinaman’s Creek is from downstream of the wetland to Port Philip Bay) (Healthy Waterways Strategy – Melbourne Water 2013, p213). This is a potentially high value waterway for the people of the Mornington Peninsula and so maintaining amenity is important. It is outside the scope of the current project however to develop methods to monitor the efficacy of any actions taken to maintain or improve amenity of the lower section of Chinaman’s Creek (e.g. through distributing questionnaires to local residents, tracking visitors to the waterway etc.).

As part of the Better Bays and Waterways strategy (a joint strategy involving Melbourne Water, the Environmental Protection Authority (EPA) and the state and federal governments) and the recently released A Cleaner Yarra River and Port Phillip Bay: A Plan of Action (State Government of Victoria) protecting water quality in Port Phillip Bay is a high priority. It is beyond the scope of the current project to consider in detail the responsibilities of the various organisations under these strategies, however ensuring the quality of water entering the bay is an overt focus of both strategy documents.

In addition to these published ecological objectives, based on discussions with the MPSC and Melbourne Water and following on from the review of ecological values and the identification of knowledge gaps, a number of other priorities were identified as part of this project.

- **Flora:** Both the MPSC and Melbourne Water were interested in investigating the extent and condition of relevant EVCs at the wetland, encroachment of weeds and the impact that groundwater and water quality has on these vegetation communities.

- **Fauna:** The MPSC was interested in understanding the presence and condition of ‘significant’ (threatened or having legal protection, or being of high local or community value) species, primarily the Swamp Skink, the White-footed Dunnart, the Australasian Bittern (*Botaurus poiciloptilus*), Latham’s Snipe (*Gallinago hardwickii*) and the Leafy Greenhood. The precise location and condition of populations of threatened species would be very useful for the MPSC to assist with statutory and development planning.

  The MPSC are also interested more broadly in waterbirds, in particular the Australasian Bittern. The MPSC also expressed a desire to build a greater understanding of fish, amphibians and key indicator macroinvertebrates that are important prey for other high priority threatened waterbirds, fish and amphibian species.

  Melbourne Water, consistent with the remit of the organisation, give priority to understanding bird, frog and fish species diversity and the ongoing condition of these groups at the Tootgarook Wetland.

- **Groundwater:** A priority for both Melbourne Water and the MPSC was to understand the hydrological regime of the wetland; in particular the role groundwater plays in controlling inundation in the wetland. This is a particular issue as groundwater extraction and irrigation has the potential to change the inundation patterns of the wetland. An associated concern is the presence of potential acid sulphate soils (PASS) in
the wetland which may become a serious issue if the wetland is allowed to dry out for a significant period of time.

- **Surface water quality and quantity**: Melbourne Water and the MPSC are interested in understanding surface water quality and quantity in the wetland itself, to better understand potential threats (e.g. urban and industrial runoff, and high nitrates potentially entering the wetland from nearby market gardens). This may assist with meeting responsibilities and directives outlined in the *Better Bays and Waterways* and *A Cleaner Yarra River and Port Phillip Bay: A Plan of Action* to enhance the quality of the water entering the bay.

According to the process outlined in Section 2, following the development of ecological objectives (or the identification of wetland components that require further understanding) specific monitoring questions should be identified. This has been done in the following sections, with monitoring questions that follow on from the objectives and priority areas outlined above, organised by the four priority areas (Flora, Fauna, Water Quality and Groundwater).

As the monitoring may be undertaken by different groups, separating the monitoring program by technical area has been considered to be the most simple. It should be noted however that the results of some of the monitoring programs will inform the interpretation of data from other programs. Instances where this is the case have been highlighted in the following sections.
5. Flora

The values of vegetation present within the wetland relate mostly to the rare and restricted native vegetation communities that occur within the wetland and the habitat values that are inherent in the vegetation, particularly for birdlife. Decline in the quality and extent of native vegetation, as well as changes in types of vegetation communities (e.g. freshwater meadows versus reed and shrub dominated communities) present within the wetland have the potential to reduce the values present. **Vice versa,** increases in quality and extent of native vegetation are likely to enhance identified values.

Potential direct threats which could impact native vegetation include weed invasion, cinnamon fungus, fire, changes to hydrology (both surface water and groundwater), changes to water quality, changes to land use and natural factors such as drought, flooding and climate change.

Indirect threats with the potential to impact native vegetation include the fact that there is an incomplete understanding of the hydrological regimes of the wetland and how this relates to the native vegetation present, an incomplete map of the vegetation present across the entire wetland, and differing objectives and responsibilities for management agencies and landholders.

Based on the ecological objectives and priority knowledge gaps defined in Section 4, and the key values and threats associated with flora within the Tootgarook Wetland, the following monitoring questions have been developed to guide a proposed vegetation monitoring program within the wetland:

1. **Is there a complete and coherent picture of the extent and quality of native vegetation communities across the wetland in order to understand the values present?**

2. **Is the extent and quality of the native vegetation present in the wetland changing?**
   a. Is weed cover changing in the wetland vegetation?
   b. Is the cover of Tall Marsh changing?
   c. Is species diversity changing within wetland vegetation?

5.1 **Is there a complete and coherent picture of the extent and quality of native vegetation communities across the wetland in order to understand the values present?**

**Inputs:**

Current mapping and quality assessments of the McNaught Property undertaken recently cover the majority of the wetland (see Figure 5-1) provides a base for future mapping. Mapping of vegetation communities undertaken by Mornington Peninsula Shire Council (as shown in Figure 5-2) lacks information on vegetation quality but provides a suitable information base to inform additional assessments.

**Method:**

Additional areas around the Sanctuary Park Reserve and the Tootgarook Wetland/Tern Avenue Reserve in the north and additional mapping of Tootgarook Wetland Reserve south of Browns Road and other areas not adequately mapped in Figure 5-1 should be assessed to identify the extent and quality of native vegetation across the wetland.

The Habitat Hectare method used to assess the McNaught Property, including identification of Ecological Vegetation Classes, could be adopted to provide consistency across the entire wetland. Alternatively the Index
of Wetland Condition method could be adopted but may require some re-assessment of previously mapped areas.

Although progress has been made in using remote sensing to identify the extent and certain quality parameters of wetlands, the cost of high resolution data and need for ground-truthing assessments make it less relevant in an easily accessible wetland such as Tootgarook Wetland.

Analysis:

The output should include a coherent map of native vegetation extent and quality across the entire wetland. This information can be used to inform management decisions in the future. This could also be compared to historical boundary of the wetland.

5.2 Is the extent and quality of the native vegetation present in the wetland changing?

This question includes three inherent sub-questions.

a) Is weed cover changing in the wetland vegetation?

b) Is the cover of Tall Marsh changing?

c) Is species diversity changing within wetland vegetation?

Inputs:

Mapping of native vegetation extent and quality as outlined above as part of Question 1. Other inputs that may be required to explain any change detected include results of ground and surface water monitoring including analyses of water quality, salinity and nutrient loads, and meteorological data including rainfall and temperature data from the Bureau of Meteorology.

Method:

The field based Habitat Hectare and Index of Wetland Condition methods used to provide an overview of the extent and quality of native vegetation are generally poor tools for ongoing monitoring of changes in condition over time. Methods such as transects (for assessing changes in extent of native vegetation communities) and quadrats (for assessing biodiversity and vegetation quality) should be employed to provide greater clarity in assessing changes in native vegetation condition and extent.

The methods for undertaking transects and quadrats are standard vegetation techniques but should encompass the following data in order to answer the defining question.

Transects

- Multiple transects to be established to intersect known vegetation communities. Exact location to be determined based on the completed mapping of vegetation extent and condition across the entire wetland (completed as part of Question 1);
- Ideally at least some of the transects will be located close to the sites of the groundwater monitoring (See Section 7) so that the influence of groundwater flux and quality on vegetation extent and condition can be considered directly;
- When locating transects, priority should also be given to intersecting the interface of Tall Marsh with sedgelands and grasslands as an increase in the extent of dense Tall Marsh may indicate a decline in habitat for many flora and fauna species;
- Start and endpoints of the transect should be permanently marked to ensure that the same areas are repeatedly assessed. Assessments should be conducted using GPS technology to ensure the same transect is assessed during each monitoring period;

- The change in vegetation community should be recorded along the transect to enable measurement of the proportion of each vegetation communities present along the transect;

- Species lists for each transect should be recorded.

**Quadrats**

- Quadrats should be located along transects and/or near boreholes, where possible (though areas of disturbance near these locations should be avoided);

- Multiple quadrats should be established in each vegetation community of interest. This should definitely include Tall Marsh, Brackish Wetland, Swamp Scrub, Brackish Grassland and Sedge Wetland. A minimum of 3 (preferably 5) should be used to provide statistical power in analyses;

- Quadrats should be located in areas differing in quality rather than focussing on areas of high or low quality exclusively;

- Quadrats should be no less than 25 m² to provide an accurate assessment of the community. Preference should be given to increasing the number of quadrats rather than increasing size if resources permit;

- Within each quadrat the species present and percentage of cover should be recorded (percentage cover rather than Braun-Blanquet scores are recommended to better detect change), the overall cover of bare ground, litter, native species and of introduced species should also be recorded.

**Timing**

Vegetation monitoring should be undertaken ideally yearly (but every two-three years would be sufficient and provide a more effective option) and at a similar time of year each time (spring to early summer). If resources permit, additional monitoring could be undertaken to understand seasonal change in vegetation extent and quality but this is not considered essential. Input from the Technical Reference Group should be considered in determining the timing and frequency of surveys.

**Analysis:**

Transect data detailing the proportion of each vegetation community present can be tracked over time and will indicate if changes in vegetation extent and boundary are occurring along the transect. The transect method will be an indicator of change within the entire wetland only and will indicate if further measurements are required. Further measurements could include re-mapping the extent of vegetation communities through field assessments or assessment of recent aerial imagery by an ecologist familiar with the site in order to provide empirical data on the extent of each community. The input of the Technical Reference Group should be sought to determine transect locations which will need to consider the vegetation to be measured, the proximity to water bores and should also include the wetland and buffer zones at the edges.

Quadrat analyses provide detailed data on the species composition of each community and a robust and statistically sound method to analyse whether particular plants, life forms (e.g. sedges, reeds, herbs) or other ecological parameters are changing over time. Raw percentage cover estimates are preferred to Braun Blanquet cover groupings as it allows for easier grouping of life forms when analysing data. Weed species and cover will be collected as part of the quadrat analyses.

Quadrat data can be analysed in order to determine changes within communities or differences between communities in the following characteristics related to vegetation quality:

- Species diversity (native and introduced);

- Life form diversity and cover;
- Weed cover (can be separated by species if required);
- Litter loads; and
- Other parameters which may be determined to be important in the future.

Changes in vegetation quality and extent may be driven by a range of factors and choosing management actions will require an understanding of what is driving change. It is for this reason that it is recommended that quadrats and transects be located near other monitoring locations so that changes can be better related to changes in water quality or other factors that may affect vegetation quality (e.g. natural ecological progression, seasonal change, climatic and weather conditions).
Figure 5-1 Vegetation mapping at the McNaught Property undertaken as part of the offset assessment.
Figure 5-2 Mornington Peninsula Shire Council Vegetation Mapping at Tootgarook Wetland.
6. Fauna

The faunal values of the Tootgarook Wetland have been studied through a number of targeted assessments. These include extended baseline surveys throughout the wetland area (such as those completed by Malcolm Legg), ongoing systematic and repeat monitoring (such as that currently being conducted by Birdlife Australia) and short-term targeted assessments to inform development planning (see Jacobs 2014 for a comprehensive review of monitoring completed to date).

The wetland is significant from a faunal perspective for a number of reasons. It supports a high diversity and abundance of birds (both wetland and woodland birds), including threatened species (such as the EPBC listed Australasian Bittern). The wetland also supports a range of frog, reptile and mammal species, including the threatened Swamp Skink and White-footed Dunnart (reviewed in Jacobs 2014).

Potential direct threats to the fauna of the wetland include the loss of vegetation which forms important habitat (specific threats to vegetation are outlined in Section 5). Fauna that relies on aquatic habitats, such as frogs and fish may also be directly threatened by changes in hydrological regime and water quality.

As outlined in Section 4, in terms of faunal species at the wetland, Melbourne Water are primarily interested in birds (as outlined in the Healthy Waterways Strategy), with a secondary interest in frogs and fish (and other riparian species). The Mornington Peninsula Shire Council however is interested in a range of species, including threatened and locally significant species, key species that might be critical to the ongoing health of these significant species (i.e. prey species) and species that might act as ‘indicators’ for more general wetland health.

In terms of threatened species, and other non-aquatic or riparian species, the organisational remits of Melbourne Water and the MPSC are different. In general, Melbourne Water does not have a direct responsibility for the protection of threatened species, except in relation to waterway management. In contrast, MPSC are interested in the distribution and abundance of threatened species, both to aid in the assessment of development applications and to help inform management priorities such as on ground works and possible land purchases.

As birds, frogs and fish are faunal groups of interest for both Melbourne Water and the MPSC options for future monitoring of these animal groups is considered in detail in the following sections. Also provided below is a discussion of various options for the MPSC to approach monitoring other threatened and locally valued or important species.

6.1 Birds

Both the MPSC and Melbourne Water have an interest in the distribution and abundance of birds throughout the Tootgarook Wetland. This is directly aligned with Melbourne Water’s objective for the wetland as outlined in the Healthy Waterways Strategy (see Jacobs 2014). Gaining a detailed understanding of the bird fauna at the wetland may also be important for supporting any applications to list the wetland under the Ramsar convention. The monitoring question of interest is:

1. Is there a complete and coherent picture of the distribution and abundance of bird species at the wetland? Is the distribution and abundance of bird species changing over time?

Method:

Birdlife Australia is currently undertaking standardised bird counts at a number of locations within and around the wetland area as part of a project in partnership with Melbourne Water and the MPSC. Every two months, four separate bounded survey sites are located throughout the McNaught Property. At each of the four survey sites, 20min ‘500m Area Searches’ are conducted along a consistent transect. At the other locations (the
MPSC sites) 500m area searches are conducted and point searches from the edge of the wetland (Chris Purnell, Birdlife Australia pers. comm.).

**Analysis:**

These survey methods are ideal as they allow changes over time to be detected and allow robust comparisons between sites. The MPSC can interrogate these data to assess changes to high profile species, such as the Australasian Bittern and Latham’s Snipe.

This Birdlife Australia monitoring is important from a strategic standpoint for both Melbourne Water and the MPSC and should continue. Data on species diversity and population abundance should be interpreted in association with any vegetation monitoring conducted at the wetland (see Section 5).

### 6.2 Frogs

The frog fauna of the Tootgarook Wetland predominantly consists of species that are likely to be common and abundant throughout the area. There are however records of Southern Toadlet (*Pseudophryne semimarmorata*) which is listed as ‘vulnerable’ on the Advisory List of Threatened Species (DSE 2013). In terms of frogs, the monitoring question of interest is:

1. **Is there a complete and coherent picture of the distribution and abundance of frog species at the wetland? Is the distribution and abundance of frog species changing over time?**

**Method:**

An adequate baseline of the species that are likely to be supported by the wetland has been developed by previous studies.

Robust assessments of frog abundance are difficult as they require mark recapture methodologies that can be logistically complex to implement and analyse and take several years to reveal detectable patterns. Call surveys however can be completed relatively simply and with a small amount of guidance and support, can be conducted by interested members of the public.

Based on a model similar to the successful Melbourne Water Frog Census program (which does operate in the area) it is proposed that members of the public (ideally members of ‘friends-of-the-wetland’ groups) survey a number of sites of interest across the year.

Ideally surveys should be conducted at different habitats including open, still water (ponds and disused dams), slow flowing water (Chinaman’s Creek) and seasonally inundated depressions which would form marshes following wetland inundation. The number of sites that can be surveyed will rely on how many interested participants can be recruited, the time commitment they are willing to make and how many sites can be accessed safely at night.

Surveys should be carried out over multiple nights in April (to detect autumn breeding species such as the Southern Toadlet and Victorian Froglet, *Geocrinia victoriana*), August (late winter breeders, Southern Brown Tree Frog, *Litoria ewingii*, Common Froglet, *Crinia signifera*, Verreaux’s Tree Frog, *Litoria verreauxii verreauxii*) and November/December (spring/summer breeders, Pobblebonk, *Limnodynastes dumerilii*, Spotted Marsh Frog, *Limnodynastes tasmaniensis*).

Each site should be visited after sunset, with at least 10 mins spent listening at each location. Recordings should be made on a smart phone or recording device for later quality control by a suitable specialist to ensure species identifications are accurate. Encouraging participants to download a smart phone application, such as Museum Victoria’s *Field Guide to Victorian Fauna*, would help considerably with species identifications.
Participants should be encouraged not to try and capture or handle frogs.

An alternative to conducting community led frog surveys is to use acoustic recorders to monitor the frog assemblages of the wetland. Acoustic recorders can be installed at various places around the wetland and programmed to record for a set period each night. The recording can then be analysed relatively simply using specially designed call recognition software.

Acoustic recorders and call recognition software represent a cost effective but powerful method for assessing the frog community assemblages at a wetland. They may be particularly useful in the Tootgarook Wetland for carrying out targeted surveys, for example to build an understanding of the presence and habitat use by rare species such as the Southern Toadlet.

**Analysis:**

As outlined above, estimating abundance of frogs is difficult, even with labour intensive mark recapture studies. The data collected by this program should be analysed for presence-absence, acknowledging that some species are only seasonally active.

It should be noted however, that as the majority of frog species at the wetland are common, little change may be detected using this (or any other frog survey) methodology. The detection of Southern Toadlet in the wetland would be a significant result however and participants should be briefed as to the call of this species in particular.

6.3 Fish

The fish fauna of Chinaman’s Creek (upstream, downstream and within the wetland) is dominated by small bodied, relatively common species, with some possibility that Australian Mudfish are supported (although the evidence for this is not strong). Monitoring could be conducted to assess changes in these species in the creeks and wetland, however strong consideration should be given as to whether it is a good use of resources. Despite this, a monitoring program that could be used to detect changes over time is described below, based on the following monitoring question:

1. **Is there a complete and coherent picture of the distribution and abundance of fish species at the wetland? Is the distribution and abundance of fish species changing over time?**

**Method:**

Surveys should be conducted every three to five years. This could be spring or autumn, however once decided surveys should be completed in the same season each year. Up to eight sites should be surveyed, two on Chinaman’s Creek upstream of the wetland, two on Chinaman’s Creek downstream of the wetland and four throughout the wetland (Drum Drum Alloc Creek is often dry and is unlikely to regularly support fish).

Ten bait traps should be set overnight at each site and placed in the variety of habitats that are present at the site, such as emergent and submerged vegetation, areas with overhanging vegetation and open water. Caught fish should be identified to species, weighed, measured and native species should be returned to the water as quickly as possible. Exotic species, such as Goldfish and Gambusia should be disposed of humanely.

The efficacy of setting fyke nets and electrofishing in Chinaman’s Creek should also be explored. Provided that safe and suitable access is available to allow these techniques to be used, they are likely to capture larger bodied species than bait traps alone.

**Analysis:**

The repeated, standardised survey methodology ensures that abundance can be reasonably compared between sites and over years. Analysis of the different techniques should also be completed following the initial sampling runs to investigate any efficiencies in the sampling method that may be apparent. For example, it is
likely that relatively few large bodied fish use Chinaman’s Creek and therefore electrofishing and fyke nets may not be required. The results of several years should be considered before strong inferences are drawn from a small scale survey such as this.

### 6.4 Monitoring for other species

As outlined previously, the responsibilities and interests of Melbourne Water and the MPSC are divergent when it comes to threatened species. While Melbourne Water’s responsibilities are linked to their position as waterway manager, the MPSC have a broader remit. As part of the current project, the MPSC identified a range of priority questions related to fauna monitoring including of threatened and locally significant species, key species that might be critical to the ongoing health of these significant species (i.e. prey species) and species that might act as ‘indicators’ for more general wetland health.

Understanding the distribution and relative abundance of threatened species that would flag legislative protection (such as the Swamp Skink and the White-footed Dunnart) is important. There is currently a reasonable baseline for the Swamp Skink at the wetland based on the work of Malcolm Legg and from other targeted surveys (see Jacobs 2014).

The baseline of White-footed Dunnart has not been as well established as for Swamp Skink, and to our understanding, the McNaught Property has not been comprehensively surveyed (see Jacobs 2014). Taken together however, it is likely that Legg’s surveys do give a reasonable understanding of the condition of populations at the wetland (see Jacobs 2014). Although they are present, it is unlikely that White-footed Dunnarts are common. If they were, it would be reasonable to expect that they would have been caught more frequently as part of Legg’s mammal surveys.

In contrast to establishing a baseline, long-term condition monitoring to detect changes over time for these species may be prohibitively expensive, with a high chance that capture rates will be very low or that changes will be hard to detect. As an alternative, we recommend that a detailed review of the habitat requirements of these species takes place. The extent and quality of this habitat can then be mapped at the site, using some of the outputs from the flora monitoring recommended as part of this study. This provides a risk-based approach to estimating occurrence (one that would likely have to be ground-truthed to meet planning regulations however).

Effort should also be directed into looking for opportunities for collaboration with universities or other agencies (e.g. DEPI) to complete monitoring of threatened species, particularly work completed as part of the development of management or action plans. Any data that is collected regarding threatened species in the area should be obtained and incorporated when considering overall health and condition of the wetland.

We don’t recommend at this stage that monitoring be conducted for macroinvertebrates. We instead recommend that water quality, one of the strongest indicators of macroinvertebrate community composition, be monitored.
7. Groundwater

The value of groundwater within the Tootgarook Wetland is directly related to its role in maintaining permanent saturation of the soils within the wetland system (SKM 2012). It is thought, permanent soil saturation helps maintains surface water runoff reducing any losses of surface water to the groundwater and prevents potential acid sulphate soils (PASS) from turning acidic. Through these processes groundwater helps maintain a healthy aquatic ecosystem, and provides an additional source of water to maintain evapotranspiration potential of terrestrial vegetation during dry periods. Therefore, any change in groundwater quantity or quality within the site is likely to lead to temporary or permanent loss of species with the potential to cause irreversible species loss/ habitat damage from acidification of soils, groundwater and receiving waters.

Potential threats to the Tootgarook Wetland include changes in groundwater quality and quantity from stock and domestic groundwater extraction, septic tanks, land use change such as urban and industrial development and potential contamination from the Trueman’s Road Landfill and the South East Water Boneo Water Recycling Plant. The current incomplete understanding of the surface water and groundwater interaction within the wetland means that it is difficult to determine the potential impact associated with these threats.

Based on the ecological objectives defined in Section 4 and the key values and threats associated with groundwater within the Tootgarook Wetland, the following monitoring questions have been developed to guide the proposed groundwater monitoring program within the wetland:

1. What is the relationship between surface water levels in Chinaman’s Creek and groundwater levels within the wetland?

2. What is the risk associated with groundwater extraction at the site?

3. What is the risk associated with potential contamination of groundwater at the site (e.g. contamination from SEW, landfill and land use)?

The completed groundwater monitoring program, including the monitoring method and analysis required to answer these questions are summarised below. The method proposes to utilise a number of existing (including the completed Melbourne Water GDE monitoring sites) groundwater monitoring sites including:

- Nine existing SOBN groundwater monitoring bores currently being monitored by DEPI;
- All existing Mornington Peninsula Shire groundwater monitoring bores at the Trueman’s Road Landfill;
- All existing South East Water groundwater monitoring bores at the Boneo Water Recycling Plant; and
- All completed (except MW004 at landfill site) Melbourne Water GDE program monitoring bores.

The location of these bores is provided in Figure 7-1.

7.1 What is the relationship between surface water levels in Chinaman’s Creek and groundwater levels within the wetland?

Method:

As part of the Melbourne Water GDE program, a groundwater and surface water monitoring network at Tootgarook Wetland has been developed to help understand the role that groundwater plays on the wetland’s ecosystem health. Installation of one surface water monitoring site on Chinaman’s Creek and four groundwater bores was completed in June 2014.

Monitoring should be conducted at the surface water monitoring site on Chinaman’s Creek and the two nested monitoring bores (shallow and deep; MW002 and MW003) adjacent to the surface water level monitoring site to provide an indication of the relationship between surface water and groundwater. Currently continuous data loggers record level and temperature every 6 hours at each of the Melbourne Water bores, however it is recommended that EC and pH also be monitored at each of the bores.
Analysis:
The comparison of the surface water level, EC and pH at Chinaman’s Creek and the groundwater levels, EC and pH within the wetland adjacent to the creek will provide an indication of the relationship between surface water and groundwater in the wetland and increase the understanding of the role that groundwater plays on the health of the wetland’s ecosystems. Following the installation of the bores, the conceptual understanding of the site was refined (GHD 2014).

The current conceptual understanding of the nature of groundwater-surface water connection at the wetland should be updated to reflect the findings of the analysis.

7.2 What is the risk associated with groundwater extraction at the site?

Method:
The Melbourne Water GDE groundwater monitoring network should be utilised to provide water level data to determine the risk associated with groundwater extraction within the wetland. All GDE groundwater monitoring bores, excluding MW004 due to its location within the landfill, should be monitored for water level, EC and pH. Currently continuous data loggers record level and temperature every 6 hours at each of the Melbourne Water bores, however it is recommended that EC and pH also be monitored at each of the bores to provide this groundwater data.

It is important that continuous groundwater levels are recorded (4 or 8 hourly readings) to identify water level variations related to short term rainfall events and those variations that are more likely to be a result of seasonal groundwater extraction.

DEPI currently monitor nine SOBN regional groundwater monitoring bores within the vicinity of the wetland, these are monitored on a bi-monthly basis. It is recommended that groundwater water level data be obtained from DEPI pertaining to these nine bores to provide a high level comparison of regional and local groundwater level variations/trends.

Analysis:
The data obtained from the Melbourne Water GDE groundwater monitoring bores and the DEPI SOBN bores should be analysis against rainfall at the Rosebud (Country Club) Rainfall Station (Station number 86213) and estimated groundwater extraction volumes in the region to identify any seasonal drawdowns variations from on-site and regional monitoring bores that may be associated with groundwater extraction.

The lowering of the watertable from groundwater extraction could lead to acidification of soil, groundwater and subsequent receiving waters, therefore continuous groundwater quality (EC and pH) data obtained from the Melbourne Water GDE groundwater monitoring bores should be analysed to qualitatively identify any potential acid sulphate soils (PASS) that may change the risk of groundwater extraction to the wetland.

If a risk from groundwater extraction to the wetland is identified, a subsequent assessment should be undertaken to understand the environmental water requirements of the site and determine groundwater levels which trigger the banning of groundwater extraction to maintain groundwater levels within the wetland.
7.3 What is the risk associated with potential contamination of groundwater at the site (e.g. contamination from SEW, landfill and land use)?

**Method:**

It is assumed that currently groundwater level and quantity data is being collected and analysed (in line with the Environmental Protection Authority requirements for the sites) by both the MPSC and South East Water at the Truemans Road Landfill and the Boneo Wastewater Treatment Plant respectively. Monitoring data and any groundwater monitoring reports that provide information on groundwater flow paths and plume extensions should be provided in the future to identify any potential contamination from the Truemans Road Landfill and the Boneo Wastewater Treatment Plant.

In order to determine potential groundwater contamination from land use, in particular irrigation of the market gardens in the area, it is recommended that groundwater quality monitoring be conducted at the Melbourne Water GDE groundwater monitoring bores (excluding MW004 due to its location within the Landfill). Monitoring of water quality at these bores should be undertaken bi-annually, coinciding with irrigation periods occurring within the market gardens (e.g. just post irrigation of the market gardens). Consultation with land holders will be required to determine the timing of significant irrigation periods.

For most groundwaters, 95% of the ions are represented by only a few major ionic parameters; sodium (Na⁺), potassium (K⁺), calcium (Ca²⁺), magnesium (Mg²⁺), chloride (Cl⁻), sulfate (SO₄²⁻), bicarbonate (HCO₃⁻) and nitrate (NO₃⁻). These parameters when added together account for most of the salinity that is commonly referred to as total mineralisation or total dissolved solids (TDS) (Sundaram, B. et al., 2009). Therefore, these water quality variables should be monitored at all the Melbourne Water GDE monitoring bores (excluding MW004). Groundwater quality monitoring should be undertaken in accordance with the Environmental Protection Authorities ‘Groundwater Sampling Guidelines’ (2000).

**Analysis:**

Groundwater quality monitoring data provided by the Mornington Peninsular Shire and South East Water should be interpreted to determine any potential contamination from the Truemans Road Landfill and the Boneo Wastewater Treatment Plant.

The water quality data collected from the Melbourne Water GDE monitoring bores should be analysed to qualitatively identify any contamination within the Tootgarook Wetland that may have resulted from irrigation and the market gardens. If a risk from groundwater contamination from irrigation/ market gardens is identified, additional monitoring or analysis (e.g. water quality monitoring at the regional SOBN bores) may be required to identify the likely source of contamination. However due to expense associated with additional monitoring, this is not recommended unless potential contamination is identified. The risk of groundwater contaminants, if present, to the health and survival of the wetland flora and fauna is unknown at this time and could be considered further only if any potential contaminants are detected.
Figure 7-1 Locations of groundwater monitoring bores in the Tootgarook Wetland and surrounding areas.
8. Surface water quality and quantity

Water quality in Chinaman’s Creek (and the Tootgarook Wetland) is determined by a number of major factors; urban and rural inputs, groundwater discharge to Chinaman’s Creek as it moves through the wetland area, and the erosion of the bed and bank. Water quality in Chinaman’s Creek and Drum Drum Alloc Creek has been investigated as part of a long-term and ongoing monitoring program at Eastbourne Road (downstream of the wetland) by Melbourne Water. In addition, a number of targeted studies have investigated the impact of the urban/industrial runoff into Drum Drum Alloc Creek. To our knowledge only one study has investigated water quality impacts in Chinaman’s Creek within the wetland area (WaterWatch data collected by the ‘Friends of Chinaman’s Creek).

Nitrogen concentrations are high compared to the SEPP, with the source of the nitrogen possibly related to the use of fertilizer and possibly recycled wastewater irrigation on the nearby market gardens. The levels of Dissolved Oxygen in Chinaman’s Creek are frequently well below (SEPP) guidelines of 4.5 mg/L, particularly in summer. Metals in Chinaman’s Creek generally meet water quality guidelines however the input from the industrial areas along Drum Drum Alloc Creek can be elevated. Whilst there is a small risk that the elevated metal concentrations can result in uptake by wetland flora and fauna and then be transferred along the food chain, this is unlikely to represent a significant risk to the health of the wetland.

The interaction between groundwater and surface water quality is currently poorly understood, as is the inundation patterns of the wetland more generally. Building an understanding of the inundation pattern (frequency, timing, extent, depth) would be valuable for managing the wetland with the goal of meeting the water requirements of the important species and ecosystem processes.

Based on the ecological objectives defined in Section 4 and the key values and threats associated with water quality and quantity within the Tootgarook Wetland, the following monitoring questions have been developed to guide the proposed surface water quality monitoring program:

1. **What is the risk from the water quality entering Port Phillip Bay?**
2. **What is the risk associated with potential contamination of surface water at the wetland (e.g. contamination from SEW, landfill and land use)?**
3. **What is the association between the quality of groundwater and surface water in the wetland?**
4. **What is the surface water hydrology of the site (inundation patterns related to rainfall, evaporation and groundwater interactions)?**

8.1 **What is the risk from the water quality entering Port Phillip Bay?**

**Method:**
The monthly water quality monitoring undertaken by Melbourne Water at Eastbourne Road should be continued in its current form. This provides important data to determine the quality of water entering Port Phillip Bay.

**Analysis:**
Interpretation of this data should consider that significant industrial and urban input occurs between the wetland and the monitoring location. Therefore water quality measured at this site may not be indicative of water quality in the wetland itself.
8.2 What is the risk associated with potential contamination of surface water at the wetland (e.g. contamination from SEW, landfill and land use)?

Method:

To date only limited surface water quality monitoring has been conducted upstream or within Tootgarook wetland. We recommend that for one year, monthly sampling be conducted in Chinaman’s Creek upstream of the wetland (south of Limestone Road) and at two sites within the wetland; one at the Melbourne Water surface water monitoring site (near the middle of the McNaught Property) and the other near the northern extent of the wetland, upstream of the confluence of Chinaman’s Creek and Drum Drum Alloc Creek. If surface water is present in Drum Drum Alloc Creek on the day the other sites are monitored, water quality should be collected from downstream of any industrial developments (but upstream of the confluence with Chinaman’s Creek). These monitoring locations are displayed in Figure 8-1.

This monthly monitoring should take place on the same day that the routine Melbourne Water Eastbourne Road monitoring is conducted.

The water quality variables measured at the Eastbourne Road site should be measured at each of the new monitoring locations (Temperature, dissolved oxygen, salinity (EC), pH, Turbidity, Suspended solids, NO₃, NO₂, NH₃, TKN, Total N, PO₄-filtered, Total P, *E. coli*, and a range of metals (As, Cd, Cr, Cu, Pb, Ni, Zn)).

Analysis:

Each of the recommended sampling sites has been chosen to provide information on potential contamination sources and impacts to the wetlands. Sampling upstream of the wetland gives information as to the background water quality in Chinaman’s Creek.

Although monitoring is conducted within Chinaman’s Creek (and not the wetland more broadly), the two monitoring locations within the wetland itself likely provides an indication as to the water quality more widely in the wetland. Placing one location at the site of the groundwater bore will allow surface and groundwater quality to be linked. The second within-wetland monitoring location will indicate water quality in Chinaman’s Creek prior to the influence of urban and industrial runoff from Drum Drum Alloc Creek.

It has not been recommended that surface water in the wetland itself (as opposed to in Chinaman’s Creek) be monitored. Collecting water quality from within the wetland may be logistically difficult and may be overly influence by local, rather than wetland wide factors. The proposed surface water monitoring, in conjunction with the proposed groundwater quality monitoring program is likely to provide sufficient information in the first instance, however there is potential to expand this monitoring into pooled water in the wetland itself should significant risks be identified.

Conducting all the monitoring data on the one day ensures costs are minimised, particularly if the extra sampling can be piggy-backed onto the routine Eastbourne Road monitoring. As outlined, monitoring should be undertaken monthly at the four additional sites (and Eastbourne Road) and should be conducted for a year to provide an indication of seasonal water quality. Given that irrigation is likely to be seasonal, as well as the highly seasonal hydrological regime of the wetland due to rainfall, one year is a minimum in the first instance to allow a picture of the wetland to be established. Following 12 months of monthly sampling, the data should be reviewed and if necessary, the monitoring period could be extended.

Data should be examined against the relevant SEPP and ANZECC Water quality guidelines. If any contamination is detected, the potential exo-toxicity risks to wetland species can be determined by measuring levels in surrounding vegetation (leaves are best) or available fauna (destructive sampling would be required so pre-deceased fauna only is recommended to be sampled) to better understand the risk of uptake and food chain transfer.
8.3 What is the association between the quality of groundwater and surface water in the wetland?

Method:

To establish the link between groundwater and surface water quality in the wetland, in months where groundwater monitoring is to be completed at the wetland, surface water monitoring should also be undertaken on the same day at each of the five sites described above (Section 8.2). Surface water quality at the five proposed sites should be sampled each time groundwater quality is measured (i.e. even if outside the initial year-long surface water study).

Analysis:

As groundwater and surface water quality will be collected at the same time, relative contributions of surface and groundwater contaminants can be considered directly. Monitoring over a number of years will provide data to understand the potential pollutant pathways (i.e. groundwater or surface water) to the wetland.

8.4 What is the surface water hydrology of the site (inundation patterns related to rainfall, evaporation and groundwater interactions)?

Method:

Developing an understanding of the inundation patterns of the wetland could be completed in a number of ways. The most simple, but robust and powerful method would be to develop a rainfall runoff model, which is essentially a water balance, which includes consideration of groundwater interactions, evaporation, rainfall and surface water inputs. The goal of understanding the current inundation patterns would be to then link this to the water requirements of the important species in the wetland to assess whether these requirements are being met.

To provide the information necessary to determine this model, it is recommended that in addition to the water monitoring location in Chinaman's Creek which has been installed as part of the groundwater program (see Section 7), surface water monitoring sites be installed on Chinaman’s Creek just downstream of the wetland (in the vicinity of Elizabeth Avenue) and on Drum Drum Alloc Creek just downstream of the industrial area (near Lybie Court). In this way, the contributions of the major surface water inputs to the wetland, Chinaman’s and Drum Drum Alloc Creek can be measured, as well as the flow leaving the wetland via Chinaman’s Creek.

To give some idea of inundation extent and duration in the wetland, it is recommended that an additional surface water monitoring site be installed in the wetland itself, if possible at the lowest point of the wetland. Groundwater interactions and inputs will be investigated using the methods outlined in Section 7.

Analysis:

The inputs described above combined with estimates of evaporation and transpiration and climatic information could be used to produce a rainfall runoff model to understand the frequency and timing of inundation of the wetland under different rainfall and climatic scenarios. Coupled with survey information (such as LiDAR) the extent of inundation could also be more fully understood.
Figure 8-1 Proposed surface water monitoring sites in relation to the existing groundwater monitoring locations at Tootgarook Wetland.
9. Summary and monitoring program prioritisation

The following section provides a brief summary of the monitoring programs proposed for the Tootgarook Wetland. Also provided is our assessment of the priority (high, medium or low) of these monitoring programs for Melbourne Water and the MPSC. This assessment has been informed by our understanding of the priorities and remit of each organisation (based on discussions held as part of this project) and the ability of the monitoring to inform otherwise poorly understood, or potentially important threats to the wetland. This assessment has been provided as a guide to prioritise the range of monitoring programs developed as part of this report, however both Melbourne Water and the MPSC should consider the full report when developing their own monitoring priorities.

<table>
<thead>
<tr>
<th>Monitoring question</th>
<th>Summary of proposed monitoring</th>
<th>Section of this report</th>
<th>MW priority</th>
<th>MPSC priority</th>
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<td><strong>Flora</strong></td>
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<tr>
<td>1. Is there a complete and coherent picture of the extent and quality of native</td>
<td>Additional Habitat Hectare or Index of Wetland Condition mapping to fill gaps currently in the</td>
<td>5.1</td>
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<td>vegetation communities across the wetland in order to understand the values present?</td>
<td>mapping for the site.</td>
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<td>2. Is the extent and quality of the native vegetation present in the wetland</td>
<td>Transect and quadrat based monitoring at various EVCs to assess change. Locate some transects</td>
<td>5.2</td>
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<td>High</td>
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<td>changing? a) Is weed cover changing in the wetland vegetation? b) Is the cover of</td>
<td>near groundwater bores to incorporate data on groundwater quantity and quality.</td>
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<td>Tall Marsh changing? c) Is species diversity changing within wetland vegetation?</td>
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<td><strong>Fauna</strong></td>
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<td>1. Is there a complete and coherent picture of the distribution and abundance of</td>
<td>Continue currently in place Birdlife Australian monitoring.</td>
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<td>bird species at the wetland? Is the distribution and abundance of bird species</td>
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<td>2. Is there a complete and coherent picture of the distribution and abundance of</td>
<td>Initiate community run frog call census over the year.</td>
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<td>3. Is there a complete and coherent picture of the distribution and abundance of</td>
<td>Monitor populations in Chinaman’s Creek using bait traps at a number of sites upstream,</td>
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<td>changing over time?</td>
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<td>Monitoring for other species (threatened species, indicator species)</td>
<td>Investigate the possibility of taking a risk based approach to species presence to avoid costly,</td>
<td>6.4</td>
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<td>and possibly inconclusive monitoring programs.</td>
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<td><strong>Groundwater</strong></td>
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</tr>
<tr>
<td>1. What is the relationship between surface water levels in Chinaman’s Creek and</td>
<td>Monitor water level at Melbourne Water’s GDE monitoring bore and the associated surface water</td>
<td>7.1</td>
<td>High</td>
<td>High</td>
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<tr>
<td>groundwater levels within the wetland?</td>
<td>monitoring sites using continuous data loggers</td>
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</table>

attachment 7
<table>
<thead>
<tr>
<th>Monitoring question</th>
<th>Summary of proposed monitoring</th>
<th>Section of this report</th>
<th>MW priority</th>
<th>MPSC priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. What is the risk associated with groundwater extraction at the site?</td>
<td>Monitor water level at Melbourne Water’s GDE monitoring bores throughout the wetland and compare this to data collected from the SOBN program and monitoring conducted on the bores near the Boneo Wastewater Treatment Plant and the decommissioned council landfill site.</td>
<td>7.2</td>
<td>High</td>
<td>High</td>
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<tr>
<td>3. What is the risk associated with potential contamination of groundwater at the site (e.g. contamination from SEW, landfill and land use)?</td>
<td>Groundwater quality should be monitored at the Melbourne Water GDE monitoring bores, bi-annually to coincide with significant irrigation periods.</td>
<td>7.3</td>
<td>High</td>
<td>High</td>
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<tr>
<td>Surface water quality</td>
<td></td>
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<tr>
<td>1. What is the risk from the water quality entering Port Phillip Bay?</td>
<td>Continue monthly Melbourne Water water quality monitoring at Eastbourne Road.</td>
<td>8.1</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>2. What is the risk associated with potential contamination of surface water at the wetland (e.g. contamination from SEW, landfill and land use)?</td>
<td>Complete monthly monitoring of sites on Chinaman’s Creek upstream and within the wetland and in Drum Drum Alloc Creek</td>
<td>8.2</td>
<td>High</td>
<td>Medium</td>
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<tr>
<td>3. What is the association between the quality of groundwater and surface water in the wetland?</td>
<td></td>
<td>8.3</td>
<td>High</td>
<td>Medium</td>
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</tbody>
</table>
10. References


