Review of Mangles Bay Marina Based Tourism Precinct – Public Environmental Review

Prepared for *Preserve Point Peron* and *Hands Off Point Peron*
by

Dr Mike van Keulen
School of Biological Sciences & Biotechnology
Murdoch University

Dr Mike van Keulen

Dr Mike van Keulen is Senior Lecturer in Plant Sciences and Marine Biology and Academic Chair of the Marine Science program at Murdoch University. His research interests are in seagrass ecology and rehabilitation and the ecology of coral reefs. Mike has over 25 years of research experience in seagrass ecology and more than 15 years of research experience in seagrass rehabilitation, producing numerous scientific publications in the field. He is internationally sought after for advice on seagrass rehabilitation projects. Mike has worked extensively in the Shoalwater Bay and Cockburn Sound region and played a senior role in the seagrass rehabilitation work undertaken through the collaborative Seagrass Research and Rehabilitation Programme. His team at Murdoch University has completed the largest and most successful seagrass transplantation project in Australia.

Contact details:

Dr Mike van Keulen
School of Biological Sciences & Biotechnology
Murdoch University
Murdoch WA 6150

Phone: 93602369
Email: keulen@murdoch.edu.au

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Introduction

The Mangles Bay Marina Based Tourist Precinct proposal, previously known as the Cape Peron Tourist Precinct project, has had a long history and has undergone a number of iterations before presentation in its current form. Identified environmental constraints have been a major consideration for this proposal since its inception and, aside from the overarching economic considerations, have determined the viability of previous iterations of the project. The major environmental constraints have been consistently identified as:

- seagrass loss and water quality impacts from construction and long-term impacts of the operation of the marina
- impacts on Lake Richmond and associated ecological communities from changed hydrogeology
- loss of terrestrial vegetation and fragmentation of the ecosystem on the proposal site

(EPA, 2006)

The current PER process was set by the EPA when the proposal was referred to it in September 2010.

Dr Mike van Keulen was engaged jointly by the community groups *Preserve Point Peron* and *Hands of Point Peron* to undertake a scientific review of the PER document to help inform the groups' submissions to the EPA. This report will follow the basic structure of the PER.

The scope of the research commissioned by *Preserve Point Peron* and *Hands of Point Peron* was to advise:

1. Whether the proposal described in the PER poses any serious or unacceptable risks to the environment;
2. Whether there are any significant flaws in the PER's description and analysis of (a) the proposal's environmental impacts and risks and (b) the measures proposed to offset, minimise and/or manage such impacts and risks;
3. Whether sufficient research and analysis has been conducted in order to evaluate the environmental impacts and risks of the project. If not, what additional research is necessary;
4. Any other matters considered relevant to the environmental impact assessment of the proposal.

General overview of the PER

The introduction of the PER documents provides a history of proposed developments for the Mangles Bay region from the early 1970s to the present proposal. The introduction includes a rationale for the development proposal and outlines key issues that resulted in deferment of the proposal to the present time. A summary of the environmental assessment processes that are being followed is presented, including preparation of a Strategic Environmental Review for EPA evaluation in 2006 and the key environmental issues identified by the EPA. The body of the PER comprises a series of chapters addressing the various environmental impacts the project is expected to have and how these impacts might be expected to be minimised.

The key sections are:

- Terrestrial environment (including groundwater, surface water, flora and vegetation, terrestrial fauna and conservation areas).
- Marine environment (including water quality, coastal processes, benthic primary producer habitat and marine fauna).
- Matters of National Environmental Significance.
- Social surrounds (including recreation and public access, Aboriginal and European heritage and visual amenity).
- Other Environmental Factors (including traffic, contaminated sites and acid sulfate soils and construction impacts of dust, noise and waste).

This report will focus particularly on key impacts of the proposed Mangles Bay Marina Based Tourist Precinct on the marine environment; however other aspects of the proposal will be addressed as appropriate.

Groundwater impact and Lake Richmond

The proponent has undertaken groundwater modelling to determine the level of impact of the proposed development on Lake Richmond. The impacts include potential salt water (marine) intrusion into the groundwater, potential impacts from dewatering during construction, changes in surface water levels in Lake Richmond during construction and operationally after construction, surface drainage from the proposed development after construction.

While the buffer proposed appears adequate to account for potential salt water intrusion, based on estimates of groundwater flow, there are a number of contingencies that have not been considered. Foremost among these is the potential for sea level rise, which would be expected to push the coastal salt wedge inland, potentially affecting the lake. There appears to be considerable variability in groundwater flow rate in the area and this raises doubts about the reliability of the modelling predictions. There is also potential for salt water intrusion to affect the root zone of coastal vegetation, which may affect the long term health and survival of coastal trees and compromise the integrity of the retained bushland within the development and the proposed reorganisation of bush areas.

Concerns about potential impacts from dewatering during the construction phase appear to have been met by adopting a wet excavation method, which will minimise the need for dewatering.

Modelling by the proponents indicates that the proposed marina development itself will be responsible for a reduction in water level of up to 0.038 m during operation post construction. While this may be within tolerances for the shoreline communities of Lake Richmond, it is not possible to isolate the proposed marina development from realignment and duplication of the Sepia Depression Ocean Outlet Landline (SDOOL) by the Water Corporation; the proposed marina development cannot proceed without realignment of the SDOOL. The combined marina and SDOOL developments are predicted to affect water levels in Lake Richmond by 0.25 m during the construction phase (Environmental Resources Management Australia, 2011), which may impact the shoreline communities in the lake, including the thrombolites.

Drainage from the new development does not appear to have been adequately considered. The destination of surface runoff has not been identified and may influence the Lake and groundwater; the significant land clearing and building proposed may affect groundwater recharge rates and therefore groundwater flow rates (and possibly direction). Additional contaminants can be predicted to enter the groundwater and/or drainage from surface runoff; these will likely end up in Lake Richmond or Mangles Bay.

A significant omission from discussions is the potential for climate change impacts on groundwater flow. With rainfall in the southwest of Western Australia already reduced and predicted to continue to fall (Climate Commission, 2011), groundwater recharge rates will decline in future years. This will exacerbate any potential salt water intrusion impacts. Sea level rises of up to 1 m are predicted by 2100 (Department of Climate Change, 2009), with recorded sea level rises in southern Western Australia being higher than the global average. At these predicted rates, enhanced salt water intrusion into the groundwater will be considerably greater than predicted based on present models and the integrity of Lake Richmond may be expected to be compromised.

As a minimum, consideration should be made of the likely impacts of a 1 m sea level rise on groundwater flows and salt water intrusion; this is likely to require additional research, as there is considerable uncertainty over the existing groundwater modelling.

Terrestrial Flora and Fauna impact

Considerable land clearing of bushland is proposed as the development proceeds, including significant areas that are listed as Bush Forever sites. The proponents have suggested that a lot of the existing Bush Forever land is degraded and can be replaced with land currently cleared and allocated elsewhere. Restoration of degraded bush would appear to be a much simpler approach than complete restoration of previously cleared and developed land. The risks associated with further disrupting the existing bush are significant; fragmentation of the existing bush corridors risk displacing native fauna, with little option for nearby resettlement.

A further consideration is the potential for the development to disrupt the hydrology of the bushland; changes to local drainage can result in changes to micro-habitats which host pockets of specific flora and fauna. Changes in groundwater conditions, resulting from increased salt water intrusion, will be expected to impact the root zones of coastal trees, affecting tree health and consequently the integrity of coastal vegetated ecosystems. This will be exacerbated by future sea level rises. More accurate groundwater modelling that takes into consideration predicted sea level rises will help in understanding the likely impacts on coastal vegetation; the information obtained thus far appears inadequate to fully predict these impacts.

Marine water and sediment quality

The proposal will have a number of impacts on the marine environment of Mangles Bay; these include direct impacts due to dredging, land reclamation and breakwater construction as well as indirect impacts due to resuspension of sedimentary pollutants and long term changes in water quality due to the presence of the marina itself.

Sediment resuspension

Dredging, land reclamation and breakwater construction are anticipated to result in sediment resuspension for considerable periods of time as the marina is developed. While measures are proposed to be installed to minimise impacts due to suspended sediments from construction, some leakage of sediment plumes during spoil transport and drainage is inevitable. It is likely that seepage of fine sediments from constructed breakwaters and reclaimed land will occur over an extended period after construction is complete, as was observed after construction of the causeway for the boating facility at Coral Bay (unpublished data); this would be expected to contribute to local sediment load for some time post construction.

Dredging can result in the release of pollutants bound in the sediment, potentially including nutrients and toxic compounds, some of which can be retained in sediments for extended periods after initial contamination. Even low levels of contamination can be a problem as a number of common pollutants are bio-accumulators and will multiply to high levels as they move up the food chain. Cockburn Sound has a long history of pollution as a result of a range of industrial activities and pollution from groundwater sources. The poor flushing of Cockburn Sound has led to the accumulation of fine organic sediments in Mangles Bay. The heavy use of Mangles Bay as a mooring location over several decades may have contributed to an increase in organotin compounds, some of which may have settled deep into the sediment. PAHs, PCBs and pesticides are all known to have been released into Cockburn Sound in the past; many of these have long residence times in marine sediments and may be released during the dredging process.

The access channel is proposed to be dredged to a depth of 4 m through the existing seagrass meadow. Samples were taken from mooring scars within the seagrass meadow rather than among the seagrass to avoid additional seagrass loss during the sampling process. The mooring scars are better flushed than the seagrass meadow and it is likely that any contaminants will have been flushed out of the sediment that was collected. This is also reflected in the low percentage of fines reported in the sediment samples (Oceanica, 2012). For these reasons it is felt that the sampling process for sediments does not adequately represent the likely level of sedimentary contamination at the site.

Destabilisation of sediments

The Mangles Bay seagrass meadow is dominated by fine organic sediments; it is likely that this is one of the key reasons for the relatively poor overall health of seagrasses in this area compared to elsewhere in Cockburn Sound (see the section on seagrasses later in this report). The dredged access channel will bisect the already fragile seagrass meadow in Mangles Bay, changing the topography and local flow characteristics. The shallow nature of the surrounding meadow may result in enhanced drainage flow into the channel; the possible impacts of this are unknown. It is anticipated that the low density sediment that the seagrasses are growing in will be more vulnerable to resuspension as a result of the new channel, increasing the risk of erosion and further loss of the abutting seagrass meadow.

Long-term disturbance can be expected in the form of wash from boats entering and exiting the marina via the access channel; this would particularly be a problem if larger boats are anticipated where the draft occupies a relatively large portion of the channel. The marina is proposed to be able to accommodate larger yachts and commercial vessels and these may produce sufficient drag as they traverse the channel to disturb the bottom and adjacent sediments. The low density of sediments and lack of stability may also result in sediment slumping into the channel from the adjacent seagrass meadows, with consequent implications for continued erosion of the seagrass meadow and also for maintenance dredging. The channel forms a deep point in the middle of the seagrass meadow and it is anticipated that seagrass wrack will accumulate in it, potentially causing a nuisance for boaters.

Water quality

The waters in Mangles Bay are already acknowledged as of relatively poor water quality, with chlorophyll *a* levels consistently higher than environmental quality standards (Oceanica, 2012) and have been so for some time (Western Australian Auditor General, 2010). It has been postulated that this is the result of nutrient inputs from groundwater and the Lake Richmond overflow drain, exacerbated by the poor flushing of this part of Cockburn Sound (Western Australian Auditor General, 2010). Poor water quality is likely to contribute to the poor seagrass health observed in the Mangles Bay area, by increasing turbidity.

By enclosing waters within a marina of this nature, water quality is acknowledged to deteriorate, with enhanced nutrients and chlorophyll *a* levels leading to stagnation and possible reductions in dissolved oxygen in very poorly flushed systems. The proponents expect nutrients that come into the marina via groundwater to be partially taken up by phytoplankton, with the result that chlorophyll *a* levels in the proposed marina are expected to be approximately twice that of the adjacent waters in Mangles Bay. While modelled flushing rates are quoted by the proponents as adequate to prevent build up of nutrients or contaminants (Strategen, 2012), the modelled times appear to be sufficient to allow significant development of phytoplankton blooms: 4-13 days depending on location within the marina and time of year (APASA, 2011). This is of particular concern during the warm and calm autumn months, when conditions are ideal for phytoplankton growth. Rapid build up of phytoplankton populations can result in excessive dissolved oxygen demand, particularly a concern in the warm waters experienced in Perth during summer. The outcome of this process is likely to be the release of very low quality water onto the already vulnerable adjacent seagrass meadows.

Coastal processes

The proposal to build a marina at Mangles Bay adds to an already significantly disturbed environment that is under continued stress. The construction of the Garden Island causeway in the early 1970s initiated a major disruption to longshore sand movement, with areas of erosion on the eastern side of the causeway and accretion on the western side (Department of Transport, 2009). The survival of the beach along Mangles Bay is likely due to a combination of the sheltered nature of that part of Cockburn Sound and the stabilising influence of the extensive seagrass growth close to shore.

Construction of the proposed marina and access channel through the seagrass meadow could result in destabilisation of the seagrass meadow in Mangles Bay and the release of fine sediments which have accumulated in the bay. In the longer term, wash from boat traffic through the access channel could result in additional destabilisation of sediment and the bisected seagrass meadow, making the system vulnerable to erosion during winter storms. Initial erosion of the seagrass could extend to tens of metres from the channel; however in the longer term more widespread losses could occur and lead to the loss of the seagrass meadow as a contiguous structure. If the seagrass meadow is lost from Mangles Bay the sediment adjacent to the shoreline may become destabilised and coastal erosion would be a distinct possibility.

Global climate change impacts have not been addressed. Results from a wide range of modelling exercises suggests that sea level rises of up to 1 m may be reasonably expected by 2100. Southern Western Australia has been experiencing greater levels of sea level rise than the global average and large areas of the southwest coastline are under threat of regular inundation and coastal erosion (Department of Climate Change, 2009). No acknowledgement has been made of likely global climate change impacts and this is a major short-coming in any planning of coastal developments; particularly in southern Western Australia, where the sedimentary coastlines are likely to be more significantly affected than elsewhere.

Benthic Primary Producer Habitat

The access channel for the marina will be dredged to a depth of 4.0 m through the existing seagrass meadow. The proposal will involve the direct removal of 5.36 ha of seagrass with a further 0.3 ha estimated to be lost due to halo effects around breakwaters. The proponents are proposing to offset these losses by rehabilitating seagrass habitat at other locations within Cockburn Sound.

There are several issues of concern resulting from these activities; including the direct loss of seagrass habitat, sediment destabilisation, the rehabilitation process and drainage impacts on adjacent seagrass meadows. There are also concerns about epiphyte loads resulting from increased nutrient outflow via the marina channel.

Direct loss of seagrass habitat

The proposal will effectively result in the loss of 5.66 ha of seagrass out of the existing meadows in eastern Mangles Bay. The seagrass meadows in this part of Cockburn Sound have been identified as having reduced health, with lower shoot density than would be expected elsewhere in the region. The report on Benthic Primary Producer Habitat (Oceanica 2012) uses the CSMC report cards as a basis for its observations on site health; however the Auditor General's report on environmental management of Cockburn Sound identified errors and inconsistencies in the seagrass monitoring programme commissioned by CSMC (Western Australian Auditor General, 2010). This included incorrect calculations of long term shoot density trends against a reference site in Warnbro Sound, which was found to be also declining. Seagrass health in Mangles Bay was singled out as an issue for concern by the Auditor General, having been consistently below the EQS set by the State Environmental Policy for Cockburn Sound for several years (Western Australian Auditor General, 2010). It is clear that the CSMC report cards for the last several years cannot be relied on as a baseline reference for seagrass health in Mangles Bay.

It is believed the poor seagrass health conditions in Mangles Bay are largely the result of circulation patterns in Cockburn Sound as modified by the presence of the Garden Island causeway since the early 1970s. The consequent reduction in flushing of Cockburn Sound has resulted in the Mangles Bay effectively being a sink for fine sediments (and pollutants generated within the Sound). The settlement of fine sediment particles onto seagrass leaves in Mangles Bay very probably reduces the amount of light available for photosynthesis, compromising the overall health of the seagrasses. Historical pollution of Cockburn Sound included significant quantities of nutrients and metals, which are believed to have accumulated in the sediments of the Mangles Bay area. As a consequence, seagrass health in Mangles Bay has been consistently poorer than elsewhere in the region (Waddington and Meeuwig, 2010).

Regular monitoring commissioned by the Cockburn Sound Management Council (Cockburn Sound Management Council, 2009) shows that shoot densities in Mangles Bay are consistently lower than elsewhere in Cockburn Sound and epiphyte loads are higher than elsewhere. Shoot densities in the area have remained relatively stable over the last several years although there has been an overall decline since the monitoring programme was

established in 2005; seagrass meadow health at Mangles Bay must be considered compromised and vulnerable to disturbance.

Seagrass shoot densities have on occasion fallen below 50% of the EQS target (Western Australian Auditor General, 2010); studies on seagrass density declines have suggested that if the shoot density drops to 25% or less of natural (reference) meadow density, the structural integrity of the meadow becomes compromised and catastrophic loss may result from erosion due to hydrodynamic disturbance (van Keulen, 1998). Negative impacts on water quality or disturbance to sediment can be expected to undermine the stability of the meadows and potentially lead to catastrophic loss. At this point it is anticipated that events such as elevated chlorophyll *a* levels, elevated nutrient levels causing increased epiphyte loads, increased light attenuation due to turbidity plumes, and changes in hydrology, as might be expected to result from dredging the access channel to the marina, could all trigger a collapse in the remaining seagrass population in Mangles Bay. With sustained environmental impacts on the seagrass ecosystem it is likely that the majority of the seagrass meadow in Mangles Bay will become fragmented and lost, leaving only scattered small clumps of remnant vegetation.

Sediment dynamics of the Mangles Bay seagrass habitat

Cockburn Sound is a relatively sheltered embayment with circulation restricted by the surrounding geomorphology, including Cape Peron, Southern Flats, Garden Island, Woodman Point and Parmelia Bank. This generally results in a wind-driven circulation pattern that varies seasonally; the nature of the circulation in Cockburn Sound means that the sheltered area that includes Mangles Bay experiences reduced flushing. As water flow decreases, finer sediment fractions can drop out of the water column; fine organic material is less dense than most suspended sediment and is more likely to be transported until it reaches areas of deposition, such as Mangles Bay. As a result, this region of Cockburn Sound is a major sink for fine sediments, nutrients and other pollutants sourced from the rest of Cockburn Sound, in particular the industrialised eastern sill.

The fine organic sediments in Mangles Bay form a relatively unstable substrate for seagrass growth and it is likely that this, together with high epiphyte loads caused by relatively high ambient nutrient levels, is responsible for the relatively poor seagrass growth in the area. The loose nature of the sediments in Mangles Bay also presents a risk to the long-term stability of the seagrass meadows in the area; the seagrasses are not well-anchored and are susceptible to mechanical disturbance. Any additional disturbance caused by dredging the access channel may be sufficient to destabilise the seagrass, resulting in a wider zone of influence than currently predicted and ultimately fragmentation of the entire meadow.

The wash from additional boating traffic travelling along the access channel can be expected to compromise the stability of the seagrass meadows abutting the channel. This may result in accelerated erosion of the already unstable seagrass along the channel, leading to a destabilisation of the channel margins. Apart from the higher than anticipated loss of seagrass, this also has implications for the frequency of maintenance dredging, as sediment may slump into the channel.

Seagrass rehabilitation proposal

The EPA has established a policy of no net loss of seagrasses for Cockburn Sound in light of the extensive loss of seagrass over the past 50 years (EPA, 1998). The proponent proposes to

offset the loss of seagrass by a seagrass replanting programme that would combine replanting existing mooring scars in Mangles Bay (up to 3 ha available) with replanting other areas in Cockburn Sound (areas adjacent to the existing Seagrass Research and Rehabilitation Programme transplant site on Southern Flats have been proposed).

Pilot transplantation experiments into mooring scars by the Marine and Freshwater Research Laboratory for Oceanica Consulting (Oceanica, 2012) suggest that survival of these transplants is poor, with less than 50% overall survival after 12 months. The poor results of these pilot experiments has been attributed to poor light conditions due to turbidity, bioturbation and low water flow over the site; these are the same conditions that have compromised the health of the surrounding seagrass meadows in Mangles Bay. Replanting the mooring scars at Mangles Bay is likely to be problematic at best as the transplantation process is stressful to the seagrass and requires good conditions at the recipient site to allow rapid recovery of the transplanted plants. A key principle for successful seagrass rehabilitation is that the underlying problem causing seagrass loss should be removed before transplanting can be considered (Fonseca et al., 1998). In this instance, the natural seagrass meadow in Mangles Bay is in an unhealthy state due to low water quality and poor sediment condition and rehabilitation operations should not be considered until the condition of the recipient site improves. This will require improvements in water quality and sediment stability, both of which are long-term concerns for Mangles Bay. A research programme is required to determine appropriate methods for improving water quality in Mangles Bay, followed by research to examine how the existing seagrass can be stabilised.

The large-scale seagrass rehabilitation programme on Southern Flats has resulted in the transplantation of 3 ha of seagrass over a period of five years; the programme is considered the most successful in Australia, with overall survival of around 70-80% (Verduin et al., 2011). However parts of the Southern Flats site were not able to be successfully replanted for unknown reasons (possibly sediment or nutrient related), despite repeated attempts. Storm damage reduced survival and damaged sections had to be replanted. Transplantation was only successful after extensive experimentation and refinement of techniques over many years.

One of the issues encountered during the transplantation programme was the need to increase the density of transplants from 1 m spacing between transplant units to 0.5 m spacing. This was found to be necessary to achieve target shoot densities within the required timeframe set in the Ministerial Conditions for the project and arises from the need to have adequate shoot densities to achieve a return of ecosystem functionality. Ecosystem functions for seagrass meadows include overall productivity, support for associated organisms and physical factors that include seabed stability and internal support for continued meadow growth and colonisation. Increasing transplant shoot density greatly increases the effort required and will significantly add to the overall cost of the proposed offset programme. Estimates of costs for transplanting seagrass in Western Australia are between $84,000 and $168,000 per hectare, depending on spacing of transplants (Paling et al., 2009).

To be sure of long term success in seagrass transplantation, monitoring is required for an extended period (five years is considered a minimum and ten years would be a more realistic target). The transplanted seagrass appears to be vulnerable to storm damage for a considerable period after planting, presumably due to the lack of a mature rhizosphere that helps to stabilise the entire meadow. The cost quoted by Paling et al. (2009) does not include monitoring costs.

While seagrass rehabilitation of seagrasses to other locations in Cockburn Sound may be an offset option for the proponents, the proposal to revegetate the mooring scars in Mangles Bay is unlikely to be successful. The proposed marina development will effectively reduce the amount of seagrass in Mangles Bay and will bisect the existing meadow, fragmenting the existing habitat. This has implications for the community structure as a whole, with risks of further fragmentation and impacts on foraging activities by larger animals like penguins and dolphins.

Marine Fauna

The marine fauna of the Mangles Bay area face a number of threats as a result of the proposed development. The PER documents and supporting appendices highlight some of these. Of particular concern is the reduction and fragmentation of foraging areas for larger marine fauna, in particular dolphins and penguins.

The proposal will result in the direct removal of almost six hectares of seagrass in an area where seagrass health is already compromised. Removal of this amount of habitat will place pressure on the larger fauna by reducing the amount of foraging area (and presumably the amount of prey). The proposed access channel will bisect the seagrass meadow in Mangles Bay, which is acknowledged to be an important shelter and nursery area for various fish and invertebrate species (McLean, 2012); some of these are key prey organisms of penguins and dolphins (Cannell, 2012). Both these groups feed on the edges of the seagrass meadow and it is likely that fragmentation of this habitat will make foraging more difficult. With increased boat traffic along the new channel there will also be an increased risk of boat strikes on marine fauna trying to feed across the two halves of the seagrass meadow.

In its 1998 statement on environmental management of Cockburn Sound the EPA declared that, while each of several developments proposed for Cockburn Sound at that time (which included the Mangles Bay Marina) was likely to remove only a relatively small amount of seagrass, combined these developments would be responsible for significant seagrass habitat loss (EPA, 1998). This is particularly a problem for larger fauna that travel widely to feed. The loss or fragmentation of feeding areas will be expected to compromise the broader viability of Cockburn Sound for foraging by populations of these marine fauna.

The expected increase in boating traffic through the area will result in increased likelihood of interactions between humans and larger marine fauna. This includes both the risk of accidental boat strikes and direct human-animal interactions (attempted physical contact and feeding). Both forms of interaction clearly put the marine fauna at risk.

Summary and Conclusions

The PER for the Mangles Bay Marine Based Tourism Precinct has a number of flaws and omissions that should be addressed as a matter of urgency. Key issues that require further research and consideration are:

Groundwater impact and Lake Richmond

- Impacts of climate change and sea level rise (combining to reduce groundwater recharge and therefore flow rates and additional salt water intrusion); this requires extensive research;
- Lack of acknowledgement of salt water intrusion impacts on root zones of terrestrial vegetation;
- The projected draw down of the level of Lake Richmond by the combined marina construction and realignment and duplication of the Water Corporation SDOOL has not been adequately acknowledged by the proponents; it is not possible to examine the marina impact without also considering the SDOOL impact as the marina cannot be developed without realignment of the SDOOL;
- Surface drainage implications from the marina have not been addressed; it is anticipated that surface runoff will largely end up in Lake Richmond or Mangles Bay.

Terrestrial Flora and Fauna impact

- Significant risks are attached to clearing existing bushland and revegetating currently cleared areas; substituting existing bushland, even if degraded, with currently cleared land to be revegetated seems an inherently cumbersome approach and likely to produce a poor result;
- There has been no discussion of likely hydrological changes to terrestrial vegetation; in particular, the implications of changes to salt water intrusion into the root zones of trees may have significant impacts on vegetation health and long term viability;
- There has been no discussion of the likely impacts sea level rise on groundwater and salt water intrusion and the impacts on coastal vegetation in the development footprint.

Marine water and sediment quality

- The proponents have underestimated the likely level and impact of sediment resuspension associated with the dredging, land reclamation and breakwater construction aspects of the development;
- Sampling for potential contaminants in the sediments of Mangles Bay was flawed; samples were collected from existing mooring scars within the seagrass meadow, which would be better flushed and therefore likely to contain reduced levels of contaminants than sediments stabilised by seagrass;
- The access channel will be dredged through a seagrass meadow that is already compromised by the presence of high levels of fine organic sediments, potentially destabilising the remaining seagrass and surrounding sediments;
- Additional boat wash associated with increased boating traffic is likely to impact the edges of the access channel, with the risk of further destabilising the fine organic sediments that occur in Mangles Bay; the impacts of boat traffic through a narrow channel through a seagrass meadow are unknown and require further research;

- The low density organic sediments in Mangles Bay are more likely to resuspend after development with increased likelihood of slumping of the edges of the channel; this is likely to be exacerbated with the influx of larger vessels, as expected by the proponents;
- Flushing models predict flushing times of the marina at between 4 and 13 days; this is particularly of concern during warm calm periods and could result in deoxygenation of the water following plankton bloom events;
- Water quality in Mangles Bay is already below target EQS; marinas are acknowledged to increase the likelihood of phytoplankton blooms, contributing to the efflux of contaminated water into the adjacent bay.

Coastal processes

- The shoreline of Mangles Bay is already significantly disturbed, with reduced flushing due to the Garden Island causeway resulting in the health of seagrass being compromised;
- Additional dredging of the access channel will further compromise the seagrass meadow, bisecting it and leading to potential loss of a contiguous seagrass meadow; this in turn could result in accelerated coastal erosion;
- There has been no mention of sea level changes resulting from global climate change; some of the highest rates of sea level rise have been reported from southern Western Australia and the Rockingham region is likely to experience significant impacts from sea level changes in the next two decades.

Benthic Primary Producer Habitat

- The proposal will remove over 5.5 ha of seagrass from the already vulnerable Mangles Bay seagrass meadow; seagrasses in Mangles Bay have consistently shown reduced shoot density and enhanced epiphyte cover compared to other locations in the region;
- High levels of fine organic sediment in the water column settle on the seagrass leaves, resulting in a likely reduction in light available for photosynthesis; the impacts of this level of sedimentation requires further research;
- The proponents are relying on the flawed seagrass shoot density report cards produced by the Cockburn Sound Management Council as a baseline reference for seagrass health estimates; it appears that shoot densities have fallen below 50% of the EQS on occasion and evidence suggests that falling to 25% may trigger a structural collapse of the meadow;
- The proposed access channel will bisect the existing seagrass meadow, compromising productivity, ecosystem functions that include sheltered nursery habitat, foraging grounds for larger marine fauna and sediment stability;
- Other impacts from the marina, including suspended sediments from construction, reduced quality water flowing out of the marina and disturbance from boat traffic are all expected to impact heavily on the already vulnerable seagrass;
- The sediments that have accumulated around the seagrasses in Mangles Bay carry a large proportion of fine organic sediment, making the entire meadow relatively unstable and vulnerable to physical erosion, including the disturbances from dredging and boat wash once the channel is operational;
- Pilot transplantation into the mooring scars in Mangles Bay has been relatively unsuccessful compared to other transplantation exercises in the region; this is likely due to the poor sediment and water quality conditions in Mangles Bay;

- The successful large-scale transplantation programme recently completed on Southern Flats should not be seen as a panacea for offsets in this instance; transplantation into Mangles Bay is likely to have a poor outcome due to existing environmental quality issues;
- Transplantation on Southern Flats has been experimental and techniques have improved over time; best results have been obtained using 0.5 m spacing between transplants, although some areas have remained problematic for transplantation;
- Monitoring of transplanted seagrass should be carried out for a minimum of 5 years and up to 10 years; this is particularly important in large-scale transplants where differences in fine-scale environmental conditions can result in considerable variability on transplantation success;
- Cost estimates for seagrass transplantation at 0.5 m spacing are of the order of $168,000 per hectare (2009 $ values), which does not include monitoring costs.

Marine Fauna

- A number of species of larger marine fauna (dolphins and penguins) are known to forage for food in or around the seagrass meadow in Mangles Bay;
- Fragmentation of the seagrass meadow will reduce the ecological functionality of the meadow, with possible reductions in overall productivity, nursery and shelter functions and sediment stability;
- The loss of seagrass in Mangles Bay will further degrade the value of Cockburn Sound as a sustainable feeding ground for larger marine fauna;
- Associated with the increased boat traffic around the proposed marina is increased risk of vessel strikes on marine fauna and an increased risk of harmful human interactions.

The PER document for the Mangles Bay Marina Based Tourism Precinct has addressed some of the traditional concerns raised for previous development projects in this region; however there is no escaping the fact that Mangles Bay and the Point Peron region represents a vulnerable ecosystem that will be irreversibly changed by any major development of this nature.

The impact of the marina development on the marine environment of Mangles Bay is significant, with risks to the important seagrass habitat in the bay; this will have flow-on effects on larger marine fauna as well as posing a risk to sediment (and so shoreline) stability. The on-shore components of the project will have consequences for the terrestrial environment and wetlands, including inadequately forecast impacts on Lake Richmond. Land clearing and excavation will have major impacts on the terrestrial vegetation, compromising the ecological value of the remaining coastal vegetation in this area.

It is disappointing that the proponents have not addressed any aspect of global climate change, in particular sea level rise, that has been widely forecast to occur within the next 20-30 years. The southwest of Western Australia is particularly vulnerable to predicted sea level rises; the sedimentary coastline makes it very susceptible to coastal erosion measured and sea level rises over the past 20 years have been higher here than in most other parts of Australia. Sea level rise is likely to have a major environmental impact on most aspects of the proposed development, including marine habitats and coastal stability, terrestrial environments and groundwater quality and Lake Richmond. When several government agencies have expressed serious concerns about the imminent impacts of sea level rise within a few years, it is very

disturbing that the proponents of such a significant coastal development have not acknowledged it, let alone planned for its impacts.

The Mangles Bay and Point Peron region is already highly disturbed and vulnerable to further impacts from development; the Mangles Bay Marina Based Tourism Precinct presents a significant risk to both marine and terrestrial environments. Mangles Bay is not suitable for a development of this nature, given the nature and extent of the environmental problems that would accompany it.

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