IN PURSUIT OF A SUSTAINABLE FUTURE FOR OUR ECONOMY

WESTERN HARBOURS ALLIANCE

BUILDING RESILIENCE AND UNDERTAKING RESTORATION – COCKBURN SOUND

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PROPOSAL TO ESTABLISH A MARINE CENTRE RESPONSIBLE FOR ENHANCING THE ENVIRONMENT OF THE COCKBURN SOUND

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PROPOSAL TO ESTABLISH A MARINE CENTRE RESPONSIBLE FOR ENHANCING THE ENVIRONMENT OF COCKBURN SOUND

This paper is about enhancing the environment of Cockburn Sound. It sets out a pathway to sustainability through restoring resilience in the Sound in the face of increased challenges and a changing climate.

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Supported by the Western Harbours Alliance Inc.

> ***"Ongoing protection of Cockburn Sound is an important priority for the Western Australian Government to ensure that it continues to support the multiple values for which it is renowned. The purpose of this updated Policy is to ensure that the future of the Sound is secure." – State Environmental (Cockburn Sound) Policy 2015***

1. PURPOSE

The aim of this proposal is to provide a case for the need and means to strengthen the natural environment of Cockburn Sound, given its history of development and loss of major components of its natural environment, particularly its seagrass. It recognises that over the last 65 years Cockburn Sound has lost significant environmental resilience and has been struggling to cope with adverse environmental changes and development impacts. This has resulted in challenges to maintaining the marine environment, its natural health and regeneration processes, and its capacity to support a range of human uses. Future large-scale developments in the Sound are proposed and rather than add to the burden of sustainability, there is an opportunity to bring new and continuing funding for the Sound's restoration and future health.

Only substantial and well-targeted investment in Cockburn Sound's environment will minimise community concern and outrage over further environmental impacts that future developments will have on this popular and economically important marine embayment of metropolitan Perth.

It is argued that a restoration centre should be established to manage a large-scale restoration initiative with supporting partners and consistent scaled funding. The restoration strategies, lessons learned and techniques developed with this initiative could then be applied to other impacted WA marine and coastal environments. This would lead the way for a model to help repair and rejuvenate other systems in WA and Australia.

2. BACKGROUND

Between the 1960s and 1980s Cockburn Sound lost 78% of its temperate seagrasses, approximately 4000ha originally, reduced to approximately 900 ha today. This was due to excessive nutrient enrichment (primarily nitrogen) from industrial discharges and, to a certain extent, reduced water circulation created by the completion in the mid-1970s of the causeway linking Garden Island to the mainland at Point Peron.[1]

Industry has drastically reduced nitrogen containing nutrient inputs from annual levels of several thousand tonnes to well below 250 tonnes today and has substantially reduced other contaminants.[2] While water quality has significantly improved from its nadir in the late 1970s, unfortunately seagrass extent has not recovered in any equal measure: at several monitoring sites from the annual Cockburn Sound Management Council monitoring program seagrass has declined and there has been only light regrowth in a small number of shallow areas (<10 m deep), although small areas of regrowth seems to be occurring on the eastern shelf.

In recent times, fish kill incidences have occurred (e.g. snapper and squid) and occasional blooms of micro-algae or phytoplankton have also occurred during some summer and autumn seasons. One such bloom in November/December 2015 is believed to have contributed to a large snapper fish kill incident.[3] Declines in water-dissolved oxygen have also been recorded in the various deep-water regions of the Sound. Seagrasses vital to the health of the marine environment remain under extreme threat. The recent Drivers-Pressures-State-Impacts-Responses Assessment Report in 2017 and released in 2018[4] described the state of the marine environment and its various habitats and estimated how they had changed since European settlement and more recent eutrophication during the 1960s and 70s. In almost all respects there were greater losses in habitat extent, faunal composition and function than gains. It concluded that there is limited understanding of the ecological resilience of the Sound's marine environment following the loss of seagrass and the wholesale transfer of primary productivity to the water column. However, this report while extremely timely and informative, based much of its information on modelling, biological data and environmental surveys undertaken mainly before 2010, most were more than 10 years ago. While insightful, more contemporary spatial and temporal information is necessary to confidently report on the status of the various components of Cockburn Sound's marine environment.

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1 2008, 2009, 2010, 2011, 2012. *State of Cockburn Sound. Reports 2009-2012*. Cockburn Sound Management Council, Department of Environment Conservation.

2016. Keesing, J.K., Greenwood, J., Donn, M.J. and McFarlane, D.J. *Spatial and temporal analysis of water quality monitoring data collected from Cockburn Sound and Warnbro Sound between 1982/83 and 2013/14.* Report to the Cockburn Sound Management Council and the Western Australian Department of Water. CSIRO, Australia.

2 2013. *Cockburn Sound Contaminant Review Final Report.* Report by GHD for the Cockburn Sound Management Council and Department of Environment and Conservation – Environmental Regulation Division.

2016. Greenwood, J., Keesing, J.K., Donn, M.J. and McFarlane, D.J. *Nitrogen budget for Cockburn Sound, Western Australia.* Report to the Cockburn Sound Management Council and the Western Australian Department of Water. CSIRO, Australia

3 2016. *Summary of Cockburn Sound Monitoring and Research Programs 2016*. Cockburn Sound Management Council, Department of Environment Regulation.

2016. *2015-2016 Cockburn Sound Report Card*. Cockburn Sound Management Council, Department of Environment Conservation.

4 2018. *Cockburn Sound Drivers-Pressures-State-Impacts-Responses Assessment 2017*. Final Report. Prepared by BMT Western Australia Pty Ltd, July 2018, Report No. 1362_001/Rev1. Prepared for Department of Water and Environmental Regulation, the Kwinana Industries Council, the City of Rockingham and the City of Kwinana on behalf of the Cockburn Sound Management Council.

Despite this history, amateur fishing, boating and other recreational pursuits, commercial shipping and industrial activities have increased substantially, making Cockburn Sound the most intensively used marine embayment in Western Australia:

- It is Western Australia's second largest spawning ground for pink snapper, after Shark Bay;
- It continues as a popular tourist destination with its long beaches and safe swimming, particularly in the southern Sound;
- The adjoining Kwinana Industrial Area and Australian Marine Complex in Henderson have grown to become one of Australia's largest industrial and boat building-service areas;[5]
- The Garden Island Stirling Naval Base is Western Australia's largest naval facility and is planning on expanding its operations;
- It is estimated that commercial shipping has increased to near 1000 large vessel movements a year and recreational boating has increased to well over 100,000 boat movements a year;
- Recreational fishing pressure on snapper, crabs and other fish and decapod species including squid is intense, and while seasonal, is generally consistent throughout much of the year;
- Dolphin, and to a lesser extent little penguin, seabird and sea mammal based eco-tourism is growing where up to 180 dolphins and approximately 300-400 little penguins reside in Cockburn Sound at Garden Island. Many penguins from Penguin Island in the adjacent Shoalwater Bay also feed and forage in the southern Sound;[6]
- More recently, the surrounding urban population in the catchment of Cockburn Sound has grown to over 300,000 people and is still growing, further increasing the demands of public access and use.

Cockburn Sound is a large, complex and often competing multiple-use environment with a range of interest groups concerned for its environment and natural resources. Furthermore, climate change is a mega-trend factor that is exerting influence on the Cockburn Sound marine environment, its temperate seagrasses and biota, through warmer sea temperatures, increased storminess and coastal erosion.[7]

The risks for the sustainable health of the Sound created by these multiple uses and pressures must become central to all aspects of planning for its future.

3. A CASE FOR INVESTING IN COCKBURN SOUND'S ENVIRONMENT

Any new additional developments, such as a large industrial port, increased industrial and military development, marinas, increased boating, moorings and fishing will further stress and threaten Cockburn

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[5] 2013. *Western Trade Coast – Integrated Assessment: Environmental, Social and Economic Impact*. Report prepared by Sinclair Knight Mercz and the Resource Economics Unit commissioned by the Western Trade Coast Industries Committee. Available on www.kic.org.au/library/

[6] 2007. *Shoalwater Islands Marine Park Management Plan 2007–2017*. *Management Plan No 58*. Department of Environment and Conservation and Marine Parks and Reserves Authority.

Belinda Cannell – pers comm. Penguin numbers

2017. Chabanne, D., Finn, H. and Bejder, L. *Identifying the Relevant and Local Population for Environmental Impact Assessments of Mobile Marine Fauna*. Frontiers in Marine Science, Vol 4, Article148, pp1-17.

2007. State of Cockburn Sound Report. Cockburn Sound Management Council, Department of Environment Conservation.

[7] 2013. *Coastal Vulnerability Study – Erosion and Inundation Hazard Assessment report*. A report prepared for the Cockburn Sound Coastal Alliance by Coastal Zone Management, Damara, University of Western Australia and Oceanica.

Sound's environmental health. They will also jeopardise the current balance of intensive multiple uses and free provision by Cockburn Sound's natural environment of a range of benefits, partially those listed earlier.

It is important though to emphasise that some threats must be balanced with the economic benefits they can bring to the region and to the Western Australian economy. For example, economic and employment benefits can be created or maintained by having a large industrial port supporting an integrated industrial supply chain. Future industries with potential location in the Kwinana Industrial Area must also be considered, e.g. the recent growth in lithium process manufacturing.

Increased boating, fishing, commercial shipping and a new large industrial port facility will require innovative environmental enhancements and management. These developments, particularly any large industrial outer port facility, will require adequate and proportional resourcing to counterbalance impacts. Failure to provide this resourcing will be viewed as not only a failure of government to recognise the importance of the environment and sustainability in Cockburn Sound, but also a failure to provide innovative enhancements and management with adequate funding, and could penalise government, industry and the economy for years to come. A broken Cockburn Sound will be a poor economic, recreational and environmental resource.

Any future large-scale development will encounter a vocal and potentially divisive and acrimonious opposition unless significant environmental issues, recreational access and fishing pressures are addressed and well managed. Thus, if Cockburn Sound can be made more resilient and productive by returning the system significantly closer to its original healthy state with more ecological linkages and processes, it would be better able to withstand development proposals such as a larger industrial port. It would also lessen other threatening marina developments, recreational use and the impacts caused by the wide range of current multiple-use demands on its environment. Importantly, Cockburn Sound would be in a better state to withstand long-term climate change impacts such as sustained erosive storms, rising sea levels and warming ocean temperatures.

For this resilience to occur, Cockburn Sound will need realistic and measurable "improvement" and restoration, i.e. improved environmental health, such that positive environmental gains are produced over and above just replacement or minimisation of environmental impacts with existing and proposed harbour and marina development proposals.

New developments integrated into the State's economy offer an opportunity to create a financially sustainable basis to initiate and maintain a restoration program to improve and enhance Cockburn Sound's environment.

Thinking strategically, other developments approached in the same manner throughout the State could also utilise this restoration program, once it has shown its capability in restoration and cost effectiveness. This could be applied and extended into those regional environments that also need restoration and enhancement because of human development impacts or extreme environmental perturbation (e.g. Peel-Harvey estuarine system, Shark Bay seagrasses, and possibly Albany Harbours, Leschenault Inlet and the Swan-Canning estuarine system, Port Hedland port and channel areas).

3.1. CURRENT ENVIRONMENTAL PROTECTION, ASSESSMENT AND MANAGEMENT OF ENVIRONMENTAL IMPACTS

While many may disagree, and some recognise imperfections, it can be argued that the current process of assessing environmental impacts of development proposals under Western Australian environmental legislation is balanced and results in a robust assessment process with reasonable environmental management of construction and operational impacts. Under Part IV of the Western Australian *Environmental Protection Act* (1986) (EP Act 1986), the environmental impact assessment process is applied to proposals or acts that are deemed to have a significant impact on the environment. Those that can be satisfactorily managed often result in a Ministerial approval and generate a Ministerial Statement with environmental conditions and/or have proponent environmental commitments. It can also be argued that environmental regulations applied to premises that qualify under the *Environmental Regulations* (1987) of the EP Act 1986 and later Acts, regulations and amendments, provide a licensed basis to manage environmental impacts of "discharges or release" to the environment. In general, this process and regulatory control has worked in many situations. While industry may argue that this "green tape" assessment and regulatory process is onerous and business unfriendly, conservationists and other segments of the Western Australian public feel that too many proposals have been approved with weak or inappropriate conditions or have weak regulatory controls.

There is a strong and substantiated view that environmental impact management ***after*** the environmental assessment process has occurred, has resulted in poor environmental outcomes for the already impacted marine embayment of Cockburn Sound and other areas of WA. Impacts in Cockburn Sound since the 1980s have generally been minimised, but the original impacts during the 50s, 60s and 70s have still removed components or substantially compromised the marine environment, e.g. loss of seagrass, deep benthos and altered fisheries.

3.2. ENVIRONMENTAL OFFSETS AND MITIGATION

Environmental offsets have been poorly applied in WA and as a result have had poor results for Cockburn Sound. For example, approval of the Perth Seawater Desalination Plant required the Water Corporation to establish a large tree plantation to help offset the carbon footprint of this critically important water infrastructure facility. This offset was established in regional WA and not in or near Cockburn Sound where it could directly help the Sound's environment. While the current Cockburn Sound Management Council had an environmental offsets policy *Like-for-like, local and improve* - it has not been applied or communicated widely and was intended to only be relevant when impacts have occurred to the system or cannot be avoided (approved by the CSMC in 2010). The WA State has an offsets policy finalised in 2011 and implementation guidelines (2014) however their status applied to marine environments is unknown.

Regardless of the views held on environmental management or impact assessment, Cockburn Sound has experienced a consistent history of environmental loss and not restoration. Environmental management and impact assessment have not enhanced its environment.

3.3. CURRENT INSTITUTIONS AND CAPABILITY

There is substantial expertise in Western Australia currently investigating aspects of marine and coastal restoration, particularly in seagrass and fisheries (i.e. through aquaculture and fish culture), and investigating the current state of many marine habitats. This expertise is located in most WA universities and regional CSIRO and AIMS. Furthermore, WA has the Marine Science Institute (WAMSI), which has

completed its 3rd generation of Study Nodes and is starting its fourth, with most recent nodes addressing aspects of the impacts of dredging and further refinement of coastal habitat mapping.

Many of WA's universities have programs or centres dedicated to the study of marine and coastal ecosystems, but one can argue that our ability to restore terrestrial vegetation, particularly around mine sites or farmlands, is more advanced than that for most aspects of marine and coastal ecosystems. The only exceptions may be for temperate seagrasses, certain fish species and invertebrates and possibly artificial fish attraction habitat devices or structures. Seagrass restoration has yet to be practised on a large scale; most experimental areas are between 10 m^2 and two to three hectares (e.g. Seagrass Research and Rehabilitation Program 2003-09, and possibly Princess Royal Harbour informal efforts up to 3.1 ha). Almost all experimental plots were rarely monitored consistently for long periods of time, something which is required to provide critical longitudinal information.

If marine restoration efforts were adequately and sustainably resourced, integrated and structured to focus on restoring critical components of coastal marine ecosystems and methods, and techniques were applied over longer temporal and larger spatial scales, then meaningful restoration of many of our coastal and marine ecosystems could occur. It could also be argued that organisations with expertise to undertake restoration employ a kind of destructive and overly competitive approach to applying for funding from existing inadequate and diminishing national and State funding sources. If adequate resources were available, there could be a more integrated focus on working for the common good – effective long-term restoration of important ecosystems.

4. BUSINESS CASE FOR A COCKBURN SOUND MARINE CENTRE

The Sound and its catchment are estimated to cover over 350 km^2 (Cockburn Sound 190 km^2) with a growing population of over 300,000 people. It is estimated that activities and work on the Western Trade Coast that include the Kwinana Industrial Area, the Australian Marine Complex in Henderson, Rockingham Industrial Area and the Stirling Naval Base on Garden Island generate $10 billion annually to the Australian economy and employ well over 18,000 (up to 30,000) people in direct and indirect jobs.[8] Aside from industrial, commercial and defence work, recreation (particularly fishing and boating), tourism, aquaculture and coastal real estate activity also generate substantial income for the economy.

The future of this Western Trade Coast economy should not be undermined by a failing environment and the loss of social capital to support future prospects for the area. Investment in the resilience of Cockburn Sound at this point will demonstrate the values of sustainable collaborative efforts.

Large scale port and industrial development on the Western Trade Coast offers an opportunity to establish a restoration program of significant scale to provide consistent funding for critical research and adequately scaled field restoration in Cockburn Sound.

Some short-term restoration efforts have been undertaken in the past by industry and government, such as the Seagrass Research and Rehabilitation Program (SRRP) by Cockburn Cement and Department of Industry and Resources that became Department of State Development. This was conducted between 2003 and 2009 and resulted in 2.1 to 3.1 ha of seagrass meadows reputedly being created or restored in both Cockburn Sound (Southern Flats) and Albany Harbours. Pink snapper has also been cultured, farmed and released into Cockburn Sound for several years by Fremantle-Challenger TAFE with community and RecFishWest support, but this effort has not been supported by complementary research to indicate if it enhanced the existing snapper stocks and whether food resources were adequate to support increased

[8] 2018 *Trade Flow and the Development of Westport*. Report prepared by InfraNomics commissioned by the Kwinana Industries Council. Available on https://www.westernharboursalliance.com/wp-content/uploads/2018/04/InfraNomics-Report-1-FINAL.pdf

young and feeding snapper. However, this fish stocking stopped several years go. To improve chances of success, efforts for seagrass and fish restoration will need to be reviewed and lessons applied to new restoration efforts.

4.1. FINANCIAL RESOURCES

Finances for this initiative could come from future industrial, defence, recreational and possibly residential developments in and around Cockburn Sound. Initial start-up State funding could be used to begin work with future large-scale funding coming from these developments. In this manner, a consistent and large enough restoration fund would be established. There are Commonwealth funding opportunities, but at present these are extremely difficult to access and initially unlikely to be enough for the establishment of a marine centre. Sustained restoration in the Sound can occur once substantial partners and secure long-term funding linkages are obtained.

There are several ways to describe the scale of funding needed to effectively restore major components of Cockburn Sound's environment. For example, an initial funding of approximately $20-30 million over the first five years would start restoration investment and activity in the Sound; then as Industry expanded, and in this case with a large-scale port, industrial processing and manufacturing trains (e.g. lithium and other metals, specialised plastics or products), a levy of 50^{C} to a dollar or two could be applied to tonnages, volumes or units that move into and out of the area. For example, a levy of $1-2 dollars on containers or tonnes, depending on total annual turnover would generate substantial finances to undertake the assessment, research and fieldwork required for a restoration program. In turn this fund and research effort would attract extra federal and industry funding to synergise effort and add to the knowledge and success of the program. This method of funding would need to be carefully calibrated to not remove economic incentive or build barriers to development but must also be adequate to fund a meaningful appropriately scaled restoration program.

To initiate such a program, budgetary priorities would need to elevate the program to a State priority. Future dividends to the State could be large if this program is given a chance to apply restoration at an appropriate scale, gain knowledge and have technical capacity for future restoration in other impacted systems. This would allow a unique, progressive and sustainable solution to the impact of many future large-scale developments in WA and Australia.

Care would need to be exercised if this involves drawing on funds generated by regulatory licenses imposed on large industrial enterprises. Many of these are maintained by industry as "insurance" in case of unexpected failures or emergency situations. Several Cockburn Sound industries now operate with little current impact on the receiving environment based on the legal definition for some of the requirements to have regulated and licensed premises under the EP Act's *Regulations* (1987). In sum though, this source of funding would be inadequate and possibly face strong industry resistance.

4.2. MANAGEMENT STRUCTURE

Western Australia is fortunate that there are several government agencies and research institutions capable of contributing substantial management and expertise support. However, all government agencies lack financial capacity and expertise necessary for an integrated restoration program, and/or do not have legislative responsibilities for large-scale integrated environmental restoration. Many universities have excellent expertise for aspects or elements of a restoration program but are confined by financial constraints and competitive grant mind-sets.

A management structure would need to bring together all the knowledge assets currently available and direct the work towards the sustainable outcomes required. Iterative stages could involve the utilisation of the WA Marine Science Institute (WAMSI) to help set up a restoration centre.

Substantial initial work is required to review and assess current data, integrate understanding and conclusions and to generate recommendations focussing on the restoration program. These recommendations would need to provide a priority ranking of effort to enable work to begin in a short-time frame while also helping to structure and direct medium and long-term efforts into fieldwork and relevant applied research. This review would need to encompass the findings and fill in critical gaps in knowledge from recent CSIRO and UWA reviews conducted for the Cockburn Sound Management Council between 2015 and 2018. For example, environmental monitoring has been rarely undertaken between autumn and spring and thus there is a lack of knowledge on how the Cockburn Sound environment changes during these three seasons. Analysing and interpreting this gap in information may help to better understand how restoration efforts will fare during these more variable, wet, energetic and cooler seasons.

It is proposed that WAMSI be utilised to create a node to study Cockburn Sound, fill in critical gaps in environmental information and recommend prioritised strategies and directions to direct a new restoration institute or centre. It could also recommend a structure for the operation of a restoration institute. While the WAMSI node is working, a new restoration institute would be created with interim priorities, to determine timing for field restoration to begin. This is based on the opinion that seagrass restoration will be a major priority and activity. We are fortunate to have advanced local knowledge with current research on the critical suite of seagrass species that create an important "keystone" habitat in the Sound.

Seagrass restoration will take time, but it is essential to re-establish areas of seagrass meadows because they contribute to critical ecosystem processes that will affect other restoration efforts as well as the whole ecology of the Sound.

4.3. ACCOUNTABILITY

While WAMSI may be currently reviewing its future, it has a history of undertaking marine research and communicating improved knowledge about WA marine processes, habitat mapping, regional ecosystems and human impacts. It would be possible that, following its initial work reviewing gaps in knowledge on Cockburn Sound, WAMSI could provide key recommendations that would eventually structure and direct a recipient restoration institute. The concept of a restoration institute or centre is really one of a management facility to coordinate and fund various universities and Commonwealth institutions such as CSIRO and AIMS, if they had the restoration capacity to deliver effective progress to restoring Cockburn Sound. It is envisioned that to streamline research, minimise competition and repetition of effort, the institute would coordinate and fund restoration groups to deliver key restoration programs under strict deliverables and timelines. If unable to meet deliverables, they would be required to outline focussed research requirements to address deficiencies in capacity that need to be overcome.

This institute would strive to be efficient and strategic about deliverables and results so that funding was not wasted and timely results were achieved. It is appreciated that universities generally have space, laboratories and students, and professorial technical expertise, but it is argued that they lack funding to undertake the scale and longevity of study and field work that only long-term funding can address. The institute would operate with very strict terms of reference which could be reviewed on a regular basis.

To assist in directing investment, a formula provided in an article in *Decision Point* (No 29, pp7-10) could be used as a basis for allocating the funding for identified activities:

$$E = \frac{W \times B \times S}{C}$$

Where **E**=benefits/dollar
W=values
B=benefits
S=success
C=costs
All values are between .1 and 1

5. LIKELY DIRECTIONS OF INITIAL INVESTMENT IN RESTORATION

Review and initial environmental monitoring – In order to systematically address ecosystem resilience in Cockburn Sound, let alone improve it, the system must be described in its current state. This would need to be more than just monitoring water quality for 3-4 months of the year as is done now, once a week, during the day in summer and the first two weeks of autumn, with limited sediment and phytoplankton-bacteria sampling during this period. Current monitoring is done to address the State Environmental Policy for Cockburn Sound established by WA government in 2005 (13-14 years ago) and more recently updated in 2015. It is a compliance program to inform and track policy rather than a descriptive and quantitative characterisation of the ecosystem which would be necessary for a restoration program. The monitoring necessary to baseline and characterise water quality and other environmental parameters including animal and plant biota would need to cover Cockburn Sound's full range of environmental conditions, biophysical and geochemical processes, ecology, habitats, standing crops of fauna and the inputs and outputs over a minimum of three years including day-night differences if relevant and in all seasons of those years. This would provide a baseline characterising the system and indicate where/when restoration would most likely succeed and where there were critical gaps in knowledge that would help restoration. Once this and a review of all monitoring and assessment data was made, a five-year program could lead initial restoration efforts and could be reviewed continuously every three to five years or on an as-needs basis.

5.1. INITIAL EFFORT

Because of the critical baseline importance of seagrass to this warm temperate water marine embayment, initial restoration work would likely be directed to seagrass restoration. It is probable this would be through continuous or seasonal wide-scale seeding or transplants into favourable areas deemed most likely to be successfully re-established. More efficient and possibly modified methods could be applied later to more energetic areas and deeper regions (>8-10 m depths) of Cockburn Sound. Simultaneously, work could also begin on re-seeding and establishing invertebrate populations necessary for fish and other consumer populations while techniques were refined to culture a wider range of fish and invertebrate species if they were found to be important to re-establishing environmental health in the Sound.

The previous initial efforts mentioned are notional because it is anticipated that the WAMSI review and directives, recommendations and strategies would inform and direct initial and then later restoration efforts. Costs that have been outlined in Appendix One are based on experience and estimates would need to be refined for a five-year program until sustained funding from industrial port use was established and underway.

6. CONCLUSION

Cockburn Sound has lost substantial components of its natural environment with over 78% of its seagrass and much of its benthic community gone, mainly in its deeper areas. This has been due to nutrient enrichment, reduced water circulation from the Garden Island causeway and substantial multiple use

pressures created by industrial, military, recreational and human population pressures surrounding the Sound in southern metropolitan Perth.

> **The Cockburn Sound is an environment much-loved by the community who utilise the area for recreation especially fishing and tourism, as well as an important economic area for industry and defence. The community will expect that everything possible will be done to protect the viability of the Sound into the future.**

Current and future developments for Cockburn Sound, particularly large-scale industrial developments such as a commercial port provide an excellent opportunity to restore and enhance Cockburn Sound's environmental resilience. The funding for such an initiative could be embedded into business cases for these developments. A simple but adequate levy or tax on quantums of material or product which are exported from the Sound could be used to provide base funding and become an element of doing business in Cockburn Sound and its surrounding environs. Initial start-up funds combined with sustained levies on industrial and export activity would provide a long-term source of funding. This would enable a restoration initiative to be undertaken on a large enough scale and duration to substantially improve Cockburn Sound's marine environment.

It is proposed that a strategy to undertake restoration on a large scale in Cockburn Sound would be to establish an institute to coordinate various initiatives for seagrass, nekton and fish, other invertebrates and habitat restoration. The Institute could be possibly managed by a directorate and/or steering committee structure. This structure would follow through on a focussed assessment and set of recommendations made possible by a WAMSI science node that would assess data, advise and help structure and lead restoration efforts.

An investment cost of approximately $25 million over five years would be needed to begin a large-scale restoration program in Cockburn Sound. Failure to re-invest in Cockburn Sound's environment will meet a vociferous and outspoken community backlash that will make future developments extremely difficult in the Cockburn Sound region, let alone a large industrial port, as well as question the sustainability for these developments and future regional economic activity.

The additional benefit of this proposal is that it could be repeated in other related programs, not only would it provide long-term environmental benefits but would also demonstrate that adherence to sustainability principles provides a social licence for future economic pursuits in the State of Western Australia.

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APPENDIX ONE – ESTIMATED COSTS

Table 1. Estimated costs over five years (State investment could be smaller if a funding stream is recognised early in establishment of a restoration program and possible management institute with better detailed costings obtained from specialists). Bracketed numbers have not been included in estimates, they are dependent on external or deferred costing factors.

Actions	Estimated costs over five years $	Comments and Investment
1. Habitat restoration		
Seagrass restoration	5 million	WA has world class scientists specialising in seagrass with UWA, Murdoch University and Edith Cowan having complementary expertise. Seagrass habitat is the foundation to Cockburn Sound's ecology and critical to re-establish. Adequate funding is required to undertake reseeding, replanting and culturing on a large and long enough scale (e.g. 100s of ha's over 10-20 years). Ensuring adequate genetic diversity to handle climate change, increasing temperatures and diseases will be challenging.
Rocky hard substrates	0.5 million	Faviids (brain) corals and some kelps dominate several rocky exposed substrates along the western edge of the

		Kwinana shelf and northern Garden Island. There are expected to be some losses from port developments.
Fish attraction devices (FADs) and habitats	2.5 million	FADs will be necessary to help attract local fish, provide extra habitat, allow juveniles to grow and compensate for growing fishing pressure on local fish stocks.
2. Invertebrate farming-culturing		
Crabs	0.2 million	Culturing the common blue manna will be dependent on review and assessment of data and necessity.
Mussels	1.5 million	Currently only one commercial enterprise grows mussels located near the CBH grain terminal. Historically wild mussel beds existed in numerous areas in waters less than 10 m before poor water quality is reputed to have decimated them in the 1960s and 70s.
Worms, clams, snails	0.75 million	It may be necessary to enhance existing deep and shallow benthic standing crops to improve diversity, abundance or function in terms of their role in water filtration, nutrient cycling and food availability for fish and other predators.
Echinoderms	0.75 million	A rich echinoderm community reputedly dominated the deep benthos and provides important food items for fish.
Corals	(1 million)	Culturing local corals may be difficult. Assessment and restoration priorities will determine the degree of priority for restoring this taxon (there are reputedly over 23 coral outcrops in Cockburn Sound).
3. Fish farming		
Snapper	3.5 million	Pink snapper is the mainstay of recreational fishing in the Sound and after assessment may need to be cultured and farmed on a larger scale than in the past, i.e. >5000 fish a year. Ensuring genetic diversity and disease resistance in breeding stock and that food availability is adequate in the Sound will be necessary.
Garfish, herring, salmon, tailor, dhu fish	2 million	These recreational fish species are also popular, and culturing and farming techniques may need to be investigated or refined.
Scaly mackerel, atherinids-hardy heads, forage fish	1.5 million	These fish are important food for recreational fish stocks but also to piscivorous birds such as local little penguins and terns.
4. Hydrodynamic adjustments		
Garden Island causeway openings	(500-750 million)	The causeway was estimated to have reduced water circulation in the southern Sound by over 40% when it was completed in the early 1970s, exacerbating poor water quality for that region. An engineering review is required but, if feasible and adequate, large pipes under the existing roadway may help improve flushing, water exchange and water quality and be less expensive than building extensions onto the current bridge span on the causeway. Recent workshop has indicated marginal improvements to water quality if another span constructed.
5. Coastal access/erosion control/revegetation	(8-10 million)	Dependent upon need and external funding. There are many existing grant sources for this terrestrial issue.
6. Education and awareness campaigns	1.5 million	A cross-media, social and educational program to raise awareness and inform community of progress will be essential to foster awareness and sustainability for using

		Cockburn Sound's natural resources.
7. Baseline surveys to establish current state of environment		
Benthos – standing crop	0.4 million	Critical – a source of food for animals and nutrient re-cycling. Aside from macro benthos, studies would also need to be made of the (bottom sediment) microphytobenthos, microbial ecology and meiofauna to ensure their role is fully appreciated and assessed for their importance in restoration efforts.
Zooplankton – standing crop	0.4 million	Critical for transport and dissemination of eggs, larvae, juveniles, food items and effects on water quality.
Nekton and fish including establishing diets and cropping rates	1.5 million	The fish community and large decapods and other nekton are critical consumers and are targets for recreational fishing, also important for structuring the natural marine community.
Seagrass mapping and comparison	0.8 million	Developing the best descriptive maps and methods to validate map accuracy, and reviewing and updating mapping on a regular basis will be necessary.
Monitoring and data review	1.2 million	The whole suite of environmental data on Cockburn Sound – historical, current and wide-ranging environmental data will require robust, scientific and innovative review techniques that will underpin assessments and directions for restoration.
Assessment and development of database management system (DBMS)	0.35 million	A capable fit-for-purpose DBMS will be essential to store data, provide interpretative outputs and be a repository for the institute and may need to have inter-operability with other databases systems.
8. Development of decision support tools	0.4 million	Undertaking an interacting process with the community and stakeholders to establish contemporary environmental values, constraints, opportunities and priorities would help underpin assessments and recommendations for restoration and assess new developments. This would need to be captured and integrated into a weighted decision support system to help assist management of the Sound and direct restoration efforts. Such decision support models must have a contemporary high-resolution ecosystem model to underpin decision making.
9. Office – staff (5-6 staff?)	0.65 million	A resource office with management staff to service a restoration institute, steering committee entity and be a focal point for restoration management and reporting will be required. Implementation, financial and contract management and communication strategies in context of restoration will be critical.
TOTAL	**$25.4 million**	**Funds for first five years** (excluding corals, causeway & coastal erosion costs)

*** Urban drainage improvements may be needed with more gross pollutant traps and sediment detention basins, maybe small artificial wetlands to help clean up surface water outflows. Many will be small-scale designs and most large drains in the region already have some of these features.**