Report

ME03 Evaluation of Peel-Harvey Water Quality Recovery Program (WQ01)

17 NOVEMBER2009

Prepared for

South West Catchments Council

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Bunbury Delivery Centre
Bunbury WA 6231

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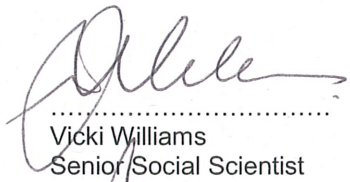

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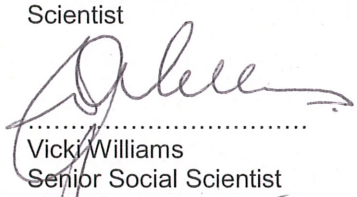

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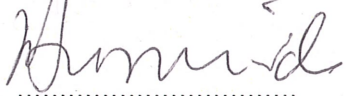

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Abbreviations

Abbreviation	Description
BMP	Best Management Practice
CCI	Coastal Catchments Initiative
DAFWA	Department of Agriculture and Food Western Australia
DEC	Department of Environment and Conservation
DOW	Department of Water
DPI	Department for Planning and Infrastructure
DSS	Decision Support System
EPA	Environmental Protection Authority
EQO	Environmental Quality Objective
EPP	Environmental Protection Policy
ERA	Economic Regulation Authority
LASCAM	Large Scale Catchment Model
N	Nitrogen
P	Phosphorous
PHCC	Peel-Harvey Catchments Council
SQUARE	Streamflow Quality Affecting Rivers and Estuaries Model
SWCC	South West Catchments Council
TN	Total Nitrogen
TP	Total Phosphorous
WAPC	Western Australian Planning Commission
WQIP	Water Quality Improvement Plan
WSD	Water Sensitive Design
WSUD	Water Sensitive Urban Design

Executive Summary

This report presents the findings from an evaluation on the effectiveness and impact, efficiency, appropriateness and legacy of the **Peel-Harvey Catchment Council's (PHCC) Water Quality Recovery Program** funded through the South West Catchments Council's (SWCC) allocation of National Action Plan for Salinity (NAP) and National Heritage Trust (NHT) Commonwealth and State funding in the South West region of WA.

Background

Water quality in the Peel-Harvey Catchment has been of concern to scientists and others since a decline was noticed in the 1950s. Studies have been undertaken into the eutrophication of the estuary, catchment phosphorus sources, nutrient point sources, water quality monitoring and modelling of future water quality scenarios. To a large extent it has been these technical studies that have driven the approaches taken to resolve the deterioration of the Peel-Harvey water quality.

The approach taken to this evaluation has been influenced by this long history of investigation and intervention in the Peel-Harvey region.

The publication of the *Water Quality Improvement Plan for the Rivers and Estuary of the Peel-Harvey System - Phosphorous Management* in November 2008 (WQIP-P) offered a more holistic approach to dealing, at least, with phosphorous levels in the Peel-Harvey system. It has provided a raft of management measures and control actions aimed at reducing phosphorous inputs. The key components are primarily directed towards improved land and water management practices rather than technical solutions (e.g. the Dawesville Channel).

During the course of the evaluation it became evident that the success of this group of projects hinged on the adoption of an integrated and holistic approach in keeping with the approach taken to the WQIP-P.

A conceptual model for analysis

Rebekah Brown and Jodi Clark (2007) from Monash University's National Urban Water Governance Program have provided a useful model for understanding the "key institutional change ingredients" for mainstreaming water sensitive urban design. While Brown and Clark's focus was on water sensitive urban design in Melbourne, the framework they have developed provides a useful structure for other water management attempts including that undertaken in the Peel-Harvey.

In their study, Brown and Clarke (2007) drew from transition theory to show the shifts that have occurred in respect of Melbourne urban stormwater quality management. Their research identified a "range of interconnected activities and initiatives" and a critical "*interplay* between industry champions and important context variables that has provided the structure and catalyst for the transition". They argue that it is the "enabling context that has shaped, constrained and provided opportunities" for the industry champions to push for the changes that have occurred (p. iv, emphasis in original).

The eight key components comprising the 'enabling context' described by Brown and Clarke are as follows:

Socio-political capital: aligned community, media and political concern for improved waterway health, amenity and recreation;

Bridging organisations: dedicated organizing entity that facilitates collaboration across science and policy, agencies and professions, and knowledge brokers and industry

Trusted and reliable science: accessible scientific expertise, innovating reliable and effective solutions to local problems

Binding targets: a measurable and effective target that binds the change activity of scientists, policy makers and developers

Accountability: a formal organizational responsibility for the improvement of waterway health, and a cultural commitment to proactively influence practices that lead to such an outcome

Strategic funding points: additional resources, including external funding injection points, directed to the change effort

Demonstration projects and training: accessible and reliable demonstration of new thinking and technologies in practice, accompanied by knowledge diffusion initiatives

Market receptivity: a well articulated business case for the change activity.

In conducting this evaluation we wondered what the enabling contexts were in respect of the Water Quality Recovery program. Where there gaps and might these provide some clues for how future attempts could be framed?

The Evaluation Question

The overarching evaluation question originally devised for this project was:

To what extent have the Peel Harvey Water Quality Recovery Program contributed to achieving the objectives of the Water Quality Improvement Plan?

As the evaluation proceeded it became apparent that undertaking an investigation that sought to answer this question would limit the ability of the evaluation to provide meaningful direction to both the PHCC and the SWCC as it moves forward (particularly in light of recent changes to funding models at the Commonwealth level).

A revised evaluation question was devised to guide the process of the evaluation and that is;

How have the individual components of the Water Quality Recovery Program contributed to providing an integrated response improving the water quality of the rivers and estuary of the Peel Harvey system?

Evaluation Findings

Four components were initially funded to deliver on several management measures contained within the WQIP-P. One, the development of a Nitrogen version of the WQIP did not proceed. The evaluation found that the other three components have successfully delivered on their objectives. At the outset the Program Managers recognised that improving water quality in the rivers and estuary of the Peel-Harvey system would require a long-term approach and commitment of some 30 years or more. The projects that have been completed with the funding provided by SWCC represent one small component of the overall effort required.

Locally, the socio-political capital of the Peel-Harvey catchment has built over the years and aligns the goals and aspirations of concerned community members and political agents. There is some question as to whether the socio-political capital invested in the Peel-Harvey catchment has translated to the broader stage, that is, at the state level. While a number of policies have been adopted and statutory

mechanisms enacted there has not been the same level of organisational or financial commitment from the State. It is suggested that without the 'algal bloom' environmental crisis that had prompted action in the past some currency and urgency has been lost for those situated outside of the Peel-Harvey area who are not confronted on a daily basis of the problems in the water ways systems.

The legacy of these earlier environmental crises is a series of policy and guideline documents that still lack sufficient force to effect change. It has been suggested that if each of the planning guidelines were followed then a good proportion of the negative land use effects would be diminished. However, adherence to the guidelines is erratic and not strictly enforced. One of the reasons for this may be the continued fragmented accountabilities for water quality management, with several state government agencies responsible for areas and impacts on water quality.

Funding provided to the PHCC through SWCC and the earlier CCI has enabled it to act, and develop capacity as a bridging organisation. Over the course of the five years of the two funding rounds the PHCC has been able to develop an integrated and holistic plan of action. The CCI enabled the development of the WQIP-P and the SWCC funding has enabled implementation of some of the (many) management measures contained within the WQIP-P but there remain significant challenges to overcome.

Challenges in Water Quality Management

The greatest challenges facing program managers concerned with improving water quality in the Peel-Harvey system are summarised below.

- Responsibility for delivering water quality related initiatives is fragmented across multiple agencies (at state and local government level) often acting in relative isolation of each other. This inhibits the 'whole-of-government' implementation of the array of binding policies and strategies, which if implemented could deliver desired outcomes.
- There is inconsistency between some sectors responsible for water management, notably the issues highlighted in drainage management between Water Corporation and Local Government.
- Information and data tends to collect within the agency responsible for its gathering and is not readily accessible to others, or is not presented in a form that makes it useable to other land and water users and managers.
- Much of the funding that has been directed at water quality management in the Peel-Harvey Catchment has been short-term and uncertain, resulting in projects being selected on the basis of the ability of an organisation to achieve (and report on) an outcome in a short period of time.
- This focus on short-term projects contrasts with the lengthy time-lags between action and response in a large biophysically complex catchment. It is evident that achievement of the nutrient targets, first set 17 years ago, will require sustained, consistent and determined action over a lengthy period.
- In particular, there must be a consistent and long-term commitment to sufficient monitoring of water quality across the catchment to enable (i) on-going validation and improvement of model outputs, (ii) determination of trends at locality and sub-catchment scale, and (iii) targeting of management investment and action into identified 'hot spots'
- Following from the above point, changing land and water uses in the Peel-Harvey Catchment, and a growing population is increasing the biophysical complexity of the environment, and the community diversity. Further, the pace of change is rapid, and growing. The implication is that the

mechanisms to achieve water quality targets must match this complexity and diversity. In short, one size will not fit all.

- There are economic drivers emerging for some practice changes, such as WSUD in new developments that will deliver win: win arrangements for land use and environment. However, in other areas such as agricultural practices, economic drivers are yet to be demonstrated. As noted in previous sections, voluntary practice change in broadacre agriculture will be difficult to achieve without economic drivers.
- Even where economic drivers may be favourable, behaviour change (urban and rural) is a challenge in a large and diverse population with varying interests and knowledge in land and water management. Part of the long-term action referred to in a previous point needs to be a commitment to change agent programs. However, the decline in public sector change agent programs, especially in agriculture, will inhibit the rate of behavioural change.
- There will always be tension in the allocation of resources between technical research (data, acquisition, system understanding, etc) and behaviour change projects (demonstrations, publications etc). While WQ01 achieved a reasonable balance, the 'application gap' between the knowledge developed in the catchment modelling, and the use of that information in land use planning needs to be bridged.

Recommendations for Consideration

The following recommendations are offered for consideration by SWCC. While some are within SWCC's power to influence directly, it is recognised that many are not. However, if viewed favourably by SWCC, others could be promoted to the responsible agencies or organisations.

Recommendation One: In several places in this report, the need to carry the work commenced in WQ01 through to completion or to logical hand-over points is mentioned. Areas include the perennial pastures research and development, building capability in using modelling to inform decision making, building capacity in drain management and maintaining support for WSUD implementation in local government. Without adequate on-going support in these areas, the investment made through WQ01 will not be fully realised.

Recommendation Two: There is a need for on-going support for a bridging organisation that can coordinate activities, provide leadership and act as a clearing house for ideas and information. This was the PHCC, but other models (e.g. statutory vs. non-statutory) have been proposed by people consulted for the evaluation. Whatever the preferred model, adequate, long-term funding and a governance structure that is commensurate with the scale of the problems set out in the WQIP is required.

Recommendation Three: Following from the above point, in delivering large, multi-disciplinary programs, bridging (or 'host') organisations need to be provided with sufficient program management resources to allow for coordination across components, data and information sharing, identification and capture of synergies between components, and coherent presentation of recommendations to land and water managers. This was an area that was "underdone" in WQ01.

Recommendation Four: Component WQ01b – the nitrogen version of the WQIP was not delivered for a range of sound logistical and organisational reasons. The importance of nitrogen in waterways and estuary health is being recognised through more research work. The need for a WQIP-N should be reconsidered and if required prepared as soon as possible.

Recommendation Five: SWCC, which includes in its area several major coastal catchments where nutrient management is a challenge, is well placed to facilitate a Centre for Excellence in Nutrient Management to coordinate scientific endeavours and disseminate information. There is potential to form a partnership with the Centre for Eco-hydrology at the University of Western Australia. It may be that a 'node' of that centre could be established in the region (Mandurah?) as a means of building regional capacity.

Recommendation Six: Following from the above point, the model system calibrated for Peel-Harvey could be located in Mandurah and administered by the Department of Water. In this way local governments in the region could more readily access the outputs of the

modelling work and better understand the impacts of some of the their decision-making.

Recommendation Seven: The SWCC should continue to press for drainage reform in the Peel-Harvey Catchment. It is likely that implementation of drainage management reform will rely largely on the Department of Water's program in preparing drainage and water management plans to cover the major urban expansion areas across the Perth to Peel and South West regions. However, institutional reform in licensing drainage management will still be required, and SWCC needs to maintain of focus on this objective.

Recommendation Eight: The incorporation of WSUD (or Urban Water Management) into the curricula for engineering and planning courses would build skills in people joining local governments and planning companies. Other opportunities exist for working with academic institutions in providing access to data for Honours or Masters students.

Recommendation Nine: The development of grass roots extension to change the behaviours and knowledge of people in the catchment is an on-going need. At present there does not appear to be political/government commitment to the provision of extension. Delivery of extension might be achieved through regional or sub-regional resource management or catchment groups.

1 Introduction

1.1 The Evaluation of the Peel-Harvey Water Quality Improvement Project

The aim of this evaluation is to provide a report on the effectiveness and impact, efficiency, appropriateness and legacy of the **Peel-Harvey Catchment Council's (PHCC) Water Quality Recovery Program** funded through the South West Catchments Council's (SWCC) allocation of National Action Plan for Salinity (NAP) and National Heritage Trust (NHT) Commonwealth and State funding in the South West region of WA.

1.2 Improving Water Quality in the Peel-Harvey Estuary Program (WQ01)

Modelling for the *Peel-Harvey Water Quality Improvement Plan – Phosphorous Management* had shown that no single management practice will achieve the water quality objectives in isolation but that a combination of practices is required (Zammit et al, 2006). The Peel-Harvey Catchment Council (PHCC) devised the 'Improving Water Quality in the Peel-Harvey Estuary and Associated Rivers' program to bring together a range of actions that might have a cumulative effect on water quality.

The PHCC commenced the Peel-Harvey Water Quality Recovery Program (herein "WQ01 Program") in January 2007 (originally slated to start in July 2006). In funding application documentation dated 31 October 2006 the project was described with four distinct components:

1. **Decision Support System and Monitoring (WQ01a):** refinement of the DSS model to enable provision of information relating to land use and BMPs. The further development of the DSS model for the Peel-Harvey Catchment will focus on expansion of the DSS to the entire P-H Catchment; instructed by the DSS to select two well matched focus sub catchments and develop demonstration sites within them for the implementation and comprehensive assessment of the BMPs specified in the WQIP.
2. **Development of Water Quality Improvement Plan Stage 2 (WQ01b)**: the objective was to develop a nitrogen version of the Peel-Harvey Water Quality Improvement Plan to complement the Phosphorous Water Quality Improvement Plan. However, for a range of quite legitimate reasons, this was not progressed and the funding was returned to the South West Catchments Council (SWCC) un-spent.
3. **Rural and Urban Drainage (WQ01c and d):** to provide better planning and drainage operation to meet environmental outcomes consistent with contemporary public expectations; and explore water quality differences (nutrients) between drainage systems of differing form and function via a combination of desktop review and on ground survey.
4. **On-ground work and capacity building (WQ01c and d):** to help prioritise and target works to improve nutrient and sediment reductions; improve the quality of water discharged into sensitive high priority water bodies such as Ramsar and EPP wetlands; reduce the incidence of algal blooms and fish kills by reducing nutrient inputs of particular impact on the river systems of the Peel-Harvey; and improve drainage to benefit biodiversity and conservation values. This was supplemented in the final project description with a further component, being "the provision of financial incentives to land owners wishing to participate in the project as well as learning opportunities for the broader communities in the application, cost and ongoing management of BMPs"

1 Introduction

These projects operationalise several of the key management measures outlined in the *Water Quality Improvement Plan for the Rivers and Estuary of the Peel-Harvey System – Phosphorous Management* (WQIP-P) to reduce phosphorous inputs to the estuary. These measures relate to:

- management of agricultural land practices;
- management of urban land practices;
- management of rural and urban effluent;
- management of licensed discharges;
- protection and vegetation of wetlands and waterways through maintenance of buffers ad riparian vegetation and stock exclusion;
- modification to drainage management practices; and
- research and investigation; monitoring and reporting; uptake of best management practices; and fostering of community partnerships.

A total amount of $1,249,052 was provided by the SWCC to the PHCC over two years (June 2006 to July 2008) for the WQ01 program. This amount was supplemented with additional income received from alternative sources including the Peel Development Commission, the Department of Water and industry such that total funding for the Water Quality Recovery Program was $1,376,028. Table 1-1 provides detail on income and expenditure of allocated funds over the accounting period.

Table 1-1 Statement of income and expenditure for the period 1 July 2006 to 31 Dec 2008 (PHCC 2009a)

Income	$	Expenditure	$
		Employment:	
SWCC Grant received:	1,249,052.00	Salaries / Wages (FTE's)	451,665.39
		On-costs	90,180.54
		Contractors and Consultants:	
Income from other sources:		Urban WSD Consultants	73,930.68
Alcoa Funding (WQ 01d)	100,000.00	**Operational Expenses**	
		On-ground works	285,135.10
Peel Development		Water Quality Monitoring Costs	153,920.70
Commission	15,500.00	WSD Tour development, printing and events	44,024.50
Dept of Water	3,000.00	WSD Conference / Forum	
Mirvac (WA) Pty Ltd	3,000.00	Field Days	9,087.60
Toro Australia	1,159.09	Vehicles	6,000.00
Peet Mandurah Syndicate	1,000.00	Office, Communications and Committee	42,915.02
Port Bouvard	909.09	Audit and Audit Preparation	31,159.15
Davey Water Products	454.55		
Other Funding	1,953.83	**Corporate Overheads**	2,390.65
		Corporate Overheads (DoW)	
		Corporate Overheads (PHCC)	
		Corporate Overheads (DAFWA)	33,006.00
		Organisational Mgt Overhead (DoW)	10,000.00
			4,200.00
		Program Overheads	8795.00
		PHCC Program OMO (Overall 5%)	
			60,924.00
		Unspent funds for the remainder of the project	68,694.23
Total	**1,376,028.56**	**Total**	**1,376,028.56**

1.3 Approach

The approach taken to this evaluation has been influenced by the already long history of investigation and action in the Peel-Harvey region.

1.3.1 Background

Water quality in the Peel-Harvey Catchment has been of concern to scientists and others since a decline was noticed in the 1950s. Studies have been undertaken into the eutrophication of the estuary, catchment phosphorus sources, nutrient point sources, water quality monitoring and modelling of future water quality scenarios. To a large extent it has been these technical studies that have driven the approaches taken to resolve the deterioration of the Peel-Harvey water quality.

The publication of the *Water Quality Improvement Plan (WQIP-P) for the Rivers and Estuary of the Peel-Harvey System - Phosphorous Management* in November 2008 (EPA, 2008) offered a more holistic approach to dealing, at least, with phosphorous levels and movement in the Peel-Harvey system. The WQIP-P provided a raft of management measures and control actions aimed at reducing phosphorous inputs. The key components are primarily directed towards changes management practices rather than one-off technical solutions (for example the creation of the Dawesville Channel).

1.3.2 Challenges in completing the evaluation

This evaluation has not sought to evaluate nor assess measures of water quality because each of the projects components has included a rigorous monitoring element and these have been reported either throughout the program or are included in documentation produced within the program. The reference list provided in Section 7 lists reports generated out of the WQ01 Program.

The evaluation provides some discussion of the individual components of the WQ01 Program and presents findings of the investigation and, where appropriate, makes recommendations for future actions. However, it quickly became evident during the evaluation process that the success of the group of projects hinged on there being an integrated and holistic approach to the evaluation. The evaluation has largely found that while each component did deliver on its outputs and each has contributed to the overall objective of improving water quality in the Peel-Harvey Estuary, that contribution has been limited. Partly this has been because of a lack of integration between all of the components; and partly it is a result of the limited time span of the projects – being too short a period to determine long-term outcomes from the projects.

1.3.3 A framework for assessing the Program's contribution

In order to understand how large and complex programs, such as those seeking to address water quality issues, contribute to desired outcomes, Brown and Clark (2007) developed a useful model for understanding the "key institutional change ingredients". While Brown and Clark's focus was on water sensitive urban design in Melbourne the framework they have developed has provided a useful structure for other water management attempts including that undertaken in the Peel-Harvey.

In their study, Brown and Clarke (2007) drew from transition theory to show the shifts that have occurred in respect of Melbourne urban stormwater quality management. Their research identified a "range of interconnected activities and initiatives" and a critical "*interplay* between industry champions and important context variables that has provided the structure and catalyst for the transition". They

argue that it is the “enabling context that has shaped, constrained and provided opportunities” for the industry champions to push for the changes that have occurred (p. iv, emphasis in original).

The eight key components comprising the ‘enabling context’ described by Brown and Clarke are as follows:

Socio-political capital: aligned community, media and political concern for improved waterway health, amenity and recreation;

Bridging organisations: dedicated organizing entity that facilitates collaboration across science and policy, agencies and professions, and knowledge brokers and industry

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Accountability: a formal organizational responsibility for the improvement of waterway health, and a cultural commitment to proactively influence practices that lead to such an outcome;

Strategic funding points: additional resources, including external funding injection points, directed to the change effort;

Demonstration projects and training: accessible and reliable demonstration of new thinking and technologies in practice, accompanied by knowledge diffusion initiatives; and

Market receptivity: a well articulated business case for the change activity.

The focus of the evaluation centred on the inter-linkages between the project components and, using the framework provided in the work of Brown and Clarke, to assess how the components have responded to and contributed to the ‘enabling context’. That is, how they have shaped, constrained and provided opportunities for achievement of the aims of the WQIP-P (see discussion in Sections 4 and 5).

1.4 The Evaluation Question

The overarching evaluation question originally devised for this evaluation was:

> *To what extent has the Peel-Harvey Water Quality Recovery Program contributed to the objectives of the Water Quality Improvement Plan?*

As the evaluation proceeded it became apparent that undertaking an investigation that sought to answer this question would limit the ability of the evaluation to provide meaningful direction to both the PHCC (as program deliverer) and to SWCC (as program funder), particularly given the changes to Commonwealth government funding models. A revised evaluation question was devised and has subsequently guided the evaluation, that is:

How have the individual components of the Water Quality Recovery Program contributed to providing an integrated response to improving the water quality of the rivers and estuaries of the Peel-Harvey system?

This revised question is specifically directed at querying the assumptions of the WQIP-P, which itself represented one of the first attempts at pulling disparate water quality improvement projects together into an integrated package of works.

1.5 Methodology

The methodology for this evaluation included the following components:

- Preliminary interviews to clarify scope and documentation of the program logic;
- Review of project documentation and literature review;
- Semi-structured interviews with past participants of the program and facilitators; and
- Workshop with Discussion Panel.

Each of these components is outlined below.

1.5.1 Documenting the program logic

After consultation with key personnel from the Peel-Harvey Catchment Council the URS team developed a program logic which captured the theory of change of the Peel-Harvey Water Recovery Project. This logic is shown below in Figure 1-1.

The program logic articulates, in the form a diagram, the "theory" underlying the water quality recovery project. The aim is to depict the assumed linkages between program inputs, activities, and outputs and ultimately to the accomplishment of program outcomes and objectives. Developing a program logic enables program planners and program evaluators to clarify what and how a program hopes to achieve its goals.

1.5.2 Document and literature review

URS undertook a literature and document review that encompassed:

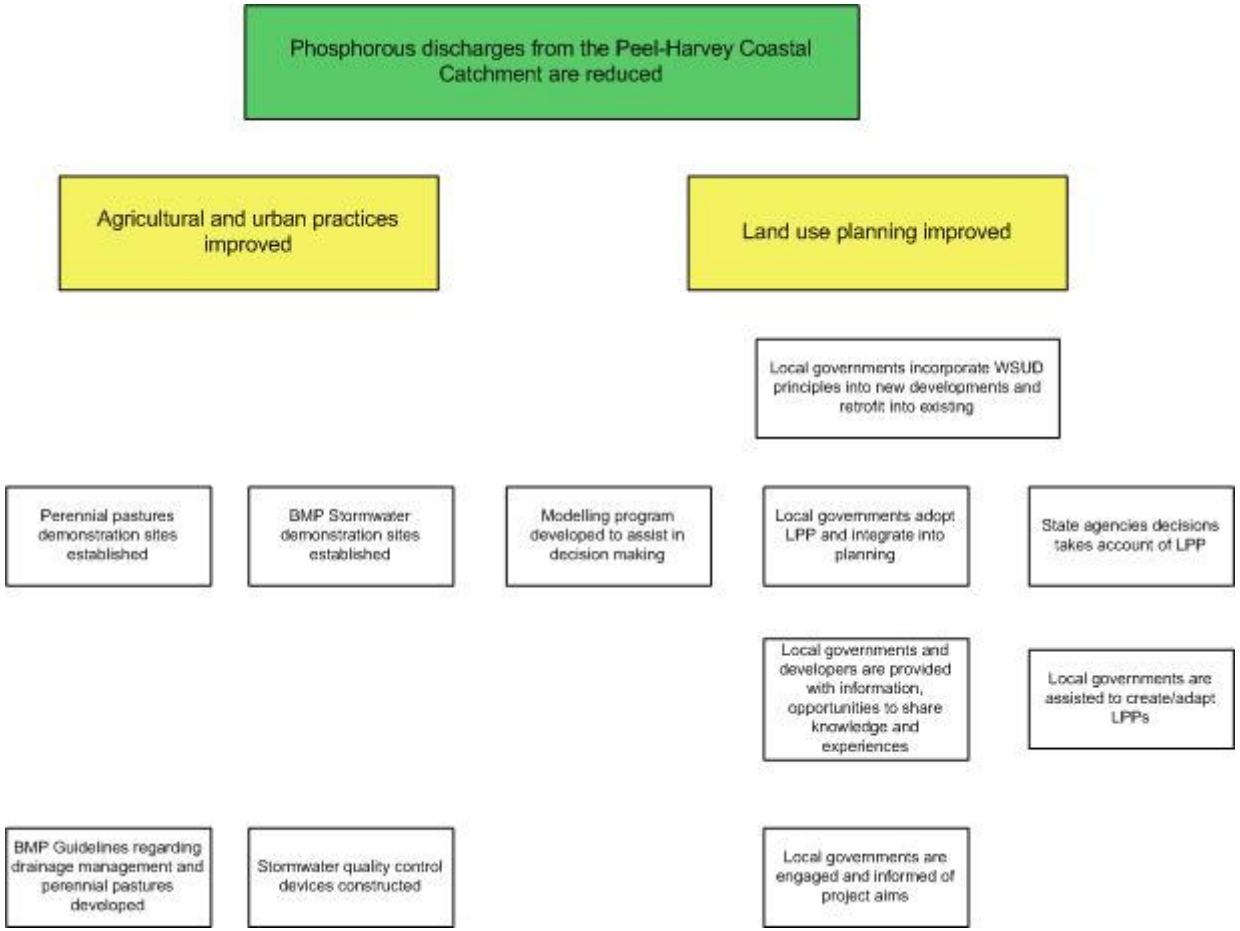
- reports delivered by the PHCC to the SWCC specific to the Peel-Harvey Water Recovery Program;
- government legislation, regulations and policy documents relating to the Peel-Harvey Catchment specifically as well as those directed towards water management and planning in Western Australia; and
- reports, studies and journal articles publicly available related to water management and water quality in the Peel-Harvey Catchment.

1.5.3 Semi-structured interviews

A set of questions was developed for each of the components for this project to guide the interview process. These questions were informed by information gathered through the literature review process and were specific to each component. Semi structured interviews were then undertaken with key personnel involved in the delivery of the four components as well as with local government officers, development company staff and personnel of the Peel-Harvey Catchment Council.

Interviews were primarily conducted face-to-face although some were also conducted via telephone.

Figure 1-1 Program Logic for Project WQ01



1.5.4 Workshop with Discussion Panel

URS convened a Discussion Panel comprising Project Managers involved in the delivery of the four components of the WQ01 Program. The Discussion Panel met on 20 October 2009. The meeting was facilitated by Dr Don Burnside, Principal Natural resource Scientist from URS. Members of the Expert Panel are shown below.

Damien Postma	Formerly Manager, Peel-Harvey Catchment Council (now A/CEO SWCC)
Grahame Heal	City of Mandurah
David Rogers	Department of Agriculture and Food
Andrew McTaggart	URS, Water Quality (Advisor)

The following Project Managers were unable to attend:

Peta Kelsey	Department of Water
Shelley Shepherd	Essential Environmental Services
Jesse Steele	Formerly Peel-Harvey Catchments Council

An Information Paper was provided to the Panellists prior to the meeting. The Information Paper provided a summary of the four components of the program, including the preliminary findings, and set out the evaluation framework and approach taken on this project.

The Discussion Panel deliberated on each of the projects and provided comment on the findings presented and suggestions for future works. The session was completed with an overall discussion of the 'enabling contexts' and how projects to improve water quality in the Peel-Harvey might be enhanced in the future.

The content of the Information Paper, with amendment after input from Discussion Panel members, has been included in this Report.

2

Background

The following discussion is informed by the literature review undertaken for this project.

2.1 The Peel-Harvey Estuarine System

The Peel Inlet and Harvey Estuary make up a single shallow waterway located in the south west of Western Australia. The Peel Inlet has a surface area of 75 square kilometres and a volume of about 61 million cubic metres (61,000 megalitres), while the Harvey Estuary has a surface area of 61 square kilometres and a volume of about 56 million cubic metres (56,000 megalitres). The average depth of the combined system is 90 centimetres. The Estuary lies in the northern portion of the south-west NRM region and encompasses all, or the major portions, of twelve local government areas with lesser portions of five more. (Land Assessment Pty Ltd, 2005).

Geographically the catchment comprises two distinct regions. The coastal land around the Inlet and the Estuary is generally of low relief, and flat land (less than 20 metres above sea level) extends up to 30 kilometres inland from the coast. Much of this land is prone to inundation, and there were abundant wetlands in this area prior to agricultural development. To the east of this coastal plain lies the Darling Scarp, rising to the Darling Plateau. This land is characterised by steep slopes, rising in some places 400 metres over 10 kilometres, with valleys deeply incised into the plateau (URS 2009).

The Peel-Harvey Basin has a Mediterranean climate with hot, dry summers and cool wet winters. Most rainfall comes between April and October with approximately 900mm on the coastal plain and 1300mm per year over the Darling Scarp.

The major industry of the region in terms of employment comes from the mining of bauxite, gold and mineral sands. Much of the land is given over to agriculture which is second to mining in terms economic contribution to the catchment (PDC 2006). The agriculture in the western portion of the catchment is based around dairy and beef cattle and orchard fruit production. Much of the traditional broadacre agricultural landuse has been replaced with intensive horticulture such that there is now considerable quantities of wine, vegetables, wool, pigs, eggs, olive oil, flowers, grain and poultry produced. Along the coastal plain there is a significant equine industry with intensive horse activity areas. Across the Darling Range and into the Wheatbelt region agriculture in the form of wheat and sheep farming predominate but are supported by the production of grapes, olives, nut crops and aquaculture activities. In addition, timber production and fishing contribute to the Peel-Harvey economy (source).

Parts of the catchment are also important tourist destinations. Due to its proximity to Perth, the City of Mandurah has become a centre for day-trippers and shoppers. The City and surrounding areas adjacent to the coast and the estuary are also a holiday destination for domestic and international tourists attracted to the variety of marine recreational activities, such as fishing and yachting. The Peel-Harvey region more broadly attracts a significant number of visitors each year. (PDC 2006).

The Peel-Harvey coastal catchment encompasses the following local government areas: Serpentine-Jarrahdale, Murray, Mandurah, Waroona, Harvey, Cockburn, Kwinana, Rockingham, and lesser portions of Armadale. Pressures on the Peel-Harvey region are increasing through the rapid and widespread urbanisation across the region and in close proximity to waterways. The shires bordering and draining to the main waterways have experienced since the 1950s, and continue to experience, rapid development and changes of land use. The northern portion of the region has been impacted by this urbanisation process becoming a major commuting centre adjacent to the southern metropolitan

region. These changes have led to the creation of a number of natural resource management (NRM) issues within the catchment.

2.2 Resource Management in the Peel-Harvey Estuary

2.2.1 Defining the nutrient management problem

In undertaking the literature review for this evaluation it soon became apparent that water quality in the Peel-Harvey Estuarine System has been thoroughly investigated and has been the subject of scientific debate since the mid-twentieth century when abundant weed growth in the Peel-Harvey Estuary offered the first sign that the estuary environment was deteriorating. When a large bloom of *Nodularia Spumigena* occurred in the Harvey estuary in 1973 it was a clear indication that the system was severely nutrient-enriched and that management was urgent (Humphries and Robinson, 1995; McComb, 1995). By 1976 scientists were describing this once pristine waterway as 'a biological* desert' (Land Assessment Pty Ltd, 2005). Since then the estuary and its catchment have been the subject of ongoing intensive investigation and management.

In 1980, a study into the problems of the Peel-Harvey concluded that the main cause of the weed problem was the excessive phosphorous in the estuary water and that superphosphate fertiliser was the principal source. The government, through the (then) Department of Agriculture, launched a major extension program aimed at increasing fertiliser use efficiency. Considerable financial assistance was provided to farmers to help them take up soil testing with nearly all farmers on the coastal plain being tested once under the program. Where superphosphate use had previously been applied at the rate of 27,000 tonnes per annum in 1974 by 1987, this had fallen by 65% to 9,500 tonnes per annum. Despite these reductions the water quality within the catchments did not improve (Keipert *et al* 2008).

Humphries and Croft (1984) carried out a review of a range of possible management options as part of an Environmental Review and Management Programme (ERMP) for the Peel Inlet and Harvey Estuary Management Strategy. In this a number of short- and long-term strategies were provided including weed harvesting, agricultural fertiliser management, building the Dawesville Channel, control of rural point sources of nutrients, and in the longer term, changes in land use.

In 1985, the Environmental Protection Agency concluded that the estuarine water quality was "seriously degraded and required significant improvement to make it environmentally acceptable" (EPA, 1994). They acknowledged the importance of the estuary as a wildlife habitat of international importance, for water based recreation, fishing and tourism while noting the increasing development pressures. The EPA (EPA, 1988, Part I, p. 18) concluded that:

Successful management of the estuary can only be achieved by both reducing phosphorous and other nutrient inputs to the system, increasing the rate at which phosphorous and other nutrients are lost from the estuarine system, and by making the estuarine system more marine and therfore unfavourable to the blue-green algal (cyanobacterial), particularly Nodularia growth.

This reflects a traditional approach to water quality management which tended to adopt a technical approach that takes advantage of complex ecological knowledge, hydrological and water allocation models, tools such as GIS and engineered solutions (Pahl-Wostl, 2002).

2.2.2 Early action by Government

By 1989 a Management Strategy for the Peel Inlet and Harvey Estuary System was approved for implementation by the Minister for Environment. An *Environmental Protection (Peel Inlet – Harvey estuary) Policy (1992)* and the *Peel-Harvey Coastal Plain Catchment Statement of Planning Policy (SPP) No. 2* were introduced to drive phosphorous reductions within the Peel-Harvey Catchment.

The Environment Protection Policy (EPP) sets out the environmental quality objectives for the Peel-Harvey estuary and the means by which the Environmental Quality Objective (EQOs) are to be achieved and maintained. The EPP set the EQOs as the median load of total phosphorus flowing from the entire catchment into the estuary of less than 75 tonnes, with the median load of total phosphorus flowing into the estuary being less than 21 tonnes for the Serpentine River, less than 16 tonnes for the Murray River and less than 38 tonnes for the Harvey River (Government of Western Australia, 1992a).

The Management Strategy consisted of five elements:

- Construction of a new channel to the ocean at Dawesville;
- Continuation of weed (macroalgal) harvesting;
- Continuation of fertilizer modification practices;
- Implementation of stricter catchment management measures; and
- Changes in land use.

The Strategy was ambitious and highlighted the need for a whole-of-government integrated approach to solving environmental problems and, in particular, the problem of excessive nutrient loads. The Minister for the Environment nominated three relevant Ministers (Ministers for Transport, Agriculture and Waterways (now Water) as the proponents for implementation of the Strategy. This set the scene for a more collaborative effort for addressing the water quality problems.

Humphries and Robinson (1995) cautioned on relying on technical engineered solutions, such as the construction of Dawesville Channel, as a means of addressing the complex problems evident on the Peel-Harvey Estuary. They suggested that until the rural community reduced their fertiliser application, thereby reducing phosphorous inputs to the catchment, the Channel on its own would not be successful. In 1995 they were questioning:

- the Department of Agriculture's focus on agricultural production that required an over-reliance on superphosphate;
- the complexity of the state's planning legislation that sees little coherence between local and state level planning;
- the impacts of policy mechanisms that are non-statutory, out of date, vulnerable to change, and "impossible to monitor" on an individual property basis (p. 262);
- the wisdom of unfettered development along the Channel when it is it is an important area for water birds and migratory waders;
- a lack of political will to apply pressure to rural and animal industries to reduce their phosphorous inputs;
- a lack of commitment from landholders to tree planting and other schemes to retain water in the landscape; and
- a lack of cost-effective technologies for the management of urban stormwater.

Their questioning in 1995 reflected a broader discussion that was taking place about the effectiveness of end-of-pipe solutions that were resource intensive and increasingly expensive (Pahl-Wostl, 2002).

It was considered that environmental problems were complex and comprised of environmental, economic and social dimensions. The recognition here is that some problems cannot be resolved by means of technology but only through changing the behaviours of human actors.

While a January 2003 review of the effectiveness of management of the Peel-Harvey estuarine system (EPA Bulletin 1087) concluded that the predicted beneficial environmental changes from the Dawesville Channel were valid, the estuarine system was reported to be remaining in a fragile condition. Indeed, modelling of Best Management Practices undertaken for the Coastal Catchments Initiative project (see below) has shown that no single management practice will achieve the targets but that a combination of practices is required (Zammit *et al*, 2006)

2.2.3 Coastal Catchments Initiative (CCI) Projects

In 2003 the Australian and Western Australian Governments initiated a series of projects that would lead to preparation of the *Water Quality Improvement Plan - Phosphorous Management (WQIP-P)* and a framework for its implementation. The Coastal Catchments Initiative (CCI) sought to meet Australia's commitments under the Global Program of Action for protecting the marine environment from the impacts of land-based activities. The Western Australian and Commonwealth Governments jointly co-funded the development of the CCI programme for three iconic coastal waterways and catchments - the Ramsar listed Peel-Harvey Estuary, the Swan-Canning Rivers and Geographe Bay and its catchment which includes the Vasse-Wonnerup wetlands.

A series of projects was undertaken in the Peel-Harvey Catchment to inform the science and policy that underpins the WQIP-P. The projects were undertaken by relevant government agencies, integrated through program meetings and professional collaboration. The projects were completed over a 2-3 year period, and were comprised of projects that delivered the following activities and outputs.

- **Water quality monitoring**. A water quality monitoring strategy was prepared to calibrate an existing catchment predictive water quality model. A series of gauging stations were established or upgraded to meet this purpose as well as provide the capacity for long-term monitoring and tracking implementation.
- **Predictive modelling and decision-support tools**. The Large Scale Catchment Management (LASCAM) model is now calibrated to predict the effects of climate change and changes in catchment land use and land management in order to achieve the WQIP-P phosphorus load targets. The model is also providing essential information to guide planning and development in the catchment. decision-support tools were prepared to evaluate and promote the relative effectiveness of management practices and treatment trains in agricultural systems, and the rate of practice adoption required to achieve the WQIP-P load targets;
- **Water sensitive urban design (WSUD)**. WSUD planning policies and technical guidelines were prepared for incorporation into town planning schemes and to underpin statutory decision-making. The policies are based on achievement of the WQIP load targets, reflecting local environmental conditions and sub-catchment targets. State agencies are working with local government to institutionalise these provisions, a key element to WQIP implementation;
- **Agricultural source controls**. Projects were implemented for both broadacre and intensive agricultural activities. This included developing and implementing programmes to reduce nutrient loss from horticultural and dairy industries, as well as surveying, evaluating and demonstrating effective agricultural practices that reduce or eliminate nutrients leaching from farms (e.g. soil

testing to determine application rates). Modelling of inputs and outputs of nutrients in agricultural sub-catchments is providing information to manage application rates and, secondly, for developing scenarios for the Decision Support System (DSS model).

- **Licensing and regulatory arrangements**. The objective of this project was to develop innovative measures to regulate both point and diffuse sources of nutrient contamination. The existing licensed premises have been identified and areas of potentially a high risk of nutrient discharge were identified using existing datasets. This information will be incorporated into the DSS and used to determine the loads from those sources required to meet desired water quality in the receiving waters.

2.2.4 New drivers for implementing strategies for the Peel-Harvey region

The nutrient load entering the Peel-Harvey Estuary has increased over the last few decades. Between 1977 and 1988 an average of 1200 tonnes of nitrogen and 140 tonnes of phosphorus annually entered the Peel-Harvey Estuary. The current estimated phosphorus winter load has increased to 145 tonnes per year, which is 49 per cent above the current phosphorus reduction target described in the WQIP-P (DoW, 2009). Monitoring of total nitrogen concentration by the Department of Water has shown values above the ANZECC 2000 in several monitoring sites in the Serpentine River.

A number of key drivers have been changing the environment for strategy development and implementation in the Peel-Harvey Catchment. A key driver noted in the previous sections has been the wealth of scientific information and an extensive history of intervention in the area. The current major natural resource management issues within the Peel-Harvey catchment as identified in the Peel-Harvey NRM Plan 2005 are:

- control of drainage and water quality;
- loss or fragmentation of biodiversity;
- salinity (particularly within eastern portions of the catchment);
- adoption of best agricultural management practices;
- allocation of water resources;
- weeds and feral animals;
- climate change (particularly rainfall);
- potential effects of acid sulfate soils;
- support and funding for on-the-ground community-based NRM activities; and
- inappropriate land development arising from perceived inadequacies in land use planning and environmental impact assessment procedures.

In recent years there has been a rapid urbanisation and population growth across the area. Due to its proximity to Perth, areas around the City of Mandurah have witnessed rapid urban and peri-urban expansion. This has resulted in increased demands on the estuary and additional burdens on the system, for example through increased water extraction, spraying for mosquito control, agricultural production, foreshore development and access, boat use and moorings and jetties (DEWHA, 2009). This urbanisation has become an increasingly significant threat to the water quality and ecosystem health because of the impacts of poor urban drainage. It is fair to say that hydrological change is the most visible environmental impact of urbanisation and strongly influences water quality. Lee *et al* (2006) suggests that urbanisation typically increase run-off peak flows and total flow volumes and damages water quality and aesthetic values.

The present driving issue in water quality management in the Peel-Harvey Catchment is the urban development referred to in previous paragraphs (Australian Government, 2006). Currently 6 per cent of the catchment area is occupied by developed urban areas but they contribute about 30 per cent of nutrient input to the estuary. Recent modelling studies indicate that full development of current urban planning schemes would produce a four-fold increase in urban-sourced nutrient loadings to the waterway (WQIP-P).

With increasing urbanisation has come a greater recognition of the inherent value of the environment and higher demand for recreational use and enjoyment. The Peel-Harvey estuaries and rivers have an inherent social and environmental (and for some an economic) value and are invested with socio-political capital. The occurrence of an environmental crisis in the form of algal blooms generated an expression of concern and a desire for action from the community and those who represent them in Parliament. Action followed and from one of these actions, the creation of the Dawesville Channel, emerged an invigorated commitment to maintaining the environmental, social and economic value of the Peel Inlet.

2.3 Water Quality improvement Plan – Phosphorous Management

The *Water Quality Improvement Plan for the Rivers and Estuary of the Peel-Harvey System – Phosphorous Management (WQIP-P)* was published in November 2008 and outlines a range of management measures and control actions to improve water quality by reducing phosphorous discharges from the catchment through changes to agricultural and urban practices. The objective of the WQIP-P is to reduce the median loadings of total phosphorous to estuarine water to less than 75 tonnes per annum in an average year.

While the WQIP-P recognises the importance of 'hard' technical solutions (e.g. retrofitting septic tanks) it heeds Humphries and Robinson's (1995) concerns with behavioural change and what can be considered 'soft' technologies (e.g. development of wetlands for water quality improvement).

The ten key components of the WQIP-P are directed towards instituting behavioural changes of some form. They are:

- **management** of agricultural land practices using, better fertiliser, soil amendment, perennial pastures and better management of irrigation systems;
- **management** of urban land practices, better fertiliser and soil amendment practices, and water sensitive design that focuses on a 'whole of water cycle' approach, applied through the environmental and planning referrals and approvals processes;
- **management** of urban and rural effluent, including retrofitting of septic tanks with nutrient reducing alternatives, full connection to sewerage, and cleanup of livestock practices;
- **management** of licensed discharges entering the estuarine system through licensing of agricultural nutrient discharges;
- **protection and revegetation of wetlands and waterways** through maintenance of buffers and riparian vegetation and stock exclusion;
- modification to **drainage management practices** to reduce in-channel sediment movement as opportunities arise;
- continued research and investigation into **best management practices** available for nutrient reduction in the rural and urban landscapes of the Peel-Harvey Catchment to ensure improved understanding of how nutrient reduction measures are performing and to refine actions;

- implementation of a **monitoring (at a range of scales) and reporting program** of suitable indicators and targets to allow evaluation of the efficacy of the Plan;
- identify and address **barriers to uptake** of best management practices within the catchment and measures that may increase the rate of uptake; and
- fostering of **community partnerships**, to promote awareness of and collectively manage water quality issues.

While some of the components refer to technical solutions, the implementation of those technical solutions and other components rests upon the collective actions of many individuals. Looked at in this way, water quality improvement in the Peel-Harvey Estuary is dependent upon human actors applying socio-technical solutions over a long time frame (20 to 50 years). This understanding turns attempts at water quality recovery from the more traditional reductionist approaches of detailed process studies at small scales to broader holistic approaches that take account of the complex interplay between multiple impacts and multiple players. It is an approach that suggests that to 'work on water quality, you have to work on people'.

Project components - objectives and findings

This section presents each of the components of the project separately, describing the objectives of that project, background to the project and the findings from the interviews.

3.1 Component WQ01a - Decision Support Systems and Monitoring

3.1.1 Objectives

The funding received in the 2006-2008 period sought to deliver seven project outputs:

1. Training session conducted for key stakeholders on use and application of DSS model in the Peel-Harvey Catchment;
2. Continued operation of the current DSS LASCAM model developed for the Peel-Harvey Catchment to target sub-regional investment in NRM activities and ensure that the maximum outcomes are achieved for the investments made;
3. DSS Workshop held with key stakeholders to gain local knowledge input into DSS sub-catchment delineation for the Peel-Harvey Catchment;
4. Development of a Sampling Analysis Plan for monitoring program in the Peel-Harvey Catchment;
5. A robust water quality monitoring network capable of gathering WQ data at the catchment and sub catchment scale established/enhanced for the Peel-Harvey Catchment;
6. Water Quality monitoring data report for Peel-Harvey catchment developed; and
7. Further development and expansion of the DSS model for the Peel-Harvey Catchment.

3.1.2 Background

The need for a Decision Support System/Model

The development of a Decision Support System (DSS) can achieve a number of objectives for catchment management. It can:

- provide a common tool for agencies concerned with water resource management;
- evaluate the productivity and impacts of the catchment;
- investigate situations of land use change and land conversion that might happen in the catchment;
- optimise land use activities according to needs and opportunities;
- prioritise and address the problems to be managed and overcome; and
- recommend alternative crops and management practices for sustainable land management and income sustainability.

Development of LASCAM

The Department of Water, supported by the Commonwealth's Coastal Catchment Initiative (CCI) Program initiated development of a catchment model for the Peel-Harvey catchment, based on the LASCAM or (La)rge (Sc)ale (Ca)tchment (M)odel. LASCAM was originally developed with the aim of predicting the impacts of land use and climatic change on the daily trends of stream flow and water quality (salinity, sediments, nutrients etc).

The model was used, in the 2003 CCI-funded project, as the basis for a Decision Support System (DSS), adapted for the Peel–Harvey catchment, to examine nutrient management scenarios (Weaver *et al*., 2005). The risk based DSS was then used to estimate how different Best Management Practices (BMP), particularly perennial pastures, soil amendment (Alkaloam™), fertiliser management,

riparian management and effluent management compared in terms of costs and water quality benefits when implemented in the DSS individually at 100% adoption, or in scenarios of different levels of adoption of each (25%, 50%, 75% 100%).

In the 2003 project a list of 30 scenarios were developed and the actions implemented through the BMPs modelled using the LASCAM. In analysing the various BMP scenarios the study found that few BMPs have the potential to reduce load and concentration to the desired levels; that substantial reduction of load and concentration could be obtained by a combination of different BMPs on different reporting catchments; and that urban BMPs should be considered in order to be successful in meeting the different targets. The study found the most successful BMPs in terms of load and concentration reduction to be:

- No export from Agricultural licensed premises;
- Connection to Infill Sewerage;
- Use of soil remediation techniques in agricultural and urban catchments;
- Use of Red Coat Coastal Super Phosphate as fertiliser;
- Reduction of Phosphorus fertiliser applied on the ground;
- Reafforestation of urban land use;
- Land use change;
- Dairy Effluent Management; and
- Replacement of annual pasture by perennial pasture.

Results from the LASCAM modelling undertaken by Zammit *et al* (2006) indicated a large spread of sources for excessive nutrients. The land use that delivered the majority of phosphorous to the estuary was identified as grazing at 39 per cent. Residential (urban and rural) accounted for 17 per cent of phosphorous input to the estuary.

The Peel-Harvey WQIP relied on outputs from LASCAM. The focus was on being able to model, and then predict phosphorous fluxes in the catchment, through to entry into the receiving water body (Zammit and Summers 2005).

The development of SQUARE

The underlying architecture of the model was significantly improved and altered and the new tool is now described as the SQUARE model – meaning (S)treamflow (Q)uality (A)ffecting (R)ivers and (E)stuaries. SQUARE has been applied to the Swan-Canning, Geographe Bay and Scott River catchments, in assisting the preparation of WQIPs for those two areas. This work has been funded by Commonwealth and State Governments separately to the SWCC investment.

SQUARE is based on processes occurring at sub-catchment scale, with the processes distributed evenly over the sub-catchment at a daily time-step temporal scale. The Peel-Harvey catchment has been sub-divided into 500 sub-catchments for the purpose.

SQUARE was also used in another CCI project to inform the development of the 'Ecotones' model, developed by Simon Neville (Ecotones Pty Ltd) and David Weaver (Department of Agriculture and Food). This model is non-dynamic (i.e. can only provide annual averages) and is designed to identify the costs and benefits of intervention with agricultural best practices in a defined area – as 'viewed' from the receiving body. The two models (SQUARE and Ecotones) are complementary.

3.1.3 Activities supported by the SWCC investment

Modelling supported by SWCC investment

An appreciation of the importance of nitrogen in catchment and receiving water body health came from work done in the Swan-Canning Catchment. LASCAM, and its successor SQUARE were not calibrated to predict nitrogen dynamics in the catchment. The SWCC investment has allowed re-design and recalibration of the model to include a sub-component that addresses N fluxes. Further, several of the underlying data sets including hydrology and land use have been updated to improve the model's accuracy and reliability. The model is now calibrated for phosphorous (total P and free radical P) and all forms of nitrogen fluxes. Operation of the model requires spatial data on landuse, vegetation, and waterways. The model is driven by rainfall and evaporation.

The development work was led by Dr Christian Zammit (Department of Water until November 2007, now with AECOM), and the modelling was done by Depak Shakya. SQUARE is owned by the Department of Water and is being operated by Dr Peta Kelsey. SQUARE is now fully operational for the Peel-Harvey catchment, and is available to support land use and water resource planning in the region, in running scenarios for different options for land use change. Advice is that application is best suited to predicting the impact of large land use change projects on the receiving water body (the Peel-Harvey Estuary). For example, it will be suitable for regional land use and water resource planning, but is not suitable for predicting the localised impact of individual urban developments. A single query in respect of land use change at sub-catchment scale would require about 2 weeks work.

The more suitable model for sub-division planning is MUSIC, which is a derivation of the MIKE-SHE model. This will be able to support drainage and water management planning.

In supporting regional land and water use planning, the operation of SQUARE can identify sub-catchments where further investigation is warranted (i.e. what is required to reduce export by x), and can be used in conjunction with land capability maps in planning land use change. The use of the Ecotones model can then provide cost information. SQUARE can also be used to determine the impact of climate change.

Activities involving application of SQUARE follow.

- Average annual nutrient loads into the Peel-Harvey have been modelled and calibrated, catchment and by source. These data are shown in Table 3-1. These whole of catchment data provide a snapshot of the N and P fluxes in the catchment, and overall sources.
- The Department of Planning and Infrastructure has commissioned (and funded) DoW to use the model in predicting environmental outcomes from land use planning options in the Southern Metro Peel Scheme. The model has been used to predict the impact (in terms of water and nutrient flows) of additional residential and industrial development on the areas waterways.
- Some modelling has been done in the Point Grey area, which is on the eastern side of the Peel-Harvey Estuary.
- Training has been provided in the use of SQUARE. This has been run by the DoW modelling staff from the Water Science Branch, with 19 people attending. The training session provided the detail in regards to the capability and context of the SQUARE model developed, its evolution over time, capabilities limitations and how the stakeholders can access the information from the model.

- The scenario work done in the Swan Canning catchment has shown that it is very hard to reduce N & P levels in stream flows into receiving water bodies. Nitrogen is harder to reduce than phosphorous, with soil amendments being the most useful tool in management of phosphorous.

Table 3-1 Average annual loads to Peel-Harvey Estuary

Factor	Nutrient (tonnes)	Catchment							Total
		Dirkbrook	Estuary	Harvey	Lower Serpentine	Murray	Nambellup	Serpentine	
Fertiliser input	TP*	96.57	399.27	544.47	115.19	3,708.45	156.15	572.29	**5,592.40**
	TN**	722.66	2,633.46	3,191.61	704.46	21,459.96	1,060.09	3,352.31	**33,124.56**
Septics input	TP	0.10	0.30	6.61	7.64	6.63	0.55	12.97	**34.79**
	TN	0.51	1.50	33.07	38.20	33.13	2.73	64.83	**173.95**
Total input	TP	96.67	399.57	551.09	122.83	3,715.08	156.70	585.25	**5,627.19**
	TN	723.17	2,634.97	3,224.67	742.66	21,493.09	1,062.82	3,417.14	**33,298.51**
Total output	TP	5.59	36.14	47.19	4.27	10.41	10.46	27.34	**141.40**
	TN	51.05	100.37	274.01	17.58	255.27	42.96	145.25	**886.49**
Total output (as % of total input)	TP	5.78%	9.05%	8.56%	3.48%	0.28%	6.68%	4.67%	**2.51%**
	TN	7.06%	3.81%	8.50%	2.37%	1.19%	4.04%	4.25%	**2.66%**

Source: Information provided by Peta Kelsey, Department of Water
*TP – total phosphorous **TN – total nitrogen

Sampling Analysis Plan and Monitoring

A network of Load Measuring Units (LMU's) as well as a grab sampling routine were undertaken throughout the catchment to provide the spatial and temporal resolution of data required to assess trends in water quality in the Peel-Harvey catchment; and effectively operate the SQUARE model. Towards the latter half of the project some rationalisation in sampling had to occur due to the rate at which funds were being expended on sample chemical analysis.

P-H Water Quality Data trend analysis completed to draft stage and information added to Statewide River Water Quality Assessment Database http://apostle.water.wa.gov.au/idelve/srwqa/index.jsp - the processing of the information for the Statewide River Water Quality Assessment Database was considered and reported by DoW Water Science to be an achievement of the output.

3.1.4 Evaluation Findings

From the Final Report

A final report prepared by the PHCC at the completion of the funding period noted:

the previous LASCAM model updated to new SQUARE architecture, several underlying datasets such as land use, streamflow, rainfall etc were updated including the introduction of LIDAR data and the model recalibrated to accurately include nitrogen flux. A re-delineation of catchment boundaries was undertaken.

A comprehensive water quality monitoring program was operated in the catchment for a period of 2.5 years with significant data sets developed and information included in the WIN data base and made accessible via systems such as the as State-wide River Water Quality Assessment Database.

The future of SQUARE

A review of the literature, interviews with people with intimate knowledge of SQUARE, its history, and potential, and feedback from the Discussion Panel provided the following information.

Ownership and operation

The Department of Water, as the owner of SQUARE would like to release the model for wider use, although on-going support is required. It is estimated that model maintenance (e.g. updating as land use changes, and as more stream flow data become available) will require about 0.25-0.30 FTE. As at July 2009, on-going funding was guaranteed for only three months. This requirement has been challenged with an alternative view being that annual upgrades would require about 0.08 FTE (one person-month).

Further model development

Further development could include other parameters of water quality including BOD, dissolved oxygen, and pH. Model operators would also like to build a tool for smaller areas that would be more useable for Local Government Authorities (LGAs).

Uses and users

There will be two levels of users, as follows:

- For development of scenarios in linking land and water use planning, and
- For use at expert level in contributing the design and refinement of other mathematical models.

Essentially, the future of SQUARE will depend upon the level of demand from public and private users. Further, it will also rely on on-going water quantity and quality monitoring throughout the catchment to provide the data fro re-calibration. This monitoring will enable point sources to be identified, to avoid excess 'trust in the model' and to continually compare real and modelled impacts of land use change.

Next steps

A need has been identified by one person interviewed for a long-term marketing and development strategy that:

- identifies priority areas in the catchment for further investigation (i.e. where Local Planning Schemes are being modified);
- develops a strong connection with LGAs and major land uses;
- develops a link with a graphical interface;
- provides more training opportunities in interpretation of output for LGAs; and
- provides for model maintenance, new data incorporation and continuous validation (testing of assumptions).

Commitment to model use and development could be secured through a Memorandum of Understanding (MOU) between the Peel Development Commission, the Department of Water, the Department of Environment and Conservation and the Department of Planning and Infrastructure. It has been suggested that LGAs using the model would be advised to obtain model operation services on contract, and instead focus on developing skills in interpreting and using the model outputs.

Discussion Panel

It was generally agreed that the work completed for the modelling component represented an advance in the knowledge of the water and land use impacts in Peel-Harvey system and that it is providing fundamentally important information. The question that arose for the Panel was how the information within, and provided by the SQUARE system could be 'translated' for everyday use at the local level. Until that was achieved, it was considered by the Panel that the potential to influence practice change through use of the model was limited.

Currently, with the system unable to operate at the sub-division scale, there seems little likelihood that it could influence the decisions of local government planners or the property development industry. It had been hoped that the modelling might link Local Planning Policy in setting targets for developments but this has not eventuated and is considered by some with close involvement with local government to be unachievable.

The Discussion Panel considered that use of SQUARE is unlikely to be in demand from local government in its current form. A suggestion was made that was supported in principle by the Panel for the system, calibrated for Peel-Harvey, to be located in Mandurah and administered by the Department of Water. In this way local governments in the region could more readily access the outputs of the modelling work and better understand the impacts of some of the their decision-making. If this option were pursued it would be necessary to promote the limitations of the system (i.e. does not operate at the paddock-scale). A more collaborative working relationship could be established that saw local government's contributing data for input to the system, and benefiting from the information provided out of the system.

The Discussion Panel was in agreement that further investment into the modelling and decision support system to maintain the currency of data provisions was worthwhile not only for the Peel-Harvey system but also for wider knowledge building.

3.2 Component WQ01b - Water Quality Improvement Plan (Nitrogen)

3.2.1 Objectives

The Environmental Protection Authority published the *Water Quality Improvement Plan for the Rivers and Estuary of the Peel-Harvey System - Phosphorous Management* in November 2008. This plan (as the name suggests) aims to reduce phosphorous loading into the waterways through changes to agricultural and urban practices and land use planning.

It had been generally accepted that the limiting nutrient necessary for the growth of algal blooms in inland water systems is phosphorous and therefore management of the problem of algal bloom has been based upon the premise that phosphorous-load reductions to waterways is the key control factor (Algal Management Strategy, 1993). However, more recent work highlighted the role that nitrogen

plays in encouraging algal growth, and this component of the Program was designed to develop a 'nitrogen version' of the Water Quality Improvement Plan.

Outputs for this component of the project were noted as:

1. Development of a 'nitrogen-based' nutrient management plan/Peel-Harvey catchment plan to build on the existing WQIP-P and Peel-Harvey Catchment NRM Plan; and
2. PHCC website updated with project information and outputs to assist in information distribution and consultation.

3.2.2 Evaluation Findings

The final report prepared by the PHCC provided the reasons that this component was unable to be completed. Funding for this component was returned unspent.

Their report (PHCC 2009) notes:

It was hoped the PHCC could access the scientists/consultants involved with the original CCI [Coastal Catchments Initiative] project as they have the background information already complete and understand the dynamics of the catchment. This would represent a significant cost saving in comparison to engaging completely new consultants. A comparatively small budget was available for this component so it was feared that little could be achieved for this amount with new consultants starting the process from the beginning, fearing the background research would use a significant proportion of the allocated budget.

Further, the same scientists previously engaged on the Peel-Harvey Coastal Catchments Initiative (P-H CCI) were working on and progressing the N and P CCI projects/WQIP's for the Swan-Canning and Vasse-Geographe systems; the information they were developing is of direct relevance to the P-H system and represents the leading edge of nutrient management practice and investigation in WA; it was feared to start the development of the P-H Nitrogen WQIP concurrently would result in a duplication of process, on a much reduced budget, and hence would constitute a significant waste of funds. Due to delays in completing the Vasse-Geographe and Swan-Canning work, these same people, the preferred contractors, have not been available to start the Peel-Harvey work. The release of a tender had been delayed to allow these scientists to quote on the project and the PHCC was subsequently informed there would be no availability before December [2008] due to the on-going commitments to government contracts.

An essential tool in the development of the Nitrogen WQIP for the Peel-Harvey was the updated SQUARE model, calibrated for nitrogen. The delays in the progress of component A have also been a factor in the lack of progression / options for component B.

It was also hoped the P-H Phosphorus WQIP would be released in it [sic] final form prior to the beginning of the N WQIP as the information is required. For multiple reasons, including a change of government at the state level [this] had not occurred until late December.

No investigations (as part of the evaluation) were conducted for this component.

3.3 Component WQ01c - Rural Drainage and Agricultural BMPs

3.3.1 Developing Rural Drainage BMPs

Objectives

The Drainage BMP aspect of the project was designed to monitor and analyse nutrient and sediment transfer in the drainage systems of two paired catchments to assess and further develop effective drainage BMPs including fencing, streamlining, maintenance regimes and appropriate channel form. This aspect was the responsibility of the PHCC who utilised a proportion of funding to engage additional staff to undertake works required. The work was undertaken principally by Jesse Steele, who was engaged as a Rivercare Officer at PHCC.

The product from the investment is a Final Report entitled *Management of diffuse water quality pollution in the Peel-Harvey Coastal Drainage System. A strategic approach to implementation of Best Management Practices* (Peel-Harvey Catchment Council 2008a).

Background

As an initial step, the Peel-Harvey Catchment Council prepared a literature review as part of the larger study to examine the design and operation of the drainage systems of the Swan Coastal Plain (Steele, 2006). The review was aimed at:

- highlighting the narrow focus and detrimental impact of current drainage management practices on water quality including nutrient flux and sediment transport;
- reviewing current knowledge of water quality improvement techniques around rural drains both internationally and in south-western Australia;
- considering the potential use of buffers and wetlands in the Peel-Harvey catchment, especially as they relate to soil type; and
- considering how well buffers and wetlands work; examining whether past monitoring strategies are sufficient to assess their impact and if not how assessment may occur.

The review found that the drainage system is

> "a highly degraded and modified system where works along drainage lines need to be prioritized due to limited funding, where institutional change in drainage management practices is needed and where the downstream receiving waterbodies are of international ecological significance" (p. 82).

Steele (2006) highlights the inadequacy of implementing drainage reform through a piecemeal and uncoordinated approach that is not informed by reliable technical data. The result, he argues, is the development of a drainage system with no over-riding guiding design criteria.

Activities supported by the SWCC Investment

Developing a strategic approach to drainage management

The aims of the second aspect of the project, as stated in the Final Report were:

1. Develop a classification scheme for the coastal drainage system to document differences in channel character and functioning.

2. Characterise sediment as a pollutant, channel forming material and important transport and storage mechanism for nitrogen and phosphorus.
3. Catalogue Best Management Practices available and the appropriateness of these BMPs to different channel classes.
4. Evaluate riparian buffers as a Best Management Practice.
5. Investigate the role of in-channel sediment in controlling nutrient fluxes.

Findings from the work undertaken

The conclusion to the *Management of Diffuse Water Quality Pollution in the Peel-Harvey Coastal Drainage System: A Strategic Approach to Implementation of Best Management Practices* report (PHCC 2008a) states that it was 'commissioned primarily to answer two questions.

- How can catchment works be targeted so that the impacts of these works are maximised?
- Does revegetation of drainage lines produce significant water quality benefits?' (p. 188)

The work undertaken pulled together a large amount of existing work on nutrient and water fluxes, and management of drains and water at paddock scale in classifying the nature of the diffuse nutrient sources and pathways into the drainage system. The work has identified the importance of sediment movement within the catchment, with a recommendation that targets for this should be set alongside existing nutrient targets.

The work has also defined a major distinction between sandy and clay catchments in how nutrients and sediments move, and the implications for management. This has enabled a strategic approach to where and how BMPs should be implemented for maximum effectiveness, and the likely benefits in sediment and nutrient supply and transport identified. However, further evaluation of how N and P are managed in a local context will be required. Additional analysis of the nutrient store in the rural drainage system is required to determine, how large and how mobile the nutrient store is, and what impacts this may have on future nutrient load targets. Finally, further work is required to determine nutrient transformation processes that are occurring along the drainage system. The predominance of 'sediment P' in vegetated zones has been reported in this and other reports. There is a need to ensure that riparian buffers will not increase the delivery of sediment P to sensitive downstream water-bodies.

Evaluation findings

Although there are some remaining questions, the findings on 'what works and where' should increase landholder and drainage manager confidence in implementing BMPs to reduce sediment and nutrient movement. Further, the classification system can be used in identifying hotspots for targeted investment. There are complementarities between the work done in this study and the modelling work done in WQ01a in that the classification system will be used to contribute assumptions into further modelling, whereas the modelling can be used to predict the impact of implementing BMPs on nutrient flows at sub-catchment levels.

Three of the recommendations in the Report summarise the challenge facing strategic and targeted implementation of BMPs in the Peel-Harvey Catchment. They state:

5. 'Implementation of most of the water quality BMPs in this report will require reform in the way the drainage system is managed by the drainage service provider (Water Corporation). More importantly new incentives and strategies for landowners are required as the most successful place

to manage water quality issues is at the paddock (source zone) scale which is managed by the landowner.

6. BMPs are not a substitute for poor land management techniques. Monitoring has shown riparian buffers will not protect the drainage system from poor fertiliser practices. There remains a strong need to continue to engage landholders in evaluation of their fertiliser practices.

8. The drainage system provides a range of opportunities including nutrient assimilation, ecological restoration, water reuse and flood mitigation. To achieve such benefits the planning, funding and on-ground implementation needs significant changes.' (PHCC 2008a, p. 191)

Thus, while the SWCC investment has developed a sound and strategic approach to categorising and recommending BMPs throughout the Peel-Harvey drainage system and associated waterways, implementation remains a challenge, given that it requires institutional change on the one hand, and landholder behavioural change on the other.

An associated concern amongst those interviewed is that the momentum towards land use and water resource management reform generated through the projects in the WQ program will be lost due to lack of long-term funding to take the recommendations through to implementation. URS has recently been advised that funding (estimated $ million) has been provided by the Department of Water to pursue actions identified in the WQIP-P. At the time of preparing this report, how that funding is to be allocated is unknown. How it is allocated may have implications for how the investment by SWCC in the WQ01 activities can be realised in terms of changed management of land and water resources in the Peel-Harvey Catchment.

Institutional change

Management of the drainage network by the Water Corporation is a controversial subject. It has been addressed in a number of studies and inquiries (see for example, Drainage Reform Group 2004; Ironbark Environmental 2007; Star *et al.* 2004; and URS 2003), but until now there has been no change to the licence conditions issued by the Economic Regulation Authority (ERA) under which the Water Corporation delivers the drainage management services. These conditions do not address water quality or sediment loads entering or being conveyed through the drainage system.

The most recent investigation into drainage governance was also commissioned by the Peel-Harvey Catchment Council as part of the Design and Operation of a Coastal Drainage System project (W6-01). This project (Ironbark Environmental 2007) was also a strategic initiative of the South West Catchments Council funded by the Natural Heritage Trust (NHT) and the National Action Plan for Salinity and Water Quality (NAP). The Report, which addresses drainage governance and system design, is strongly complementary to the work done in this project on management of diffuse sources of nutrients. High priority actions recommended include:

- A controlled trial in the catchment of modified gazetted drainage management practices to commence within two years of report endorsement.
- Development of a Draft Regional Drainage Policy supported by a Regional Drainage Advisory Committee.
- Trial preparation of at least one Sub-Catchment Drainage Management Plan to commence within two years of report endorsement.
- That a public review and assessment of the drainage system's effectiveness be conducted.
- Surveying of the gazetted drainage system to establish current conveyance capacities to be completed within 2 years of report endorsement (Ironbark Environmental 2007).

It is likely that implementation of drainage management reform as recommended in Peel-Harvey Catchment Council (2008a) and Ironbark Environmental (2007) will rely largely on the Department of Water's program in preparing drainage and water management plans to cover the major urban expansion areas across the Perth to Peel and South West regions. The Department is using the PHCC reports to support this work. Additionally, regional water plans are being prepared to bring together existing statutory water management, including drainage and floodplain management plans into one planning document based on a catchment management approach (Department of Water *pers comm.*). However, it is outside the scope of this evaluation to speculate on the specific impact that these planning processes will have on drainage management in the Peel-Harvey Catchment.

Landholder behavioural change

Changing land holder behaviour, particularly in the areas of fertiliser practices, riparian management and pasture management is more challenging again. The recommendations for changes in fertiliser management are not new (see EPA 2003, Weaver *et al*. 2006). However, the PHCC (2008a) Report has raised even higher, the importance of environmentally sound fertiliser management in reducing nutrient movement into the drainage system, and ultimately into the estuary.

Effective fertiliser management is not straightforward. It involves knowing when, where and how to apply the right fertilisers at the right rate to supply the correct nutrients to maintain production, reduce fertiliser expenses and minimise off-farm environmental effects. Best Management Practices for fertiliser management include:

- conducting regular soil and/or tissue testing to determine the required nutrients to meet crop, pasture or animal needs;
- applying fertiliser after the break of season, preferably in split applications;
- applying fertilisers in spring when nutrient requirements are greatest;
- having buffers between fertilised areas and watercourses;
- calibrating your fertiliser spreader;
- avoiding fertilising when intense rainfall is forecast;
- avoiding fertilising firebreaks;
- applying nutrients according to the recommendations of soil or tissue testing;
- providing covered areas for stored fertiliser; and
- using nutrient budgeting in making fertiliser decisions (see URS 2009).

Although the recommendations in PHCC (2008a) and other reports are clear, and the benefits of implementation becoming demonstrable, there is no evidence that voluntary uptake of BMPs will be sufficient to have a meaningful impact on nutrient and sediment movement. This is not a new finding (see URS 2005), and advice from those interviewed for this evaluation stressed that a long period of working with land holders in building confidence in the BMPs, together with financial incentives will be required for implementation to occur. However, the same people note with concern the lack of long-term funding, either for the relationship building with landholders, or the payment of incentives for implementing BMPs.

Discussion Panel

The Discussion Panel acknowledged the academic rigour evident in the reports prepared by Jesse Steele and the contribution that his work has made to better understanding drainage impacts and options in the Peel-Harvey region.

In respect of rural drainage the Panel concurred with the evaluation findings above particularly with regard to the need for institutional reform. There was some question as to the political will to implement any major drainage reform program but a recognition that a shift in the Government's position on drainage governance is a necessary part of the overall process of improving water quality in the Peel-Harvey catchment and waterways.

Moving into the future, the Panel considered that political engagement was key to bringing about change. Some significant investment will be required to implement much of the drainage modification recommended in the reports generated through the WQ01 Project and there will be a need to investigate options to influence Water Corporation decision making either through the ERA or collaboration. The recommendation from the Panel is that the Department of Water is the agency best positioned to drive future initiatives.

3.3.2 Perennial Pastures in the Peel-Harvey Catchment

Objective

The suggested role for perennial pastures in nutrient management provided the context for the investment by SWCC into further perennial pastures research and demonstration, through WQ01c. The project was designed to develop two high profile demonstration sites with appropriate monitoring programs to measure the effectiveness of the use of perennial pastures in reducing nutrient losses and increasing productivity. The basis for comparison is the existing dominant annual pasture system. The demonstration sites were to be used as the focus for education and extension programs for farmers with the aim of reducing nutrient loss from cattle grazing but similarly applicable to all grazing areas. Responsibility for this component rested with DAFWA.

Background

Through the Coastal Catchments Initiative project '*Evaluation and implementation of agricultural Best Management Practices (BMPs*)', a budget for phosphorus was developed by identifying all P sources, transfers and sinks (Weaver *et al*. 2006). The budget is presented below in Table 3-2.

Table 3-2 Phosphorus budget for the Peel-Harvey Catchment

Item	Phosphorus (t)	Phosphorus storage (t)	Phosphorus out (t)
Fertiliser applications	2000		
Non-fertiliser inputs (e.g. stock feed)	610		
Products (food, waste)			540
Storage in soils		1200	
Storage in drains and waterways		730	
Discharge to estuary via streams			140

Adapted from: Weaver *et al.* (2006) t = tonnes

Total exports to the estuary were estimated at 140 tonnes annually, with the majority of the phosphorus, 82 per cent (116 tonnes), coming from agricultural sources, with most of the remainder (17%) coming from urban sources. Of the agricultural sources, grazing of beef cattle contributes 68

per cent and dairy enterprises 17 per cent. Intensive point source industries of piggeries, feedlots and poultry sheds contribute 5 per cent and other irrigated sources are indicated to contribute 5 per cent. Overall, grazing activities contribute more than 91 per cent of the total exports from agriculture.

The CCI work recommended perennial based pasture systems as one of the few options for nutrient management in the catchment that could potentially provide a significant reduction in nutrient movement while also providing a positive economic outcome to the grower. The use of perennial pastures was subsequently identified in the WQIP-P as a Best Management Practice to increase in situ phosphorous use and hence reduce discharges to the environment (see Section 4.1.6 of WQIP). The WQIP-P recommends the establishment of an extension, demonstration and incentive program to promote the uptake of perennial pastures (e.g. kikuyu, paspalum, couch, rhodes and veldt grass).

The Coastal Catchments Initiative (CCI) supported a range of activities that researched aspects of perennial pastures incorporation into grazing systems in the catchment. As part of the CCI project, a BMP audit undertaken by Lavell *et al.* (2004) found that half of all properties in the Peel-Harvey catchment area had perennial pastures with 33 per cent growing kikuyu, 14 per cent growing Rhodes grass and 11 per cent growing couch grass. Of these properties only 25 per cent of their land was given over to perennials. From this the researchers determined that 12.5 per cent of the catchment had turned to the use of perennial pastures.

Activities supported by the SWCC Investment

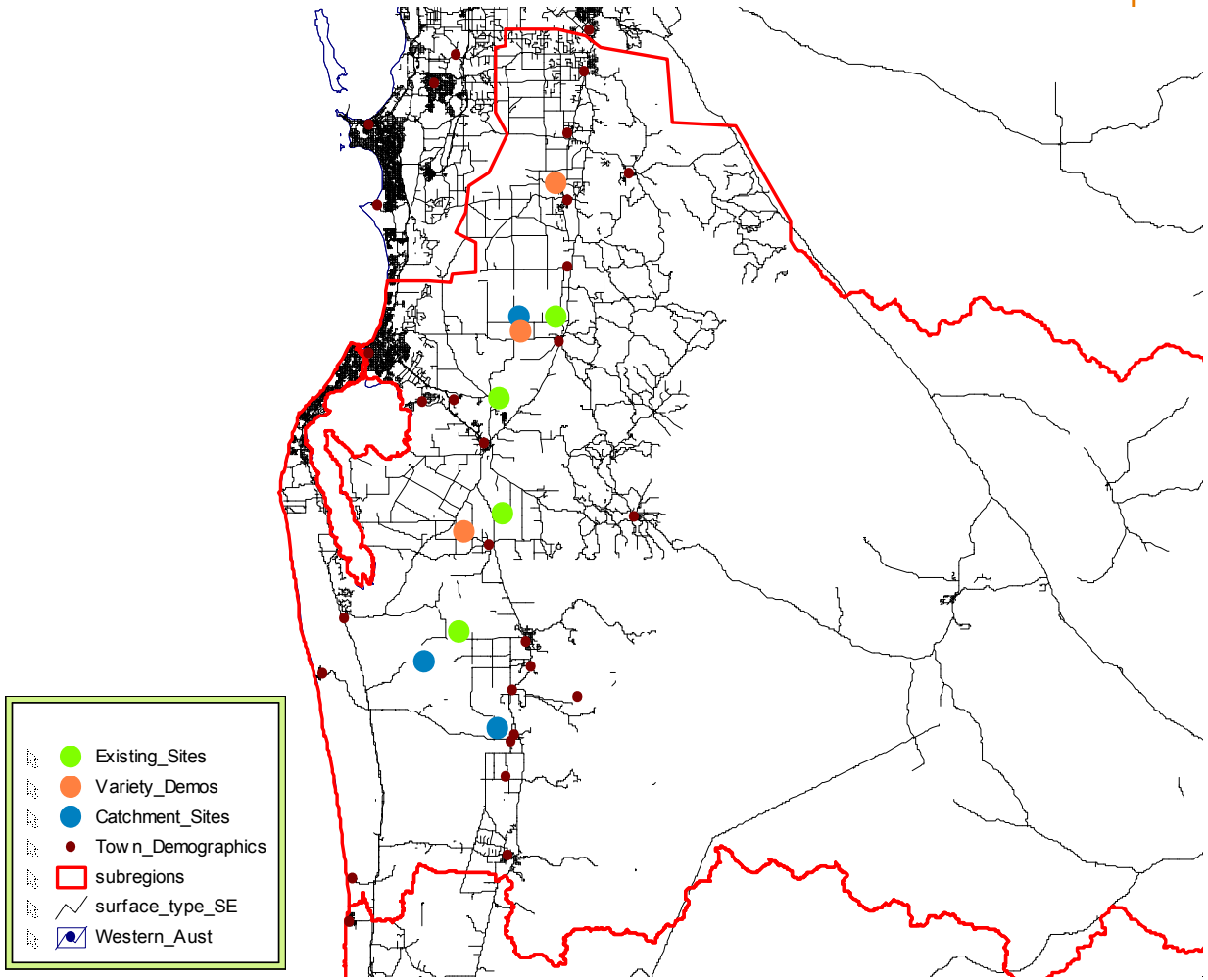
Twelve outputs were planned for this component. The planned outputs are compared to achievements in Table 3-3. Figure 3-1 below shows the location of demonstration sites established for this project.

The project has confirmed that perennial pasture systems can be a technically feasible option in the Peel-Harvey Catchment with pasture production and quality being very similar to annual pasture systems. However, in discussion with the DAFWA staff involved, further development work is required to determine their role in farming systems, long-term management requirements, economic value and contribution to reducing nutrient losses off-site. These are dealt with separately in the sub-section below.

Table 3-3 Planned and actual outputs in perennial pastures work

Planned output	Actual output
1. Perennial pasture demonstration sites established	7 demonstration sites established, including 3 variety (18 different varieties) demos (and others below) All demonstration sites were used as part of field days and field walks.
2. Development of field site monitoring program for perennial pasture demonstration sites established in the Peel region.	2 major M&E sites, with perennial and annual pasture swards established. Data also collected from 2 sites established in a previous project
3. Sampling and Analysis plan developed for Agricultural BMP Perennial pasture monitoring program undertaken in the Peel-Harvey catchment.	2 paddock scale monitoring sites established with growers who have perennial systems on a large scale as part of normal practice. Measurements of production, quality and environmental benefits taken
4. Research report developed outlining findings of Agricultural BMP perennial pasture trials undertaken in the Peel-Harvey Catchment.	Reports on individual sites developed and distributed at Field Days. These do not appear to be available electronically on DAFWA or PHCC websites.
5. Written material developed to support field trials undertaken in relation to Agricultural BMP perennial pasture demonstration sites established in the Peel-Harvey Catchment.	As above
6. Displays developed and exhibited at regional agricultural shows in the Peel-Harvey catchment.	Poster displayed at local shows in the Peel-Harvey Catchment
7. Media opportunities achieved in local/agricultural media in the Peel-Harvey Catchment to promote perennial pasture demonstration sites.	6 articles published in the *Agmemo*, and local newspapers, and one article in the Hoofbeats magazine
8. Development of BMP Guidelines associated with drainage management and perennial pastures in the Peel-Harvey catchment.	DAFWA farmnote on perennial pasture establishment on the Swan Coastal plain has been updated (2007)
9. PHCC website updated to include project detail and outputs when completed perennial pasture demonstration sites established.	Not yet available on the PHCC website
10. Two field days held in the Peel-Harvey catchment to raise awareness and inform Agricultural community on benefit of and methodologies required for the establishment of perennial pastures.	15 separate presentations at seminars, field days and field walks to a total of 450 people. 9 of these events were held in the Peel–Harvey Catchment. Significant one-to-one assistance given to many growers in the areas follow-up to field days. Directly involved with establishment of 30 ha new perennial pastures.
11. Monitoring programs will be established / significantly enhanced in the Peel-Harvey Catchments for both the rural drainage and Agricultural BMP (existing BMP sites) aspects of the project (Repetition of outputs in 07 represents temporal enhancement of monitoring program).	As above
12. Water quality data analysis reports developed for Agricultural BMP aspects of project undertaken in the Peel-Harvey Catchment.	Work has begun on assessing the value of perennial pastures on nutrient run-off. No information yet available in public domain

Figure 3-1 Trial and demonstration sites - Perennial pastures



Source: David Rogers pers comm.

Evaluation findings

Incomplete findings and conclusions

In reporting on the project outcomes DAFWA staff noted that the work on assessing the ability of perennial pastures to reduce the movement of nutrients off site and into waterways had produced some interesting initial findings.

- There has been higher nitrogen (N) capture by perennial pastures (compared to annual pastures), with a very significant difference early in the winter growing season. This is explained as perennials being able to respond quickly to early rains in capturing N that has mineralised over the summer period, compared to annual pastures which are too slow growing to be able to capture available N.
- Monitoring to date has shown no increased capture of phosphorous (P) by perennial pastures. Researchers are hesitant to say that there has been no effect, as perennial root systems in the demonstration sites may not yet be well enough developed. Further, perennial pastures have a lower P requirement, and there may have been some over-fertilising at the time of establishment.

These findings highlight that data collection at the demonstration sites needs to continue longer than the timeframe of the project to provide a clear understanding of nutrient fluxes in a perennial pasture, as compared to an annual pasture. This will involve analysing the data using the STELLAR model which will enable comparison of the systems in a whole farm/ whole paddock scale nutrient budget.

Developing the farming system

There is work to be done in determining what the production system will look like with a significant component of perennials in the farming system. Further, economic analysis of the pasture systems is underway, with a whole farm program being analysed using the DAFWA Program STEP. This is important work, in that it will determine the economic value of including perennials in a farm system, and will also contribute to the design of an optimum system.

This will then enable the documentation of Best Management Practices which is requirement of the project. URS was unable to locate such documentation on either the DAFWA or PHCC websites.

Funding requirements

There is limited funding support for this on-going work, which is required if the value of the SWCC investment is to be fully realised. DAFWA officers advise that a small amount of funding has been provided by the Department of Water, and a submission has been put forward for State NRM funds.

Landholders and approach to change

The broadacre grazing industry (either beef cattle or horses) in the Peel-Harvey Catchment is atypical in that only an estimated 20 per cent of growers are fully reliant on farm income. There are a fewer number of very small grazing enterprises, which are either horse enterprises, or 'hobby farms'. Most growers have small farms (200-250 ha) and rely on off-farm income to supplement farm income. As such, there is less incentive for improving the production system through adoption of best management practices, although DAFWA staff report that people in this landholder category are keen for information.

However, in the survey completed in 2004 (Lavell 2004, and Lavell *et al* 2004, as reported in URS Australia 2005), 35 per cent of those interviewed think they are currently practicing BMPs and will not

or don't need to change; 16 per cent want funding to encourage them to adopt BMPs and 8 per cent think they are too old. A further 8 per cent would like training to tell them what the BMPs are and what ones would be suitable to their properties. In short, a majority of those interviewed said nothing would persuade them to change and that they were content with current management practices and profits.

In respect of fertiliser management, 46 per cent of farmers believe their fertiliser practices are not affecting nutrient levels in water leaving their properties - they believe their management practices are having no negative impact (social, economic and / or environmental) on themselves, their neighbours or anybody in the wider community (Lavell 2004, and Lavell *et al* 2004, as reported in URS Australia 2005).

Recommendations to achieve change

This situation is not encouraging for a project that is pushing a *very* significant change in the farming system from annual to perennial pastures, and highlights the challenge in achieving sufficient change to have a beneficial impact on nutrient fluxes in the catchment. If it is not possible to demonstrate a sizable economic benefit from the adoption of perennials, then it is very unlikely that widespread adoption will occur. Conversely, as noted above, there are landholders in the catchment eager for information. Further, although changed grazing management (continuous to rotational management) requires new learning, DAFWA staff advise that those who have made the shift find it an easy farming system to operate (see further comment below).

Implementation measures to achieve adoption of BMPs, based on an evaluation of their efficiency and effectiveness in reducing nutrient movement off-site, and their economic value to the landholder were developed through the CCI project (see URS Australia 2005). The following actions relevant to the adoption of perennial systems are recommended to achieve cost-effective outcomes from investments in nutrient management in the Peel-Harvey catchments.

- If a perennial pastures farming system is shown to have very significant economic benefits, then traditional extension techniques (demonstrations, field days, training sessions, workshops, hard copy and web-based information) targeted to deliver information on BMPs and their benefits to farmers is required to achieve sub-catchment water quality targets.
- If a perennial pastures farming system is shown to be economically marginally better than annual pastures (or economically more costly), and is shown to be very much more effective at managing nutrients, some form of incentive program will be required. Efficiencies in this approach of direct investment can be obtained with the use of a Natural Resource Management (NRM) 'auction system' to target nutrient reduction investments. This system can be used to ensure environmental benefits are delivered at least cost, and that investments are targeted to sub-catchments where nutrient reductions can be achieved at least cost.
- If a perennial pastures farming system is shown to be economically marginally better than annual pastures (or economically more costly), and is shown to only marginally better in managing nutrients, there is no value in pursuing the option.

Determining which of these actions (extension, incentives, no action) should be pursued in further work with perennial pastures can only be decided after further work in determining the economic and environmental benefits and adoptability of perennial pasture systems. Without completing the work that is in train (see previous sub-sections), the full value of the investment to date will not be realised.

Discussion Panel

The value of the research

The project undertaken for the WQ01 has, to some extent, challenged some of the long-held assumptions (contained in the WQIP-P and other information sources) about the potentiality for perennial pastures to effect significant change in nutrient loss from pastures, in comparison to the current situation with annual pastures. In this respect, the project has made (and will make) a useful contribution to validating (or questioning) assumptions made in the WQIP-P. Further, the productive relationship established between 'science and practice' in the establishment of the demonstrations will yield more quality information as the science informs practice and vice-versa. However, for the full value of the project investment already made to be realised, on-going monitoring of established sites, and further applied research will be required.

Prospects for adoption of perennial pasture-based farming systems

Based on advice from Panel members, the larger landholders with grazing enterprises (one of the largest growers in the Peel-Harvey region is an operation owned by a major resources company) are 'set in their ways' and have not historically responded to calls for change. Any calls for changed practices will also come up against perceptions that annual pastures are easier to operate and that rotational grazing systems are cumbersome (although growers who have adopted the rotational systems suggest that once established the practices are simple to maintain).

The problem of influence is further compounded by the withdrawal over many years of traditional extension techniques. Looking to the future, the Panel considered that the development of grass roots extension practices to change the behaviours and knowledge of people in the catchment was crucial. These would need to be supported with a range of publications providing information to farmers to encourage the practice change required. At present there does not appear to be political/government commitment to the provision of extension. Delivery of extension might be achieved through regional or sub-regional resource management or catchment groups. Obtaining a commitment to, and funding of, extension activity would be beneficial to spreading the message about the benefits of perennial pasture systems. While SWCC can tackle this at some levels through its networks and future projects, funding constraints may limit how much effort can be delivered.

The Discussion Panel also emphasised the matter of financial benefit (see above). The Panel agreed with the evaluation finding that the economic benefit for instituting a perennial system would have to be shown as very significant to encourage widespread adoption by farmers.

3.4 Component WQ01d - Urban Drainage Peel-Harvey

3.4.1 Objectives

The purpose of this component of the project was in two parts:

a) to facilitate adoption of the Water Sensitive Urban Design (WSUD) local planning policy (LPP) by six of the local governments (Rockingham, Kwinana, Serpentine-Jarrahdale, Murray, Waroona, Mandurah) within the Peel-Harvey Coastal Catchment[1]; and
b) to improve the capacity of local governments to identify and implement retro-fitting activities associated with urban stormwater.

[1] This evaluation has not investigated implementation of the LPP in Kwinana or Rockingham

Essentially the first part of this component focused upon new development while the second part focused on existing structures.

Outputs for component D of the Peel-Harvey Water Quality project were listed as:

1. Water sensitive design tours conducted of WSD installations within the Peel Region;
2. Water sensitive design self drive tour brochure, with full explanations and signage developed for WSD installations within the Peel region model stormwater management plan developed for adaptation by LGs;
3. Media opportunity related to stormwater retrofit / stormwater BMP sites and/or greater project;
4. PHCC website enhanced to include project detail and outputs;
5. Local governments assisted to implement improved governance practices in relation to WSD planning and stormwater management for existing areas within the Peel-Harvey Catchment;
6. Improvement of drains for water quality benefits; and
7. Storm water quality control devices constructed / stormwater retrofitting BMP demonstration sites established for improving water quality in the Peel-Harvey Catchment.

3.4.2 Background

Principles of Water Sensitive Urban Design

The National Water Commission has defined the Urban Integrated Water Cycle Management as: the integration of water supply, sewerage and stormwater, so that water is used optimally within a catchment resource, state and national policy context (see Figure 3-2). It promotes the coordinated planning, development and management of water, land and relation resources (including energy use) that are linked to urban areas and the application of WSUD principles within the built urban environment.

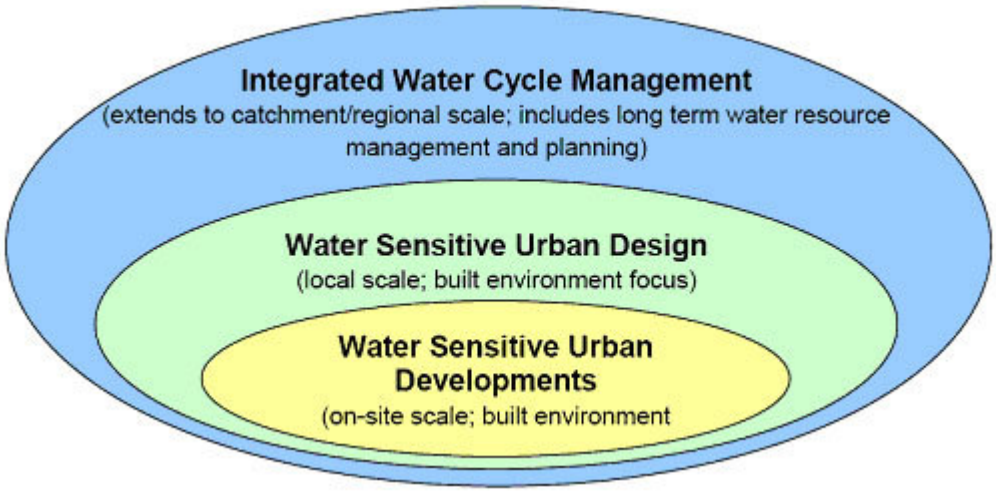


Figure 3-2 Urban integrated water cycle management

Water Sensitive Urban Design seeks to minimize the extent of impervious surfaces, integrate stormwater and landscaping water flows and mitigate changes to the natural water balance.

National Water Initiative defines Water Sensitive Urban design as: the integration of urban planning with the management, protection and conservation of the urban water cycle that insures urban water management is sensitive to natural hydrological and ecological cycles.

State Government Policy Context

A number of Western Australian State Government policies provide the framework for urban drainage and water sensitive design generally, and specifically in the Peel-Harvey catchment:

- State Water Plan (2007);
- State Water Strategy (2003);
- Government response to the Irrigation Review (2006);
- A Blueprint for Water Reform in Western Australia (2006);
- Stormwater Management Manual for Western Australia (2004);
- State Planning Policy No. 2: Environmental and Natural resources (2003);
- State Planning Policy No. 2.1: Peel-Harvey Coastal Plain Catchment (2003);
- State Planning Policy No. 2.9: Water Resources (2006);
- *Better Urban Water Management;*
- Peel Region Scheme (WAPC); and
- Environmental Protection Policy: Peel-Harvey Estuarine System (1992).

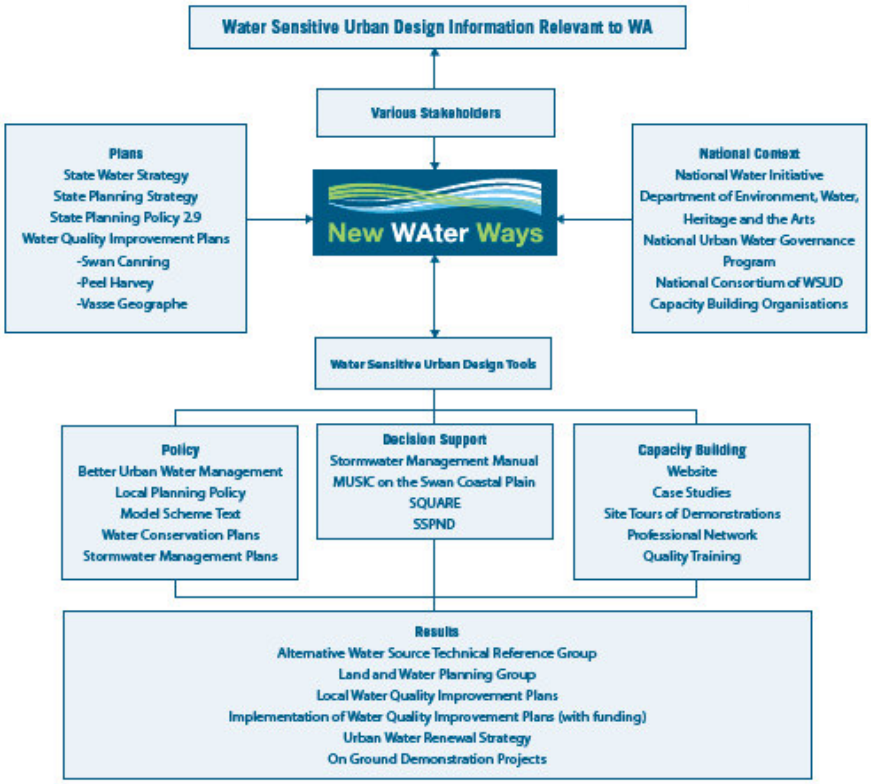


Figure 3-3 Policy Context (source: New Water Ways, 2009)

The history of WSUD in the Peel-Harvey catchment

Water Sensitive Urban Design (WSUD) was developed in Western Australia in the 1980s for urban planning and design. A WSUD Framework aims to minimise the negative impacts of urbanisation on the natural water cycle. In implementing the framework water quality, quantity and conservation are addressed along with broader social and environmental goals. A key focus of the WSUD framework is the integration of WSUD into the planning process to achieve better water management outcomes in urban development settings.

Funding provided through the CCI had led to the development of strategies for integrated land use planning and water sensitive design throughout the Peel Region (the Water Sensitive Design Project). This earlier project had aimed to establish water sensitive design principles, performance standards and land-use planning prescriptions to ensure nutrient export rates from new development and subdivision is minimised and maintained to meet water quality targets set under the WQIP (Land Assessment Pty Ltd 2005).

The WQIP-P identified the need for an increased focus on total water cycle management and Water Sensitive Urban Design (WSUD) to improve the management of stormwater, particularly nutrients, and increase the efficiency of the use of water (WQIP p. 37).

A model Peel-Harvey Local Planning Policy (LPP) for Water Sensitive Design was prepared for incorporating into statutory delivery mechanisms such as town planning schemes, statements of planning policy and environmental protection policies. The LPP encourages the application of the following Water Sensitive Urban Design principles:

1. Provide protection to life and property from flooding that would occur in a 100 year Average Recurrence interval (ARI) flood event;
2. Retain and restore existing elements of the natural drainage system, including waterway, wetland and groundwater features and processes, and integrate these elements into the urban landscape, possibly through the use of multiple use corridors;
3. Minimise pollutant discharge through implementation of appropriate non-structural source controls (such as town planning controls, strategic planning and institutional controls, pollution prevention procedures, education and participation programs and regulatory controls) and structural controls. The aim being to reduce pollutant export via runoff and leaching from urban development;
4. Manage rainfall events to minimise runoff as high in the catchment as possible. Use multiple low cost ‘in-system’ management measures to reduce runoff volumes and peak flows (e.g. maximise infiltration from leaky pipes, soakwells and stormwater pits installed above pollutant retentive soil media);
5. Maximise water efficiency, reduce potable water demand and maximise the reuse of water harvested from impermeable surfaces.

In addition to this, the Peel-Harvey Technical Guidelines for WSUD were developed to support implementation of the Peel-Harvey Water Sensitive Urban Design Local Planning Policy and the objectives of the Peel-Harvey Water Quality Improvement Plan. These Technical Guidelines were prepared to provide local government, developers and consultants with an insight into the importance of site characteristics with respect to the selection of individual WSUD elements in the ‘build-up’ and design of appropriate combinations of structural and non-structural practices or treatment trains (PHCC: Water Sensitive Design Project).

3.4.3 Activities supported by the SWCC Investment

Water Sensitive Urban Design (WQ01d.i)

The funding provided by SWCC for this component was provided to build upon the work already completed through the CCI Water Sensitive Design project which included the development of the WSD Model Local Planning Policy (LPP) and Peel-Harvey Water Sensitive Design Technical Guidelines.

Appointment of a planning consultant

The project commenced with the appointment of a planning consultant whose role was to work with the Peel-Harvey local governments to assist in the adoption and implementation of the Peel-Harvey model LPP within each LGA to achieve higher standards of water management in new urban developments. In addition, the officer was responsible for increasing the level of awareness and understanding of the benefits of WSUD (for many still an under-defined concept) by developing a WSUD "self drive tour" and brochure describing existing WSUD installations and their various functions.

To deliver on this component the Peel-Harvey Catchment Council engaged Essential Environmental Services to provide WSUD planning services. This company had previously been involved in the development of the *Better Urban Water Management* document[2] for the Department of Planning and Infrastructure (DPI) and the Western Australian Planning Commission (WAPC).

Adoption of WSUD by Local Government

Essential Environmental Services (2008, p. 6), the consultancy engaged to facilitate the adoption of WSUD into Local Planning Policies, have noted the key components contributing to successful implementation of water sensitive urban design. These are:

- clear governance structures with defined and well-known roles, responsibilities and accountabilities;
- integration of water planning with the land use planning system in a manner which does not complicate the existing approvals system;
- information on hydrological conditions to support planning for development in areas under development pressure;
- guidelines which clearly identify requirements for information to support decision making and tools which aid and standardise the assessment of supporting information;
- capacity building of government and industry in the process and practice of water sensitive urban design, including effective transfer of information and development of professional networks; and
- a coordinated research and development program to gather information on the performance, cost and maintenance requirements of best management practices.

Essential Environmental Services worked closely with planning staff at each of the local governments within the Peel-Harvey catchment including the Shires of Murray, Waroona, Serpentine-Jarrahdale, the Town of Kwinana, and the Cities of Mandurah and Rockingham. The evaluation has excluded the City of Rockingham and the Town of Kwinana. Through a collaborative approach a draft LPP for Water Sensitive Urban Design was prepared for each local government. At the time of the evaluation,

[2] This document provides guidance on the implementation of *State Planning Policy 2.9 Water Resources* (Government of WA, 2006), which is a requirement of the *State Water Strategy for Western Australia*.

LPPs had been adopted by the City of Mandurah, Shire of Waroona and Shire of Serpentine-Jarrahdale. Although it has not formally adopted the LPP for WSUD, the Shire of Murray planners are utilising the principles of WSUD in their decision making.

Water Sensitive Design Tour

The importance of the WSUD Tour rested in it being a practical demonstration of the implementation of the WSUD Planning Policy. Ten urban development sites formed part of the tour:

1. Quandong Park, Seascapes, Halls Head
2. Santalum Circus, Seascapes, Halls Head
3. North Port Stage 12, Linville Street & Boxgum Link, Port Bouvard, Wanannup
4. Channel View, Port Bouvard, Dawesville
5. Enchantress Lane & Estuary Road, Dawesville
6. Snake Drain, Mariners Cove, Dudley Park
7. Alcoa Wetland, Pinjarra Road, Pinjarra
8. Cantwell Park, South West Highway, Pinjarra
9. Meadow Springs Drive, Meadow Springs
10. Jane Kennaugh Reserve, Loretta Parkway Lakelands; Yindana Lane, Lakelands; Ballard Meander, Lakelands

The Tour was based upon the PHCC's Landcare landscapes format. The package developed for this provides a self-contained tour, with maps, descriptions of the sites and links to other resources. Each site has been developed in response to the conditions and constraints evident and the sites were chosen to achieve the objectives of water sensitive urban design while supporting the urban and community vision for each development. The key water management objectives for each site are highlighted, together with the leading management practices which have been implemented on the ground.

A number of tours have been conducted with attendees ranging from PHCC board members and staff, local government councillors and officers, consultants, New Waterways staff, SWCC Natural Resource Management Officers to land developers.

A Water Sensitive Design Land Developers Forum was held on 27 March 2008 attracting speakers from state and local government and from industry including consultants who had been involved in delivering on the Water Quality Recovery project. The event was well attended and included a brief talk by the Minister for Environment and Climate Change. The aim of the event was to provide practical case studies where water sensitive design had been successfully incorporated and achieving positive results.

Stormwater Management and Retrofitting (WQ01d.ii)

Stormwater has long been recognised as an important and prevalent pollutant source. Urban development in the Peel-Harvey Catchment accounts for a small proportion of total land use but contributes some 30 per cent of the total phosphorus entering the Peel-Harvey Estuary (Environmental Protection Agency, 2007).

Stormwater management planning

A stormwater officer [Jesse Steele] was employed to work with the Peel-Harvey region local governments to develop a template for stormwater management plans relevant for the retrofitting of

existing stormwater systems in the Peel-Harvey Catchment. The officer was to assist the Local Government's to initiate the required data gathering (such as GIS mapping of the existing stormwater systems) and water quality monitoring required to eventually allow each local government to develop Stormwater Management Plans to address water quality issues.

One of the milestones of this component of the larger project was to provide stormwater monitoring guidance for local governments in the region. The Stormwater Officer has prepared guidelines for Local Governments to develop their own stormwater monitoring programs (PHCC, n.d.).

A report was to be prepared to detail a variety of options available to local governments in the Peel-Harvey region for the installation of pollutant traps, infiltration systems and sub-surface stormwater detention systems. The report was to provide a summary of the key features of the various available options, costs to purchase and install, and examples of where similar options had been implemented.

Two retro-fitting demonstration sites were also scheduled to be developed as a way of showing some of the techniques that could be used to alter existing drainage networks in order to achieve positive water quality outcomes through using either a treatment train or end of pipe approach.

Reporting in March 2007 for the previous three months, the PHCC noted a change in focus for the retro-fitting component of WQ01d. Initially this component was to develop a Stormwater Management Plan. This became redundant when the Department of Water released their template as part of the Stormwater Management Manual (2004). In substituting for this output, PHCC developed guidelines to assist local governments in selecting appropriate stormwater retrofitting technologies.

There was recognition of the difficulties associated with retrofitting of stormwater networks where new solutions have to work with existing infrastructure. The review undertaken by the PHCC sought to assess a number of stormwater products available that profess to improve water quality in terms of their applicability to the Peel-Harvey region.

A very detailed Stormwater Management Plan / Townsite drainage strategy was developed for the Shire of Waroona.

Outputs for WQ01d.ii

A number of retrofit projects were implemented in the local government areas of the Peel-Harvey region.

- In Pinjarra (Shire of Murray) two stormwater retrofits were installed - Cantwell Park and Pinjarra Wetland. Significant improvements were reported to have been made to the urban stormwater drain and wetland through the Pinjarra Wetland project. Funding for the Wetland project was provided by a range of government and private sectors organisations including Alcoa, Pindan, Greening Australia as well as the SWCC, the Peel Development Commission, Shire of Murray and state and federal government.
- Also in the Shire of Murray, a project to manage the treatment of water from the Pinjarra commercial district saw the installation of a Gross Pollutant Trap in Cantwell Park to reduce nutrient and sediment load from this catchment.
- The Shire of Waroona were assisted to undertake a stormwater quality retrofit of the Thatcher Street site to increase the local level infiltration and reduce discharge to local drains and streams and reduce overland flow.

3.4.4 Evaluation Findings (WQ01d)

Progressing Water Sensitive Design in local government

A number of semi-structured interviews were conducted with personnel from the Shires of Mandurah, Murray, Serpentine-Jarrahdale and Waroona in August 2009 who had been involved in developing the Shire-specific Local Planning Policies based upon the model Peel-Harvey Local Planning Policy (LPP) for Water Sensitive Design and Technical Guidelines for WSUD.

The interviews highlighted the great differences in resources, data needs and enthusiasm towards the project within each of these local governments. At the time of this evaluation, the Shires of Serpentine-Jarrahdale, Waroona and Mandurah had adopted a Water Sensitive Design LPP. The Shire of Murray had yet to finalise their LPP for WSUD.

Shire of Serpentine-Jarrahdale

The following provides an overview of information gathered through interviews with the Manager Environmental Services/Strategic Community Planning and the Project Manager - Water Sensitive Urban Design at the Shire of Serpentine-Jarrahdale.

The Shire is experiencing period of rapid growth with a population influx over the past 1 to 2 years. In comparison to nearby metropolitan areas, the property prices in the Serpentine-Jarrahdale local government area are more affordable which has seen a rise in development proposals. It was suggested that the lower valuations limits the profitability of development such that developers are not inclined to incorporate water sensitive design principles into their proposals. However, developers must submit an *Urban Water Management Plan, Local Structure Plan, Local Water Management Strategy* for all submissions within the Shire.

The Shire of Serpentine-Jarrahdale had been pursuing water sensitive urban design (WSUD) practices prior to the WQ01 project commencing but acknowledged that the interactions with the consultant engaged for this project provided added impetus. They acknowledged that the implementation of the WQ01 project was integral to the Shire's ongoing commitment to water sensitive time and water quality management more broadly.

The benefit in being involved in the project was that it brought the various local governments in the Peel-Harvey region together to focus on a shared vision for water quality management. This linking together with other local governments and also with property developers was useful and gave legitimacy to what was trying to be achieved.

In the past the Shire has had limited human resources and a high rate of staff turnover making adoption of water sensitive design into planning difficult. There has recently been a change to the organisational structure of the Shire which has led to a reduction in 'silos', the building of strong cross-functional teams; and the appointment of a specialist Project Manager WSUD who operates across all teams. The Project Manager is involved in development projects at the planning stage, and follows the planning through consultations with the engineering, landscaping, and community development teams. This provides a coordinated approach to decision-making and generates buy-in across the organisation.

Currently, the Shire of Serpentine-Jarrahdale is working towards the development of standards, quality control mechanisms and data collection tools that will enable the vast range monitoring data collected across the region to be centralised. The Shire recognises the importance of informing their decision-

making around further development with up-to-date scientific information to improve environmental outcomes.

Overall, the Shire of Serpentine-Jarrahdale has embraced the principles of WSUD across the board. They are enthusiastic about the potential for incorporating water sensitive design principles into new works planned across the Shire. The rapid urbanisation in the shire is providing opportunities to work with developers to introduce WSUD into new developments.

In the interview both Managers emphasised the importance of face-to-face contacts and linkages within the shire itself (i.e. between the divisions) as well as across local governments, to developers and catchment councils.

Shire of Waroona

An interview was conducted with the Senior Town Planner who has been involved during the CCI funded projects as well as in this current SWCC funded project. The following provides a synopsis of that interview.

The Shire of Waroona had previously been involved in the CCI funded project to develop Technical Guidelines for WSUD. The Shire had been approached by Richard Morup, Water Sensitive Design Project Officer with the Peel Development Commission (PDC) to enter into a partnership with PDC to 'road test' the Local Planning Strategy provisions of the WSUD Planning Policy prepared by the PDC. They agreed to this at a council meeting in Feb 2005.

The Technical Guidelines developed by the PDC and published in October 2006 were the basis for policies developed in the Shire.

The Shire was assisted by the consultant engaged for the WQ01d project to develop their Local Planning Policy based upon the generic model already existing. The LPP was adopted at the Council meeting by unanimous decision and is well supported by Shire officers including Technical Services, Planning, Community Development and Range Services.

In addition to the adoption of the LPP the Shire of Waroona has instigated a number of other initiatives that demonstrates their commitment to water quality management. For example, the Shire of Waroona is signed up to the ICLEI Water campaign and has completed the 'Corporate' module which focuses on the local government's own facilities and operations. The module considers both water consumption and water quality issues through a series of five milestones as follows:

- Milestone 1: Inventory of water consumption and water quality issues;
- Milestone 2: The setting of consumption reduction and water quality goals;
- Milestone 3: Development of a Local Action Plan (LAP);
- Milestone 4: Implementation of the LAP; and
- Milestone 5: Evaluation and review of targets and strategies (Shire of Waroona, 2007).

The Shire also engaged a consultant to prepare a report on existing drainage systems in the town of Waroona recognising that poor drainage will limit urban development opportunities.

There is recognition that bad water management practice in the shire has negative impact on the Peel-Harvey Estuary and that the previous approach towards 'end-of-pipe' solutions is no longer appropriate. Instead, new approaches must find solutions 'at source'. This requires shires like Waroona to address water quality issues locally such that the water that does escape to the estuary has been treated and therefore nutrient export (both Phosphorous and Nitrogen) is minimised.

For a very small Shire with limited resources and limited urban growth, the Shire of Waroona has embraced water sensitive design in their planning decisions. They have not only adopted a WSUD Local Planning Policy but are also actively involved in other water initiatives and projects. Of note in this Shire was the level of autonomous decision-making in respect of planning decisions. The Council of Waroona delegates many decisions to the CEO and subsequently to the various divisions within the organisation. It would appear that this delegation promotes ownership of the decisions being made and ensures that staff become more fully engaged in the planning process in which they are involved.

Shire of Murray

An interview was conducted with the Manager Design and Asset Services at Shire of Murray who had worked on the stormwater retrofit projects discussed above. The officer who was more closely involved in the WSUD project is no longer working at the Shire and was not able to be contacted for this evaluation.

The Shire was assisted to develop a draft LPP which was made available for public comment in late 2007. After receiving one submission the Shire opted to delay adoption of the LPP until after the release of the Better Urban Water Management Framework (BUWM)[3] in October 2008.

Development applications in the Shire are generally referred internally to the Environment Section and the Technical Services section for review. Any development applications received that are located within a floodway are referred to the Department of Water (DoW) for assessment. Similarly, District Scheme Amendments and Outline Development Plans are referred to DoW as part of the required advertising process.

The Shire of Murray has confirmed that the LPP Water Sensitive Urban Design has not yet been adopted in the Shire and could not say when this was likely to happen. They have, however, supported other stormwater management initiatives such as retrofitting and using wetlands as a method for managing water quality issues.

City of Mandurah

This interview was conducted with the Manager of Infrastructure Development within the City of Mandurah.

The City of Mandurah is one of Western Australia's fastest growing Local Government Areas. Between 1978 and 2007 the population of Mandurah increased from about 10,000 to 61,000 and is forecast to increase to 100,000 by 2022. This increasing urbanisation in the City of Mandurah will have significant water quality impacts if not managed appropriately.

The City of Mandurah has been an early adopter of water sensitive design approaches, having investigated WSD for at least the past 9 years. The City was closely involved in the CCI initiative to develop the Technical Guidelines and works collaboratively with the Peel-Harvey Catchments Council.

While the City of Mandurah already had a LPP in development prior to the WQ01 project commencing, they gained added impetus once the consultant came on board. The LPP was progressed and eventually adopted by the Council in March 2008.

[3] The BUWM Framework was formulated as part of the strategy for implementing water sensitive urban design on the Swan Coastal Plain, with particular regard for the Swan-Canning and Vasse-Geographe catchments. The strategy is a sub-program of the Coastal Catchments Initiative (CCI) for the Swan-Canning and Vasse- Geographe catchments.

Promotion of WSD is led by the engineers in Mandurah but receives significant buy-in across the City from environmental scientists, landscape architects and planners.

There are a number of points of difference between the City of Mandurah and other local government entities in the Peel-Harvey region. For example, the City of Mandurah undertakes all assessments of subdivisions and developments internally rather than referring them to the Department of Water. This provides a level of autonomy and authority to the City that the other local governments do not have. Additionally, the City of Mandurah maintains all drainage within their boundaries is are not reliant upon drains supplied or managed by the Water Corporation. This provides a significant benefit to the City in that all drainage and water management decisions are theirs alone. Finally, there is no loss of land for Public Open Space (POS) to developers. In other local governments this is usually assessed as being 10 per cent of the gross subdivisional area or it requires a cash-in-lieu contribution by agreement between the subdivider, Commission and local government.

Given the long history of adoption of water sensitive design principles, the City has developed strong and productive relationships with several of the larger property developers and promotes the benefits of adopting a WSUD approach to these organisations. The City has calculated the direct financial benefits to the developer (when compared to a more traditional approach) including reduced costs associated with stormwater pipe installation, clearing and earthworks, and sump construction along with increased marketability of 'green' developments. Similar advantages flow to the City which benefits from reduced maintenance costs and infrastructure replacement costs with regard to traditional water management approaches.

The City of Mandurah is a forward-thinking, well resourced local government that is implementing a significant program of works to address water quality and water management issues. Staff have been working collaboratively with the PHCC over a number of years and were already well on the way to adopting a WSUD approach even before the SWCC project commenced. The City's involvement on the project has been useful however as the advanced positioning has allowed other local governments to see a working and practical example of what can be achieved through WSUD. The City could be considered a 'champion' and its influence could extend well beyond the Peel-Harvey Catchment area.

The City's commitment to, and promotion of WSUD through the tours is generating broader interest as developers in other metropolitan locations and other local governments are asking for guidance from the City of Mandurah to implement their own WSUD initiatives.

Overview

The concept of water sensitive urban design has been considered in Western Australia since the early 1990s. Wong (2006: 1) notes the following:

…the original conceptualisation of WSUD (in Perth, Western Australia) was as an alternative planning and design framework for urban development that attempts to break the dependency of urban environments on large water services infrastructure that is not integrated in a manner that manages all water streams as resources, promotes recycling, mitigates the impact of urban stormwater on the urban water environment through the promotion of at-source detention and retention of stormwater using landscaped features. This 'radical' approach did not gain favour in the early 1990s, and it was in the mid to late 1990s that the stormwater management aspect of this framework was further developed (in the eastern states of Australia) in response to a wider international appreciation of the impacts of urban stormwater quality on the ecological health of urban waterways.

With the greater focus now being placed upon maintaining water security across Australia, water sensitive design practices are gaining a stronger foothold in public and political discourse. The interviews conducted for this evaluation have found that a commitment to water sensitive design and a desire to integrate the principles of WSUD into decision making in all four local governments where there has been a high rate of staff turnover momentum has been difficult to maintain. But there are some challenges.

As discussed in Section 3.3.1, management of the drainage network by the Water Corporation is a controversial subject. Some local governments expressed frustration at the lack of integration between Shire water management, planning and practices and those of the Water Corporation. In some cases the two systems are considered to be at odds with one another where benefits gained through the local planning approaches are rendered ineffective by incompatible Water Corporation decisions.

There is recognition of the role that state and local government planning has to play in the implementation of WSUD, primarily through the planning approvals process. A variety of planning mechanisms guide planning decisions including State Planning Policies (e.g. *SPP 2.9 - Water Resources; SPP 2.1 - Peel-Harvey Coastal Plain Catchment*; the *Liveable Neighbourhoods* Policy), development control policies, region and local planning schemes, structure plans, water management plans and subdivision conditions. Although there is this vast array of statutory mechanisms in place the uptake of water sensitive design technologies will only become more widespread (and effective at catchment scale) if every agency/organisation/industry is implementing complementary water management systems. While the political will at the local level is recognised, the commitment at the state level does not appear to have been supported through resource allocation such that the onus remains on the local governments to implement, and to a large extent, regulate activities and actions locally.

Stormwater and Retrofitting

Discussions with officers from the Shires of Murray and Waroona found enthusiasm for the retrofitting projects that were undertaken. The involvement of the Shires in the processes of preliminary design and fitting of the drainage adjustments has provided a number of benefits.

One key outcome has been the improved capacity of local government to identify and implement retrofitting activities associated with urban stormwater. Importantly it has also provided some impetus for directing resources into drainage management and into additional drainage infrastructure. Also, significantly, the involvement of the four local governments (Mandurah, Murray, Serpentine-Jarrahdale and Waroona) has led to a combined commitment to the Peel-Harvey region and acknowledgement that action (or inaction) in one location can have lasting and important impacts on areas beyond administrative boundaries.

Discussion Panel

The Discussion Panel acknowledged that the works completed for this component have had far-reaching benefits beyond the boundaries of the Peel-Harvey region. Other local governments have expressed an interest in learning about the various water sensitive practices implemented in Peel-Harvey. In particular, the Shire of Wanneroo appear keen to investigate options for water sensitive developments. The work in the Peel-Harvey Catchment also supports that being undertaken in other catchments, notably Vasse-Geographe and Swan-Canning.

The potential to influence others is enhanced through the WSUD Tour. The tour provides an opportunity for developers, local government planners/engineers, and state government officers to inspect techniques and see for themselves the appeal and benefit of incorporating those techniques into existing and proposed developments. The City of Mandurah has been active in presenting information about their practices at many conferences and other forums which is assisting in promoting the water sensitive urban design message. The Discussion Panel consider the tours to be a useful mechanism for information transfer and suggests they continue to be funded to operate. Additional case studies of successful practice would also assist in promoting WSUD across a wider audience.

While the LPPs have been adopted the Discussion Panel were unsure as to the effect that they might be having on the ground. One panel member noted that if the range of planning guidelines/policies were followed as written then new developments would include all the necessary features for good water management. The problem is seen as a being inconsistency in application. There is no suggestion that the guidelines/policies be removed but that the legitimacy/authority of the LPPs would be supported with greater buy-in from the State Government agencies.

Both the WSUD and the retrofitting have benefited from the promotion provided by several champions. It is evident that in driving the LPPs, Shelley Shepherd (Essential Environmental Services) has been instrumental in the three local governments adopting LPPs. Similarly, Jesse Steele (formerly Rivercare Officer, PHCC, now Environmental Officer, Boddington Gold) was a key driver in promoting the retrofit projects completed. With these two champions no longer involved in this type of work in the Peel-Harvey there is a risk that the momentum gained may wane and future projects may be deferred.

One suggestion made by the Discussion Panel that may be explored in the future is incorporating WSUD (or Urban Water Management) into the curricula for engineering and planning courses. Other opportunities exist for working with academic institutions in providing access to data for Honours or Masters students.

4

Framework for Analysis

During the course of this evaluation it became evident that the success of this group of SWCC funded projects, and the efforts to improve the water quality of the Peel-Harvey overall, hinged on a coordinated and holistic approach. Brown and Clark (2007) provide a useful model for understanding the "key institutional change ingredients" for mainstreaming water sensitive urban design. While Brown and Clark's focus was on water sensitive urban design the framework they have developed provides a useful structure on which this evaluation can proceed.

In their study, Brown and Clarke (2007) have drawn from transition theory to show the shifts that have occurred in respect of Melbourne urban stormwater quality management. Their research identified a "range of interconnected activities and initiatives" and a critical "*interplay* between industry champions and important context variables that has provided the structure and catalyst for the transition". They argue that it is the "enabling context that has shaped, constrained and provided opportunities" for the industry champions to push for the changes that have occurred (p. iv, emphasis in original).

The eight key components comprising the 'enabling context' described by Brown and Clarke are as follows:

- **Socio-political capital**: aligned community, media and political concern for improved waterway health, amenity and recreation;
- **Bridging organisations**: dedicated organizing entity that facilitates collaboration across science and policy, agencies and professions, and knowledge brokers and industry
- **Trusted and reliable science**: accessible scientific expertise, innovating reliable and effective solutions to local problems
- **Binding targets**: a measurable and effective target that binds the change activity of scientists, policy makers and developers
- **Accountability**: a formal organizational responsibility for the improvement of waterway health, and a cultural commitment to proactively influence practices that lead to such an outcome
- **Strategic funding points**: additional resources, including external funding injection points, directed to the change effort
- **Demonstration projects and training:** accessible and reliable demonstration of new thinking and technologies in practice, accompanied by knowledge diffusion initiatives
- **Market receptivity**: a well articulated business case for the change activity.

Brown and Clarke offer the framework they have developed as a model to assist urban water strategists to identify "enabling context deficits" where that deficit will hinder effective achievement of water management goals (2007: 56).

In the following discussion section, aspects of the Peel-Harvey Water Quality Improvement Project (WQ01) are aligned to the enabling contexts to show where the project is making contributions to improving the water quality in the Peel-Harvey Estuary but also to determine whether any deficits exist that may frustrate improvement goals.

Discussion

5.1 Socio-political capital

Aligned community, media and political concern for improved waterway health, amenity and recreation.

In the 1960s public awareness of the fragility of the Peel-Harvey Catchment was raised as algal blooms began to emerge, first in the Peel Inlet and then in the Harvey Estuary. The impact of those toxic and odorous algal blooms were felt by commercial fisherman, recreational fishers, estuary users (swimming, boating) and people living within 10 km of the estuary who were at risk of a virus transmitted by mosquitoes. This "environmental crisis" brought together a range of disparate campaigners with a common goal of rectifying the deterioration of the estuarine system.

The 1960s also marked the start of significant population growth in Mandurah and surrounding areas. While it had long been a tourist destination for the people of Perth, in the 1960s Mandurah became a desired destination for retirees. This growth has continued and the region has undergone a period of rapid urbanisation. Housing development along the Murray River and beside the Peel Inlet at the Dawesville Channel, for example, have brought more people closer to the waterways which has placed additional pressures on the waterways and estuaries but at the same time has also built the critical mass of people who value the environment in which they live.

The persistent algal blooms had generated enough concern that by the 1980s the Peel-Harvey Catchment had been invested with an inherent value that ought to be protected. This was further enhanced when the Peel-Yalgorup wetland system, of which the Peel-Harvey Catchment is part, was designated a "Wetland of International Importance" under the Ramsar Convention on Wetlands. Where once the value of the Catchment was measured in terms of agricultural and fishing production it now rested on social, environmental as well as economic worth and its well-being became the responsibility of all. Strategies to address the water quality issues took both a top down and a bottom up approach.

Through the 1980s the Western Australian government became far more involved in addressing the environmental issues in the Catchment as it began to develop a range of regulatory and legislative measures aimed at addressing the water quality. This activity culminated in the publication of the Management Strategy for the Peel Inlet and Harvey Estuary System in 1989 followed by gazetting of the *Environmental Protection (Peel Inlet – Harvey estuary) Policy and the Peel-Harvey Coastal Plain Catchment Statement of Planning Policy (SPP) No. 2 in 1992*. Accompanying the statutory instruments there was also promotion of a bottom-up voluntary reduction of fertiliser use and other best management practices by land holders.

Throughout the 1990s the socio-political capital surrounding the Catchment was enhanced as a number of Landcare groups and Land Conservation District Committees formed along with over 100 community groups addressing natural resource management issues.

In March 2000 the Peel-Harvey Catchment Council (PHCC) was established to provide a coordination point for catchment management. In 2003 the Peel-Harvey Coastal Catchment was identified as a priority hotspot under the Coastal Catchments Initiative. Subsequently a number of projects were developed in partnership with the Government of Western Australia primarily through the Department of Environment (now Department of Environment and Conservation, and the Department of Water), the Department of Agriculture and Food, the Peel Development Commission and the Western Australian Environmental Protection Authority.

5 Discussion

In October 2006, the Peel Development Commission released *Peel 2020: Sustainability Strategy* (PDC 2006b). The development of this document involved a wide range of community and other stakeholders and resulted in the articulation of the Peel 2020 Vision. One component of this vision relates specifically to the environment:

Our natural environment is wisely managed to ensure its ecological balance is protected and environmental impacts are reduced for both current and future generations. We are recognised for the sustainable management of our internationally significant waterways and natural assets.

Policy documents such as these, and the process of their development, add to the socio-political capital in an area as they build a common vision for the members of the community.

The socio-political capital evidenced in the common concerns of community members, government agencies, property developers and environmental organisations about the health of the Peel-Harvey Catchment has grown as each environmental crisis has been reported. The decisions to take remedial actions, prompted by algal blooms, fish deaths and surface scum (WQIP, 2008: pp.14-15) have been reinforced by a network of aligned interests with a growing awareness of, and commitment to protecting and improving the quality of the estuarine system.

The Peel-Harvey Water Quality Recovery project, particularly those components that have a more public aspect, continue to support the socio-political capital invested in the catchment. For example, the implementation of water sensitive design projects by the City of Mandurah and the water sensitive design tours have created a broader awareness of the water quality issues. The construction of landscape features in Mandurah to manage stormwater creates a permanent, highly visible reinforcement of the water quality message and as a tourist destination; this local water quality message has far greater reach as people come into the area for holidays and day trips and then return to their usual place of residence

By integrating water sensitive features into new domestic structures and promoting the retrofit of features into existing structures awareness of water issues builds across the community. This is supported by government incentives to encourage water conservation and reuse.

Similarly, the perennial pastures demonstration sites and exhibitions at field days disseminate the message to a wider audience - not only those impacted by water quality issues, but others from outside the Peel-Harvey region who attend such events.

That the local governments in the region (with the exception of the Shire of Murray) have adopted the Local Planning Policy - Water Sensitive Urban Design has also added to the socio-political capital for water quality recovery. This is reinforced by external initiatives such as the Department of Water's Better Urban Water Management Framework, and the current water quality improvement projects being undertaken in the Swan-Canning and the Vasse-Geographe Catchments.

One concern is that the socio-political capital is localised and that broader support for improving the water quality in the Peel-Harvey catchment is waning, particularly at the state government level. For example, although the *Peel-Harvey Water Quality Improvement Plan* has been endorsed and launched by the Environmental Protection Authority, the funding for implementation is believed by most commentators to be inadequate to address what is a major problem.

5.2 Bridging organisations

Dedicated organising entity that facilitates collaboration across science and policy, agencies and professions, and knowledge brokers and industry.

For many years there was no coordinated approach to managing the water quality issues of the Peel-Harvey Catchment. Scientific investigations were instigated by various government agencies with responsibility for different aspects of the "problem". Thus, at different times reports have been generated from, or commissioned by the Department of Agriculture, Waters and Rivers Commission, Department of Environment, Department of Water, Environmental Protection Authority as well as from groups such as the ARWA Centre for Ecohydrology based at the University of Western Australia. There is no dearth of information about the Peel-Harvey but there has been historically a lack of coordination between the various organisations with an interest in the Peel-Harvey environment and its management.

In more recent years the Peel-Harvey Catchment Council (PHCC) has been instrumental in focusing attention and actions in the Peel-Harvey Catchment. The organisation has a vision to work with "landholders, community groups, industry, the Australian Government, Government of Western Australia and local governments to affect change 'on-ground' and in the way we manage our environment" (PHCC, 2005). The membership of the PHCC is made up of community members as well as representatives from local government and the Department of Water, Department of Agriculture and Food, the Peel Development Commission and the Department of Environment and Conservation.

The PHCC has acted as a conduit for funding from the Commonwealth and State Governments into projects affecting the health of the water systems and has fostered relationships between various organisations. One of the benefits in administering government through non-government groups such as the PHCC lies in its location outside of government. This separation from the state means that the PHCC is able to effectively engage the community as well as lobby for change at the State government level and politically.

The advent of the CCI projects in 2003 administered by the PHCC represents something of a watershed in cooperation in the Peel-Harvey. This range of seven complementary projects provided an opportunity for information sharing of science, policy and behavioural change knowledge across agencies, local government, industry and community. The extension of the CCI through the SWCC funded Water Quality Recovery project (WQ01) extended this opportunity for two further years. This evaluation, however, has found that, although the four projects were designed to complement each other, for information to transfer between the projects, the extent of coordination between the four component projects is questionable.

The four components of the project essentially operated in isolation of each other. To a large extent this could be attributed to a lack of overall project management. It is understood that the PHCC had requested additional funding for the appointment of a Project Manager to oversee the four components of the Project but this request was declined by SWCC. PHCC have reported that, to a certain extent, this has resulted in inadequate record keeping and where outputs have been achieved, a failure to adequately disseminate the findings to other components of the WQ01.

As individual projects, each can be considered (with the exception of the production of the Nitrogen version of the WQIP) to have successfully delivered on their individual objectives. As a suite of projects, more could have been achieved. For example, one local government stated that access to

monitoring and modelling data would be beneficial to their planning decisions but this information has not been readily available. It is in bringing these disparate projects (and data requirements) that a bridging organisation has a role to play.

The impact of recent changes to Commonwealth funding arrangements in Natural Resource Management is yet to be felt but without this funding the role of PHCC as a key bridging organisation is in doubt. The lack of a bridging organisation drawing other organisations together and facilitating collaborative efforts and outcomes would be a real loss. It is important for water quality improvement in the Peel-Harvey Catchment for the momentum gained through the CCI and SWCC funded projects to be maintained. There is scope for this role to be fulfilled by the EPA but as a regulatory authority aligned with government they may not render the same level of cooperation and trust that has been evident with the PHCC. Some other non-statutory governance structure may be investigated or a governance structure modelled on the Swan River Trust may be pursued. Nevertheless, a bridging organisation must emerge to coordinate future efforts.

5.3 Trusted and reliable science

Accessible scientific expertise, innovating reliable and effective solutions to local problems.

There is no lack of scientific data on water quality, phosphorous and nitrogen loads, farming practice, land use and drainage in the Peel-Harvey Catchment. This has been collected over the past 100 years with an increase in output in the latter part of the 20th century. Earlier studies focused upon the technical aspects of water degradation and it has only been relatively recent that studies have begun to investigate the effects of human behaviours.

The funding provided through the bridging organisation (i.e. PHCC) has enabled the further development of scientific knowledge on the Peel-Harvey Catchment. Each of the components has comprised a monitoring element and the data collected through these contributes to the overall Peel-Harvey knowledge base.

- Component WQ01a of this project has produced a comprehensive data set on water quality in the catchment which is available through the state-wide River Water Quality Database. The SQUARE model is now fully operational for the Peel-Harvey catchment and is available to support land use and water resource planning in the region. It will be suitable for regional land use and water resource planning but is not suitable for predicting the localised impact of individual urban developments. The future of SQUARE will depend upon the level of demand from public and private users - the local governments in the region have expressed an interest although their knowledge of the opportunities that SQUARE might provide appeared limited when queried during evaluation interviews. Whether the SQUARE model provides what local governments require is yet to be confirmed but there is clearly an opportunity for greater links to be made between the model provider (DoW) and users.
- Component WQ01c has contributed data regarding the effects of perennial pastures on nutrient concentrations and has provided an economic analysis of perennial pasture systems. This information can be utilised by land owners to make informed decisions about their own farming practices. Similarly, the classification system developed in this component for drainage management complements the modelling work done in WQ01a to identify hotspots for targeted investment in drainage re-design.
- Component WQ01d also has added to the knowledge base for urban stormwater management, particularly the benefits provided through the retrofit of existing stormwater drains.

In summary, much scientific data has been collected over the course of this project. How it is utilised becomes the important point. As a bridging organisation the PHCC could become the holder of the combined data (each contributor will also be a holder of their own data) and play a role in information/technology transfer. It would be useful for a "taking stock" of the information to occur to determine where the next efforts should be directed. This should ensure that knowledge gained is applied to best effect and maintains the momentum for action. But as this evaluation has found, the provision of knowledge or information does not always lead to changes in the way that things get done as is evidenced in the rural BMPs project. This is why "trusted and reliable science" is situated within the broader enabling context provided by Brown and Clarke's framework.

The Discussion Panel has suggested the creation of a Centre for Excellence in Nutrient Management or similar to coordinate scientific endeavours and disseminate information. Where this would be located and how it would be funded was not considered by the Panel but is something that SWCC might investigate. There is potential to link with the recently announced Centre for Ecohydrology at the University of WA.

5.4 Binding targets

A measurable and effective target that binds the change activity of scientists, policy makers and developer.

Targets for phosphorous reduction were first articulated in a policy setting in the *Environmental Protection (Peel-Harvey Estuarine System) Policy 1992*. Clause 7 of this EPP stated:

The environmental quality objectives to be achieved and maintained in respect of the Estuary are a median load (mass) of total phosphorous flowing into the Estuary of less than 75 tonnes with --

a) The median load (mass) of total phosphorous flowing into the Estuary from the Serpentine River being less than 21 tonnes;
b) The median load (mass) of total phosphorous flowing into the Estuary from the Murray River being less than 16 tonnes; and
c) The median load (mass) of total phosphorous flowing into the Estuary from the Harvey River being less than 38 tonnes.

These targets have been replicated in the WQIP-P released in 2008. Additionally, the WQIP-P has set the objectives such that water quality at the draining point (outlet) of each catchment meets a median winter concentration value of 0.1 mg/L (0.2 mg/L in the shorter term) for Total Phosphorus (TP). This methodology was based on Swan River Trust research and used in catchment based modelling, where it was predicted that if this concentration value is met then estuarine loadings of 75 tonnes per year set in the Ministerial environmental conditions can in time be met (Zammit *et al*., 2006). The Discussion Panel has suggested that the 0.1 mg/L concentration value has been guiding decisions at the local government level.

Phosphorous load to estuary was reported as 145 tonnes in the WQIP-P (EPA, 2008: 24) suggesting that significant reductions are required to meet the targets set in 1992 and reiterated in 2008.

The targets set in the EPP are reinforced through the State Planning Policy 2.1 and are supported by other Policies (e.g. the Peel-Harvey Coastal Catchment Water Sensitive Design Technical Guidelines and the Model Peel-Harvey WSUD Local Planning Policy).

The establishment of these binding targets has given some direction to local governments in drafting their Local Planning Policy for Water Sensitive Urban Design. Studies have identified where the major sources of nutrients such as Phosphorous are originating (see Zammit *et al.*, 2006). Combining measurements with targets, lends authority to policy makers when they direct their attention to specific areas and specific land users (e.g. residential land-use accounts for 17 per cent of the total phosphorous load - this lends support for the adoption of water sensitive design policies).

It would have been expected that a binding target for Nitrogen be developed if the second component of this program, the development of a Water Quality Improvement Plan for Nitrogen, had proceeded. At this point in time no specific targets for Nitrogen have been set. In terms of delivering a holistic approach this would have been useful. However, guidance form Vasse-Geographe data may be extrapolated for use in the Peel-Harvey.

The Peel-Yalgorup wetland system was designated a "Wetland of International Importance" under the Ramsar Convention on Wetlands in June 1990. The Ecological Character Description (ECD) of the Peel-Yalgorup System was released in February 2008. The description forms the benchmark against which management planning and actions are set. The ECD provides:

- An ecological character description (ECD) for the Peel-Yalgorup System, that follows the guidance set out in the *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar wetlands*;
- Nutrient water quality objectives for the estuarine system that will help to maintain the ecological health of the wetland; and
- A monitoring program for the wetland system, that will allow for the detection of changes to the ecological health of the system.

The recommended monitoring to meet the obligations under Ramsar and the EPBC Act (1999) with respect to the Peel-Yalgorup Ramsar site were listed within the document. Monitoring relating to water quality in the Peel-Harvey Estuary include tests for pH, salinity, dissolved oxygen, turbidity, secchi depth, total and dissolved nutrients, chlorophyll-a.

Additional targets may emerge out of the range of activities and studies in the region. The extent to which they may bind future land use planning is yet to be seen.

5.5 Accountability

A formal organisational responsibility for the improvement of water way health, and a cultural commitment to proactively influence practices that lead to such an outcome

Responsibility for water (management, quality, use) in the Peel-Harvey Catchment is spread across a number of State Government agencies and statutory bodies. In terms of state government agencies the following can be said:

- The Department of Water assists the Minister for Water in administering a number of Acts of legislation related to water resource definition, use, management and health.
- The supply of drinking water, bulk water for irrigation and the provision of wastewater and drainage services is the responsibility of the Government owned Water Corporation which delivers these services under licences issued by the Economic Regulation Authority (ERA). Drainage systems in the Peel-Harvey region are largely supplied by the Water Corporation.

- The Department of Environment and Conservation is responsible for protecting and conserving the State's environment on behalf of the people of Western Australia. This includes managing the State's national parks, marine parks, conservation parks, State forests and timber reserves, nature reserves, marine nature reserves and marine management areas.
- The Environmental Protection Agency is responsible for protecting the State's environment through the preparation of environmental protection policies and the assessment of development proposals and management plans, as well as providing public statements about matters of environmental importance.
- The Department for Planning has responsibility for administering the overall planning system in Western Australia at a state-wide, regional and local level. It is this Department that maintains responsibility for policy relating to land use and property development.
- The Department of Agriculture and Food has a wide scope of responsibility that takes in agricultural practice, biodiversity, natural resource management, salinity management and other areas that are related to water quality in the state.

The accountability of these agencies for Peel-Harvey water quality is formalised in various policy statements and legislation. For example, the Minister for Environment nominated three relevant Ministers (Ministers for Transport, Agriculture and Waterways (now Water) as the proponents for implementation of the Management Strategy for the Peel Inlet and Harvey Estuary System endorsed in 1989.

Even just taking the State Government agencies into account it is easy to see that accountability for improving the water quality in the Peel-Harvey region is fragmented across multiple organisations. The fragmentation is further divided if Commonwealth agencies are added and further still when NRM groups such as SWCC and PHCC are added. With such fragmentation comes a risk that work is undertaken without reference to any other works taking place.

An example from the evaluation; the report *Management of Diffuse Water Quality Pollution in the Peel-Harvey Coastal Drainage System: A Strategic Approach to Implementation of Best Management Practices* (PHCC, 2008a) declares that implementation of most of the water quality BMPs outlined in this report will require reform in the way the drainage system is managed by the drainage service provider (Water Corporation). This was supported during interviews with local governments who also noted the disconnect between way the Water Corporation manages drainage compared to their water sensitive design attempts. If it continues, this fragmented accountability will hinder progress towards achieving the aims of the WQIP-P.

A report on the progress and compliance with the Environmental Conditions set by the Minister for the Environment in 1989, 1991 and 1993 acknowledged the challenges to implementing an integrated management strategy for the Peel-Harvey and suggested the implementation of the whole strategy would be assisted by having a single person who is responsible for ensuring that the whole strategy is implemented (EPA, 2003: 10). The "governance" situation in the Peel-Harvey has not significantly changed since that report was published. Ultimate accountability for improving the water quality in the Peel-Harvey Catchment remains fragmented and until resolved will represent a sufficient barrier to change (See also Section 5.2).

5.6 Strategic funding points

Additional resources, including external funding injection points, directed to the change effort

Many projects directed towards improving the water quality in the Peel-Harvey Estuary have been delivered through the Peel-Harvey Catchment Council, having been facilitated by the injection of significant funds. This occurred initially through the Coastal Catchments Initiative and more recently through the National Heritage Trust (NHT) and National Action Plan for Water and Salinity (NAP), joint initiatives of the Australian and Western Australian Governments administered by the South West Catchments Council.

The Peel-Harvey Catchment Council also obtains funding from other sources including the Regional Development Scheme (WA Government), Envirofunds and Community Water Grants (Australian Government) and directly from local governments and industry partners such as Alcoa Limited.

While the funding amounts have been significant they are short-term (generally 2 years), require considerable time and effort to secure and subsequently leave the organisation vulnerable. The funding cycles for most government sponsored activity is usually short. For some programs this does not present a problem but for those programs that do not expect impacts from their endeavours for 20 to 30 years, as is the case with the majority of natural resource management programs, then short-term funding cycles make long-term planning difficult.

From 1 July 2009 the Commonwealth Government commenced with new “Caring for our Country” funding arrangements. These new arrangements allocate funds regionally. In relation to the Peel-Harvey Catchment contracts were previously established with the Council to deliver projects. Funding now will be provided to the South West Catchments Council who will be responsible for the delivery of projects. Additionally, priority areas for Caring for our Country funding have shifted to four program themes: biodiversity protection, coastal environments; sustainable agriculture; and community knowledge, support and engagement. Aligning the work required in the Peel-Harvey with these new program themes will demand a re-adjustment of focus for project managers.

Sub-regional Catchment groups such as the PHCC rely upon external funding and have pursued sources additional to Commonwealth funding, for example, state government agencies, local government and industry have all supported PHCC financially. The time and effort involved in sourcing funding from multiple supplies, often providing for short-term actions is not conducive to developing or implementing a long-term plan for water quality recovery. It leads to a lack of continuity of projects and a loss of momentum for the project staff who manage them.

Issues with funding were raised for each of the projects in the WQ01 Program. In all cases continuation of the works would require an injection of additional resources. There is a concern that the momentum gained towards land use and water resource management reform, generated through the WQ01 Program will be lost due to the lack of long-term funding to take recommendations through to implementation. The recently announced (October 2009) funding from the Department of Water for on-ground works is timely. This funding may be a means to attract further funding from additional sources as it provides for core capacity to commence projects that others may be inclined to support.

5.7 Demonstration projects and training

Accessible and reliable demonstration of new thinking and technologies in practice, accompanied by knowledge diffusion initiatives

The three components of the Water Quality Recovery Program have included demonstration projects that have provided real examples of the technologies in practice. One of the key demonstration projects has been the creation of the Water Sensitive Urban Design Tour ("the Tour").

The Tour took in ten urban development sites in the City of Mandurah and the Shire of Murray. A number of these sites have been developed in collaboration with property development companies while others are initiatives supported by local government, industry and catchment groups.

A second demonstration project was established to showcase perennial pasture adoption. Three variety demonstration sites were established with 9 annual pasture varieties and 13 perennial pasture varieties. These sites were utilised at field days and field walks for discussions on variety selection, productivity and management issues.

A key aspect of projects funded through the Peel-Harvey Catchments Council is a focus on awareness raising. Each of the projects evaluated initiated a range of information provision sessions, publication of updates, press releases etc. There is an understanding that the program's success is contingent upon knowledge transfer and information sharing and this has been delivered well by individual projects.

While the evaluation has found some reluctance by landholders to change their existing fertiliser and farming systems practice there is no doubt that the provision of practical demonstration sites does assist in bringing about the behavioural change required. The demonstration sites provide opportunities to influence farmer behaviour by showing, for example, the relative advantage that BMPs provide as well as some level of social proofing (i.e. guidance from others on how to behave).

Currently there is a lack of extension programs able to provide the training and information sharing that have shown to be successful in agriculture. There may be opportunities to develop grass roots extension but the issue of funding would need to be resolved.

5.8 Market receptivity

A well articulated business case for the change activity.

A coming together of two phenomena has provided the impetus for the adoption of new approaches to water management in the Peel-Harvey Catchment. The first is the rapid urbanisation that has been occurring over the past 20 or so years. This has exacerbated the already deteriorated state of the waterways in the Catchment and has placed further pressure on existing drainage infrastructure. Coupled to this has been the increasing emphasis placed on water security. Consequently, there is a growing enthusiasm and support for a fundamental change in the way water resources are managed, particularly buy the newcomers to the region.

Property developers are one group who have responded to the challenge and have begun to acknowledge that incorporating innovative water features within urban developments can sell real estate and that 'softening' the urban landscape can be a key marketing tool (Lloyd, 2001).

Although the newly adopted Local Planning Policies encourage uptake of water sensitive design by developers there is also a demonstrated economic incentive promoted in presentations by the City of

Mandurah. A presentation, "Water Sensitive Urban Design can benefit all parties", provided to the evaluation team by the Manager of Infrastructure Development at the City outlines some of the benefits that flow to developers and local governments. For example, benefits to the developer are listed as:

- Improved landscape amenity of subdivisions;
- Reduced construction costs;
- No reduction in Public Open Space (POS) credit - integrate stormwater into landscape;
- Better financial returns when compared to traditional approach; and
- Opportunity to market 'green' developments.

And to the local government entity the following benefits are noted:

- Good community outcomes in urban land form and landscape;
- Protection of water quality in natural and man-made waterways;
- Reduction in maintenance costs; and
- Reduction in infrastructure replacement costs.

The market, at least in Mandurah, has been very receptive to implementing water sensitive design as they have been shown and benefited from the financial rewards for doing so. Local governments, too, are responding to the need for targeted actions as is evidenced in the urban drainage retrofits undertaken by the Shires of Murray and Waroona.

Where there has been less receptivity to adopting improved practice is in the agricultural sector. With nearly half of the Phosphorous entering the Peel Inlet-Harvey Estuarine System originating from mainstream agricultural land uses, it will be important to encourage changed practices in this sector along with changed urban development practices. A review of the documentation has found no evidence that voluntary uptake of BMPs in the area of fertiliser practices, riparian management and pasture management by landholders has had any meaningful impact on nutrient and sediment movement. It has been recommended that a number of measures will be required to improve the BMP adoption rate, specifically showing the economic benefits to landholders from changed practices.

Conclusions and Recommendations

This evaluation has sought to answer the following question and to report on the effectiveness and impact, efficiency, appropriateness and legacy of the Peel-Harvey Catchment Council (PHCC) Water Quality Recovery Program:

How have the individual components of the Water Quality Recovery Program contributed to providing an integrated response to improving the water quality of the rivers and estuaries of the Peel-Harvey system?

6.1 Conclusions

Four components were initially funded to deliver on several management measures contained within the WQIP-P. One, the development of a Nitrogen version of the WQIP did not proceed. The other three components have successfully delivered on their objectives, as the previous discussions have noted. At the outset the Program recognised that improving the water quality in the rivers and estuary of the Peel-Harvey system would require a long-term approach and commitment of some 30 years or more. The projects that have been completed with the funding provided by SWCC represent one small component of the overall effort required.

Locally, the socio-political capital of the Peel-Harvey catchment has built over the years and aligns the goals and aspirations of concerned community members and political agents. There is some question as to whether the socio-political capital invested in the Peel-Harvey catchment has translated to the broader stage, that is, at the state level. While a number of policies have been adopted and statutory mechanisms enacted there has not been the same level of organisational or financial commitment from the State. It is suggested that without the 'algal bloom' environmental crisis that had prompted action in the past some currency and urgency has been lost for those situated outside of the Peel-Harvey area.

The legacy of these earlier environmental crises is a series of policy and guideline documents that still lack sufficient force to effect change. Previously we have suggested that if each of the planning guidelines were followed then a good proportion of the negative land use effects would be diminished. However, adherence to the guidelines is erratic and not strictly enforced. One of the reasons for this may be the continued fragmented accountabilities for water quality management, with several state government agencies responsible for areas and impacts on water quality.

Funding provided to the PHCC through SWCC and the earlier CCI has enabled it to act, and develop capacity as a bridging organisation. Over the course of the five years of the two funding rounds the PHCC has been able to develop an integrated and holistic plan of action. The CCI enabled the development of the WQIP-P and the SWCC funding has enabled implementation of some of the (many) management measures contained within the WQIP-P.

6.2 Continuing challenges in water quality management

The greatest challenges facing program managers concerned with improving water quality in the Peel-Harvey system are summarised below.

- Responsibility for delivering water quality related initiatives is fragmented across multiple agencies (at state and local government level) often acting in relative isolation of each other. This inhibits the 'whole-of-government' implementation of the array of binding policies and strategies, which if implemented could deliver desired outcomes.

- There is inconsistency between some sectors responsible for water management, notably the issues highlighted in drainage management between Water Corporation and Local Government.
- Information and data tends to collect within the agency responsible for its gathering and is not readily accessible to others, or is not presented in a form that makes it useable to other land and water users and managers.
- Much of the funding that has been directed at water quality management in the Peel-Harvey Catchment has been short-term and uncertain, resulting in projects being selected on the basis of the ability of an organisation to achieve (and report on) an outcome in a short period of time.
- This focus on short-term projects contrasts with the lengthy time-lags between action and response in a large biophysically complex catchment. It is evident that achievement of the nutrient targets, first set 17 years ago, will require sustained, consistent and determined action over a lengthy period.
- In particular, there must be a consistent and long-term commitment to sufficient monitoring of water quality across the catchment to enable (i) on-going validation and improvement of model outputs, (ii) determination of trends at locality and sub-catchment scale, and (iii) targeting of management investment and action into identified 'hot spots'
- Following from the above point, changing land and water uses in the Peel-Harvey Catchment, and a growing population is increasing the biophysical complexity of the environment, and the community diversity. Further, the pace of change is rapid, and growing. The implication is that the mechanisms to achieve water quality targets must match this complexity and diversity. In short, one size will not fit all.
- There are economic drivers emerging for some practice changes, such as WSUD in new developments that will deliver win: win arrangements for land use and environment. However, in other areas such as agricultural practices, economic drivers are yet to be demonstrated. As noted in previous sections, voluntary practice change in broadacre agriculture will be difficult to achieve without economic drivers.
- Even where economic drivers may be favourable, behaviour change (urban and rural) is a challenge in a large and diverse population with varying interests and knowledge in land and water management. Part of the long-term action referred to in a previous point needs to be a commitment to change agent programs. However, the decline in public sector change agent programs, especially in agriculture, will inhibit the rate of behavioural change.
- There will always be tension in the allocation of resources between technical research (data, acquisition, system understanding, etc) and behaviour change projects (demonstrations, publications etc). While WQ01 achieved a reasonable balance, the 'application gap' between the knowledge developed in the catchment modelling, and the use of that information in land use planning needs to be bridged.

6.3 Recommendations

The following recommendations are offered for consideration by SWCC. While some are within SWCC's power to influence directly, it is recognised that many are not. However, if viewed favourably by SWCC, others could be promoted to the responsible agencies or organisations.

1. In several places in this report, the need to carry the work commenced in WQ01 through to completion or to logical hand-over points is mentioned. Areas include the perennial pastures research and development, building capability in using modelling to inform decision making, building capacity in drain management and maintaining support for WSUD implementation in local

government. Without adequate on-going support in these areas, the investment made through WQ01 will not be fully realised.

2. There is a need for on-going support for a bridging organisation that can coordinate activities, provide leadership and act as a clearing house for ideas and information. This was the PHCC, but other models (e.g. statutory vs. non-statutory) have been proposed by people consulted for the evaluation. Whatever the preferred model, adequate, long-term funding and a governance structure that is commensurate with the scale of the problems set out in the WQIP is required.
3. Following from the above point, in delivering large, multi-disciplinary programs, bridging (or 'host') organisations need to be provided with sufficient program management resources to allow for coordination across components, data and information sharing, identification and capture of synergies between components, and coherent presentation of recommendations to land and water managers. This was an area that was "underdone" in WQ01.
4. Component WQ01b – the nitrogen version of the WQIP was not delivered for a range of sound logistical and organisational reasons. The importance of nitrogen in waterways and estuary health is being recognised through more research work. The need for a WQIP-N should be reconsidered and if required prepared as soon as possible.
5. SWCC, which includes in its area several major coastal catchments where nutrient management is a challenge, is well placed to facilitate a Centre for Excellence in Nutrient Management to coordinate scientific endeavours and disseminate information. There is potential to form a partnership with the Centre for Eco-hydrology at the University of Western Australia. It may be that a 'node' of that centre could be established in the region (Mandurah?) as a means of building regional capacity.
6. Following from the above point, the model system calibrated for Peel-Harvey could be located in Mandurah and administered by the Department of Water. In this way local governments in the region could more readily access the outputs of the modelling work and better understand the impacts of some of the their decision-making.
7. The SWCC should continue to press for drainage reform in the Peel-Harvey Catchment. It is likely that implementation of drainage management reform will rely largely on the Department of Water's program in preparing drainage and water management plans to cover the major urban expansion areas across the Perth to Peel and South West regions. However, institutional reform in licensing drainage management will still be required, and SWCC needs to maintain of focus on this objective.
8. The incorporation of WSUD (or Urban Water Management) into the curricula for engineering and planning courses would build skills in people joining local governments and planning companies. Other opportunities exist for working with academic institutions in providing access to data for Honours or Masters students.
9. The development of grass roots extension to change the behaviours and knowledge of people in the catchment is an on-going need. At present there does not appear to be political/government commitment to the provision of extension. Delivery of extension might be achieved through regional or sub-regional resource management or catchment groups.

References

Australian Government, 2006, *Australia's National Programme of Action for the Protection of the Marine Environment from Land-based Activities: Case Study 20 – Peel-Harvey Waterway*, October 2006, retrieved 17 July 2009, http://www.environment.gov.au/coasts/pollution/npa/pubs/peel-harvey.pdf

Broderick, K., 2008, Adaptive Management for Water Quality Improvement in the Great Barrier Reef Catchments: Learning on the Edge, Geographical Research, vol. 46, no. 3, pp. 303-313

Brown, R.R. and J.M. Clark, 2007, Transition to water Sensitive Urban Design: The story of Melbourne, Australia, Report No. 07/1, Facility for Advancing Water Biofiltration, Monash University, June 2007, ISBN 978-0-9803428-0-2

City of Mandurah, 2007, Town Planning Scheme No. 3: Draft Local Planning Policy - Water Sensitive Urban Design, June 2007

City of Mandurah, n.d., Water sensitive urban design can benefit all parties, PowerPoint Presentation Handout, provided to the author, August 2009

Dart, J.J. and J. Mayne, 2005, Performance Story, in Mathison, S. (ed.), *Encyclopaedia of Evaluation*, Sage Publications, Thousand Oaks

Department of Environment 2004, *Stormwater Management Manual for Western Australia*, Department of Environment, Perth

Department of Environment - Aquatic Science Branch, 2008, Sampling and Analysis Plan for KP-C-LMUCCI Water Quality Management Plan and Infrastructure Project, May 2008, DEC Perth

Department of Environment, Water, Heritage and the Arts [DEWHA], 2009, 'Peel Inlet and Harvey Estuary', retrieved 21 August 2009, http://www.environment.gov.au/water/policy-programs/nwqms/wqip/wa/peel-harvey.html

Department of Water, 2008, Peel-Harvey Modelling Analysis and Scenarios, SWCC DSS Modelling Project 2008, Water Science Branch, Water Resource Management Division, October 2008

Department of Water, 2009, 'Peel–Harvey estuarine water quality monitoring program: Monthly total nitrogen snapshot: data collected on 10 August 2009', [online], retrieved on23 September 2009, http://www.water.wa.gov.au/Water+regions/Kwinana+Peel/Peel+Waterways+Centre/Water+data+information/Monthly+total+nitrogen+snapshot/1216.aspx

Drainage Reform Group (2004) White Paper February 2004 *Reforming Drainage – Moving Towards Total Water Cycle Management in Western Australia*, Perth

Environmental Protection Authority, 1992, Environmental Protection (Peel-Harvey Estuarine System) Policy 1992, *Government Gazette*, No. 175, 11 December 1992

Environmental Protection Authority, 1994, *Review of Peel Inlet - Harvey estuary Management Strategy, Stage 2, Environmental Conditions: Public Discussion Paper*, Bulletin 749, July 1994

Environmental Protection Authority, 2003, *Peel Inlet and Harvey Estuary System Management Strategy: Progress and Compliance by the Proponents with Environmental Conditions set*

by the Minister for the Environment in 1989, 1991 and 1993, Advice of the Environmental Protection Authority EPA Bulletin 1087, January 2003

Environmental Protection Agency, 2007, Draft Water Quality Improvement Plan for the Rivers and Estuary of the Peel-Harvey System, Environmental Protection Agency, Perth, Western Australia

Essential Environmental Services, 2008, 'Achieving better urban water management in Western Australia', retrieved 18 August 2009, http://www.swanrivertrust.wa.gov.au/science/catchment/Documents/Achieving%20better%20urban%20water%20management%20in%20Western%20Australia.pdf

Everall Consulting Biologist, 2002, Economic Development and Recreation Management Plan for the Peel Waterways, report prepared for the Waters and Rivers Commission, August 2002

Government of Western Australia, 1992a, 'Environmental Protection (Peel Inlet-Harvey Estuary) Policy 1992', Government Gazette Perth, 11 December 1992, pp 5968-5975.

Government of Western Australia, 1992b, 'Statement of Planning Policy No. 2, The Peel-Harvey Coastal Plain Catchment', Government Gazette Perth, 21 February 1992

Hamilton, B. 2002, South West Regional Strategy for Natural Resource Management - Technical Report #1, Prepared for South West Catchments Council

Hick, P., 2004, Biodiversity on the Peel-Harvey Catchment, Report prepared for Peel-Harvey Catchment Council Inc.

Hodgkin E. P., F.B. Birch, R.E. Black. and R.B. Humphries, 1980, The Peel-Harvey Estuarine System Study (1976-1980), report prepared for Department of Conservation and Environment, Report No. 9, Perth, Western Australia.

Humphries, R. and S. Robinson, 1995, Assessment of the success of the Peel-Harvey Estuary System Management Strategy – A Western Australian attempt at integrated catchment management, Water Science and Technology, vol. 32, no. 5-6, pp. 255-264

Ironbark Environmental 2007, *Peel-Harvey Catchment Council Drainage Reform Plan Volume One: Policy and Governance Discussion Paper*, Prepared for the Peel-Harvey Catchment Council, Mandurah, Western Australia.

Kiepert, N., D. Weaver, R. Summers, M. Clarke and S. Neville, 2008, 'Guiding BMP adoption to improve water quality in various estuarine ecosystems in Western Australia', *Water, Science and Technology*, IWA Publishing, pp. 1749-1756

Land Assessment Pty Ltd, 2005, *Peel-Harvey Catchment Natural Resource Management Plan - Main Report*, prepared for the Peel-Harvey Catchment Council, March 2005

Lavell, K., 2004, *Findings of a nutrient management social survey*. Unpublished Report prepared by the Department of Agriculture and Food, Waroona.

Lavell, K., Summers, R. N., Weaver, D. M., Clarke, M. F., Grant, J. & Neville, S. D., 2004, 'An audit of the uptake of agricultural nutrient management practices in the Peel–Harvey catchment', paper presented at the 7th International River Symposium, Brisbane Australia, Aug 31st–3rd Sept 2004.

7 References

Lee, S.Y., R.J.K. Dunn, R.A. Young, R.M. Connolly, P.E.R. Dale, R. Dehayr, C.J. Lemckert, S. Mckinnon, B. Powell, P.R. Teasdale and D.T. Welsh, 2006, 'Impact of urbanization on coastal wetland structure and function', Austral Ecology, vol. 31, pp. 149-163

Lloyd, S. D., 2001, Water sensitive urban design in the Australian context; synthesis of a conference held 30-31 August 2000, Melbourne, Australia (CRC for Catchment Hydrology Technical Report 01/7), Cooperative Research Centre for Catchment Hydrology, Melbourne

Lloyd, S.D., T.H.F. Wong and C.J. Chesterfield, 2002, Water Sensitive Urban Design - A Stormwater Management Perspective, Cooperative Research Centre for Catchment Hydrology, Melbourne

Mayne, J., 2003, Reporting on outcomes: setting performance expectations and telling performance stories, Office of the Auditor General: Canada, http://www.oag-bvg.gc.ca/domino/other.nsf/html/99pubm_e.html

McComb, A.J. 1995, *Eutrophic Shallow Estuaries and Lagoons*, Murdoch University, Perth

Moore, G., P. Sanford and T. Wiley, 2006, Perennial Pastures for WA, *Australian Society of Agronomy* [online], retrieved 26 August 2009, http://www.regional.org.au/au/asa/2006/poster/pests/4685_mooreg.htm

Neville, S.D., 2005, SSPRED: The Support System for Phosphorus Reduction Decisions - Model Framework Development Report. Report to Agriculture Western Australia, Ecotones & Associates, Denmark WA

Neville, S.D., R.N. Summers, D.M. Weaver and K. Lavell, 2005, Improving Water Quality in the Coastal Catchment of the Peel-Harvey Inlets, Paper presented at Turning Waste into Water Symposium, Denmark Centre for Sustainable Living, Dec 9, 2005

New WAter Ways, 2009, *New WAter Ways Strategy 09*, Perth, Western Australia

NSW Department of Primary Industries (DPI) and the Department of Natural Resources (DNR) Goulburn, Queanbeyan and Yass and Hawkesbury-Nepean Catchment Management Authority, 2006, *Best Management Practices for Temperate Perennial Pastures in New South Wales*, 2nd Ed., NSW Government: Sydney

Pahl-Wostl, C., 2002, Towards sustainability in the water sector – The importance of human actors and processes of social learning, *Aquatic Sciences*, vol. 64, pp. 394-411

Peel Development Commission [PDC], 2006a, Peel: Economic Perspective, July 2006, PDC: Mandurah, Western Australia

Peel Development Commission [PDC], 2006b, Peel 2020: Sustainability Strategy, October 2006, PDC: Mandurah, Western Australia

Peel-Harvey Catchment Council [PHCC], n.d., *Development of a Stormwater Monitoring Program Guidelines for Local Government,* PHCC: Mandurah, Western Australia

Peel-Harvey Catchment Council [PHCC], 2005, 'Our Organisation', retrieved 10 August 2009, http://www.peel-harvey.org.au/content/our_organisation/our_organisation.asp

Peel-Harvey Catchment Council [PHCC], 2007, Project Status Report (WQ01c), Statement provided to SWCC 30 July 2007

7 References

Peel-Harvey Catchment Council [PHCC], 2008a, *Management of Diffuse Water Quality Pollution in the Peel-Harvey Coastal Drainage System: A Strategic Approach to Implementation of Best Management Practices*, PHCC, Mandurah, Western Australia

Peel-Harvey Catchment Council [PHCC], 2008b, *Stormwater Retrofitting: Products Available in the Peel for Stormwater Management*, PHCC, Mandurah, Western Australia

Peel-Harvey Catchment Council [PHCC], 2009a, Final Audited Financial Statement (IP2 Project), Statement provided to SWCC 5 March 2009

Peel-Harvey Catchment Council [PHCC], 2009b, Final Report (IP2 Project), Statement provided to SWCC 5 March 2009

Rogers, S. and S. Vivian, 2008, Perennial Based Pasture Systems for the Peel-Harvey Catchment: Intensive Demonstration Sites Report for 2008, Report prepared for the Peel-Harvey Catchments Council

Rose, T., 2003, *Water Quality Monitoring Programme for the Peel-Harvey Coastal Catchment Perth*, Western Australian Department of Environment, Perth

Shire of Waroona, 2007, *ICLEI Water Campaign Corporate And Community Local Action Plan Draft*, September 2007, Retrieved 6 August 2009, http://www.iclei.org/fileadmin/user_upload/documents/ANZ/WhatWeDo/Water/CPM3Waroona.pdf)

Sinclair Knight Merz, 2007, Sediment Sampling Plan, Report prepared fro the Peel-Harvey Catchments Councils, April 2007, Perth

South West Catchments Council, 2008, WQ01 Peel-Harvey Water Recovery Project Final Project Report, December 2008

Star J., Postma D. & Morup R. 2004, *Case Study: Peel-Harvey,* In: Drainage Reform Group (2004) White Paper February 2004 Reforming Drainage – Moving Towards Total Water Cycle Management in Western Australia, Perth

Steele, J.J., 2006, Management of Diffuse Water Quality Issues in the Peel-Harvey Coastal Drainage System: Literature Review, report prepared for the Peel-Harvey Catchment Council, September 2006

Syrinx Environmental Pty Ltd, 2007, Wetland Design - Pinjarra Road, Pinjarra, Report prepared for the Peel-Harvey Catchment Council, October 2007

Thompson McRobert Edgeloe, 2009, Waroona Drainage Study, Report prepared for the Shire of Waroona, January 2009

URS Australia 2003, *A Discussion Paper on Drainage Reform in WA*, Prepared by URS for the Drainage Reform Group, Perth.

URS Australia 2005, Implementation Measures that Support, Influence, Encourage or Require Uptake of Best Management Practices for Nutrient Management, Report prepared for the Department of Agriculture, October 2005

7 References

URS Australia, 2009, 'State of Play: Peel Eastern Estuary Environmental Assessment: Report on Phases 2 and 3', report prepared for the Department of Water by URS Australia Pty Ltd, Perth

Weaver, D.M. and S.D. Neville, 2005, *SSPRED - Support System for Phosphorus Reduction Decisions*, Poster presentation at Environment Institute of Australia and New Zealand, Environmental Sustainability in Practice Conference, 29 Mar - 1 Apr 2005, Hotel Grand Chancellor, Christchurch

Weaver, D.M., S.D. Neville, R.N. Summers, and M.F. Clarke, 2004, Reducing nutrient discharge from agriculture through the implementation of BMPs – how far can we go? Paper presented at the 7th International River Symposium, Brisbane Australia, Aug 31st – 3rd Sept 2004

Weaver, D., R. Summers, S. Neville and K, Lavell, 2006, *Coastal Catchments Initiative in Peel-Harvey, Agricultural BMPs Results and Gaps*. A presentation to the CCI Geographe Vasse meeting, Busselton, 13 March 2006

Western Australian Planning Commission, 2006, *State Planning Policy 2.9: Water Resources*, WAPC, Perth

Western Australian Planning Commission, 2008, *Better Urban Water Management*, October 2008, WAPC, Perth

Wong, T. H. F., 2006, Water Sensitive Urban Design - The journey thus far. *Australian Journal of Water Resources.* Special Issue on Water Sensitive Urban Design, 10(3): 213-222

Zammit, C. and R. Summers, 2005, Modelling catchment processes in the Peel-Harvey basin, Paper presented to the 2005 WA Coastal Conference, November 17th 2005, Busselton WA.

Zammit, C., P. Bussemaker, J. Hall, 2006, *Establishment of a Decision Support System for Water Quality Improvement and Protection of the Peel Inlet and Harvey Estuary*, Department of Environment NRM and Salinity Division Aquatic Science Branch, Perth

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Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of South West Catchments Council and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 23 March 2009.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between July and October 2009 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Appendix A Resource Condition Targets

RCTCode	Description
ARCT 1	For rural, urban and industrial centres in the South West Region to be moving towards improving ambient air quality by 2006
ARCT 2	Water to be sustainably allocated in light of climatic change and rainfall by 2024.
ARCT 3	Greenhouse gas emissions in the region are reduced by 20% by 2024
BRCT 1	No indigenous species or community to become extinct in the wild in the SW NRM region during the period 2004 to 2024.
BRCT 2	The condition, viability and conservation status of at least 5% of the region's identified natural biodiversity assets are improved by 2024 (5% (assets) to be quantified by Dec 2005).
BRCT 3	No loss of habitat contributing to a decline in threatened & at-risk native species by 2024
BRCT 4	No net loss of extent or condition of native vegetation on land managed for conservation within representative landscapes during the period 2004 to 2024.
BRCT 5	No reduction in area of poorly conserved ecological types during the period 2004 to 2024 (poorly conserved will be defined see MAT BT 7 BT 8).
CRCT 1	Coasts habitat integrity to be improved by 2025 (To be reviewed and quantified by 2006).
LRCT 1	Total area of land affected by dryland salinity no more than X times the 2004 area at 2020 (targets to be developed with the community for specified catchments using MAT LT1 by December 2005)
LRCT 2	Rates of rising groundwater levels reduced by at least X% across the Region (targets to be developed with the community for specified catchments using MAT LT2 by December 2005)
LRCT 3	No more than x% of soils on agricultural land with low subsurface pH (pH<4.5 at 10-20 cm) by 2020 (target to be developed using MAT LT4 by December 2005).
LRCT 4	No net increase in area of soils on agricultural land with low organic carbon (<1%) by 2020 (target to be developed using MAT LT4 by December 2005).
LRCT 5	No new ecologically significant invasive vertebrate or insect pest established in the region by 2020 (priority list of pests to be developed using MAT-LT18 by December 2005); and
LRCT 6	No new ecologically significant invasive weed or disease established in the region by 2020 (priority list of weeds and diseases to be developed using MAT-LT18 by December 2005).
LRCT 7	The area of remnant vegetation and regrowth on rural land across the region is at least X% of the 2004 area by 2020 with no further loss thereafter (target to be developed using LT52 by December 2005).
LRCT 8	State forest and private native forest management follows ecologically sustainable forest management guidelines as outlined in the Forest Management Plkan (Conservation Commission of WA 2004) by 2013
MRCT 1	Marine habitat integrity to be improved by 2025.
MRCT 2	No decline in fisheries by 2025.
MRCT 3	No additional marine pest species to become established by 2025
PRCT 1	100% of all identified Indigenous cultural significant areas (land, water/seascapes) within the region are conserved and protected from threatening processes (e.g. salinity, water quality decline, urbanisation) by 2020.
PRCT 2	All intellectual property and knowledge given by the Nyungar community is protected by 2015
PRCT 3	Relationship between indigenous access to land, maintenance of cultural heritage and natural resources recognised and accepted in the NRM community by 2020
WRCT 01	Reduced sedimentation, pool infilling, erosion and aquatic fauna barriers by 10% for priority waterways and estuaries by 2020.
WRCT 02	Increase the level of retention, restoration and management of remnant vegetation by 20% along the riverbanks, estuaries and around wetlands by 2024.
WRCT 03	Decrease the level of vegetation clearing, filling and excavation of priority wetlands to

Appendix A

RCTCode	Description
	10% by 2020.
WRCT 04	Improved health and extent of Ramsar, Directory of Important Wetlands in Australia (DIW), Register of the National Estate (RNE), Environmental Protection (Swan Coastal Plain) Policy Wetlands, and conservation category wetlands by 2008.
WRCT 05	The condition of the regions natural floodplain areas are improved by 2024
WRCT 06	Decrease levels of water quality parameters including turbidity and levels of TN, TP and soluble nutrients in priority waterways, wetlands and estuaries by 2024
WRCT 07	Significant algal blooms in priority waterways and estuaries reduced by 10% by 2010.
WRCT 08	A progressive reduction in fish kills throughout the region of 20% by 2010 and 60% by 20202
WRCT 09	Decrease the level of salinity by 10% in marginal waters (up to 1500mg/L) and 10% in brackish waters (up to 5000mg/L) in priority waterways by 2024.
WRCT 10	Salinity of the Wellington Dam is reduced to <500mg/L by 2015.
WRCT 11	Salinity of the Warren River is reduced to <500mg/L (measured at Bakers Rd site) by 2030.
WRCT 12	All water resources used within sustainable limits by 2020.
WRCT 13	Reduced exposure of Acid Sulphate Soils (ASS) by 2010
WRCT 14	All surface and groundwater drinking water sources maintained to National and State drinking water standards
WRCT 15	Regional, State and Commonwealth framework for water supply developed in consultation with key stakeholders by 2007
WRCT 16	Reduce water related point source and diffuse pollution in the region by 2024.

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