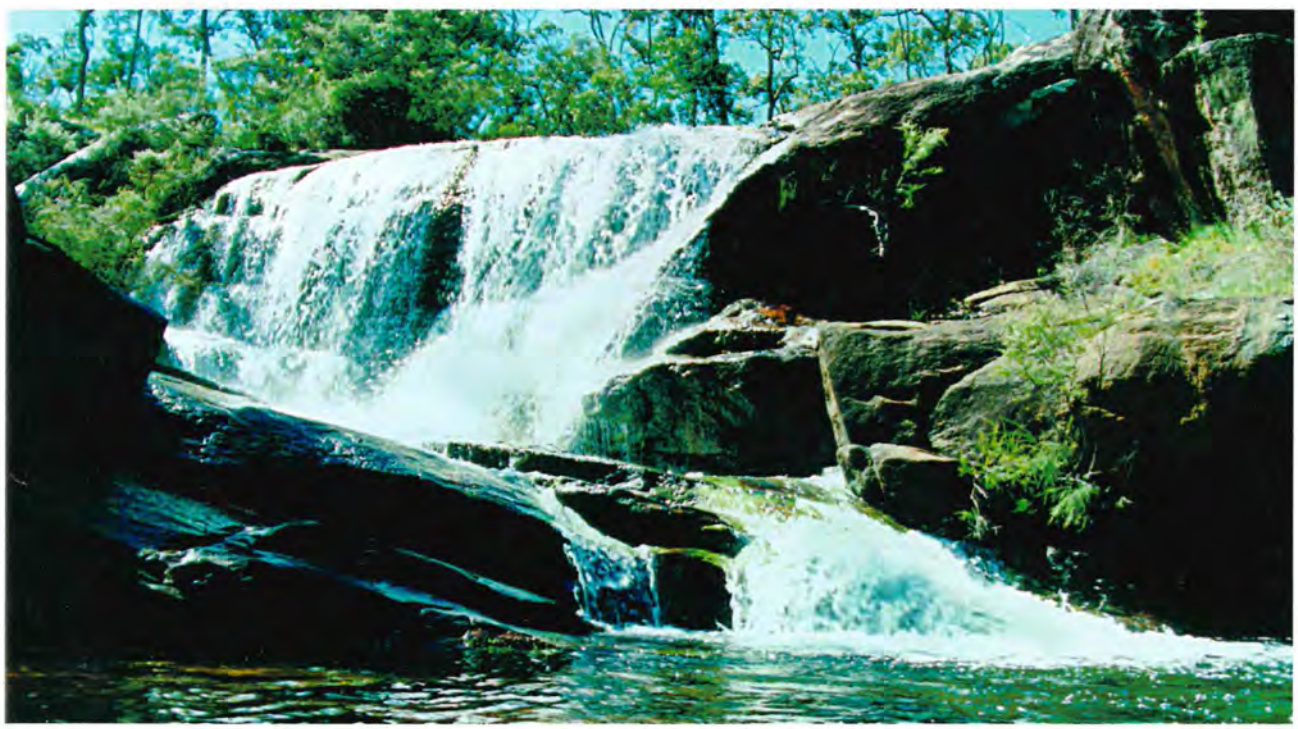
GOVERNMENT OF WESTERN AUSTRALIA

PROPOSED HARVEY BASIN SURFACE WATER ALLOCATION PLAN



WATER RESOURCE ALLOCATION AND PLANNING SERIES

WATER AND RIVERS COMMISSION REPORT WRAP 14

1998

WATER AND RIVERS COMMISSION

PROPOSED
HARVEY BASIN
SURFACE WATER ALLOCATION PLAN

Water and Rivers Commission
Policy and Planning Division

WATER AND RIVERS COMMISSION
WATER RESOURCE ALLOCATION AND PLANNING SERIES
REPORT NO WRAP 14
1998

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This report was prepared by the Water and Rivers Commission with the assistance of Welker Environmental Consultancy under the direction of Roy Stone of the Water Allocation Branch of the Water and Rivers Commission. Charlie Welker led the study team for this plan, which was completed within a tight timeframe. Jeni Alford provided input on environmental matters, supported the study process and assisted report production. Mark Pearcey and John Ruprecht of the Commission provided advice and input on surface water hydrology and Jeff Kite on environmental water provision matters.

Jo Ann Beckwith of Beckwith and Associates managed the public consultation process and carried out the social impact analysis. Peter Davies of Streamtec Pty Ltd assessed the environmental water requirements of the Harvey River.

Mattiske Consulting Pty Ltd surveyed the vegetation and flora; and Paul de Tores and Suzanne Rosier conducted a western ringtail possum survey in areas subject to proposed inundation.

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Preface

In accordance with the Water and Rivers Commission Act, a primary function of the Commission is planning for sustainable use of the State's water resources. Under its legislation, the Commission is required to do those things necessary to ensure this function is successfully carried out.

This report concerns the allocation planning for the surface water resources of the Harvey Basin.

The proposed allocation plan defines surface water available for use on an ecologically sustainable basis after providing water for the environment and important social uses.

Proper planning for the use of the water resources of this basin must take account of a range of factors with particular emphasis on sustainable use, environmental, social and recreational impacts. This report seeks to provide an integrated appraisal of the effect of these factors on water resource values to ensure a well informed debate. In canvassing these factors, the Commission does not intend to imply it is crossing over into the domain of other authorities which will also contribute to the debate.

The *Perth's Water Future* strategy identified the surface water resources of the Harvey Basin as having a strategic role in meeting the future water needs of Perth and Mandurah. The Commission reviewed the strategy and set down its requirements for future water allocations in *Allocating Water for Perth's Future.* In particular the Commission stipulated that a subregional allocation plan would need to be prepared to determine the acceptability of the water supply developments proposed for the Harvey Basin. This Harvey Basin Surface Water Allocation Plan fulfils that need.

Allocating Water for Perth's Future also set out a process which integrates the Commission's water allocation planning with the EPA's environmental assessment process. In accordance with this process the Commission is now submitting this proposed Plan to the Environmental Protection Authority for review and is also releasing the report for public comment.

It is believed this report will help set in context the respective roles and responsibilities of the various agencies involved in the planning and development of water resources for a sustainable future of Western Australia.

You are invited to contribute to the finalisation of this important allocation plan by making a personal or group submission or comment.

Invitation to comment

The Water and Rivers Commission (Commission) and the Environmental Protection Authority (EPA) invite people to make a submission on this proposal. Persons who have comments to make on the environmental aspects of the plan should address their submissions to the EPA. Submissions on all other matters should be addressed to the Commission.

The Proposed Harvey Basin Surface Water Allocation Plan proposes surface water allocations for beneficial uses including public water supply, irrigation, self-supply and industrial use after making provisions to the environment and social uses.

The Proposed Harvey Basin Surface Water Allocation Plan is available for public review for up to 8 weeks from 27 **March, 1998,** closing on **25 May, 1998.**

Comments from government agencies and from the public will assist the Commission to finalise the proposed plan and the EPA to advice on the environmental aspects of the plan.

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action - including an alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the Commission or EPA will be acknowledged. Submissions will be treated as public documents unless provided and received in confidence subject to the requirements of the Freedom of Information Act, and may be quoted in full or in part in each report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining with a group or other groups interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues, discussed in the plan or the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more acceptable.

When making comments on specific proposals in the plan:

- clearly state your point of view;
- indicate the source of information or argument if this is applicable;
- suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- attempt to list points so that issues raised are clear. A summary of your submission is helpful;
- refer each point to the appropriate section, chapter or recommendations;
- if you discuss different sections of the document, keep them distinct and separate, so there is no confusion as to which section you are considering;
- attach factual information you may wish to provide with details of the source. Make sure your information is accurate.

Remember to include: your name and address
date; and
whether you want your submission to be confidential.

The closing date for submissions is **25 May 1998.**

Address submissions on environmental aspects to:

Chairman
Environmental Protection Authority
Westralia Square
141 St Georges Terrace
PERTH WA 6000
Attention: Dr Felicity Bunny

Address submission on all other matters to:

Chairman
Water and Rivers Commission
PO Box 6240
EAST PERTH WA 6892
Attention: Mr Roy Stone

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Executive Summary

1. The Harvey Basin

The Harvey Basin (the Basin) is about 110 km south of Perth and contains the Harvey River which discharges into the Harvey Estuary (Figure 1 in main report).

The coastal plain component of the Basin is predominantly cleared and accommodates the Harvey and Waroona Irrigation districts, which support a valuable agricultural industry (principally dairying). A comprehensive drainage system has been progressively constructed in and adjoining the irrigation districts to reduce waterlogging and flooding of agricultural land and the Harvey townsite.

Almost all streams on the coastal plain have been extensively modified by artificial drainage, irrigation and clearing of native vegetation.

The Darling Range portion of the Basin consists mostly of State Forest with some private land, which has been substantially cleared for agriculture, in the Harvey Weir and Wellesley Creek sub-catchments.

There are a number of towns in the Basin, the largest being the Town of Harvey, which is on the Harvey River about 2 km downstream of the Harvey Weir.

2. Basin Allocation Planning Approach

The Commission, in its response to the Water Supply Strategy for Perth and Mandurah, indicated that a sub-regional allocation plan for the Basin had to be prepared before an additional allocation could be determined for public water supply from the Harvey River resource.

The process for the preparation of this plan (Figure 2 in main report) involved technical, environmental and social investigations to identify:

- current and historical streamflow;
- significant environmental and social values and/or beneficial uses that are dependent on streamflow;
- environmental and social impacts and management associated with development options to achieve additional allocations; and
- water supply characteristics of development options.

The Commission also conducted an extensive public consultation process that included potentially affected landowners, Harvey, Murray and Waroona Shires, South West Irrigation, Harvey River Land Conservation District Committees, State Government agencies, farmer organisations and community groups.

3. Existing Water Resource Development

The water resources of the Harvey Basin are already highly developed. Reservoirs have been constructed on:

- Drakes, Yalup and Samson Brooks (Waroona, Drakes and Samson Brook dams and Samson Brook pipehead dam for irrigated agriculture and Wagerup and Chasede dams for industrial use), yielding about 19.4 GL/yr; and
- Logue Brook and Harvey River (Logue Brook Dam, Stirling Dam and Harvey Weir principally for irrigated agriculture), yielding about 68 GL/yr.

Small streams that are not subject to substantial damming or barriers (unregulated and semi-regulated streams) have been identified as potential sources for water supply. These streams may potentially yield in total up to 37 GL/yr without allowances for environmental water provisions.

Currently about 50% of the mean annual streamflow of the Harvey River above the Harvey Weir is allocated to irrigation and to industrial and public water supply uses.

4. Basin Streamflow

Water supply developments, irrigation and drainage works and agricultural activities have radically altered the hydrology of the Basin. Modelling, by the Commission, of annual streamflows has shown that:

- flow into the Harvey Estuary from the Basin is currently 50% greater than it was prior to European settlement;
- flow from the Darling Range portion of the Basin to the Harvey Estuary is about 40% of that in pre-European times;
- flow (including irrigation water returns) from the coastal plain component of the Basin to the Harvey Estuary is about 300% greater than it was prior to European settlement; and

- almost all the overflow from the Harvey Weir (44 GL/yr) is diverted down the Harvey Diversion Drain to the Indian Ocean.

The Darling Range streams are not significantly affected by salinity and have low salinity levels (less than 300 Total Dissolved Solids). Turbidity levels are elevated where runoff is received from cleared land with uncontrolled access of livestock to streams.

5. Significant Values and Beneficial Uses of Basin Water Resources

The Commission engaged Streamtec Pty Ltd to conduct ecological studies of the Basin. These studies revealed the following:

- the loss of in-stream habitat, the clearing of riverine vegetation and river channel instability are the major causes of river degradation;
- despite human influence, significant ecological values were identified downstream of the Harvey Weir but were confined to the Harvey River below the Harvey Main Drain (the key ecological values and features identified were wetlands, riverine and floodplain vegetation, fish, aquatic invertebrates, ecosystem processes and channel maintenance);
- current streamflow in the lower Harvey River is sufficient to support important ecological values; however, channel maintenance and river flood plain connections are not practicable given the physical characteristics of the existing river and the environmental damage that may result from releases to make these connections;
- the identified ecological values are sustained by unregulated, semi-regulated and regulated flows from Darling Range tributaries that join the Harvey River below the Harvey townsite;
- the Harvey Diversion Drain does not support any significant ecological values;
- existing barriers in streams disrupt the upstream movement of fish and the downstream movement of carbon; and
- restoration of key components of the Harvey River is required in order for environmental water provisions to have a beneficial impact.

A public consultation program and social analysis conducted by Beckwith and Associates identified the following existing key social values or beneficial uses of water:

- a range of recreational activities are conducted on the Waroona and Drakes Brook dams;
- whitewater canoeing is regarded by the Harvey community as a valuable use of the Harvey River;
- aesthetic flow through the Harvey tourist precinct is regarded by the Shire of Harvey as important; and
- there are a number of self-supply users throughout the irrigation districts and on the Harvey Diversion Drain near Myalup.

6. Impacts of Harvey River Hills Options

The configuration of a water resource development influences resource yield, cost, environmental (including ecological) and social impacts. The acceptability of an additional allocation to public water supply uses can only be determined after considering the social and environmental impacts that arise from water resource developments designed to achieve the allocation.

After consultation with stakeholders, the Commission identified four basic options for achieving an additional allocation for public water supply from the Harvey River Hills resource (Figures 11a–11d in main report). These options are:

- Option A – direct injection to the Perth Metropolitan Water Supply Scheme (PMWSS) without a new Harvey Dam with the option of storage in the South Dandalup Dam;
- Option B – a new Harvey Dam with a full supply level between 70 and 90 m and with irrigation and public water supply taken from the new dam;
- Option C – a new Harvey Dam with a full supply level between 70 and 90 m and with irrigation supply taken from the new dam and public water supply from the Stirling Dam via a pipeline; and
- Option D – raising the height of the Stirling Dam.

A pumpback facility on Wellesley Creek is possible with Option A (with storage at South Dandalup Dam) and highly likely with Options B and C.

The water supply and environmental and social implications of these options were assessed in detail. None of the options impacts on downstream ecological values and none is likely to significantly impact downstream self-suppliers drawing water from the Harvey Diversion Drain.

The key findings of this assessment were:

- Unacceptable aspects of a new Harvey Dam may be overcome by locating pipelines out of riverine areas and limiting the full supply level to 78 m.
- Environmental and social impacts that result from inundation under Options B and C are avoided by Option A. Potential environmental impacts of inundation include loss of remnant vegetation and habitat of the western ringtail possum, which is a Specially Protected Fauna, and the displacement of landowners.
- Options A with storage in South Dandalup Dam and Option D would give rise to substantially higher greenhouse gas emission rates.
- Water resource yield would be severely restricted with Option A (18.5 GL/yr) without storage in South Dandalup Dam. Option B provides the best opportunity to take advantage of enhanced water resource yields from a Wellesley Creek pumpback facility (total yield of 43 GL/yr) and trading in surplus irrigation water. Option C can be modified to match the potential yield of Option B but at a relatively higher cost (4 c/kL more) and with some risk to the continuance of whitewater canoeing.
- Options A (without storage in South Dandalup Dam) and C would have the lowest cost water (52 c/kL) followed by Option B (59 c/kL). Option A with storage at South Dandalup Dam would have the highest cost (80 c/kL).
- Options A, B and D would require the implementation of measures to maintain or reduce risks to water quality. These measures may restrict future opportunities for recreation on Harvey River reservoirs and land-use activities in the Harvey River Hills catchment.

Other development configurations that reduce impacts and achieve an additional allocation are not precluded.

7. Allocation Principles and Policies

The Commission has formulated a series of principles and policies to guide the determination of allocations of water at planning and licensing levels.

These principles and policies cover many aspects of water resource management and include:

- water entitlements, trading and capacity sharing;
- environmental water provisions, ecologically sustainable development and community benefit;
- water resource allocation, access and multiple uses and usage of drainage and waste waters;
- hoarding of water, water use efficiency, inter-regional transfer of water and protection of existing licensed allocations;
- climate variability; and
- community participation.

8. Identified Beneficial Uses

The Commission has identified the following broad beneficial uses of the Basin's water resources through the process of public consultation and from the results of environmental studies and water resource investigations:

- ecological;
- recreation and tourism;
- aesthetics;
- irrigation;
- public water supply;
- self-supply; and
- industrial.

9. Environmental Water Provisions

Ecological

The present streamflow down the Harvey River is more than adequate to support the identified key ecological values and features.

The Commission recognises the importance of the northern tributaries of the Harvey River for the maintenance of ecological values of the lower Harvey River. It believes that 95% of the mean annual flow of semi-regulated and unregulated streams (other than Wellesley Creek) should be provided to the environment. No further significant development of regulated streams (outside the Harvey Hills) should occur until environmental water provisions are established for these streams.

Clearing of native vegetation and dieback on private land in the Wellesley Creek catchment has led to a greater than threefold increase in streamflow. This resource does not support any significant ecological values outside the State Forest portion of the catchment. The streamflow that existed prior to European settlement should be an adequate provision for the environment.

Aesthetic

The Commission recognises that the maintenance of flow in the Harvey tourist precinct is an important beneficial use. It has established an allocation which would ensure that adequate streamflow is maintained in this section of the Harvey River in summer. This allocation may be satisfied by a flow of 0.25 GL over the summer period.

Recreation – Whitewater Canoeing

Releases of water for whitewater canoeing has caused erosion in vulnerable areas of the Harvey River between the Harvey Weir and the Stirling Dam. This erosion appears to be more related to the number of whitewater release events from the Stirling Dam than their duration.

The Commission recognises the social importance of whitewater canoeing and has established an allocation that maintains whitewater conditions on 55 canoeing days each irrigation season. The conditions that would apply to this allocation include:

- a flow rate of 14 kL/s for an average period of 7 hours for each whitewater canoeing day;
- reliability of this allocation to be the same as for irrigation water; and
- the WA Canoeing Association to demonstrate its best endeavours to reduce the number of release events from the Stirling Dam to minimise erosion.

Recreation – on Reservoirs

The Commission believes that any change to the consumptive use of water from existing storages (Waroona, Logue and Drakes Brook Dams), where water-based recreation values are well established, should not result in the loss of these values without the approval of the Commission.

The Commission recognises the need to establish an appropriate balance between protecting and reducing risks to water quality and developing recreation on a new Harvey Dam. It considers there may be opportunities under appropriate conditions to accommodate recreational activities such as canoeing, sailboating, marroning, fishing and bushwalking because of the intention to treat any water from the Harvey Reservoir used for public water supply.

10. Allocations for Consumptive Uses

The Harvey River Hills Resource

The Commission believes that an additional 34 GL/yr may be allocated to public water supply from the Harvey River Hills resource provided that:

- the full supply level of a new Harvey Dam does not exceed 78 m;
- water pipelines are located outside riverine areas;
- the allocations for aesthetic flow and whitewater canoeing in this plan are met;
- the environmental water provisions in this plan and the requirements of the EPA, CALM and the Department of Aboriginal Affairs are met;
- riverine areas within the Basin are restored; and
- there is a capacity to take water from a new Harvey Dam for public water supply.

Achievement of an additional 34 GL/yr public water supply allocation would result in social impacts that would require careful and sensitive management.

The Commission believes that the allocation would be conditional upon the following major social issues being adequately addressed:

- reducing uncertainty for landowners through a commitment, by the developer of the resource, to a development option upon finalisation of this plan;
- employing a land acquisition process that is open and transparent and ensures landowners are compensated, as far as is possible, so that they are not "worse off";
- consider alternative options to the proposed new access road alignment; and
- conduct additional heritage investigations to determine how best to minimise loss of heritage values.

A development configuration that achieves this conditional allocation is shown in Figure 15 in the main report.

An allocation of 0.2 GL/yr (in addition to existing riparian entitlements) has been established for self-supply use. In addition, the Commission would encourage a future public water supply developer to enter into agreements with landowners adjoining a new Harvey Dam for the supply of water from this storage.

11. Other Water Resources

Harvey Diversion Drain

The Commission believes the existing use of drainage water from the Harvey Diversion Drain can be supported. However, a more detailed study of usage and streamflows in this drain is warranted in order to set a sustainable yield from this source. Until these studies are completed, the level of abstraction for self-supply use from this drain should not be increased.

By-law 11 Users

The Commission considers that there is sufficient water within the existing irrigation entitlements to supply all existing By-law 11 users with their current needs. The Commission would support the clarification and codification of allocations via customer contracts with South West Irrigation (SWI) to former By-law 11 users where their water needs can be demonstrated.

Coastal Plain

Streamflow from the coastal plain greatly exceeds that which existed prior to European settlement.

Under average rainfall conditions (based on the sequence 1962–96) water available for consumptive use on the coastal plain could be as high as 60 GL/yr.

Darling Range Tributaries of the Harvey River

The Commission has established the following allocations for this resource:

- 9 and 3 GL/yr respectively for public water supply and self-supply use from the Wellesley Creek resource;
- a total of 2 GL/yr for self-supply use from regulated tributaries; and
- a total of 1 GL/yr from unregulated and semi-regulated tributaries.

Further significant development of regulated streams (Logue, Samson and Drakes Brooks) outside the Harvey River Hills would be subject to the establishment of environmental water provisions for these streams.

12. Review of Allocations

The above consumptive allocations and environmental provisions are based on existing knowledge and present understanding of future circumstances. A review of these allocations through an open and public process may be required with substantially improved knowledge or with major unanticipated changes in social circumstances or future trends.

Climate change or changes in community values or the need to prescribe more refined environmental water provisions may trigger such a review.

13. Restoration of River Health

The health of the Harvey River needs to be improved for environmental water provisions to have a beneficial impact. The loss of in-stream habitat, the clearing of riverine vegetation and channel instability are the major causes of degradation particularly in the lower reaches of the river.

The Commission would coordinate, as required, the preparation of a catchment management plan to provide a framework for river restoration.

The Harvey River Restoration Trust

The Commission would establish a Harvey River Restoration Trust to promote the rehabilitation of the Harvey River. The Commission, in conjunction with an advisory board of representatives, would administer this Trust. Representatives would be drawn from land conservation district committees, water resource developers and the community.

The Trust would receive funds from water resource developers in compensation for the loss of riverine and wetland systems. An additional allocation to public water supply from the Harvey River would involve the loss of riverine systems in the upper Harvey River and Wellesley Creek. The Commission would require the developer of these resources to make a major contribution to the Trust.

14. Implementation Program

The Commission has developed an implementation program for this plan. This program outlines the allocation licensing structure that would apply in the Basin as well as water resource management objectives and measures for eight management areas in the Basin. This program would guide the issue of allocation licences, water resource developments, catchment management and water resource protection in public water supply catchments.

Licensing Structure

The allocation licensing structure that would operate in the Basin would consist of:

- access licences (to be issued only to major water resource developers) would set aside water for a

- access licences (to be issued only to major water resource developers) would set aside water for a future purpose as a precursor to an entitlement to take water;
- headworks operating licences would provide a right to divert, halt the flow of, collect or store water from a surface water resource; and
- take and use licences would provide a right to self-suppliers or service providers to take water from water resources.

The Commission would be prepared to issue access licences to a future developer of the Harvey River Hills and Wellesley Creek resources subject to a number of conditions.

Licensing Guidelines

The Commission has developed a set of guidelines to guide the issue of take and use licences to self-suppliers. The guidelines are intended to manage allocations to self-supply users to protect large-scale public water supply developments, existing users and environmental water provisions proposed in the plan.

Water Quality Protection

The Commission would prepare a water quality protection plan to guide future land-use activities within the Harvey River Hills and Wellesley Creek catchments in close consultation with landowners. The protection plan would ensure that future land-use activities are compatible with the use of the water resources for public water supply.

Land uses such as extensive livestock grazing and broadacre cropping are likely to be considered acceptable, but management practices of some activities such as viticulture and marron farming may have to be adjusted. Intensity of rural subdivision would be limited and some potential land uses such as intensive horticulture and operating wineries may be prohibited.

Recreation Management Plan for Harvey River Hills Reservoirs

The Commission would prepare a recreation management plan for reservoirs in the Harvey River Hills catchment that recognises the need to balance protecting water quality for public water supply and developing recreation opportunities. The management plan would be prepared in consultation with the Harvey Shire, local landowners, recreation organisations and the developer of the Harvey River Hills resource.

The Commission believes there is potential to accommodate some passive recreational activities on the reservoirs.

Trading Water Entitlements

Under Council of Australian Governments (COAG) reforms, the Commission is committed to reform water law to allow the potential for water users to lease, buy or sell irrigation water. If water trading is ultimately allowed, it offers the opportunity for a future water resource developer to trade from a new Harvey Dam or to purchase surplus irrigation entitlements for public supply.

15. Environmental Assessment of Allocation Plan

Environmental factors are reviewed to assess whether the implementation of this plan is consistent with environmental protection objectives for these factors. Those factors associated with increased inundation from a new Harvey Dam are vegetation communities, declared rare and priority flora, terrestrial fauna, mosquitoes, European heritage and usage and Aboriginal heritage.

The Commission believes that environmental impacts are potentially manageable and the EPA's environmental objectives can be met with restoration of riverine areas and substantial commitments from a future water resource developer. These commitments are likely to include:

- further fauna surveys;
- preparation of acceptable management plans for protecting vegetation and Specially Protected Fauna,
- investigating and minimising impacts on European heritage; and
- compliance with the requirements of the *WA Aboriginal Heritage Act 1972*.

In addition the Commission has made a provision to maintain whitewater canoeing, aesthetic flows in the Harvey tourist precinct and would prepare a recreation management plan for a Harvey Dam and the Stirling Reservoir.

Alterations to downstream flow from a new Harvey Dam and Wellesley Creek pumpback facility would not give rise to any significant environmental impacts. Such flow does not currently support any significant ecological values.

1. Introduction

1.1 Background

The Water Supply Strategy for Perth and Mandurah to 2021 (WAWA 1995) proposed the use of water resources outside the Perth metropolitan area to meet some of the future demand of the Perth Metropolitan Water Supply Scheme (PMWSS). The proposals include the diversion of surface water from the Harvey–Waroona area by using surplus water from existing irrigation dams and increasing the yield from the Harvey River Hills resource by the construction of a new Harvey Dam.

The Water and Rivers Commission (the Commission) indicated that sources in the Harvey Basin may be considered as a potential source for Perth (WRC 1997a) subject to the completion of a sub-regional allocation plan for the Harvey Basin.

1.2 The Water and Rivers Commission

The Commission was established on 1 January 1996 as a result of the Western Australian Government's decision to separate the functions of the water resource management (the Commission) from water supply (now largely the Water Corporation) and supply regulation (the Office of Water Regulation).

The Commission is responsible for the allocation and protection of the State's water resources. Regional and sub-regional allocation plans are prepared by the Commission to provide a framework for its subsequent issuing of allocation licences.

1.2.1 Roles of Other Water Agencies

The Water Corporation is a separate corporatised Government agency which provides commercial water, sewerage and drainage services to customers under water allocation licences issued by the Commission.

The Office of Water Regulation is a separate Government agency responsible for ensuring the quality and integrity of water service provision to the end user.

1.3 Why Prepare a Harvey Basin Allocation Plan?

The water resources of the Harvey Basin are already highly developed. Before additional allocations can be determined for consumptive beneficial uses (such as public water supply), the sustainable water needs of the environment are to be provided and social beneficial uses (including recreational and aesthetic) of the water resource need to be appropriately considered.

In addition, an assessment of the social and environmental impacts of the means (options) by which additional allocations might be achieved is required to ensure environmental impacts are acceptable and social impacts are manageable.

The allocation plan is also necessary to establish a policy framework or rules which provide for more certainty for the future allocation of water to users through the licensing process. Allocations to future water users through the Commission's licensing procedures would be made in accordance with the allocation plan.

The Commission commenced preparation of the sub-regional water allocation plan for the Harvey Basin (this plan) in July 1997.

1.4 The Harvey Basin

The area covered by this plan is shown in Figure 1. In total the area of the Harvey Basin (the Basin) is 2055 km^2, and it includes the Waroona Irrigation District and most of the Harvey Irrigation District. Approximately 29% (605 km^2) of the Basin is State Forest and 45% (925 km^2) is cleared.

The Basin contains a series of small rivers and brooks that originate in the Darling Range and drain onto the Swan Coastal Plain. The watercourses and major drains include:

- the Upper Harvey River, stretching from the Darling Plateau to the Harvey River Main Drain;
- the Lower Harvey River, stretching from the Harvey River Main Drain to the Harvey Estuary;
- Harvey River Main Drain;

- Harvey Diversion Drain (taking overflow from the upper Harvey River to the Indian Ocean);
- Coolup Main, South Coolup, Mealup, and Caris Drains, which empty directly into the Harvey Estuary;
- Mayfields, Waroona, Logue, Bancell Brook, Samson Brook, Meredith and Clarkes Brook drainage lines, which all empty into the Harvey River;
- numerous creeks and brooks conveying water from the Darling Range to the drainage systems on the Swan Coastal Plain; and
- Wellesley and Wokalup Creeks.

1.5 Purpose

This plan is intended to define surface water available for consumptive beneficial uses on a sustainable basis after providing water for the environment and important social uses. In addition, the plan would provide a framework for the issue of allocation licences and potential trading of water entitlements throughout the study area.

The allocation plan also provides a rational basis for ensuring security of access to water resources for service providers and self-supply users as long as environmental and social water provisions are met.

The proposed allocations are based on existing knowledge of the water resources, the environment, social circumstances and the present understanding of future trends in the Basin. A review of these allocations may be required with improved knowledge or where there are unanticipated changes in social circumstances or future trends.

1.6 Plan Objectives

The objectives of the allocation plan are:

1. To identify the existing and potential ecological, social and economic values and beneficial uses of the Harvey Basin's surface water resources and their contribution to the waterway values of the Peel–Harvey Estuary.
2. To identify additional allocations from water resources in the Harvey Basin potentially available for consumptive beneficial uses and any conditions that apply to these allocations.
3. To set environmental water provisions to meet important ecological and social needs.
4. To provide a policy framework for the issue of allocation licences and management of surface water resources.

1.7 Scope

Because the plan is not a water supply strategy it has not examined alternative sources of supply to meet future consumptive demands. Water supply strategies are the responsibility of water service providers. The plan identifies the amount of water that may potentially be diverted for consumptive beneficial uses while ensuring adequate provision for both environmental (including ecological) and social uses.

However, it is recognised that construction of a new Harvey Dam has been considered a possible future option for many years, and such a development was proposed in the Water Supply Strategy for Perth and Mandurah (WAWA 1995).

The plan considers surface water and not coastal ground water resources in the Basin. Groundwater resources have been effectively allocated to private supply (such as horticulture) and town supplies.

The plan establishes environmental and social water provisions and water available for consumptive use from Darling Range and coastal plain catchments within the Harvey River Basin.

The plan assesses options for achieving additional allocations of water for public water supply from the Harvey River Hills water resource.

1.8 Preparation Process

The process for the preparation of the plan is shown in Figure 2 and involves:

- scientific, technical and modelling studies which:
  - * identify environmental impacts and values and ecological water requirements;
  - * identify water resource yields, supply costs and development configurations; and
  - * quantify streamflow in the Basin under current and historic conditions;
- an extensive public consultation process (refer Section 1.8.1);
- social impact analysis and Aboriginal heritage studies to determine the impact of additional consumptive allocations from the Harvey River resource; and

- public review prior to the finalisation of the plan by the Commission.

1.8.1 Public Consultation

The Commission's objective for the public consultation process has been to involve the community in a fair and open planning process. Over the course of preparing the plan, discussions were held with a broad range of stakeholder interests including local and State government agencies, interest groups, and affected landowners. At the start of the study, an issues scoping exercise was conducted with the objectives of:

- identifying key stakeholders;
- informing the stakeholders about the allocation study;
- identifying stakeholder issues to be addressed in technical studies;
- obtaining preliminary comment on specific allocation options identified in previous studies; and
- identifying the stakeholders' public involvement needs.

Information was collected from a range of stakeholders through face-to-face interviews using a structured interview format.

Those interviewed included representatives of:

- Murray, Waroona and Harvey Shires;
- State Government agencies including Department of Conservation and Land Management (CALM), Department of Resources Development, Agriculture WA, South West Development Commission and Ministry for Planning;
- South West Irrigation Co-operative, WA Farmers Federation and Harvey River Land Conservation District Committee (Harvey LCDC); and
- local interest groups, including the Harvey Hills Preservation Group.

A list of those agencies and interest groups consulted during the study is provided as Appendix A.

In October 1997, the Commission released an "Issues and Options Discussion Paper" which provided an overview of stakeholder issues and the Commission's responses.

The scoping exercise was supported by the production of newsletters, an information display at the Harvey Show and ongoing discussions with various stakeholders. Additional consultations occurred as the allocation planning process progressed. Interviews with Harvey Hills landowners were held as part of a social impact assessment, and discussions took place with local Aboriginal spokespersons on heritage matters.

1.9 Structure of this Document

This document is structured as follows:

- a general introduction and background to the preparation of the allocation plan;
- the allocation planning and licensing structures;
- Basin environment and surface water resources;
- existing and potential surface water uses and demands in and outside the Basin;
- ecological water requirements and environmental water provisions;
- water resource, environmental and social implications of Harvey River Hills allocation options;
- water allocation principles and policies;
- proposed water resource allocations for environmental, social and consumption uses;
- implementation of the plan; and
- a review that addresses environmental factors relevant to the proposed additional allocation from the Harvey River Hills resource, environmental water provisions and river restoration.

1.10 Public Review of the Plan

The plan has been submitted to the Environmental Protection Authority (EPA) for advice on relevant environmental factors.

The EPA's environmental impact assessment and the Commission's allocation planning processes (refer Figure 3) are being run in parallel and include a common public review period.

The plan is available for public review for eight weeks. Persons wanting to make a submission may address their comments to the Commission. The Commission will pass on a copy of all submissions to the EPA for its consideration.

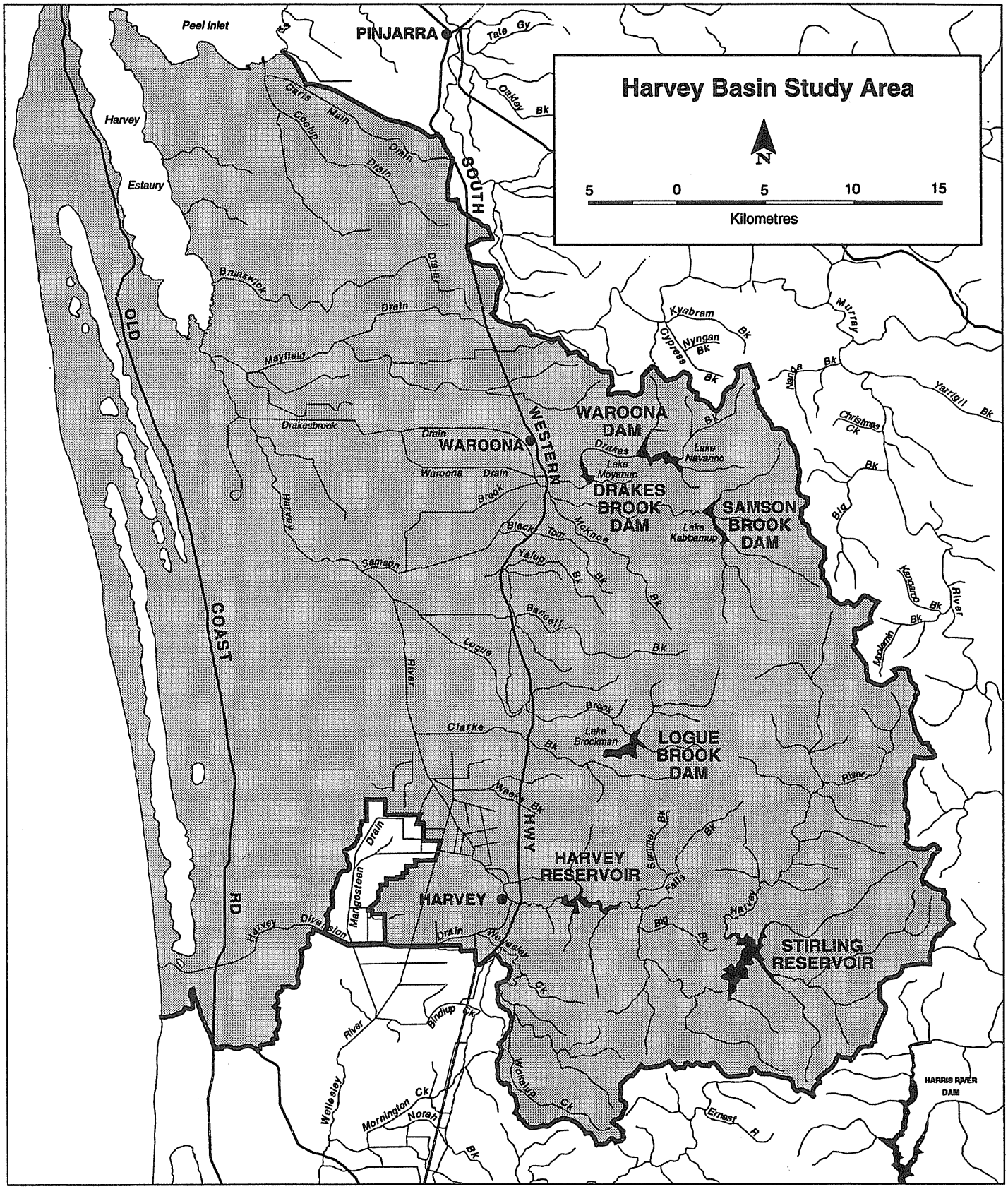


Figure 1. Map of Harvey Basin

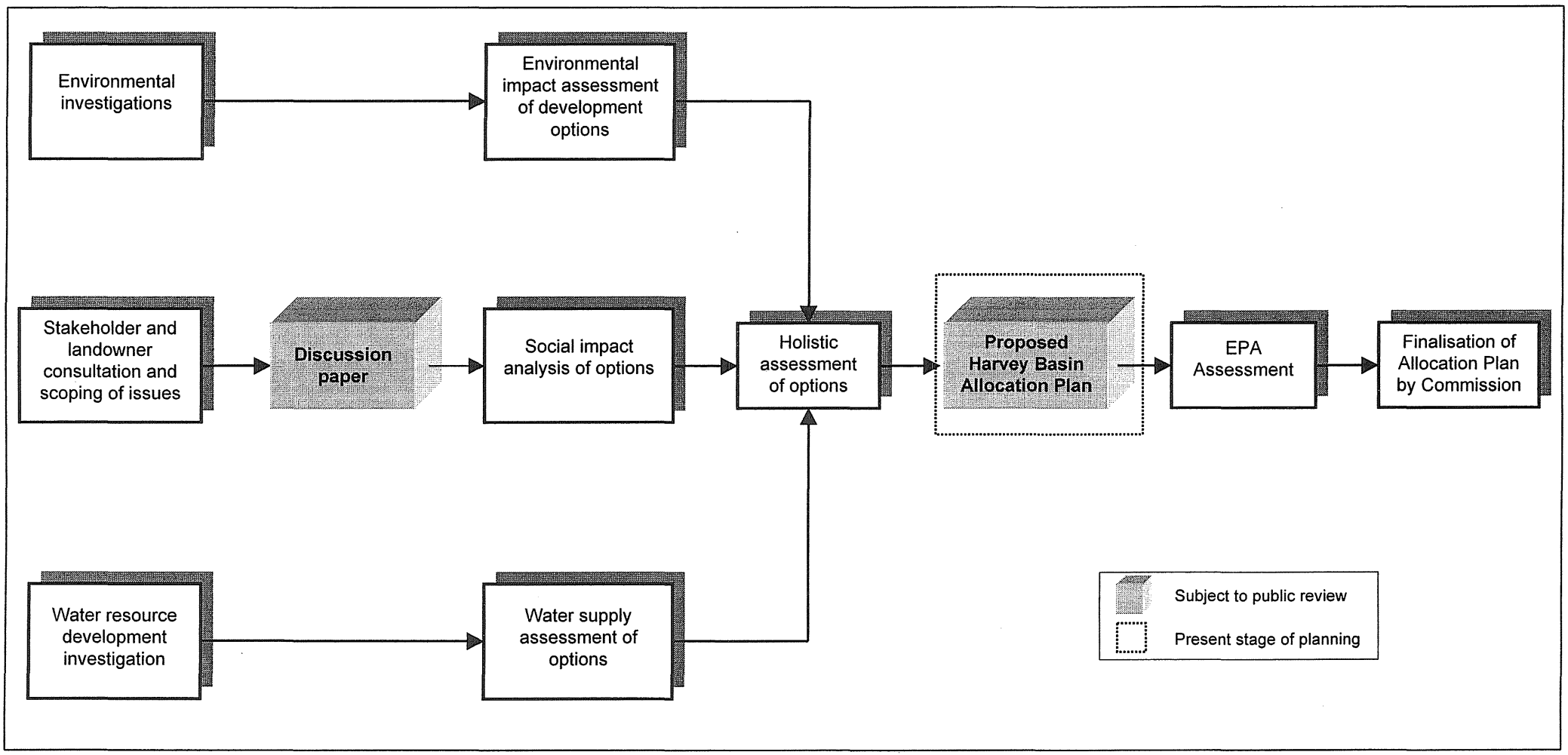


Figure 2. Process for the preparation of the Harvey Basin Sub-regional Allocation Plan.

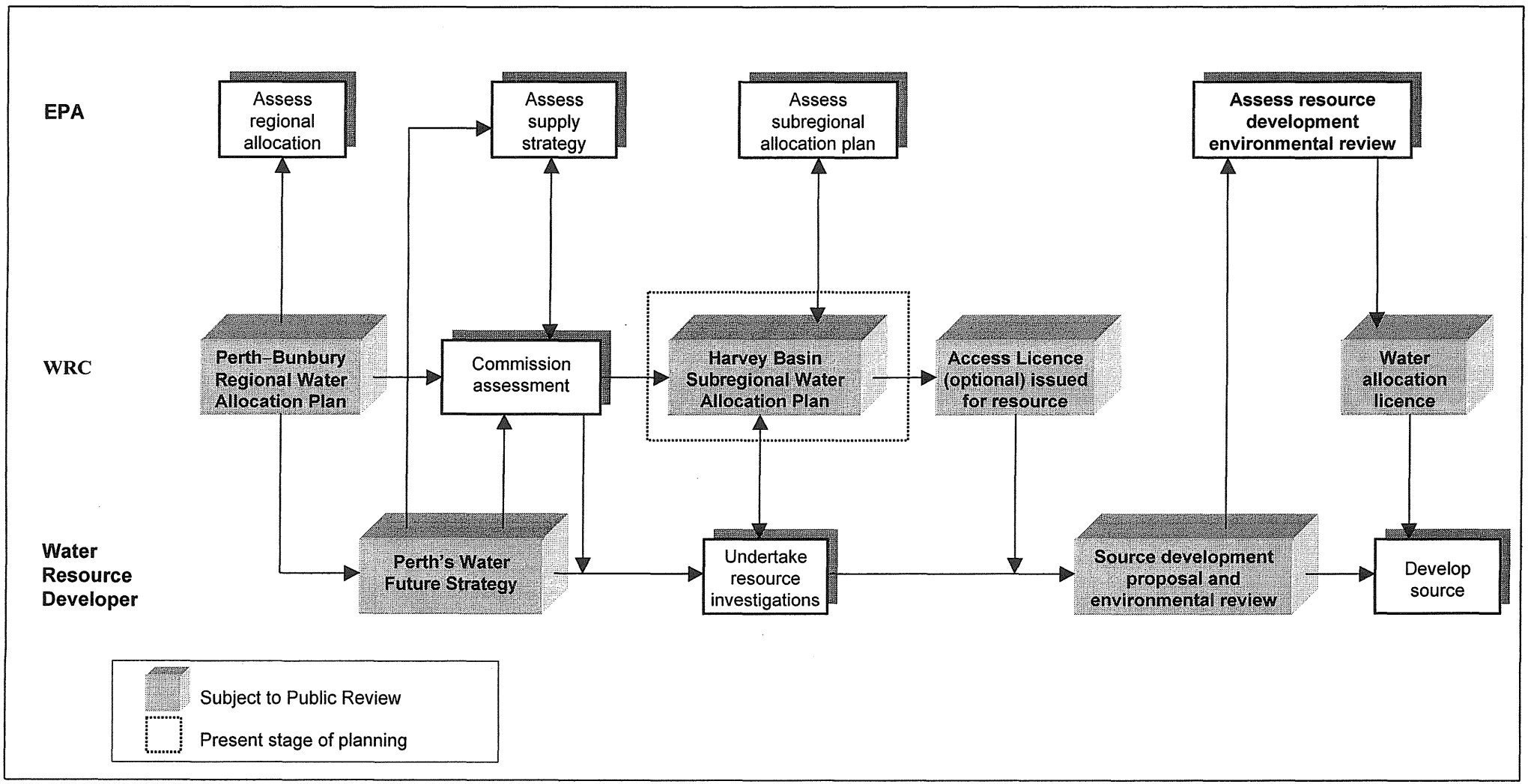


Figure 3. The allocation planning process.

2. Water Allocation Planning Structure

Effective water resource management requires careful long-term investigation and planning which is responsive to community needs and values. Environmental, social and economic values as well as engineering and scientific aspects need to be considered in water resource management. The basis for an effective allocation system has been evolving in Western Australia over several decades.

The COAG water reform framework and the establishment of the National Principles for the Provision of Water to Ecosystems (AWRC & ANZECC 1996) provided increased impetus to finalise the allocation procedure.

The proposed approach is documented in the third discussion paper in the water reform series, which is currently out for public comment (WRC 1997b).

The water allocation process ensures a balanced approach to water resource management and considerable opportunity for public involvement and environmental impact assessment by the EPA (Figure 3). As the pressure on a water resource increases, the degree of investigation and the need for forward planning through the allocation planning process also increase.

2.1 Water Resource Beneficial Uses and Values

Water resources support a wide range of beneficial uses and/or values. These include the use of water resources by the ecosystems they sustain; non-consumptive in-stream uses (including recreation, scientific and educational use and heritage values); and consumptive uses, including irrigated agriculture and water supplies for farms, towns and industry.

The allocation planning process takes into account existing and potential ecological, social and economic values of the water resources when allocating water among various beneficial uses. Some water resources may be allocated to compatible multiple uses. An existing example is the Waroona Dam where water from the reservoir is used for recreation (such as waterskiing) as well as for irrigated agriculture.

Allocation plans establish the ecologically sustainable limits on the development of surface water resources.

The term "allocation" means giving a party an entitlement to use water or setting aside a water resource for a designated use.

2.2 Regional Allocation Plans

Regional allocation plans may be prepared where there is an existing and a potential high demand for consumptive uses over many water resource systems. For example the Perth–Bunbury Draft Regional Allocation Plan (Western Australian Water Resources Council (WAWRC) 1988) provided a process for determining the priority environmental values and beneficial uses of water resources in the Perth–Bunbury region. This level of planning enabled "filtering" of those sources whose substantial environmental or social values precluded their use and provided an indication of the water potentially available for consumptive uses.

2.3 Sub-regional Plans

Planning at the regional scale will rarely provide sufficient detail to resolve allocation issues arising from new large-scale source development proposals and growing small-scale self-supply demands. The sub-regional planning will usually be undertaken at the water resource system level (for example a river basin), where the emphasis is:

- to establish scientific criteria, water requirements and water provisions to protect water-dependent ecosystems and the social and economic values of water;
- to provide a policy and principle framework for allocation licensing;
- to estimate the maximum water available for consumptive uses having in mind options for large source developments; and
- to establish monitoring programs to refine ecological water requirements (EWRs).

This plan is sub-regional, covering the entire Harvey Basin but focusing on the catchment of the Harvey River.

2.4 Management Area Plans

Management area plans are prepared when there is a requirement for establishing detailed rules for water

resource management and the issue of allocation licences in a portion of a water resource system. Under these plans standard conditions for licences may be established, water market operating conditions specified and detailed environmental water requirements set.

2.5 Integration with the EIA Process

The water allocation planning process has been developed to synchronise with the environmental impact assessment (EIA) process of the EPA. Section 13 of this plan is a review of the environmental factors that may be relevant to any future additional allocation of the Basin's water resources. The purpose of this review is to ascertain in the water allocation planning process whether the allocation of water to consumptive uses is likely to meet the EPA's environmental objectives.

In addition the Commission is seeking an indication of any further investigations or monitoring that may be required to progressively refine future environmental management and environmental water requirements.

The public review process will provide a further opportunity for community input to the allocation planning process.

3. The Harvey Basin Environment

3.1 Physical Environment

3.1.1 Climate

The climate of the Basin is a warm temperate Mediterranean type with distinct seasons. Summers are dry and warm to hot and winters wet and cool. Seasonal and annual variation in climate results from the migration of the subtropical anticyclone belt.

Most rainfall occurs between May and September and annual rainfall ranges from 840 mm along the coast to more than 1200 mm on the Darling Scarp between the Harvey and Stirling reservoirs. The long-term average annual rainfalls for the towns of Harvey and Waroona are 1012 mm and 1053 mm respectively (Figure 4).

The average annual evaporation rate varies from 1200 mm per year in the south to 1600 mm in the north of the Basin. Average monthly evaporation varies from about 50 mm in June to 300 mm in January.

3.1.2 Climate Variability and Change

Annual rainfall in the town of Harvey has not on average been above the long-term average for the last 20 years. The 10-year rolling average for rainfall at Harvey and Waroona shows a steady decline from the late 1960s to 1980, but this trend was reversed during the 1980s (Figure 4).

Lower rainfall is amplified in streamflow records. A decline in annual rainfall of 10% has been shown to reduce streamflow in jarrah forest catchments by about 30–40%. There has been a statistically significant reduction in streamflow for the period from 1975 to present (WRC 1996).

Climate change from global warming resulting from the increased concentration of greenhouse gases in the atmosphere has been examined by the Climate Impact Group in the CSIRO Division of Atmospheric Research (CSIRO 1996). This group has developed climate change scenarios which are continually updated.

The latest scenarios for the year 2030 for the south-west of Western Australia are:

- temperature increase of between 0.3 and 1.3° C; and
- rainfall increases in the November to April period of -4% to +12% and rainfall changes for May to October period of -8% to +2%.

Streamflow is very sensitive to rainfall in the south west of Western Australia, reduction being up to 2–3 times the rainfall response.

Interannual and decade scale climate variability will continue in the future and will remain a source of uncertainty in projecting the impacts of future climate change.

3.1.3 Geological History

The Darling Scarp is the most prominent physiographic feature of the south western region of Australia, rising steeply to 300 m above sea-level. The Scarp is an ancient erosional feature, now lying 1–2 km east of the Darling Fault, which separates the Archean Yilgarn Block from the Phanerozoic sedimentary deposits that underlie the Swan Coastal Plain to the west.

The Darling Range is the uplifted edge of the Yilgarn Block, part of the Precambrian Western Plateau, which extends to the Goldfields. Much of the Swan Coastal Plain consists of sandy aeolian soils with a sequence of alluvial clay soils along its eastern part. Soils of the coastal plain and the foothills are Pleistocene–Holocene in age while the Darling Range is dominated by Tertiary laterites over Archean granites and metamorphic rock.

The important feature of rivers of the region is that they rise in the ancient Darling Range and flow across the relatively young coastal plain.

3.1.4 Soils and Landforms

The landscape of the Harvey Basin has three distinct physiographic areas with associated landforms and soils.

The Darling Plateau

This area consists of ancient crystalline granite rock, which varies in height, covered by lateritic hardcap and associated clays. The soils include shallow sand over sheet laterite, gravelly duplex soils and grey sands. Minor shallow valleys occur on the plateau surface with gravelly duplex soils on the side slopes of the Yarrigal and Pindalup Units while red and yellow duplex soils occur on the Catterick Unit.

The Darling Scarp

This is a dominant and steep feature, which forms the western edge of the Darling Plateau.

The Swan Coastal Plain

This land area west of the Darling Scarp is predominantly low-lying, with a gently undulating to flat surface. The coastal plain consists of the following systems:

- the Quindalup Dune system consists of the Quindalup Dunes, which are composed of calcareous sand, and the Quindalup Flats, which consist of sheltered flats and calcareous sand;
- the Estuarine and Lagoonal System consists of poorly drained plains composed of mixed and unconsolidated estuarine and marine deposits located in low-lying areas with fringing estuaries and coastal lake systems;
- the Spearwood Dune System is situated east of the Quindalup Dunes and consists of siliceous sands overlying Tamala limestone;
- the Bassendean Dune System, situated immediately east of the Spearwood Dune System, consists of low dunes which are generally leached of calcium carbonate; and
- the Pinjarra System consists of an alluvial surface which slopes westwards between the hills and the edge of the Bassendean Dune System.

3.2 Biological Environment

3.2.1 Coastal Plain River and Floodplain Vegetation

Coastal plain regions of the Harvey Basin are predominantly broad flats with poor natural drainage, seasonally inundated swamps and depressions, and poorly defined natural stream channels. Wetlands are often interconnected by surface water, which ultimately flows into drainage lines. Clearing for agriculture and construction of drains for flood control have resulted in the loss of most of the original riparian habitats.

The lower reaches of the Harvey River (i.e. below the confluence with Samson Brook South Drain) and Mayfield Drain still support woodlands of flooded gum, *Eucalyptus rudis*, and paperbarks, *Melaleuca parvifloral,* with some *Agonis linearifolia.* Dense stands of *Melaleuca rhaphiophylla* occur in the wetlands adjacent to the channels.

Riverine zones in some regions extend for more than 200 m, and continued recruitment of these species was evident in surveys conducted during 1997 (Streamtec 1998). Little of the original understorey, however, remains intact, and introduced *Watsonia* and grass species dominate. In the upper sections of the drainage channels, the natural vegetation has been replaced by pasture species (*e.g.* Weekes, Clarke, Logue, Bancell and Samson Brooks and Drakes Brook Drain).

The composition of natural vegetation associations of the Harvey Basin is determined to a large extent by height above the water table (Wells 1989). At the highest elevations, low banksia woodlands occur on sandy soils grading into jarrah–marri (*Eucalyptus marginata – E. calophylla*) associations on wetter soils. The banks of drainage channels support an overstorey of *Eucalyptus rudis*, *Melaleuca parviflora* and some *Banksia littoralis*, while swamps and seasonally inundated depressions are dominated by *Melaleuca* species and sedges such as *Lepidosperma longitudinale.*

3.2.2 Darling Range Vegetation

Hills catchment areas are mainly State Forest with extensive areas of relatively undisturbed natural riverine vegetation. Jarrah – marri forest dominates, with open woodlands of moonah (*Melaleuca preissiana*) and *Agonis linearifolia* and an understorey of *Banksia grandis* and *Allocasuarina fraseriana* over water-tolerant Myrtaceae and sedges.

Mattiske Consulting Pty Ltd (1997) surveyed areas of remnant vegetation and other flora that may be affected by a new Harvey Dam. The results of this survey are presented in Section 13. Some of the areas of remnant vegetation are subject to System 6 Recommendation C79.

3.2.3 Aquatic Fauna

The macroinvertebrate fauna of streams of the upper Harvey Basin is characterised by a high level of variation between locations and shares a common Gondwanaland origin with the fauna of south-eastern Australia, including Tasmania, and other Southern Hemisphere continents.

The predictable climate imposes a degree of structure to life histories of many of the macroinvertebrate species. Functionally, the macroinvertebrate fauna feeds mostly on detrital material, with shredders and collectors dominant in shallow rough riverbed areas of upland (Darling Range) streams.

There are fundamental differences between the ancient upland fauna and the more cosmopolitan lowland river fauna. The upland fauna, particularly in forested permanent reaches, is considered to have higher conservation value compared to that of temporary streams and lowland reaches.

3.3 Wellesley Creek

Wellesley Creek is a first and second order tributary flowing into the Harvey Diversion Drain downstream from the Harvey townsite.

The creek is highly degraded due to extensive catchment clearing. This clearing has resulted in substantially increased streamflow which has subsequently downcut (channel erosion) the creek in some places by up to 2 metres. The downcutting is a recent event caused by the stream transferring more water than the initial channel "evolved" to transfer.

Presently, the creek has the ability to convey about 2–3 times the initial (pre-European) capacity. Much of the native riverine vegetation has been removed, and in many places there is uncontrolled livestock assess to the river, further promoting bank erosion and increased river turbidity.

Turbidity was observed during the preparation of this plan to be substantially elevated in reaches downstream from livestock watering areas.

3.4 Peel–Harvey Estuary

3.4.1 Estuarine Wetlands

The southern part of the Harvey Estuary and the lower Harvey Delta consist of saline tidal flats and sand and mud flats covered by salt marshes. The lower 1–2 km of the Harvey River and the salt marshes around the Harvey Delta have been identified as wetlands of international importance under the Ramsar Convention. The region also contains a number of important reserves for conservation of flora and fauna, together with Drainage and Recreation Reserves vested with the Minister for Water Resources and local shires.

Waterbirds

The Peel–Harvey is one of the most important estuaries in the South West for the conservation of waterbirds, including pelican, coot, grey teal, red-necked stilt, banded stilt and hoary-headed grebe (Woodcock 1992). Some species of waders are listed in the Japan–Australia Migratory Birds Agreement (Latchford & McComb 1995). The Harvey Estuary typically supports greater bird numbers than the Peel Estuary, particularly in late summer when thousands of ducks utilise the banks of the Harvey Delta (Chalmers et al. 1990; Woodcock 1992). Halse et al. (1993) found a strong correlation between numbers of water birds and both salinity and fringing vegetation. Greatest species numbers were found in tree or shrub-sedge/rush habitats.

Salt Marshes/Samphire Marshes

Salt marshes are located on the fringes of the Peel–Harvey Estuary Basins and in the tidal reaches of the tributary rivers. They are an important component of the riverine vegetation. The distribution of the salt marshes is primarily influenced by annual tidal inundation, though river flooding will also affect distribution (Murray et al. 1995b).

Topography of the salt marshes varies from 0 to 2.0 m AHD, while salinity of the inundating waters varies from 0 to 53 parts per thousand. The salt marshes are dominated by samphire, *Sarcocornia* spp., close to the water edges, *Halosarcia* spp. and sedge, *Juncus kraussii*, higher up the banks and *J. kraussii* in less saline areas along drainage channels. Behind the salt marshes vegetation is often dominated by fringing woodlands of saltwater paperbark, *Melaleuca cuticularis*.

Samphire marshes cover an estimated 630 ha in the Peel–Harvey Estuary, the Harvey Delta having the largest area, of approximately 145 ha (Murray et al. 1995a). In contrast to the salt marshes in other regions of the Peel–Harvey, the *Sarcocornia* and low flats around the Harvey Delta are considered to be relatively young (salt marsh near Heron Point as young as about 30 years). The delta may be the result of recent sedimentation caused by upstream erosion (Murray et al. 1995a; Rose & McComb 1995).

To date there have been few data available on the impact of the Dawesville Channel on salt marshes in the Harvey Estuary. Potential changes may include an increase in variability and frequency of tidal ranges and a decrease in the annual salinity range, with salinity at or near marine levels for most of the year.

These changes may alter salt marsh distributions and plant community structure and, subsequently, the distributions of estuarine and aquatic invertebrates that inhabit them (Keally, Latchford & Davis. 1995). One effect of the Dawesville Channel may be the slow advance of fringing vegetation out into the Harvey Estuary, as has occurred in Leschenault Inlet (Rose & McComb 1995).

Monitoring by CALM may help to determine the extent of changes as a result of the Dawesville Channel .

3.4.2 Nutrient Enrichment

Clearing, cultivation and drainage on the coastal plain have increased the input of nutrient-rich water to the Peel–Harvey Estuary (Table 1). River flow and consequently the total nutrient input to the estuary is strongly seasonal, with approximately 85% of nitrogen and phosphorus loadings occurring during winter.

Massive blooms of nitrogen-fixing blue-green algae, *Nodularia spumigena,* develop in response to relatively high phosphorus levels, low nitrogen-to-phosphorus ratio and water temperatures greater than 18°C (Hodgkin et al. 1980). Increased flows from the Harvey River drainage districts will increase the nutrient loss from agricultural areas and will contribute towards algal growth.

Chambers, Wrigley & McComb (1993) note that wetlands in areas of high phosphorus export (e.g. the Meredith Drain subcatchment) act as nutrient sinks, collecting phosphorus from agricultural runoff. These wetlands, dominated by paperbark (*Melaleuca*) woodlands with sedge (*Lepidosperma longitudinale*) understoreys, occur in seasonally flooded basins isolated from drainage channels for most of the year. Phosphorus levels in the wetlands and in riverine vegetation are much greater than in drainage waters, and disturbance may lead to phosphorus loss from wetland vegetation and soils into the drains.

The input of phosphorus in particular has led to the loss of seagrass communities, which dominated the estuary up until the mid-1960s, and their replacement by a macro-algal based ecosystem. More than 50% of phosphorus loadings to the Peel–Harvey estuarine system come from the catchments of the Harvey River (32%), Mayfields Drain (52%) and other drains (16%).

3.5 Social Setting

The Harvey Basin study area falls within three local government jurisdictions:

- the southern portion of the Shire of Murray, including the Harvey Estuary;
- the Shire of Waroona; and
- the northern half of the Shire of Harvey.

The Shires of Murray and Waroona are part of the Peel Region, while the Shire of Harvey is included in the Bunbury–Wellington Region.

In the State Planning Strategy (Western Australian Planning Commission, 1996), the population centres of Waroona and Harvey form part of the South West Urban System. In an attempt to manage the growth of the Perth Metropolitan Area, the Strategy indicates that policies will be developed to increase the population of a number of smaller towns and communities along the foothills of the Darling Range, including Waroona and Harvey. Land between population centres will be conserved in rural use for agricultural production, landscape conservation and lifestyle purposes.

Land use on the coastal plain within the shires of Murray and Waroona and in the northern portion of the Shire of Harvey is strongly influenced by the WA Planning Commission's Statement of Planning Policy No. 2 (1992), and by the Environmental Protection (Peel–Harvey Estuarine System) Policy.

3.5.1 Shire of Murray

Although the Shire covers an area of 1813 km^2, only the southern portion of the Shire around the Harvey Estuary is included within the Harvey Basin study area. The primary feature of this part of the Shire is the Peel–Harvey Estuary. The management of the Peel–Harvey Estuary (including the lower reaches of the Harvey River) is the responsibility of the Peel Inlet Management Authority (PIMA) in cooperation with other State and local government authorities.

The estuarine system has for generations been a holiday and fishing venue as well as a valuable local, regional and State economic and environmental resource. The Peel–Harvey system is a unique landscape feature which has been placed on the Register of the National Estate (Waterways Commission 1992). A program has been put in place to guide management of the system and maintain an appropriate balance between the competing needs of system users, including increased pressures due to projected population growth, increases in tourism and intensive agriculture on the coastal plain. Much of the area under the management of PIMA will form the Peel Regional Park.

3.5.2 Shire of Waroona

Lying south of the Shire of Murray, the Shire of Waroona covers 835 km^2 and has a population of just over 3000 residents. The largest population and administrative centre is the Waroona townsite, located close to the Darling Scarp, with other townsites located at Hamel and along the coast at Lake Clifton and Preston Beach.

Table 1. Estimated phosphorus inputs to the Peel–Harvey Estuary.*

Harvey River Segment	Phosphorus (mg/L)		Streamflow (m^3x10^6/a)		P Load (t/a)	
Catchment	circa 1930	1977–86	circa 1930	1977–86	circa 1930	1977–86
Hills	0.01	0.01	195	65	2	1
Coastal Plain	0.09	0.46	180	370	16	170
Total	**0.04**	**0.39**	**375**	**435**	**18**	**171**

*Source Kinhill 1988.

Industry within the shire includes dairying, beef, horticulture, sheep, mineral sand mining and Alcoa's Willowdale Bauxite Mine and Wagerup Alumina Refinery.

Just east of the coast are Preston and Clifton lakes, which are situated within the Yalgorup National Park. Further from the coast is an area of plain covered by swamplands and farmlands supporting sheep and cattle. On the plain, but closer to the Darling Scarp, is the Waroona Irrigation District, which supports dairying and beef operations and market gardeners growing potatoes, vegetables and citrus fruit.

Along the scarp, the Waroona, Samson Brook and Drakesbrook reservoirs provide water to the Waroona Irrigation District as well as offering residents and visitors a variety of recreational uses. The Darling Ranges provide bushwalking and picnicking areas, and camping is permitted at Nanga Brook. The eastern portion of the shire consists of the Darling Plateau, which is primarily State Forest and used for conservation, recreation, water production and mining.

3.5.3 Shire of Harvey

The Shire of Harvey is approximately 140 kilometres south of Perth, with an estimated population of 14,000. Only the northern half of the shire falls within the Harvey Basin. There is a significant area of horticulture and fodder cropping north of the Leschenault Estuary near Myalup. The central townsite of Harvey is 48 kilometres north east of Bunbury. The area around the town supports a range of agricultural activities including dairying, beef cattle raising, citrus fruit growing and viticulture.

To the east of the townsite is the area known as the Harvey Hills, which includes the footslopes of the Darling Scarp. Traditionally an agricultural district, it has become a popular area for both hobby farmers and those seeking a rural lifestyle. The Harvey Weir and Stirling Dam are located in this area and supply water to the Harvey Irrigation District and the Town of Harvey. The dominant land uses on the Darling Plateau are State Forest and pine plantations, both of which are managed by the Department of Conservation and Land Management (CALM).

3.5.4 The Waroona and Harvey Irrigation Districts

The first irrigation scheme in the South West Region was constructed in 1915–16 to service the citrus orchards in the Harvey Region with water from a small weir on the Harvey River. Over the years, the irrigation system has expanded significantly to form the South West Irrigation Area, which consists of three irrigation districts – Waroona, Harvey and Collie. Dairying has become the mainstay of the irrigation area, with 70% used for this purposes.

Of the three irrigation districts, only the Waroona District and the northern half of the Harvey District fall within the Harvey Basin. In 1994 the Harvey District accounted for two-thirds of the dairy cows in the South West Irrigation Area. Other activities include grazing and horticulture. Horticulture is capable of a greater presence in the Harvey area, and in recent times there has been a trend away from beef production toward viticulture. Within the Waroona Irrigation District there has been a reduction of irrigated farming over the past decade, but the shire is hopeful that horticultural enterprises in the Perth area, which are faced with encroaching urbanisation, will relocate to the Waroona District.

In response to concerns about the future of the irrigation area, the State Government commenced the South West Irrigation Area Strategy Study in 1989 to develop a strategy for the future operation and rehabilitation of the irrigation area. By 1996 this had resulted in the privatisation of the South West Irrigation Area, creation of South West Irrigation (SWI) and establishment of a system of Transferable Water Entitlements (TWEs).

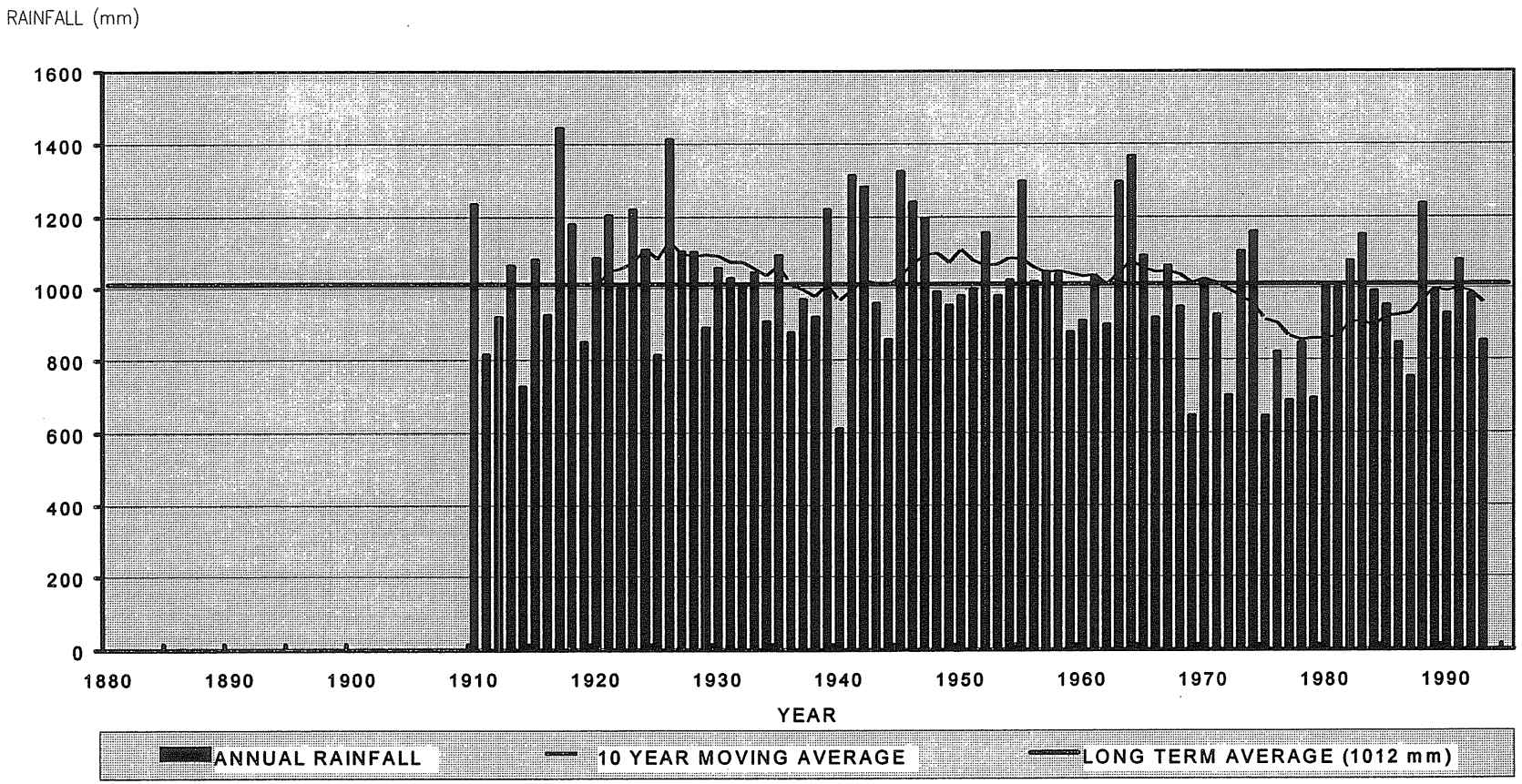


Figure 4. Annual rainfall at Harvey since 1911

4. Description of Basin Surface Water

The Harvey Basin contains a number of small rivers and streams, which drain the Darling Range between Waroona and Harvey. The Basin is about 45% cleared, principally in the valleys and extensively on the coastal plain.

Almost all streams on the coastal plain have been extensively modified by artificial drainage, irrigation and clearing of native vegetation.

4.1 Darling Range Catchments

Minor clearing of native vegetation has occurred in these catchments. This has mostly taken place in the catchment of the Harvey Weir, where about 35% has been cleared. Some parts of the catchments have been severely affected by dieback (*Phytopthora*) which has increased the runoff in these areas.

4.1.1 Principal Streams

The major streams and rivers that rise in the Darling Range (Figure 1) are:

- the Harvey River;
- the Samson, Drakes, Logue, Clarke, Bancell, North Yalup, South Yalup, McKnoe and Black Tom Brooks; and
- Waterous Formation, Wokalup and Wellesley Creeks.

4.1.2 Existing and Potential Sources

The largest (and most southern) of the streams is the Harvey River, on which the Harvey Weir and the Stirling Dam are located.

Several of the small streams north of the Harvey River are also dammed, including the Bancell (pipehead only), Drakes, Logue, Samson and Yalup Brooks.

The present yield, based on the current level of development, is 68 GL/yr from the Harvey Weir, Stirling Dam and Logue Brook Dam and 18.4 GL/yr from dams on Drakes and Samson Brooks. The water from these resources is used principally for irrigated agriculture.

The Water Resources Review and Development Plan for the Bunbury–Mandurah Region, prepared by the Commission (WRC 1996), indicated that about another 80 GL/yr was potentially divertible for consumptive use from surface water resources in the Basin. This estimate did not assume any provision for environmental uses.

A summary description of the water resources of the Darling Range catchments, which includes potential additional developments, is presented in Table 2.

4.1.3 Streamflow from the Darling Range

Surface water data have been collected in the Basin since 1939. The first continuous streamflow measurements were commenced on the Harvey River in that year.

Using this streamflow data, the Commission has developed a Harvey Basin water balance model which enables the examination of past, current and future annual streamflow scenarios (WRC 1998). This model can be used to establish annual and monthly average streamflows that are considered to have existed before European settlement and those that are considered likely to occur if a new Harvey Dam is developed. Average annual streamflow entering the Harvey Estuary from the Harvey Basin was estimated to be 142 GL/yr prior to European settlement, whereas it currently averages about 202 GL/yr (Table 3 and Figures 5 and 6).

The pre-European conditions are based on zero vegetation clearing, zero dieback and a natural frequency of the drainage network of rivers and streams.

Under average climatic conditions, approximately 42% (77 GL) of the current total mean annual streamflow is diverted from the Darling Range catchments for irrigation and town water supplies. Another 34% (63 GL/yr – Harvey River, Wellesley and Wokalup Creeks streamflow) is diverted to the Harvey Diversion Drain, which eventually discharges to the Indian Ocean at Myalup. The remainder, 24% (32 GL), from streams north of the Harvey River, is discharged to the Harvey River and eventually to the Harvey Estuary.

Using the same average climatic conditions, the Darling Range catchments would have discharged about 85 GL/yr to the Harvey River (approximately 250% greater than the present annual discharge) at the Diversion Drain prior to European settlement.

Table 2. Summary of existing and potential water sources of Darling Range catchments.*

Stream	Impoundment (year constructed) *Potential Development Location**	Catchment Area (km^2) (% cleared)	Storage (GL)	Surface Area (ha)	FSL (m AHD)	Mean Annual Flow[1] (GL)	Estimated Yield [1,2] (GL)	Utilisation (%)	Use
Harvey River	Harvey Weir (1916, 1931))	380 (30)	9	150	64.2	43.5	16	37	Irrigation, public water supply
	Stirling Dam (1948)	254 (minimal)	56	394	158.5	59.4	37	64	Irrigation, whitewater canoeing
	New Harvey Dam (80 m)	*380 (30)*	*70*	*651*	*80*	*103 (total)*	*50*	*85*	*Irrigation, public supply*
Logue Brook	Logue Brook Dam (1963)	38 (minimal)	25	200	158	14	11	79	Irrigation
	DS13.5	*10 (minimal)*	*8.5*	*49*	*120*	*3.8*	*3.0*	*79*	
Bancell Brook	Bancell Brook Pipehead (1952)	8 (50)	minimal	minimal	111	7.7	0.1	minimal	Irrigation
	DS10	*14(16)*	*10.0*	*66*	*245*	*4.9*	*4.2*	*86*	
South Yalup	Wagerup Dam (1978)	2 (15)	1.2	28	53	1.4	1.0	71	Industrial
Drakes Brook	Drake Brook Dam (1931)	12 (15)	2.3	42	71.2	3.0	1.8	60	Irrigation
	Waroona Dam (1966)	41 (15)	15	144	211	11.6	7.9	70	Irrigation, recreation
Samson Brook	Samson Brook Dam (1941)	64 (minimal)	9	104	245	16.6	7.6	46	Irrigation. recreation
	Lower Samson Brook Pipehead (1962)	10 (minimal)	minimal	NA	NA	2.6	1.0	38	Irrigation
	Chasede Dam (1998)						0.5		Industrial
	DS1.8	*6 (minimal)*	*5.0*	*38*	*92*	*1.8*	*1.6*	*32*	*Irrigation, public supply*
Clarke Brook	Unregulated *DS9*	*17 (<10)*	*2.7*	*16*	*160*	*2.9*	*2.4*	*83*	-
Waterous Formation	Unregulated *DS4*	*9 (minimal)*	*5.0*	*56*	*87*	*1.7*	*1.3*	*76*	
North Yalup Brook	Unregulated *DS6.5*	*6 (15)*	*1.0*	*NA*	*NA*	*2.4*	*1.0*	*42*	
McKnoe Brook	Unregulated *DS2*	*29 (5)*	*2.7*	*23*	*100*	*10.6*	*8.6*	*81*	
Black Tom Brook	Unregulated *DS5*	*5 (5)*	*1.0*	*2.0*	*107*	*1.0*	*0.8*	*80*	
Wokalup Creek	Unregulated, *Pipehead at DS4*	*50 (55)*	*NA*	*NA*	*NA*	*15*	*10*	*75*	
Wellesley Creek	Unregulated, *Pumpback at DS30*	*10 (55)*	*1.6*	*64*	*56.5*	*18*	*12*	*67*	

Italics indicates potential additional resource yield from future source development.
*Source WRC, 1996.
1 Based on 1962–94 period.
2 Estimated divertible yield on the basis of existing and *potential* development.

Variations in monthly streamflow throughout the year are difficult to estimate accurately by the above modelling method because of the limitations of streamflow data. However the model was considered suitable to calculate monthly averages using data for the period 1962–96 (average climatic conditions) under current and pre-European scenarios (Table 3).

The results of these calculations indicate:

- monthly average streamflows vary greatly according to season;
- in most months coastal plain runoff is now almost twice the pre-European values;
- in most months Darling Range runoff to the Harvey Estuary is about one-third the pre-European values; and
- generally, total runoff from the Basin is currently substantially greater in the winter months than under pre-European conditions. In October to December, total runoff to the Peel–Harvey system may be significantly greater than in pre-European times.

Figures 7 and 8 show comparisons of estimated monthly average streamflows for Darling Scarp and coastal plain catchments under current and pre-European conditions.

4.2 Swan Coastal Plain Catchment

Prior to European settlement a substantial proportion of the coastal plain catchment would have been an extensive wetland, where the channelisation of the river was minimal. The lower reaches of the Harvey River were probably characterised by substantial pools caused by large woody debris. These pools, formed in the river by fallen riverine vegetation, would have been characterised by lower water velocities, a stable river substrate and therefore probably increased rates of in-stream primary production.

Currently, the Harvey River on the coastal plain is a highly degraded system the result of artificial channelisation and straightening. The degradation of this system is due to an almost total absence of both in-stream habitat and suitable riverine vegetation. The samphire flat that has developed at the mouth of the Harvey River over the past 50 years is in response to deposition of material most likely derived from upstream bank and channel erosion.

4.2.1 Drainage Systems

The coastal plain component of the Harvey River Basin is served by a comprehensive drainage system, which conveys water away from flood-prone and waterlogged areas. The Harvey River and drainage channels convey drainage water to the Harvey Estuary and the Harvey Diversion Drain directs drainage water to the Indian Ocean.

The drainage system was developed over a long period in response to the indirect natural drainage, which was perceived as adversely impacting the development of agriculture. The course of the middle section of the Harvey River was ill-defined because of the low gradient of the Harvey River Flats. A number of streams drained into this middle section, which formed a near continuous wetland that extended across to the sandhills near Lake Clifton (Figure 9). Overflow from this section eventually reached the lower part of the Harvey River which flows into the Harvey Estuary.

The principal milestones in the development of the drainage system in the Harvey Basin were:

- 1899. Major drainage works commenced, involving the conversion of a series of small brooks into deep fast-flowing drains directing water onto the Harvey River Flats. Work commenced on clearing and deepening the Weekes, Clarkes, Logues and Samson Brooks;.
- 1900–1902. Lower reaches of the Harvey River were cleared of trees and logs (de-snagged).
- 1902. Work commenced on the construction of the Harvey River Main Drain.
- 1902. Work commenced on the Coolup Main and Greenland Road Drains to the Harvey Estuary and was completed in 1905.
- 1911. The basic (present-day) Harvey drainage scheme was almost complete.
- 1932. The construction of the Harvey Diversion Drain commenced. This Drain takes water from the Harvey and Wokalup Rivers (including Wellesley Creek) to the sea at Myalup. The Wokalup River and Wellesley Creek previously discharged to the Wellesley River.
- 1934. Upon completion of the Harvey Diversion Drain other drains were constructed to drain the wide Harvey River Flats.
- 1950s and 1960s. A number of new drains were constructed on the flats to the west of the Harvey River.
- 1964. Following the floods in this year, the Harvey River was deepened and levee banks strengthened.

The Harvey and Brunswick drainage systems before the construction of the Harvey Diversion Drain are shown in Figure 9.

The drainage system has resulted in increased soil water flow and nutrient loss. In 1985–88, the Water Authority of Western Australia and the Environmental Protection Authority negotiated to place a moratorium on further drain construction and introduce controls on farm drainage (Kinhill 1988; Ruprecht & George 1993).

The drainage system, combined with extensive clearing of native vegetation and irrigated agriculture, has resulted in a radical alteration to the hydrology of the coastal plain in the Harvey Basin.

4.2.2 Streamflows

The Commission's water balance model (WRC 1998) was used to estimate the mean annual and monthly flows under average conditions, taking into account clearing of native vegetation, irrigation and drainage density on the coastal plain. This modelling illustrates the changes in streamflow that have occurred since European settlement, primarily as a result of clearing and construction of drainage systems. Some important observations that can be drawn from the modelling results (Table 3) are:

- The total annual flow received by the Harvey Estuary from the Harvey River is about 164 GL. This flow is about 25% greater than it was prior to European settlement.
- The predominant contribution to current flow in the Harvey River is coastal plain runoff (including the return of irrigation water and groundwater discharge).
- The coastal plain runoff (including irrigation returns) is about three times greater than it was prior to European settlement.
- The Darling Range catchments now contribute only about 16% (32 GL/yr) of the annual flow (202 GLyr) from the Harvey Basin into the Harvey Estuary, whereas these catchments contributed about 60% of this flow prior to European settlement.
- The streamflow from the Harvey Weir, Stirling Dam and Wellesley Creek catchments contributes about 80% of the average annual flow in the Harvey Diversion Drain. However, streamflow in summer months in this drain is believed to be predominantly from groundwater discharge and some return of irrigation water.

There is more water entering the Harvey Estuary from the Harvey River system, even with the diversion of water from the Darling Range catchments, than there was prior to European settlement. In addition, current summer streamflow in the Harvey River on the coastal plain appears to be almost entirely derived from groundwater discharge and the return of irrigation water.

The pre-European flows are the "historic hydrograph", considered fundamental baseline information to establish any modified flow regime.

4.2.3 Drainage Districts

The Harvey Basin includes the Waroona Drainage District and a substantial proportion of the Harvey Drainage district. These districts are divided into areas corresponding to the catchments of major drains or watercourses (Figure 10). The drainage catchment areas in the Harvey Basin are listed in Table 4.

Drainage districts are under the control of the Water Corporation.

Table 3 Monthly average streamflows (GL) to Peel–Harvey Estuary from Darling Range and Swan Coastal Plain catchments.

Catchment	Situation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Darling Range	Pre-European	2.7	1.7	1.5	1.9	3.9	9.5	15.2	16.7	12.9	9.8	5.8	3.4	85
Swan Coastal Plain	Pre-European	0.1	0	0	0.1	0.7	8.0	21.1	15.9	9.1	1.5	0.5	0.1	57
Total	Pre-European	2.8	1.7	1.5	2.0	4.6	17.5	36.3	32.6	22.0	11.3	6.3	3.5	142
Darling Range	Current	0.6	0.4	0.4	0.5	1.0	2.3	4.7	6.2	5.3	4.0	1.4	0.8	32
Swan Coastal Plain	Current	1.3	1.4	1.4	1.4	2.0	22.1	57.3	42.7	24.7	4.3	2.9	1.7	170
Total	Current	1.9	1.8	1.8	1.9	3.0	24.4	63.0	48.9	30.0	8.3	4.3	2.5	202

4.2.4 Irrigation Districts

The Harvey Basin includes the Waroona Irrigation District and a substantial proportion of the Harvey Irrigation District. The Harvey Irrigation District, which is the larger of the two, covers an area of 14,650 ha. Of this, approximately 5500 ha is designated as rateable area.

The consumption of irrigation water is difficult to estimate, as accurate measurement of water use at the farm gate is limited. Data are available for the amount of water entering the Harvey Irrigation District, which sources its water from storages on the Logue and Harvey Rivers. The amount of water released for this district varied from 52 to 74 GL/yr and averaged 60 GL/yr over the 1962–96 period.

The Waroona Irrigation District uses water from the Waroona, Drakes Brook and Samson dams. Consumption in this district has varied from 12 to 20 GL/yr and averaged 15.6 GL/yr over the 1962–96 period.

Water balance modelling has determined that about 19% of the water used for irrigation returns as surface water to the drainage system.

The irrigation districts are under the control of SWI.

4.2.5 Water Quality

Streams from the Darling range are usually of low salinity, ranging from 100 to 310 mg/L TDS. Streams from catchments that are substantially cleared usually have higher levels of turbidity. The catchment of the Harvey Weir is such an area, and the water in this reservoir requires treatment for turbidity to meet public water supply standards.

Turbidity is usually closely associated with slope and bank erosion, and is strongly influenced by livestock access to streams. In addition to affecting the appearance of water, when the particles causing turbidity settle they can result in the in-filling of pools and water supply reservoirs, reducing their capacity.

The measurement of turbidity is also a useful indicator of catchment disturbance.

The Commission engaged Streamtec (Streamtec 1998) to investigate turbidity in tributaries above the Harvey Weir. This organisation found that turbidity varied widely and was dependent on location and the magnitude of flows (Table 5). The sediment load in the Big Brook tributary was 20 times that of Falls Brook. Base sediment flow in the Harvey River was 3 times the Falls Brook tributary, whereas this increased 30,000-fold on an instantaneous basis during geotechnical (bankfull) releases from the Stirling Dam.

Table 4. Drainage catchment areas.

Drainage Catchment Area	Darling Range Streams	Drainage District	Destination
Coolup Main Drain	None	Waroona	Harvey Estuary
Mealup Drain	None	Waroona	Harvey Estuary
South Coolup Drain	None	Waroona	Harvey Estuary
Mayfields Drain	Small foothills streams	Waroona	Harvey River
Harvey River	Drakes, Samson, McKnoe, North Yalup, South Yalup, and Clarke Brooks, Harvey River (minor)	Waroona, Harvey	Harvey Estuary
Logue Brook	Bancell, Black Tom and Logue Brooks	Waroona, Harvey	Harvey River
Meredith Drain	None	Harvey	Harvey River
Harvey Diversion	Harvey River (major) and Wellesley and Wokalup Creeks	Harvey	Indian Ocean

Table 5. Turbidity in streams upstream from the Harvey Weir.

Site	Turbidity (as NTU)	Discharge (m^3/s)	Load (NTU*discharge)
Falls Brook	0.41 (0.10)	0.04 (0.02)	0.016
Big Brook (farmland)	34.56 (21.41)	0.01 (0.01)	0.346
Big Brook (immediately upstream from confluence with Harvey River)	41.40 (10.21)	0.01 (0.01)	0.414
Harvey River (base flows)	0.89 (0.23)	0.05 (0.01)	0.044
Harvey River (irrigation flows)	1.45 (0.12)	0.10 (0.03)	0.145
Harvey River (geotechnical flows)	39.67 (12.35)	12.89 (2.56)	511.34

*These values are instantaneous loads. The loads from Big Brook will be all year round. However, those due to geotechnical releases (dam safety testing) will occur only during the release.

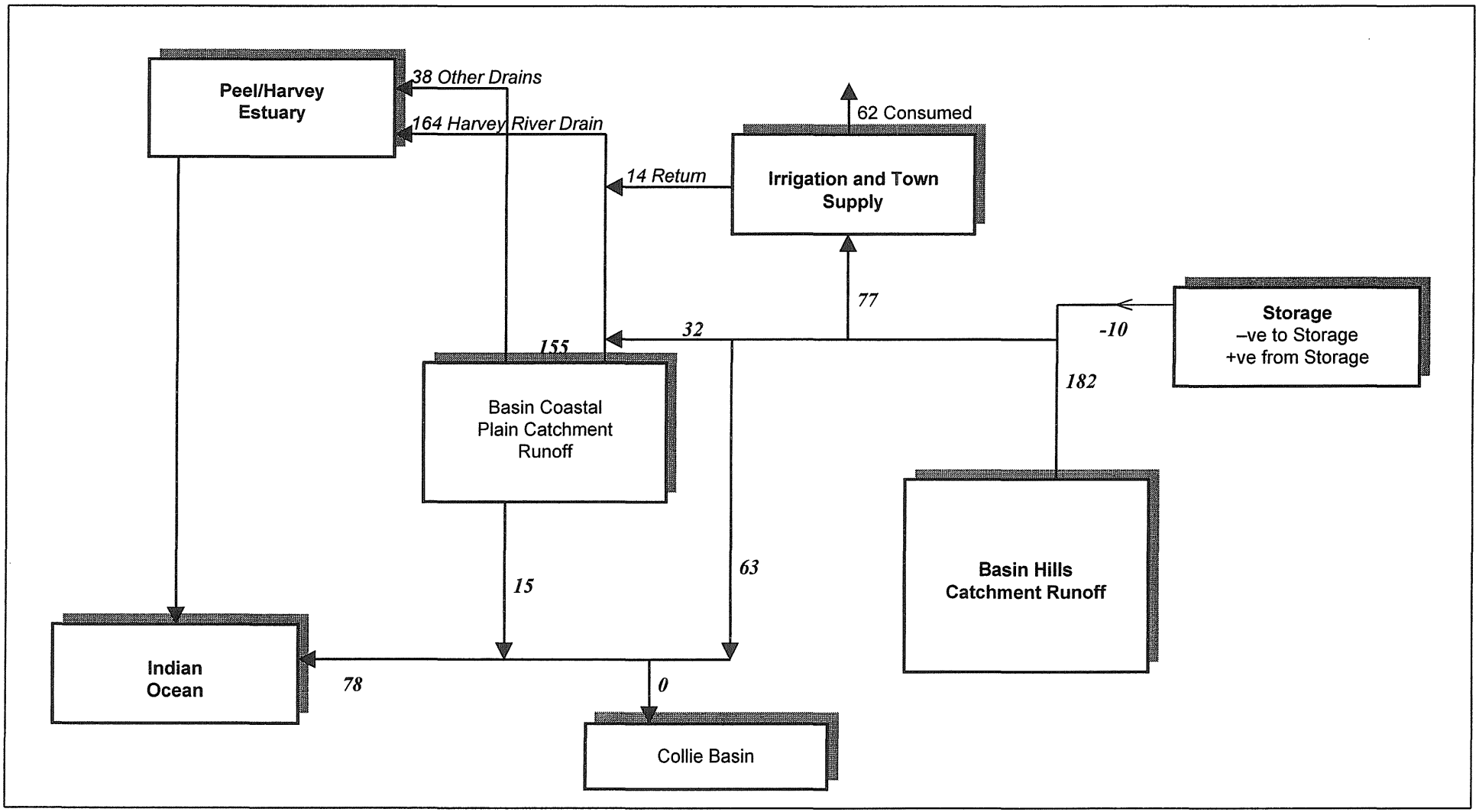


Figure 5. Current annual streamflows in the Harvey Basin under average climatic conditions (GL).

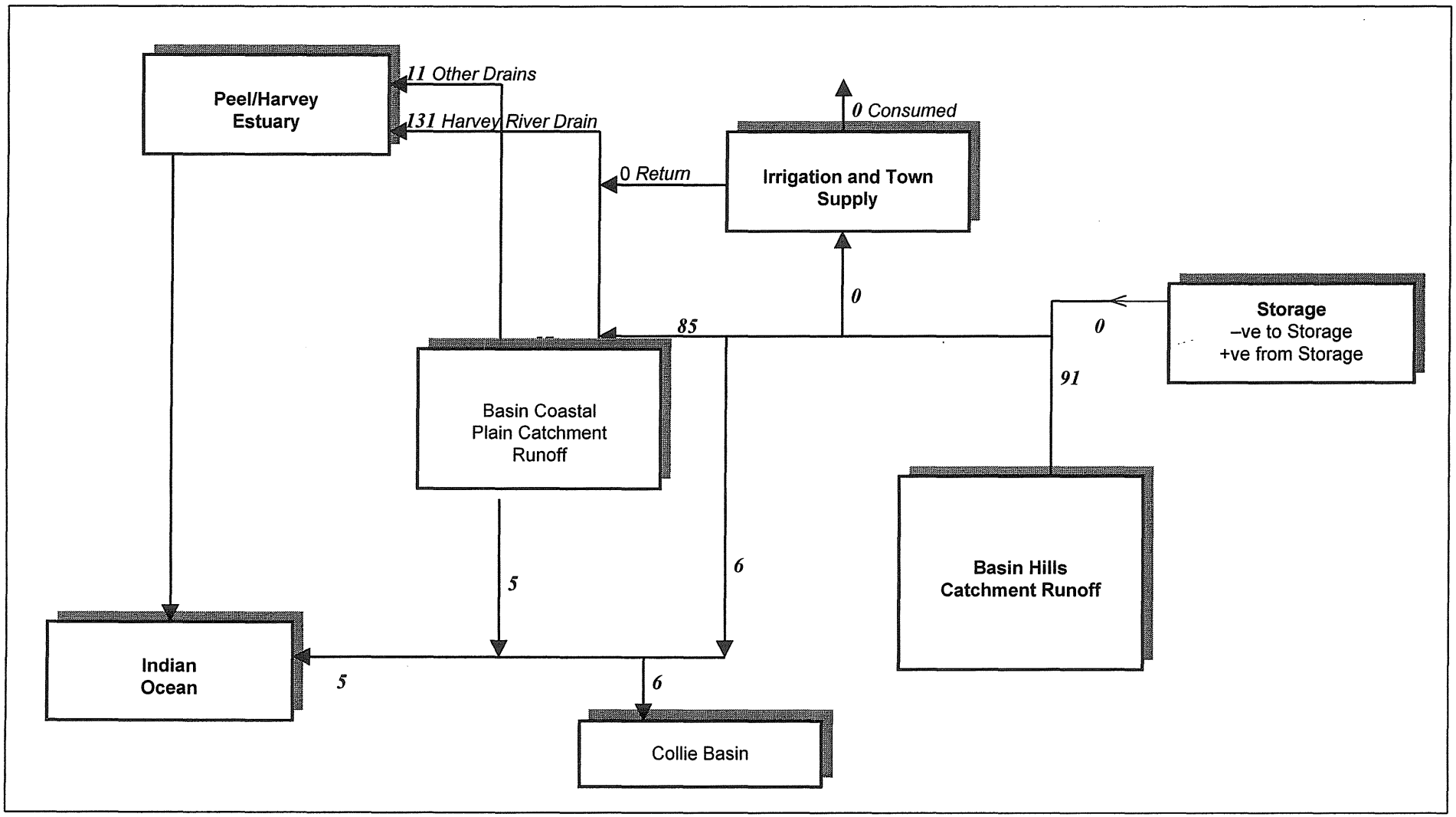


Figure 6. Pre-European annual streamflows in the Harvey Basin under average climatic conditions (GL).

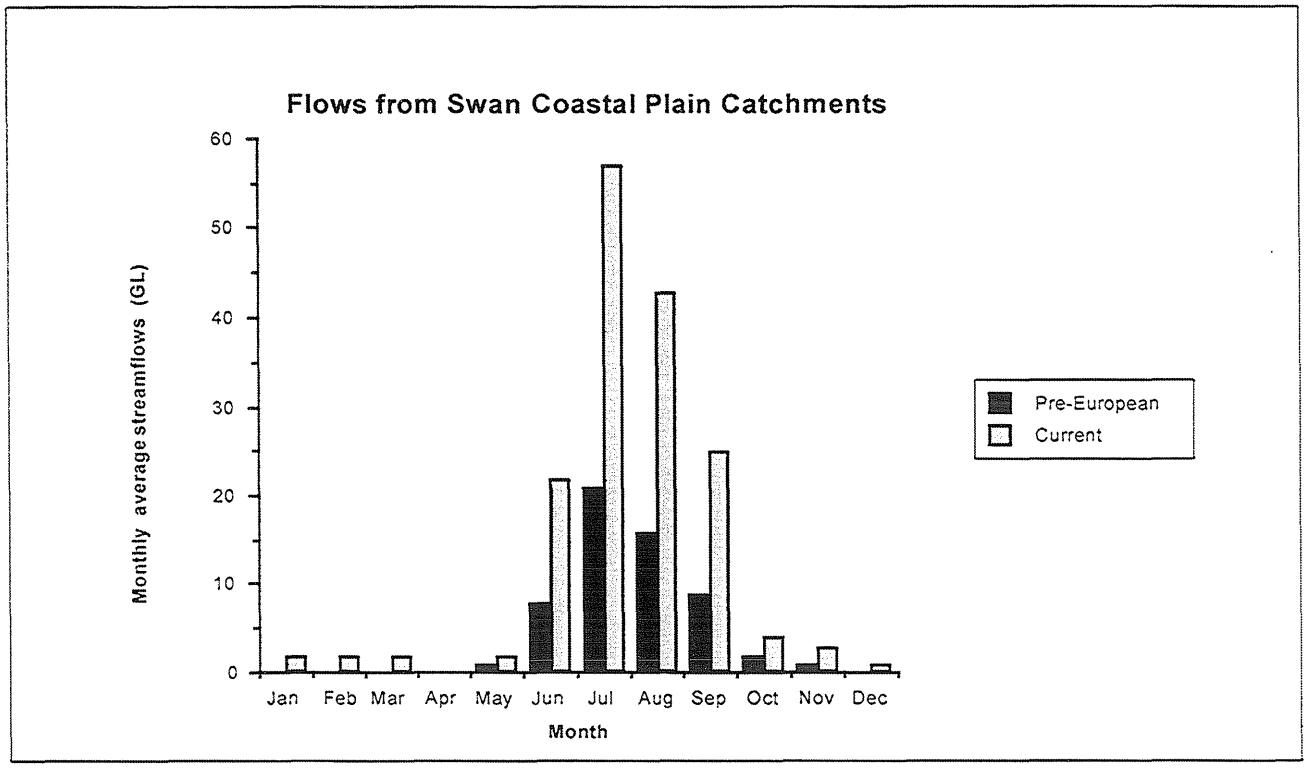


Figure 7. Monthly average streamflows for Swan Coastal Plain catchments.

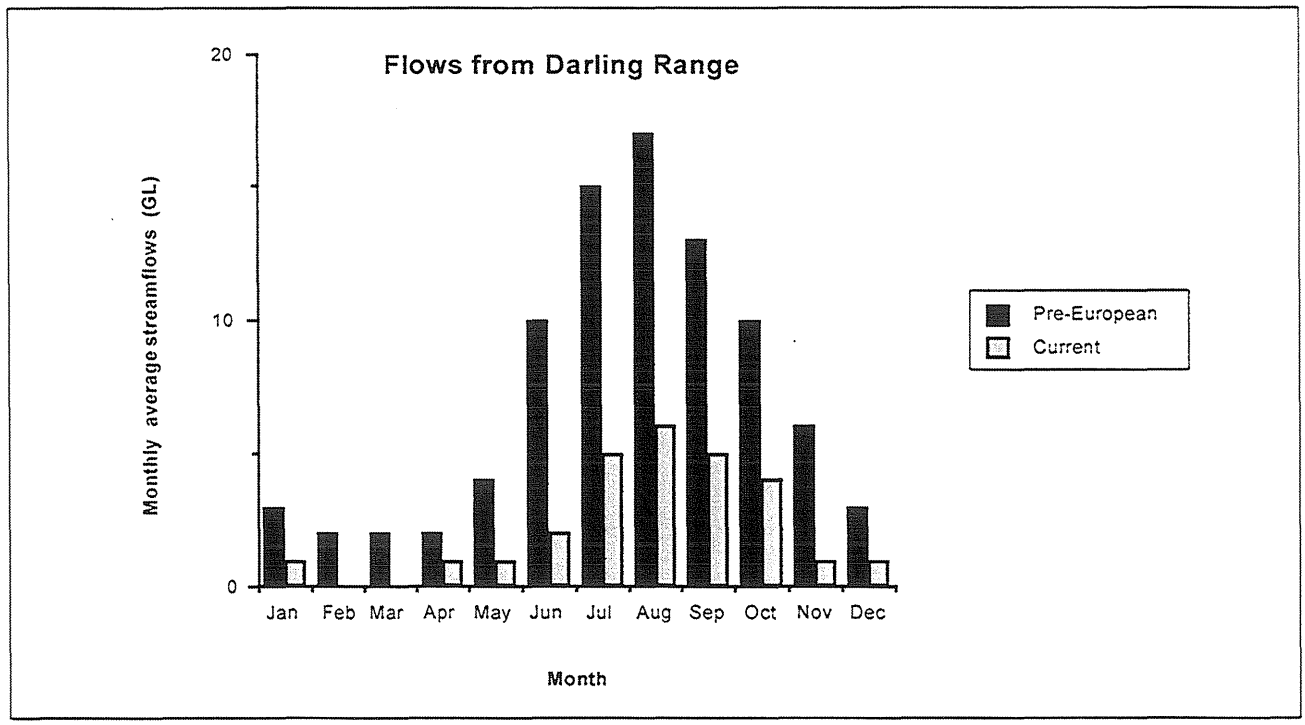


Figure 8. Monthly average streamflows for Darling Range catchments.

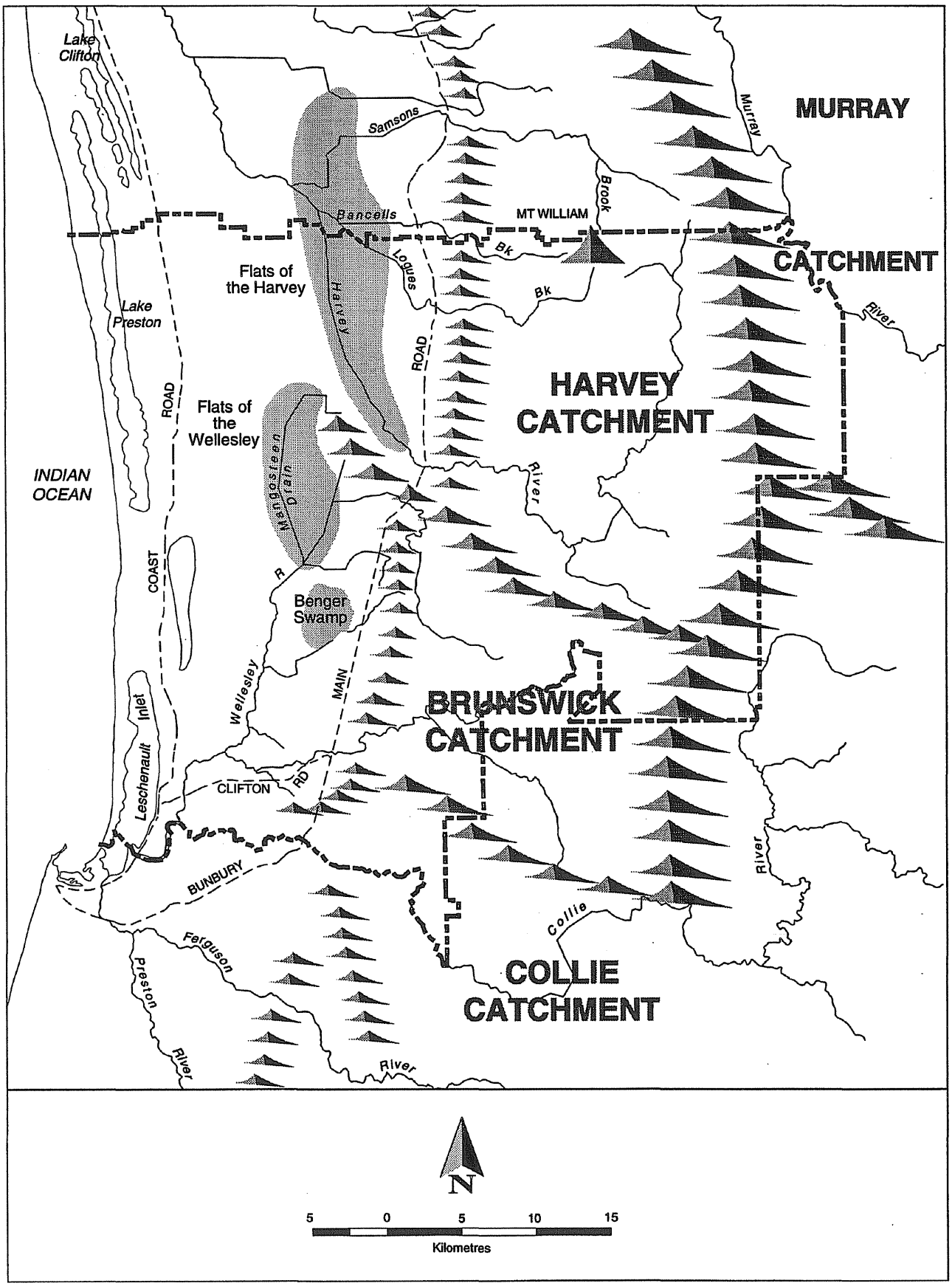


Figure 9. Harvey–Brunswick drainage system prior to construction of Harvey Diversion Drain.

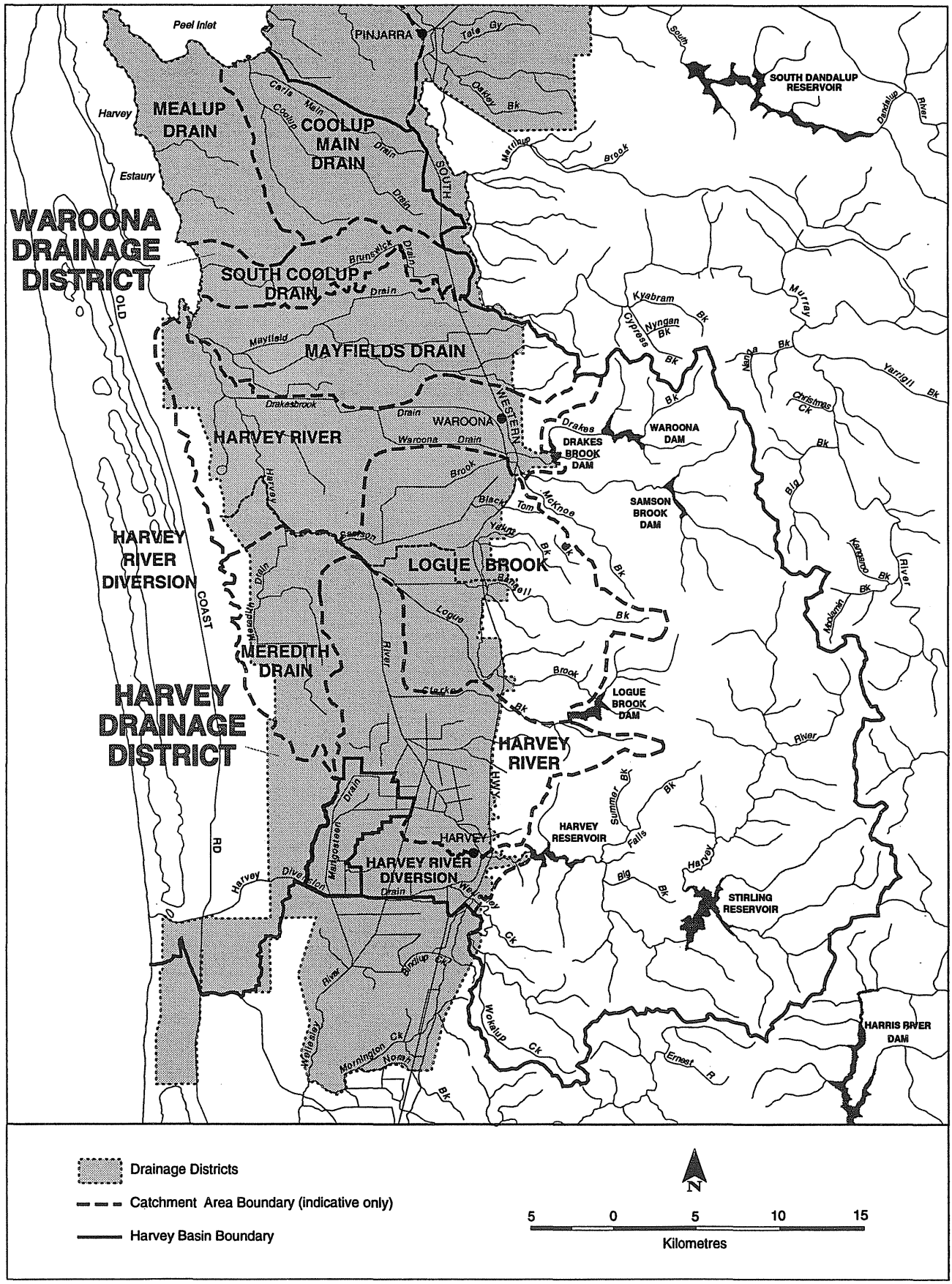


Figure 10. Drainage districts in the Harvey Basin.

5. Existing and Potential Use Demands

Existing and potential future demands for surface water resources in the Harvey Basin arise from:

- agriculture usage, principally for irrigated pasture and horticulture;
- local town water supply;
- Perth metropolitan water supply;
- industry;
- recreation and tourism (usually non-consumptive); and
- riparian usage.

While an assessment of future demand through this plan will provide an indication of trends in water usage, this plan will not allocate water to particular future consumptive uses. The forecasts of water demand will provide information to be considered in the allocation licensing process.

5.1 Public and Town Supply

Many of the coastal towns in the Basin are reliant on groundwater. However, their future demands for water will be seen as being a potential future draw on surface water resources of the Basin. Such consideration is warranted given the concerns expressed about the quality and limitations of groundwater in meeting future demands of coastal communities.

Table 6 provides a summary of the existing and potential future demand for town water supply in and near the Basin. The Perth Metropolitan Water Supply Scheme (PMWSS) may be a potential demand on the Basin's surface water resources. The Water Supply Strategy for Perth and Mandurah (WAWA 1995) did indicate that additional development of the Harvey River resource could meet some of the future demand of the PMWSS.

The town of Binningup is outside the study area, but may exert a potential future demand on the Harvey/Stirling source.

The total demand for town water supply from towns within or near the Basin is expected to be between 2.35 and 3.21 GL/yr in the year 2035.

5.2 Agriculture

Agriculture in the Basin and surrounding areas is a major economic base for the South West region, and has been a major contributor to overall production in Western Australia.

Irrigated agriculture dominates the demand for water from the agriculture sector. Currently irrigation is used for dairy and beef pasture and fodder, with some horticulture (vegetables and fruit) on heavier soils near Myalup. Irrigation water is obtained from self-supply sources including groundwater, drains and watercourses, and from irrigation schemes using water storages in the Darling Range.

Table 6. Existing and future town water supply demands within and adjoining the study area.

Town	Resource	Demand (ML/yr)	
		1994/5	2025
Binningup	Leederville Formation	103	360–470
Hamel	Samson Brook	17	20
Harvey	Harvey Weir	696	750–990
Myalup	Leederville Formation	37	50–90
Preston Beach	Leederville Formation	71	90–100
Park Ridge	Groundwater	91	120–140
Waroona	Samson Brook	462	840–970
Wokalup	Harvey Weir	20	20
Yarloop Wagerup	Bancell Brook	288	400–410
Total		**1785**	**2350–3210**

Source: WRC 1996

Water from private surface water sources in the South West Irrigation Area was estimated to meet about 6% of total irrigation demand in 1995 (WRC 1996).

Water use in agriculture has varied considerably from year to year. The past demand for irrigation water in the Harvey Irrigation District has been on average about 60 GL/yr over the last three decades. In the Waroona Irrigation District the average demand has been about 16 GL/yr over the same period.

There are number of factors that complicate forecasting of future agricultural demand in the Harvey Basin:

- formation of a cooperative of users to manage the South West Irrigation Area;
- phased implementation of a full-cost-recovery pricing policy for irrigation water;
- promotion of water use efficiency; and
- potential for trading water entitlements between shareholders and service providers.

These changes are likely to encourage the transition to higher value agricultural production and reduce the amount of water used per unit area. From interviews with stakeholders in the area, the present trend of declining beef production and increasing horticulture is expected to continue.

The water demand for horticulture varies from 4 ML/yr/ha for wine grapes to 15 ML/yr/ha for market gardens.

The net effect of these changes is that it is unlikely, even under an optimistic demand scenario, that the agricultural demand for water from scheme sources within the Harvey Basin will exceed the existing licence allocations over the next 10–15 years.

The existing licence allocations for the Harvey and Waroona Irrigation Districts are 68 and 17 GL/yr respectively. If average irrigation water use continues at current levels, there is the potential for the trading of surplus water in the future.

5.3 Industrial

The downstream processing of resources to add value to exports is a major emphasis of the State Government's economic development policy. The south west of Western Australia has a wide variety of mineral, forestry and agricultural resources together with a well-developed infrastructure to facilitate the development of value-added industries.

The Kemerton Industrial Park, which is located near but outside the Harvey Basin, is expected to be a major focus for resource processing industry in the South West. There are already a number of major industries in the region, including alumina refineries, a silicon smelter, coal fired power stations and titanium dioxide pigment, superphosphate, mineral sands processing and particle board manufacturing plants.

Downstream processing of resources will often require a guaranteed supply of water of suitable quality.

Within the Harvey Basin, the industrial water demand in 1995 was 1.4 GL/yr, of which 69% was met from surface water impoundments (WRC 1996). This demand is expected to grow at an average rate of 1% per annum over the period to 2025, when the total demand is expected to be about 1.9 GL/yr.

The major industrial user of surface water in the Basin is Alcoa for its Willowdale Mine and Wagerup Refinery operations. Alcoa presently uses water from the South Yalup Dam and a detention dam on Samson South Drain. These sources are augmented by water from the Water Corporation's Samson Brook Dam when Alcoa's storages are low.

Alcoa has recently commenced the construction of the 0.5 GL Chasede Dam on a tributary of Samson Brook, upstream from the Samson Brook Dam. This development, together with the existing supplies from the Wagerup Dam on Yalup Brook, is expected to meet the need of the Wagerup Refinery in the medium term.

The future water demand of the Kemerton Industrial Park under a medium growth scenario is expected to increase substantially, to 10 GL/yr. Under a high-growth scenario the demand for water may increase to 14 GL/yr. Industrial requirements for water quality vary from industry to industry, with Millennium Industrial Chemicals (formerly SCM) requiring water with a salinity of TDS <600 mg/L (DRD, pers. comm.).

Presently water demand at Kemerton is met from groundwater abstraction from Cockleshell Gully and Yarragadee aquifers, where water is slightly brackish, salinities being in excess of 2600 mg/L. The sustainable yield and environmental impacts of abstraction from these aquifers are not well defined, and the water quality is less than desirable for some industries. Consequently surface water source options may be considered to meet any future scheme demand for Kemerton.

The Brunswick and Collie Rivers as well as the Harvey River are potential sources. The low salinity of the Harvey River resource makes it attractive.

The maximum demand that industry may exert on the Basin's surface water resources (if Kemerton water demand is met from the Basin) is about 16 GL/yr under a high-growth scenario.

5.4 Riparian and By-Law 11 Users

The *Rights in Water and Irrigation Act 1914* differentiates between the rights of the Crown and those of public and private landowners to take water from a watercourse. Riparian rights apply to landowners where a watercourse flows through their property and there is no publicly reserved land between the private property

and the watercourse (Boddington 1998, in draft). The Act does not specify how much water landowners can take, however, the Commission recommends using 1500 kL per annum per property as a limit for domestic and ordinary use. Where there are more than a few head of livestock the water use is considered to be commercial, not riparian.

Most By-law 11 users are located within the Harvey Irrigation District, although some abstractions occur from the downstream drainage network and include abstractions from the Harvey Diversion Drain. The water has mainly been used to meet stock water and relatively small scale irrigation needs.

Approvals to abstract this water and raise charges for its use were issued under Part IV and By-law 11 of the Rights In Water and Irrigation Act. Supplies were not guaranteed, as specific releases to meet these needs were not formally made. A recent survey (SWI 1998) indicated that this usage of drainage water is less than 0.1 GL/yr. There is the potential for this volume to substantially increase (up to 1.4 GL/yr) if existing users on the Myalup end of the Harvey Diversion Drain were to irrigate with drain water instead of groundwater.

Further study would be required to quantify the water demand of riparian and By-law 11 users, but it is not likely to make a substantial demand on the Basin's water resources.

The water available to these users may be unaffected by diversion of additional water to public water supply from the Harvey River Hills resource. Most flow below the Harvey Weir during summer is from return of irrigation water and surface and groundwater runoff from the coastal plain.

5.5 Recreation and Tourism

Recreation use of water resources within the Basin are currently opportunistic and non-consumptive.

Three irrigation dams in the Shire of Waroona already provide a range of recreation opportunities. Situated approximately 6 km due east of the Waroona townsite on the edge of the Darling Range, the Waroona Dam (Lake Navarino) covers some 200 hectares. Most of the land in the Waroona Reservoir's catchment is State Forest (about 82%), which is managed by CALM. While the reservoir stores water principally for irrigation purposes, since opening in 1966 it has been used extensively for water-based recreational activities.

A management plan has been implemented to ensure that the reservoir's water quality is maintained. The plan also assigns specific areas for designated recreational activities so as to avoid conflicts between recreational pursuits such as waterskiing and swimming. Direct contact recreation activities include waterskiing, canoeing, sailing, windsurfing, swimming, marroning and fishing. While many of these pursuits occur year round, there is a definite peak season during the warmer months. Pursuits along the edge of the reservoir include picnicking, sightseeing and trail bike riding. There are caravan park and camping facilities at the reservoir, and the shire has estimated that up to 20,000 people use the area (including State Forest and Lane–Poole Reserve) over holiday weekends.

The Drakesbrook Weir, which is only 5 km south east of Waroona, is an important recreational resource for the local community as well as supplying water for irrigation. It has established picnic areas, a swimming area and a jetty, and fishing and marroning are permitted. Samson Dam provides Waroona residents with reticulated scheme water as well as serving irrigation purposes. It also provides some limited recreational opportunities. Fishing and marroning are permitted, but boating is not allowed and there are no picnic areas.

Built in 1963 and located within the Shire of Harvey, the Logue Brook Dam supplies water for irrigation and is also an important recreation resource. Pedestrian access is permitted to all of the catchment and the public have access to the reservoir, which is known as "Lake Brockman". There is a caravan park and a boat-launching ramp, along with 5 picnic areas. Fishing and marroning are permitted, and a designated waterskiing area is available. Similar to the Waroona Dam, a management plan has been implemented to ensure that the reservoir's water quality is maintained. Approximately 90% of the catchment is State Forest, managed by CALM.

In terms of recreation, the Harvey Weir and the Stirling Dam and their surrounds are used primarily for passive forms of recreation. There are public barbeques and picnic tables available, and fishing and marroning are popular activities. Since the 1970s, the WA Amateur Canoeing Association has operated a whitewater slalom facility and downriver canoe course below the Stirling Dam wall. Rally Australia is an annual event that attracts many visitors (as well as competitors) to the Harvey District, which uses roads near the two reservoirs through State Forest.

Discussions with the staff of the Harvey and Waroona Shires, the South West Development Commission and the WA Tourism Commission support the view that the demand for recreation facilities, especially water-based

recreation, will continue to grow in the region. This demand will be fuelled by continued population growth in the Perth Metropolitan Area, the Peel Region, which is the fastest growing in the State, and Bunbury. By the year 2029, Bunbury is expected to be a significant city, having more than doubled its current population and achieved the status of the State's second largest city. The management plans for the Waroona and Logue Brook reservoirs predict that the recreational capacity of these reservoirs will eventually be fully utilised (CALM & WAWA 1989a, 1989b).

5.6 Future Local Demand

The local demand on Basin surface water resources is likely to be dominated by irrigated agriculture (76 GL/yr on average) for the foreseeable future. Town water supply demand is small (about 3.2 GL/yr in 2025) and only a portion of this demand may need to be met from Basin resources.

Kemerton could make a demand on Basin resources (a maximum of 14 GL/yr in 2025) but other sources outside the basin are being investigated to satisfy it.

6. Water Supply Considerations

6.1 Introduction

This plan does not examine allocations potentially available from alternative resources which are outside the Harvey Basin. The alternative resources for supply to the PMWSS were addressed in detail during the formulation of the Water Supply Strategy for Perth and Mandurah (WAWA 1995).

The Commission has provided its response to this strategy, in which it indicated that the Harvey River is considered to be an appropriate potential source for Perth.

The strategy indicated that a new Harvey Dam 800m downstream from the existing Harvey Weir could increase water yield from the Harvey River Hills resource by up to 40 GL/yr (WAWA 1995). This source yield estimate was based on streamflow information over the 1948 to 1995 period.

6.2 Water Resource Development Options

The configuration of a water resource development influences resource yield, cost and environmental (including ecological) and social impacts. The acceptability of an allocation to consumptive beneficial uses can only be determined after considering the social and environmental impacts that arise from water resource developments designed to achieve the allocation.

The Commission has assumed that there are four basic options for achieving an additional allocation for public water supply from Harvey River Hills resource. These options include direct injection to the PMWSS without a new Harvey Dam, storage in the South Dandalup Dam or a larger Stirling Dam and the construction of new Harvey Dam. These options will be examined in this and subsequent sections to assist in the determination of an acceptable allocation from the resource.

The options are described in the following sections and summarised in Table 7.

However, it is possible that a water resource developer may propose a substantially different option that may achieve an acceptable allocation to consumptive uses. Such a proposal would trigger a review of this plan.

The Water Corporation has supplied information on costs and the potential additional resource yields. The Commission has reviewed this information and is satisfied that it is based on accepted methods of estimation and is appropriate for this stage in the allocation planning process.

6.3 Water Resource Yield

Periods that include a relatively high number of dry years (such as the last 20 years) would indicate a lower yield than one containing a relatively higher number of wet years. The yield would also be dependent on the characteristics of water resource developments.

In this section additional Harvey River Hills water resource yields are based on average stream flows over the 1948–95 period unless otherwise stated.

6.4 Water Resource Development Costs

The cost estimates used in this plan are consistent with those in the Water Supply Strategy for Perth and Mandurah (WAWA 1995), but provide a substantial revision based on recent more detailed source investigation work. The estimates for each option cover the capital, operating and replacement costs of the potential source and its pipeline system to Perth.

The major components included in these costs are items such as dam or weir structures, treatment plants, pipes, pump stations, land purchases, road realignments and power lines. The simplest expression of the total cost of each source is the unit of the water in cents per kilolitre (c/kL). This accurately reflects the price that the harvested water would have to be sold at to recover these costs in perpetuity.

The estimates of the unit cost and yield of each option are important in order to compare the water supply benefits of one option over another. In comparing two options, one that provided a higher source yield at a lower unit cost would obviously be better from a water supply viewpoint. Conversely an option that provided less yield at a higher unit cost would clearly be of lower water supply benefit.

In general terms an option providing higher yields is better unless its unit costs are significantly greater and the incremental gain is not worth the incremental cost.

The replacement of the Harvey Weir to improve dam safety would be required for those options that do not involve the construction of a new Harvey Dam. The cost of replacement has been included accordingly.

6.5 Option A – Direct Injection from Harvey Weir to PMWSS

This option does not involve achieving additional yield by the construction of a new Harvey Dam but does use the existing Harvey Weir (storage capacity of 9 GL) as a pumpback site (Figure 11a) to pump water to the PMWSS. Under this option additional water would be obtained by:

- direct injection into the PMWSS; or
- direct injection with storage at South Dandalup Dam.

Both the above sub-options involve the construction of a large pump station. Sub-option 1 requires a 65 km pipeline to link with the PMWSS at Ravenswood. Sub-option 2 requires an 80-km pipeline to the South Dandalup Dam.

This option would involve a high level of water treatment to reduce turbidity to meet public water supply standards. The main contribution to turbidity is believed to be from the Harvey Weir catchment, where extensive clearing has taken place and where there is uncontrolled stock access along watercourses.

The estimated potential source yield is a maximum of 27 GL/yr with a pump capacity of 300 ML/day and storage in South Dandalup Dam. The yield would decrease to 18.5 GL/yr without storage. The unit cost of water for this option would be 80 c/kL with storage (Sub-option 2) and 59 c/kL without storage.

This option limits the potential yield (particularly without storage at South Dandalup Dam) from the Harvey River Hills resource as well as any yield enhancement from any future pumpback development on Wellesley Creek and trading surplus irrigation water.

6.6 Option B – New Harvey Dam for irrigation and PMWSS

This option involves obtaining an additional allocation from the Harvey River Hills resource by the construction of a new Harvey Dam from which water both for irrigation and the PMWSS would be taken. Under Option B a pipeline would not be required from the Stirling Dam to the new main PMWSS supply line on the coastal plain.

A new Harvey Dam could be constructed to various full supply levels, 70 m, 80 m and 90 m sub-options being examined in this plan (Figure 12). The area of inundation would vary according to the full supply level of the dam, as shown in Figure 11b.

The increased area of inundation from the new dam would require the relocation of the Harvey–Quindanning Road.

This option involves a higher level of water treatment to reduce turbidity and meet public water supply standards.

There is the potential to boost the source yield of the resource by the development of a pumpback facility on Wellesley Creek and trading of surplus irrigation water.

This option could provide a potential source yield of around 34 GL/yr based on a full supply level of 80 m. With Wellesley pumpback the yield would rise to 42 GL. The unit cost of water for this option is 59 c/kL and with Wellesley pumpback 52 c/kL.

Option B provides the highest overall additional resource yield or potential allocation. It also provides for yield enhancement, and consequently a greater allocation for public water supply by a Wellesley pumpback and trading of surplus irrigation water.

This option also allows an allocation for whitewater canoeing releases from the Stirling Dam without affecting the yield of the resource.

The cost of this option (with Wellesley pumpback) is lower than for Options A and D. Its cost is higher than for Option C owing to the need for treatment to meet PMWSS standards.

6.7 Option C – New Harvey Dam with Public water Supply from the Stirling Dam

As with Option B, this involves obtaining an allocation for public water supply by the construction of a new Harvey Dam. The main differences (Figure 11c) are:

- a pipeline from the Stirling Dam would supply water directly to the new main supply line to the PMWSS on the coastal plain; and
- water from a new Harvey Dam would be used only for irrigation.

This option does not require a high level of water treatment since it draws the better quality water available from the Stirling Dam.

Similarities to Option B include:

- construction of a new dam with a full supply level between 70 and 90 m;
- storage capacity of 25–140 GL, depending on full supply level;
- the relocation of the Harvey–Quindanning Road; and
- potential for yield enhancement by Wellesley Creek pumpback and trading of surplus irrigation.

There would be a potential resource yield of around 34 GL/yr rising to 39 GL/yr with the inclusion of the Wellesley pumpback.

The unit cost of water for this option with a 34 GL/yr yield is 52 c/kL. The unit cost decreases to 48 c/kL with yield enhancement by a Wellesley pumpback facility.

This option provides the cheapest water for public water supply, with a small reduction in source yield compared to Option B. Enhancement of the yield from a pumpback facility on Wellesley Creek would be limited if an allocation was required for whitewater canoeing. Trading of surplus irrigation water is more limited than for Option B because a new Harvey Dam would be for irrigation supply purposes only.

Option C may substantially limit the allocation of water to whitewater canoeing.

6.8 Option D – A Raised Stirling Dam

This option would involve achieving an additional allocation for the PMWSS by raising Stirling Dam without a new Harvey Dam or enlarging the existing Harvey Reservoir (Figure 11d). A new pumping and dedicated pipeline facility would be required (in addition to the pipeline to the new main supply line on the coastal plain to the PMWSS) to pump excess water from the Harvey Weir to the Stirling Dam.

Table 7. Summary of Harvey River Hills options.*

Characteristic	Option A – Direct to PMWSS		Option B – New Harvey Dam for Irrigation and PMWSS			Option C – Irrigation from New Harvey Dam and PMWSS from Stirling Dam			Option D – Raised Stirling
	Without storage	With Storage	70 m	80 m	90 m	70 m	80 m	90 m	-
Pipeline to PMSS (km)	65	80	65	65	65	65	65	65	65
Pipeline Stirling/Harvey (km)	-	-	-	-	-	15	15	15	2X15
Road relocation	-	-	Minor	Major	Major	Minor	Major	Major	-
Energy Consumption (MWhr/yr)	10542	37873	NA	13403	NA	NA	11952	NA	22023
Higher water treatment	Yes	Yes	Yes	Yes	Yes	No	No	No	Possible
Increased area of inundation	None	None	131	471	764	131	471	764	Not known
Wellesley pumpback option	V unlikely	Unlikely	V likely	V likely	V likely	Likely	Likely	Likely	Unlikely
Storage (GL)	9	9	25	70	140	25	70	140	Up to 130
Pot. source yield (GL/yr)	18.5	27 31**	NA	34 43**	NA	NA	34 39**	NA	29
Capital cost ($m)	127	242	NA	240	NA	NA	241	NA	232
Unit cost (c/kL)	59	80 73**		59 52**	NA		52 48**	NA	68

*Source: Water Corporation
** With Wellesley pumpback
NA – Not available

The anticipated potential increased source yield is 29 GL. The storage capacity of the raised Stirling Dam is expected to be up to 130 GL. The existing capacity is 55 GL.

The unit cost of water for this option is 68 c/kL.

This option has a relatively high unit cost and results in a substantially lower potential allocation to PMWSS. Enhancement of the resource yield from a pumpback on Wellesley Creek is unlikely. Yield enhancement through the trading of surplus irrigation water may take place under this option.

6.9 Climate Variability Effects

Average rainfall over the last two decades has been significantly lower than the long-term rainfall average based on the period since 1911. Future rainfall patterns are uncertain, but it is prudent to investigate the effects of a continuation of this low rainfall sequence on the source yields of options.

Table 8 below summarises the results based on the 1975–95 rainfall sequence. The effect of the dry sequence is to reduce overall source yields or consumptive use allocations by about 10–15% per year and increase unit costs by about the same amount.

The relative size of yields and costs remains basically unchanged between the sources. The Harvey River catchment has a higher and more reliable rainfall than the Perth region. The catchment has been affected by the drier rainfall sequence since 1975 than surface water catchments close to Perth. Consequently there is value in maximising source yields from a relatively reliable resource such as the Harvey River.

Table 8. Harvey River Hills source yields based on 1975–95 rainfall sequence.*

	Option A		Option B	Option C	Option D
	Without Storage	With Storage	80m	80m	Raised Stirling
Source yield (GL)	16	22	29	29	24
Unit cost (c/kL)	65	83	67	60	77

*Source: Water Corporation

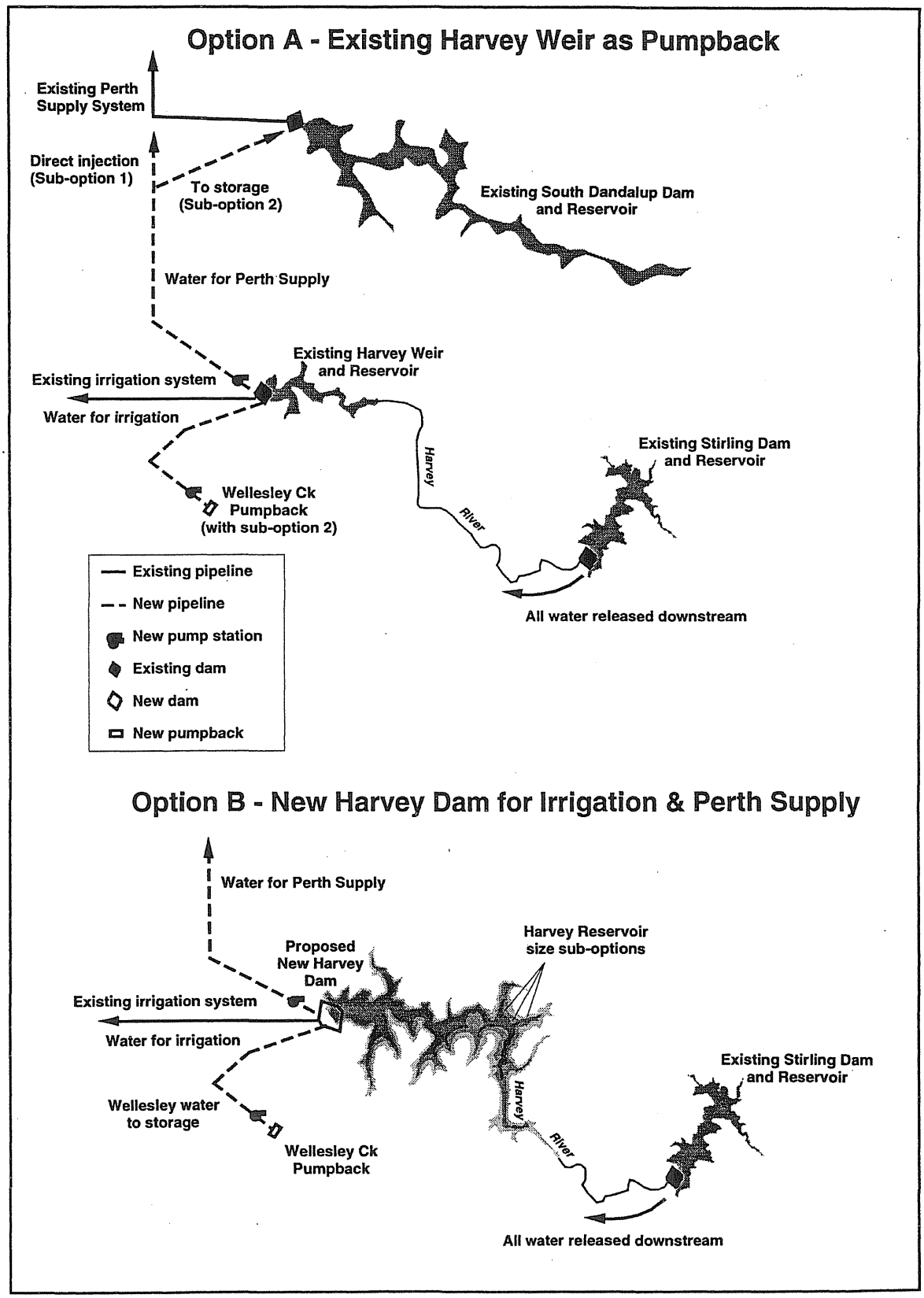


Figure 11 a–b. Harvey Stirling development options.

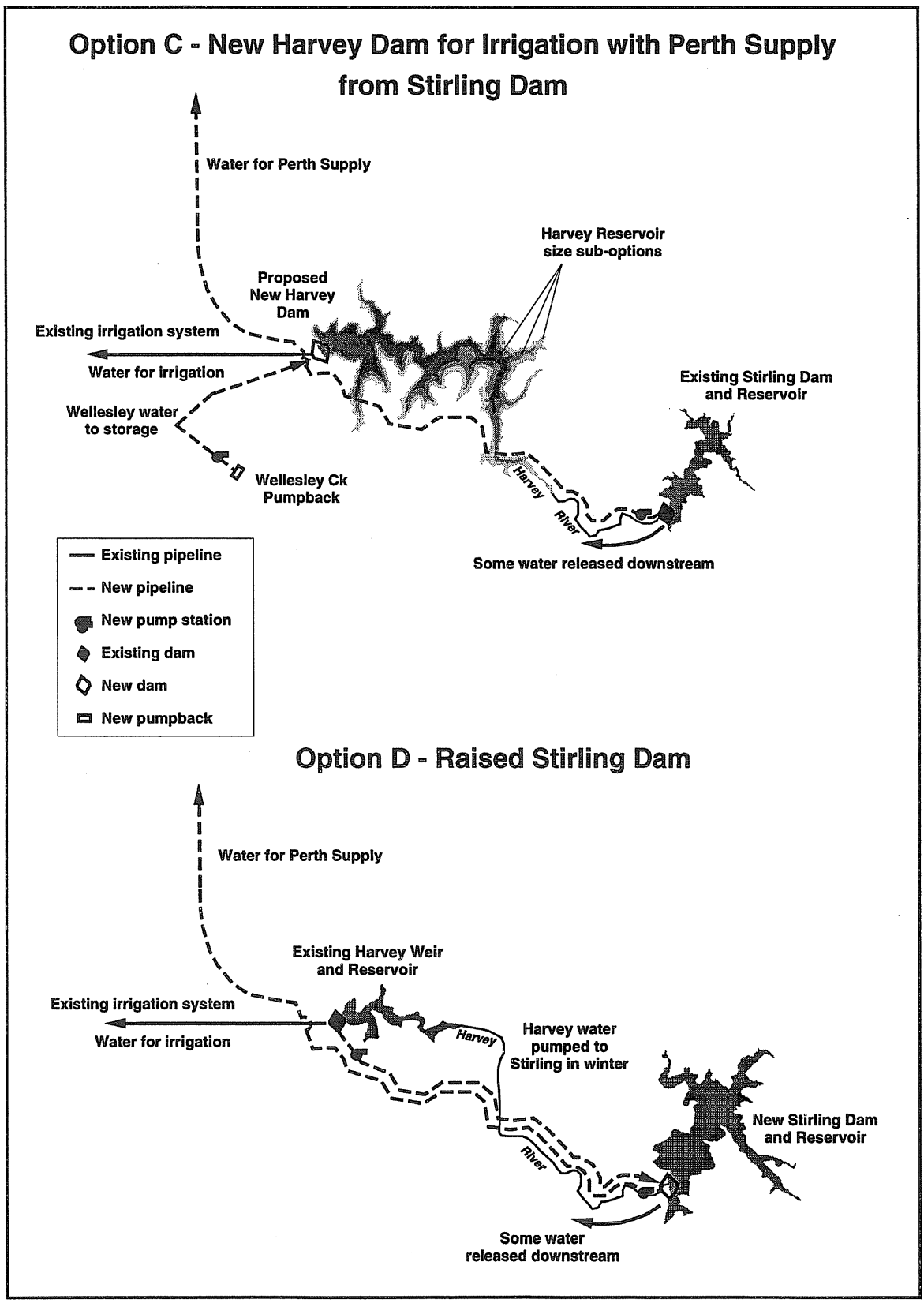


Figure 11 c–d Harvey Stirling development options.

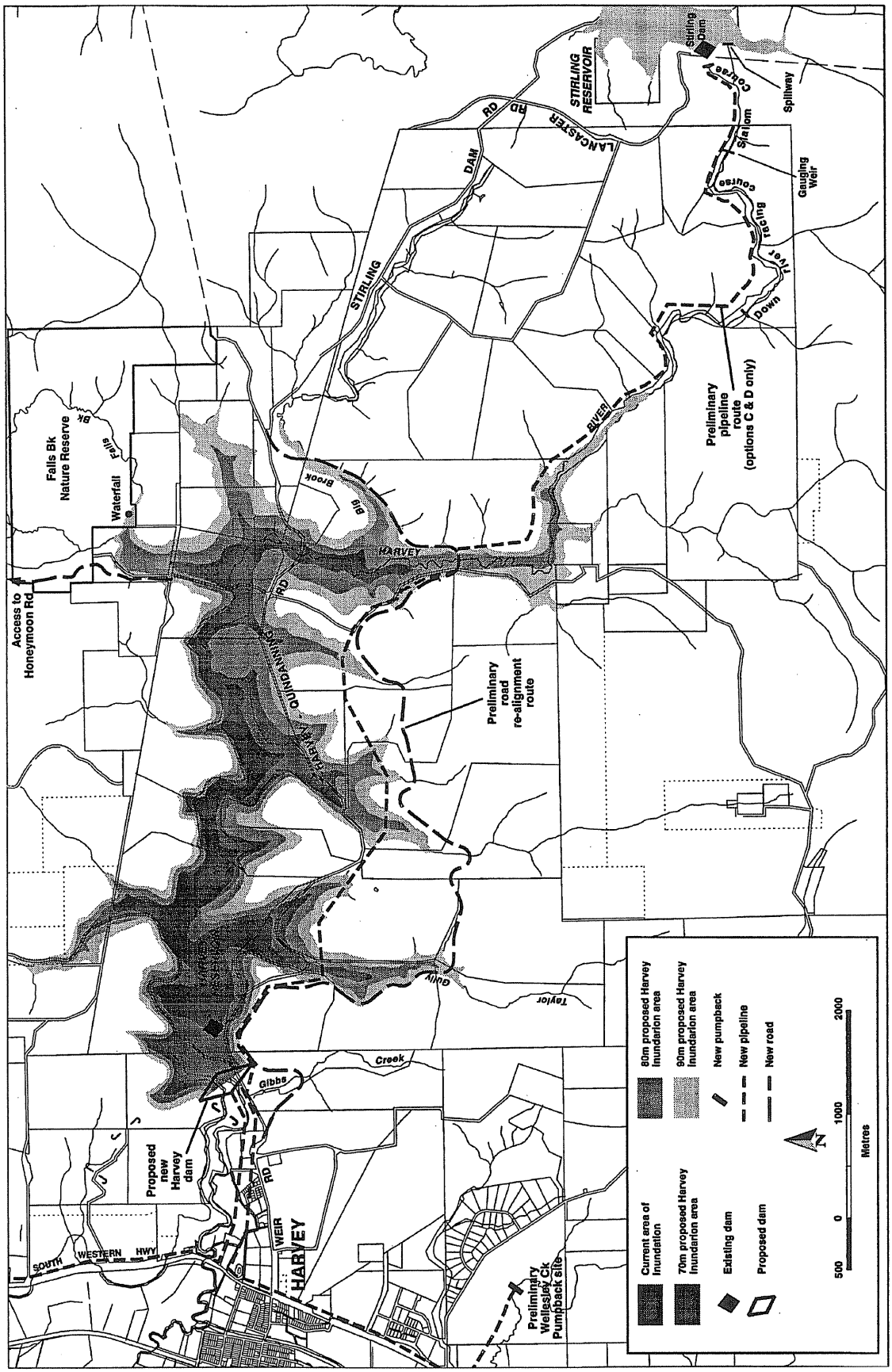


Figure 12. Inundation area for 70-m, 80-m and 90-m full supply levels for a new Harvey Dam.

7. Environmental Considerations

Environmental impacts resulting from the diversion of surface water for consumptive uses may arise from:

- Modifications to downstream streamflow. The more the streamflow is modified from the natural or existing regime the greater the ecological impact.
- Inundation of upstream riverine and other areas by water stored upstream from dam structures. Inundation impacts are dependent upon the design and operation of the impoundment. The larger the impoundment the larger the impact.
- Barrier effects on upstream migration of riverine biota and downstream carbon movement.
- Infrastructure such as pipelines and roads associated with the construction and operation of the impoundment. Impacts would be dependent on the location and construction of infrastructure. Avoiding areas of environmental significance would reduce impacts.

The Commission has considered all the above environmental aspects in the preparation of this allocation plan. While impacts on non-riverine areas may not be considered part of a water resource, the early indication of any environmental "fatal flaws" would assist in determining the feasibility of additional allocations.

The environmental impacts associated with the construction of a new Harvey Dam and infrastructure (such as noise, dust and traffic) have not been addressed in this plan. These matters would be considered in any environmental impact assessment of such a proposal.

Section 13 of this plan provides a strategic assessment of the impacts (particularly inundation impacts) of an additional allocation to consumptive uses on environmental factors of interest to the Environmental Protection Authority.

This section deals principally with the establishment of environmental water provisions for significant ecological values highlighted downstream from the existing Harvey Weir. A summary of the inundation impacts of allocation options is also presented.

7.1 Modifications to Downstream Streamflow

The construction of dams and weirs leads to reduced flows into the lower sections of rivers thereby potentially impacting on the receiving downstream ecosystem. The use of river water to provide reliable supplies for domestic use, industry and agriculture requires the construction of dams, weirs and diversion systems and hence flow regulation. These "off-stream" uses of water tend to alter the seasonal patterns of flow as well as reducing the quantity of water left in the stream.

The river channel may become a conduit for the transfer of water from storage to abstraction points, with the result that river ecosystems frequently experience much higher flows, and more abrupt water level changes, than under natural conditions. Whilst some of the water passing down the channel to abstraction points may help to achieve environmental objectives, other requirements of river biota would not be suitably met.

Typically the further a stream is removed from its historic flow regime, the more the environmental conditions of the stream are degraded.

7.2 Ecological Water Requirements and Provisions

In-stream environmental flows are defined as those retained in the river or stream to achieve various environmental objectives. In-stream flows may be retained simply to protect the aesthetic features and recreational values of rivers, but the main objective of in-stream flow allocations is to preserve some of the river's native biota and ecological features.

The terminology used in this plan is based on that used in the *National Principles for the Provision of Water for Ecosystems* (ARMCANZ & ANZECC 1996), where:

Ecological Water Requirements (EWRs) describe water regimes (spatial and temporal) needed to sustain the ecological values of water-dependent ecosystems at a low level of risk.

Environmental Water Provisions (EWPs) are that part of the environmental water requirements that can actually be met after consideration of social and economic factors.

The need to recognise the ecological impacts of flow regulation and diversion has also occurred through various Federal policies:

- Principles of Ecologically Sustainable Development (1992);
- Intergovernmental Agreement on the Environment (1992);
- The COAG Strategic framework Agreement for Water Reforms (COAG 1994), which included the need to provide water for the environment as part of the introduction of comprehensive systems of water allocation; and
- Draft National Water Quality Management Strategy (1994).

The Commonwealth and State agreement on water allocation reform reflects the importance of EWRs. The Harvey River catchment is characterised by substantial regulation or diversion (70%) of the forested upland streams.

EWRs are determined on the basis of the best scientific information available. Ecological or environmental water provisions (EWPs) are those parts of ecological water requirements that can be met given that tradeoffs between environmental impact and social and water supply considerations are often required. However, the end result of such tradeoffs should be ecologically sustainable.

There is a presumption in allocation planning that water will be provided to sustain significant environmental values and features prior to water being diverted to consumptive uses. In other words only the water that is left after meeting significant environmental needs is available for consumptive uses.

In addition, the Commission regards EWPs as not tradeable.

The Commission has developed the following process for establishing EWRs and EWPs:

1. Identify significant water-dependent ecological values, key features and hydrology of the river system.
2. Determine vital or important components of the ecosystem that support significant values and which are sensitive to changes in the water regime.
3. Determine water requirements to sustain key features of the river system and the most sensitive components of the ecosystem which support important values.
4. Determine indicative water available for consumptive use after meeting EWRs.
5. Formulate water resource management objectives for the water resource system.
6. Establish EWPs using existing information on EWRs after considering management objectives and any tradeoffs that may be required to meet vital consumptive uses.
7. Determine actual water available for consumptive use after allowing for EWPs and any further investigations required to refine EWPs.
8. Review EWRs/EWPs as information becomes available from monitoring and research.

The above process includes public input to the determination of the environmental values and any proposed water provisions to protect them.

The Commission engaged Streamtec Pty Ltd to conduct ecological studies downstream of the Harvey Weir and identify the important ecological values and features and the ecological water requirements. The results are documented in Harvey Basin Surface Water Allocation Plan: Environmental Water Requirements (Streamtec 1998)

7.2.1 Limitations on the Determination of EWRs

The lack of a historic flow record, which can show the magnitude of individual events, limits the capacity to prescribe detailed EWRs. Consequently the available historic flow record was simulated to give monthly means.

The Dawesville Channel would probably impact on estuarine ecological values adjacent to the Harvey River to a greater extent than any mitigation gained by river flows. At this stage, there is little published information on the impact of the channel on these values.

Streamtec's investigations of ecological water requirements were primarily concentrated on the Harvey River downstream from the Harvey Weir.

7.3 Determination of Ecological Water Requirements

Rivers are very complex ecosystems requiring a holistic approach to management. The provision of in-stream flows to protect habitat and fish passage, and to flush blue-green algae and areas of poor water quality, is insufficient to protect all key ecological features.

The holistic approach uses a range of flow-related parameters in a methodology where significant environmental flows are determined and used to derive a comprehensive environmental flow strategy. Under this approach, flow requirements or in-stream flow "building blocks" for important river ecosystem components are separately determined. These building blocks are used to construct in-stream ecological flow requirements to sustain these important components.

This approach assumes that the natural flow regime maintains, in a dynamic manner, the morphology of river channels, all of the in-stream biota, riverine vegetation, floodplain and wetland systems, and any estuarine and offshore systems affected by streamflows.

7.4 Water Requirements to Sustain Harvey River Ecological Values and Features

Although all of a river's features and ecological processes may be important at some level, some are considered by the Commission to be more important than others.

Much of the native riverine vegetation within the coastal plain segment of the Harvey River catchment has been cleared. There are, however, patches of remnant riverine vegetation along the main watercourses (Figure 13). Variable water levels have special significance for riverine plant communities. Aquatic and semi-aquatic plants along the river margins are confined to a band whose width varies with the magnitude of the water level changes. This riverine zone is a major focus for both aquatic and terrestrial fauna and represents a major concentration of biodiversity.

The key water-dependent ecological values and associated streamflow requirements established for the Harvey River (Streamtec 1998).

The key features and values identified were:

- estuarine wetlands;
- riverine and floodplain vegetation;
- riverine fish;
- estuarine fish;
- aquatic invertebrates;
- ecosystem processes; and
- channel maintenance.

In addition, estuarine nutrient management, while not normally an ecological water requirement, was considered to be an important environmental issue which needed to be addressed.

This section discusses the ecological water requirements and proposes environmental water provisions for the above values. Table 9 provides a summary of the ecological requirements for important ecological values and river features.

The flow regime (overall environmental water provision) to maintain the above values is presented in Table 10.

7.4.1 Estuarine Wetlands

Salt marshes are important in controlling erosion, providing organic nutrient sources for detrital estuarine food chains and as a habitat for birds and insects. They provide a buffer between nutrient sources and the estuary, and may provide important "signals" that influence the entire estuarine ecosystem (Rose & McComb 1995). They are highly productive ecosystems (approx. 20–45% of the Peel–Harvey system total primary productivity), now considered rare and requiring urgent conservation measures (Woodcock 1992).

While changes in tidal regime due to the creation of the Dawesville Channel are expected to have a dominant influence on salt marsh distribution, irregular or unseasonal very high river flows have the potential to increase scouring and uprooting of seedlings and inhibit the germination of light-sensitive seedlings. Glasson, Birch and Black (1995) also report a loss of samphire marshes in the Black Lakes area of the Peel–Harvey, likely due to increased river flows resulting in either reduced salinities or increased nutrient supply to competitive species. In the Swan River Estuary, major loss of salt marsh and fringing estuarine vegetation has occurred where drains discharge fresh water directly into the vegetation rather than running through it (Pen 1983, 1992).

Too little freshwater discharge may also lead to changes in riparian vegetation. The replacement of estuarine fringing *Juncus–Melaleuca* associations by samphire in parts of Leschenault Inlet and the Maylands peninsula is believed to be due to increased salinities, as drains now pass through fringing vegetation areas rather than discharge into them (Pen 1983, 1992).

Distribution of the samphire is primarily influenced by annual tidal inundation, though river flooding will also affect distribution.

Table 9. Environmental water requirements for key ecological values and features.

Value/Feature	Ecological Water Requirement
Estuarine wetlands	Seasonal inundation (stimulus for seeding and recruitment). Maintenance of existing salinity and water levels.
Riparian and floodplain vegetation	Seasonal inundation. Sufficient river flows for the maintenance and recruitment of vegetation intercepting river flows.
Estuarine fish	Sufficient water to maintain a diversity of habitats. River flows to stimulate recruitment. River flows transporting nutrients and other material from the catchment.
Riverine fish	Sufficient water for reproductive migration. Sufficient water to maintain nests (e.g. cobbler). Water to inundate streamside vegetation during periods of spawning.
Aquatic macroinvertebrates	Flows that do not cause channel or bank erosion and pool aggradation. Flows that maintain a diversity of hydraulic habitats.
Ecological processes – energy/carbon flows	An unregulated flow from the forested regions to the lower reaches (this maintains a downstream flow of carbon and other materials which subsidises the food webs of downstream ecosystems). Flows that do not result in river bed instability. With instability, primary production is low and nutrients are transported unprocessed into the estuary.
Channel maintenance	Flows that maintain the active channel morphology and scour material from pools etc.

Table 10. Proposed flow provisions (ML) for the environment compared with percentile flows (present and estimated historic) for the gauging sites.

Month	Proposed Monthly Flow Allocation (ML)	Bristol Rd. Present (percentiles)	Bristol Rd. Historic (percentiles)	Near Harvey Estuary Present (percentiles)	Near Harvey Estuary Historic (percentiles)
Jan	65.1	2	1	<1	<1
Feb	58.8	8	8	2	3
Mar	63.0	8	9	2	3
Apr	65.1	7	7	3	3
May	123.0	5	3	2	<1
Jun	11,664*	>100	>100	>100	>100
Jul	11,664*	>100	>100	>100	>100
Aug	865	6	7	2	1
Sep	808	10	10	2	<1
Oct	865	18	10	4	1
Nov	241	19	8	2	1
Dec	196	2	1	<1	1

* Flood flows are over a period of days. An allocation to maintain these flows is not proposed.

Topography of the salt marshes in the Harvey Basin varies from 0 to 2.0 m AHD, while salinity of the inundating waters varies from 0 to 53 parts per thousand. In contrast to the samphires in other regions of the Peel–Harvey, the *Sarcocornia* and low flats around the Harvey Delta are considered to be relatively young and have shown a steady increase since 1977.

To date there are few available data on the impact of the Dawseville Channel. Potential impacts are considered to be mostly due to an increase in variability and frequency of tidal ranges and a decrease in the annual salinity range, with salinity at or near ocean levels for most of the year. These changes may alter salt marsh distributions and plant community structure and, subsequently, the distributions of estuarine and aquatic invertebrates which inhabit them.

Altered tidal regimes are expected to have a more pronounced effect in the Harvey Estuary, which has greater invertebrate species richness and abundance. Increased flows from the Harvey River have the potential to partly ameliorate effects of increased winter salinity levels on freshwater species in the lower reaches of the Harvey River and the Harvey Delta. Conversely, increased summer river flows may exacerbate a

decrease in soil salinity (due to increased tidal inundation), promoting invasion of marshes by less salt tolerant species such as *Juncus kraussii* and *Melaleuca* species.

Environmental Provision

The present flows into the Harvey Estuary are sufficient for the maintenance of estuarine wetlands (in particular samphire flats). A reduction of the present streamflow into the Harvey Estuary might be acceptable provided that flows were not reduced below pre-European settlement levels. However, the Dawesville Channel is likely to have a dominating effect by increasing salinities in the samphire and riverine areas immediately upstream. This may lead to changes in species composition in these areas.

Monitoring of these areas is required to determine the impact of the Dawesville Channel and to establish appropriate environmental water provisions.

7.4.2 Riverine and Floodplain Vegetation

Melaleuca woodlands play an important ecological role in providing a source of organic material for aquatic invertebrate communities in streams and estuaries. The high accumulation of leaf litter is indicative of a highly productive ecosystem and there is also potential for these woodlands to act as nutrient sinks (Congdon 1979; Greenaway 1994).

Changes in drainage patterns may significantly alter plant community structure, distribution, productivity and growth. *Melaleuca–Agonis* communities subject to large flushing-flows during winter may be succeeded by *Eucalyptus–Melaleuca–Juncus* communities if winter flushing is reduced and irrigation flows maintained in streams over summer months (Pen 1983).

Unseasonal and/or high velocity flows have the potential to result in scouring and destabilisation of banks and to uproot recolonising native vegetation. Increased discharge from drains or changes to drainage patterns may also facilitate invasion of wetlands by weed species (Pen 1983, 1992).

Recharge of soil moisture from high river flows is important for recruitment of riverine trees. At sites that have been highly disturbed by livestock grazing, competition for moisture, light and nutrients from annual grasses and herbs may prevent germination of native trees.

Flood events are important to the maintenance of the river–floodplain connections. During connection, a massive exchange of nutrients and detrital material may occur, which is considered necessary for ecological processes within the river (Froend & McComb 1994).

The reduced frequency of small to medium floods as a result of river regulation can lead to a reduction in vigour and recruitment of riverine trees and a shift in food resources from relatively nutritious to less nutritious algal-based resources.

Loss of all floodplain trees, however, does not necessarily follow a reduction in frequency and duration of flooding. Trees growing at >15 m away may be less affected by reduced surface water flows. Regular flooding, however, may still be required to recharge groundwaters upon which tree species depend.

Riverine vegetation is severely restricted in the lower Harvey system. Generally, flood flows inundate this vegetation and are an important stimulus for seed-set and subsequent recruitment. Without sufficient recruitment, there is no replacement of senescent trees and understorey. For these processes, flood flows over the bankfull capacity of the channel are generally necessary.

Some regions of the Harvey Basin (e.g. the lower reaches of the Harvey Main Drain and Mayfield Drain) still support woodlands of flooded gum, *Eucalyptus rudis,* and paperbarks, *Melaleuca parviflora,* with some *Agonis linearifolia.* Dense stands of *Melaleuca rhaphiophylla* and sedges such as *Lepidosperma longitudinale* occur in the swamps and seasonally inundated depressions. Riverine zones may extend to >200 m, and continued recruitment of these species was evident in surveys conducted during November 1997.

Little of the original understorey, however, remains intact, and introduced *Watsonia* and grass species dominate. In the upper sections of the drainage channels, the natural riparian and littoral vegetation has been replaced by pasture species (e.g. Weekes, Clarke, Logue, Bancell Samson Brooks and Drakes Brook Drain). The survey conducted during November 1997 showed recruitment of native plants in riparian zones strongest for *Melaleuca* and *Agonis* species, with a wide range of size classes. Young eucalypt trees (predominantly *Eucalyptus rudis*), ranging in height from 0.5 to 5m, were also observed; however, recruitment appeared limited by strong livestock grazing pressures. Strong recruitment was also noted for the emergent macrophytes *Lepidosperma longitudinale* and *Juncus kraussii*, though distribution of these species was limited.

No recruitment was apparent in open pastures away from drainage lines, or along drains with steep (2–3 m)

vertical banks (e.g. the Harvey Main Drain, Mayfield and Waroona Drains).

Frequent short high flows in the naturally wet months are necessary to flush the substrates and saline reaches. Prolonged drought or inundation will reduce growth and reproduction rates in riverine species (Froend & McComb 1994). The reduction in vigour and recruitment of riparian vegetation, normally associated with the reduction in frequency of small to medium floods following regulation, may be ameliorated by increased runoff from catchment clearing. However clearing and grazing have resulted in extensive loss of native vegetation and possibly a shift in riverine community food resources from relatively nutritious to often less palatable algal-based resources.

Environmental Provision

Dam and low-level weir construction in the Harvey Basin has resulted in reduced exchanges between the river and its floodplain. The major floods required for large-scale recruitment of riverine and floodplain biota,now no longer occur.

The present riverine vegetation and wetland-dependent vegetation (where present) show a reasonable amount of seed-set and subsequent recruitment and are therefore probably intercepting surface water flows from the coastal plain.

The Harvey River Main Drain and Diversion Drain are trapezoidal channels capable of conveying substantial volumes of water. The bankfull discharge rate of the Main and Diversion Drains is estimated at 45.2 and 88.1 cubic metres per second respectively. This corresponds to flows with average return intervals (ARI) in both systems of substantially >100 years. There are insufficient instantaneous flows (both present and historically) to enable the current river channel to over-top the banks. This is due to the large extent of downcutting of the current river channel.

The allocation of reservoir water, in prescribed releases, for these highly-modified water-dependent ecosystems is not appropriate, and would result in significant bank and channel erosion and further in-filling of pools.

7.4.3 Riverine Fish Species

In-stream flow management has the potential to both preserve indigenous fishes and control the spread of exotic fish species.

The south west of Western Australia has an indigenous fish fauna with a low number of species and a high degree of genetic variation between locations (Pusey et al. 1989). Temporary streams of these catchments have a reduced species richness compared to permanent waters downstream, due to problems of accessibility and the limited food supply for young fish (Pusey & Edward 1990a, 1990b; Pen, Potter & Calver 1993).

In lowland areas where populations are confined by natural and artificial barriers, the spawning migration takes fish into drainage channels and flooded areas of the Swan Coastal Plain. Studies by Pen and Potter (1991a, 1991b) in the Collie River have shown that spawning activity may extend from late June to the end of September, with spawning reaching a peak in August when water temperatures start to rise. The western minnow requires the stimulus of fast-flowing waters in tributary streams to spawn successfully (Pen & Potter 1991b).

In lowland areas, spawning migrations of the western minnow are interrupted by impassable v-notch weirs, which cut off access to drainage channels and flooded areas on the coastal plain which may be essential for successful spawning. On the escarpment, temporary headwater streams isolated above large dams appear to be colonised by residual populations of the Minnow from within the reservoirs (Pusey et al. 1989).

The maintenance of late winter and early spring flows of sufficient magnitude is required to ensure spawning and recruitment of the nightfish, *Bostockia porosa*. Flooding of streamside vegetation appears to be important to provide suitable spawning habitat. Predictable winter/spring flooding is required to ensure breeding success and strong recruitment of the pygmy perch. Reduced flooding and low water levels in tributary streams may increase the probability of competition between species.

The maintenance of winter floods appears to be necessary to restore or maintain natural habitat characteristics in the lower reaches and hence to reduce the suitability of the system for proliferation of the introduced mosquitofish, *Gambusia holbrooki*.

In the regulated system of the Harvey Basin, irrigation water releases from impoundments occur during the drier months (particularly during the spring dry period) and may compromise fish spawning and the survival of fry. High release flows or sudden large fluctuations in water levels during this time may further compromise spawning and fry survival.

Environmental Provision

Given the patterns of spawning and dispersal, and the habitat associations of particular fish species, maintenance of the period of low stable flows, followed

by some level of flooding, is an important feature of the flow regime.

Without corrective management, impoundment of streams by barriers such as weirs and reservoirs causes a reduction of flow and the inhibition of upstream fish migration. In these circumstances the stream has insufficient power to maintain the channel, resulting in the accumulation of fine sediments and weeds, and, in many cases, introduced fish species including the mosquitofish.

August to October are considered critical months for reproduction and movement of native fish in the lower Harvey River, based on known periods of spawning and dispersal.

The present flows are sufficient for fish passage. To ensure passage through the lower river system, a minimum depth of 8 cm was used to determine streamflow required for fish passage (Table 10).

Existing barriers in unregulated and semi-regulated streams should be removed or modified and these streams separated from the irrigation water supply system, wherever practicable, in order that:

- the upstream migration of native fish is not impeded;
- the downstream movement of particulate carbon (which is the food resource of invertebrates which are, in turn, food for fish) is not impeded; and
- natural variations in flow are maintained.

7.4.4 Estuarine Fish Species

Altering flow regimes may impact not only riverine species, but also species in estuarine and in-shore marine environments. Estuarine fish fall into three categories:

- the migratory species that utilise riverine environments for spawning or feeding;
- species whose life cycle can be completed entirely within estuaries; and
- small numbers of freshwater fish.

The Harvey Estuary is under the influence of tides and, with a relatively stable salinity (compared to rivers) over most of the year, provides a nursery ground for a variety of fish species that support large recreational and commercial fishing industries. In contrast, salinities in tributary rivers often undergo pronounced seasonal fluctuations. These tributaries typically support fewer fish species and lower biomass. This situation is compounded during times of low salinity by the movement of fish out of rivers and into the estuary basins.

Salinity is important in determining estuarine and tributary fish composition, with differences strongly correlated to differing salinity regimes. The composition of riverine fish fauna may significantly alter during the dry season, when reduced freshwater flushing and increased salinities allow the influx of marine species. Physical effects of flushing may be greatly reduced in rivers with persistent salinity gradients. For example, the Murray River, with just such a gradient, offers habitat for marine species that would otherwise only opportunistically utilise the riverine environment.

Effects of modified stream discharge and flow regimes on commercial and recreational estuarine fisheries will be varied. The tolerance of fish to changes in salinity varies greatly within and between species. The Peel-Harvey and Swan estuariine marine species such as sea mullet (*Mugil cephalus*), yelloweye-mullet (*Aldrichetta forsteri*) and cobbler (*Cnidoglanis macrocephalus*) are less likely to be adversely affected by increased river discharge, and subsequently reduced salinities, as they typically inhabit the deeper waters.

Extreme flow events, both high and low, in the Murray River corresponded to differential catch rates for commercial fisheries in the Peel–Harvey Estuary. Sea and yelloweye mullet are often only available to fisheries if there is sufficient rainfall to maintain low salinities long enough to allow recruits to reach commercial size. In winter and spring, juvenile sea mullet migrate rapidly upstream from the estuary mouths to waters of lower salinity.

Flow regimes that lead to increased summer freshwater discharges are likely to result in high mortality in species such as the Perth herring (*Nematalosa vlaminghi*).

Other marine fish that are known to penetrate far upstream during dry periods of increased salinity are the trumpeter (*Pelates sexlineatus*), the western whiting (*Sillago schomburgkii*) and *Atherinomorus ogilbyi*. In contrast, indicator species for wet periods in the lower reaches of tributary rivers tend to be dominated by the estuarine rather than marine species, for example grunter (*Amniotaba caudavittatus*, estuarine in south western Australia), hardyhead (*Atherinosoma wallacei*) and goby (*Favonigobius suppositus*).

Reduced or restricted flow during normally wet periods will lead to:

- a summer pattern of fish community structure in lower reaches of rivers and upper to middle reaches of estuaries; and
- a reduction in seasonally available habitat for freshwater species and juveniles of migratory marine species such as commercially fished sea- and yelloweye mullet.

Unpredictable or unseasonal in-stream flow will impact fish movement and spawning.

Environmental Provision

The linkage between river flows and estuarine productivity is a function of a number of parameters including the rates of influx of catchment-derived nutrients and the input of fresh water. A positive relationship between river flows and fish catch the following year exists for a number of species, including prawns.

However, with the creation of the Dawesville Channel, estuarine productivity and the abundance of fish/crustaceans will undoubtedly be reduced. In addition, catchment management in the Basin aims to reduce nutrient loading into the estuary.

The present flows are sufficient for estuarine fish passage. To ensure passage through the lower river system, a minimum depth of 8 cm was used to determine streamflow required for passage (Table 10). These flows are sufficient for migration, spawning and, in addition, maintaining the cobbler "nests" under the water level of the active river channel.

7.4.5 Aquatic Macroinvertebrates

There are marked seasonal changes in both macroinvertebrate community structure and function in upland streams in south western Australia. This has been attributed to the influence of a highly seasonal and predictable Mediterranean climate, with high winter flows and low summer flows. Some fauna may be influenced by seasonal differences in water temperature (e.g. stenothermic stoneflies); however, it appears that stream flow and/or flow-related variables are the important underlying factors.

Macroinvertebrate fauna respond to differing flow conditions both on a spatial scale (habitats) and a temporal scale (seasonality). In streams of the northern jarrah forest, there is a linkage between near-bed water velocities and macroinvertebrate community structure (Davies 1993).

Macroinvertebrate communities immediately below a reservoir may be substantially affected by changes to flow regimes. However, streamflow from a subsequent unregulated major tributary may provide adequate "compensation" flows into the river to "re-set" community structure back to pre-impoundment conditions (Storey et al. 1990).

Species that are susceptible to high and variable flows can synchronise their life cycles so that the sensitive stages (e.g. the larvae of crustaceans or pupating stages of some insects) occur only during the dry season. As a consequence, unusually high flow events during the dry season may be detrimental to the persistence of these species. It is important, therefore, that dry season flows below proposed impoundments remain benign, without dramatic changes in flow rate.

Metapenaeus dalli (western school prawn) are abundant in estuaries throughout south western Australia, and they complete their entire life cycle within the larger estuaries of the Peel–Harvey and Swan. In the Peel–Harvey Estuary, spawning takes place predominantly in the low-salinity tributary rivers.

Prawns that have migrated, or have been flushed out into estuary basins or out to sea during winter, move back into the rivers in spring as flow rates decrease and salinities rise. These migration patterns are reflected in increased commercial catch rates of *M. dalli* in rivers, most particularly the Murray River, during summer. Between January and March most school prawns have moved out of the Peel Inlet and Harvey Estuary and into the Murray River, and this is the area targeted by professional prawn fishermen over summer.

The evolution of such estuarine life history strategies may represent a response to the landlocking of south-western Australia's estuaries. This landlocking, which can occur seasonally or for a number of years, occurs when sandbars form a barrier at the estuary mouth.

Environmental Provision

Aquatic macroinvertebrate communities are regulated, to some degree, by the volume and seasonality of flow. The majority of the aquatic fauna inhabit the streambed and are therefore highly dependent on streambed conditions. However, the lack of suitable in-stream habitat and the instability of the substrate of the lower Harvey River are considered to have a dominant impact on the aquatic fauna. In this context, the existing flow regime is sufficient for the maintenance of the existing aquatic fauna and no specific water provisions are required.

7.4.6 Ecosystem Processes

Community metabolism or energy flows describe the major functions "driving" ecological processes in rivers and streams. In the lowland river systems of the Swan Coastal Plain much of the catchment has been changed by intensive agriculture, and urban developments and rivers cannot be considered in isolation from the upstream catchment. Understanding the sources and fate of organic carbon in streams and rivers is fundamental to the successful management of these environments as "healthy" ecosystems. In part, this is due to carbon being the principal building block of all living tissue and the fundamental element whose movement drives ecological systems.

Current models describing ecosystem function in terms of carbon movement of larger rivers are shown in Figure 14.

The river continuum concept model best describes the functioning of the existing Harvey River. In this river, stable carbon isotope analysis has shown upstream carbon subsidising the lower river fauna. Pre-European conditions would probably have been described by the flood pulse concept, where extensive lower river wetlands would have been connected seasonally to the main river channel.

The extent of regulation of Darling Range catchments (streamflow is now 40% of pre-European values) and the importance of upstream-downstream linkages for carbon flow emphasise the importance of unregulated sub-catchments.

The most significant feature of the community metabolism of the coastal plain streams in the Basin was the large seasonal differences in both gross primary production (GPP) and community respiration. Essentially, winter values of both these parameters were almost zero. The large seasonal differences in metabolic rates were attributed to changes due to seasonal increases in near-bed water velocity and associated erosion of the river bed.

Environmental Provisions

Shear flows are important for both the preservation and the removal of benthic algal mats, which are the major determinant of metabolism and macroinvertebrate biodiversity in the lower Harvey River system.

To maintain riverbed algal mats in the lowland river during the summer months, daily flows ideally should be greater than 2000 m^3 but less than about 4000 m^3.

The homogeneous fine to coarse sands of the lowland Harvey River are eroded and unstable due to these high discharge rates. These eroded areas are both metabolically inert and have a low biodiversity. Increased river stability would increase the local processing of nutrients, result in a more diverse aquatic fauna and reduce the export of nutrients from rivers into the estuary.

Increased winter stream metabolism will only occur where there is appropriate river restoration in the Swan Coastal Plain portion of the Harvey River Basin.

Higher up in the catchment, barriers are present that impede the downstream migration of carbon, which is important for consumers in downstream ecosystems.

The maintenance of unregulated flows (without barriers) to the Harvey Estuary will be important in providing carbon material to subsidise food webs in streams and drains on the coastal plain.

7.4.7 Stream Channel Maintenance

In-stream flows influence channel form and channel maintenance through physical processes such as scouring.

An analysis of the hydraulic geometry of catchments has established that there were significant relationships between active channel width and drainage area, and between channel depth and drainage area, in several streams. On the other hand bankfull width in these streams was more strongly correlated with bankfull streamflow, as was bankfull depth.

Not only would stream habitat be lost under conditions of reduced bankfull discharge, but habitat would also be degraded by a decrease in the degree of scouring and disturbance of the streambed. The net effect would be accumulation of smaller bed materials at downstream sites, and siltation and accumulation of organic debris and aquatic plants, with potentially severe implications for the riverbed invertebrate fauna.

High winter flows are required to maintain existing river channel dimensions and prevent the accumulation of sediment and organic debris. Disturbances from these events may also be important in structuring benthic communities and have a profound influence on ecosystem function.

Unseasonal and/or high velocity flows can, however, also result in scouring, destabilisation of banks and subsequent increased sediment loads downstream.

Environmental Provision

Given the high flow rates required to give bankfull flows (refer Section 7.4.2 above) and the consequent erosion damage that may be caused to channels and drains, releases for this purpose are inappropriate.

7.4.8 Estuarine Nutrient Management

Ecological water requirements do not normally extend to flushing water contaminated by anthropogenic activities from streams. The construction of the Dawesville Channel and implementation of catchment management programs are intended to reduce the artificially high nutrient load to the Peel Inlet and Harvey Estuary. The high nutrient load results from fertiliser application as a consequence of agricultural land use in the catchment.

The establishment of environmental water provisions to sustain key features and values should not work against the objective of reducing nutrient loading and the occurrence of detrimental algal blooms.

Regulation of rivers and drainage schemes in the Harvey Basin has reduced the natural flow variability and seasonally reversed some of the wetting and drying cycles. Dams on Darling Range catchments have also greatly reduced the input of nutrient-poor water, while clearing, cultivation and drainage on the coastal plain have increased the input of nutrient-rich water to the Peel–Harvey Estuary (Black & Rosher 1980).

Any further reduction in river flow from the Darling Range catchments would reduce any beneficial flushing action to the Harvey Estuary.

River flow and the total nutrient input to the estuary are strongly seasonal, with approximately 85% of nitrogen and phosphorus loadings occurring during winter. Increased flows down the Harvey River from the coastal plain component of the Basin will increase the nutrient loss from agricultural areas and so contribute towards problematic algal growth.

7.5 Wellesley Creek

Due to the degraded nature of the creek, there are not any specific water-dependent ecosystems that would warrant a determined flow allocation.

Presently the creek flows into the Harvey Diversion Drain. This drain is a channel simply constructed to convey floodwaters and, as such, has little ecological "value". Again, the major river restoration issue for Wellesley Creek is not EWRs but the lack of in-stream habitat and the absence of suitable riparian vegetation.

7.6 Summary of Inundation Impacts of Allocation Options

The social impacts, including impacts on landowners, aesthetics and recreation, of the allocation options and Wellesley pumpback are described in Section 8 of this plan.

This subsection concentrates on the impacts that may potentially occur on the biophysical environment. Table 11 provides a summary of the biophysical impact of all options.

A vegetation survey (Mattiske Consulting Pty Ltd 1997) and a survey for the western ringtail possum (de Tores & Rosier 1997) were carried out in the area of potential inundation by a new Harvey Dam. These studies and a previous study on the potential impacts of a new Harvey Dam (Havel Land Consultants 1994) were used in the environmental impact assessment of options.

Option A

Option A does not result in any increase in the area of inundation beyond that of the existing Harvey Weir.

However, all other options (B, C and D) do result in increased areas of inundation, depending on the final full supply level chosen for a new Harvey Dam or a raised Stirling Dam.

Options B and C

For the same full supply level these options would have equivalent environmental impacts. The extent of environmental impact would be greater as the full supply level of a new Harvey Dam increases. At a full supply level of 80 m, the area of inundation would be approximately 650 ha. A pumpback facility on Wellesley Creek likely to be associated with Options B and C would lead to inundation of an area of about 9 ha for a storage volume of 0.25 GL.

Options B and C may potentially impact on the following significant features of the biological environment:

- a portion of the area subject to System 6 Recommendation C 79;
- remnant and riverine vegetation;
- one priority flora species;

- habitat of the rare western ringtail possum and possibly other Specially Protected Fauna; and
- the Falls Brook Nature Reserve.

A number of these impacts may be reduced, depending on the management measures employed.

The Commission considers that any significant inundation of the Falls Brook Nature Reserve and the location of pipelines in riverine areas should be avoided.

The Commission believes that with a full supply level of 78 m the impacts on the biophysical environment that result from inundation are manageable provided (refer Section 13 for details):

- an appropriate vegetation protection plan is prepared by a developer of a new Harvey Dam that includes restoration of Lowdon vegetation complex (and other important complexes) on the escarpment and coastal plain;
- a faunal management plan is prepared by a developer of a new Harvey Dam that protects the western ringtail possum

Option D

The increase in the height of the Stirling Dam would lead to increased inundation of State Forest. A substantial proportion of the area inundated is a pine plantation. No detailed vegetation survey of this area was undertaken, but this option is likely to lead to a lower impact on the biophysical environment than a Harvey Dam with a full supply level exceeding 70 m.

7.7 Greenhouse Gas Emissions

Each allocation would give rise to increased greenhouse emission, depending on the amount of pumping involved (Table 12). Furthermore, those options involving a new Harvey Dam or increasing the height of the Stirling Dam would give rise to additional greenhouse gases resulting from the inundation of vegetation.

Option A with storage at South Dandalup Dam gives rise to the highest annual rate (47,872 t/yr) and unit rate (1.54 kg/kL) of greenhouse gas emissions. This option without storage has the lowest annual rate of greenhouse gas emissions (11,575 t/yr) but a relatively higher rate of greenhouse gas emissions per kL of water (0.63 kg/kL).

Table 11. Summary of inundation impacts on biophysical features.

Environmental Value	Option				
	A	B and C			D
		70 FSL	80 FSL	90 FSL	
Plantation forest	None	4	17	37	Not measured
Priority flora	None	None	*Hibbertia silvestris* P4	*Hibbertia silvestris* P4 over a larger area	No survey undertaken
Plant taxa affected	None	175	224	289	Not known but likely to be less than a new Harvey Dam
Falls Brook Nature Reserve	None	None	Some flooding of Falls Brook below the falls	Flooding of the falls and the valley of Falls Brook	None
Forrestfield complex	None	8 ha*	17 ha*	20 ha*	None
Lowdon riverine	None	40 ha*	50 ha*	60 ha*	Not known
Lowdon mid slope		6 ha*	25 ha*	30 ha*	Not Known
Helena	None	4 ha*	42 ha*	99 ha*	None
Darling Scarp	None	2 ha*	5 ha*	6 ha*	Not known
System 6 C79	None	54 ha*	80 ha*	105 ha*	None

* Preliminary estimate

Table 12. Greenhouse gas emissions for options.*

Option	Description/Pumping Rate	Yield	Energy Consumption		Greenhouse Gas Emissions	
		(GL)	(MWh/yr)	(kWh/kL)	(t/yr)	(kg/kL)
A	Direct injection (150 ML/day)	18.5	10542	0.57	11575	0.63
A	Storage at Dandalup (300 ML/day)	27	37873	1.40	41585	1.54
A	Storage at Dandalup (300 ML/day) plus Wellesley pumpback	31	43590	1.40	47862	1.54
B	200 ML/day	34	13403	0.39	14716	0.43
B	200 ML/day plus Wellesley pumpback	43	22508	0.52	24713	0.57
C	200 ML/day	34	11952	0.35	13123	0.38
C	200 ML/day plus Wellesley pumpback	39	19414	0.50	21317	0.55
D	150 ML/day	29	22123	0.76	24156	0.83

*Based on 1.098 tonnes CO_2 per MWh (*Minerals Industry Greenhouse Challenge Workbook*, Australian Coal Association and Minerals Council of Australia

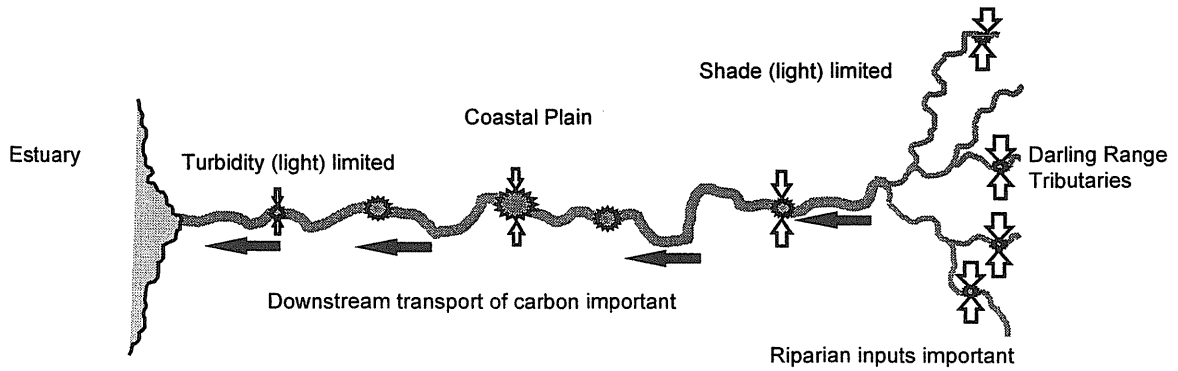
Option C has the second lowest annual rate (13,123 t/yr) and lowest unit rate (0.38 kg/kL) of greenhouse gas emissions. Option B has marginally higher emission rates; 14,714 t/yr and 0.43 kg/kL.

Greenhouse gas emissions from Option A with storage at South Dandalup Dam (the option with the highest rate of emissions) is about 0.06% of total emission of these gases from Western Australia in 1990 (60 million tonnes (DEP 1997)).

Figure 13. Ecological values of the Harvey Basin.

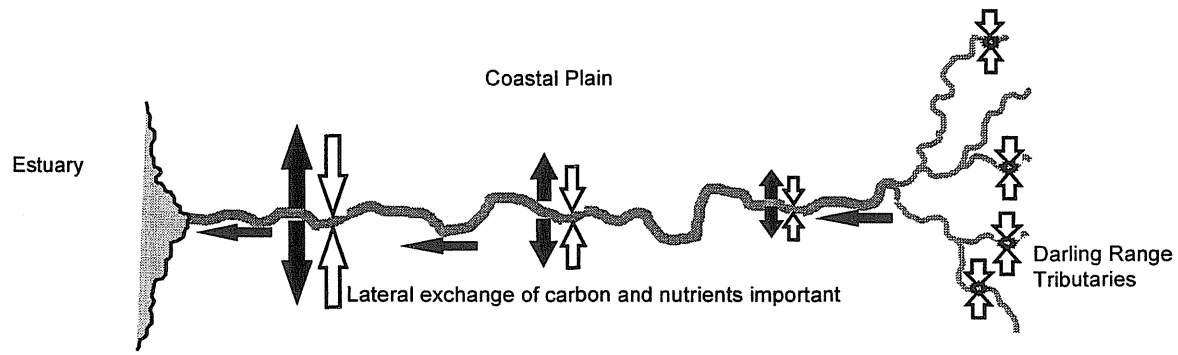
(a) River Continuum Concept

This concept (Vannote et al, 1980) emphasises the importance of carbon and nutrients "leaked" from upstream processes subsidising the function of lower river reaches.



(b) Flood-Pulse Concept

This concept (Junk et al, 1989) emphasises that important river-floodplain food webs are driven by production from the floodpain rather than by transported organic matter from upstream.



(c) Riverine Productivity Model

This concept emphasises the importance of local primary production (phytoplankton, riverbed algae, other aquatic plants) and direct inputs from the adjacent riverine zone.

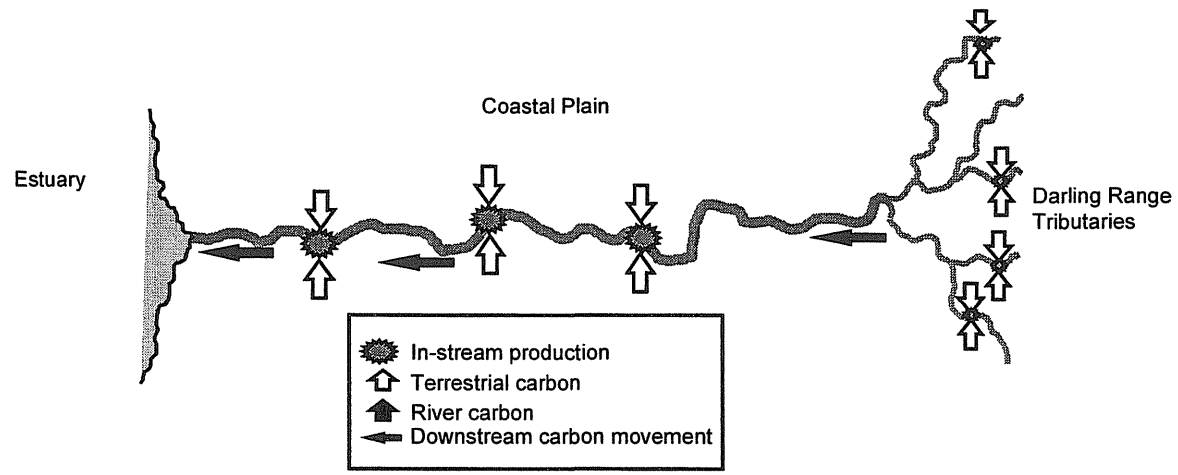


Figure 14. Models describing the ecosystem process of carbon movement in river systems.

8. Social Analysis of Allocation Options for the Harvey Hills Resources

The primary focus of the social impact assessment has been the evaluation of potential options for obtaining an additional allocation from the Harvey River Hills resource. The Commission engaged Beckwith and Associates Environmental Planning to conduct a detailed social impact analysis of these options. The results of this analysis are documented in "Harvey Basin Allocation Plan: Social Impact Analysis of Harvey/Stirling Options" (Beckwith & Associates Environmental Planning 1998). This section draws on the more significant contents of this report.

The social impact analysis involved an extensive program of public consultation, interviews and review of available documentation on the social environment in the Harvey Basin.

Detailed Aboriginal ethnographic and archaeological surveys were conducted of the area that may be inundated by a new Harvey Dam (Quartermaine Consultants 1998; O'Connor 1998). In addition, a preliminary assessment was made of the significance of the Harvey River near the Harvey Estuary to Aboriginal people (O'Connor 1998).

An in-depth economic analysis of the impact of allocation options was not conducted as part of the social impact analysis. The social impact of a Wellesley Creek pumpback facility was not examined in detail, but interviews were conducted with potentially affected landowners.

8.1 What is Social Impact?

The positive or negative effects that allocation options have on people and their surroundings are their social impact. The construction and implementation of these options can result in changes in lifestyle, culture and community. Normally proposals would result in a level of change in the social environment, which may be welcomed by some people while found to be undesirable by others.

Social impacts are usually not the result of simple cause-and-effect processes but a complex interaction between factors such as:

- the nature of the proposal;
- the characteristics of the individuals and communities involved;
- the ongoing process of social change;
- the affected community's history;
- the attitudes and perceptions of those likely to be affected;
- the willingness and ability of people to cope with predicted change; and
- measures available to mitigate or manage potential impacts.

8.2 Methodology

Initial consultations with a range of stakeholders were used to develop a number of social impact evaluation factors and indicators that were used to determine social impacts.

The significance of impacts was assessed on the basis of the following:

- potential to mitigate or manage predicted impacts;
- substitutability (the potential to substitute a loss with another resource);
- duration of impact;
- magnitude of effect;
- cumulative effects; and
- community acceptance of predicted impacts and proposed management strategies.

The impact analysis used information from a number of sources including:

- a scoping process involving interviews with a range of stakeholder representatives;
- face-to-face interviews with landowners potentially affected by inundation and associated infrastructure of a new Harvey Dam;
- review of planning, heritage and soil capability documents;
- interviews with key local and State Government agencies and community groups;

- site visits; and
- visitors to the study team display booth at the Harvey Show.

Impact management measures considered in the evaluation of allocation options include:

- mitigation measures to minimise potential impacts;
- compensation measures to lessen residual impacts and hardships;
- contingency measures to help identify potential problems and to make provision for a rapid response to a problem that may arise; and
- control measures to facilitate public confidence and trust.

In some cases impact management measures can significantly reduce or even eliminate predicted negative impacts or enhance potential benefits.

8.3 Analysis of Harvey River Hills Resource Options

Social impacts arising from development of the Harvey River Hills resource can be considered in four parts:

- upstream impacts arising from inundation and the presence of a water storage.
- infrastructure impacts arising from construction and use of pipelines and new or upgraded roads;
- downstream impacts resulting from changes to streamflow; and
- construction impacts arising from the construction of new or enlarged reservoirs.

8.3.1 Construction Impacts

All options require the construction of an extension of the main trunkline of the PMWSS to the Harvey Weir or a new Harvey Dam. This route would most likely be located along the South Western Highway and within existing road reserves. Some impacts arising from noise, dust and traffic during construction may be anticipated.

All options have the potential to generate construction-related impacts but insufficient information is available to enable evaluation of the impact of options on local accommodation and community facilities and services. Such information would be available during the detailed design phase of any development option.

Referral to EPA is required of any proposal to construct or enlarge reservoirs or build pipelines that may have a significant effect on the environment. Construction impacts should be addressed in detail through this process and will not be considered extensively in this plan.

8.3.2 General Issues

Community Acceptance

The Harvey community outside the Harvey Hills appears to be generally accepting of the possible development of a new Harvey Dam. But the acceptance of some of these people is dependent on:

- irrigators being guaranteed an adequate water allocation;
- some level of aesthetic flow being maintained below the Harvey reservoir; and
- development of the recreation potential of the Harvey Reservoir.

Lack of Certainty

Most landowners and residents potentially affected by a new Harvey Dam stated that uncertainty surrounding the development of this new dam was stressful and did not enable them to plan their futures. The consensus view was that the sooner a decision was made the better it would be for them, even if the decision was not a favourable one.

The allocation planning process was seen as a mechanism to provide such certainty.

The Commission believes that a definite commitment by a water developer to an acceptable development of the Harvey River Hills resource would be required to reduce uncertainty at the end of the allocation planning process.

Whitewater Canoeing

The Harvey River immediately below the Stirling Dam has been used as a slalom or whitewater canoeing course since the early 1980s. Water is released from the Stirling Dam during the irrigation season to ensure demand can be met from the Harvey Weir. Some of these releases are conducted in such a manner as to create whitewater conditions in the downstream man-modified course. Whitewater canoeing may therefore be considered an opportunistic use of irrigation releases.

The value of this course was raised by many stakeholders, and concern was expressed about any development options that would jeopardise it.

The whitewater course is internationally recognised, and is described by the Australian Canoe Federation as the best in Australia. The course has the potential to be a venue for national championships and a pre-Sydney 2000 Olympic training course for international teams. The whitewater course is used by up to 100 paddlers each weekend during the irrigation season.

Whitewater canoeing is believed to bring significant economic benefits to the Town of Harvey.

Transfer of Water to Perth and Guaranteed Allocations

Most stakeholders and landowners accepted the concept of transfer of water out of the region provided local needs, in particular irrigation needs, were met. However, concern was expressed about priority among water users and the need to guarantee allocations to specific uses. Some felt that a specific allocation should be made for recreational use of the Harvey Reservoir to guarantee that recreation activities would remain viable, particularly during the summer months.

8.3.3 Inundation and Infrastructure Impacts

The social impacts vary according to the allocation option and variations to these options being considered. Clearly those options that result in greater inundation of land than the present Harvey Weir would have greater social impact than those that involve only pumpback to the PMWSS.

The social impacts arising from each of the options described in Section 6 are discussed below and summarised in Table 15.

8.3.4 Impact of Option A

Under this option, water would be pumped back from the existing Harvey Weir either directly to the PMWSS all year round or to the South Dandalup Dam in winter.

This option avoids the inundation and infrastructure impacts from additional pipelines and relocation of the Harvey–Quindanning Road associated with the construction of a new Harvey Dam under Options B and C.

Land Use and Recreation

The impacts of principal interest result from potential restrictions on land use and activities in the Harvey Weir and Stirling Dam catchments and reservoirs. These restrictions arise from the use of water from the Harvey River Hills resource for public water supply and the need to protect water quality for this purpose.

The application of the Priority 2 land use policy to private land is consistent with the Harvey Shire's intention to keep the Harvey Hills area predominantly agricultural. However, the form and type of agricultural activities would be determined by the Priority 2 policy.

The present Class II classification of the Harvey Weir, which prohibits contact recreation, would remain and, as a consequence, severely limit recreation development on this storage.

8.3.5 Impact of Options B and C

These two options are similar in that they involve the construction of a new Harvey Dam with a full supply level between 70 and 90 m and the relocation of the Harvey–Quindanning Road. Potential variations to these options include a pumpback facility on the Wellesley Creek.

8.3.6 Impacts Common to Both Options B and C

Private Properties

The most significant impacts associated with these options are those that result from inundation of private properties and residences. The significance of any residential displacement would be dependent on whether the resident is full- or part-time and the person's ability to cope with relocation. Generally, social impacts from displacement are more significant for full-time and long-term residents, and those who are elderly may find relocation particularly stressful. Those who have strong emotional attachment and kinship ties to an area are more adversely impacted by involuntary relocation.

The relocation of the Harvey–Quindanning Road may exacerbate impacts from inundation, even for those residents not displaced, by affecting access to properties.

Table 15 summarises the social impacts on those properties potentially affected by inundation and the relocation of the Harvey–Quindanning Road. As may be expected, social impacts are greatest for a new

Harvey Dam with a 90-m full supply level and least for a 70-m full supply level.

With a 90-m full supply level, 20 private properties are affected (18 landowners and 7 residences) to some extent by inundation. For 3 of these properties the impact would be relatively minor. For an 80-m full supply level, 18 properties (5 residences) would be affected to some extent whereas a 70-m dam would affect 13 properties (3 residences), 3 of these to a minor extent.

The number of properties with full-time residents affected (other than in a minor way) by inundation varies from one for 70-m to three for the 90-m full supply level.

The social impact of the relocation process would depend on individual characteristics of the landowner, the acceptability of purchase arrangements and the ability to find a suitable replacement property.

The process of relocation would be more easily managed if a land acquisition policy were developed which:

- promotes an open and transparent process; and
- ensures that landowners are compensated, as far as is possible, so that they are not "worse off".

Relocation of Harvey–Quindanning Road

The proposed route for the relocation of the Harvey–Quindanning Road would affect 11 properties, and 5 properties would not have access to this new route. The proposed route raised considerable comment from Harvey Hills landowners. The most severe social impacts that might result from the new route is the fragmentation of land and disruption to farming operations.

Many of these impacts might be avoided or reduced by modifying the tentative route in consultation with landowners and by examining alternative options, such as the upgrading of Logue Road, in consultation with the Shire of Harvey.

Heritage Values

There are no buildings or places in the Harvey Hills that have been placed on the Register of the National Estate, but heritage assessments have identified buildings and features with heritage value. Those that could be affected by inundation are listed in Table 13.

A study (Hocking 1997) found the Harvey Hills to be a landscape of cultural significance at the State and local levels. A new Harvey Dam would make a significant modification to the landscape of the area.

Agriculture and Other Land Uses

Agricultural activities might be affected by the loss of agriculturally productive land and by any land use restrictions resulting from water quality protection measures applied to the Harvey Weir catchment. All inundation scenarios would result in a loss of some agricultural land. The low-lying areas would be the first affected and these tend to contain the more highly valued agricultural soils.

The impact of water quality measures is described below.

Table 13. Potential inundation of buildings of heritage value.

Building	70 m dam	80 m dam	90 m dam
Jardup	Possible*	Yes	Yes
Nicklup	Yes	Yes	Yes
Dr Ferguson's	Yes	Yes	Yes
Glentana	No	Yes	Yes
Sunnyvale	Possible*	Possible*	Possible*

*Insufficient contour information available.

Harvey Agricultural Senior High School

This teaching farm is running at full capacity, with a shortage of land restricting the expansion of the school's farming enterprises. The school wants to move to a larger property at Wokalup Research Station, but has yet to obtain the necessary funds for the transfer. The construction of a new Harvey Dam would adversely affect the school by significantly reducing the land available for practical agricultural education and displacing some orchards and dairy pasture.

This impact would be overcome if funds became available for relocation. Some funds might be available from sale of subdivided school land (assuming that water quality can be protected) in the vicinity of a new Harvey Dam.

Landscape Values

The landscape values of the Harvey Hills are recognised by the Harvey Hills community, the Shire of Harvey Town Planning Scheme and the Bunbury–Wellington Region Planning Study (DPUD 1992).

8.3.7 Differences Between Options B and C

The major socially significant differences between these options are:

Pipeline Construction

Option C involves the construction of a pipeline between Stirling Dam and a new Harvey Dam.

This difference would result in only minor additional social impacts related to the construction of the pipeline.

Water Quality Protection Measures – Potential Impact on Recreation and Land-Use Activities

Option B involves taking treated water for public water supply from a new Harvey Dam, whereas Option C involves taking water only from the Stirling Dam for public water supply.

Option B would require more stringent restrictions on future land uses and activities in the Harvey catchment than would be the case for Option C. Similarly, potential for future development of recreational activities on the reservoirs would be less than for Option C.

However, allowable land-use activities would be similar to those obtained at present, since the existing Harvey Weir is currently used for drinking water and Option B water would be fully treated. The treatment facility and the large reservoirs would allow some scope for passive recreation.

The imposition of a Priority 2 land-use classification on the Harvey Dam catchment would impose restrictions on private land uses and commercial operations. Silviculture management practices might also need to be adjusted to be compatible with the requirements of public water supply catchment.

Option C would provide the opportunity to develop the reservoir's recreation potential if the sole purpose of water supply from a new Harvey Dam was for irrigation. However, increased recreation has the potential to generate adverse impacts on the local environment and the use and enjoyment of nearby properties.

A reservoir management plan would be prepared by the Commission in consultation with the community to prescribe in detail the activities that would be permitted on the reservoirs, to ensure that an appropriate balance would be achieved between recreational, environmental and water quality objectives.

Reduction of Streamflow Between the Reservoirs – Potential Impact on Whitewater Canoeing

Under Option C, there is a dramatic reduction of streamflow between Harvey Reservoir and Stirling Dam, which could reduce the potential for whitewater canoeing. If the Wellesley pumpback is developed, there would be little need under Option C to release water from Stirling Dam to meet irrigation demand. Under these circumstances whitewater canoeing would no longer be an opportunistic use of irrigation water releases, but would require specific releases for the purpose.

Given the relatively high social value of whitewater canoeing, provision might have to be made for whitewater releases, thereby reducing the viability of the Wellesley pumpback. Notwithstanding its high social value, the release of whitewater is causing erosion in reaches of the Harvey River.

8.3.8 Impact of Option D

The social implications of this option are similar to those for Option A, with additional impacts arising from inundation of State Forest areas around the existing Stirling Dam and the installation of pipelines between the reservoirs.

In summary, additional social impacts arising from this option in comparison to Option A are:

- loss of an area of pine plantation and native forest in State Forest;
- loss of the Harvey Falls recreation area; and
- pipeline construction impacts.

8.3.9 Downstream Impacts

With the construction of a new Harvey Dam and pumpback facility on Wellesley Creek, the mean annual streamflow immediately below the Harvey Dam and in the Harvey Diversion Drain would be reduced by up to 75% and 55% respectively (Table 14 below). The incidence of summer streamflow from the dam would occur only to satisfy aesthetic flow considerations (refer Section 11. Proposed Water Resource Allocations) and possibly during unusually high summer rainfall events. At present, outflows from the Harvey Weir occur only during such events.

According to flow records over the last four years, outflow from the Harvey Weir is predominantly discharged down the Harvey Diversion Drain. Small flows, in the order of 5 GL, have been directed down

Water Users

Some people draw water from the Harvey Diversion Drain for domestic and agricultural (mainly horticultural) purposes. Many of these users do not have approval from the drain owner and, of those that do, their usage is not well known.

Table 14. Impact on streamflow from new Harvey Dam.

Scenario	Myalup		Harvey Diversion Weir	
	MAF[a]	Jan ave[b]	MAF[a]	Jan ave[b]
Existing situation	78	0.75	41	0.017
New Harvey Dam	44	NA	7	NA
New Harvey Dam and pumpback	35	NA	7	NA

[a]Mean annual streamflow (GL) modelled for 1962–96
[b]Ave of gauging station data (GL) for January for 1983–96.

The demand for water is predominantly in the summer months, when streamflow in the Diversion Drain is believed to be maintained by irrigation return water and groundwater discharge. Significant streamflow in summer has been gauged at Myalup with no outflow from the Harvey Weir.

Even with a large reduction of streamflow (predominantly in winter), no significant impact from a new Harvey Dam and a Wellesley pumpback is anticipated on existing users downstream from the town of Harvey.

Recreation and Aesthetics

Most stakeholders generally supported the provision of aesthetic flows in the Harvey River, particularly in the part that passes by the Stirling Cottage and tourist precinct. In addition, the Harvey Shire Council has indicated that it is concerned with the present unattractive state of the diversion drain within the townsite.

With the construction of a new Harvey Dam and without an environmental allocation, winter outflows from the dam would be insignificant except during higher rainfall years. The purpose of the diversion drain within the townsite might require review.

Aesthetic flows to ensure that some water remains all year round in the tourist precinct could be managed through controlled releases from the new dam.

Dam Safety

A new Harvey Dam would be built to the latest Australian National Committee On Large Dams (ANCOLD) standards, providing a higher level of safety to residents downstream. The formulation of an emergency response plan is considered to be a normal component of "best practice".

Table 15. Summary of social impacts of Harvey River Hills development options (excluding construction).

Social Factor	Option A	Option B and C			Option D
		70 m	80 m	90 m	
Residential displacement	No impact	3 dwellings, 1 with full-time residents	5 dwellings 2 with full-time residents	7 dwellings, 3 with full-time residents	No impact
Disruption to use and enjoyment of property	No impact	13 properties affected	16 properties affected	20 properties affected	No impact
Aboriginal heritage	No impact	2 sites might be affected	2 sites might be affected	2 sites might be affected	No impact
European heritage	No impact	2 buildings and 1 possible	4 buildings and 1 possible	4 buildings and 1 possible	No impact
Community lifestyle/character and stability	No impact	Least impact	Greater impact	Same as for 80 m	No impact
		B		C	
Road relocation	No impact	Significant disruption		Same as B	No impact
Recreation/tourism	Recreation on Harvey Weir highly restricted. Whitewater canoeing may continue.	Recreation development on Harvey and Stirling Dams highly restricted. Whitewater canoeing may continue.		Recreation development possible on new Harvey Dam but highly restricted on Stirling Dam. Whitewater canoeing may be restricted or eliminated.	Recreation development on Harvey and Stirling Dams highly restricted. Whitewater canoeing may continue. Harvey Falls would be lost.
Aesthetic flows in Harvey tourist precinct	Potential for no summer flow through tourist precinct	Potential for no summer flow through tourist precinct.		Potential for no summer flow through tourist precinct.	Potential for no summer flow below Harvey Dam.
Downstream users	Minimal	Minimal		Minimal	Minimal
Land use compatibility	P2* land use restrictions likely to apply.	Loss of agriculture land and some pine plantation. P2 land use restrictions likely to apply.		Loss of agriculture land and some area of pine plantation.	P2 land use restrictions likely to apply. Loss of some area of pine plantation and native forest.

*Priority 2 source protection area (WRC 1997d)

9. Overall Assessment of Options

9.1 Introduction

The acceptability of allocations to public water supply can only be determined after considering all the water supply issues (including cost) and social and environmental impacts that arise from water resource developments designed to achieve these allocations.

In addition, such an examination is required to determine the environmental, social and water resource conditions that should apply in order that acceptable allocations can be established.

Four basic options (Figures 11a–d) have been reviewed in previous sections to determine the water supply, environmental and social impacts. This section integrates the findings of these previous assessments to obtain a holistic view of the impacts of the options.

This holistic assessment assists the Commission in establishing the acceptability and conditions that might apply to the allocations from the Harvey River Hills resource. A water resource developer might propose other options, in which case a review of this plan would be necessary.

In summary the basic options are:

- ***Option A*** – Direct injection from the existing Harvey Weir to the Perth Metropolitan Water Supply Scheme (PMWSS), with or without storage in the South Dandalup Dam, resulting in a potential allocation of 13.5–29 GL/yr of the Harvey Hills resource for public water supply.
- ***Option B*** – New Harvey Dam (70, 80 or 90 m full supply level) for irrigation and public water supplies, resulting in a potential allocation of about 34 GL/yr of the Harvey Hills resource for public water supply.
- ***Option C*** – New Harvey Dam (70, 80 or 90 m full supply level) with public water supply from Stirling Dam, resulting in a potential allocation of about 34 GL/yr of the Harvey Hills resource to public water supply.
- ***Option D*** – A raised Stirling Dam resulting in a potential allocation of about 29 GL/yr of the Harvey Hills resource to public water supply.

The installation of a pumpback facility on Wellesley Creek might, to varying degrees, increase the yields of Options A, B and C.

The additional yields or allocations are calculated on the basis of streamflow records for the period from 1948–95.

9.2 Assessment Criteria for Options

The Commission has considered the following criteria when determining acceptable additional allocations to public water supply of the Harvey Rivers Hills resource:

- environmental impacts are acceptable and adequate provisions are available for the environment;
- social impacts are manageable and adequate provisions are available for significant social uses such as aesthetic flows and whitewater canoeing;
- source yield is maximised having regard to costs and potential future enhancements of this yield from pumpback and possible water trading;
- existing licensed or approved users or service providers are not adversely affected; and
- can be developed at a reasonable cost.

9.3 Downstream Impacts

All options involve harvesting more water from the Harvey River Hills resource upstream from the Harvey Weir. Overflows from the present Harvey Weir are principally directed down the Harvey Diversion Drain and to the Indian Ocean at Myalup. Investigations (Streamtec 1998) conducted during the preparation of this plan have shown that this drain does not support any significant ecological values. In addition the existing ecologically significant areas on the Harvey River downstream from the Harvey Weir are not supported by overflow from the weir.

Consequently, none of the options would have a significant impact on downstream ecosystems.

9.4 Overall Assessment

A summary of the overall assessment of Options A to D is presented in Table 16, together with a relative ranking

for each factor. The rankings are presented to provide a means to compare options. The weightings of factors are not equivalent, and ranking should not be summed to provide an "overall ranking".

The environmental, social and water resource implications of options and associated resource development configurations are discussed below.

Option A

Option A has the lowest social and environmental impacts. It would be unlikely to adversely affect other users downstream from the Harvey townsite or the potential for whitewater canoeing below Stirling Dam. The unit cost of water for Option A (without storage at South Dandalup Dam) is estimated to be 59c/kL.

However, this option has the lowest additional source yield (18.5 GL/yr), with little opportunity for enhancement through a pumpback on Wellesley Creek or the trading of surplus irrigation water unless water is stored in the South Dandalup Dam.

Storage at South Dandalup Dam increases source yield (and consequently the potential allocation) to 27 GL/yr but at a much higher unit cost (80 c/kL). This option would have the highest greenhouse gas emissions (41,585 t/yr or 1.57 kg/kL) because of the additional pumping required. The annual emission rate is about 3 times that of Options B and C

A pumpback to South Dandalup Dam via a facility at Wellesley Creek has the potential for enhancement of source yield. This enhancement would bring the combined yield to 31 GL/yr at a cost of 73 c/kL.

Option D

Option D has a low social impact, but would lead to the inundation of State Forest and the Harvey Falls recreation area and consequently has a significant environmental impact. The construction of pipelines in riverine areas downstream from the Stirling Dam is considered an unacceptable impact on the Harvey River Hills resource, which could be avoided by locating the pipeline outside riverine areas.

As with Option A, the implementation of this proposal would be unlikely to affect users downstream from the Harvey townsite or the potential for whitewater canoeing.

The high pumping capacity would lead to a higher greenhouse gas emission rate (24,156 t/yr or nearly twice that of Options B and C).

The potential additional yield from the source is 29 GL/yr (lower than Options B and C) and has limited potential to be enhanced by a pumpback facility on Wellesley Creek.

The cost of this option is relatively high (68 c/kL).

Options B and C

These options are based on the development of a new Harvey Dam with a full supply level (FSL) between 70 and 90 m. They have substantial social impacts on residents and landowners in the Harvey Hills.

The larger the dam the larger the social and environmental impact. A FSL above 78 m is considered to lead to unacceptable impacts on environmentally significant areas in the Falls Brook Nature Reserve. Option C requires a pipeline downstream from the Stirling Dam. The construction of the pipeline along the riverine area downstream of Stirling Dam is considered to be an unacceptable impact; it could be avoided by locating the pipeline outside riverine areas.

Areas of remnant vegetation and some habitat of the western ringtail possum would be inundated. The environmental acceptability of flooding these areas would depend on CALM requirements and EPA assessment. These requirements would be likely to include restoration or protection of remnant vegetation elsewhere and a management plan for the protection of the western ringtail possum.

Option B might to lead to greater restrictions on recreation on a new Harvey Dam and on land-use activities in the catchment of the dam. On the other hand, Option C might substantially reduce the potential for whitewater canoeing without an agreement to maintain sufficient water releases.

As with Option A, the implementation of either of these options would be unlikely to affect users downstream from the Harvey townsite.

The potential additional source yield for both options is equivalent (34 GL/yr) at a FSL of 80 m, but the yield of Option C is likely to be significantly reduced if whitewater canoeing releases were maintained at previous levels.

Both options have the potential for enhancement of source yield by a pumpback facility on Wellesley Creek. However, enhancement for Option C would be 5 GL/yr – less than for Option B, which allows a combined yield of 43 GL/yr with no impact on whitewater canoeing. Similarly, enhancement of source yield through trading of surplus irrigation water is

possible for both options, but more limited for Option C because public water supply would not be taken from a new Harvey Dam without the provision for a treatment plant.

Option C has a lower unit cost (52 c/kL) than Option B (59 c/kL) because the latter includes the cost of additional water treatment for public water supply from a new Harvey Dam. However, inclusion of a Wellesley Creek pumpback decreases the unit cost of Options B and C to 52 c/kL and 48 c/kL respectively.

Options B and C would have the lowest greenhouse emission rates – 14,716 t/yr and 13,123 t/yr respectively

Table 16. Overall impact of options.*

Factor	Option A	Option B	Option C	Option D
Environmental impact (inundation)	Minimal, but increased greenhouse gas emissions. Ranking: 1	Areas of remnant and riverine vegetation and rare fauna habitat destroyed. Potential inundation of falls on Falls Brook. Ranking: 3.	Areas of remnant and riverine vegetation and rare fauna habitat destroyed. Potential inundation of falls on Falls Brook. Destruction of riverine area from construction of pipeline. Ranking: 4	Inundation of State Forest. Substantial greenhouse gas emissions. Ranking: 2
Environmental impacts (downstream)	No impact, as the Upper Harvey River and Wellesley Creek are presently diverted to the ocean.	No impact, as the Upper Harvey River and Wellesley Creek are presently diverted to the ocean.	No impact, as the Upper Harvey River and Wellesley Creek are presently diverted to the ocean.	No impact, as Upper Harvey River and Wellesley Creek are presently diverted to the ocean.
Environmental impacts (greenhouse gases)	11,575 t/yr and 0.63 kg/kL, and 41,585 t/yr and 1.57 kg/kL (with pumpback) Ranking: 1 or 4	14,715 t/yr and 0.43 kg/kL Ranking: 1	13,123 t/yr and 0.38 kg/kL Ranking: 1	24,156 t/yr and 0.86 kg/kL Ranking: 3
Social impact	Minimal, but would restrict recreation development on the Harvey Weir and land uses in the catchment. Potential to restrict aesthetic flows in tourist precinct. Ranking: 1	Potential inundation of up to 7 dwellings and 4 (plus 1 possible) homesteads of heritage significance. Potential to restrict recreation development on the Harvey Reservoir and land uses in the catchment. Allows for whitewater canoeing to continue. Potential to restrict aesthetic flows in tourist precinct. Ranking: 3	Potential inundation of up to 7 dwellings and 4 (plus 1 possible) homesteads of heritage significance. Opportunities for recreation development on the new reservoir. Limited restriction on land-use activities. Potential to severely restrict whitewater canoeing. Potential to restrict aesthetic flows in tourist precinct. Ranking: 3	Potential to restrict recreation development on the Harvey Reservoir and land uses in the catchment. Potential to restrict aesthetic flows in tourist precinct. Inundation of pine plantations and Harvey Falls recreation area. Ranking: 2
Impact on downstream users	Minimal	Minimal	Minimal	Minimal
Resource yield	Lowest yield (18.5 GL/yr for direct injection and 27 GL/yr for pumpback) with limited ability to enhance yield from pumpback facilities or trading surplus irrigation water. Ranking: 4	High yield for all full supply levels (34 GL/yr at 80 m height) and can readily be enhanced by Wellesley pumpback (up to 43 GL/yr) and trading surplus irrigation water. Ranking: 1	High yield for larger full supply levels (34 GL/yr at 80 m), but yield may be affected by releases for whitewater canoeing. With whitewater canoeing yield cannot readily be enhanced by pumpback facilities and trading surplus irrigation water. Ranking: 2	Yield (28.5 GL/yr) is lower than B and C but higher than A. Yield enhancement is unlikely Ranking: 3.
Unit cost	59 c/kL for direct injection and 80 c/kL for pumpback. Ranking: 2–4.	59 c/kL and 52 c/kL with 9 GL/yr of Wellesley pumpback. Ranking: 2	52 c/kL and 48 c/kL with 5 GL/yr of Wellesley pumpback. Ranking: 1	68 c/kL Ranking: 3
Water quality	Protected or enhanced. Ranking: 1	Protected or enhanced. Ranking: 1	May deteriorate in Harvey Reservoir catchment. Ranking: 3	Protected or enhanced. Ranking: 1

*Ranking of options is on the basis of 1–4 (from most desirable to least desirable).

10. General Allocation Planning Principles and Policies for the Harvey Basin

Allocations and entitlements to water would be in accordance with the following general principles and policies. Many of these principles and policies are also described in the Commission's Water Reform Series Reports Nos 1, 3 and 4 (WRC 1997b, 1997e, 1997f).

1. Entitlement to Take and Use Water

Water entitlements (the right to take and use water from a watercourse or lake, lagoon, swamp or marsh) would be provided in accordance with the following structure. Trading of entitlements might occur only where environmental water provisions are being met.

Riparian Rights

The Rights in Water and Irrigation Act provides a right to members of the public and an owner or occupier with property which is contiguous with a watercourse or other water body to use water for stock watering and domestic purposes only. The Commission has little administrative control over this entitlement except to ensure that the entitlement and use are consistent with the Act. Riparian rights are not available to owners and occupiers where there is a reserve separating the watercourse from the property.

Special Parliamentary Acts

Agreement Acts between the State and large resource development companies usually include clauses that commit the State to provide water allocations. These entitlements are usually subject to Commission management through licensing under the Act.

Licensed Allocations (Take and Use)

This entitlement would generally be described in terms of a maximum annual quantity to be taken, subject to conditions relating to resource management and monitoring. Allocations are made for specific purposes such as public water supply, irrigated pasture, irrigated horticulture and industrial use.

As a change in purpose may have an impact on the water resource (by changing the pattern of abstraction), any modification to use would require the approval of the Commission.

Licence terms vary with the majority provided for up to ten years. Long-term licences may be obtained where management policies and rules are well established.

Customer Contract or Cooperative Shares

A customer may obtain access to scheme water by Statute, by contract, through shares (e.g. an irrigation cooperative) or through consents issued under By-law 11 or 11A pursuant to the Act. Consents may also be issued under this by-law for taking water from drains.

The Commission would support the use of such consents even for the taking of small amounts of water from watercourses or other water bodies in irrigation districts provided:

- environmental values are protected;
- such entitlements are issued within the framework of an allocation licence for the service provider; and
- regional and sub-regional allocation plans are in place.

2. Ecologically Sustainable

Development and storage of water must be within ecologically sustainable water resource development limits. Water resource developments are sustainable if:

- their potential to meet reasonably foreseeable needs of future generations is not diminished;
- important ecosystems and their biological diversity, are protected; and
- detrimental effects of their use and development are reduced to a reasonable minimum.

3. Environmental Water Provisions

Environmental water provisions are to be established in accordance with ecologically sustainable development principles. These provisions are not tradeable and may require refinement (e.g. adaptive management) as more scientific data on water-dependent ecosystems become available.

4. Appropriate Water Resource Allocation

Future consumptive use proposals should be in accordance with ecologically sustainable development principles and in particular should:

- be the most appropriate for intended uses;

- be efficient in water resource utilisation terms;
- be cost-effective;
- be acceptable to the Environmental Protection Authority;
- have manageable social impacts; and
- be managed to reduce to a reasonable minimum any negative impact on water resource values.

Allocations may be reviewed with improved knowledge or where there are unanticipated changes in social circumstances or future trends.

5. Use of Drainage and Wastewaters

The Commission recognises that drainage water or wastewater is a water resource that may be used productively and therefore requires reasonable management to ensure its orderly development. The use of such resources may have water resource conservation and environmental benefits by postponing the development of new sources and reducing nutrient inputs to the Peel–Harvey Estuary.

However, such benefits may only be realised where any environmental values sustained by drainage water are not significantly degraded.

6. Community Benefit

Allocations must be for a worthwhile purpose and assessed on their contribution to the economic or social development and wellbeing of the community. If there are substantial changes to value or benefits of allocations in the future, the relevant allocation plan would be reviewed through a public and transparent process.

7. Water Use Efficiency

Service providers (such as the Water Corporation) are required to demonstrate the need for an allocation and make commitments to achieve water use efficiency targets. All providers must demonstrate efficient or best practice use of water within reasonable limits.

8. Hoarding of Water

An entitlement to take or use water (licensed allocation) is only issued if the applicant for the licence has demonstrated a need for the water.

The entitlement to take or use water may continue while the user can demonstrate a need for the entitlement. The intention of the Commission is to prevent the hoarding of water entitlements by monitoring the use of water by licence holders.

9. Access to a Resource

All users need to demonstrate a genuine need for water in order to be issued with and hold an allocation licence. Where lead times are longer than five years, a means of licensing the service provider to secure access to a resource for future use is required. To obtain an access licence to a water resource, service providers have to demonstrate that water will be required at a defined future time.

An access licence sets aside water for a defined future purpose. Access licences are also useful in encouraging investment in exploration and investigation activities required for assessing a new resource.

10. Protection of Existing Licensed Allocations

Existing licensed allocations are entitled to continue until the term of the licence expires. If at that time the need for the use continues, existing licence conditions have been met and any new conditions imposed can be fulfilled, the licence would normally be reissued upon application. The term of the licence reflects the acceptability of existing environmental water provisions or the sustainability of the existing use. The lower the confidence of the Commission in these matters the shorter the term of a licence.

Any new allocation or entitlement to take or use water must not unduly impact existing water entitlements that are being used in accordance with these principles.

11. Interregional Transfer of Water

The interregional transfer of water would not be permitted if such transfer would be to the detriment of existing or likely future use in the Basin or the environment. In the case of the Harvey Basin, out-of-region transfer means the transfer of resources out of the area defined by the South West and Peel Development Regions.

12. Multiple Uses of Water Resources

The use of water storages for existing non-consumptive purposes such as recreation may continue provided water quality objectives for the storage can be met. Where social (recreation, cultural) or economic values based on non-consumptive uses are well established, the consumptive use of the resource should not be changed to the detriment of these established values without the approval of the Commission.

13. Climate Variability

The Commission recognises that climate variability may reduce the originally estimated yield of some water resources.

The needs of the environment are of primary concern. Consequently, changes to water source yields resulting from climate change or variability would be subject to the need to maintain adequate provision of water for the environment. Recognition of changes to source yields would be reflected in modifications to licensed allocations.

14. Harmless Use of Water

The use of the water by licensed water users must not unduly damage the environment or third parties, with damage being avoided, mitigated or compensated.

15. Trading Water Entitlements

Riparian Rights

These rights cannot be traded but are transferred upon change of ownership of land abutting a river or watercourse as defined under the Rights in Water and Irrigation Act.

Trading within Service Provider Distribution Systems

Trading may take place between customers of a service provider such as an irrigation cooperative. These must be within the context of the take and use licence issued to the service provider, who may oversee and record such trades. A service provider may purchase entitlements from a customer who cannot find a willing buyer from other customers of the service provider.

The South West Irrigation Management Cooperative (SWI) was created in 1996 and issued a number of shares to its members based on their original annual water allocations. These shares are water entitlements that may be traded between members of the Cooperative who are in the same irrigation district. The Cooperative may purchase any excess water entitlements from members.

Trading in Take and Use Licences

The Commission is promoting changes to the allocation licensing system that would support trading of water entitlements under take and use licences provided:

- the entitlements of service provider customers are preserved;
- environmental water provisions are met and result in environmentally acceptable impacts;
- the trade is consistent with any allocation plan; and
- the trade is consistent with the appropriate use of the resource.

Under the proposed trading system a service provider or a self-supply user may lease or sell a portion of its take and use licence to other users, subject to the approval of the Commission. The Commission would consider a wide range of issues, including geographical limits and environmental impacts, in making the assessment of acceptability.

A permanent trade of a water entitlement would result in a corresponding reduction of the licensed allocation whereas a temporary trade (lease) would not. A temporary trade may only take place on an occasional basis.

SWI, being a service provider, may engage in such trading of excess water entitlements on a permanent or temporary basis.

Self-supply users who own surface storages may trade water entitlements in accordance with a headworks operating licence and the above criteria.

16. Capacity Sharing

Rather than defining an entitlement in terms of water volumes, a share of the capacity (not contents) of surface water storages and water resources may be defined. Under this approach each bulk user of a reservoir (say SWI or the Water Corporation) is allocated by the Commission a percentage share of the reservoir capacity and net inflows. Net inflows are total inflows less evaporation and seepage for a nominated period.

An independent reservoir authority may be necessary to implement capacity sharing. The authority would keep detailed records of withdrawals and net inflows to monitor the quantity of water in each user's capacity share. All records would be made available to users and audited by the Office of Water Regulation.

A bulk user or service provider may choose to occasionally trade some of its capacity share contents with other users that share the reservoir. A bulk user could also chose to permanently trade a portion of its unutilised capacity share entitlement. Such trades would not be permitted to the detriment of the customers of any service provider.

The Commission would hold and manage an "unallocated water" capacity share account. If a user consistently used less than its allocation entitlement, its capacity share contents could increase to the point where it exceeded its full capacity share volume. Under these circumstances, unless the surplus water was traded with another bulk user (with spare capacity), it would spill to the Commission's "unallocated water" account.

17. Community Participation

The processes for determining water allocations would be open and transparent, with the opportunity for public input and involvement before final decisions are made.

11. Proposed Water Resource Allocations

11.1 Introduction

This section establishes surface water allocations that balance environmental and social impacts and water resource development. In particular, this section outlines the following:

- environmental water provisions in terms of flow;
- allocations of surface water for self-supply and potential allocations for public water supply from the Harvey River Hills and Wellesley Creek resources, based on allocation planning principles, satisfying environmental water provisions and considering social and environmental impacts;
- recreational uses of water resources;
- restoration of environmental values in the Harvey River and its tributaries; and
- implementation program.

This plan allocates water to broad beneficial uses or environmental values. The Commission has identified the following broad beneficial uses of the Basin's water resources through the process of public consultation and from environmental studies and water resource investigations:

- ecological;
- recreation and tourism;
- aesthetics;
- irrigation;
- public water supply;
- self-supply; and
- industrial.

The proposed allocations described in this section are based on existing knowledge and present understanding of future circumstances. A review of these allocations through an open and public process would be required with substantially improved knowledge or where there are major unanticipated changes in circumstances or future trends.

Climate change or changes in community values or the need to prescribe more detailed environmental water provisions may trigger such a review.

11.2 Environmental Water Provisions

The prerequisites for determining an acceptable level of development of the Basin are a review of the current level of overall water resource development and a determination of environmental water provisions for the Basin as a whole. A detailed review of the environmental water requirements is presented in Section 7 and Streamtec (1998).

Flows in the most downstream section of the Harvey River are presently at least 25% greater than the modelled pre-European conditions (Figures 5 and 6). The hydrology and the ecological water requirements of the Harvey catchment are in contrast to most other cases (e.g. Murray–Darling system), where impoundment and subsequent abstraction have substantially reduced downstream flows.

Existing levels of development and diversion in the Basin are reasonably high (about 50% of hills streamflow is abstracted), and a substantial level of development of the Harvey River would increase this further. However, the overflows from the present Harvey River Hills resource are directed down the Harvey Diversion Drain and are therefore not providing support to any significant ecological values in the Swan Coastal Plain section of the Harvey River.

The most significant environmental values downstream from the Harvey Weir are in the lower Harvey River. This section of the river, although highly modified by human activities, is sustained by tributaries in the northern parts of the Basin and runoff from the coastal plain. The lower Harvey River is dependent for its health on the remaining streamflow from the hills segments of these tributaries (but not the Harvey River and its tributaries above the Harvey Weir or Wellesley Creek).

The Commission believes that substantial development of the Harvey River Hills resource is acceptable provided that specific conditions relating to the scale of development are met. Further development of other Darling Range resources in the Basin would be subject to the environmental water provisions for these resources (refer Sections 11.2.1 to 11.2.7).

11.2.1 Tributaries of the Harvey River

Unregulated and semi-regulated tributaries are streams that are not substantially impacted by dams or barriers (Table 17). Those unregulated and semi-regulated streams located in the northern portion of the Basin, in the absence of upper Harvey River flows, provide sufficient water in the typical seasonal patterns to ensure the adequate functioning of the downstream riverine and estuarine related ecosystems.

These streams provide an opportunity to obtain unbroken linkages from the Harvey Estuary to the foreste, upland streams.

Many of the unregulated and semi-regulated streams join the irrigation water supply system in irrigation areas which eventually discharge into the drainage system on the coastal plain. In summer, these streams may carry irrigation water, and barriers (stop boards) are inserted to divert flow for on-farm use generally shortly before and/or during the irrigation season.

Table 17. Unregulated, semi-regulated and regulated tributaries.

Unregulated and Semi-regulated	Regulated
Clarke	Logue
Black Tom	Samson Brook
Bancell Brook (semi-regulated)	Drakes Brook
McKnoe	
Weekes	
Waterous Formation	
Yalup (semi-regulated)	
Wellesley/Wokalup	

While natural winter flow profiles would be maintained, irrigation water and abstraction of water for irrigation use would distort summer, early autumn and late spring flows when scheme irrigation water is not available.

The Commission proposes the following environmental provisions for unregulated, semi-regulated and regulated streams in the Basin:

- an interim provision should be made to the environment of 5.5 GL/yr or about 30% of annual streamflow of the Wellesley and Wokalup Creeks (this is approximately equal to the annual streamflow prior to European settlement);
- no less than 95% of the present mean annual flow in unregulated and semi-regulated streams (except Wellesley and Wokalup Creeks) from the Darling Scarp should be provided to the environment;
- no further significant development of regulated streams should occur until environmental water provisions are established for these streams; and
- release strategies from existing storages should be developed to maximise the benefits of future river restoration.

11.2.2 Harvey River Hills Catchment

Falls Brook

Falls Brook is a first- to second-order (headwater) tributary of the Harvey River forming a confluence before flowing into Harvey Reservoir. The Brook is an excellent example of a forested upland stream of the jarrah forest. It has intact native riverine vegetation, high biological water quality and unregulated flows. This results in a high biodiversity of aquatic fauna, with very few introduced species.

As the Brook is characterised by high water quality, its importance is also the dilution of water of lesser quality (e.g. from Big Brook) in the Harvey Reservoir. For example, the turbidity load from Big Brook into the Reservoir is 22 times that from Falls Brook.

The Commission allocates all the existing flow in Falls Brook to the environment within the Falls Brook Nature Reserve. The brook can be considered near-pristine and flows are important both for existing stream fauna and for dilution of Harvey Reservoir water.

Off-stream storage on private land below the Reserve may be acceptable provided that streamflow is not reduced below that of an equivalent uncleared catchment.

Big Brook

Big Brook is another first- to second-order (headwater) tributary of the Harvey River forming a confluence about 3 km upstream of the Harvey Reservoir. Big Brook has been extensively degraded by past catchment clearing and continued uncontrolled livestock access. Catchment clearing has resulted in greater stream flows than prevailed in historic conditions, leading to substantial channel and bank erosion. Livestock access is the cause of the high turbidity loads from the brook.

A lowering of flows from Big Brook would limit further erosion and reduce turbidity loads in Harvey Reservoir.

The Commission believes that current streamflow is in excess of environmental requirements. Abstraction of

water for self-supply may be acceptable provided that streamflow is not reduced below that of an equivalent uncleared catchment.

Harvey River from Stirling Reservoir to Harvey Weir

The Harvey River is regulated by the Stirling Dam to the Harvey Reservoir. However, flows are maintained by agricultural releases and some unregulated flows come via smaller tributaries. Whitewater releases from the Stirling Dam are believed to cause erosion in some downstream areas.

The tributaries and agricultural releases are considered sufficient for environmental water requirements of the Harvey River between the impoundments. The agricultural release maintains a base flow, which is augmented by unregulated flows from tributaries. The white-water releases introduce a flow regime outside the scope of the historic hydrograph, particularly causing bankfull flows when the water level in the channel was low.

11.2.3 Coastal Plain Catchment

Runoff from the Swan Coastal Plain to the Peel Harvey system is currently about three times the amount in pre-European times (Figure 6).

The flow regime to protect identified key features and values is described in Table 10, and in total volume terms is far less than the current flow in the lower parts of the river.

Provided flows are not altered from the pre-European flow regime, sufficient water would be available to meet ecological requirements.

11.2.4 Aesthetic Flow in the Harvey Tourist Precinct

The Shire of Harvey has expressed a desire for sufficient flow to be maintained in the tourist precinct to make the area more attractive. The Commission recognises the importance of this beneficial use and proposes the following provision in the Tourist precinct:

- streamflow to be maintained all year round;
- streamflow to be sufficient to maintain a healthy stream free of excessive algal growth; and
- streamflow to be sufficient to maintain an active stream width for visual amenity during the day.

This provision may be accomplished by:

- installing a small barrier to back water up past the Stirling Cottage tearooms, with a small flushing flow to overcome any potential water quality problems; or
- by allowing continuous flow through the precinct.

Flows observed in the precinct during December 1997 were considered more than sufficient for the aesthetics of the precinct. Based on water velocity and channel dimension measurements, the flow during this month was estimated to be about 280 L/s, or 9 GL/yr on an annual basis.

The Commission believes that such a large provision is not warranted.

This section of the Harvey River does not have any significant ecological values and is not important in maintaining ecological flows to the lower Harvey River and Estuary. The Commission considers that banking up flow behind a barrier would be an acceptable and more efficient use of water, provided water quality problems are avoided in the impoundment.

Preliminary design work suggests that water quality problems would be overcome by a minimum streamflow of 25 L/s over the summer period.

This flow rate equates to about 0.25 GL over the summer months.

Any aesthetic flow (or any other normal flow) that passes through the precinct should be directed down the Harvey Main Drain to help maintain the reaches of the Harvey between the tourist precinct and the next major unregulated tributary (Weekes and Clarke Brooks).

11.2.5 Provision for Whitewater Canoeing

Whitewater canoeing is a recreational activity highly valued by the local community. However, whitewater releases have caused significant erosion of sections of the Harvey River (between the Harvey Weir and Stirling Dam), which has been exacerbated by past farming practices.

The high turbidity loads caused by bank erosion are a water quality issue for the Harvey Reservoir. Similarly, these high erosion loads have resulted in the in-filling of river pools and a resultant loss of aquatic habitat. In spite of the whitewater releases, macroinvertebrate and fish biodiversity is high in this section of the Harvey River (Streamtec 1998).

The riverine environment more than 3–4 km downstream from the Stirling Reservoir is characterised by cleared understorey, uncontrolled livestock access

and the inherently vulnerable Helena type soils. These factors, when combined with the bankfull white water releases, lead to bank erosion.

In the forested regions (within 3–4 km of the Stirling Dam), the riverbanks are naturally more armoured with a rock substrate. These areas are characterised by intact riverine understorey, lack of livestock and a substrate more cobble-based than the sandy type Helena soils. Additionally, the riverbed in the forested area is, in many places bedrock, thereby limiting the extent of channel erosion.

Consequently, the forested regions have the ability to "absorb" whitewater releases to a far greater extent than the cleared, farming areas situated on Helena soils.

Whitewater Canoeing Provisions

Traditional use has involved approximately 40 releases from the Stirling Dam over the irrigation season. On average, a whitewater release event has involved the discharge of 0.4 to 0.5 GL of water over a period of 8–10 hrs. This corresponds to an annual water release of 16–20 GL.

The amount of erosion is considered to be more dependent on the number of releases than the duration of a release event. In addition, an excessive allocation to this activity has the potential to reduce additional yield for consumptive uses from the Harvey River Hills resource, depending on how the resource is developed (for instance if drinking water were taken directly from Stirling Reservoir).

Any new Harvey Dam may potentially inundate riverine areas that are vulnerable to erosion. These areas would be exposed when the water level in such a dam is below the full supply level. Under these circumstances traditional whitewater releases might still cause erosion and add to turbidity levels.

The Commission believes that the social value of this activity is very high and supports the continuance of this beneficial use provided best endeavours are made to reduce erosion.

The Commission believes a reasonable provision over the irrigation season for whitewater canoeing from the Harvey River Hills resource would be as follows:

- a flow rate of 14 kL/s to maintain whitewater conditions;
- an average of 7 hours for each whitewater canoeing day;
- a minimum of 40 whitewater canoeing days, with an additional 15 days available for training and the conduct of national or international slalom, provided sufficient notice is given to the service provider and the Commission; and
- the reliability of this provision would be determined by the Commission during the process of determining the conditions that would apply to a take and use licence for the Harvey River Hills resource.

This provision is conditional upon the WA Canoeing Association demonstrating to the Commission that a release strategy would be adopted to reduce release events from the Stirling Dam to a practical minimum. One release event may include more than one canoeing day. This allocation, as with all allocations, is subject to review through an open and public process if there is a substantial unanticipated change in future circumstances (refer Section 11.2).

This release strategy may be amended and the number of release events from the Stirling Dam increased by the Commission if appropriate erosion mitigation measures are implemented by a developer of a new Harvey Dam.

11.2.6 Recreation on Other Reservoirs

The recreation values of Drakes Brook and Waroona Dam, in addition to their importance as sources of irrigation water, are well established and have local and regional importance. There is a possibility of diverting water from these sources for public supply purposes at some point in the future should surplus water from the Waroona Irrigation District become available (WAWA 1995).

However, it is not clear when this opportunity might arise. The Commission recognises the importance to the community of the recreation and tourism values of the Waroona and Drakes Brook dams . As an allocation planning principle, the Commission is committed to minimising any significant negative impact on non-consumptive water values. Where the values of non-consumptive uses are well established, the existing consumptive use should not be changed to the detriment of these established values without the approval of the Commission.

These aspects will be addressed further when market rules for bulk water trading are developed.

11.2.7 Nutrient Management

Since European settlement, nutrient inputs to the Peel–Harvey system have greatly increased as a consequence

of agricultural practices. Current instability of the drain beds results in nutrient transport downstream rather than local depletion by increased primary production.

In the virtual absence of suitable in-stream habitat there is little capacity for elevated primary production and the local uptake of nutrients. Unprocessed nutrients are exported into the already enriched Peel–Harvey Estuary.

A Ministerial Condition previously imposed by the EPA on the North Dandalup Dam project required 13.5 GL/yr of flow from the Harvey River to be diverted down the Harvey Main Drain to the Harvey Estuary. This condition was imposed prior to the construction of the Dawesville Channel. The Channel was established essentially to flush the Peel–Harvey Estuary with marine water, in contrast with the above condition, which was to flush the estuary with higher quality river water.

The provision of in-stream flows to flush blue-green algae and areas of poor water quality is no longer considered appropriate given:

- the influence of the Dawesville Channel on nutrient flushing via tidal exchange;
- the environmental water provisions described above; and
- current flows (and flows following any additional allocation of 34 GL/yr from the Harvey River Hills resource to public water supply) into the Harvey Estuary are above those that existed in pre-European times.

The emphasis in the future would be to maintain existing streamflows from the Darling Range to the lower reaches Harvey River while reducing nutrient enriched runoff from coastal plain areas.

11.3 Allocation of the Harvey River Hills Resource to Consumptive Uses

The existing licensed allocations from this resource would stand, provided environmental water provisions are met and the user can demonstrate that the water is needed.

11.3.1 Irrigation

Presently about 55 GL/yr is allocated for irrigation use from the Harvey and Stirling Reservoirs. The Commission would support the trading of surplus irrigation water to a future PMWSS supplier. Where such trades take place, existing recreation or tourism values dependent on streamflow from reservoirs should not be unduly impacted.

11.3.2 Additional Allocation to Public Water Supply

The Commission has evaluated potential options through an allocation planning process that has included extensive public consultation and detailed analysis of the environmental, social and water resource implications of development options. This process has attempted to strike an appropriate balance between the environmental, social and water supply requirements of the community. In addition, any development of the Harvey River Hills resource is required to be consistent with the allocation planning principles and policies outlined previously (Section 10).

In considering the additional allocation of water for consumptive use (particularly public water supply) from the Harvey River Hills resource, the Commission was mindful of the following:

- Maximising resource yield at reasonable cost within acceptable environmental impacts and manageable social impacts. The high reliability of the Harvey River Hills resource makes it particularly valuable in a drier climate. A large storage also facilitates yield enhancements from pumpback facilities and potential trading of surplus irrigation water.
- The Commission's response to the Water Supply Strategy for Perth and Mandurah (WRC 1997a) and requirements for water use efficiency.
- Existing streamflow from Wellesley Creek and the upper Harvey River being directed down the Harvey Diversion Drain to the Indian Ocean. The Diversion Drain does not support any significant ecological values and overflow from the Harvey Weir is not a significant source of water for self-supply users.
- The highly modified state of the Harvey River and its tributaries on the Swan Coastal Plain.
- Streamflow into the Harvey Estuary from the Basin being about 50% greater than it was prior to European settlement, whereas flow from the Darling Range catchments to the Harvey Estuary has been substantially reduced (about 60%) since that time.
- The ecological benefits of maintaining unregulated flows to the Harvey Estuary and the benefits of restoring the health of the Harvey River.

- Riverine vegetation and in-stream habitats are valuable components of the riverine ecosystem.

Having taken the above factors and potential environmental and social impacts into account, the Commission believes that an additional allocation to public water of up to 34 GL/yr is acceptable provided that:

- The full supply level of a new Harvey Dam is no greater than 78 m (subject to detailed surveying) in order that it does not adversely impact the Falls Brook Nature Reserve.
- Any new pipelines are located outside riverine areas.
- There is capacity to take water from a new Harvey Dam for public water supply.
- The existing irrigation allocation from the Harvey and Logue Rivers to SWI is maintained. The Commission has proposed an allocation for irrigation use in the Harvey Irrigation District of 68 GL/yr (based on 80% reliability over the 1950–93 period) assuming 25% loss before the farm gate (WRC 1997c).
- Provision is made for whitewater canoeing releases below the Stirling Dam and aesthetic flow within the tourist precinct in the Harvey townsite (refer Sections 11.2.4 and 11.2.5).
- Environmental water provisions are met (refer Section 11.2).
- Social impacts are managed (refer Section 11.3.3).
- Self-supply demand studies are conducted in accordance with Commission requirements.
- Riverine areas of the Harvey River (including the section within the Harvey townsite) and its tributaries are restored as compensation for any riverine areas lost by the construction of a new dam, raising the height of a reservoir or construction of a pumpback facility (refer Section 11.6 below).
- The EPA's environmental objectives for relevant environmental factors (refer Section 13) are conformed with.
- CALM is compensated for any adverse impact on commercial tree plantations.
- Aboriginal heritage issues are resolved to the satisfaction of the Aboriginal Affairs Department.
- Water quality protection measures are implemented by the Commission to ensure that present water quality is either maintained or improved.

The 34 GL/yr allocation might be reasonably achieved by the development of a new Harvey Dam. Option B (with a full supply level of 78 m) might more readily meet all the above conditions. However, Option C might have to be modified to achieve the full yield benefit from a pumpback facility on Wellesley Creek and to achieve the proposed whitewater canoeing provision. This modification would involve taking some water from the new Harvey Dam and treating it. This would achieve an equivalent yield to Option B but might be slightly more expensive and less readily able to meet the whitewater canoeing provision.

The impacts of Options B and C are considered manageable in light of the proposed conditions and additional water yield benefits.

Direct injection from the Harvey Weir (Option A) or the raising of the Stirling Dam (Option D) would have substantially lower environmental and social impacts. However, these options might give rise to substantially higher (up to 3 times higher) annual rates of greenhouse gas emissions. For each gigalitre of water harvested, the emission of greenhouse gases is about 4 times higher for Option A with storage at South Dandalup.

Direct injection from the Harvey Weir without storage would significantly reduce the amount of water harvested (18 GL/yr) and prevent any potential yield enhancement from Wellesley Creek pumpback and potential trading of surplus irrigation water. Substantial increases to resource yield could only be achieved under this option, at a relatively higher cost, by storage in South Dandalup Dam.

Similarly, Option D is relatively expensive (68 c/kL) and would provide a smaller allocation (29 GL/yr) for public water supply. If a water resource developer was seriously considering Option D (or a variation of it), a further review by the Commission would be required to determine an acceptable full supply level.

A development configuration that achieves the above conditional allocation is shown in Figure 15. However, other development configurations that reduce impacts and achieve the additional allocation are not precluded.

The conditional allocation proposed by the Commission would:

- mitigate impacts on riverine ecosystems;
- reduce social and environmental impacts from inundation because of a lower full supply level for the Harvey Dam;

- enable whitewater canoeing without significantly reducing the allocation for public water supply;
- provide for enhancements to the allocation from pumpback facilities (by up to 9 GL/yr) and future trading of surplus irrigation water entitlements without additional environmental or social impacts; and
- require major river restoration and management of social impacts in the Basin.

To achieve this allocation and future yield enhancements, the preparation of a water quality protection and reservoir recreation management plan would be required to ensure that land use activities are compatible with the requirements of a public water supply catchment.

11.3.3 Management of Major Social Issues

A number of major social issues would need to be addressed in achieving the above allocation. The Commission proposes that the allocation of 34 GL/yr should be conditional on the following matters being adequately addressed.

Reduced Uncertainty

The prospect of a new dam on the Harvey River at some point in time has created uncertainty for the Harvey Hills landowners in planning the future of their properties. To reduce this uncertainty, the Commission would expect a water resource developer to provide a firm commitment for achieving the public water supply allocation on the conditions outlined above upon finalisation of this plan by the Commission. Such a commitment is likely to be a condition of an access licence to the Harvey River Hills resource.

Access licences set aside water for a specified future purpose as a precursor to an entitlement to take water, and would be conditional upon the water resource developer investing in the Harvey River Hills resource and committing to detailed environmental investigations.

Inundation of Private Properties

Substantial social impact would arise from the construction of a 78-m full-supply-level Harvey Dam. The process of relocation would be more easily managed if a land acquisition policy were developed to:

- promote an open and transparent process; and
- ensure that landowners are compensated, as far as is possible, so that they are not "worse off".

The developer should also give adequate consideration to any impacts from the relocation of the Harvey–Quindanning Road.

Aboriginal Heritage

A new Harvey Dam may potentially inundate two archaeological sites of significance. The developer of any new dam must obtain permission under section 18 of the *WA Aboriginal Heritage Act 1972* before any disturbance may occur. This requirement would be a pre-condition on obtaining a take and use licence for the Harvey River Hills resource.

European Heritage

Several buildings and remnant sites of heritage significance may be inundated or affected by a new Harvey Dam. The Commission would, as a condition of any access licence, require investigations to determine the best way to minimise the loss of heritage values. The developer would also be required to consult with landowners, the Shire of Harvey and the Heritage Council during such investigations.

Harvey Agricultural School

The construction of a new Harvey Dam might substantially affect the future viability of the Harvey Agricultural School. The Commission would advise the Minister for Water Resources that the relocation of this school to Wokalup Research Station should be facilitated before a dam is built.

Relocation of Harvey–Quindanning Road

The proposed relocation of the Harvey–Quindanning Road has the potential to substantially disrupt farming operations and affect the amenity of residents.

The Commission suggests that any future water resource developer should investigate modified and alternative routes that might include:

- relocation of the road on property boundaries as far as possible; and
- the use of Logue Road and/or Honeymoon Road.

These investigations should be conducted in consultation with the Shire of Harvey and affected landowners.

11.3.4 Self-supply Allocation

The Commission believes that there should be an allocation for small self-supply users (in addition to

riparian entitlements) of streamflow from Big Brook and small tributaries of the Harvey River.

The allocation would ensure continuation of existing licensed use with some additional capacity for growth. However, the allocation should not significantly affect public water supply potential.

The self-supply allocation (which is in addition to any existing riparian entitlement) established for this resource is 0.2 GL/yr. In addition, the Commission would encourage the public water supply developer to come to an agreement with any landowner adjoining a new Harvey Dam who wishes to obtain water directly from it.

11.4 Consumptive Allocations from the Coastal Plain Resource

The existing licensed allocations from this resource would stand, provided environmental water provisions were met and the user could demonstrate that the water was needed.

11.4.1 Self-supply Use Outside Irrigation Districts

Limited information is available on the existing level or potential demand of self-supply use in the Basin. A study has been conducted (SWI 1998) but a comprehensive assessment of self-supply demands has yet to be undertaken.

The Commission believes that a detailed inventory of existing and future self-supply demands in the Basin is warranted.

Harvey Diversion Drain

At the Myalup end of the Harvey Diversion Drain, (which is outside the Harvey Irrigation District) there are a number of self-supply users that opportunistically abstract water from this drain. These users may also have allocation licences that permit the abstraction of groundwater. The volume abstracted from the drain has the potential to increase substantially – up to about 1.5 GL/yr – if existing users were to irrigate with drain water instead of groundwater.

Annual streamflow in this drain would be substantially reduced with an additional allocation from the Harvey River Hills and Wellesley Creek resources to public water supply (Figure 16). The Commission believes that the existing use can still be supported under these circumstances because summer streamflow in the Myalup end of the drain is mostly maintained by coastal plain runoff. However, a more detailed study of usage and streamflows in this area is warranted to determine the sustainable limit of the Harvey Diversion Drain resource.

The Commission believes that the existing level of abstraction for self-supply use from the Harvey Diversion Drain should not be considered until these studies are completed.

Remainder of the Coastal Plain

Under average rainfall conditions (for example 1963–96) the average amount potentially available for consumptive use could be as high as 60 GL/yr. However, the ease with which this resource might be developed is probably limited.

Increased usage of this resource would also reduce nutrient loadings to the Harvey Estuary.

11.4.2 Allocations to Existing By-law 11 Users in the Irrigation Districts

Small non-metered water users have traditionally abstracted water from the irrigation channels, drains and natural watercourses of the Harvey River Basin during the summer months. These abstractions have only been possible because of releases from the upstream irrigation headworks, return flows from upstream irrigators, upstream irrigation water distribution practices and groundwater discharge.

The water has mainly been used to meet stock and small-scale irrigation needs.

The Commission considers that there should be sufficient water (still to be precisely quantified) within the irrigation allocation to supply all the existing By-law 11 users with their current needs. However, the Commission is keen to promote improved overall irrigation distribution efficiencies.

11.5 Consumptive Allocations from Darling Range Tributaries of the Harvey River

The existing licensed allocations from this resource would stand, provided environmental water provisions were met and the user could demonstrate that the water was needed.

However, release strategies and associated environmental water provisions from existing reservoirs would be developed by the Commission in conjunction with service providers to maximise the benefits of river

restoration. A listing of tributaries outside the Harvey River Hills area is provided in Table 17.

11.5.1 Irrigation

The existing allocation of 29 GL/yr from reservoirs on the Logue, Samson and Drakes Brooks would be maintained while the need for the water can be demonstrated.

11.5.2 Public Water Supply

The Commission has established a provisional allocation of 9 GL/yr to public water supply from the Wellesley and Wokalup Creeks, subject to the establishment of environmental water provisions. Significant additional investigations would be required to determine pumpback site, environmental water provisions and self-supply needs.

No allocation from other unregulated and semi-regulated streams for public water supply is proposed in order to meet environmental water provisions for the lower Harvey River.

Any additional allocation to public water supply from regulated streams would be considered after the establishment of environmental water provisions

The Commission would support the trading of surplus irrigation water to a future PMWSS supplier. Where such trades took place, existing recreation or tourism activities on these reservoirs should not be unduly impacted.

11.5.3 Self-supply Use

The Commission has established the following allocation for self-supply use of the resource:

- 3 GL/yr provisionally from the Wellesley and Wokalup Creeks outside forested areas subject to the refinement of environmental water provisions;
- a total of 1 GL/yr, or 5% of the mean annual streamflow, from unregulated and semi-regulated Darling Range streams north of the Harvey River Hills (Table 17); and
- a total of 2 GL/yr, or 5% of the mean annual streamflow, at storages from regulated tributaries on the Darling Range north of the Harvey River Hills (Table 17).

Allocations for Wellesley and Wokalup Creeks and regulated tributaries are subject to the setting of environmental water provisions and the outcome of studies of existing and future self-supply demand.

11.5.4 Industrial

The existing allocations to Alcoa are 1.4 GL/yr from Yallop Brook and 0.5 GL/yr from Samson Brook. These allocations would be maintained, but the Commission would support the trading of surplus irrigation water to industrial use. Where such trades took place, existing recreation or tourism activities on existing reservoirs should not be unduly impacted.

11.6 Restoration of the Harvey River

The restoration of key components of a Harvey River ecosystem is required in order for environmental water provisions to have a more beneficial impact.

The health of the Harvey River is dependent on a number of factors in addition to adequate environmental water provisions. These include:

- appropriate water quality;
- suitable in-stream habitat;
- channel stability; and
- suitable riverine–stream linkages.

The loss of in-stream habitat, the clearing of riverine vegetation and channel instability are the major causes of degradation, particularly in the lower reaches of the Harvey River. Restoration of the riverine zone would require revegetation, limiting livestock access and fencing to enable regrowth of the understorey. Channel stability might require modifications to channel dimensions, and in-stream habitat would require the installation of large woody debris to create a diversity of habitat types. Raising the water level would reduce the amount of water required for riverine and wetland inundation.

Although the drains are constrained by their easement, and therefore meander may be minimal in some parts of the Harvey River, there is a large capability for restoration using techniques shown to be successful elsewhere in the catchment.

11.6.1 Catchment Management Plan

The Commission believes that the restoration plan for the Harvey River should be developed within a catchment framework. The Commission would facilitate the preparation of the restoration plan and coordinate, as required, the preparation of a catchment management plan for the Harvey Basin through a

community-coordinated catchment management process.

Streamlining of drains and streams and no significant development of unregulated sub-catchments are critical to the restoration of river health. Maintaining unregulated streams would establish the critical riverine–stream linkages and maintain low nutrient streamflow to the Harvey Estuary.

The reconstruction of major drains to improve both aesthetic and ecological values should be a major emphasis in any restoration. The Harvey Diversion Drain presently has a huge bankfull capacity far exceeding typical flood flows. Restoration should require the re-battering of the drain slopes to make them more suitable for vegetation and more similar to natural river channels.

11.6.2 Harvey Diversion Drain Review

The Water Corporation should review the need for the Harvey Diversion Drain.

The development of the Harvey River Hills resource, with a pumpback facility on the Wellesley Creek, might reduce annual flow to the Indian Ocean by about 70%. Any aesthetic flows through the Harvey townsite could be directed down the Harvey Main Drain, and there is the potential to direct streamflow from the Wellesley Creek down the Wellesley River following the installation of any future pumpback facility to a new Harvey Dam.

With the proposed allocations for consumptive use, the average flow carried by the drain would be very small compared to its current design capacity.

While the normal flows might be substantially reduced the drain might have a role in flood mitigation.

11.6.3 Establishment of a Harvey River Restoration Trust

The Commission proposes to establish a Harvey River Restoration Trust to promote rehabilitation of the Harvey River system while meeting water supply and drainage objectives.

The Trust would be administered by the Commission in conjunction with an advisory board of representatives from land conservation district committees, water supply developers and the community. The Trust would receive funds from water supply developers in compensation for the loss of riverine and wetland systems arising from water supply developments. The compensation would be dedicated to restoring riverine areas in the Basin to achieve a net environmental benefit from water supply developments.

The 34 GL/yr and 9 GL/yr public water supply allocations from the Harvey River Hills and Wellesley Creek resources would result in a loss of riverine systems upstream from dam walls. The Commission would require the developer of these resources to make a major contribution to the Trust. The funds would be used to support restoration of Wellesley and Wokalup Creeks and a substantial length of the Harvey River, including that within the Harvey townsite, the Big Brook tributary and the lower reaches of the Harvey River and its tributaries.

The Trust would provide financial support for community-based river restoration projects which might receive in-kind or financial contributions from community organisations, Government agencies and private organisations.

All projects supported by the Trust would have to be consistent with:

- a catchment management plan;
- any restoration plan prepared for the Basin; and
- regional land and water care strategies prepared by natural resource management agencies in partnership with the community.

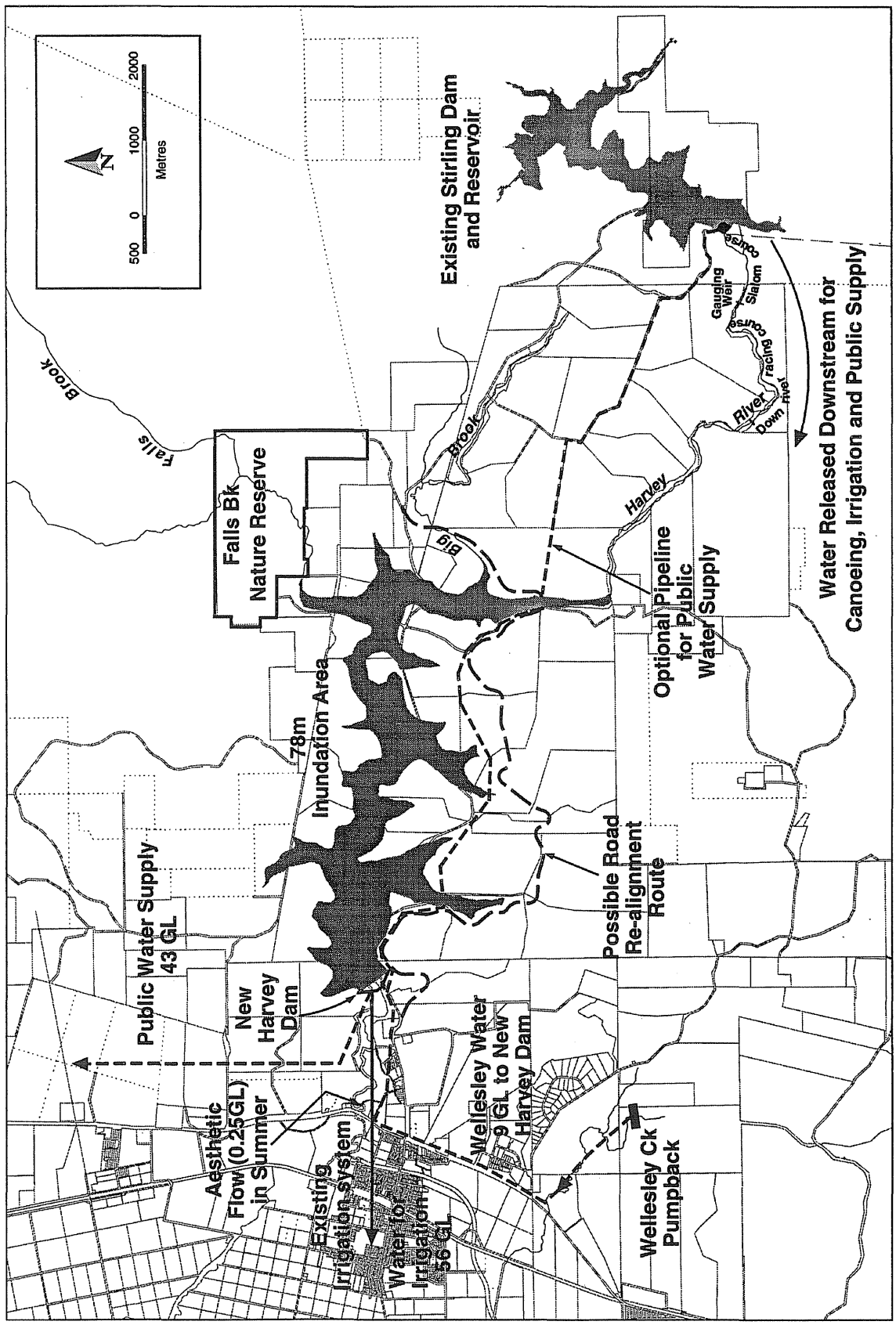


Figure 15. Potential development of Harvey River Hills Resource.

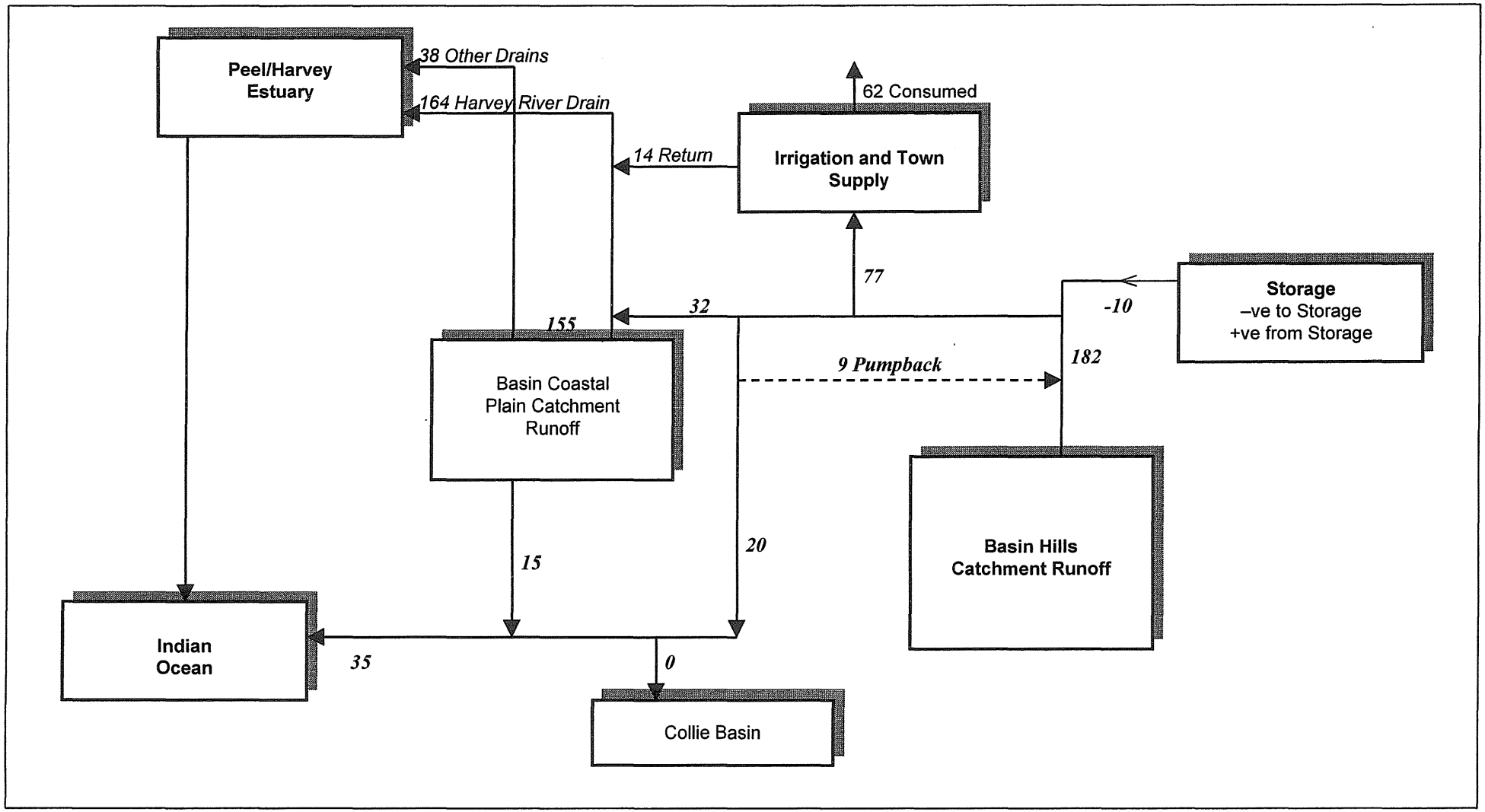


Figure 16. Impact of public water supply allocations on annual average streamflows (GL).

12. Implementation Program

The Commission has developed an implementation program to give effect to this plan. The program describes:

- the allocation licensing structure that would apply in the Basin;
- eight key management areas in the Basin (Figure 17); and
- management objectives and key management measures that apply to each key management area.

Water resource management objectives are based on proposed allocations and river restoration requirements. The objectives and management measures would guide the issue of allocation licences, water resource development, water resource protection and catchment management within the Basin.

12.1 Allocation Licensing Structure

The Commission is responsible for the administration of the allocation licensing system under the Rights In Water and Irrigation Act.

An allocation licence is required, under the Act, by any person who:

- diverts water from any watercourse, lake, lagoon or swamp or marsh water other than owners or occupiers adjoining such water bodies diverting water for domestic (including irrigation of a domestic garden 2 ha or less) or stock watering purposes only; or
- constructs or draws water from an artesian well; or
- abstracts groundwater in a proclaimed groundwater area. (Normally licences are not required in these areas where abstraction is only for domestic purposes).

A watercourse for the purposes of licensing may include a conduit that wholly or partially diverts a river, creek, stream or brook from its natural course and forms part of the river, creek, stream or brook.

The Commission would apply the following hierarchy of water entitlements in the Basin.

Access Licences

An access licence would allow a water service provider to better forward-plan and invest in exploration prior to developing a new water resource.

An access licence would set aside water for a future purpose as a precursor to an entitlement to take water. These licences would be conditional upon the holder investing in resource and environmental investigations. The licences would be likely to be issued only in limited circumstances where long-term demand growth can be demonstrated, for example that associated with a growing major population centre such as Perth.

Headworks Operating Licences

A headworks operating licence would provide a right to divert, halt the flow of, collect and store water from a surface water resource after satisfying environmental (including social) water provisions. The water might be abstracted from the resulting reservoir or might be released back into the stream system for another party to take and use downstream.

Take and Use Licences

This licence provides a right to a self-supply user or service provider to take water from a resource system and use the water subject to any conditions of licence. A take and use licence may or may not be associated with a headworks licence.

12.2 Management Areas

12.2.1 The Harvey Hills Catchment Area

Management Objectives

- To efficiently harness the water resource yield from the Harvey River Hills catchment in accordance with the conditional allocation for public water supply.
- To maintain or enhance water quality consistent with the use of the resource for public water supply.
- To ensure that water resource developments do not adversely affect water resource and nature conservation values of the Falls Brook Reserve.

- To ensure that environmental (including riverine) and social impacts of water supply developments are reduced to a reasonable minimum.
- To ensure that an appropriate provision is made for whitewater canoeing between the Stirling and Harvey Dams.
- To improve the water resource values and riverine areas of Big Brook.

Management Measures

1. Access Licences to Developer(s) to Meet Public Water Supply Demand

The Commission would be prepared to issue an access licence and associated conditions to a future developer for the Harvey River Hills resource. This licence would be for an additional 34 GL/yr, which is the sustainable diversion limit from Harvey River Hills resource based on the 1948–95 rainfall record.

The issue of an access licence does not give approval to build any dam or other structure, nor does it allow more water to be taken. An access licence would allow the potential developer to explore the feasibility of harvesting water in the future.

Any proposal to build a dam would subject to environmental impact assessment under Part IV of the *Environmental Protection Act 1986* and assessment by the Commission prior to the issue of a take and use licence.

The issue of the access licence would be conditional upon:

- demonstrating justified long-term demand projections based on efficient water use as specified in the Commission's response (WRC 1997a) to the Water Supply Strategy for Perth and Mandurah (WAWA 1995)) to serve public water supply needs;
- specifying the proposed time-frames for development of the resource within an accepted source development program;
- demonstrating that the existing users of these resources would not be adversely affected;
- thoroughly investigating the impact of the proposed development and operational strategy on whitewater canoeing; and
- meeting all other relevant conditions outlined in this plan.

2. Self-supply Demand

The Commission has determined an allocation of 0.2 GL/yr for self-supply use on limited information. The Commission would require the developer of the Harvey River Hills resource to fund a study of existing and potential self-supply use demand in this management area as a condition of an access licence.

Depending on the results of this study, the Commission would confirm, or otherwise amend this allocation through a public process. This requirement is consistent with the conditional allocation for public water supply prescribed in Section 11.3.2.

3. Licensing Guidelines for Self-supply Use

The allocation for self-supply is in addition to existing licensed use and any agreement between a public water supply developer and landowners for supply of water from a new Harvey Dam.

Small-scale water allocation licences would only be issued where there is no significant impact on existing users, water quality or allocations for future public water supply, aesthetics or recreation.

4. Water Quality Protection

Refer to Section 12.2.9 below for details of water quality protection measures.

12.2.2 Harvey River in the Town of Harvey

Management Objectives

- To ensure that aesthetic flows are maintained in the Harvey tourist precinct.
- To improve the aesthetic and other environmental values of riverine areas within the town of Harvey.

Management Measures

1. Aesthetic Flow Facility

A future public water supply developer would be required, as a condition of a take and use licence, to ensure an acceptable aesthetic flow in the tourist precinct in summer. The developer would be required to design and construct any facility required to give effect to the allocation for aesthetic flow in consultation with the Shire of Harvey.

2. Licensing Guidelines for Self-supply Users

Given the small catchment area below a new Harvey Dam and the need to maintain aesthetic flows through

the tourist precinct, self-supply use would be restricted so as not to adversely affect aesthetic flow. A specific allocation has not been designated for self-supply users because each licence application would need to be individually assessed.

12.2.3 Harvey River Main Drain

Management Objectives

- To encourage the development of suitable in-stream habitat.
- To encourage the on-farm use of local runoff and drainage water.
- To reduce the export of nutrients into the Harvey Estuary.
- To keep irrigation scheme water supply systems separate from unregulated and semi-regulated streams.

Management Measures

1. Unregulated Streams (streams not subject to substantial damming, barriers or diversion)

The Commission believes that streamflow from unregulated streams (Clarke and Weekes Brooks) should, as far as practicable, be kept separate from the irrigation water supply system. This might be accomplished in some instances by piping irrigation scheme water. Piping also has the advantage of reducing losses in the irrigation system.

2. Use of Water from Drains

The Commission encourages the use of drainage water within and outside irrigation areas to improve the efficiency of water use and reduce the irrigation demand on Darling Range water resources. Based on modelling of streamflow under pre-European conditions, up to 60 GL/yr might be available on the coastal plain in the Basin for consumptive uses.

3. By-law 11 Users

Approvals to abstract water have been issued under Part IV and By-law 11 of the Rights in Water and Irrigation Act. Supplies were not guaranteed, as specific releases to meet these needs were not formally made. In practice, however, water has been regularly available to the former By-law 11 users.

Allocation provisions were effectively made for them through their inclusion in the allowances for irrigation distribution losses throughout the district. Historic practices have also established community expectations for continued flows down particular drainage lines through the region.

Irrigation services in the area are now provided by SWI as authorised under their operating licence and operating area established under the *Co-ordination of Water Services Act 1995*.

The Commission would support the following initiatives:

- clarify and codify allocations (via customer contracts with SWI) to former By-law 11 users where their water needs can be demonstrated;
- promote improved irrigation water distribution efficiencies (including the upgrading of the methods of service delivery) over time; and
- consider the social and environmental benefits and costs of the summer water regimes in the drainage systems of the irrigation area over the next two years and update any interim water provisions as required.

12.2.4 Lower Harvey River and Drainage Lines in the Irrigation Area

Management Objectives

- To encourage the creation of suitable in-stream habitat and wetland areas.
- To restore and rehabilitate riverine vegetation through an integrated catchment management process.
- To monitor the impact of the Dawesville Channel on lower riverine vegetation.
- To encourage the on-farm use of local runoff and drainage water.

1. Unregulated Streams (streams not subject to substantial damming, barriers or diversion)

The Commission believes that streamflow from unregulated streams (Clarke and Weekes Brooks) should, as far as practicable, be kept separate from the irrigation water supply system. This might be accomplished in some instances by piping irrigation scheme water. Piping also has the advantage of reducing losses in the irrigation system.

2. Self-supply Use Demand

Most of this management area is outside the Harvey and Waroona Irrigation Districts. The Commission has very

limited information available on existing and potential self-supply demand.

The Commission intends to ensure further information is collected in order to better plan for these needs.

The amount of water potentially available on the coastal plain for consumptive uses is of the order of 60 GL/yr, based on streamflow that existed before European settlement.

3. By-law 11 Users

Refer to Section 12.2.3 above

12.2.5 Northern Unregulated and Semi-regulated Darling Range Streams

Management Objectives

- To promote unimpeded streamflow from the Darling Range to the Harvey Estuary.
- To restore and rehabilitate riverine vegetation through a catchment management process.
- To maintain existing streamflows from the Darling Scarp.

Management Measures

1. Self-supply Use Demand

The Commission has determined an allocation of 1.0 GL/yr for self-supply use from all unregulated tributaries, based on achieving environmental water provisions. The Commission intends to gain further information of existing and potential self-supply demand in this management area.

2. Licensing Guidelines for Self-supply Use

Small-scale water allocation licences would only be issued where there would be no significant impact on existing licensed users.

Approvals would not be given to construct new dams or barriers to flow unless it could be demonstrated that ecological carbon flow, fish passage and the natural flow regime would not be significantly affected.

Licences to pump from streams during winter to off-stream storage might be approved provided the total allocation of all licences do not exceed the allocation (1 GL/yr) for this use. The main purpose of licensed water use would be limited to meeting the needs of small-scale irrigation and stock.

3. Industrial Use

The existing industrial use would stand and the Commission would support trading in surplus irrigation water from storages in other catchments, provided recreational use of those storages was not unduly impacted.

12.2.6 Regulated Tributaries of the Harvey River

Management Objectives

- To ensure any changes in beneficial uses of reservoirs do not unduly impact recreation activities that are in accordance with recognised management plans.
- To establish environmental water provisions for all tributaries.
- To restore and rehabilitate riverine vegetation through a catchment management process.
- To ensure further development is consistent with established environmental water provisions.

Management Measures

1. Recreation On Reservoirs

Recreation activities that are in accordance with existing management plans should continue. Any change to the beneficial use of the water in storage should not unduly impact these activities without the approval of the Commission.

2. Potential for Public Water Supply

The Commission would anticipate that any trading of surplus irrigation water to public water supply would be conditional upon an appropriate level of water treatment.

3. Self-supply Use Demand

The Commission has very limited information available on existing and potential self-supply demand. The Commission intends to ensure further information is collected in order to be able to better plan for this beneficial use.

4. Licensing Guidelines for Self-supply Use

Allocation of the resource in this area would be 2.0 GL/yr based on 5% of streamflow at existing storages. This allocation would be subject to the determination of environmental water provisions and the demand studies for self-supply use.

Small-scale water allocation licences would only be issued where there was no significant impact on existing licensed users.

5. Industrial Use

The Commission would support trading in surplus irrigation water from storages in other catchments provided recreational use of those storages was not unduly impacted.

12.2.7 Wellesley Creek Catchment

Management Objectives

- To efficiently harness water for public water supply that is surplus to environmental provisions and self-supply users.
- To ensure self-supply developments do not adversely affect other existing users or the allocation for public water supply.
- To encourage the restoration of riverine areas.

Management Measures

1. Public Water Supply

The Commission would be prepared to issue an access licence and associated conditions to a future developer for the Wellesley Creek resource. This licence would be for a provisional allocation of 9 GL/yr from Wellesley Creek resource based on the 1948–95 rainfall record. Significant additional investigations of this resource would be required to confirm or amend this additional allocation.

The issue of an access licence does not give approval to build any dam or other structure nor does it allow more water to be taken. An access licence would allow a potential developer to explore the feasibility of harvesting water in the future. Any proposal to build a dam would have to go through the environmental impact assessment process under Part IV of the Environmental Protection Act and assessment by the Commission.

The issue of the access licence would be conditional upon:

- demonstrating justified long-term demand projections based on efficient water use (as specified in the Commission's response (WRC 1997a) to the Water Supply Strategy for Perth And Mandurah (WAWA 1995)) to serve public water supply needs;
- specifying the proposed time-frames for development of the resource within an accepted source development program;
- investigations being conducted to define pumpback site and reservoir size;
- investigations being conducted of streamflows, potential water yields, self-supply use for the 1975–95 rainfall record and effects of future self-supply demand;
- demonstrating that the existing users of this resource would not be adversely affected;
- investigations being conducted on ecological water requirements; and
- meeting other all relevant conditions outlined in this plan.

2. Self-supply Use Demand

The Commission has determined a provisional allocation of 3.0 GL/yr for self-supply use on limited information. The Commission would require the public water supply developer of the Wellesley Creek resource to fund a study of existing and future self-supply use demand as a condition of an access licence.

Depending on the results of this study, the Commission will confirm or otherwise amend this provisional allocation through a public process. This requirement is consistent with the conditional allocation for public water supply prescribed in Section 11.3.2).

3. Licensing Guidelines for Self-supply Use

Small-scale water allocation licences would only be issued where there is no significant impact on existing licensed users.

12.2.8 Harvey Diversion Drain

Management Objectives

- To review the purpose and function of the Drain and during this review consider:
  - * the creation of in-stream habitat and wetland areas in accordance with the review;

* the improvement of aesthetic and other environmental values of the drain within the town of Harvey; and

* the creation of ecological values such as wetlands and habitat diversity.

- To regularise any current water abstractions that are beneficial, do not significantly impact on others and are consistent with the requirements of this plan.

Management Measures

1. Drain Review

The Commission would expect the Water Corporation to conduct a review on the future and purpose of the Harvey Diversion Drain.

2. Self-supply Demand

The Commission has determined the allocation of 1.5 GL/yr for self-supply use on limited information. The Commission would request the public water supply developer of the Wellesley Creek resource to fund a study of existing and potential self-supply use demand as a condition of an access licence.

Depending on the results of this study, the Commission will confirm or otherwise amend this allocation through a public process. This requirement is consistent with the conditional allocation for public water supply prescribed in Section 11.3.2.

3. Licensing Guidelines for Self-supply Use

Licensed usage up to the allocation limit of 1.5 GL/yr would be allowed, provided that water need could be demonstrated and other licensed users would not be adversely affected.

12.2.9 Protection of Water Quality in the Public Water Supply Catchments

The Commission would develop and implement the following measures to protect water quality in the Harvey River Hills and Wellesley Creek catchments.

Water Quality Protection Plan

This plan allocates water from the Harvey River Hills and Wellesley Creek resources for public water supply. The Commission has existing policies which provide a protection framework regarding the acceptability of private and public land uses within catchments where the provision of public water supply is a high priority. A water quality protection plan would be established to ensure no increased risk of pollution to the Harvey and Stirling Reservoirs and the Wellesley Creek pipehead dam.

The Commission recognises that landowners currently engage in a variety of land-use activities primarily of an agricultural nature, including grazing of dairy cattle and sheep, citrus fruit growing, marron farming, table grape production, hay production, silviculture (blue gums) and operating farmstay chalets. The establishment of a water quality protection plan covering the catchments would allow them to remain predominantly an area of large-scale farming activity consistent with the Harvey District Planning Scheme's objectives for the area.

While the Commission considers land uses such as extensive livestock grazing and broadacre cropping are compatible catchment activities, other existing land uses such as silviculture, marron farming, viticulture and orcharding might require some changes to existing farm management practices to ensure their compatibility with a public water supply catchment. The intensity of rural subdivision (minimum 4-ha lots) would also be limited by the protection plan.

In order to protect water quality, the plan would be likely to prohibit some potential land uses, most notably intensive horticulture (e.g. market gardening) and operating wineries, which are regarded as incompatible activities within public water supply catchments.

With respect to public land, nature reserves (e.g. Falls Brook Nature Reserve) are a compatible land use, while forestry is considered a restricted activity. This may have some implications for CALM for its management of State Forests and pine plantations in the catchment.

The Commission would develop the water quality protection plan in close consultation with the Harvey Shire, local landowners, CALM and the future developer of the Harvey River Hills and Wellesley Creek resources.

Policy for Recreation On and Around Dams

The Commission recognises the need to establish an appropriate balance between protecting water quality for public supply purposes, developing the recreation potential of the Harvey Rivers Hills reservoirs and maintaining the amenity of the area. While the existing level of recreational activity is limited, a new Harvey Dam would provide a much larger surface area for recreational activities. However, the water level in a new dam would fluctuate from year to year by as much as 20 m, thereby limiting some potential recreational activities and the attractiveness of the area for tourism development.

The community has expressed considerable interest in seeing the recreation potential of the Harvey Reservoir developed further.

The previous policy, prepared by the WA Water Resources Council (WAWRC 1985), is being reviewed by the Commission. The Commission believes that this policy lacks flexibility and needs to take into account any existing and proposed treatment of the public water supply.

The Shire of Harvey has indicated that it considers the following passive recreation activities (in addition to whitewater canoeing) are appropriate on and around a new Harvey Dam:

- canoeing;
- sailboating;
- marron fishing (snare only);
- fishing;
- bushwalking;
- using a kiosk and interpretive centre; and
- using picnic areas at selected locations.

The Commission considers that there would be opportunities to accommodate the interpretative centre and picnic areas below the new dam. There is potential to accommodate some recreation activities, given the intention to treat the public water supply from the Harvey Dam.

The Commission would develop a recreation management plan for the Harvey and Stirling Reservoirs and their surrounds. The plan would clearly establish what forms of recreation might occur on and around the reservoir. This approach has been adopted previously by the Commission for the Waroona and Logue Brook Reservoirs.

The recreation management plans would be developed in close consultation with the Harvey Shire, local landowners, recreation organisations and the future developer of the Harvey River Hills resource.

12.2.10 Trading of Water Entitlements

The Commission is committed, under the COAG Agreement in 1994, to reform water law to allow the potential for water users to lease, buy or sell irrigation water. This possibility is currently being discussed and considered throughout the State by the Commission and water users. If water trading is ultimately allowed, it would offer the opportunity for licence holders to match their water allocations to their needs. Current allocations to irrigation that are surplus to needs could be traded soon after the establishment of a market.

The Commission hopes to have trading established in nominated groundwater areas by the end of 1998. It also is planning to provide for bulk water trading between industry sectors in the Perth to Bunbury Region within this timeframe.

12.3 Further Investigations

Further refinement or definition of environmental water provisions and studies of self-supply use demands would be required for some catchments of the Harvey River. Future developers of these water resources would be required to support these investigations prior to being granted an access or take and use licence.

12.3.1 Plan Review

This plan is based on preliminary information and would require regular review to update environmental water provisions and allocations to consumptive uses.

The instigation of a review would be at the discretion of the Commission but at intervals of not more than five years. A review may follow the completion of major water resource investigations, EPA advice on a source development proposal or substantial changes in bulk water use.

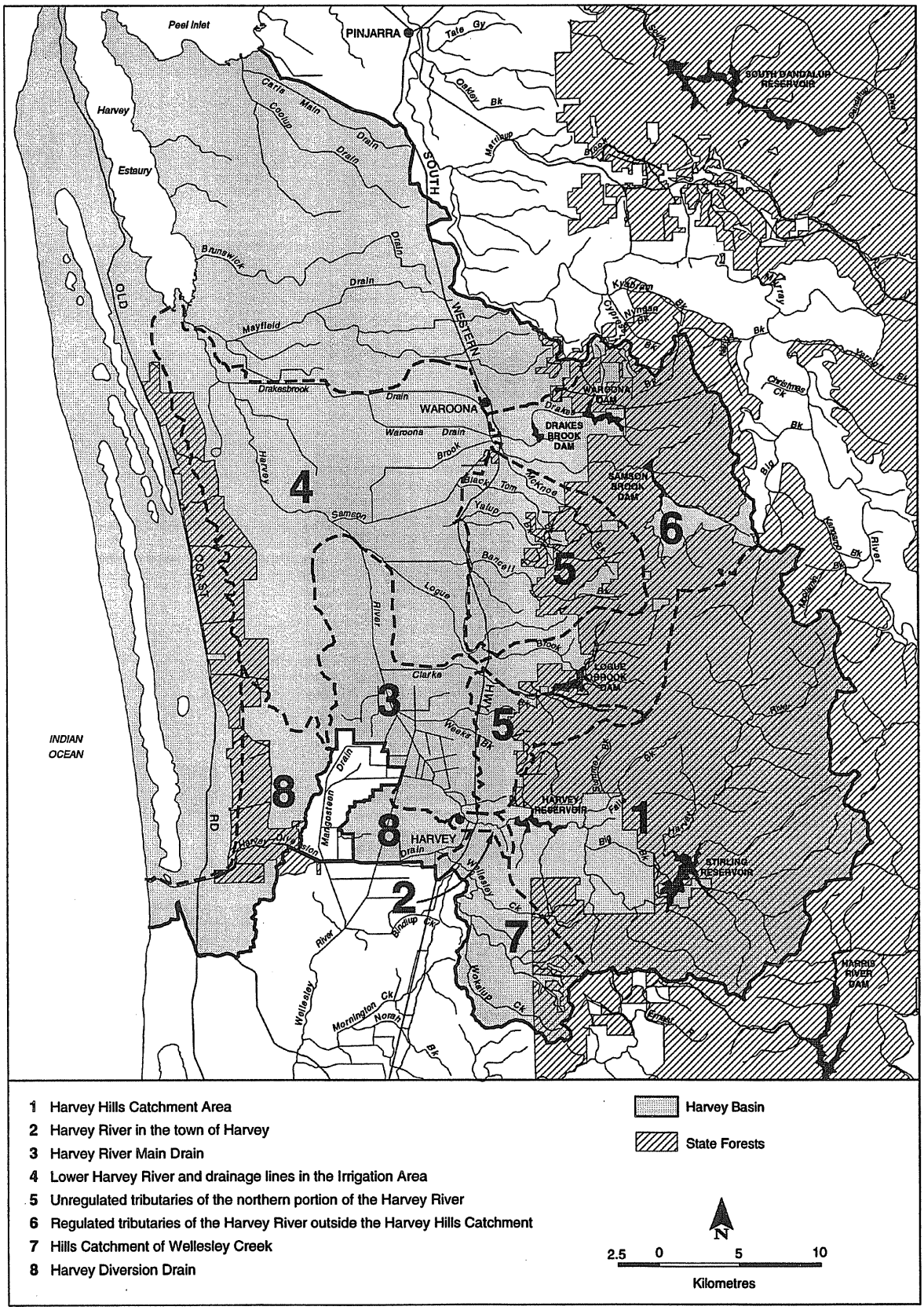


Figure 17. Water resource management areas in the Harvey Basin.

13. Assessment Of Relevant Environmental Factors

13.1 Introduction

This section provides a preliminary review of the environmental impacts associated with the proposed 34 GL/yr allocation from the Harvey River Hills resource and outlines environmental water provisions and the proposed river restoration program. Environmental considerations associated with the four allocation options and environmental water provisions for the Harvey River are addressed in detail in Section 7 and Streamtec (1998).

The objective of this preliminary review is to determine early in the allocation process whether there are any potential "fatal" flaws. The impacts associated with construction of pipelines and new roads that may arise out of the development of the Harvey River Hills resource are considered only peripherally. These matters, along with all relevant environmental factors, would be addressed in detail in any environmental review prepared by the proponent of a new Harvey Dam.

13.2 Public Consultation

An extensive process of public consultation was conducted as part of the preparation of this allocation plan (refer Section 1.8). Discussions were held with a broad range of stakeholder interests, including local and Government agencies, interest groups and affected landowners.

The scoping exercise was supported by the production of newsletters, an information display at the Harvey Show and ongoing discussions with various stakeholders. Additional consultations occurred as part of the technical studies undertaken during the allocation planning process. These included interviews with Harvey Hills landowners as part of the social impact assessment and discussions with local Aboriginal spokespersons on heritage matters.

13.3 Assessment of Alternatives

Sections 8 and 9 describe and evaluate the environmental, social and water resource implications of options for achieving an additional allocation from the Harvey River Hills resource. This process led to the Commission proposing an additional allocation of 34 GL/yr to public water supply from this resource, subject to satisfying a number of conditions (Section 11.2).

The assessment of allocation options also involved a detailed analysis of social impacts, including impacts on European heritage (Beckwith and Associates 1998) and Aboriginal heritage (Quartermaine Consultants 1998; O'Connor 1998).

A vegetation survey (Mattiske Consulting Pty Ltd 1997) and a survey for the western ringtail possum (de Tores & Rosier 1997) were carried out in the area of potential inundation. These studies and a previous study on the potential impacts of a new Harvey Dam (Havel Land Consultants 1994) were used in the environmental impact assessment of options.

The impact of allocation options on downstream flow, which may support significant ecosystems, was assessed on the basis of studies which identified downstream ecological water requirements and values (Streamtec 1998).

The additional allocation is based on the full supply level for a new Harvey Dam not exceeding 78 m. This height was selected from a range of options as being able to meet the allocation requirements without adversely affecting the environmentally significant Falls Brook Nature Reserve.

The above studies considered impacts for a full supply level of 70, 80 or 90 m. The environmental impacts described in this Chapter are based on an 80-m full supply level, and are therefore likely to be slightly over-stated.

This review is divided into four parts:

- assessment of inundation impacts (Section 13.3);
- assessment of downstream environmental impacts (Section 13.4);
- proposed environmental water provisions (Section 13.5); and
- river restoration framework and principles (Section 13.6).

13.4 Inundation Impacts

The scoping of environmental impacts from the proposed allocation from the Harvey River Hills resource has led to the identification of the following key environmental factors in relation to inundation from a new Harvey Dam:

- vegetation communities;
- Declared Rare and Priority Flora;
- terrestrial fauna;
- Specially Protected (Threatened) Fauna;
- mosquitoes;
- European heritage and land usage; and
- Aboriginal heritage.

13.4.1 Vegetation Communities

Environmental Protection Objective

- To maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities.

Assessment Procedure

The landscape that would be inundated following construction of a new Harvey Dam is highly modified by past agricultural and forest activities. Most of the area affected is private land, cleared mainly for pasture and orchards. Secondary land uses include recreation and softwood timber production.

The area potentially inundated by a pumpback facility on the Wellesley Creek (9 ha) is cleared agricultural land with riverine vegetation along the creek line.

Mattiske Consulting Pty Ltd was engaged by the Commission to survey areas of remnant vegetation that may potentially be inundated (Mattiske Consulting Pty Ltd 1997).

The significance of remnant vegetation lost was determined by considering the following:

- the area of the vegetation complex likely to be inundated;
- the condition of the vegetation within the complex;
- the area of the complex in the Darling Range region (where relevant) which has reserve status (this gives an indication of the amount of the complex already protected); and
- the area of the complex in the Darling Range (where relevant) irrespective of reserve status (this gives an indication of the amount of complex still available for inclusion into the reserve estate).

Commission Assessment

The area for the assessment of this factor was the Darling Scarp.

The only area having some formal level of conservation status is the System 6 area C79 for conservation of flora and fauna as a Regional Park (DCE 1983). This overlaps Water Supply Reserve C15515.

An overall assessment by Havel Land Consultants (1994) considered that the proposed new Harvey Dam and Stirling Dam projects would have a relatively minor impact on flora, although this assessment did not include vegetation on private property.

Six areas of remnant (including riverine) vegetation adjacent to, or within, potential inundation areas were assessed for conservation significance (Mattiske Consultants 1997). These are shown on Figure 18 and summarised below:

- Area 1: Western part of System 6 recommendation C 79 (Reserve C24002);
- Area 2: South-eastern side of Reserve C15515;
- Area 3: Northern side of Reserve C15515;
- Area 4: South-western part of System 6 recommendation C80 (Reserve 10745);
- Area 5: Private property; and
- Area 6: Private property.

The following landform complexes were identified from the surveys as likely to be affected by inundation from a new Harvey Dam:

- Darling Scarp: Steep rocky escarpment of the plateau; skeletal soils with numerous outcrops of granite.
- Lowdon: Major valley slopes and scarps with little laterite and with mainly exposed weathered or unweathered surfaces.
- Helena: Major valleys with steep slopes deeply incised into the plateau; shallow red and yellow earths with frequent risk outcrops.

- Forrestfield: Sandy gravel spurs of Red Hill Shelf fringing the Darling Scarp.

Table 18 summarises the impact of a new Harvey Dam (a supply level of 80 m) on each vegetation complex.

The conservation value of remnant vegetation that would be lost through inundation, in order of significance, is as follows:

- The Forrestfield vegetation complex in Area 2. The Forrestfield complex within the Darling Scarp is anomalous. The remnant vegetation includes *Eucalyptus wandoo* over *Agonis flexuosa*, which is unusual and hence considered to be of high value.

- The Lowdon and Darling Scarp complexes. These do not contain vegetation in particularly good condition; however, they are not well represented in conservation reserves (0.23% and 3.8% respectively).

- The Helena complex in Area 5, followed by the Helena complex in Area 6. These areas (on private property) contain vegetation in very good condition on the mid to upper slopes however, this complex is well represented in reserves (26.84%).

Approximately 8 km (50 ha) of riverine vegetation would be lost if a new Harvey Dam and Wellesley pumpback facility were constructed.

The Commission views riverine vegetation as being a very important component of a water resource, as it plays a crucial role in both providing habitat and ecological processes of rivers. The Lowdon vegetation complex is not well represented in the conservation estate and is a habitat for the western ringtail possum. However, a substantial amount of the Lowdon vegetation complex 16.5% is contained in State Forest which is subject to special conditions to protect riverine areas.

The Commission's policy is to require the replacement or restoration elsewhere of any riverine vegetation lost through water resource development projects. The Commission would require a developer of a new Harvey Dam (or any other substantial impoundment on the Harvey River system) to support the restoration of the Harvey River and its tributaries. A major emphasis of this restoration would be to restore the Lowdon complex in Darling Range areas of the catchment.

Section 13.8 provides details on the proposed riverine restoration program.

Compliance with the environmental protection objective for vegetation would be dependent on the developer of a new Harvey Dam preparing a vegetation protection plan. An acceptable protection plan is likely to require the restoration of remnant vegetation within the vicinity and/or improved protection of similar vegetation elsewhere.

Table 18. Vegetation complexes likely to be inundated.

Vegetation	Area Affected (km^2)*	Vegetation Condition[a]	Complex in System 6 in DRSG area[b] (ha)	Complex in DRSG area[b] (ha)	Complex in RFA area [a]	Complex in Conservation Reserves [a],[e] (%)
Lowden	50 (riverine) 25 (mid slope)	High weed invasion in understorey, overstorey remains intact throughout	421	18666	17355	3.7 16.8#
Darling Scarp	5	As above	2785	26450	not available	1.53
Forrestfield	17	Good, but anomalous	30	160	not applicable	not available
Helena (M/H)	40	Very good in the upper to mid slopes, reasonable nearer the Harvey River	5095	16997	not available	26.84

* Preliminary estimate.
# In State Forest.
[a] Source Mattiske Consulting Pty Ltd 1997
[b] Modified from data in Darling Range Study Group (1982): Tables 6.10, 6.19, 6.20, 6.22.
[c] The amount of the complex in System 6 C79 is an approximation of the amount of complex in the vicinity of the inundated complex.
[d] Modified from data in Darling Range Study Group (1982): Tables 6.17, 6.19.
[e] Havel 1989: Table 4.
[f] Modified from data in Darling Range Study Group (1982): Tables 6.10.

Some mitigation measures that may employed to protect and restore appropriate vegetation communities might include one or more of the following.

- Increase vegetation stands on the fringe and midslope areas around a new Harvey Dam.
- Increase vegetation standards downstream from a new Harvey Dam.
- Purchase land containing Lowdon vegetation complex for protection or inclusion in the conservation estate.

On the basis of:

- riverine restoration requirements of the Commission;
- the preparation of an acceptable vegetation protection plan by a developer of a new Harvey Dam; and
- riverine vegetation in State Forest is subject to special protection,

the Commission believes environmental impacts on native vegetation are potentially manageable and consequently, the EPA's objective for vegetation communities can be met.

13.4.2 Declared Rare and Priority Flora

Environmental Protection Objective

- To protect Declared Rare and Priority Flora, consistent with the provisions of the *Wildlife Conservation Act 1950.*
- To maintain the abundance, species diversity and geographical distribution of terrestrial flora.

Commission Assessment

The assessment area for this factor is the Darling Range.

CALM classifies flora of conservation significance as Declared Rare Flora (Extinct or presumed Extinct), or Priority 1 to 4 in order of most to least rarity.

Unlike Declared Rare Flora, it is not an offence "to take" Priority flora, although it is advisable to avoid their destruction wherever possible.

The survey undertaken by Mattiske Consulting Pty Ltd (1997) did not locate any Declared Rare Flora as listed by CALM in the survey areas.

The survey located one priority (P4) plant species in Areas 5 and 6 – *Hibbertia silvestris*, – which would be affected by an 80-m full supply level. Of the nine occurrences of *Hibbertia silvestris* identified from the survey, four are located outside the inundation area.

The occurrence of this species elsewhere in the South West region suggests that the viability of this species will not be affected.

Notwithstanding this, a developer of a new Harvey Dam is likely to be required to minimise the impact on areas containing priority species. Enhanced protection or restoration of priority species is likely to be a component of a remnant vegetation protection plan.

On the basis of:

- declared rare flora are unlikely to be affected by inundation; and
- the preparation of an acceptable vegetation protection plan by a developer of a new Harvey Dam,

the Commission believes that impacts on declared rare flora and priority flora are manageable and consequently the EPA's objective for this environmental factor can be met.

13.4.3 Terrestrial Fauna

Environmental Protection Objective

- To protect Specially Protected Fauna, consistent with the provisions of the Wildlife Conservation Act.
- To maintain the abundance, species diversity and geographical distribution of terrestrial fauna.

Commission Assessment

The assessment area for this environmental factor is the Darling Range.

Specifically Protected Fauna listed in Schedule 1 pursuant to Section 14(2)(ba) of the Wildlife Conservation Act is fauna that "is likely to become extinct or is rare".

The area inundated is mostly cleared farmland, but areas along the Harvey River provide habitat for terrestrial fauna. In particular peppermint (*Agonis*) in riverine areas is a habitat for the western ringtail possum, *Pseudocheirus peregrinus.* Hence a fauna survey of the inundation area was undertaken to determine whether this species was present.

Other Schedule 1 fauna which may be potentially affected by the proposed inundation include:

- chuditch, *Dasyurus geoffroii;*
- quenda or southern brown bandicoot, *Isonodan obesulus fusciventes*; and
- quokka, *Setonix brachyurus*.

Fauna surveys for these would be required as part of a detailed environmental impact assessment for a new Harvey Dam.

Western Ringtail Possum

The western ringtail possum was declared rare in 1983. The decline of the species' distribution has been attributed to habitat loss and/or habitat modification, predation by introduced predators and changed fire regimes.

The site of the proposed Harvey Dam is within the former known distribution of the species. A CALM survey commissioned during September–October 1997 by the Commission found that the western ringtail possum was present in the proposed inundation area, that this population may be at a critically low density and that it may not be viable. Further surveys were recommended. Full details are reported by de Tores and Rosier (1997).

The western ringtail possum is currently managed by CALM in accordance with a (draft) Interim Recovery Plan (IRP). In accordance with the plan, populations have been translocated to Leschenault Peninsula Conservation Park, Yalgorup National Park, the northern jarrah forest south-east of Dwellingup and Karakamia Sanctuary, near Chidlow. To date, only the Leschenault Peninsula translocation has been deemed successful (a self-sustaining population is present). Research is still under way to determine translocation success at the other sites.

Achievement of the EPA's objective with respect to this species would be dependent upon a future developer of the Harvey Dam formulating for the protection of the western ringtail possum a management plan that meets the requirements of CALM.

Chuditch

The chuditch was once common throughout the south-west and wheatbelt of Western Australia. Chuditch populations rapidly declined after European settlement, although they remained fairly common in Perth suburbs until as late as the 1930s. Habitat alteration through clearing, grazing and frequent fires, and predation by and competition from foxes and cats, have had a major impact on the chuditch. They are now at low densities throughout the jarrah forest and the drier woodlands and mallee shrublands. Fox baiting at Mundaring, Batalling and Kingston has resulted in localised increases in chuditch numbers.

A captive breeding program at the Perth Zoo has provided individuals that have been translocated into the Julimar Conservation Park and Lake Magenta Nature Reserve.

In the Harvey Basin, the chuditch is most likely to be present in the forested areas, particularly where dense understorey plant species provide additional cover from foxes. There is a lesser likelihood that chudich are present in vegetation remnants, since they have relatively large home ranges.

Quenda

The quenda was once distributed throughout the southwest of Western Australia from the Moore River east to Hyden and south to Israelite Bay. The current distribution of this species is within the coastal strip from Two Rocks to Esperance and in low numbers throughout the jarrah and karri forests. Quenda are generally restricted to dense streamside vegetation in the jarrah and wandoo forests. The main threats to their survival are fragmentation and loss of habitat, fire and predation by foxes and cats. It is likely that there are populations of quenda in the dense riverine vegetation adjacent to the forest blocks and the Falls Brook Nature Reserve.

Quokka

The quokka was originally distributed on mainland Western Australia from Moore River to Albany, and quokka bones have been found in surface deposits as far east as the Fitzgerald River National Park. The quokka is now restricted to swamps with dense vegetation. Christensen (1985) recorded them in tea tree thickets on sandy soils in the upper reaches of small creek systems. Twelve swamps in State Forest around Dwellingup supported quokka in 1972, although recent surveys indicate that they now occur in only one of the swamps.

The proposed inundation would cause the loss of a small area of wetland vegetation around the existing Harvey Weir. The species is not likely to be present because of past disturbance, but this would need to be confirmed by an appropriate survey.

A detailed environmental review of the impact of a new Harvey Dam on Schedule 1 Specially Protected Fauna should be based on appropriate fauna surveys.

Commitment to the preparation of a management plan to address any impacts on fauna would probably be required.

Other Species

The range of the following priority fauna may include the inundation area:

- brush-tailed phascogale, *Phascogale tapoatafa* (Priority 3)
- western brush wallaby, *Macropus irma* (Priority 4)
- native water rat, *Hydromys chrysogaster* (Priority 4)
- square-tailed kite, *Lophoictinia isura* (Priority 4)
- forest red-tailed black cockatoo, *Calyptorhynchus banksii naso* (Priority 4)
- barking owl (south-west population), *Ninox connivens connivens* (Priority 2)
- masked owl, *Tyto novaehollandiae* (Priority 4)
- crested shrike-tit (s-western subsp.), *Falcunculus frontatus leucogaster* (Priority 4)
- Dell's skink, *Ctenotus delli* (Priority 4)
- carpet python, *Morelia spilota* (Schedule 4)

The proponent of a new Harvey Dam would be expected to address impacts on these fauna in a detailed environmental review required by the EPA.

On the basis that:

- western ringtail possum population in the area may not be viable;
- further fauna surveys are conducted; and
- an acceptable management plan to protect the western ringtail possum is prepared by a developer of a new Harvey Dam,

the Commission believes that the impacts on terrestrial fauna are manageable and consequently, the EPA's objective for this environmental factor can be met.

13.4.4 Mosquitoes

Environmental Protection Objectives

- To ensure that mosquito numbers on the site do not adversely affect the health, welfare and amenity of future residents.
- To ensure that the breeding of mosquitoes is controlled to the satisfaction of the Health Department without adversely affecting flora and fauna.

Commission Assessment

The assessment area for this factor includes the habitable district near a new Harvey Dam and the town of Harvey.

Mosquitoes will breed where there is protection from predators, such as in swampy, well-vegetated areas (Tony Wright, *pers. comm.*). The upper reaches of the proposed new Harvey Dam where the water depth may be shallow and fluctuating is the area most likely to support mosquitoes in numbers that may pose a problem to people. Steep banks devoid of vegetation are least suited to mosquito breeding. Generally, mosquitoes have been a problem only in muddy paddocks within the irrigation areas in the Shire of Harvey (Scott Dandridge, *pers. comm.*).

The developer of a new Harvey Dam should undertake an assessment of the mosquito breeding potential and most likely would be required to commit to the implementation of an appropriate mosquito control program.

On the basis that:

- an acceptable management plan for the control of mosquitoes is prepared, in consultation with the Shire of Harvey by a developer of a new Harvey Dam;

the Commission believes that mosquito breeding is manageable and consequently, the EPA's objective for this environmental factor can be met.

13.4.5 European Heritage and Usage

Environmental Protection Objectives

- To ensure that the proposal complies with statutory requirements in relation to places and sites of heritage significance.
- To ensure that changes to the biological and physical environment resulting from the proposal do not disadvantage land users.

Commission Assessment

The assessment area for this factor includes the Harvey Hills and the town of Harvey.

1. **Private Properties** (refer 8.3.6)

The construction of a new Harvey Dam would have substantial social impacts on residents and landowners in the Harvey Hills. A detailed social impact analysis has been conducted (Beckwith and Associates 1997) is summarised in Section 8.

The significance of any residential displacement would be dependent on whether the resident is full- or part-time and on the person's ability to cope with relocation. Generally, social impacts from displacement are more significant for full-time and long-term residents and those who are elderly. Those who have strong emotional attachment and kinship ties to an area are also more impacted by involuntary relocation.

For 80-m full supply level, 18 properties (5 residences) would be affected to some extent.

The social impact of the relocation process would depend on the individual characteristics of the landowner, the acceptability of purchase arrangements and the ability to find a suitable replacement property.

The process of reallocation would be more easily managed by the developer of a new Harvey Dam if a land acquisition policy were developed which:

- promotes an open and transparent process; and
- ensures landowners are compensated, as far as is possible, so that they are not "worse off".

2. Relocation of Harvey–Quindanning Road

The proposed relocation of the Harvey–Quindanning Road would affect 11 properties and 5 properties would not have access to the new route. The proposed road relocation has the potential to fragment land, disrupt farming operations, affect access to properties and alter the amenity of residents.

The Commission has suggested that the developer of a new Harvey Dam should investigate alternative options that may include:

- the location of the relocated road on property boundaries as far as possible; and
- the upgrading of Logue Road.

These investigations should be implemented in consultation with the Shire of Harvey and affected residents and landowners. The outcome of this process and associated environmental impacts could be included in an environmental impact assessment required by the EPA for a new Harvey Dam proposal.

3. European Heritage (refer Section 8.3.6)

There are no buildings or places in the Harvey Hills that have been placed on the Register of the National Estate. However heritage assessments have identified buildings and features of heritage significance that would be inundated or affected by the proposed Harvey Dam. The Commission would, as a condition of any access licence issued in future, require additional heritage investigations to determine how best to salvage heritage values. The developer would be required to consult with landowners, the Shire of Harvey and the Heritage Council during such investigations.

The outcome of this process could be included in an environmental impact assessment required by the EPA for a new Harvey Dam proposal.

4. Agricultural Land Uses

Agricultural activities may be affected by the loss of productive land and by any restrictions placed that result from water quality protection measures applied to the Harvey Weir catchment. A new Harvey Dam would result in a loss of agricultural land in low-lying areas where the more highly valued agricultural soils are located.

Allowable land-use activities would be similar to those that exist at present, since the existing Harvey Weir is currently used for drinking water.

5. Whitewater Canoeing (refer 11.1.5)

A new Harvey Dam would not detrimentally affect whitewater canoeing activities between the Harvey and Stirling Reservoirs.

The Commission is proposing that whitewater releases continue at historic levels, with additional releases for specific national or internationally significant events. These releases would be conditional on the WA Canoeing Association demonstrating to the Commission that best endeavours would be applied to minimise erosion impacts by implementation of an appropriate water release strategy.

6. Aesthetic Flow

The Commission would require releases from a Harvey Reservoir to maintain aesthetic flow in the Harvey tourist precinct.

7. Recreation on Reservoirs (refer Section 11.2.6)

The Commission recognises the need to establish an appropriate balance between protecting water quality for public supply purposes, developing the recreation potential of the Harvey Rivers Hills reservoirs and maintaining the amenity of the area. While the existing

level of recreational activity is limited, a new Harvey Dam would provide a much larger surface area for recreational activities.

The previous policy prepared by the WA Water Resources Council (WAWRC 1985) is being reviewed by the Commission. The Commission believes that this policy lacks flexibility and needs to take into account any existing and proposed treatment of the public water supply.

The Shire of Harvey has indicated that it considers a number of passive recreation activities (in addition to whitewater canoeing) to be appropriate on and around a new Harvey Dam.

The Commission considers that there are opportunities to accommodate the interpretative centre and picnic areas below the new dam. There is potential to accommodate recreational activities given the intention to treat the public water supply from the dam.

The Commission would develop a recreation management plan for the Harvey and Stirling Reservoirs and their surrounds. The plan would clearly establish what forms of recreation may occur on and around the reservoir.

The recreation management plan would be developed in close consultation with the Harvey Shire, local landowners, recreation organisations and the future developer of the Harvey River Hills resource.

On the basis that:

- a transparent and reasonable procedure is developed by a developer of a new Harvey Dam for compensation of landowners;
- alternative options for a Harvey-Quindanning Road re-alignment would be investigated by a developer of a new Harvey Dam;
- additional heritage investigations to best salvage heritage values would be required;
- whitewater canoeing will be maintained;
- an aesthetic flow would be provided in the Harvey tourist precinct; and
- a recreation plan is developed by the Commission for the new Harvey Dam and Stirling Reservoir;

the Commission believes that the impacts on European heritage and usage are manageable and consequently, the EPA's objective for this environmental factor can be met.

13.4.6 Aboriginal Heritage

Environmental Protection Objective

- To ensure that the proposal complies with the requirements of the Aboriginal Heritage Act.
- To ensure that changes to the biological and physical environment resulting from the proposal do not adversely affect cultural associations with the area.

Commission Assessment

Detailed Aboriginal ethnographic and archaeological surveys were conducted of the area that may be inundated by a new Harvey Dam (Quartermaine Consultants 1998; O'Connor 1998). In addition, a preliminary assessment was made of the significance to Aboriginal people of the Harvey River near the Harvey Estuary (O'Connor 1998).

A new Harvey Dam may potentially inundate two archaeological sites of significance.

The developer of any new Harvey Dam must obtain permission under section 18 of the WA Aboriginal Heritage Act before any disturbance may occur.

The Commission would require compliance with the WA Aboriginal Heritage Act as a pre-condition to obtaining a take and use licence for the Harvey River Hills resource. In addition, the developer of the resource should consult with local Aboriginal people during the detailed design phase of a new Harvey Dam.

On the basis that:

- the a developer of a new Harvey Dam will be required to comply with the Aboriginal Heritage Act; and
- consultations would take place with the local Aboriginal people,

the Commission believes that the impacts on Aboriginal heritage are manageable and consequently, the EPA's objectives for this environmental factor can be met.

13.5 Downstream Environmental Impacts

The Pinjarra–Waroona–Harvey Drainage Catchment has an area of 2055 km^2 and is the largest of the catchments in the Peel–Harvey estuarine system. Historically, the largest drainage line within the catchment was the Harvey River, now also referred to

for about one-half of its length as the Harvey River Main Drain.

The Harvey River was dammed in 1916 with the construction of the Harvey Weir. In the 1930s, the River's flow was substantially diverted directly westwards by the construction of the Harvey Diversion Drain, which discharges to the ocean at Myalup. In 1948 the Stirling Dam was constructed upstream of the Harvey Reservoir.

About 60% of native vegetation has been cleared from the catchment. Drains have been progressively constructed up till the 1980s for winter flood relief and irrigation. A consequence has been increased soil water flow and nutrient loss (Streamtec 1998).

Over 1985–88, the Water Authority of Western Australia and the Environmental Protection Authority negotiated to place a moratorium on further drain construction and introduce controls on farm drainage.

Changes in flow regime in the Harvey catchment since European settlement, together with changes resulting from the proposed dam, are summarised in Table 19

The key features to note are:

- discharges to the Harvey Estuary from the catchment have increased since European settlement due to increased runoff from the Swan Coastal Plain. While environmental water provisions have been established to protect significant environmental values (refer Section 7), there is more than enough streamflow to meet these requirements;
- discharges from the catchment to the Peel–Harvey Estuary would be unaffected by a new Harvey Dam; and
- discharges to the Indian Ocean via the Harvey River Diversion Drain would be approximately halved with the construction of a new Harvey Dam.

The construction of a new Harvey Dam and a Wellesley pumpback facility would not significantly affect flows down the Harvey River on the coastal plain. In addition, there are no significant ecological values associated with the Harvey Diversion Drain that may be adversely affected by modification of streamflow brought about by a new Harvey Dam and a Wellesley pumpback facility.

13.6 Environmental Water Provisions

Ecological (refer Section 7.4)

A review of environmental water requirements and provisions for identified significant environmental values are presented in Section 7 and detailed by Streamtec (1998). Environmental provisions that would apply to water resources other than the Harvey River Hills resource are outlined in Section 11.2.

The most significant environmental values downstream from the Harvey Weir are in the lower Harvey River. This section of the river, although highly modified by human activities, is sustained by tributaries in the northern parts of the Basin and runoff from the coastal plain. The lower Harvey River is dependent for its health on the remaining streamflow from the hills segments of these tributaries (but not the Harvey River and its tributaries above the Harvey Weir or the Wellesley Creek).

A water regime for the lower Harvey River has been established to protect existing ecological values (Section 7, Table 10).

Table 19. Changes in flow regime in the Harvey Basin.

	Catchment	Annual average flow (GL)	Discharge to Peel Harvey Estuary (GL)	Discharge direct to ocean (GL)
Pre-European	Darling Range	85		
	Swan Coastal Plain	57		
	Total	147	142	5
Current	Darling Range	32		
	Swan Coastal Plain	170		
	Total	202	202	78
New Harvey Dam (with Wellesley pumpback	Total	202	202	23

The unregulated tributaries (Section 11, Table 17) in the northern portion of the Basin, in the absence of upper Harvey River flows, provide sufficient water and typical seasonal patterns to ensure the adequate functioning of the downstream riverine and estuarine ecosystems.

The Commission has established the following environmental provisions for unregulated, semi-regulated and regulated tributaries of the Harvey River:

- an interim provision of 5.5 GL/yr or 30% of annual streamflow of the Wellesley and Wokalup Creeks;
- no less than 95% of the present mean streamflow in unregulated and semi-regulated streams (except Wellesley and Wokalup Creeks) from the Darling Scarp;
- no further significant development of regulated streams to occur until environmental water provisions are established for these streams; and
- release strategies from existing storages to be developed to maximise the benefits of river restoration.

Aesthetic Flows (refer Section 11.2.4)

The Commission supports the need for aesthetic flows in the Harvey tourist precinct and has set an allocation to meet this need (Section 11.2.4). This allocation would improve the visual amenity of the precinct during the dry summer months.

The Commission believes that banking up flow behind a barrier may be an efficient use of water, provided water quality problems are avoided in the impoundment. Preliminary design of such a facility would suggest that water quality problems would be overcome by a minimum streamflow of 25 L/s over the summer period.

13.7 Greenhouse Gas Emissions

Environmental Protection Objective

- To ensure that all reasonable and practicable measures are taken to minimise the emission of greenhouse gases.

Commission Assessment

Greenhouse gas emissions for development options are described in Section 7.7 and Table 12. The maximum emission of greenhouse gases for options involving the development of a new Harvey Dam and a pumpback facility on Wellesley Creek is estimated to be 24713 t/yr.

This amount is roughly equivalent to about 0.04% of the amount of greenhouse gases emitted in Western Australia in 1990.

Some greenhouse gases would be emitted from the inundation of vegetation but these emissions are anticipated to be more than offset by restoration of riverine vegetation elsewhere.

The Commission would expect that the developer of a new Harvey Dam would implement a strategy to minimise greenhouse gases in accordance with EPA requirements.

On the basis that:

- the annual emissions from greenhouse gases from any development of the Harvey River Hills resource would be relatively small;
- the Commission would require the restoration of riverine vegetation that would more than offset greenhouse gases lost through inundation of vegetation; and
- a strategy to reduce greenhouse gases would be required'

the Commission that the impacts from the emission of greenhouse gases are potentially manageable and consequently, can meet the EPA's objectives.

13.8 River Restoration

As described in Section 11.6, restoration of key components of the Harvey River ecosystem is required for environmental water provisions to have a beneficial impact. The mechanisms proposed to give effect to a restoration program would include:

- the establishment of a Harvey River Restoration Trust;
- a Catchment Management Plan coordinated by the Commission;
- the preparation of a Harvey River Restoration program; and
- a review of the role of the Harvey Diversion Drain by the Water Corporation.

13.8.1 Ecological Values and Features

This section contains an outline of objectives and guidelines for the restoration of ecological values and features of the Harvey River.

Ecological values and features are described in Section 7.4.

Environmental Protection Objectives

- To maintain and enhance the identified ecological values by creating and managing appropriate features and habitat in the Harvey River.
- To maintain the abundance, species diversity, geographic distribution and productivity of existing riverine vegetation and wetlands and create new wetlands where possible.
- To ensure that the Environmental Protection Policy (EPP) lakes are protected and their key ecological functions are maintained.

The identified ecological values and features are listed in Table 20

Table 20. Harvey River ecological values and features.

Ecological Value	Ecological Feature
Riverine fish	Suitable in-stream habitat
Aquatic invertebrates	Channel stability
Estuarine fish	Channel morphology
Riverine and floodplain vegetation	Ecosystem processes
Wetlands	Riverine–stream linkages

Riverine vegetation, floodplain vegetation and wetlands are described in Section 7.4

There are no EPP wetlands likely to be affected by the proposed dam. Care would need to be taken, however, to ensure that riverine restoration does not compromise the ecological integrity of wetland systems.

Coastal plain wetlands in areas of high phosphorus export act as nutrient sinks, collecting phosphorus from agricultural runoff. Disturbance of these areas may lead to phosphorus loss into the drains from wetland vegetation and soils.

Further research is suggested on the ability of wetland species to tolerate variable water regimes.

Restoration Guidelines

Suggested key elements for river restoration are:

- using compensatory basins to reduce flow velocities in river sections below impoundments/drainage channels;
- stabilising streambeds prior to bank stabilisation;
- using large woody debris in streams to create a stable substrate for aquatic macroinvertebrates and to provide fish habitats;
- examining the role of v-notche weirs and other barriers to the upstream migration of fish;
- replanting native riverbank vegetation to reduce scouring, while taking care to ensure local flow velocities are not altered;
- concentrating replanting for the reduction of nutrient inflows in regions of smaller catchments;
- ensuring that livestock access to riverine vegetation is restricted to prevent erosion and allow vegetation recolonisation;
- ensuring that weeds and feral animals are controlled;
- ensuring that if erosion is due to insufficient stream capacity to carry flood flows, vegetation is not replanted nor allowed to recolonise sediment bars;
- ensuring that drains do not empty into salt-marshes but cut across them;
- ensuring that drains do not empty into stationary water bodies, as this facilitates the spread of weed species;
- ensuring that drains empty into Melaleuca swamp associations, but only if drain flow replaces natural drainage flow;
- ensuring that there is some erosion and siltation in order to maintain dynamic relationships of wetland vegetation and channel morphology; and
- planting the periphery of drainage channels with sedge species to prevent excessive erosion, aid in reducing flow velocities and act as a vegetative nutrient buffer.

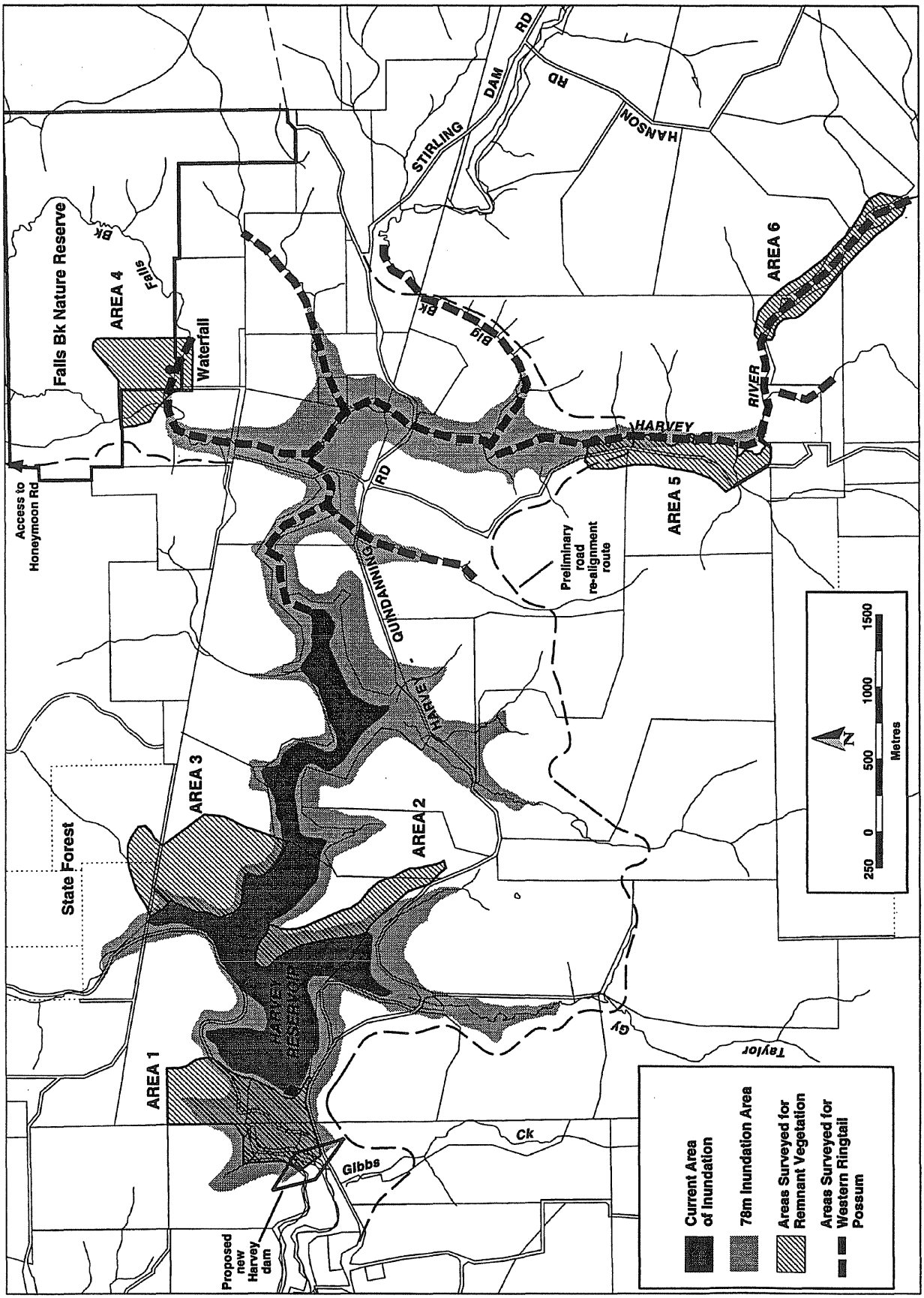


Figure 18. Remnant vegetation in the vicinity of a new Harvey Dam.

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15. Glossary

TERMS

Allocation Giving an entitlement to use water or setting aside a water resource for a designated use.

Aquifer A geological formation or group of formations capable of receiving, storing and transmitting significant quantities of water.

Beneficial use The current or future uses for a water resource that have priority over other potential uses because of their regional significance to the community. Beneficial use designations provide guidance in determining the management and protection of the quality and quantity of the resource.

Catchment The surface area from which run-off flows to a river or a collecting reservoir such as a lake or dampland.

Channelisation The down-cutting of streambeds as a result of streamflow, or artifically by the construction of channels which alter the river bed.

Consumptive use Any activity that depletes the total flow or volume of water in a water body.

Dam A structure constructed across a river valley to store streamflow and allow it to be diverted for water supply use and for release in a controlled manner for downstream use.

Demand The amount of water required from the water supply system.

Diversion Development of a water resource to harvest some or all of its divertible water.

Divertible water The average annual volume of water that could be removed from developed or potential sources on a sustainable basis.

Drain Every channel, gutter, ditch, tunnel, pipe, cutting or passage on, above or underground, constructed used, or intended to be used for draining or diverting water from land, except a navigable river, and except a main or branch water-race made for the supply of any reservoir, dam or pit for the conservation of water.

Ecological water requirements Water regimes needed to sustain the ecological values of aquatic ecosystems at a low level of risk.

Ecologically sustainable development Development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends.

Environmental water provisions That part of environmental water requirements that can be met.

Fresh water Water of salinity less than 500 mg/L TDS.

Geotechnical releases Releases from storages for safety testing purposes.

Gigalitre One billion litres.

Groundwater Water that occupies the pores and crevices of rock or soil. Sub-surface water in the zone of saturation.

Instream water use Any use of the flow or waters of a water body that does not remove the water (e.g. swimming).

Inundation Covering with water.

Irrigation Any method of causing water from a watercourse, a water services works or an artificial collection of water to flow upon and spread over land; or applying water to land from a watercourse, a water service works or an artificial collection of water for the purpose of cultivation of any kind or of tillage or improvement of pasture.

Key stakeholders Persons or organisations that have a substantial interest in a particular matter.

Kilolitre One thousand litres.

Megalitre One million litres.

Pipehead A small dam from which water is piped directly for use or into a storage dam.

Pumpback Diverting some streamflow by pumping from a dam through a pipeline into another storage.

Regional Water Resource Allocation Plan A document prepared by the Water and Rivers Commission setting out the background, policy and rules relating to protection of the water resource and the environment, and to allocation of water resource to classes of use.

Regulated stream A stream on which are located substantial dam(s) or barriers which divert a major proportion and substantially alter the pattern of streamflow.

Resource yield The yield of water that may be obtained from a resource using a certain development configuration.

Riparian rights The owner or occupier of any land alienated from the Crown through or contiguous to which runs any watercourse, or contiguous to which, or partly within which, is situated any lake, lagoon, swamp or marsh, has the right, to take water in that water-course, lake, lagoon, swamp or marsh free of charge for the domestic and ordinary use of himself and of his family and servants, and for watering cattle or other stock; and every owner of land alienated from the Crown has a further right to take such water for the irrigation of a garden not exceeding 2 hectares in extent, being part of that land and used in connection with a dwelling.

River basin The catchment of river(s) as defined by the Australian Water Resources Council for presenting hydrological data.

Samphire (salt marsh) A type of vegetation found in sheltered river estuaries subject to frequent covering by tides.

Scheme supply Water diverted from a source (or sources) by a water authority or private company and supplied via a distribution network to customers for urban, industrial or irrigation use.

Self-supply Water diverted from a source by a private individual, company or public body for their own individual requirements.

Semi-regulated stream A stream that is subject to some damming or barriers that may divert a significant proportion of streamflow and significantly alter its pattern.

Storage reservoir A major reservoir of water created in a river valley by constructing a dam.

Surface water Water flowing or held in streams, rivers and other wetlands in the landscape.

Sustainable use Diversion of water at a replenishable rate.

Sustainable yield The rate of water extraction from a source that can be sustained on a long-term basis without exceeding the rate of replenishment.

System yield The maximum demand that the water supply system can sustain under specified expectation of restrictions (currently restrictions are expected in 10% of years).

Treatment The application of techniques such as settlement, filtration and chlorination to render water suitable for drinking purposes.

Turbidity The clouding of water by suspended material, causing a reduction in the transmission of light.

Unregulated stream A stream that is not subject to damming or barriers which significantly affect streamflow.

Water resources Water in the landscape (above and below ground) with current or potential value to the community and the environment.

Wetland An area of seasonally, intermittently or permanently waterlogged soils or inundated land, whether natural or otherwise, fresh or saline.

Yield benefit The increase in system yield which occurs when a new source is added to the water supply system.

ABBREVIATED TERMS

AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
AWRC	Australian Water Resources Council
CALM	Department of Conservation and Land Management
COAG	Council of Australian Governments
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EPA	Environmental Protection Authority
FSL	Full supply level

GL	Gigalitres
ha	Hectares
kL	Kilolitres
km	Kilometres
LCDC	Land Conservation District Committee
m	Metres
MAF	Mean Annual Flow
ML	Megalitres
PIMA	Peel Inlet Management Authority
PMWSS	Perth Metropolitan Water Supply Scheme
ppt	Parts per thousand
SWI	South West Irrigation
t	Tonne
TDS	Total Dissolved Salts.
WAWA	Western Australian Water Authority
WAWRC	Western Australian Water Resources Council
WRC	Water and Rivers Commission
yr	Year

Appendix A
Persons and Organisations Interviewed

Keith Leece	Shire of Harvey
Chad Hunt	Shire of Harvey
Sue Sanders	Harvey Agricultural Senior High School
Rob Van Leeuwen	Operations Manager, Rally Australia
Jan Watts	Harvey Districts Tourist Bureau
Barrie Price	Harvey Chamber of Commerce
Neil Guise	Agriculture WA
Larry Guise	Ministry of Planning (Bunbury)
Rob Paull	Ministry of Planning (Bunbury)
Ellen Gude	Shire of Waroona
Phil Moyle	South West Table Grape Growers
Dominique van Gent	SW Development Commission
Steve Bunce	Logue LCDC
David Lofthouse	WA Farmers Federation
John Bradshaw	MLA, Member for Wellington
Michael Lowe	Viticulture consultant
Ian Hocking	Hocking Planning and Architecture
Tony Snelling	Water Corporation (Bunbury)
Mark Leathersich	Water Corporation (Perth)
Gary Crisp	Water Corporation (Perth)
Helena Coles	Alcoa (Booragoon)
Ken MacIntosh	Alcoa (Willowdale)
Colin Thorpe	WA Water Canoeing Association
Bruce Withnell	State Emergency Services (Harvey)
Elaine Green	Harvey Oral History Group
Kerry Davis	Harvey Historical Society
Tom Perrigo	National Trust of Australia (WA)
Ian Elliot	Heritage Council of WA
Wally MacKowiak	WA Trout & Fresh Water Angling Assoc. Inc.
Peter Hanley	CALM (Bunbury)
Peter Henderson	CALM (Bunbury)
Ron Stone	Alcoa Wagerup Refinery
Tony Hiscock	Alcoa Farm Properties
Patrick Dick	Department of Resources Development
Lorele Fry & members	Harvey Farm Improvement Group
Geoff Calder	South West Irrigation
Dan Norton	South West Irrigation
Ian Eckersley	South West Irrigation
Jon Warren	Agriculture WA (Peel Harvey Catchment)
Christine Sharp	MLC (South West)
Kevin O'Connor	Shire of Waroona
John Scharf	Ministry for Planning (Peel Region)
Jim Sargent	WA Tourism Commission (Peel Region)
Brett Flugge	Shire of Murray
Warren Tucker	Harvey Hills Preservation Group
Chris Boyle	Harvey Hills Preservation Group
John Parravacini	Harvey Hills Preservation Group
Murray Sharp	Harvey Horticultural Improvement Group
Rob Knight	Harvey Horticultural Improvement Group

Greg Williams	Peel Development Commission
Neil Ovens	Greening WA
Rodney Lenanton	Fisheries Department
Rob Towes	CALM
Murray Love	CALM (Nature Conservation)
John Hughes	Peel Inlet Management Authority
Tim Sparks	Peel Inlet Management Authority