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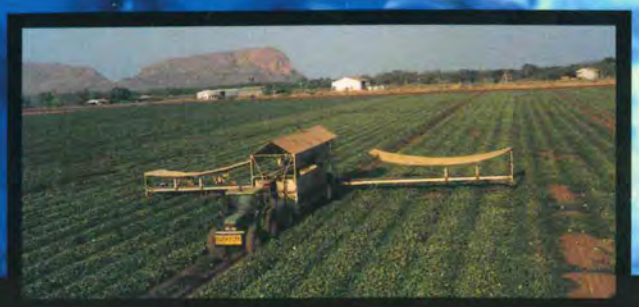


ORD LAND AND WATER MANAGEMENT PLAN 2000




PREPARED BY THE COMMUNITY OF KUNUNURRA

THE GOVERNMENT OF WESTERN AUSTRALIA
Agriculture WESTERN AUSTRALIA
WATER AND RIVERS COMMISSION
Natural Heritage Trust

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Foreword

The Land and Water Plan started when some locals wanted to address the problems of rising ground water in the irrigation area. When the love for our country and the need to preserve its well being were recognised it became obvious that we needed to involve the whole community in developing a plan to cover all the areas of our environment.

We have been lucky, as a community, to have had the time to study the environmental challenges we face. For the last three years the community of Kununurra and the Lower Ord has worked towards a plan to improve how we manage our natural resources. That plan is nearing completion so that now, when dealing with a resource problem, we have a process that can use knowledge, common sense and feeling to develop workable solutions, rather than just self interested passion.

The land and water management plan has been developed with every community member having the opportunity to be involved and have input. It has been interesting to see people with such diverse opinions and beliefs respecting each other so they could work together to set realistic goals and develop a range of workable strategies.

The steering committee has been fierce in keeping it local, with everybody having input.

They have encouraged the community to take control, to look after its own problems and tum them into opportunities and challenges. So lets take control of our community, its land, the river and the people and use the Ord Land and Water Management Plan to work for us. BUT with control comes responsibility and this is going to hurt unless we join in and work together on the challenges.

We each need to really try when we say, **"When we do what we do we should not affect others negatively."**

The support from Government Departments and the respect they have given the community during the development of the plan have been appreciated and their commitment to the future is acknowledged.

We need to develop a gentleness and respect towards our use of the natural resources of our area, we cannot continue *"to bang them about."* We have to look at the whole and not just the parts and develop ways that don't just treat the symptoms but genuinely meet the challenges.

We can be ***World leaders*** and be proud of it.

Tim Croot
Chairman Steering Committee

Community Steering Committee (L-R) Jenny Haley, Joe Sherrard, Tim Croot (Chairman), Andrew Kelly, Wilhelm Bloecker, Tarnya Vernes, Geoff Lodge

Chapter 1 – Executive Summary

1.1 The Imperative

The wise use of the land and water of the Ord has become an imperative driven by increasing awareness of the impacts of current uses on ground water and the on the quality of the Ord River itself.

We have been lucky as a community that these resources are still in reasonable order and that we have the time to address the resource management challenges associated with our use of them. There is a wide range of land and water management issues to be addressed and all those involved have responsibilities to address some of those issues.

1.2 Our Approach

Our approach was to empower the community to identify the issues it saw as important to the long term wise use of the land and water that make up the natural resources of the Ord River Irrigation Area and surrounding riverine systems.

The Project was conducted in a number of stages from an initial information and communication phase through to the implementation of the recommendations.

Phase 1: Information transfer and awareness building using a number of media forms, central to which was a regular newsletter that contained brief stimulating articles associated with land and water management. This phase was completed by the election of a steering committee to oversee the rest of the project.

Phase 2: Identification of the management issues through extensive consultation with industry, community and other interest groups culminating in the formation of four Local Action Groups made up of interested community members with a wide range of interests.

Phase 3: The setting of goals and development of strategies to address the issues identified during phase 2. This Plan marks the end of this phase.

Phase 4: The implementation of the plan using structures established by the community through the work of the Local Action Groups. These structures establish the framework for the development of the partnerships between Industry the Community and Government Agencies that will be necessary to successfully implement the plan.

1.3 Implementing the Plan

The Community through its local action group members decided the best option was for a ***Board of Local People*** to oversee the implementation of the Plan.

This Board should be provided with resources to enable it to function and to employ a full time coordinator.

- **This Board would consist of six elected community members.**
- **They would have the power to coopt two additional full time members if they considered particular groups within the community were under represented.**
- **These six to eight members would then form the full time membership of the board.**
- **Relevant experts would be brought in to help make decisions on particular aspects of the plan implementation.**
- **These experts would function as full members of the board during the deliberations within their field of expertise.**
- **Only residents of the Shire of Wyndham East Kimberley would be eligible to serve as community board members.**
- **Upon leaving the Shire the member's position on the Board would be deemed to become vacant.**
- **The inaugural board would be responsible for deciding on their operating rules, succession plan, values, vision and goals while overseeing the appointment and management of a project coordinator.**
- **They would be charged with implementing the recommendations contained within the Land and Water Management Plan and for ensuring an ongoing commitment to improving management of land and water in the ORIA.**

1.4 The Plan

A wide range of issues associated with our use of the land and water of the Ord has been identified. The existing knowledge and more importantly the knowledge gaps associated with these issues have been identified. The essence of the Plan is the goals and strategies for achieving them and they are summarised here.

1.5 Ground Water

1.5.1 Goals

- **Reduce ground water levels to below two metres from the surface across the whole irrigation area within five years while preventing any new areas from rising above that level.**
- **Hold the quality of ground water at or above the high quality present in 2000.**

Strategies

Reduce the rate of entry of water into the ground water by:

- Improving irrigation management
- Reducing leakage of water from infrastructure and fields

Remove ground water and either reuse or remove it to drains by:

- Installing and operating a system of de-watering bores
- Planting high water use trees

Monitor management impacts and research improved irrigation and drainage management methods by:

- Continuing to monitor ground water levels
- Gathering information from bores and excavations to refine ground water models
- Identifying areas of "leakage"
- Identifying and testing low volume pumping systems
- Developing whole management systems based on best current available knowledge

Minimise the risk of contaminating ground water by:

- Understanding risks of contamination posed by nutrients, salinity, agricultural chemicals and harmful bacteria.
- Reducing the risk from mobile nutrients
- Conducting education programs to create an awareness of the potential problem and ways of reducing the risks

Provide useful information on the levels of contamination

- Monitoring ground water quality
- Including quality tests of ground water as part of quality assurance programs.

1.6 Irrigation Efficiency

1.6.1 Goals

- **To improve irrigation management to achieve 65% average annual water use efficiency on all irrigation farms within 5 years.**
- **To improve irrigation infrastructure and management to achieve a water delivery efficiency of 75% within five years**

Strategies

Improve water use efficiency and reduce surface water losses by:

- Adopting alternative irrigation systems
- Investigating and installing tail water reuse and recycling systems where appropriate.
- Developing optimal field layout, run length, grade, siphon size, irrigation time, bed and furrow size and shape recommendations
- Ensuring irrigation fields are leveled to appropriate uniform grades

Improve water use efficiency and reduce ground water recharge by:

- Identifying areas of soils that leak
- Developing irrigation systems to manage soils of high permeability.
- Implementing practices that minimise accessions to ground water during pre irrigation
- Ensuring that on farm water stores are correctly sealed

Provide research, demonstration and monitoring services to:

- Quantify the level of accessions to ground water and measure trends in ground water levels.
- Quantify the volume irrigation tail water
- Demonstrate new irrigation techniques
- Map soil permeability
- Develop guides for irrigation field layout

1.7 Surface Water Quality

1.7.1 Goals

- **To reduce the load of chemical contamination in tail water by 40% within 5 years**
- **To reduce the load of nutrient contamination in tail water by 40% within 5 years**
- **To reduce sediment loads in tail water by 40 % within 5 years**

Strategies

Improve irrigation management by reducing sediment loads in tail water by:

- Ensuring that all irrigation fields are leveled and tail drain and farm drainage outlets are constructed to minimise the risk of erosion.
- Designing irrigation fields with run length, grade, siphon size and watering interval such that fields can be fully watered in the shortest practical time.
- Employing erosion stops, sediment traps and drop-structures

Reduce the volume of tail water by:

- Investigating and adopting alternative irrigation techniques
- Identifying suitable locations for demonstrating the effectiveness of tail water reuse and recycling systems
- Developing and testing tail water recycling systems

Use farming practices designed to reduce erosion during both the cropping and wet seasons by:

- Growing cover crops
- Using Polyacrylamide (PAM) to retain sediment (including colloids) infield.
- Developing farming systems that are designed to reduce soil loss
- Using minimum tillage practices where possible.

Employing off farm management options by:

- Installing artificial wetlands within the drainage system
- Revegetating high erosion risk areas adjacent to drains and the river.

Minimise the risk of fertiliser movement off farm by:

- Placing fertiliser accurately
- Matching applications to crop growth demands
- Using foliar fertiliser to meet crop demands
- Applying PAM to irrigations following fertiliser application

Prevent fertiliser from reaching the river system by:

- Using artificial wetlands
- Using less mobile forms of fertilisers and nutrients

Reduce the risk of chemical movement off farm by:

- Certification and audit of commercial and farm spray operators.
- Accurately placing pesticides.
- Using less volatile formulations of pesticides.

Reduce the amount of chemical used by:

- Supplying information on correct application rates.
- Implementing Integrated Pest Management programs for all crops.
- Utilising modern gene technology.
- Developing farming systems that maximise the natural plant defences against pest and disease attack.

Reduce the environmental risk posed by pesticide use by:

- Encouraging the registration and use of products with short half-lives that are known to be soft on the environment.

Provide research, demonstration, monitoring and training services to:

- Monitor soil loss from farms and sediment, nutrient and chemical loads of drains and river systems.
- Develop and update a spray calendar for the irrigation area.
- Quantify the soil, nutrient and chemical composition of sediment mobilised in tail water, and trapped in silt traps.
- Monitor tail water flow volume.
- Investigate new management initiatives and to demonstrate systems for managing sediment movement.
- Use crop scouting services to monitor pest populations.
- Ensure registration of appropriate chemicals for crops being grown in the irrigation area.
- Encourage the continued development and availability of new improved chemicals.
- Provide training in chemical use, farming methods and nutrition management for crops on the Ord.

1.8 Pest and Pesticide Management

1.8.1 Goals

- **A 100% increase in the adoption of Integrated Pest Management for all compatible crops within five years.**

Strategies

Reduce the risk of resistance build up in chemical control measures by:

- Using all chemicals according to recommended rates and concentrations.
- Adhering to a spray calendar.
- Using crop scouting to determine spray requirements.
- Using integrated pest management systems.
- Understanding the patterns of resistance development to reliably predict problems.

Increase the adoption of Integrated Pest Management by:

- Demonstrating the advantages of using a range of control measures.
- Developing IPM systems for all crops.
- Establishing insect population thresholds to initiate sprays under tropical conditions.

Ensure optimal performance of all spray operators by:

- Encouraging all operators to be properly accredited.
- Minimising the risk of accidental chemical contamination of the river system.
- Encouraging the use of modern spray equipment

Improve the image of spray operators and of aerial spraying as a control method by:

- Ensuring good communication between neighbours to minimise the risk of conflict associated with spraying operations.
- Increasing the amount of information on spraying and chemical use to increase community understanding about spraying.
- Developing a code of practice and adhering to it.

1.9 Chemical Handling and Storage

1.9.1 Goals

- **100% of farmers to be accredited chemical applicators within two years**
- **100% of farm chemical stores to comply with Australian and Western Australian Standards within five years**
- **All past chemical container dump sites to be identified, assessed and, where necessary, contained within five years**

Strategies

Ensure the safe handling and storage of chemicals by:

- Creating greater awareness of the storage guidelines.
- Encouraging safe chemical storage and handling on farm.
- Ensuring that safe handling and wash down areas are included in quality assurance programs.
- Ensuring chemical handling facilities are designed and located to safely contain spills.
- Ensuring all chemical users are appropriately accredited under the Farm Safe Program.

Ensure the safe disposal of used chemical containers by:

- Encouraging the Shire of Wyndham East Kimberley to become a participating shire in the Drum Muster Program.
- Implementing an information program to encourage chemical users to participate in the Drum Muster Program.

Identify, contain and render safe past chemical container dumping sites by:

- Identifying and clearly marking past disposal sites.
- Identifying the current and future risks associated with them.
- Removing the risks to the environment or to human health associated with these sites.

1.10 Sugar Mill

1.10.1 Goals

- **A sugar mill that always operates at or above Australian Best Management Practices for the management of by-products.**

Strategies

Ensure that all by-products are returned to farm by:

- Marketing mill by-products profitably.
- Encouraging the production and use of compost.

Reduce the level of by-products by:

- Improving management methods to reduce the amount of mud being brought to the mill.
- Developing new varieties of cane that produce less bagasse than existing varieties.

Monitor the ground water levels and quality around the ash settling and drying ponds.

1.11 Fish Stock Management

1.11.1 Goals

- **To maintain and protect existing fish stocks with a view to increasing them if required in the future.**

Strategies

Protect the existing fish stock from overfishing by:

- Understanding the carrying capacity of the fishery.
- Licensing recreational fishers to fish on the Ord River and to keep a log book as part of this license requirement.
- Developing and promoting a fishery management plan for the Ord River fishery.
- Increasing policing to prevent overfishing.
- Researching the impact that all land and water users have on the capacity of the river to support a healthy fishery.

Investigate proposals relating to fish stock management on the Ord River including:

- Considering the stocking of Lake Kununurra with barramundi.
- Examining the feasibility of a fish ladder Lake Kununurra to the Dunham River.

Ensure better understanding of how to sustainably fish the river for recreation by:

- Conducting extensive publicity and education programs.
- Involving the whole community in research, information gathering and monitoring.
- Increasing the understanding of the fishery.

Minimise the potential conflict between aquaculture and other land uses by:

- Ensuring aquaculture ventures meet the environmental standards required of them.
- Ensuring that planning schemes provide for the segregation of aquaculture and agriculture/ horticulture.
- Identify and resolve potential conflicts between competing land users.
- Supporting well planned aquaculture ventures.

1.12 Recreational River Use

1.12.1 Goals

- **To develop a recreational and commercial use plan for the Ord River within 3 years**

Strategies

Reduce rubbish and other pollution of the river by:

- Developing guidelines for river management.

Reduce the pressure on the river from recreational use by:

- Developing management guidelines for recreational use of the river.
- Ensuring these guidelines are developed in conjunction with the community, implemented and that they are enforceable.
- Managing high use areas.

Improve the understanding of issues associated with recreational use of the river by:

- Conducting information and education programs.
- Involving all recreational groups in planning for recreational use.
- Encouraging recreational user groups to manage the areas they use.
- Developing and implementing best management practices for recreational use of the river and lakes.

Improve safety on the water by:

- Enforcing boating codes of practice.
- Regulating speed limits at specific locations along the river.
- Maintaining awareness of crocodile presence in waterways.

1.13 Riparian Areas

1.13.1 Goals

- **To prevent further damage and modification to the natural riparian vegetation**

Strategies

Reduce the impact of use on the riparian areas by:

- Educating the public about the importance of the riparian zone.
- Limiting user access to particular serviced access points.
- Including the riparian areas in an overall river management strategy.

Prevent further damage and modification to the natural riparian vegetation by:

- Implementing a river management strategy.
- Excluding cattle from areas where they are having a negative impact.

Monitor changes in the riparian zone ecology by:

- Monitoring changes in the condition of the riparian zone.

1.14 Water Allocation

1.14.1 Goals

- **To develop a plan to allocate water from the Ord River to competing uses including he environment. To develop the plan with full community involvement within 5 years.**

Strategies

Develop understanding of the environmental requirements of the river downstream of the irrigation area by:

- Encouraging planned research to determine the Environmental Water Requirements.
- Basing river flow management on up to date information from monitoring programs.

Develop a Water Allocation Plan by:

- Taking into account the requirements of:
  - (a) the downstream environment
  - (b) Stage 1 Irrigation Area
  - (c) Ord Hydro Pty Ltd
  - (d) Recreational users
  - (e) Other potential water users including Stage 2.
- Ensuring involvement of key stakeholders in the development of the Water Allocation Plan

1.15 Dunham River

1.15.1 Goals

- **Reduce the off farm exports of chemicals nutrients and soil into the Dunham River during the dry season by 50% within 5 years**
- **Within ten years develop a full catchment plan for the Dunham River that involves all the stakeholders**

Strategies

Improve the quality of water flowing through the Dunham River by:

- Revegetating the catchment of the river.
- Providing cleaner water from the irrigation system.
- Managing the water flows in the Ord to improve the management of the Dunham River.

Reduce the amount of drainage water entering the Dunham during the dry season by:

- Reducing the amount of tail water leaving irrigation farms.
- Investigating the reuse of tail water.

Provide monitoring and research information to enable adjustments to management by:

- Quantifying the flows and requirements to maintain a healthy Dunham river.
- Regularly monitoring water quality in the Dunham.
- Ensuring that all stakeholders have timely access to monitoring information.

1.16 Surplus ORIA Stage 1 Water - Cave Springs Gap

1.16.1 Goal

- **Minimise the impact of Stage 1 float and management water on the flora and fauna of the Weber Plain**

Strategies

Reduce the amount of system float water leaving Stage 1 by:

- Minimising the amount of water leaving the Stage 1 system.
- Investigating the recycling of water from Stage 1.

- Ensuring this water becomes a part of the supply system for Stage 2.

Better understand the likely impact should Stage 2 not go ahead by:

- Monitoring impacts of this water on vegetation, wildlife and ground water.

1.17 Flood Management

1.17.1 Goals

- **Develop, with community involvement, a plan to manage flooding of the Ord River by December 2000.**

Strategies

Minimise the impacts of flood events on water users by:

- Developing a flood management strategy that includes:
  a) A communication strategy and,
  b) Timely monitoring and forecasting.

Incorporate a coordinated flood management strategy in the planning for the Ord River.

1.18 Pest and Feral Animals

1.18.1 Goals

- **Ensure there are no new feral species introduced into the irrigation area that have the potential to reach problem proportions and have a negative impact on native species**
- **Increase the understanding of pest and feral species, their impacts and control methods.**

Strategies

Reduce the impact of pest and feral animals by:

- Monitoring pest, feral and potential feral species
- Educating animal owners and making them aware of pest issues.
- Researching potential feral and pest species, behaviour and control .

Encourage SWEK, in consultation with the Agricultural Protection Board, to develop management guidelines for pest and feral species in the Shire {*}.

1.19 Fire

1.19.1 Goals

- **Increase the understanding of causes and frequency of unplanned fires and their impact to enable effective management**
- **Reduce the frequency of unplanned fires in the area by 10% per year over the next five years**

Strategies

Reduce the risk of and damage caused by unplanned fires by:

- Encouraging pro-active fire management.
- Developing a fire education and awareness program.

Encourage SWEK, the Volunteer Brigades and the Fire and Emergency Services Authority of WA to work together to develop a detailed response plan for fire events in the Shire {*}.

Encourage SWEK to develop guidelines for pro-active fire management in the area by:

- Enforcement and surveillance of council By Laws.
- Encouraging pro-active management on vacant town areas.
- Compiling a database of fire "hotspots" from around the area.

1.20 Weeds

1.20.1 Goals

- **Ensure that there are no uncontrolled outbreaks of new weed species in the area in the future.**
- **Ensure the development of the Regional Weed Strategy in order to reduce the impact of current weed species on the area.**

Strategies

Prevent the introduction and spread of new weed species to the area by:

- Maintaining the border checkpoint.
- Continuing the development of the Regional Weed Strategy.
- Developing an education and awareness program about current weed species and future potential.
- Developing an easy to read booklet on weeds in the region.

- Encouraging fishermen, bushwalkers, etc to report sightings of weed species.
- Providing plant identification material that is easy for the general public to access.

Control the spread of weed species by:
- Finalising the Regional Weed Strategy.
- Developing an education and awareness program about the risk posed by weeds.

Eradicate weed species where appropriate and feasible.

Encourage SWEK and the Agricultural Protection Board (AGWEST) to develop guidelines for the management of weeds in the area. {*}

1.21 Off Property Clearing

1.21.1 Goals

- **Ensure there is no illegal off property clearing.**
- **Ensure that clearing that is undertaken conforms to appropriate formal processes.**

Strategies

Reduce off property clearing, by:
- Ensuring guidelines for clearing and development are unambiguous.
- Ensuring that landholders are aware of and adhere to these guidelines.

Improve the management of roadside verges, by:

- Managing weed species in these areas.
- Including these areas in an "Environmental Management Plan."
- Clarifying the purpose and use of these areas.

1.22 Bush Corridors

1.22.1 Goals

- **Preserve the remaining areas of native vegetation that have the potential to act as wildlife corridors**
- **Within 5 years identify where new corridors are required for the conservation of biodiversity.**

Strategies

Encourage the preservation of remnant vegetation areas that still exist by:
- Identifying the location of areas of remnant vegetation.
- Working with landholders to help manage these areas.
- Conduct research on the requirements for wildlife corridors given the geography and scale of the ORIA.

1.23 National Parks and Conservation Reserves

1.23.1 Goals

- **Increase the area in the reserve system by incorporating currently proposed areas (Packsaddle Swamp, Carr Boyd ranges, Cambridge Gulf Marine Reserve).**
- **Within two years develop a plan to manage the impact of visitors on popular recreational areas that are outside national parks.**

Strategies

Encourage joint planning on fire and weed management around National Parks and Conservation Reserves by:
- Involving CALM, SWEK, DOLA, fire brigades, the Kimberley Bush Fire Service and Traditional Owners in a joint planning initiative

Reduce the impacts of visitors on popular recreation areas (outside the National Parks) by: {*}
Education and awareness.

- Appropriate signage.
- Provision of facilities.
- Involving the landholder (station management, traditional owners, DOLA (for areas of UCL) etc) and the SWEK in the management of these areas.

1.24 Native Plants and Animals

1.24.1 Goals

- **Maintain and protect the biodiversity of the plants and animals within the Ord River Irrigation area and surrounding areas included within this study.**
- **Increase the understanding of and interrelationships between native plant and animal species found in the area.**

Develop a local database for recording native plants and animals by:

- Developing an easy to use catalogue of Native species found on the ORIA.
- Encouraging local community groups to record results from field trips.
- Encouraging cooperation and involvement with existing research and monitoring programs.
- Publicising the local recording system to ensure interested people can utilise it.

Establish a corridor to allow the migration of aquatic fauna along the Ord River by:

- Investigating different options for developing an aquatic corridor.
- Considering safety issues for users of Lake Kununurra and the river when developing options for a corridor.

1.25 Land Use Planning

1.25.1 Goals

- **To ensure that recommendations from the Kununurra Wyndham Area Development Strategy are adhered to for the time-frame of the plan (25yrs) and that any changes to this and other town planning schemes only occur through due process.**

Strategies

Community participation in land use planning by:

- Reducing community confusion and frustration with planning processes.
- Ensuring consultation with key community groups as well as informed individuals.
- Ensuring adequate levels of advertising to provide the community with sufficient information to enable constructive participation in plan development and implementation.

1.26 Waste Water Treatment Plant

1.26.1 Goals

- **To ensure that waste water effluent is removed from the M1 channel and put to productive use within two years.**
- **To ensure that within two years potential ground water contamination around the waste water treatment plant is monitored.**

Strategies

Reduce the impacts of the Waste Water Treatment Plant on downstream water users by:

- Removing WWTP effluent from the M1 Channel, and;
- Confining the excess effluent to a specific area.

Monitor the impacts of the Waste Water Treatment Plant on downstream users by:

- Regular sampling of the M1 Channel water for nutrient and biological factors.
- Establishing guidelines for microbiological activity in the M1 Channel water.

Monitor the impact of Waste Water Treatment Plant on the immediate area by:

- Regular sampling of ground water around the waste water treatment facility.
- Recording complaints about odours from the plant.

Reduce the impact of waste water on ground water by:

- Providing a deep sewerage service to all of the town of Kununurra.

Ensure awareness and understanding within the community about the Waste Water Treatment Plant and related issues by:

- Ensuring that the information from the above strategies is made public.

1.27 Town Rubbish Tip

1.27.1 Goals

- **To ensure that inputs to and outputs from the rubbish disposal site are managed to Department of Environmental Protection requirements within 2 years.**
- **To increase the utilisation of recyclable refuses including green waste, aluminium, glass, etc by 50% in four years.**

Strategies

Reduce the risk of adverse effects from illegal dumping of rubbish by:

- Manning the tip.
- Encouraging the responsible disposal of chemical containers.

Reduce the amount of waste being generated by:

- Recycling green waste, plastics, glass, aluminium, etc.
- Reusing glass, aluminium, plastic and paper, etc.

Increase the level of education and awareness about waste related issues by:

- Encouraging educational programs.
- Utilising existing newsletters and media outlets.
- Investigating other avenues for awareness raising across cultural boundaries.

1.28 Town Drainage

1.28.1 Goals

- **To reduce the impacts of drainage from town areas on local water ways by 50% within five years.**
- **To ensure that industrial storage areas all comply with Australian and Western Australian standards within two years.**
- **Eliminate the risk of waterway contamination from surface water run-off from the airport within two years.**
- **Eliminate the risk of waterway contamination from fuel leakage or spills from sites within the town and at the airport within five years.**

Strategies

Minimise the impacts of the urban area on surrounding waterways by:

- Increasing education and awareness about urban impacts on waterways
- Ensuring there is a current contingency plan for dealing with aviation fuel run-off from the airport.

Monitoring the impacts of the urban area on the waterways by:

- Sampling drainage water flows during rainfall events to determine the level of contaminants in the run-off water.

Chapter 2 - Introduction

2.1 The Ord River Irrigation Area - Physical

Developed in 1962 with the construction of the Diversion Dam which led to the formation of Lake Kununurra, the Ord River Irrigation Area (ORIA) comprises approximately 13,000ha of irrigable soils. The first stage of the project was completed in 1973 with the building of the Ord Dam that created Lake Argyle and ensured water supply for an irrigation project of more than 50,000 hectares. See Map "Location of the Ord River Scheme"

Designed in the late 1950s, the irrigation system was constructed to take advantage of what, at the time, was thought to be abundant supplies of water to flush the system, ensuring no build up of farming residues within the irrigation area. A network of channels fed, by a single main channel, deliver water to farms and an extensive drainage system, including some very large trunk drains, removes excess irrigation and wet season flood water from the farms. Hillside drains are located to protect the internal channels and drains from large wet season overland flows. (See MAP "Irrigation Infrastructure of Ivanhoe and Packsaddle Plains.").

Stage 1 of the ORIA consists of a little more than 10,000 hectares of land on the Ivanhoe Plain, being mainly cracking clay soils of the Cununurra series. Areas between the main plain and river are sandier soils of the river levee bank and the Pago and Cockatoo sands between the plain and nearby hill systems. Some areas of very heavy Aquitane clay soils are located on the flatter margins of the main Ivanhoe Plain. A further 2,000 hectares of land on the Packsaddle Plain includes most of the soil types found on Ivanhoe Plain as well as significant areas of medium textured red clay soils of the Packsaddle type. For details of the soils of the ORIA see MAP " Soils and Cadastre of the Ivanhoe and Packsaddle Plains."

More than 60% of the ORIA is underlain with sand and gravel beds of the old (Palaeochannel) bed of the Ord River. These sand and gravel beds conduct water well and form extensive interconnected aquifers beneath the irrigated areas of both Ivanhoe and Packsaddle plains. The water in these aquifers is generally low in electrical conductivity (indicating low levels of dissolved salts), with a few localised exceptions. (See map 3).

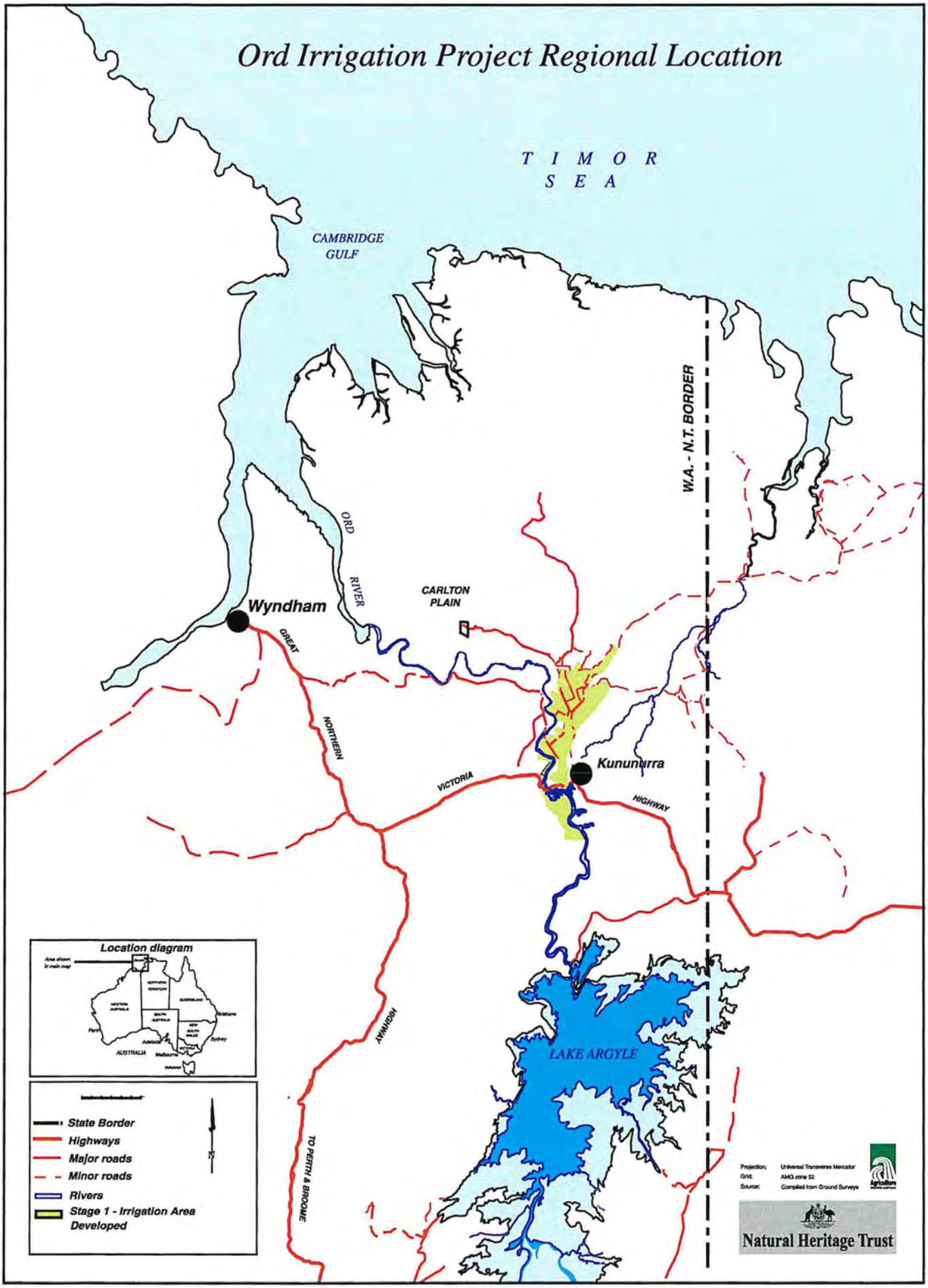
2.2 Agriculture on the Ord

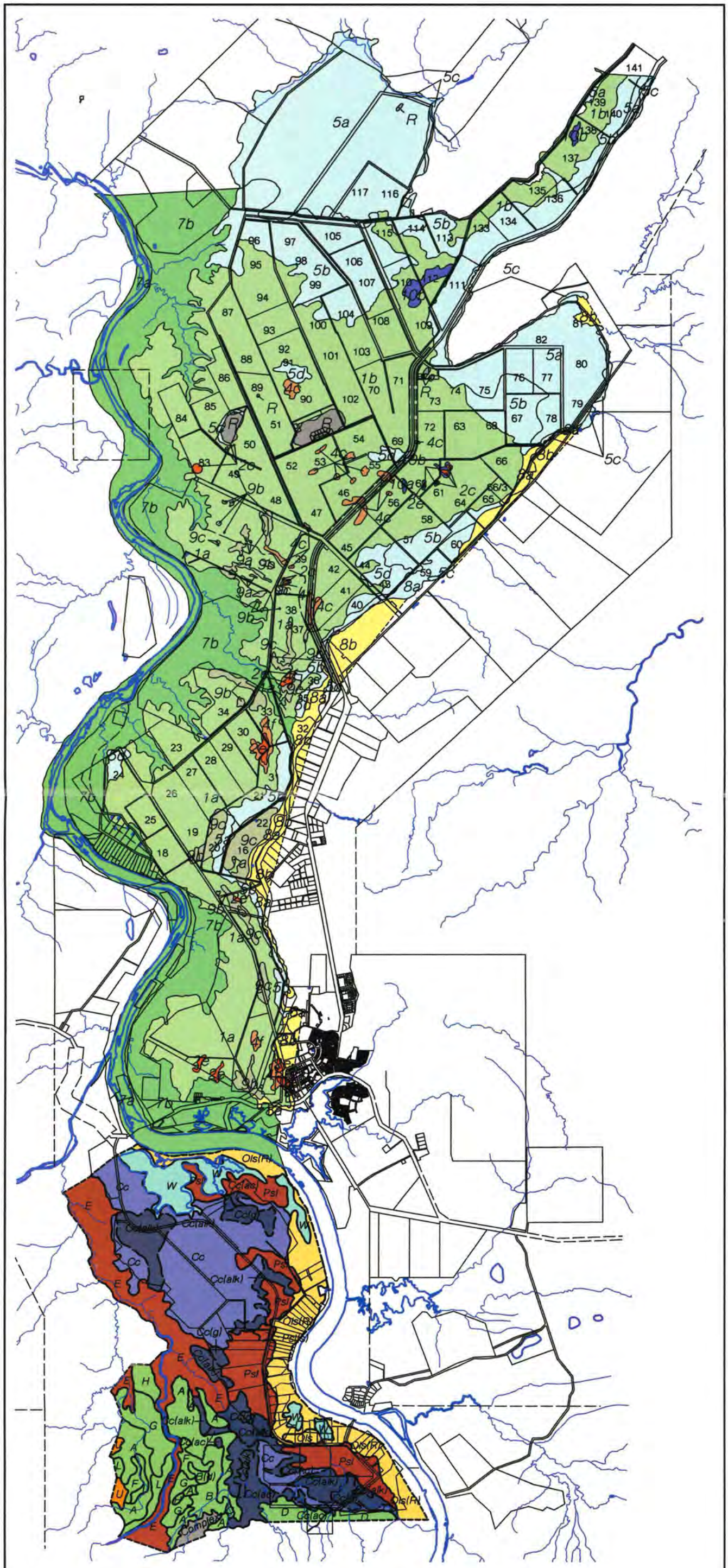
History

Following extensive cropping trials throughout the 1940s and 1950s, the initial irrigation farming system was based on cropping cotton over the wet season. Farms of about 240 hectares were released in the early 1960s. Most farms were made up of three irrigation bays of approximately 80 hectares. Farms were serviced with irrigation supply points and drainage outlets as required and conditions were placed on the development of the farms to encourage rapid development of the irrigation land.

From 1962 to 1974 cotton was the mainstay of the irrigation area, although many crops were tried both experimentally and on farm. The area under crop during this period peaked at a little more than 7,000 hectares. With the closure of the cotton industry in 1974 a period of restructuring continued throughout the 1970s to mid 1980s. During these years the area under crop declined to less than 3,500 hectares and a wide range of crops was tested experimentally and on farm for their suitability. Many of the crops that showed early promise (rice, grain sorghum, peanuts, hay, millet, etc) later failed because of poor yields, poor quality or poor prices.

Towards the end of the 1980s horticulture was introduced and crops that could generate large profits became the norm. Cucurbit crops grown for the domestic market out of season with the southern temperate supplies, and bananas that were grown for the Perth market enabled a new breed of farmers to become established. Profits from these high value crops enabled other crops such as sugarcane to be grown and resulted in all the available irrigation land being brought into production. By 1998 more than 12,000 hectares of land were harvested and the range of crops included: -
sugarcane, leucaena pastures for cattle, sandalwood, hybrid seed, culinary grains such as chickpea and berlotti beans, maize, sunflowers, horticulture crops such as rockmelon, watermelon, pumpkin, bananas, mangoes and a wide range of small crops including zucchini, squash, onions, tomatoes,


Ord Irrigation Project Regional Location
T I M O R
S E A
CAMBRIDGE
GULF
W.A. - N.T. BORDER
ORD
RIVER
Wyndham
CARLTON
PLAIN
GREAT
NORTHERN
VICTORIA
HIGHWAY
Kununurra
KYNUHEIN
LAKE ARGYLE
TO PERTH & BROOME
Location diagram
Area shown in main map
AUSTRALIA
State Border
Highways
Major roads
Minor roads
Rivers
Stage 1 - Irrigation Area
Developed
Projection: Universal Transverse Mercator
Grid: AMG zone 52
Source: Compiled from Ground Surveys
Natural Heritage Trust



Soils of the Ivanhoe Plain

J.M. Aldrick, A.J. Clarke & M. Van Cuylenburg
Agriculture Western Australia

Map unit names have been selected to conform with the common map key for the entire Ord Irrigation Area (Aldrick et al 1990), and hence numerical designations may not be consecutive.

- 1a — ***Brownish cracking clays with finely structured high pH topsoils (cununurra alkaline phase):*** confined to southern (younger) province.
- 1b — ***Greyish cracking clays with relatively coarsely structured almost neutral pH topsoils (Cununurra leached phase);*** confined to northern (older) province.
- 2c — ***Red earths with sandy topsoils (Weaber normal phase);*** occurs as 'islands' in broad cracking clay pans; Eucalypt woodland.
- 2e — ***Heavy-textured red earths (Weaber heavier phase)*** occurring as 'islands' in clay pan.
- 4c — ***Brownish cracking clays with carbonate nodules and high pH topsoils (Keep normal phase),*** minor Cununurra clays; confined to northern (older) province.
- 4f — ***Complex areas, a mixture of cracking clays (Cununurra) and red earths (Weaber);*** surround land units 2c and 2e, southern (younger) province.
- 5a — ***Cracking clays with hydromorphic attributes (Aquitaine 'blueish' phase, minor Keep flooded phase);*** occurs in broad low-lying areas, usually where the clay plains adjoin sandy or lateritic land systems; seasonally inundated to moderate depths for long periods; thick Eucalyptus micro-theca/Excoecaria parvifolia woodland.
- 5b — ***Cracking clays with hydromorphic attributes (Aquitaine'greyish' phase);*** occurs in broad low-lying areas of the clay plains, often near land unit 5a; seasonally inundated to shallow depths for short periods; open *Eucalyptus microtheca/Exoecaria parvifolia woodland.*
- 5c — ***Cracking clays with hydromorphic attributes (Aquitaine'blueish' phase) with 'debil-debil' micro-relief and inclusions of stone and rock;*** occurs in depressed linear zones marginal to unit 5a and immediately adjacent to sandy or laterlitic sand systems; seasonally inundated to significant depths for long periods; treeless
- 5d — ***Cracking clays with reduced internal drainage capacity (Cununurra wetter phase);*** occurs within broad cracking clay plains; seasonally waterlogged; usually treeless
- 7a — ***Rivers and major creeks with associated steep banks;*** frontage vegetation.
- 7b — ***Cracking clays in a severely eroded and truncated condition (Cununurra eroded phase)*** and other soils bordering the rivers and major creeks; minor levees, point bars and swamps; predominantly *Lysiphyllum cuninghamii* woodland.
- 8a — ***Complex, depressed peripheral zones adjoining sandy or lateritic land systems; soils very variable but mainly heavy clays with sand inclusions;*** depressions are seasonally inundated; *Eucalyptus microtheca* dominated woodland, some *Exoecaria parvifolia.*
- 8b — ***Complex zone between unit 8a and sandy land systems; soils very variable mostly duplex soils;*** variable woodland with *Eucalyptus polycarpa* and *Eucalyptus Microtheca.*
- 9a — ***About 40 percent gradational calcareous clays (Walyara) in a matrix of land unit 1a*** (brownish, cracking clays with finely structured high pH topsoils. Cununurra alkaline phase) vegetation relatively thick and includes *Lysiphyllum cunninghamii, Carissa lanceolata* and occassional eucalypts.
- 9b — ***About 20 percent gradational calcareous clays (Walyara) in a matrix of land unit 1a*** (brownish, cracking clays with finely structured high pH topsoils. Cununurra alkaline phase) vegetation includes *Lysiphyllum cunninghamii and Carissa lanceolata*
- 9c — ***Brownish cracking clays with finely structured high pH topsoils (Cununurra alkaline phase) and intergrades with Walyara soils;*** about 2 percent gradational calcareous clays (Walyara); vegetation includes *Lysiphyllum cunninghamii* and *Carissa lanceolata.*
- 10a — ***Cracking clays (Cununurra leached phase) with considerable coarse sand throughout;*** slightly reduced moisture holding capacity; some intergrades with Weaber soils.
- 10b — ***Cracking clays (Cununurra leached phase) with some coarse sand;*** reduced moisture holding capacity
- R — ***Rock outcrops of varying extent and lithology***
- — — ***Unsurveyed Boundary***

Field survey and interpretation of aerial photography flown 1970.
Natural Resource Managment Services maps ***Nos. 277, 278 and 279***
"Soils of the Ivanhoe Plain Western Australia" 1974

Soils of the Packsaddle Plain

T.C. Stoneman, A.J. Clarke & W.F.Holman
Agriculture Western Australia

Cc	Normal phase Cununurra clays.	B	Unamed soil 'B'.
Cc(ac)	Acid phase Cununurra clays.	B(d)	Unamed soil 'B' (deep phase).
Cc(alk)	Alkaline phase Cununurra clays.	C	Unamed soil 'C'.
Cc(g)	Gilgaed phase Cununurra clays.	D	***Un-named soil 'D'.***
Ols	Ord loamy sand.	F	Un-named soil 'F'.
Ols(R)	Ord loamy sand with recent alluvial soils.	G	Un-named soil 'G'.
Psl	Packsaddle sandy loam.	H	Un-named soil 'H'.
Psl(s)	Shallow phase packsaddle sandy loam.	L	Un-named soil 'L.
Psl(s)	Eroded soils near Packsaddle Creek	U	Unknown soil area.
W	Swamps and flooded areas.	Complex	Complex soil structure
A	Unamed soil 'A'.		Unsurveyed Boundary
A\Cc(alk)	***Unamed soil 'A' with*** alkaline phase Cununurra clays.		

SURVEY IDENTIFICATION DIAGRAM

Ivanhoe Plain Survey
Packsaddle Soil Survey

Location diagram

Western Australia
Perth

Cadastral boundary
28 ***PWD Block Number***
Watercourse

Cadastre supplied by DOLA.

N

2 0 2 4 6 8 10 kilometres

ORD IRRIGATION SCHEME
STAGE 1 DEVELOPMENT
Soils and Cadastre of Ivanhoe and
Packsaddle Plains

Map Title : Ordmap 52 ***Our Ref: Xeon4***
Date First Issued : 11 May 1998 Ord\dgn\ordmaps\ordmap52_a3.dgn
Revision No. : 0 ***AMG Zone 52 projection***

Prepared by the Spatial Resource Information Group,
Natural Resource Management Services,
Agriculture Western Australia

beans. Significant areas of trial cotton (up to 900 ha) were grown as part of a program to develop counter-cyclical production based on integrated pest management strategies.

The shortage of new farming land led to proposals to develop the second stage of the ORIA including more than 30,000 hectares on the Weber, Knox Creek and Keep River plains to the north and east of Stage 1. This M2 area is currently subject to extensive study by a consortium made up of Wesfarmers, Marubeni Corporation and the WA Water Corporation with the aim of establishing a large-scale sugar industry. Additional areas north-west of Stage 1 planned for development include more than 10,000 hectares of the Carlton Plain and Mantinea areas of the lower Ord River.

2.3 Farming Today

There are more than 100 active farms in the ORIA, however more than half of these rely on off-farm income and are small. Approximately 40 are large-scale irrigation farms on which a range of crops is grown. Of these farms most are used to grow a diversity of crops in any one cropping year. The large farms are irrigated using surface flow irrigation in furrows, while more intensive tree crops, small crops and bananas are grown on the sandier soils and are irrigated using a range of sprinkler and tape systems. There has been some limited testing of trickle tape on broad-acre crops grown on the cracking clay soils.

2.4 The Plan

This land and water management plan is based on extensive community consultation and involvement over a period of three years. We have assumed that all involved and interested parties are committed to ensuring that land and water management improves throughout the irrigation area. For improvement to actually happen it will be necessary for all those involved in using land and water resources to change what they are currently doing. Implementing the plan will commit individuals, groups, organisations and agencies to actions in the short, medium and long term. All those involved will incur some costs, at least in the short term, before the benefits of improved management begin to flow. Some of the benefits will result in improved returns or reduced costs directly to users, while other benefits will be more of a community nature for which values are harder to establish.

Many of the improvements to management that could be made now, based on current knowledge, are either being implemented by users or tested under Ord conditions prior to widespread implementation. For example: laser levelling of irrigation fields; integrated Pest Management in cotton and horticulture; and polyacrylamide application to improve irrigation efficiency and reduce soil loss.

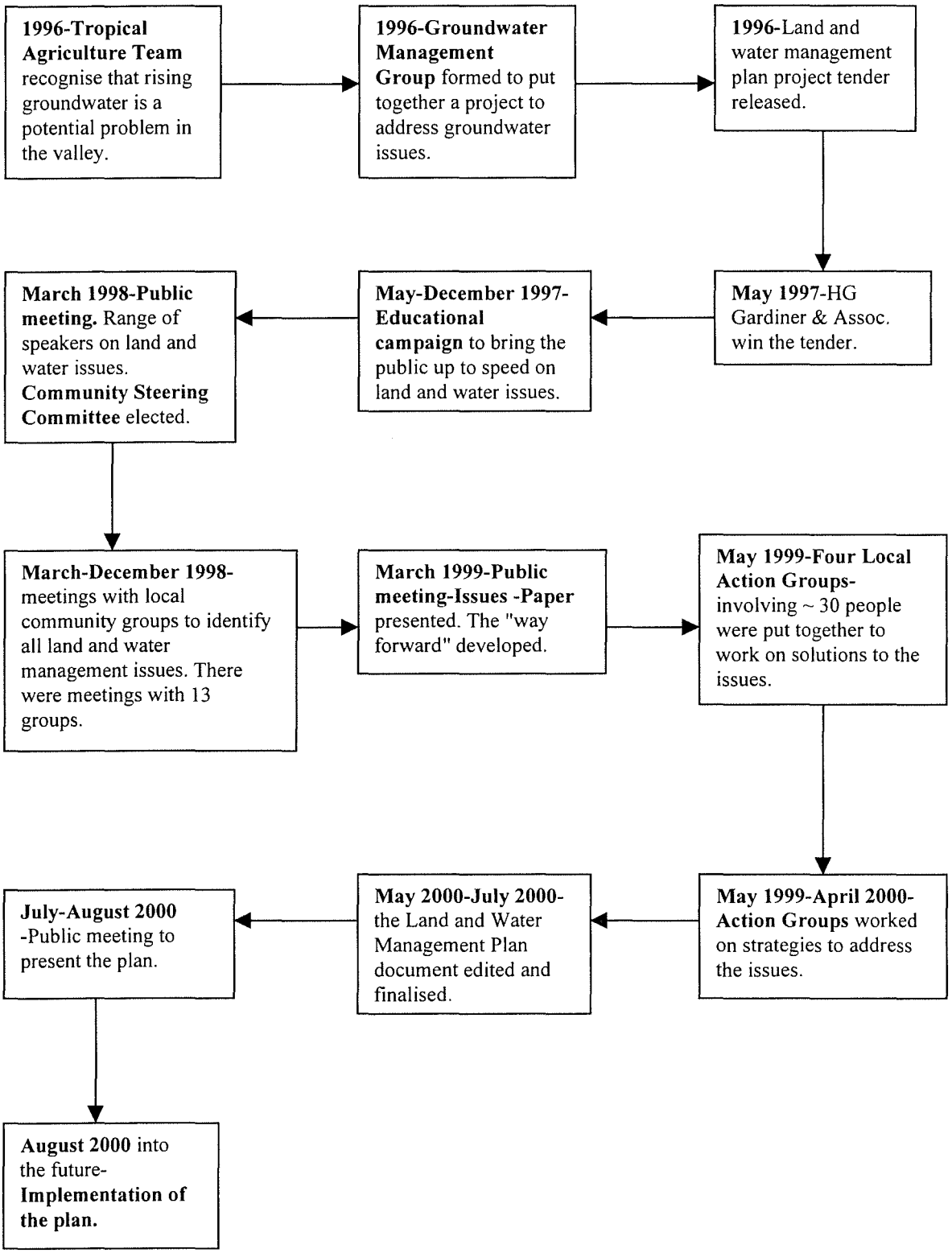
A number of other problems have been addressed during the term of this study. Horticulturists have developed a code of practice for spraying Endosulfan, the Ord Sugar Mill has removed its effluent from the irrigation channel, and de-watering bores have been tested for their ability to contribute to the management of rising ground water.

Some management changes will be necessary to avoid major land and water management problems in the future for which there are no clearly obvious financial returns, at least in the short to medium term. The extent, and even the nature, of some of these problems can not yet be clearly defined, but the trends are convincing that without action land and/or water quality will be reduced in future. In addition; there are a suite of issues for which improved management methods have either not yet been devised or for which tests of applicability for the Ord have not yet been carried out.

The challenge is to continue to measure the impacts of our use of land and water in ways that enable new and improved management strategies to be developed into the future.

There is a wide range of land and water management issues to be addressed and all those involved have responsibilities to address some of those issues. Some will fall clearly into particular groups, agency or individual areas of responsibility, but largely real progress will only be made if there are true and effective partnerships formed to address each issue constructively. These partnerships will need to be based on a recognition of what each party can achieve, the skills that each party has, the ability of each party to fund its share and a willingness to trust and respect each other. Each partner is charged with the responsibility to do the best they can to achieve the improvements required.

2.5 Methodology and Timeframe



2.6 Implementation

The local action groups have decided that there needs to be a responsible local body to deliver the outcomes from this plan. To achieve real improvement in land and water management throughout the Ord River Irrigation Area and the surrounding area there will be an ongoing need for supervision, support and encouragement for those making the changes.

Local action group members decided the best option was for a *Board of Local People* to oversee the implementation of the Plan.

- **This Board would consist of six elected community members.**
- **They would have the power to coopt two additional full time members if they considered particular groups within the community were under represented.**
- **These six to eight members would then form the full time membership of the board.**
- **Relevant experts would be brought in to help make decisions on particular aspects of the plan implementation.**
- **These experts would function as full members of the board during the deliberations within their field of expertise.**
- **Only residents of the Shire of Wyndham East Kimberley would be eligible to serve as community board members.**
- **Upon leaving the Shire the member's position on the Board would be deemed to become vacant.**
- **The inaugural board would be responsible for deciding on their operating rules, succession plan, values, vision and goals while overseeing the appointment and management of a project coordinator.**
- **They would be charged with implementing the recommendations contained within the Land and Water Management Plan and for ensuring an ongoing commitment to improving management of land and water in the ORIA.**

Chapter 3 - Land Issues

3.0 Introduction

This chapter focuses on identifying ways of minimising the impact of farming on surface water, ground water and land resources.

Many of the strategies suggest the need to develop best management practise techniques for various aspects of farming. To develop these guidelines there will need to be an ongoing commitment from farmers and research organisations. Farmers have the principal responsibility for these issues.

Please Note: *It is important to recognise that the strategies identified in this chapter will need to be built on as new knowledge is developed and targets are achieved. At this stage they provide a starting point and a framework for commitment from all the parties involved in Land and Water Management on the Ord.*

3.1 Ground water

3.1.1 Goals

- **Reduce ground water levels to below two metres from the surface across the whole irrigation area within five years while preventing any new areas from rising above that level.**

- **Hold the quality of ground water at or above the high quality present in 2000.**

3.1.2 Background

Prior to the development of irrigated agriculture the ground water levels would have fluctuated with the wet and dry seasons. As occurs in all irrigation developments where ground water is not used for irrigation, irrigated agriculture has resulted in rising ground water levels.

There is a network of monitoring bores (piezometers) located throughout the ORIA. Some of these bores have been in place and monitored since 1964, and an additional network of 60 on farm bores has been installed since 1991. This has enabled long-term trends to be established and the influence of on farm management techniques on the rate of rise of the ground water to be measured.
There are several factors that have contributed to ground water recharge and therefore caused the levels to rise. During the early years of irrigation leakage from the infrastructure (channels and drains) contributed a large portion of the recharge. As the water mounds under the leaky channel and drains approached the surface reducing the pressure gradients this source of accession declined in importance. As more areas were brought under irrigation the principal source of recharge into the ground water system has become leakage from on farm irrigation infrastructure and through irrigation fields (Water Corporation, 1997).

The preparation of hazard maps based on long term monitoring of ground water levels prompted farmers to consider the development of this Land and Water Management Plan. Rising ground water has been shown to pose a significant risk to the long-term viability of the ORIA through the related risks of salinisation and waterlogging.

3.1.3 Current Status - Ground water Levels

If ground water levels are not managed and the ground water is allowed to rise close to the surface it is likely to cause waterlogging in the short term and soil salinity in the long term.

Current estimates indicate that about 75% of dry season ground water accessions are directly related to on farm irrigation, leaving 25% of the accessions coming from leaking supply and drainage infrastructure .

Wet season rainfall can also have a significant influence on the ground water levels in the irrigation area. Prior to irrigation the dry season would have acted as the "dry down" period for the ground water, however, now that irrigation occurs throughout this "dry down period" there is no opportunity for the levels to drop.

The general rate of rise of the ground water is between 10 – 80 cm per year across most of the valley. To date there are three areas where the ground water is within two metres of the surface. Risk mapping has been completed for the ground water levels across the valley (Water and Rivers Commission, 1996). This mapping highlights areas that may be at risk in the future. There are also contour maps of the ground water levels (Water and Rivers Commission, 1996).

Management Options Available

There has been a substantial amount of work completed on ways of controlling the rate of

rise of ground water levels – both locally and in other irrigation areas around the world. Varying amounts of information are available on management approaches to rising ground water.

Known to work locally: -

De-watering

Pumping ground water and reusing it for irrigation can only occur where there are porous gravel beds (aquifers) to transmit water laterally, the water quality is generally satisfactory for reuse, and the bore yield is sufficient to justify the capital and operating costs of pumping. Such gravel beds underlie approximately two thirds of the valley and they contain reasonable quality water thus enabling pumping to be considered in these areas.

Pumping has been tested in two locations and has been shown to keep the ground water levels at a manageable level. The report done on this pump testing (O'Boy, 1998) indicated that in the short term there would need to be two additional production bores in place on the Ivanhoe Plain, and one additional bore on the Packsaddle Plain.

Photo 1: Ground water trial pump bore at Bardena Farms. *(see central colour pages)*

According to a report done by Sinclair Knight Merz for the Water Corporation in 1998, this is the best available option to control rising ground water and would be more efficient when combined with other management options such as lining the M1 Channel.

Irrigation Management

The amount of irrigation water entering the ground water can be minimised by managing irrigation water to supply the optimum amount of water to the plant while minimising the amount of water running off or infiltrating to deeper levels (*see Section 2.2 - Irrigation Management Section*).

Known to work elsewhere – not locally tested:-

Permeability mapping

This tool enables the permeability of the soil to be determined therefore identifying and improving management of "leaky" areas. This is used in rice growing areas elsewhere in Australia to define where rice can and can't be grown.

Deep Drainage

This involves using tile or mole drains. This method is used in other areas around the world, however it is a less desirable option as it relies on waiting for the ground water levels to be high (less than 1.5 metres from surface) before it can be applied.

According to the Sinclair Knight Merz report (1998) this method is likely to be effective, however it is expensive and is unlikely to be adopted by local farmers.

Tree Planting

Trees are used in other farming areas around Australia to help control localised areas with high ground water levels.

Known to work elsewhere – with some local knowledge:-

Irrigation Management

There are also techniques that are used elsewhere but have not yet been extensively tested locally, including trickle irrigation, soaker lines, lateral move and centre pivot sprinkler systems. (see Section 2.2 – Irrigation Management).

3.1.4 Potential tools - Ground water Levels

The use of flocculants

Currently flocculants are being used to aid in reducing soil, chemical and nutrient losses off farm through tail water.

Flocculants have properties that encourage fine clay particles to adhere to each other keeping air spaces open, thus increasing lateral infiltration. By increasing the rate of infiltration and therefore reducing the volume of water applied (the time taken to sub up each

seed bed would be less) the amount of water moving into the ground water may be reduced.

Projects under way

- Permeability mapping trial aimed at testing the use of the EM31 technology under local conditions.
- Irrigation management work (Refer to Section 2.2).
- Monitoring of ground water levels and salinity.

Work required

- The ability of flocculants to reduce ground water accessions.
- The use of deep drainage locally.
- The use of trees under local conditions.

3.1.5 Strategies - Ground water Levels

Strategy 1

Reduce the rate of entry of water into the ground water by:

1. Improved irrigation management that is based on:
   a. Better matching the field run length, irrigation water head, slope and siphon size to ensure the most efficient application of water within the constraints of a surface flow system and crop requirements.
   b. Using irrigation systems (such as trickle and sprinkler) that give greater control over irrigation efficiency where they can be justified.
   c. Using flocculants to improve the rate of water subbing thus reducing irrigation time necessary to fill the soil profile.
2. Reduced leakage of water by:
   a. Identifying areas of irrigation bays that leak and adjusting irrigation and cropping management to reduce or eliminate leakage from these areas. This could mean removing these areas from irrigation or planting different crops (such as tree crops) in these areas.
   b. Identifying, sealing, and /or lining leaky parts of the channel and drainage infrastructure.
   c. Developing new management systems at the time of initial irrigation (following the wet season), such as controlling soil "cracking" and therefore reducing recharge at this time.
   d. Reducing wet season recharge by using cover crops planted at the end of the dry season.
   e. Planting high water use trees on land near leaky infrastructure and strategically throughout the valley.
   f. Surveying irrigation fields and where appropriate installing interception sub-surface drainage systems below cropping areas.

Strategy 2

Remove ground water and either reuse or remove it by:

1. Installing and operating a system of de-watering bores that enables:
   a. Water of satisfactory quality to be reused for irrigation.
   b. Poorer quality water to be released safely to drainage points.
2. Planting high water use trees strategically throughout the valley.

Strategy 3

Monitor management impacts and research improved management methods by:

1. Continuing to monitor ground water levels across the irrigation area.
2. Encouraging farmers and research organisations to continue to gather information from bores and excavations to better identify the nature and extent of suitable aquifers for de-watering.
3. Investigating the usefulness of Electromagnetic (EM) technology to identify areas of "leakage" and therefore likely problem areas.
4. Identifying areas that may be suitable for low volume pumping and testing this approach to managing accessions.
5. Developing whole management systems based on best current available knowledge and testing these systems on farm.

3.1.6. Responsibility - Ground water Levels

Most of the necessary changes to irrigation management will involve farmers committing to on farm modifications to infrastructure and management systems that will affect farm operating costs.

Research into new systems and testing existing but locally untried solutions will be a responsibility shared between farmers and AGWEST. The establishment and operation

of production bores should be a shared responsibility between the farmers and Water Corporation as the main contributors to the rising ground water problem. The operation and servicing of the network of bores could be a negotiated responsibility for the Ord Irrigation Cooperative who should also be involved, with AGWEST (who are taking the lead role), in surveying the permeability of soils throughout the irrigation area.

Ongoing monitoring of regional ground water levels should remain the responsibility of the Water and Rivers Commission with AGWEST involved in on farm monitoring. Farmers will need to be involved in the collection and application of information generated from the monitoring systems.

3.1.7 Current Status - Ground water Quality

The Water and Rivers Commission has monitored the salinity in the ground water throughout the irrigation area since 1964. From this monitoring a contour map of these levels is produced (Water and Rivers Commission, 1996).

Generally, the salinity levels (electrical conductivity) in the ground water are low (500 – 1000uS/cm) and changing at very low rates. There are, however, some isolated areas where the salinity levels in the water are too high to reuse the water for irrigation (3000uS/cm). Most of the ground water across the valley has an electrical conductivity of between 500 – 2000uS/cm. This water is suitable for reuse for irrigation, by either shandying with supply water or using directly.

While the ground water is kept more than 1.5 metres from the surface the potential for sodicity problems (high sodium levels) and salinisation problems is very low. However, if this water approaches the surface then these problems are likely to occur (Water and Rivers Commission, 1997-98).

During a test pumping trial in 1997-98 the water quality at two sites was tested more thoroughly. The electrical conductivity at the Packsaddle bore location was approximately 1100uS/cm (no impact on plant growth), and the water at the Ivanhoe bore location was 2300uS/cm (which needs to be mixed with irrigation water before use on crops). There were no traces of pesticides or chemicals at either of the two sites tested.

3.1.8 Strategies – Ground water Quality

While salinity is the greatest risk to ground water quality, controlling rising levels of ground water will have the effect of reducing the risk of damage from this source. It is necessary to pay greater attention to the risk of ground water contamination, as it will have serious consequences for future use of the underground water resource as well as potential environmental damage. There are significant potential risks to human health should drinking water supplies become contaminated.

Strategy 1
Minimise the risk of contaminating ground water by:

1. Better understanding issues associated with the quality of ground water and the risks of contamination posed by nutrients, salinity, agricultural chemicals and harmful bacteria.
2. Develop management systems that reduce the risk of mobile nutrients such as nitrates, sulphates and heavy metals from reaching the ground water.
3. Conducting education programs to create an awareness of the potential problem and ways of reducing the risks

Strategy 2
Provide useful information on the levels of contamination by:

1. Monitoring ground water quality throughout the irrigation area with the necessary frequency and spatial distribution of sample points. This monitoring requires a long-term commitment from funding agencies.
2. Encouraging farmers who use ground water on farm to include quality tests of this water as part of quality assurance programs.

3.1.9 Responsibilities – Ground water Quality

Ord Irrigation Cooperative, Water and Rivers Commission and AGWEST should be involved in monitoring the quality of ground water throughout the irrigation area. Farmers should be responsible for introducing management methods to minimise the risks of contamination and they should be encouraged to adopt regular monitoring as part of quality assurance programs.

3.1.10 References

C.A. O'Boy (1998), Ord River Irrigation Area Long-Term Test Pumping, Hydrogeology Report No. 125/1998, Water and Rivers Commission.

C. Yesertener (1997), Review of Ground water Monitoring Data in the Ord River Irrigation Area, Hydrogeology Report HR60, Water and Rivers Commission.

Sinclair Knight Merz (1998), Ord River Irrigation Area Stage 1 – Control of Rising Ground water Level, Water Corporation Western Australia.

3.2 Irrigation Management

3.2.1 Goals

- **To improve irrigation management to achieve 65% average annual water use efficiency on all irrigation farms within 5 years.**

- **To improve irrigation infrastructure and management to achieve a water delivery efficiency of 75% within five years**

3.2.2 Background

Irrigation is used to provide an appropriate soil moisture environment for optimising crop production. It is essential that adequate water is supplied for crop growth and that it is provided in a way that does not adversely affect growth, for example, through waterlogging. It is also important that water is applied in a way that does not adversely impact on the on farm or off farm environment and compromise sustainability of the farming system.
Irrigation requirements vary from crop to crop and aim to replace evaporation or part thereof depending on the crop water use characteristics. On the Ord, the average evaporation is more than 3000 mm and the average rainfall close to 760 mm. The very high evaporative demand has implications for crop water requirements as well as the design of water storages.

In developing best practice irrigation management it is therefore important to consider how to apply irrigation water, how frequently to apply it (scheduling) and how much to apply at each irrigation. Optimising these factors will lead to improved water use efficiency and help ensure the viability and sustainability of irrigated agriculture.

The predominant soil types used for irrigated agriculture in the Ord are the clay soils (Cununurra clays and Aquitaines). Smaller areas of levee type soils (Ord loamy sand and Ord sandy loam), sandy soils (Cockatoo sand) and Packsaddle red soil are also irrigated. Characteristics vary greatly between these soils, influencing irrigation management requirements.

The majority of broad-acre and some horticultural crops are grown on the clay soils. These include sugar cane, cucurbits, hybrid seed, chickpeas, maize, cotton and mangoes. Water requirements and irrigation management practices vary between these crops although most are watered by furrow irrigation from head ditches with only small areas of trickle irrigation used. The levee type soils and sandy soils are used mainly for tree crops (bananas, mangoes, pawpaw and other tropical tree fruits) and annual horticultural crop production (cucurbits, onions, tomatoes and other small crops) using either under tree micro sprinklers or trickle irrigation.

While earlier work on irrigation emphasised improvement in crop productivity through development of irrigation schedules, more recent research has also emphasised the need to consider application methods to improve water application efficiency to minimise tail water losses and deep infiltration into the ground water system.

3.2.3 Current Status

Strategies to improve irrigation practices for individual crops have been investigated throughout the life of the Ord River Irrigation Area. There has been an increasing awareness about problems associated with accessions to the ground water and recent research has been oriented towards optimising water to the crop while minimising the risk to the ground water. Adoption of the research results has not been universal, however many growers are moving towards more efficient irrigation practices.

Irrigation Scheduling

Scheduling of irrigation refers to the timing of intervals between irrigations. Scheduling information has been developed for a range of crops grown in the Ord including maize, chickpeas, bananas and mangoes. For maize, it has been found that the highest yields are obtained with frequent and rapid irrigation.

Rapid irrigation is also now generally used for furrow irrigation of other crops on clay soils in the Ord to minimise waterlogging effects. While this practice can result in minimal drainage below the root zone and can result in acceptable levels of less than 30% of applied water ending up as tail water at each irrigation, scheduling irrigation at high frequency can also result in more tail water flow over the whole season. This is due to the increased number of irrigations required.

Where research hasn't been undertaken locally for all crops, there is usually adequate crop water requirement information available from elsewhere which can be adapted to local conditions.

Efficiency of Application

In addition to establishing the correct timing of intervals between irrigation, it is also necessary to determine how much water to apply and this can significantly effect efficiency of application. With furrow irrigation on clay soils, improving efficiency will depend largely on minimising both tail water run-off and deep drainage below the root zone into the ground water system.

Variation in application efficiency will result from a range of factors including soil structure, soil moisture characteristics, irrigation bay characteristics and irrigation management practices.

Tail water flows in the ORIA vary between 30 and 70 percent of irrigation water applied. Management practices which will reduce the quantity of tail water are currently being examined (Section 2.3.5 Surface Water Quality Management Strategies).

Inefficient application of irrigation water on farm is contributing approximately 75 percent of ground water accessions, through deep infiltration. It is also known that there is significant variation across the Irrigation Area in permeability of the soils with high rates of infiltration in some areas and insignificant rates in others.

Some of the areas with higher rates of infiltration have been broadly identified through observation of rapid changes in levels in ground water monitoring bores during irrigation. Other areas have been identified through observation of changes in soil moisture below the root zone during and following irrigation.

Higher infiltration rates can occur where lighter textured soils intercept surface clays and create preferred pathways for water movement. Further work will be required to adequately identify these areas to allow alternative management practices to be used in areas where deep drainage is resulting in rising ground water. Permeability mapping is planned to provide this information and this work is referred to in Section 2.2.4.

3.2.4 Projects under way

A current research project will examine optimum irrigation requirements for sugar cane. This work is examining crop response to irrigation frequency as well as ways of minimising both tail water flow and deep infiltration below the crop root zone. Economic analysis will be undertaken to determine optimum irrigation management practice for the sugar cane crop considering both production and environmental requirements. Much of this information will be adapted for use with other crops grown in the Ord.

Irrigation practices currently used for cotton production in the ORIA are based on techniques developed for the NSW industry. Research is in progress to adapt this information to improve management in the ORIA. Both frequency and duration of irrigation are being examined. Further work will be required to ensure that irrigation practices developed are also compatible with requirements for ground water and tail water management.

3.2.5 Knowledge Required

Permeability mapping to identify localised areas where soil infiltration rates are high is required. This would allow alternate irrigation practices to be used in appropriate areas, a reduction in potential accessions to the ground water system and better management of ground water through an increased understanding of how water is moving both vertically and laterally. There is a proposal currently being developed to undertake this work in the Ord using existing Electromagnetic technology developed for similar use in irrigation areas in eastern Australia.

Economic analysis to determine optimum irrigation practices for crops grown in the Ord, taking into account crop water requirements, efficiency of application and ground water management. Much of the previous work

undertaken and practices adopted have largely considered crop water requirements.

New techniques for improving infiltration within the crop root zone would potentially allow more rapid irrigation while also reducing the frequency of irrigation and hence reduce tail water flows. Some growers are using Polyacrylamides for this purpose and their use could be investigated further.

3.2.6 Strategies

Strategies designed to reduce the environmental impacts of irrigation and improve water use efficiency need to be developed within the context of the existing irrigation infrastructure. The system was designed to allow large volumes of water to flow through, thus creating a self-flushing effect during the irrigation season and enabling wet season run-off to move quickly away from cropped areas.

Irrigation management strategies are aimed at reducing environmental pressures and in so doing will have the effect of improving water use efficiency.

Strategy 1
Improve water use efficiency and reduce surface water losses by:

1. Investigating, demonstrating and adopting alternative irrigation systems for cracking clay soils including trickle, sprinkler and soaker technologies where clear environmental and economic benefits can be demonstrated.
2. Identifying suitable locations for demonstrating the effectiveness of tail water reuse and recycling systems.
3. Developing and testing tail water recycling systems that might be suitable for the Ord River Irrigation Area so that in the medium to long term tail water can be safely and cost effectively recycled.
4. Researching and disseminating information on optimal field layout, run length, grade, siphon size, irrigation time, bed and furrow size and shape based on a better knowledge of the needs of different soil types.
5. Ensuring irrigation fields are leveled to appropriate uniform grades and that the guides from 4. above are adopted.

Strategy 2
Improve water use efficiency and reduce ground water recharge by:

1. Identifying areas of soils that leak by researching the usefulness of Electromagnetic technology to map soil permeability under local conditions.
2. Developing irrigation and drainage systems to manage soils of high permeability.
3. Identifying and adopting management practices that minimise accessions to ground water during pre irrigation and initial crop irrigation. Of particular interest will be the investigation and development of methods of using Polyacrylamides (PAM) to increase the rate of water subbing across beds following crop planting.
4. Ensuring that any on farm water storage associated with tail water reuse is correctly sealed to prevent accessions to the ground water.

Strategy 3
Provide research, demonstration and monitoring services to:

1. Quantify the level of accessions to ground water and measure trends in ground water levels.
2. Quantify the volume of water leaving farms as irrigation tail water.
3. Investigate and demonstrate new irrigation management techniques with particular attention being placed on cost effective improvements in water use efficiency.
4. Map soil permeability for problem areas of the Ord River Irrigation Area.
5. Develop guides for irrigation field layout and bed and furrow configuration for optimal water use efficiency.

3.2.7 Responsibilities

By far the largest commitment in terms of direct costs associated with implementing these strategies will need to be made by the farming community. Most of these costs will be associated with implementing improved management such as laser leveling, field layout, farming inputs, machinery modification and changed practices. To balance this it is likely that they will also be the beneficiaries of the improved management through reduced water costs and improved crop performance.

There will be a requirement for commitment to support long term monitoring and research from a number of state government agencies including AGWEST, WRC and WC. Specific approaches to R&D Corporations may be necessary to develop the management guides,

monitoring methods and management practices.

3.3 Surface Water Quality

3.3.1 Goals

- **To reduce the load of chemical contamination in tail water by 40% within 5 years**
- **To reduce the load of nutrient contamination in tail water by 40% within 5 years**
- **To reduce sediment loads in tail water by 40 % within 5 years**

3.3.2 Background

Surface water quality is adversely affected by the presence of sediment, and the nutrients and chemicals carried by the sediment and dissolved in the water. There are few past records of water quality for the Ord River and surrounding waterways. Where they are available they generally relate to specific projects and therefore long term trends in water quality are not available for the area.

Chemicals

The general community sees chemicals that are entering the river via surface water as being a critical issue. In April 1998 the Water and Rivers Commission and the Ord Irrigation Co-operative undertook to design a program to monitor water quality throughout the irrigation area, the Ord River and some tributaries. Samples are collected monthly and sent to Perth for complete analysis of organophosphates, organochlorines, nutrients, salinity and turbidity levels. Throughout 1998 and 1999 the program was refined and rationalised to a total of 32 sample sites.

Since the sampling program began, the main pesticide detected has been Endosulfan. The insect pest pressure was extremely high during the 1998 growing season and there was a corresponding high number of "shows" of the chemical throughout 1998 (see Figures 1&2). Pest pressures during 1999 were lower and there were fewer "shows" of chemical, however there were high levels of Endosulfan recorded at three locations around the irrigation area during 1999. There have also been a limited number of shows of other chemicals in the water that cannot be easily explained.

It should be noted that Endosulfan is toxic to aquatic species and therefore it is the focus chemical for the water sampling program. Endosulfan is a useful and important chemical as it is "friendly" to non-target organisms (except fish) and is important for pest control as it is in a different chemical group to other insecticides available (therefore it is important for managing insect resistance to chemicals).

Photo 2: Ribbons of Blue participants sampling water in the M1 Channel. *(see central colour pages)*

Nutrients

Nutrient enriched tail water has the potential to severely degrade the river system however the impacts are less dramatic than fish kills and symptoms may take years to become obvious. In some cases impacts are only seen during unusual events such as the algal blooms on the Swan River following heavy summer rains in January 2000. With the reduced river flows possible following the development of Ord Stage 2 the risk of elevated nutrient levels in the river could increase.

Sediment

Increased sediment levels from farm run-off during the wet season would be difficult to detect due to the large sediment loads carried by the rivers at that time. However, the cost of maintaining drainage infrastructure and of the loss of topsoil from farms makes sediment reduction an important economic consideration for farmers. A significant proportion of nutrient and chemical movement off farm is on the small colloid particles within the sediments so reducing both large particle sediment and retaining the colloid fraction on farm is necessary if the river system is to be protected.

Photo 3: Sediment being measured in tail water in a farm drain. *(see central colour pages)*

3.3.3 Current Status

Tail water

Tail water has the potential to transport sediment, nutrients and pesticides from farms into the river. Tail water from the irrigation area enters the river at a number of locations. The tail water from the Packsaddle Irrigation Area enters the Ord River via Packsaddle Creek and the Dunham River (see Section 3.5 for more information). Tail water from the Ivanhoe Irrigation Area enters the Ord River at a number of locations with the largest of the

drains being the D4 drain which is the most northerly (downstream) drain that feeds water back into the river.

There are sections in the Irrigation Area where chemical shows are more frequent including a number of Packsaddle Drains, Ivanhoe Drain 2, and Ivanhoe Drain 4.

This graph also illustrates that there are limited pesticide shows during the wet season. There are limited areas of crops grown during this time that use pesticides (perennial crops such as such cane, mangoes etc grow during this time) therefore the amounts of chemical being used are limited. This trend could also indicate that the pesticides used are breaking down quickly in the environment over the wet season.

River

Under current flow conditions the threat that tail water poses to the health of the river is low to medium. The river flows for 12 months of the year and the amount of flow in the river is much greater than the flow from drains therefore leading to high dilution factors. The impacts of reduced river flows that may follow changes in water allocation is unknown.

Figure 2 illustrates that the main areas of concern regarding pesticide levels in the river are the Dunham River and Packsaddle Creek, but there have been shows in the river at Ivanhoe Crossing (August 1998) and between the D3 and D4 outlets (September 1999).

There are other factors that may be having an impact on the water quality in the river, such as rubbish, (Section 3.2 – Recreational River Use) and stock access causing erosion (Section 3.6).

Figure 1: The trend of pesticide detection at sites in the drainage network.

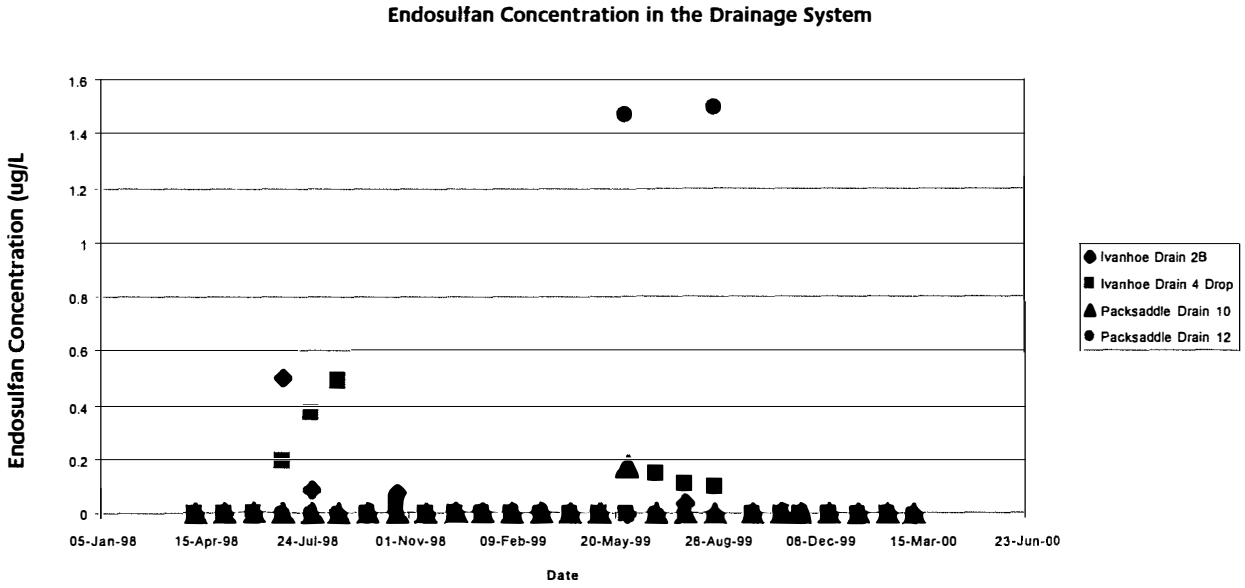
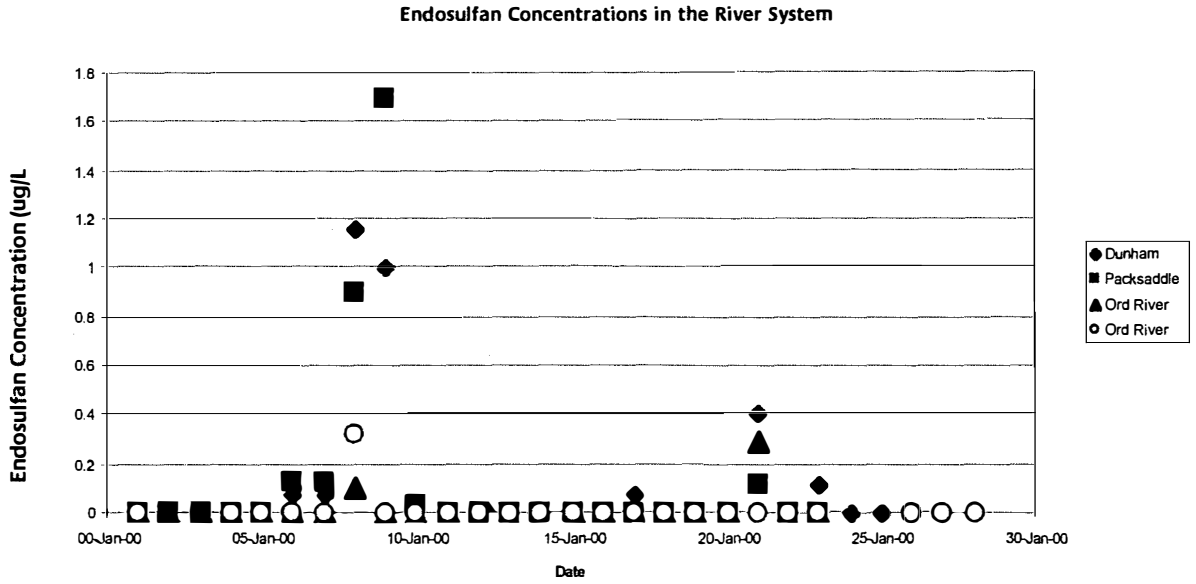


Figure 2 illustrates the trend of pesticide detection at river sites.



3.3.4 Projects Under way

- The study "*Productivity and water flow regulation in the Ord River of north Western Australia*" is now under way. The Water and Rivers Commission and two Perth universities are involved in the project, which should be completed by 2002 (*pers comm* Paula Deegan, Water and Rivers Commission, Sept 1999).
- There is currently a proposal for a project called "*Resilience of the Ord River to Irrigation Return*". This project has not yet been finalised.

3.3.5 Knowledge Gaps

- The levels of pesticides, sediments and nutrients the river can handle before there are negative impacts on the system.
- The amount of tail water that is leaving the area.
- The extent and nature of soil loss from irrigation farms throughout the cropping cycle and during the wet season.
- The actual impact of recreational use on the water quality in the river.
- The LC 50s for the native fish species for the pesticides used in the area?

3.3.6 Strategies

The three main issues with surface water quality are the sediment, nutrients and chemicals that enter these surface waters. Many of the strategies that will reduce sediment loading in the tail water will also have beneficial effects by reducing the export of nutrient and chemical from farms to the drainage and river systems.

Ultimately, a range of these improved management practices needs to be incorporated into a best management practice framework that can be updated as the benefits and costs of various strategies are identified.

General surface water quality management strategies

Strategy 1
Improve irrigation management by reducing sediment loads in tail water by:

1. Ensuring that all irrigation fields are leveled to a grade that minimises the risk of soil movement. Tail drain and farm drainage outlets need to be constructed to minimise the risk of erosion.
2. Designing irrigation fields with run length, grade, siphon size and watering interval such that fields can be fully watered in the shortest practical time.
3. Employing erosion stops and sediment traps on farm and drop-structures where tail water has to drop significant heights.

Strategy 2
Reduce the volume of tail water by:

1. Investigating the potential for alternative irrigation techniques and their likely impacts on soil loss and increasing adoption where possible.
2. Identifying suitable locations for demonstrating the effectiveness of tail water reuse and recycling systems
3. Developing and testing tail water recycling systems that might be suitable for the ORIA so that in the medium to long term tail water can be safely and cost effectively recycled.

Strategy 3
Use farming practices designed to reduce erosion during both the cropping and wet seasons by:

1. Growing cover crops to reduce erosion during the high intensity rainfall events leading up to the wet season.
2. Using Polyacrylamide (PAM) to improve irrigation efficiency and retain sediment (including colloids) infield.
3. Investigating and developing farming systems that employ forms of mulching, surface modification and other practices that are designed to reduce soil loss.
4. Reducing the number of unnecessary cultivation passes and using minimum tillage practices where possible.

Strategy 4
Employing off farm management options by:

1. Demonstrating and installing artificial wetlands where possible within the drainage system to filter tail water.
2. Revegetating areas of steep slopes and high erosion risk particularly in areas adjacent to drains and the river.

Management strategies for reducing nutrient loss

Strategy 5
Minimise the risk of fertiliser movement off farm by:

1. Accurate placement of fertiliser within the plant root zone (bury fertiliser).
2. On permeable soils applying small amounts of fertiliser matched to crop growth demands through sprinklers and drip irrigation systems
3. Using foliar fertiliser to meet crop demands
4. Applying PAM to irrigations following fertiliser placement particularly when fertilisers are spread rather than placed within the root zone.

Strategy 6
Prevent fertiliser from reaching the river system by:

1. The construction and management of artificial wetlands on the major drains within the ORIA.
2. Encourage the development and use of less mobile forms of fertilisers and nutrients (eg Nitrogen from cover crops)

Management strategies for reducing chemical export

Strategy 7
Reduce the risk of chemical movement off farm by:

1. Developing and implementing codes of practice for the application of pesticides through certification and audit of commercial and farm spray operators.
2. Implementing application methods based on accurate placement of pesticides.
3. Using less volatile formulations of pesticides.

Strategy 8
Reduce the amount of chemical used by:

1. Ensuring spray operators and farmers have all the up to date information on correct application rates.
2. Implementing well managed Integrated Pest Management programs for all crops based on :-
    a. Chemical usage being matched to a spray calendar and based on monitoring pest pressure
    b. A range of cultural, chemical and natural management strategies.
3. Utilising modern gene technology so that crops rely less on chemical control of pests.
4. Developing farming systems that maximise the natural plant defences against pest and disease attack.

Strategy 9
Reduce the environmental risk posed by pesticide use by:

1. Ensuring the registration and use of environmentally soft products with short half lives such as:
    a. Products based on natural pathogens such as bacteria and viruses,
    b. Pheromones and other products that interfere with breeding cycles.

Strategy 10
Provide research, demonstration, monitoring and training services to:

1. Monitor soil loss from farms and sediment, nutrient and chemical loads of drains and river systems at intervals throughout the year.
2. Quantify the soil, nutrient and chemical composition of sediment mobilised in tail water, and trapped in silt traps.
3. Monitor tail water flow volume.
4. Provide research facilities and resources to investigate new management initiatives and to demonstrate systems for managing sediment movement.
5. Encourage the use of crop scouting services to monitor pest populations and enable appropriate pest control methods to be applied.
6. Ensure registration of appropriate chemicals for crops being grown in the irrigation area.
7. Encourage the continued development and availability of new improved chemicals.
8. Provide training in chemical use, farming methods and nutrition management in crops on the Ord.

3.3.7 Responsibilities

By far the largest commitment in terms of direct costs associated with implementing these strategies will need to be made by the farming community, as most will be costs of implementing improved management such as laser leveling, silt traps, and general farming practices. To balance this it is likely that they will also be the biggest beneficiaries of the

improved management through reduced soil and nutrient loss.

There will be a requirement for commitment to support long term monitoring and research from a number of State Government Agencies including AGWEST, WRC, WC and CALM. Specific approaches to R&D Corporations may be necessary to develop the research and monitoring methods and framework. Chemical companies and the National Registration Authority need to be focussed on providing a suite of more environmentally friendly chemicals for tropical cropping areas like the Ord.

Community support for the strategies through voluntary programs of monitoring and information gathering will likely involve groups such as river using tour operators, recreational fishing groups and the Ribbons of Blue program.

3.3.8 References

The Water and Rivers Commission, Kununurra office, provided the water quality data.

Australian & New Zealand Environment & Conservation Council, (1992) Australian Water Quality Guidelines for Fresh and Marine Waters

3.4 Pest and Pesticide Management

3.4.1 Goals

A 100% increase in the adoption of Integrated Pest Management for all compatible crops within five years.

3.4.2 Background

The wise use of chemicals is critical to sustainability of agriculture and is a component of best management practice in modern agriculture. There are a number of issues relating to the sustainable use of chemicals that need to be considered including the management of resistance in pest species, the development of integrated pest management systems and aerial spraying operations.

Resistance Management

Prolonged exposure to a particular chemical will lead, through selection pressure, to the development of resistance to that chemical. This resistance will continue to build up until the chemical becomes less effective. Resistance to one chemical in a particular group may transfer resistance to other similar chemicals. The biology of insects is such that eventually they will develop resistance to repeatedly applied chemicals.

There is an ongoing resistance management strategy for *Helicoverpa species* in the ORIA. This is developed at the beginning of each season by Agriculture WA and the farmers. 1999 also saw the introduction of a resistance management strategy for melon aphids in the area.

Helicoverpa species

There are two species of Helicoverpa that are major pests to a wide range of crops in the ORIA. These species are called *Helicoverpa armigera* and *H. punctigera. H. armigera* has developed resistance to several groups of insecticides. This species does not migrate but remains in the area in low densities over the wet season, building up in numbers once new crops are established and usually becoming the dominant species by August. Since there is no inward migration of susceptible individuals resistance levels do not get substantially diluted from year to year.

The other species *H. punctigera,* has not developed resistance to insecticides. While small numbers persist through the wet season these are supplemented by insects which migrate to the ORIA at the beginning of the season. These migrants usually come from areas where they have not been subject to insecticides and therefore have not built up resistance. This species is usually more abundant from March to July (Resistance Management Strategy for *Helicoverpa spp* in the Ord River Irrigation Area for 1999).

Melon Aphid

The melon aphid (*Aphis gossypii)* causes problems by transferring viruses in cucurbit crops. In 1997 resistance to pirimicarb and organophosphate chemicals was detected and in 1998 resistance to pirimicarb and organophosphates increased and moderate resistance to pyrethroids was detected for the first time. Endosulfan is the only registered chemical that aphids have not yet shown resistance to.

Resistance is hard to control in the melon aphid as the female produces live young without mating, hence interbreeding does not dilute the resistance levels. When aphid populations are low wingless females are

produced and aphids will only move to touching plants. Winged females are only produced when the populations are dense and widespread dispersal and virus transmission will only occur at this stage (Resistance Management Strategy for Cucurbit Pests in the Ord River Irrigation Area for 1999).

Integrated Pest Management

The aim of integrated pest management (IPM) is to reduce the use of chemicals in pest management, and instead use a combination of control measures (biocontrol, cultural, genetic and chemical) that are less destructive to the environment (IPM, 1999).

All major agricultural industries are looking at developing IPM strategies to control their pests. One industry that has put a large amount of work into IPM is the Australian Cotton Industry.

Aerial Spraying Operations

There are two aerial spray operators currently operating in the Ord River Irrigation Area. They spray a range of crops throughout the irrigation area.

There is an Aerial Agricultural Association of Australia (AAAA) which consists of operators of agricultural aircraft. Currently this organisation has 75% of the aerial operators around Australia as members. Accreditation is an involved process and operators must:

- Demonstrate their interest in improving and sustaining their professionalism.
- Employ only industry approved, examined and trained personnel in agricultural operations.
- Comply with agricultural, health and environmental legislation.
- Abide by manufacturers' and approved recommendations regarding applications of agricultural chemicals.
- Have spraying and spreading aircraft fitted with positive shut-off equipment.
- Have spraying aircraft fitted with a smoker for drift detection and a flow metre for accurate spray application.
- Demonstrate competent house keeping in their mixing activities, loading equipment and chemical storage and handling facilities.

(More information can be found in the Pilots and Operators Manual {Woods & Lisle, 1998}).

The AAAA provides continual training for its members and up to date information on new products on the market etc.

3.4.3 Current Knowledge

Current pest control strategies for the ORIA have been developed over years of scientific study and practical application. The unfortunate legacy of the early cotton developments and consequent over reliance on chemical controls has created sensitivity among farmers to the use of chemicals. Some practices imported from other areas have not proved to be effective, however new approaches are continually being tried in an attempt to reduce the money spent on chemicals; as well as to reduce the environmental risks

Resistance Management

All farmers play an integral role in controlling resistance in pest species by having input into the resistance management strategy (in conjunction with AGWEST), at the beginning of each season.

Helicoverpa species

The current resistance management strategy for the Helicoverpa species has the following components:-

a) Prevent build up of *Helicoverpa* populations with early suicide crops.
b) Use the calendar window approach – the season is divided into three windows in which different groups of insecticides are sprayed.
c) Targeting species – knowing which of the two species is present and tailoring the spray program to suit.
d) Minimise insecticide applications – eg. by using scouting techniques and setting pest population thresholds to determine when to spray.
e) Treat larvae when small.
f) Use only recommended chemical mixtures.
g) Eliminate insecticide resistant *H. armigera* at the end of the season – for example by using suicide crops.

Melon aphids

The current resistance management strategy for melon aphids includes:

a) Using the calendar window approach.
b) Scouting and trapping.
c) Sending samples away for resistance testing.

There were much lower levels of melon aphids during the 1999 season than during 1998. As a result mosaic virus levels in cucurbit crops were also low in 1999 (Cucurbit Pest Newsletter, No.4, 1999).

The 1999 season saw much lower melon aphid levels than the 1998 growing season (due to weather conditions etc). Corresponding to this low level, the virus levels in cucurbit crops were also low in 1999 (Cucurbit Pest Newsletter, No.4, 1999).

Integrated Pest Management (IPM)

Cotton

All the cotton that is grown in the ORIA (~1000ha in 1999) is grown under an IPM system. This involves using suicide crops, companion crops, beneficial insects, soft chemicals, bug scouting techniques and genetically engineered cotton (Bt).

- Trap crops, such as lucerne and lab-lab, act to attract (and "trap") the pest insects and as refuge for the beneficial insects.
- Beneficial insects are those that are natural predators to the pest species.
- Bug scouting is done on every field twice a week and sprays are only applied when the numbers of pest species reach threshold levels.
- Soft chemicals generally do not kill the beneficial insects, and therefore, if insect numbers get over thresholds then there are chemicals that can control the pests without killing all the beneficials.
- There is no Endosulfan used on Bt cotton in the ORIA.
- Chemicals that are used in cotton include Pirimicarb, Amitraz and Gemstar (Amanda Annells, *pers comm*).

Other Crops

There are a number of other crops that are being grown in the valley utilising some aspects of the above system.

There are a number of melon growers who are adapting their management in line with some of the ideas of cotton IPM methods. Other growers are using bug checkers (eight growers employed the Ord River District Co-op to carry out bug checking for them during 1999) and threshold levels to determine when application of chemicals is required.

All of the chickpeas that are grown in the valley are scouted regularly for Helicoverpa. There was ~ 450 ha of chickpeas grown in the valley in 1999.

Aerial Spray Operations

In the ORIA there is no requirement for spray operators to be accredited with the AAAA. One operator is accredited with the AAAA and the other operator is in the process of becoming accredited.

There are a number of issues associated with aerial application of chemicals as opposed to ground application. Aerial application:

- prevents soil compaction;
- is faster and ensures the farmer/operator is less exposed to chemicals than is the case with ground rigs;
- and an aerial operator can spray while the ground is still wet.

However, by using aerial application:

- there is increased likelihood of off target drift;
- more chemical is used (when plants are small ground rigs can "band spray" and spray the plant line only),
- evokes emotion/distrust by people who see the plane spraying.

There are limits to aerial spraying and there are jobs that need to be done by a ground based spray rig.

In Western Australia there are a number of Acts which relate to aerial spraying – The Health Act, 1974, the Occupational Health & Safety Act, 1984, The Aerial Spraying Control Act, 1966, The Environmental Protection Act 1986.

According to the Civil Aviation Papers Part 20 (CASAA), Air Service Operations – Aircraft engaged in Agricultural Operations, permission is granted to fly at a lower height than 500 feet over any area other than a city, town or populous area while the aircraft is engaged in:

- Agricultural operations authorised by an aerial work license issued under the Regulations; and
- Inspection flying related to such agricultural operations; and
- Transit flights to a treatment area up to a maximum radius of five nautical miles from the aerodrome or agricultural landing area when carrying an agricultural payload.

3.4.4 Knowledge Gaps

- The combination of IPM methods that would work best for cucurbit crops in the area.
- Are the threshold levels that are currently being used effective?
- What are the relationships between different crops in terms of IPM?

- Is there a need for a regional IPM strategy?

3.4.5 Strategies

Strategy 1
Reduce the risk of resistance build up in chemical control measures by:

1. Using all chemicals according to recommended rates and concentrations.
2. Developing and rigidly adhering to a well thought out spray calendar that is aimed at protecting individual chemical groups.
3. Using chemical control measures only when crop scouting indicates that spraying is necessary.
4. Using integrated pest management systems whenever possible and minimising the use of chemicals.
5. Developing an understanding of the patterns of resistance development to enable reliable prediction of likely problems.

Strategy 2
Increase the adoption of Integrated Pest Management by:

1. Demonstrating the advantages of using a range of control measures including:
   a. Cultural methods,
   b. Soft Chemicals
   c. Predatory insects
   d. Trap Crops
   e. Crop Scouting
   f. Food Spray and other attractants
   g. Genetic modification
   h. Crop timing.
2. Further researching management methods so that satisfactory IPM systems can be implemented on a range of crops.
3. Establishing insect population thresholds to initiate sprays under tropical conditions.

Strategy 3
Ensure optimal performance of all spray operators by:

1. Encouraging all operators to be properly accredited (aerial applicators AAAA, others Farm Safe).
2. Developing a responsible cooperative approach to flight paths to minimise the risk of accidental chemical contamination of the river system.
3. Encouraging the use of more sophisticated spray equipment that permits greater control over drift, chemical placement and amounts of chemical used.

Strategy 4
Improve the image of spray operators and of aerial spraying as a control method by:

1. Ensuring good communication between neighbours to minimise the risk of conflict associated with spraying operations.
2. Increasing the amount of information on spraying and chemical use to increase community understanding about spraying.
3. Developing a code of practice and adhering to it.

3.4.6 Responsibilities

Farmers, spray operators and chemical suppliers need to work together to develop better systems. These new practices will involve certain levels of risk to farmers as control programs will be more sophisticated. There may well be cost savings through reduced chemical use. Plant breeders and seed producers will need to become more involved in looking for novel solutions through genetic modification.

AGWEST, CSIRO and other research providers have a responsibility to help farmers to develop management systems that are less dependent upon chemicals. They should also be involved with ensuring adoption of the new practices, as they become available.

3.4.7 References

Cucurbit Pest Newsletter, No 4, September 1999, Agriculture WA.

Resistance Management Strategy for Helicoverpa spp *in the Ord River Irrigation Area for 1999*, Agriculture Western Australia.

Resistance Management Strategy for Cucurbit pests in the Ord River Irrigation Area for 1999, Agriculture Western Australia.

Integrated Pest Management (1999), www.waite.adelaide.edu.au

Brain Thistleton, Kimberley Regional Entomologist

Aircraft in Australian Agriculture, A Review, The Aerial Agricultural Association of Australia Limited 1998.

Woods, N., Lisle, R., (1988), Aerial Agricultural Association of Australia –

Operation Spray Safe – Pilots and Operators Manual.

3.5 Chemical Handling and Storage

3.5.1 Goals

- **100% of farmers to be accredited chemical applicators within two years**
- **100% of farm chemical stores to comply with Australian and Western Australian Standards within five years**
- **All past chemical container dump sites to be identified, assessed and, where necessary, contained within five years**

3.5.2 Background

All farming operations will to some degree be dependent upon the application of some chemicals. Agricultural chemicals may be harmful to humans and can affect all forms of life, so they need to be handled carefully and only used according to approved (registered) safe procedures. All chemical containers come with information on the correct use and handling of the chemical concerned.

The Farm Safe program provides for the compulsory training and accreditation of all users of agricultural chemicals. In some instances it will be an offence to sell chemicals to people without accreditation. This basic training is designed to provide the understanding necessary to use chemicals safely and for their registered purpose.

The Department of Minerals and Energy determines requirements for the storage and handling of agricultural chemicals. There is also an Australian Standard for the storage and handling of agricultural and veterinary chemicals (AS2507 – 1998). The large majority of farming operations in the valley would qualify for minor storage as they do not store large amounts of chemicals on their farms at any one time (and therefore these operations do not have to be licensed to store chemicals).

3.5.3 Current Guidelines for Storage

(All information is taken from the Australian Standard for the storage and handling of agricultural and veterinary chemicals, and Department of Minerals and Energy Guidance Note – S319 REV 1 – Storage of dangerous goods on farming premises, Conditions for exemptions from licensing).

The guidelines for storage of these chemicals depends on the amount of chemical that is stored at any one time. The following is the maximum quantity of types of chemicals (PG= packaging group) that can be stored at any one time for the storage area to be classed as a "Minor Storage" area:

PG I - great danger (eg. Sodium Cyanide) 1 (litre or kg)
PG II - medium danger (eg. petrol) 250 (litres or kg)
PG III - minor danger (eg. kerosene) } 1000 (litres or kg)
NDG – not classed as dangerous goods }

Examples of chemicals – Sprayseed (PG III), 2,4-D Ester (PG II), Roundup (NDG)
For more information on specific chemicals – see their Material Safety Data Sheets (MSDS).

Requirements for Minor Storage

(These are guidelines only – not enforceable by law – and are designed to protect the handler of chemicals and the environment).

Construction

a) The floor shall be impermeable to chemicals that are being stored.
b) Where there is the possibility of soil or water contamination there needs to be a method of containing leaks or spills in the storage area.
c) The area needs to be well ventilated and protected from heat and ignition sources.
d) Fire protection measures need to be provided in easy to access locations.

Separation

The minor storage area shall be separated by:

a) at least 15m from any unrelated work area, office, amenities or the boundary of the property;
b) at least 5m from any watercourse, body of water, drain or sewer not confined on the property.
c) If there are two or more minor storage areas on the farm then they can be treated as separate if they are 500m apart.

Segregation

Segregation is the isolation of incompatible dangerous goods from each other. Incompatible dangerous goods need to be separated by at least 5m. Provision should be made so that any spillage of one product can

not flow and come into contact with another incompatible product.
Example – Petrol/diesel/solvent based pesticides with AGRAN.

Secondary Containment
Secondary containment is usually described as bunding, however it may simply be achieved by careful location of the dangerous goods on the premises.

The objective is to ensure that any spillage or release of dangerous goods is retained on the premises in a manageable area so that recovery can take place without injury to people, property or impact on the environment.

The natural contours of the ground sloping to an embankment, the use of compacted clay bund walls or deliberate sloping of the ground to a pit may also achieve this objective.

Outdoor Minor Storage

Quantities
The following amounts can be stored outdoors:
PG I 10 (litres or kg)
PG II 500 (litres or kg)
PG III 3500 (litres or kg)

Conditions
a) The size of the farm is at least 2 ha.
b) The area is kept clear of combustible vegetation for at least 3m.
c) Any potential spillage shall be prevented from reaching any protected place – using natural ground slope, kerb or bund.
d) Store is at least 10m away from any dwelling.
e) Separate from the property boundary by 15m.

Storage areas for larger volumes of chemicals than considered minor storage.

There are more specific requirements for storage if the amount of chemicals being stored is more than the above mentioned amounts. These requirements include planning and design, location of the areas and construction requirements. Most farms would not store more chemicals than covered by minor storage categories. (Details are found in Section 3 of Australian Standard 2507-1998).

3.5.4 Strategies for Storage of Chemicals

Strategy 1

Ensure the safe handling and storage of chemicals by:

1. Creating greater awareness of the storage guidelines.
2. Encouraging farmer groups to promote safe chemical storage and handling on farm.
3. Ensuring that safe handling and wash down areas are included in quality assurance programs.
4. Locating spray rig filling and chemical mixing facilities away from channels and drains and ensuring that they are designed to safely contain spills.
5. Ensuring all chemical users are appropriately accredited under the Farm Safe Program.

Strategy 2

Ensure the safe disposal of used chemical containers by:

1. Encouraging the Shire of Wyndham East Kimberley to become a participating shire in the Drum Muster Program to provide safe collection, temporary storage and disposal of used chemical containers.
2. Following 1.above, design and implement an information program to encourage farmers and other chemical users to participate in the Drum Muster Program.

3.5.5 Current Status - Historical Dumping Sites

There are a number of sites around the valley where there are historical chemical dumping sites. These sites were used in the past to dump chemical containers. There is a possibility that these areas may actually be a source of contamination to land and water resources.

There is an area behind Bethel Farm and an area on the Pacific Seeds – Cave Springs Farm. There are also lime lined disposal pits at the Research Station and at the old airstrip (this was the "best practise" at the time).

3.5.6 Knowledge Gaps

- The number of farmers who comply with the regulations.
- Other areas not listed above where chemical containers were dumped in the past.

3.5.7 Strategies – Historical Dumping Sites

Strategy 3

Identify, contain and render safe past chemical container dumping sites by:

1. Identifying and clearly marking past disposal sites.

2. Characterising those sites to identify the current and future risks associated with them.
3. Take whatever measures are necessary to remove the risks to the environment or to human health associated with these sites.

3.5.8 Responsibility

Safe management of chemicals within the environment and farming workplace will be dependent upon involving all farmers, other users, farmer groups and the community.

AGWEST should be involved with farmer groups by ensuring the development and adoption of best practice and the provision of appropriate training and accreditation systems. The Department of Minerals and Energy and the Department of Environmental Protection have responsibility for working with farmers, suppliers, users and the community to ensure that storage and wash down facilities are safe. The Department of Environmental Protection and the community have responsibility for identifying and rendering safe, past chemical container dumping sites.

3.5.9 References

Guidance Note S319 REV1, (1998) *Storage of Dangerous Goods on Farming Premises, Conditions for Exemption from Licensing,* Department of Minerals and Energy – Explosives and Dangerous Goods Division.

Australian Standard ™, The storage and handling of agricultural and veterinary chemicals, AS2507 – 1998, Standards Australia.

3.6 Fuel Storage on Farm

3.6.1 Goals

- **100% of farm fuel storages to comply with Australian and Western Australian standards within five years.**

3.6.2 Background

There are requirements from the Department of Minerals and Energy and Standards Australia on the installation of storage tanks and the storage of fuel at any location (eg. on farm, service stations etc.).

3.6.3 Current Guidelines

These guidelines refer to the storage of any flammable or combustible liquid and are sourced from Guidance Note S308, but will focus on the storage of diesel, as this is the most common fuel stored on farm in large quantities.

If the storage tank is 5000L or less (Minor Storage) then the requirements for storage and handling focus on safety issues. These are outlined in Section 2 of the Australian Standard for "The storage and handling of flammable and combustible liquids".

When the storage tank is more than 5000L there are more requirements that need to be met. These focus on minimising the risk of fire and impact on the environment. These requirements are outlined in Section 3 of the Australian Standard for "The storage and handling of flammable and combustible liquids"(AS 1940-1993). These include requirements for tank construction, venting, underground tank installations, aboveground tank installations, dispenser requirements, fill point locations, tanker filling locations and fire protection.

Aboveground Tank Installation

As the majority of on farm tanks are above the ground, the following is a summary of these guidelines.

a) Separation – the tank is required to be at least 15m away from office buildings, warehouses, workshops etc (if on the same property). The tank also needs to be not closer than 15m to the boundary. There are also requirements for separation from protected works on adjacent properties. If there are two storage areas on the property they must be at least 500m apart.
b) Bunding – a bund is required for any above ground tank in excess of Minor Storage as defined by Section 2 of AS 1940-1993. In general the bunding shall:
   i. Contain 100% of the storage capacity of the largest tank.
   ii. Be impervious to spillage and enable recovery of spillage.
   iii. Be located not less than 1m from the tank
   iv. Not be higher than 1.5m unless a means of rapid and safe entry and exit is provided and
   v. Be able to withstand exposure to fire. (See also Section 5.9 AS1940-1993)
c) Bunding can also be achieved by utilising the natural slope of the land with the use of compacted clay for bund walls (Guidance note S319).

3.6.4 Knowledge Gaps

- The best way to construct a bunding system for our conditions.
- The number of farmers who have storage areas that comply with the guidelines.

3.6.5 Strategies

Strategy 1

Ensure safe storage of fuel by:

1. Preparing and widely distributing clear easy to read guidelines to all farmers and other users of drum or bulk fuel.
2. Enforcing regulations and guidelines for fuel storage in bulk and drums.

Strategy 2

Prevent surface movement of fuel and oil products by:

Developing and enforcing Shire by-laws that prohibit the use of waste fuel and lubricants on road and track surfaces.

3.6.6 Responsibilities

Uptake and adherence to guidelines depends upon farmer and general community involvement and willingness to cooperate. Regulations relating to storage are the responsibility of the Department of Minerals and Energy while local by-laws will require a commitment from the Shire of Wyndham East Kimberley. Farmer groups, AGWEST and the SWEK should be involved in developing and effectively delivering improved educational material about fuel storage and the safe handling of waste products.

3.6.7 References

Australian Standard ®, *The storage and handling of flammable and combustible liquids,* AS1940-1993, Standards Australia.

Guidance Note S308 REV 3, (1998) *Tank Installations for the Storage of Flammable and Combustible Liquids,* Department of Minerals and Energy – Explosives and Dangerous Goods Division.

Guidance Note S319 REV1, (1998) *Storage of Dangerous Goods on Farming Premises, Conditions for Exemption from Licensing,* Department of Minerals and Energy – Explosives and Dangerous Goods Division.

3.7 Sugar Mill

3.7.1 Goals

- **A sugar mill that always operates at or above Australian Best Management Practices for the management of by-products.**

3.7.2 Background

When the sugar industry was set up in Kununurra, it was decided that the mud that entered the sugar mill on the cane would be transported back to the farms via the M1 Irrigation Channel. However, this caused management problems for the millers, the farmers and the water delivery operators (Ord Irrigation Cooperative). In 1999 the mud was removed from the channel and stockpiled on land adjacent to the mill. While this has improved the quality of the irrigation water the industry has still to deal with problems associated with disposal of by-products from the milling of sugarcane (boiler ash, mill mud and bagasse).

3.7.3 Current Status

Mill mud, boiler ash and surplus bagasse are now stockpiled on land adjacent to the mill. The cooling water is returned to the channel and this water is now of a quality that could be discharged directly into a natural waterway.

Photo 4: Cooling water from the Mill being returned to the M1 Channel. *(see central colour pages)*

The licensing requirements from the Environmental Protection Authority have been eased with the only water sampling requirement now being to sample the channel monthly for Biological Oxygen Demand (BOD), and for one sample run per year where the full suite of parameters are tested. In previous years the sampling requirements where more stringent – however after proving that the cooling water is not a threat these requirements have been eased.

The ash is now pumped into settling ponds, before being removed and stockpiled on adjacent land by a contractor. These ponds may be having a negative impact on the quality and depth of the ground water in the area.

The mud is now partially dried before being stockpiled for removal by a contractor, some of this is being returned to farmland. The demand for the mud is increasing and there

does not seem to be any foreseeable problems with disposing of the mud (Russel Kirk *pers com*)

A business making compost is being developed around the disposal of mud, ash and bagasse. Trials have been conducted to test the quality of the composted product. The plan is to use all of the mill mud, some ash and some bagasse within 3 years. The sugar industry bears the cost of removing unwanted by-products from the mill site, a cost that is likely to increase in the short term as the land adjacent to the mill becomes filled with ash, bagasse and surplus mud.

3.7.4 Knowledge Gaps

- Identify the benefits to farmers from use of the mud, ash and compost.
- Develop methods of applying, spreading and managing these by-products on farm.
- The impacts of the ash drying dams on the ground water.

3.7.5 Strategies

Strategy 1

Ensure that all by-products are returned to farm by:

1. Developing the market for them through more information about how to use them cost effectively.
2. Encouraging the production and use of compost.

Strategy 2

Reduce the level of by-products by:

1. Improving management methods that reduce the amount of mud being brought to the mill.
2. Developing new varieties of cane that have lower fibre levels and thus produce less bagasse than existing varieties.

Strategy 3

Monitor the ground water levels and quality around the ash settling and drying ponds.

3.7.6 Responsibilities

The sugar industry has already taken responsibility for the costs associated with removing by-products from the mill and both the miller and growers have responsibility for further encouraging the return of by-products to the farms. The sugar industry also has a responsibility for investigating the impacts that they are having on the ground water in the immediate area around the ash drying dams.

There is a need for some basic research into the management of by-products on farm and while the sugar industry should bear this cost assistance from research providers like AGWEST will be necessary to achieve maximum uptake. Research providers such as AGWEST, CSIRO and BSES should continue to be responsible for developing new varieties with lower fibre content. Funding for this research is likely to come from joint industry and government support through the Sugar Research and Development Corporation and AGWEST.

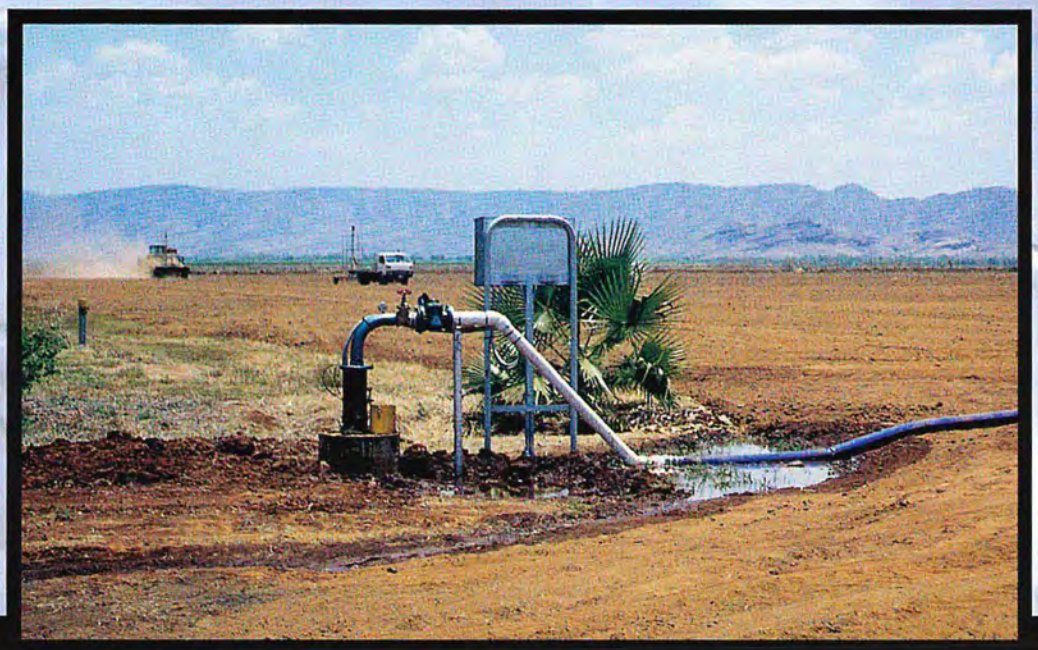


Photo 1: Ground water trial pump bore at Bardena Farms

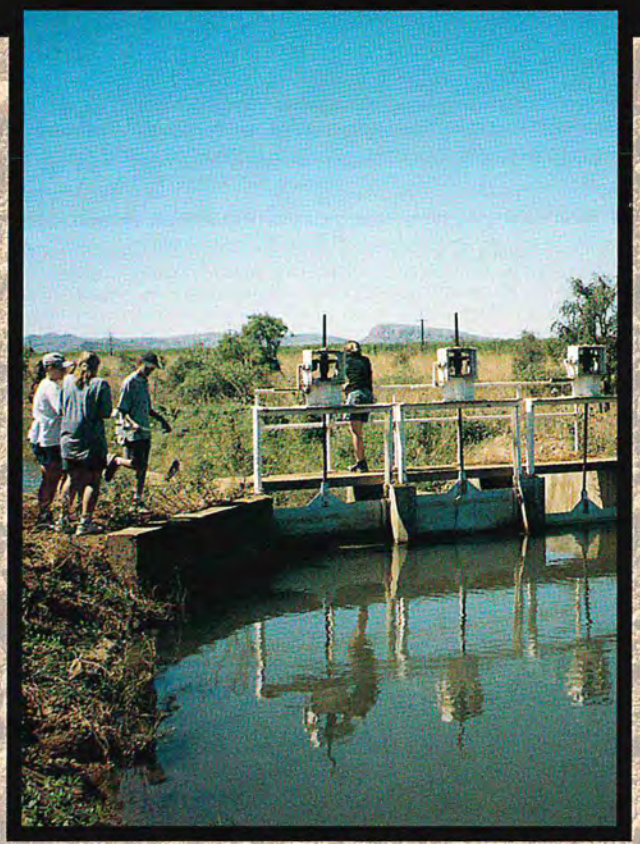


Photo 2: Ribbons of Blue participants sampling water in the M1 Channel

Photo 3: Sediment being measured in tail water in a farm drain

Photo 4: Cooling water from the Mill being returned to the M1 Channel

Photo 5: Barramundi caught in the Lower Ord River

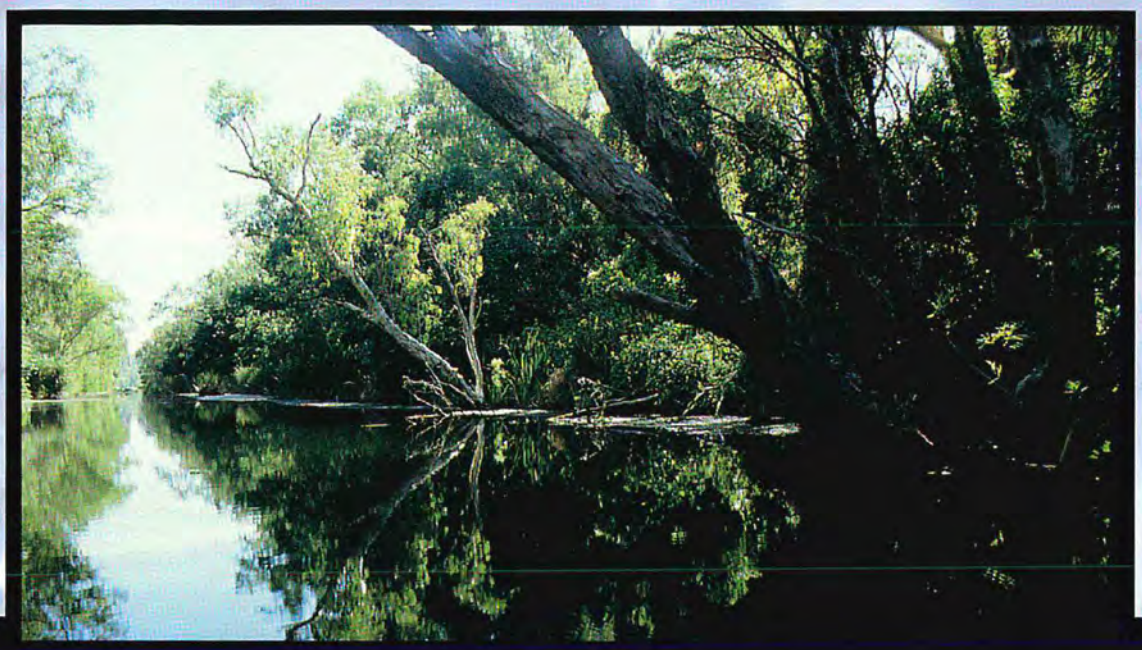


Photo 6: Riparian areas along the Ord River

Photo 7: Ivanhoe Crossing with the Ord River in flood on March 5th 2000

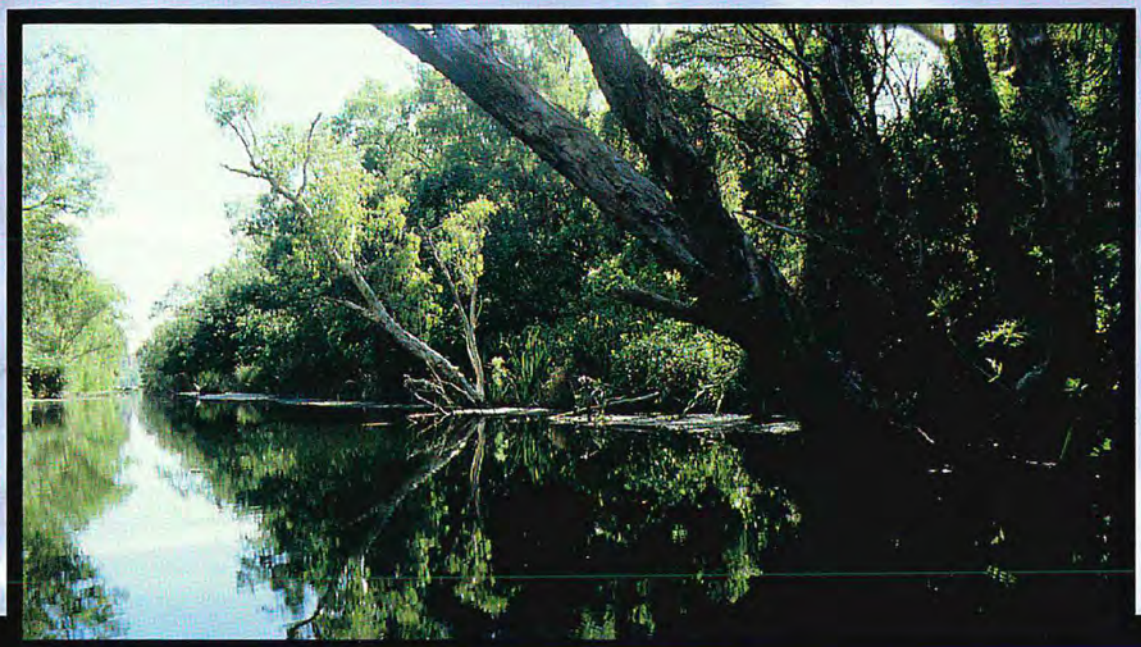


Photo 6: Riparian areas along the Ord River

Photo 7: Ivanhoe Crossing with the Ord River in flood on March 5th 2000

Photo 8: Lake Argyle spillway – 1997

Photo 9: Flow down the Lake Argyle spillway – March 2000

Photo 10: Crocodile sighted while boating on the Lower Ord River

Chapter 4 - River Issues

4.0 Introduction

This chapter deals with issues associated with the impacts of land and water users on the river and its associated values. The strategies developed suggest the need for a **River Management Strategy** for the Ord River to ensure that guidelines for improved management continue to be developed and adhered to.

Many of the issues associated with wise management of the river depend on information that has yet to be gathered. The unique nature of each river system means it is difficult to transfer information from one location to another. The general lack of information about tropical river systems makes it near impossible to proceed with wise management without significant research effort.

The management of the river cannot wait for the complete gathering and interpreting of research information but must proceed on the basis of the best existing knowledge while new knowledge is gained.

There are a number of agencies that have statutory responsibilities for managing waterways around Kununurra. These include the Water and Rivers Commission, the Water Corporation and the Shire of Wyndham East Kimberley. Local residents, tourists and tour operators also have a responsibility for minimising the impacts they have while enjoying the river.

Please note - *It is important to recognise that the strategies developed in this chapter will need to be built on as new knowledge is developed and targets are achieved. At this stage they provide a starting point and a framework for commitment from all the parties involved in Land and Water Management on the Ord.*

4.1 Fish Stock Management

4.1.1 Goals

- **To maintain and protect existing fish stocks with a view to increasing them if required in the future.**

4.1.2 Background

Fishing in the Ord River is a popular pastime for local residents and it acts as a draw card to visiting anglers (West *et al*, 1996). There are a number of charter fishing operators, and commercial fishermen who rely on a healthy fishery to support their businesses.

The main target species for fishing on the Ord River are barramundi and bream (Sooty Grunter) (West *et al*, 1996).
There are bag limits in place for both of these fish with the barramundi bag limit being one fish per angler (size range 55cm –80cm), and bream 20 fish per angler with a minimum size of 25cm (Fishing for the Future, 1998). There are other species of fish found in the area including silver cobbler (catfish) that are fished, although these are not popular as a recreational fishing species.

Since the building of the Diversion Dam and Lake Argyle the habitat range of barramundi on the Ord River has been restricted to the area of the river below the Diversion Dam (Doupe and Bird, 1999). Bream and silver cobbler can be found in Lake Kununurra and Lake Argyle as well as the Ord River.

4.1.3 Current Status

The absence of adequate fish stock information prevents any firm conclusions regarding fish stocks in the Ord River. The current barramundi stocks, however, do not appear to be in decline. The catch rate trends for the commercial fishery, general satisfaction levels for the recreational fishery and consistent anecdotal information (West *et al,* 1996) support this claim.

Photo 5. Barramundi caught in the Lower Ord River *(see central colour pages).*

Fisheries WA are the lead agency involved in fish stock management and aquaculture development around the state. The principal local group involved in recreation fishing is the East Kimberley Recreational Fishing Advisory Committee (EKRFAC). The role of this committee is to provide advice and information to the Minister for Primary

Industries and Fisheries. The EKRFAC is one of 12 regional RFAC committees located throughout the state.

There are three commercial fishermen fishing areas of the Lower Ord (downstream of Carlton Crossing) (R. Tregonning, *pers comm*). They are based in Wyndham and usually visit the Ord River two or three times a year as one of a number of rivers they fish in the area. They are not allowed to fish during the months of December and January. Their catch is relatively small, however, as they use nets to fish they do have some fish waste through bycatch (catching of non target species). They do not have the same size and bag restrictions as recreational fishers.

There are several fishing charters operating in the Lower Ord River area. Barramundi is the focus fish for these operations and they all abide by the barramundi regulations regarding size and number of fish taken.

There has been some barramundi tagging carried out in the Ord River.

Introduced Species

There are no introduced species of fish present in the "wild", however there is currently one introduced species being farmed in the ORIA – Redclaw Crayfish (*Cherax quadricarinatus).* There are strict regulations on the management of this species including pond construction (netting, fencing, etc, to prevent the escape of redclaw), and disease and quarantine protocols. For details see Fisheries Management Paper No.100 – The Aquaculture of Non-endemic Species in Western Australia (Thorne, 1997).

4.1.4 Current Projects

Range Expansion

The EKRFAC are interested in expanding the range of barramundi into Lake Kununurra. This could help to relieve perceived future pressure on the area of the river below the Diversion Dam and has the potential to create significant economic benefits. As an example, a cost – benefit analysis of the stocking of barramundi in Lake Tinaroo (QLD) indicated that each $1 spent on the program would generate a potential $31 benefit to the economy of Queensland (Makaira Pty. Ltd, 1999).

There are three proposals for restocking being discussed:

1. The option of restocking Lake Kununurra every year with hatchery raised fish;
2. Using the irrigation area to facilitate the migration of barramundi for a few months at the beginning of the year (only a small modification would be needed on the D2 drain) and;
3. To build a fishway for fish to move up the Dunham River, across the Packsaddle Plain and into Lake Kununurra.

Aquaculture

There are a number of small land based aquaculture operations currently present in the ORIA. There are a few management issues with mixing aquaculture and horticulture/agriculture. There are opportunities for land based aquaculture, however, the largest opportunity for aquaculture appears to be in Lake Argyle.

There is a commercial barramundi aquaculture operation in Lake Argyle. This has been in operation for a number of years and in 2000 the operation is aiming at producing between 100-150 tonne of barramundi. There is also a small commercial silver cobbler (catfish) fishery on Lake Argyle, which involves fishing for "wild" fish not fish grown in an aquaculture situation.

There is potential to expand aquaculture in Lake Argyle. In 1999 a Strategic Environmental Review examined the potential for expanding the aquaculture industry in Lake Argyle. This review found that a 2,000 tonne aquaculture industry could be supported in the lake without causing adverse environmental impacts. The report was completed for Fisheries WA to initiate the development of an intensive Barramundi industry in the Kimberley Region (LeProvost Dames & Moore, 1999). Fisheries WA has called for expressions of interest from investors and developers. Expressions of interest close in September 2000.

4.1.5 Knowledge Gaps

- There is an absence of adequate fish stock information and therefore the impact that fishing (both recreational and commercial) is having on the fish stock is not fully understood.
- The type of fishway required to facilitate the movement of barramundi into Lake Kununurra.

- It is not fully understood whether hatchery raised fish released into Lake Kununurra would reside in the lake or move out through the Diversion Dam gates.
- How many fish would be required to sustain the fishery in Lake Kununurra?
- What pressure would fish introduced into the lake put on current fish populations?
- How much fishing pressure is actually on the area downstream of the Diversion Dam (use numbers etc)? (Catch and effort data).
- Are other fish species numbers increasing/decreasing in the Ord River (eg Mangrove Jack numbers appear to be increasing [*pers comm* Jane Harman])?

4.1.6 Strategies

Strategy 1

Protect the existing fish stock from overfishing by:

1. Understanding the carrying capacity of the fishery.
2. Encouraging recreational fishers to become responsible for protecting the fishery through becoming licensed to fish on the Ord River and to keep a log book as part of this license requirement.
3. Developing and promoting a fishery management plan for the Ord River fishery (all fishes) – building on existing attempts to set bag and size limits.
4. Preventing overfishing by individuals who do not comply with management guidelines through increased policing (which could be funded in part through the licensing scheme).
5. Researching the impact that all land and water users have on the capacity of the river to support a healthy fishery.

Strategy 2

Investigate proposals relating to fish stock management on the Ord River including:

1. Examining and, if sustainable and acceptable to the Kununurra community, proceeding to stock Lake Kununurra with barramundi.
2. Examining the feasibility of a fish ladder concept for a bypass from Lake Kununurra to the Dunham River.

Strategy 3

Ensure better understanding of how to sustainably fish the river for recreation by:

1. Conducting extensive publicity and education programs.
2. Involving recreational fishers, school students and the community in research, information gathering and monitoring processes.
3. Developing the log book/licensing concept to increase the information and understanding about the fishery.

Strategy 4

Minimise the potential conflict between aquaculture and other land uses by:

1. Ensuring that small land based aquaculture ventures meet the environmental standards required of them.
2. Ensuring that planning schemes provide for the segregation of aquaculture and agriculture/ horticulture so as to minimise possible future conflicts.
3. Encouraging dialogue between the aquaculture and agriculture/horticulture industries on the Ord to identify and resolve potential conflicts.
4. Supporting well planned aquaculture ventures (such as those proposed for Lake Argyle and at Wyndham).

4.1.7 Responsibilities

Fisheries WA have statutory responsibility for managing the fish stock and aquaculture developments, as well as conducting research and monitoring necessary to make better management decisions. They depend on local support through the East Kimberley Recreational Fishing Advisory Committee (EKRFAC).

The Shire of Wyndham East Kimberley has responsibility for town and rural planning that identifies areas for particular land use. They also have involvement in the planning for a possible bypass with fish ladder. The WA Planning Commission can reduce the potential for conflict by appropriate long term planning through vehicles such as the Kununurra Wyndham Area Development Strategy.

AGWEST and local farmers need to be involved in managing the potential conflicts between agriculture/horticulture and aquaculture.

The general community, and in particular recreational fishers, have responsibilities to both participate in planning and observing the rules that apply to bag and size limits. Charter operators may be able to assist with monitoring fish populations, recording logbooks and conducting some research in conjunction with Universities.

4.1.8 References

Fishing for the Future: The essential guide to recreational fishing in Western Australia, Fisheries Western Australia – Recreational Fishing Program *(Brochure)*.

LD West, JG Pepperell & G Waugh, (1996), *Ord River Fishing Survey – Report to: East Kimberley Recreational Fishing Advisory Committee,* Kewagama Research.

LeProvost Dames & Moore (1999), *Kimberley Aquaculture Development Strategy, Lake Argyle Barramundi Aquaculture Industry: Strategic Environmental Review.*

Makaira Pty Ltd (1999), *The Translocation of Barramundi: A Discussion Paper*, Fisheries Management Paper No.127, Fisheries Western Australia.

RG Doupe, C Bird (1999), *Opportunities for enhancing the recreational fishery of Lake Kununurra using barramundi* Lates calcarifer*: A review*, Proceedings of the Royal Society of Queensland, *In Press.*

Robert Tregonning, Fisheries WA, *pers comm*, March 2000.

T Thorne (1997), *The aquaculture of non-endemic species in Western Australia – Redclaw Crayfish* – Cherax quadricarinatus, Fisheries Management Paper No.100, Fisheries Department of Western Australia.

4.2 Recreational River Use

4.2.1 Goals

- **To develop a recreational and commercial use plan for the Ord River within 3 years**

4.2.2 Background

All of the waterways around the town of Kununurra are popular for recreational activities (including Lakes Kununurra and Argyle, and the Lower Ord River). These recreational activities range from water skiing and sailing to barramundi fishing, canoeing and general boating.

One of the most popular of these activities is recreational fishing. The most popular fish to catch are barramundi. These are only located in the Lower Ord (as the irrigation supply reservoirs act as a barrier to the upstream migration of this species) and therefore there is significant fishing pressure on this section of the river (Doupe and Bird, 1999).

Other recreational activities are spread out across the three waterways with most of the water skiing and canoeing limited to Lake Kununurra and general boating and sailing carried out on Lake Argyle.

4.2.3 Current Status

Currently there is a community group focused on managing the access to a section of the river below the Diversion Dam. The Lower Ord Community Advisory Committee (LOCAC) focuses on the old Noogoora Burr quarantine area, and more recently areas near Buttons Gap. This group works with station management and is concerned with providing facilities – such as toilets, rubbish bins and boat ramps.

This group helped to initiate the Lower Ord Management Strategy. This strategy outlines where boats can be launched, location of other facilities (such as toilets), and permit costs for utilising the facilities, as well as general safety and fishing information (brochure available from SWEK offices).

Rubbish

In the Ord River Fishing Survey conducted in 1996 (West *et al*, 1996), there was concern raised by 23% of the respondents in regards to rubbish along the river. Of particular concern is non-biodegradable litter such as aluminium cans, fishing line, disposable nappies and plastic bags. At many of the popular fishing and recreational sites there is rubbish present. This rubbish is hazardous to native animals as well as being unsightly and ruining the "experience" that can be gained from the area.

There is a small group of community members who are making an effort to reduce the impacts of rubbish on the environment around the area. This group is called Society of Litter Eradication & Education for Kununurra (SLEEK). There was one very successful clean up in 1999 and more are planned for the future.

Cumbungi

Cumbungi growth along the river edges emerged as the primary concern across all user groups interviewed as part of the Ord Fishing Survey (1996). The main concern raised in this report and through Ord Land & Water community meetings was that the growth of Cumbungi increased the hazards posed by crocodiles and increased the risk of conflict

between crocodiles and recreational river users. .

There is also concern that cumbungi is not being well managed on Lake Kununurra and its spread is beginning to affect recreational use of the lake. With possible future changes in water levels in the Lower Ord towards the latter part of the dry season, the impact of flushing cumbungi from Lake Kununurra into the Ord River may increase.

Other groups in the community see the cumbungi as playing an important role in bank stabilisation and nutrient filtering of run-off prior to it entering the waterways.

Crocodiles

Concerns about safety and crocodiles in the Lower Ord have increased as the use of this area has increased. Lake Kununurra and Lake Argyle are both crocodile control zones (CCZ) (Section 4.7.2 - Native Plants and Animals). Below the Diversion Dam the Ord River is divided into crocodile management zones (CMZ). These zones extend to Parry Lagoons Nature Reserve and the Ord River Nature Reserve. Generally salt-water crocodiles are left to their own devices in these parts of the river, unless licenses are issued for stocking farms or individual animals are deemed to be problem crocodiles.

If there are problem crocodiles in popular areas or where they may have an impact on humans or stock, such as River Farm Road, they are generally trapped and removed. In the future there may need to be a specific management plan for crocodiles in the Ord River near River Farm Road.

Boating

Power boats

Increased powerboat activities may lead to greater leakage of oil and fuel residues into waterways. This may not cause problems in areas where the flow rates are high, however, it could have an impact in the shallow wetland areas where mixing and throughput is reduced (Watkins *et al*, 1997). There is currently a new "breed" of two-stroke motors referred to as direct injection two-strokes. These motors greatly reduce hydrocarbon emissions and increase fuel efficiency and operating characteristics (up to 80% reductions in emissions). Four stroke engines are another low-emission high-fuel efficiency alternative (www.nmma-medialink.com).

General boating

Uncontrolled access to waterways can result in serious disturbances such as the crushing and trampling of native vegetation, increasing weed growth, rubbish spills, soil compaction and fires (WRC, January 2000). This highlights the need for management of public access to the river.

Increases in canoeing and other outdoor activities that involve camping between the two dams could cause disturbances to wildlife breeding sites. Turtles, crocodiles and water monitors favour sand banks as areas for breeding sites. These sandy areas are also favoured by campers (Watkins *et al*, 1997).

There have been a number of proposals for houseboats for Lake Kununurra. These proposals need to be assessed in depth, and investigations into their possible impacts need to be completed prior to any decisions being made.

4.2.4 Knowledge Gaps

- Who is responsible for ensuring rubbish collection at popular locations?
- Should we have rubbish collection facilities at popular locations or should the message be – take your rubbish home?
- How many people actually use the river for recreational purposes and what pressures are they placing on the river?

4.2.5 Strategies

Strategy 1

Reduce rubbish and other pollution of the river by:

1. Involving the whole community in developing guidelines for river management including:
   a. active rubbish management (a take your rubbish home campaign),
   b. developed and serviced access points,
   c. promotion of modern two stroke or four stroke outboard motors to minimise possible oil pollution.

Strategy 2

Reduce the pressure on the river from recreational use by:

1. Encouraging the development of management guidelines for all types of recreational use of the river including – general boating, camping, houseboats, etc.

2. Ensuring these guidelines are developed in conjunction with the community and that they are enforceable.
3. Managing high use areas such as boat ramps and other access points.

Strategy 3
Improve the understanding of issues associated with recreational use of the river by:

1. Conducting information and education programs, for example using a log book as a source of information on native and feral species, fish species, rubbish management, etc.
2. Involving all recreational groups in planning for sensible sustainable recreational use.
3. Encouraging recreational user groups to manage the areas they use.
4. Developing and implementing best management practices for recreational use of the river and lakes.

Strategy 4
Improve safety on the water by:

1. Recognising boating codes of practice or ethics.
2. Suggesting regulated speed limits at specific locations along the river, launching areas and designated use areas.
3. Maintaining awareness of crocodile presence in waterways.

4.2.6 Responsibilities

Recreational use of the river includes a number of areas of state agency jurisdiction including Department of Transport for boat licensing and the Water and Rivers Commission for river health. The Shire of Wyndham East Kimberley have involvement with the Lower Ord Community Advisory Committee and a responsibility, along with the Tourist Bureau, for providing visitor information. Fisheries WA has responsibility for fish stock management, research, education, enforcement and monitoring associated with the recreational and commercial fisheries.

Tour operators have a responsibility to both avoid damage to the river and its environs and to spread the message about better management of recreational use. The Lower Ord Community Advisory Committee (LOCAC) has specific responsibility for advising on the management of the lower reaches of the Ord where there are a number of competing uses and issues relating to access, rubbish control and people management.

CALM have expertise in managing natural resources and recreational use so should be involved in the planning and execution of best management practices.

The general community and in particular the recreational user groups and sporting clubs need to be involved in ensuring sensible use and should form the front line for spreading the word about sustainable use.

Traditional owners and other Aboriginal groups also have a role in developing management plans and providing the necessary information and education links to Aboriginal people.

4.2.7 References

Frequently asked questions about Recreational Boating, National Marine Manufacturers Association's Information Centre for Boating Writers & Consumers (www.nmma-medialink.com/frequent .htm).

LD West, JG Pepperell & G Waugh, (1996), *Ord River Fishing Survey – Report to: East Kimberley Recreational Fishing Advisory Committee*, Kewagama Research.

RG Doupe, C Bird (1999), *Opportunities for enhancing the recreational fishery of Lake Kununurra using barramundi* Lates calcarifer: *A review*, Proceedings of the Royal Society of Queensland, *In Press.*

Watkins, D., Brennan, K., Lange, C., Jaensch, R., Finlayson, M., (1997), *Planning for Ramsar Sites in the Kimberley Region of Western Australia,* Wetlands International – Oceania, Environmental Research Institute of the Supervising Scientist Consultant.

Water and Rivers Commission (January 2000), *Protecting Riparian Vegetation, Water Notes,* WN10.

4.3 Riparian Areas

4.3.1 Goals

- **To prevent further damage and modification to the natural riparian vegetation**

4.3.2 Background

Riparian areas are those close to the margins of rivers, wetlands, streams and other drainage lines whose characteristics are determined by the presence of water. These areas are important as they act as areas of refuge for animals during dry periods, and often support a highly diverse and fragile ecosystem. Maintaining diversity of these ecosystems is important so the ability for these ecosystems to adapt to change is not lost.

Riparian land is often highly productive and often plays an important role in the lifecycle of many native animals and plants (Tubman (Ed), 1996). By its very nature riparian land is fragile. Its productivity also makes it vulnerable to overuse and to practices which cause it to deteriorate (Tubman (Ed), 1996).

The riparian areas of Lakes Argyle and Kununurra (and the Lower Ord Floodplain) are important because they are listed as Ramsar wetlands. This means that they are seen as important internationally as migratory bird habitat and must be managed so as to maintain their ecological character (James, 1997).

Photo 6. Riparian areas along the Ord River *(see central colour pages).*

4.3.3 Current Status

The more uniform river flows since the dams have been built has altered the location and nature of the riparian areas of the Ord River system.

Along the Ord River there are now four sections with quite different flow regimes that have developed unique riparian areas.

- Above Lake Argyle – where the river is still seasonal – with flood pulses that maintain a near original riparian zone.
- Lake Argyle – where the water level fluctuates, the old riparian vegetation has been drowned and a new shoreline has formed with little or no vegetation.
- Lake Kununurra – where the water level is stable the old riparian vegetation has been drowned and a new shoreline formed with reed beds and a more luxuriant riparian vegetation.
- Below the Diversion Dam –there are permanent flows with rare peak flood flows and the fresh water/salt water interface is further downstream. A new and more luxuriant riparian vegetation has developed in this portion of the Ord River system.

The diversity of plants and animals in all these areas has changed since the construction of both dams. The riparian areas around Lake Kununurra have increased in diversity as a result of having stable, permanent water levels. The shorelines of Lake Argyle may have lost diversity as a result of the fluctuating water level.

Weeds

Weeds are currently one of the primary issues of concern in riparian zones. In areas where there has been disturbance by people or stock weeds can proliferate (Tubman (Ed), 1996). There are now areas of Bellyache Bush on Lisadell Station (upstream of Lake Argyle), and a small number of these plants have been found at Buttons Gap – downstream of the Diversion Dam. Other weed species such as Parkinsonia and Noogoora Burr are common throughout parts of the catchment while plants such as Sorghum and Leucaena pose significant threats as they escape from the agricultural area. Many of the weed species are not adapted to flooding (whereas native species are) and therefore if flood events are rare these weeds can spread and become dominant (see Section 4.3 - Weeds).

Feral Animals

Feral animals are not seen as a large threat to the riparian areas at present. There are a number of small populations of feral pigs, however these numbers are not high enough to warrant a formal control program (see Section 4.1 – Pest and Feral Animals).

Stock Access

Intensive use of the river for stock watering has the ability to cause destruction of riparian vegetation and bank erosion (Water and Rivers Commission, 1997). However, where the grazing pressure is greatest, in the area downstream of the Diversion Dam, the impact from stock appears to be localised. The heaviest impact from stock is in areas where access to the river is restricted by steep banks and the pressure is increased on areas where the access is possible (Tony Start *pers comm*).

It is not necessary to permanently exclude animals from riparian lands, but it is important to control their movement and to manage grazing pressure (Tubman (Ed), 1996). See Section 3.6 – Stock Access for the management regime in place for the area of the river below the Diversion Dam (Carlton Hill and Ivanhoe Stations).

4.3.4 Current Projects

Integrated overview of values, uses and modifying processes in the Ord River's riparian zone.
This is a Tropical Savannas CRC project and the project leader Dr Tony Start is based at CALM in Kununurra. The project seeks a better understanding of the role of riparian systems, the margins of wetlands, rivers, streams and other drainage lines in the sustainable land management of tropical savannas.

Dr Karl-Heinz Wyrwoll is supervising PhD and honours students from the University of WA (all from the Geography Dept) who are looking into the hydrological aspects of sediment mobilisation, transport, and deposition. This fits in with the biological component of the project.

PhD - Factors Affecting Riparian Vegetation Recruitment on the Ord River.
Neil Pettit from Edith Cowan University.

Productivity and water flow regulation in the Ord River of north-western Australia.
The Water and Rivers Commission and two Perth Universities are involved in this project. This project will provide the basis for the determination of Ecological Water Requirements and the Environmental Water Provisions for the Lower Ord River (this is required for the Water Allocation Plan). The timeframe for project completion is 2002.

Resilience of the Ord River to Irrigation Return
The Water and Rivers Commission and two Perth Universities are working together to develop this project. The project is yet to be finalised (March 2000) and is subject to funding being approved.

4.3.5 Knowledge Gaps

- The impact of possible future change in the water regime on the riparian areas below the Diversion Dam.

4.3.6 Strategies

Strategy 1

Reduce the impact of use on the riparian areas by:

1. Educating the public about the importance of the riparian zone.
2. Limiting user access to particular serviced access points.
3. Including the riparian areas in an overall river management strategy.

Strategy 2

Prevent further damage and modification to the natural riparian vegetation by:

1. Developing and implementing a river management strategy which includes controlling the spread of weeds and feral animals (particularly pigs and cattle in the riparian zone).
2. Managing cattle grazing access to parts of the riparian zone by exclusion fencing in areas where they are having a negative impact.

Strategy 3

Monitor changes in the riparian zone ecology by:

1. Developing and implementing monitoring systems (both scientific and general observations) to follow changes in the condition of the riparian zone.

4.3.7 Responsibilities

The health of the riparian zone is linked to the health of the river so those with responsibilities include Water and Rivers Commission, the Lower Ord Community Advisory Committee and the Shire of Wyndham East Kimberley.

Others with expertise that should be involved include CALM, station management and the Ord River Irrigation Area LCDC. It is important that the management of the riparian zone be linked to river management and water allocations as minor changes in flow can create major changes in the riparian zone.

4.3.8 References

Dr Tony Start, Conservation and Land Management

James, R (1997), *A Directory of Important Wetlands in Australia – The Ramsar Convention in Australia – 25 years on.* Wetlands and Migratory Wildlife Unit, ANCA.

Paula Deegan, Water and Rivers Commission.

Water and Rivers Commission (1997), *State of the Northern Rivers.*

Wendy Tubman (Ed) (1996), *Riparian Management - Managing Riparian Land,* Land & Water Research & Development Corporation.

4.4 Water Allocation

4.4.1 Goals

- **To develop a plan to allocate water from the Ord River to competing uses including he environment. To develop the plan with full community involvement within 5 years.**

4.4.2 Background

The Water and Rivers Commission is responsible for ensuring the sustainable management of the State's surface and ground water resources. In order to achieve this, water allocation plans are required for each "water management system" to define the amount of water to be made available for each use.

Water allocation plans define the amount of water that can be legally diverted from river systems and ground water aquifers. Water allocation plans must take into account: environmental water provisions, ecological water requirements, sustainability, irrigators, recreational users and other potential users.

Allocation plans are implemented through the *Rights in Water and Irrigation Act (1914).* Licenses formalise the allocations and are subject to conditions necessary for good management of the resource. The state's water allocation system is evolving to meet the requirements of the Council of Australian Government's Water Reform Framework Agreement and licensing is to become the means to identify water allocations and their holders (WRAP 2, 1999).

The water allocation plan aims to provide strategic direction by identifying future development and associated demands for water while protecting the supply of water necessary for the environment. Environmental approval of developments (such as Ord Stage 2) is subject to the determination of an acceptable amount of water to support ecological and environmental objectives for the Ord River.

4.4.3 Current Status

The allocation plan for the Ord is currently in draft form. The Draft Interim Water Allocation Plan for the Ord River was presented to key stakeholders and released for public comment through the Environmental Protection Authority (EPA) in 1999. Public submissions were sent to the EPA and the advice from the EPA was provided to the WRC in December 1999.

The comments from the EPA suggested the need to:

(a) review the basis for determining the interim Environmental Water Provisions, and

(b) to take into account the current flow regime that has prevailed for the last 30 years. The EPA also recommended the development of an expert panel to guide the allocation process.

There is concern in the community regarding what the water levels are going to be downstream of the Diversion Dam in the future, in particular when Ord Stage 2 is fully developed. This area of the river is popular for recreation and a number of tourist operators run businesses in the area. There are concerns that reductions in water levels may have an impact on the riparian areas of the river (as they are today) and the ability to safely access this area.

Irrigators in the ORIA Stage 1 area are keen to guarantee the supply of water for irrigation for the future.

4.4.4 Current Projects

Productivity and water flow regulation in the Ord River of North Western Australia. The Water and Rivers Commission and two Perth Universities are involved in this project. This project will provide the basis for the determination of Ecological Water Requirements and the Environmental Water Provisions for the Lower Ord River (this is required for the Water Allocation Plan). The timeframe for project completion is 2002.

4.4.5 Knowledge Gaps

- How much water is required for "environmental flows"?
- Who "pays" for the environmental flows and for flow to enable recreational use of the river?
- What is the "dollar value" of the water (what is the actual cost of the water)?

- What impact will a changed water regime, resulting from greater diversion of water for Stage 2, have on the downstream environment, as well as the ability to utilise the river for recreation and tourism?
- What impact will the lower flows have on the water quality in the river?
- When will the changed water regime will begin (determines the lead-time to implement changes in management – for tour operators, farmers etc)?
- What impacts will lower water levels have on Cumbungi in the Lower Ord?
- Will it be possible to simulate flood pulses in the river that are big enough to have an impact on the health of the river system?
- What is the size and probability of flood pulses that come from the Dunham River catchment?
- What impact will lower water levels have on crocodile populations, movement and recreational user safety?

4.4.6 Strategies

Strategy 1

Develop understanding of the environmental requirements of the river downstream of the irrigation area by:

1. Encouraging well planned research to determine the Environmental Water Requirements and the likely impacts of changed river flows on the riverine and adjacent riparian environment.
2. Monitoring these environments and providing real time feed back that enables management of river flows to be based on up to date information.

Strategy 2

Develop a Water Allocation Plan by:

1. Taking into account the requirements of:
   (f) the downstream environment
   (g) Stage 1 Irrigation Area
   (h) Ord Hydro Pty Ltd
   (i) Recreational users
   (j) Other potential water users including Stage 2.
2. Ensuring involvement of key stakeholders in the development of the Water Allocation Plan (including Ord Irrigation Co-op, Stage 1 irrigators and tour operators who operate in the area)

4.4.7 Responsibilities

Water and Rivers Commission has legislative responsibility and is therefore the lead agency for the allocation of water. They have a responsibility to ensure local stakeholder involvement in the allocation process.

Water users, including irrigators, tour operators and recreational users of water, and Ord Irrigation Cooperative have a responsibility to ensure that they have input into the allocation process. The general public and other river users complete the list of potential stakeholders that need to be involved in the planning process.

4.4.8 References

Draft Interim Water Allocation Plan, Ord River Western Australia, Water Resource Allocation and Planning Series, WRAP 2, May 1999.

Draft Interim Water Allocation Plan, Ord River, EPA Bulletin 965, December 1999. Leith Bowyer, Water and Rivers Commission, Kununurra.

4.5 Dunham River

4.5.1 Goals

- **Reduce the off farm exports of chemicals nutrients and soil into the Dunham River during the dry season by 50% within 5 years**
- **Within ten years develop a full catchment plan for the Dunham River that involves all the stakeholders**

4.5.2 Background

The Dunham River is a tributary of the Ord River. The confluence of these two rivers is downstream of the Diversion Dam wall. It is a seasonal river with the majority of the flow during the wet season. During the dry season there is an altered flow regime in the section of the river between the Packsaddle Creek confluence and the mouth of the Dunham (this section of the river is the area of focus for Ord Land & Water).

This short section of the river consists of a number of deep pools and rock bars, which reduce the flow of water and has the potential to cause water quality problems associated with slow flowing systems (such as oxygen depletion in the deep pools).

To some extent the level of the Ord River controls the level in this section of the Dunham River. When the Ord River water level is high, less water can leave the Dunham River leading

to water backing up or being trapped in the Dunham and much reduced flow rates.

Irrigation tail water from the Packsaddle Irrigation Area enters Packsaddle Creek, which means that there is flow in the creek, and therefore into the Dunham River, throughout the dry season.

As the Dunham River is a seasonal river, the water level often increases during the wet season, depending on rainfall. This can lead to a flood pulse moving down the river and into the Lower Ord River. This is the main alteration in flow for the Lower Ord, as throughout most years the water released from the Diversion Dam remains relatively constant. Major rainfall events and rare "big" wet seasons can result in very large river flows that generate major flood pulses in the lower Ord.

4.5.3 Current Status

There are a number of sites in the Dunham (and Packsaddle Creek) that are sampled as part of the the program to sample water quality. During 1998 there were a number of "hits" of pesticide in both the Dunham River and Packsaddle Creek. A number of these hits were very high (see Section 2.3 – Surface Water Quality). During 1997 there was a fish kill in the Dunham River.

A bypass is being discussed as a possible means of allowing water from Lake Kununurra to flow into the Dunham River (via Packsaddle Creek). This will increase the flow of water in the lower reaches of the Dunham River as well as reducing the flow in the Ord. The overall effect should be an improvement in the quality of the water in this problem section of the river (through a diluting effect as well as an increased water flow and thus more effective flushing). There is a feasibility study under way for this project.

This bypass also has the potential to act as a fish ladder therefore allowing barramundi to enter Lake Kununurra (see Section 3.1 – Fish Stock Management).

4.5.4 Projects Under Way

- The feasibility of building a bypass from Lake Kununurra to the Dunham River via Packsaddle Creek is being studied.

4.5.5 Knowledge Gaps

- Will the bypass idea achieve the desired outcome? Will it enable barramundi to migrate?
- What can be done to improve the quality of the water in the river?
- What is the best way to manage the Dunham River?
- What impacts is it having on the water quality in the Ord River?

4.5.6 Strategies

Strategy 1

Improve the quality of water flowing through the Dunham River by:

1. Revegetating the catchment of the river thus reducing sediment loads during wet season flows.
2. Providing cleaner water from the irrigation system during the dry season by
   a. Improving irrigation and farm management to ensure cleaner drainage water,
   b. Installing and managing silt traps prior to drainage water leaving farms,
   c. Developing constructed wetlands on the Packsaddle drainage system to filter water prior to its entry into the Dunham River,
   d. Examining the feasibility and sustainability of bypassing water from Lake Kununurra to the Dunham River to dilute any drainage water from the irrigation area.
3. Managing the water flows in the Ord to improve the management of the Dunham River during the dry season.

Strategy 2

Reduce the amount of drainage water entering the Dunham during the dry season by:

1. Encouraging a reduction in the amount of tail water leaving irrigation farms by using ideas raised in Section 1.2 – Irrigation Management.
2. Encouraging investigation into reusing tail water where appropriate.

Strategy 3

Provide monitoring and research information to enable adjustments to management by:

1. Gathering sufficient research information to quantify the flows and requirements to maintain a healthy Dunham river.
2. Regularly monitoring water quality in the Dunham river (the whole river not just the area below the confluence of Packsaddle Creek and the Dunham River).
3. Ensuring that all stakeholders have access to monitoring information in a manner that enables better management decisions to be made.

4.5.7 Responsibilities

The Water and Rivers Commission is responsible for river health and will be responsible for providing research and long term river monitoring information. The Water Corporation and Ord Irrigation Cooperative have responsibility for managing the irrigation water and drains, so will be integral to any management actions resulting from research and monitoring. The Ord Irrigation Cooperative is also responsible for monitoring water quality in drainage water.

Packsaddle farmers have the greatest responsibility to improve management, install silt traps and develop recycling systems to reduce pressure on the Dunham. The SWEK has a role in managing the process to examine the potential for a bypass from Lake Kununurra. The Ord River Irrigation Area LCDC and the Halls Creek East Kimberley LCDC should be involved in helping to develop and implement management plans that will reduce sediment loads in the river and drainage systems.

4.5.8 References

Data provided by Water and Rivers Commission.

4.6 Stock Access

4.6.1 Background

In the past the main land use in the catchment of the Ord River was grazing cattle. Initially, the river was used as the source of water for stock as there were no artificial water points in place. Much of the catchment area above Lake Argyle has been destocked or access to the river controlled by fences. Downstream of the Diversion Dam cattle are still using the river as a water source.

4.6.2 Current Status

Carlton Hill and Ivanhoe Stations are situated along the river downstream from the Diversion Dam. To control erosion and better manage the parts of the stations with river access, all the paddocks that have river access are being fenced. These paddocks are destocked every second wet season to allow the grasses time to grow and set seed. Initially these areas were planted with buffel grass, however this is no longer practiced.
Since the station management has been using the program of controlled grazing in the river areas, the native grass species in these areas have proliferated (Claire Warriner Carlton Hill Station *pers comm*).

Generally the impact of stock on the riparian areas of the river is very localised (see Section 3.3 – Riparian Areas).

It is not economically feasible to fence off the river completely as this would mean having to provide artificial watering points and the loss of some of the most productive grazing areas (Geoff Warriner – Manager Carlton Hill Station *pers comm*).

4.6.3 Knowledge gaps

- Which grass species are dominant in the riparian areas.
- The levels of silt that are moving as a result of stock access.

4.6.4 Strategies

Strategy 1

Determine the impacts of stock on the river by:

1. Installing and regularly recording monitoring sites
2. Working with station management to increase the information on stock impacts on the river

Strategy 2

Manage the impacts of grazing stock by:

1. Further developing grazing management systems aimed at reducing the impact of stock on riparian vegetation.
2. Reducing the stocking pressure on areas adjacent to the river.
3. Strategic fencing that restricts stock access while enabling limited access for water.
4. Providing alternative watering points.

4.6.5 Responsibility

The main responsibility lies with the managers of Carlton and Ivanhoe stations to continue to improve management of those areas along the river that are impacted by stock. They will need support from research and development agencies like AGWEST and Water and Rivers Commission. The Halls Creek East Kimberley LCDC could also provide support for the development of improved grazing management.

4.6.6 References

Claire and Geoff Warriner, Managers Carlton and Ivanhoe Stations.

4.7 Surplus ORIA Stage 1 Water - Cave Springs Gap

4.7.1 Background

There is float water from the M1 channel and some drainage water from the northern end of the Ivanhoe Plain (Cave Springs) that runs into drains HD3 and D8 and then out into the bush. There is concern about the influence that this water is having on the area.

4.7.2 Current Status

The area under question will be part of the proposed Stage 2 development. The soil types in this area are Aquitane clays. These soils are reasonably impermeable when wet and therefore the risk to the ground water in the area is considered to be low. The water running out of the D8 drain is tested as part of the program to monitor water quality (Section 2.3 - Surface Water Quality).

There are a number of options for dealing with these waters once the Stage 2 area is fully developed, however these have not yet been evaluated (Philip Pyle, *pers comm* 1999).

4.7.3 Knowledge Gaps

- What will happen to the water until Stage 2 is developed?

4.7.4 Strategies

Strategy 1

Reduce the amount of system float water leaving Stage 1 by:

1. Improving the management of the irrigation water to minimise the amount of water leaving the system.
2. Investigate the feasibility of recycling water at the end of the system.
3. Ensuring this water becomes a part of the supply system for Stage 2.

Strategy 2

Better understand the likely impact should Stage 2 not go ahead by:

1. Monitoring impacts on vegetation, wildlife and ground water.

4.7.5 Responsibilities

The managers of the irrigation system (Water Corporation and Ord Irrigation Cooperative) have the major responsibility in this area. The proponents of Stage 2 need to be aware of the need to capture any excess water from the existing irrigation area. There may be a project for the Ord River Irrigation Area LCDC to establish a monitoring system for the wetland area created by the excess water.

4.7.6 References

Letter from Philip Pyle, Project Manager, Water Corporation (19th July 1999).

4.8 Flood Management

4.8.1 Goals

- **Develop, with community involvement, a plan to manage flooding of the Ord River by December 2000.**

4.8.2 Background

The Ord River is now a controlled river. The Kununurra Diversion Dam was finished in the early 1960s and Lake Argyle was completed in 1973. Prior to this time the Ord River was a seasonal river, drying up during the dry season and flowing according to rainfall during the wet season.

Photo 7: Ivanhoe Crossing with the Ord River in flood on March 5th 2000*(see central colour pages).*

There is a State Framework for Floodplain Management in Western Australia and there is a flood emergency plan for the Ord River that identifies agency responsibilities. Flood warning information comes through the Bureau of Meteorology. This information is available at www.bom.gov.au/weather/wa. This is updated regularly.

4.8.3 Current Status

The 1999/2000 wet season has highlighted the need for flood management, despite the Ord River being a controlled river system. Flows during this time reached record highs and several management decisions were made that had adverse impacts on upstream and downstream water users.

The Water Corporation operates the two dams. When flood flows enter Lake Argyle a stable level is maintained in Lake Kununurra to prevent flooding of the ORIA and township. The flood flows of the 1999/2000 wet season through the system were up to 1000m^3/s (with peak inflow information not yet available from

the gauging station at the Old Ord Homestead). A significant flow down the Dunham River reached magnitude of about 2,000 m^3/s. The Lower Ord is likely to have had flows well in excess of 4,000 m^3/s. These flows for both the Ord and Dunham rivers are likely to be the highest flows ever recorded. Further information on peak flows will be available in the near future.

4.8.4 Knowledge Gaps

- What impacts does flooding have on the environment below the Diversion Dam? (this is part of the EWR/EWP study mentioned below).
- How do we best manage flood conditions to minimise the impacts on the upstream and downstream users and the environment?
- What impact does flooding have on users (agriculture, tourism, recreation etc) of the system?

4.8.5 Projects under way

Productivity and water flow regulation in the Ord River of North-Western Australia. This project will provide the basis for the determination of Ecological Water Requirements and the Environmental Water Provisions for the Ord River (this information is required for the Water Allocation Plan). The Water and Rivers Commission and two Perth Universities are carrying out the project. The timeframe for completion of this project is 2002.

4.8.6 Strategies

Strategy 1
Minimise the impacts of flood events on water users by:

1. Developing a flood management strategy that includes:
    a) A communication strategy to ensure effective, timely communication between the community and relevant government agencies,

    b) Timely monitoring and forecasting to provide information for action to be taken by the responsible agencies.

Strategy 2
Incorporate a coordinated flood management strategy in the planning for the Ord River.

4.8.7 Responsibility

The responsibility for flood management lies with the Water and Rivers Commission and the Water Corporation. The hydrology information required to monitor flood flows is also the responsibility of the above agencies.

4.8.8 References

A Framework for Floodplain Management in Western Australia with a focus on Carnarvon. (July, 1998), Report of the Ministerial Taskforce into Floodplain Management to the Minister for Water Resources, ISBN 0-7309-7423-5.

Data provided by the Water and Rivers Commission, Kununurra.

Photo 8: Lake Argyle spillway – 1997 *(see central colour pages).*

Photo 9: Flow down the Lake Argyle spillway – March 2000 *(see central colour pages)*

Chapter 5 - Conservation Issues

5.0 Introduction

This chapter is focussed on identifying ways of minimising the impacts on and improving the management of the environment around the Shire of Wyndham East Kimberley.

Most of the strategies suggested throughout the chapter are environmental management guidelines. The group would like to encourage SWEK to develop an **Environmental Management Plan** using the suggested management guidelines from each issue as a starting point (the strategies in the document with an {*} are ideas for inclusion in the plan).

Other local government authorities around Australia are developing Environmental Management Plans for the better management of the environment in their local shires. Many of these organisations are using Local Agenda 21 as the basis for the environmental management strategies. Local Agenda 21 was an outcome of the International Earth Summit in Rio De Janerio in 1992. It identifies local government as the organisation that could have a major impact upon environmental problems (www.whyalla.sa.gov.au/enviro).

The overall recommendation that the Conservation Action Group would like to make is:

"For the SWEK to develop an Environmental Management Plan incorporating all the issues discussed in this chapter (and other issues that come up in the future) to improve environmental management in the Shire of Wyndham East Kimberley. This would encourage better management of the environment in the area and encourage the community to become more aware of the impacts they have on the environment."

* Please note - It is important to recognise that the strategies developed in this chapter will need to be built on as new knowledge is developed and targets are achieved. At this stage they provide a starting point and a framework for commitment from all the parties involved in Land and Water Management on the Ord.

5.1 Pest and Feral Animals

5.1.1 Goals

- **Ensure there are no new feral species introduced into the irrigation area that have the potential to reach problem proportions and have a negative impact on native species**
- **Increase the understanding of pest and feral species, their impacts and control methods.**

5.1.2 Background

Feral animals are species that have been introduced to an area and whose populations have become naturalised. For example, cats, dogs, donkeys, goats, wild horses, etc. Some native species can become pest species if their populations reach plague proportions, for example the native brown rat *Rattus villosissimus*.

CALM provides advice to property owners who are controlling pest and feral animals to ensure that the impact of the control measures on the native species is minimal.

The Agricultural Protection Board plays a role in pest and feral animal control. They have a number of feral animal control programs, including the Judas program, and they work with CALM to provide advice to property owners on pest and feral animal control and they have traps available for property owners to utilise.

5.1.3 Current Status

Donkeys

Without adequate control of donkeys it is not possible to achieve acceptable stocking rates and ensure that pastoral activities do not degrade rangelands and adversely impact on rivers and waterways (Water and Rivers Commission, 1997).

There is currently a control program under way throughout most of the East Kimberley. This program is called the Judas program – which involves using radio collars as a means of monitoring the movements of the herd and controlling numbers. As a result of this program the donkey populations in the East Kimberley are now well under control. Ivanhoe and Carlton Hill stations are involved

in the program and collars should be fitted on these stations by the end of 2000.

Pigs

There are feral pig populations along the Ord River - however these populations are currently not large enough to warrant a specific control program. Pigs have the ability to cause damage to riverbanks, create erosion in these areas, encourage weed growth and transmit disease. Pigs have the potential to cause damage in horticulture crops, as well as in cane, maize, and cucurbit crops. Agriculture WA provides advice and traps, but they do not have a specific control program.

Cats

Feral cats can be a problem as they prey on small native animals. There are currently no by-laws for the control of cats in the Shire of Wyndham East Kimberley.

During 1999 CALM carried out an initial reconnaissance survey of the status of feral cats in Purnululu National Park. CALM are planning to undertake more survey work and operational control of cats in this area in 2000 (this is subject to funding). They are also planning to undertake a feral cat survey in Mirima National Park this year (Allan Thomson *pers comm*).

Dogs

Wild dogs, (which under the Agriculture Protection Board definition includes dingoes) can cause problems for property owners who have young stock, however in the irrigation area there are few reports of them being a problem. Agriculture WA provides advice and baits to affected property owners (there is a dog-baiting program across the Kimberley).

To help reduce the problem of domestic dogs going wild and adding to the wild dog population, SWEK offers reduced dog registration fees for sterilised dogs. The difference in registration fees for one year are – entire dog $30, sterilised dog $10, and for three years – entire dog $75, sterilised dog $10 (costs as of February 2000).

European Honey Bees

European Honey Bees are regularly brought into the Ord Valley to aid in the pollination of horticultural crops that are generally not pollinated by native bees. Native bees prefer small flowers, flowers in dense bunches and flowers on trees (Heard and Allan 1998).

No European Honey Bees are allowed into WA from other states and all bees that are brought into the valley are sourced from specific apiaries (due to disease constraints). The value of Honey Bees to horticultural and agricultural crops that benefit from pollination in WA has been estimated to be worth $89 million (Lee Allan, *pers comm*).

There is some concern in the community that the European Honey Bee may be having a detrimental impact on the native bee population by swarming into the bush and competing with them for food. There has been Australia wide debate on this issue and to date much of the research done has been inconclusive.

Beneficial Insects

WAQIS (Western Australian Quarantine and Inspection Service) is to be notified of any importation of insects into WA. There is a list of insects that can be imported and postal deliveries are subject to inspection.

When growers bring in stocks of beneficial insects for release it is called augmentation. Basically this refers to releases of large numbers of natural enemies with the view of achieving an immediate impact on the pest populations.

The beneficial insects used are species that occur naturally in the area, such as the parasite *Trichogramma* which parasitises eggs of *Helicoverpa,* and predatory lacewings, which feed on aphids and other pests. Normally as pest species increase these parasites and predators would also increase; the releases merely speed up this process (Brian Thistleton *pers comm*).

Since these insects are already found in the area their release is not likely to have a significant impact on native insect populations (Brian Thistleton, *pers comm*).

Potential Problem Species

There are species found in other areas of Australia that would become a problem if they were to reach Kununurra. One example is the Cane Toad. It is important that the community is made aware of these potential problem species as well as those that are already here.

5.1.4 Knowledge Gaps

- Feral cat status in the area.
- The most effective way to prevent the further introduction of feral animals.
- The impact of European Honey Bees on Native Bee species in the area.

5.1.5 Strategies

Strategy 1

Reduce the impact of pest and feral animals by:

1. Monitoring pest, feral and potential feral species that are in the area by:
    (a) Encouraging existing community groups (such as Save Endangered East Kimberley Species {SEEKS} and the LCDC) to document what they see while they are on field trips.
    (b) Developing an easy to use recording system, such as a duplicate log-book, that can be used to document field trips and record species sighted (both native and feral species) and delegate responsibility for collating the information to a local group.
    (c) Developing easy to read identification material on feral species (such as cane toads) to ensure ease of correct identification.
2. Educating animal owners and making them aware of the issues by: {*}
    (a) Encouraging the Shire to work with animal owners and the local veterinary surgeon to reduce the impact of domestic animals on the feral population (through existing sterilisation programs, licensing, etc).
3. Researching potential feral and pest species, ways to control these species, how these species move, and how to effectively monitor these species.

Strategy 2

Encourage SWEK, in consultation with the Agricultural Protection Board, to develop management guidelines for pest and feral species in the Shire {*}.

5.1.6 Responsibilities

Responsibility for dealing with pest and feral animals lies with a number of different organisations. Local residents (who are pet owners) have a big responsibility to ensure that they control their animals in a way to reduce the impact that they have on native species. SWEK has a responsibility to ensure that suitable By Laws are developed to control feral animals in the Shire.

The Agricultural Protection Board has responsibility for providing identification material and managing feral animals that may have an impact on the agricultural industry. CALM has a role to play in controlling feral animal species such as cats in areas of their Conservation Estate. Agencies or organisations (such as Universities) involved in research need to ensure this information is made available locally.

Community groups need to be involved to help increase the amount of local information available, to improve the management of pest and feral species.

5.1.7 References

Allan Thomson, the Department of Conservation and Land Management, Kununurra Office.

Brian Thistleton, Entomologist, Agriculture Western Australia, Kununurra Office.

Dr. T Heard, Dr. A Dollin (1998), *Crop Pollination with Australian Stingless Bees,* Australian Native Bee Research Centre, Richmond, NSW.

Lee Allan, Senior Apiculturist in Agriculture Western Australia, Perth Office

M. P. Schwarz, P.S. Hurst (1997), *Effects of Introduced Honey Bees on Australia's Native Bee Fauna,* The Victorian Naturalist, **Vol. 114(1)**

R. Manning (1997), *The Honey Bee Debate: a Critique of Scientific Studies of Honey Bees* Apis melliferna *and Their Alleged Impact on Australian Wildlife,* The Victorian Naturalist, **Vol. 114(1).**

Water and Rivers Commission (1997), *The State of the Northern Rivers, WRAP 10.*

5.2 Fire

5.2.1 Goals

- **Increase the understanding of causes and frequency of unplanned fires and their impact to enable effective management**
- **Reduce the frequency of unplanned fires in the area by 10% per year over the next five years**

5.2.2 Background

As the project area is focused on the ORIA and the riparian areas along the Ord River, the regional issue of fire won't be dealt with in detail.

The problem around the town of Kununurra and surrounding waterways appears to be the almost annual frequency of fires in the same areas. Constant annual burning encourages the annual grasses such as cane grass (*Sorghum spp.*) to take over from the perennial species (in terrestrial environments), therefore changing the ecology of these environments.

There is concern along the banks of local waterways that burning of cumbungi, which happens annually in some areas (particularly Packsaddle Swamp), is having a negative impact on riparian woodlands. With repeated burning it is possible these areas of woodland will be dramatically thinned or eliminated (Watkins *et al*, 1997) therefore reducing the diversity of these areas.

Fire can be a very effective tool for managing woody weed problems (such as currant bush, and chinee apple), when used appropriately. Often, when areas have not been burnt there is a noticeable increase in the density of the native trees. Different types of fires can be used as tools (hot or cool fires) to address different issues, but it is important to maintain a frequency of burning that is conducive to natural population regeneration and enable native species to out compete weeds (O'Reagain, 1999).

Cool burns (including burning in the wet season) at different times of the year, reduces the fuel loads therefore reducing the hazard of intense hot burns. Also, burning at different times of the year gives the perennial grasses and other native plant species an opportunity to survive and set seed. An increase in broad-scale early dry season burning is likely to reduce the extent of later, more destructive, fires while providing other benefits for cattle enterprises. In areas dominated by annual sorghum which has escaped dry season fire, burning during the wet season should be effective in reducing subsequent fuel loads (Craig, 1997)

5.2.3 Current Status

Fire Control

There are a number of different organisations that are responsible for fire control. (Information provided by the Kimberley District Office of the Fire and Emergency Services Authority of WA).

Volunteer Fire & Rescue Brigade – Located in the town-site of Kununurra. This brigade is responsible for fire related issues within the town boundaries. In addition they have the responsibility for hazardous materials related incidents and Road Accident Rescue. They will provide support to Bush Fires Brigades outside of their gazetted district if requested and deemed necessary by the brigade captain.

Volunteer Bush Fire Brigades – Are registered with their respective Local Government, have responsibilities for their areas as determined by Local Government and will provide support to the Volunteer Fire & Rescue Brigade if required. These brigades also conduct hazardous reduction burning in their respective areas and are responsible for general fire management and suppression. There are Volunteer Bushfire Brigades for different areas of the valley – Ivanhoe Plain, Crossing Falls and Packsaddle Road. The Crossing Falls brigade is the only brigade with fire fighting equipment that is recognised by the Bush Fires Service (Bishop, 2000).

There is no fire suppression equipment outside the Fire and Rescue Service gazetted area to address structural fires. The area outside the gazetted area includes two caravan parks, the Hidden Valley light industrial area and the sugar mill (Bishop, 2000).

The Department of Conservation and Land Management – Have responsibility for fire on their estates (for example in Mirima National Park), and provide a support role if requested to other fire agencies.

Bush Fire Service WA (previously Bushfires Board) – Provides an advisory and training role to Local Government and the Bush Fire

Brigades throughout the Kimberley region. In addition, during large-scale wild fires they can source plant, equipment and personnel when Local Government's resources are totally committed. They provide coordination functions during major fire emergencies.

Local Government – Local Government is the Lead Combat Agency for fires outside the Fire and Rescue Service Gazetted Area (this includes all tenures of land including unallocated crown land (UCL)) (FESA, 2000). It has statutory powers (through the Bush Fires Act) to require landowners to remove fire hazards and create firebreaks and can carry out works if owners default and charge the owners the costs involved.

The council has 18 Fire Control officers appointed under the Bush Fire Act. These officers issue burning permits and carry out inspections of property to determine fire risks. The council also contributes to the establishment of volunteer brigades and is a source of funding for equipment.

5.2.4 Strategies

Strategy 1
Reduce the risk of and damage caused by unplanned fires by:

1. Encouraging pro-active fire management, by;
   (a) breaking up the landscape into a manageable mosaic of burnt and unburnt areas by carrying out control burns;
   (b) installing and maintaining fire breaks;
   (c) encouraging cool burns; and
   (d) burning at different times of the year.
2. Developing an education and awareness program, which incorporates:
   (a) providing information through mail drops, radio, newspaper;
   (b) school programs; and
   (c) a program highlighting the cultural significance of fire.

Strategy 2
Encourage SWEK, the Volunteer Brigades and the Fire and Emergency Services Authority of WA to work together to develop a detailed response plan for fire events in the Shire {*}.

Strategy 3
Encourage SWEK to develop guidelines for pro-active fire management in the area by: {*}

1. Enforcement and surveillance of council By Laws.
2. Encouraging pro-active management on vacant town areas.
3. Compiling a database of fire "hotspots" from around the area.

5.2.5 Responsibilities

Responsibility for fire control and management lies with a number of organisations. SWEK plays an important role with fire management as it has statutory powers that require landholders to remove fire hazards and install fire breaks. CALM have a responsibility for control of fires on their estate, the Volunteer Brigades and the Bush Fires Service of WA also have responsibility for fire management.

Landholders have a responsibility to ensure property protection through the removal of fire hazards and maintenance of fire breaks.

5.2.6 References

A.B. Craig, (1997), *A review of information on the effects of fire in relation to the management of rangelands in the Kimberley high rainfall zone,* Tropical Grasslands, Vol 31, pp. 161-187.

Gary Bishop, Bush Fires Service – Kimberley, Fire & Emergency Services Authority of WA, *pers comm*, 1 March 2000.

O'Reagain, (1999), *Link fire management to rainfall patterns,* Savanna Links, Issue 9, March- April 1999.

Richard Brooks, Director of Development Services, *pers comm,* 30th August 1999.

Robert Harris, Director Engineering Services, *pers comm,* 10th September 1999.

Watkins, D., Brennan, K., Lange, C., Jaensch, R., Finlayson, M., (1997), *Planning for Ramsar Sites in the Kimberley Region of Western Australia,* Wetlands International – Oceania, Environmental Research Institute of the Supervising Scientist Consultant.

5.3 Weeds

5.3.1 Goals

- **Ensure that there are no uncontrolled outbreaks of new weed species in the area in the future.**
- **Ensure the development of the Regional Weed Strategy in order to reduce the impact of current weed species on the area.**

5.3.2 Background

A weed can be described as any useless, troublesome, or noxious plant, especially one that grows profusely (The Penguin Macquarie Dictionary); a weed is any plant growing where it is not wanted (Hussey, 1997). Weeds can be divided up into two categories, declared weeds and environmental weeds. Declared weeds are those that have to be controlled in specific ways by law or statute. The level of control can range from eradication to containment.

Environmental weeds are plants, which are introduced to an area and have the potential to cause environmental problems if conditions are right.

In Western Australia, the Agricultural Protection Board (APB) plays the lead role in protecting the state's agricultural industry from pest plants, pest animals and diseases. Their primary role is in protecting agricultural viability. In terms of weed control, their role is to act as a barrier to weeds entering the state.

The APB has a Regional Advisory Committee (made up of community members) who suggest which plants should be declared. Generally if the plant does not adversely impact on agriculture it will not be listed as a declared weed as once it is declared there is a responsibility to control it. This control is the responsibility of the landholder – although the APB offers advice on the method of control.

The Department of Conservation and Land Management (CALM) has a responsibility for controlling weeds on the Conservation Estate.

The Shire of Wyndham East Kimberley can declare pest plants in the Shire (caltrop is currently a declared plant in the Shire), however once they are declared they have a responsibility to control these plants.

5.3.3 Current Status

Terrestrial Weeds

Currently the following declared weeds occur in the Ord River Irrigation Area or along the Ord River: Chinee Apple, Parkinsonia, *Sorghum alum*, Thornapple, Noogoora Burr, Calotropis and Bellyache Bush (not declared on the Ord due to the large areas – for example on the Bow River).

Weeds that are listed as environmental weeds for the areas include:
Date Palm, Hyptis, Khaki Weed, Lantana, Leuceana and Prickly Acacia. These may be seen as weeds in certain situations.

Aquatic Weeds

No invasive waterweed species have become established in the area to date (2000). A small area of Salvinia was found in the town of Kununurra and eradicated during 1998. There was also another area of Salvinia found in Lake Kununurra in May 2000. The APB and WRC identified the weed and control measures have been taken.

Many aquatic plants grow profusely in the area, however they are all native to the area and following the damming of the river have proliferated. At times these plants can cause problems with recreational use of the waterway.

There are, however, invasive waterweeds found in other parts of Australia that could pose a threat and it is important to ensure they are not introduced to the ORIA.

Acrolien® Use in the M1 Channel

Native weeds in the main irrigation delivery channel, the M1, need to be controlled as they inhibit the movement of water down the channel. The current practice used by the water delivery operators (Ord Irrigation Pty Ltd.) is to utilise Acrolien ® which kills both plants and animals living in the water by depleting oxygen levels.

Agency Involvement

The Agriculture Protection Board has a role in keeping WA weed, pest and disease free, with their core business protecting agriculture (as mentioned in Section 3.3.1). All cars entering Kununurra from the Northern Territory have to pass through a quarantine station. Vehicles carrying horses or cattle must be washed down at the quarantine yards or similar facility. This quarantine role is important, as there are a

number of invasive weed species found in the Northern Territory that are not found in WA.

During a visit by the Northern Australian Quarantine Service (NAQS) in August 1999 to three new weed species were found – one at the quarantine yards wash down bay, one in a banana plantation and one in an area of well watered lawn. These were all in small populations and have since been controlled. NAQS carries out regular weed surveys in search of any new species of foreign plants – which can then be controlled while they are in small populations (Kimberley Pastoral Memo, August 1999).

5.3.4 Projects Under Way

- There has been a Regional Weed Strategy initiated in the area. This will link in with the National Weed Strategy, while focusing on the Kimberley Region.
- The ORIA Land Conservation District Committee (LCDC) undertook a Date Palm eradication program in 1998 and 1999. This focused on plants that were growing on Lake Kununurra and any small tributaries into the lake and is likely to continue (depending on funding).

5.3.5 Knowledge Gaps

- Lack of understanding of bio-management of weed problems.
- Incomplete knowledge of the risk of genetically modified plants cross-breeding with bush species?
- What are the principal weeds that may cause problems in the future?

5.3.6 Strategies

Strategy 1
Prevent the introduction and spread of new weed species to the area by:

1. Maintaining the border checkpoint.
2. Continuing the development of the Regional Weed Strategy
3. Developing an education and awareness program about current weed species and future potential weeds by using:
   a) mail drops;
   b) the Kimberley Weeds section on the Ag WA website;
   c) local web sites;
   d) the Ribbons of Blue education program.
4. Developing an easy to read updateable booklet on weeds in the region.
5. Encouraging fishermen, bushwalkers, etc to report sightings of weed species.
6. Providing easy to access plant identification material to the general public.

Strategy 2
Control the spread of existing weed species by: {*}

1. Finalising the Regional Weed Strategy (which was initiated in 1999).
2. Developing an education and awareness program (as in 3. above).

Strategy 3
Eradicate weed species where appropriate and feasible.

Strategy 4
Encourage SWEK and the Agricultural Protection Board (AGWEST) to develop guidelines for the management of weeds in the area. {*}

5.3.7 Responsibilities

The Agriculture Protection Board has responsibility for controlling declared weed species on unallocated crown land and for providing information and awareness material to landholders and the general public. CALM have responsibility for controlling weed species on their estate. The WRC plays a role with declared weed management in local waterways. Landholders have a responsibility to ensure that they do not introduce weed species to their gardens/areas of land that have the potential to become problem species (this is particularly important for waterweed species). The SWEK has a responsibility for managing weed species in the Shire (they have the power to declare pest plants).

5.3.8 References

Hussey, BMJ, Keighery, GJ, Cousens, RD, Dodd, J, Lloyd, SG (1997), Western Weeds – A guide to the weeds of Western Australia, *The Plant Protection Society of Western Australia.*

Kimberley Pastoral Memo, August 1999, *Agriculture WA, Derby*

5.4 Off Property Clearing

5.4.1 Goals

- **Ensure there is no illegal off property clearing.**
- **Ensure that clearing that is undertaken conforms to appropriate formal processes.**

5.4.2 Current Status

The Department of Land Administration (DOLA) is responsible for the management of Unallocated Crown Land (UCL). No clearing can be undertaken on these areas without due assessment by this department in consultation with a number of other agencies, including the Water and Rivers Commission, Conservation and Land Management, Environmental Protection and the Commissioner for Soil Conservation (Derrick Chan, *pers comm*, August 1999).

All areas of land are vested in someone, whether it be the crown or specific Ministers. For example the area of land directly downstream of the Diversion Dam wall is vested in the Minister for Water Resources for protection of the Diversion Dam (Reserve 37380). Areas along side the river from the Diversion Dam to Riverfarm Road is vested in the Minister for Works for quarry sites along the Ord River (Reserve 36951) (Water Corporation, 1999).

Clearing areas between farms and the Ord River and Lake Kununurra, the development of tourist camps and rest stops along the river, and the clearing of road verges is of concern to the community as it reduces the available habitat for native animals and can destabilise river bank areas.

River front clearing

There is concern about the removal of riparian vegetation from areas between properties and the river. On Lake Kununurra some areas of land between farms and the river (and areas of the foreshore closer to town) are vested in the Shire and the Water and Rivers Commission. Therefore any proposed changes to these areas require the approval of both of these organisations.

There are small areas along the Ord River and Lake Kununurra that have been cleared for tour operations, or to enable access to the area. Before developments in these areas can go ahead, DOLA has to assess the proposal in consultation with the above mentioned agencies.

As discussed in Section 2.3, the riparian areas of the river are important to animals and often support highly diverse ecosystems.

Road side clearing

The Shire of Wyndham East Kimberley currently allows landholders to utilise land as close as practical to roads on the proviso that it may be reclaimed at any time. This does not allow for any clearing of trees, this must be addressed by the landholder through the Soil and Land Conservation Act and the Commissioner for Soil Conservation.

5.4.3 Projects Under way

Integrated overview of values, uses and modifying processes in the Ord River's riparian zone. The project leader for this project is Dr Tony Start.

5.4.4 Knowledge Gaps

- The Shire of Wyndham East Kimberley's environmental policy.
- Can roadsides be used effectively as wildlife corridors?
- Does clearing of areas along road verges and adjacent to the river have an impact on the species using these areas?
- Future planning issues?
- Is there soil erosion/movement from areas that are cleared? What is the impact from this?

5.4.5 Strategies

Strategy 1

Reduce off property clearing, by:

Ensuring guidelines for clearing and development are unambiguous{*}.

Ensuring that landholders are aware of and adhere to these guidelines by:

(a) Ensuring the agencies involved take responsibility to provide the relevant information to landholders;
(b) Developing guidelines for management of riparian areas and including them in a waterways management strategy.

Strategy 2

Improve the management of roadside verges, by: {*}

Managing weed species in these areas {*}.

Encouraging the inclusion of these areas in an "Environmental Management Plan" for the area.
Clarifying the purpose and use of these areas (including native species, access, etc).

5.4.6 Responsibilities

The SWEK, DOLA, the Water and Rivers Commission and the Water Corporation have a responsibility to clarify how areas alongside the river are to be managed. DOLA has a responsibility to clarify the guidelines for clearing outside of property boundaries (areas that are not adjacent to the river). These organisations also have a responsibility to ensure that guidelines for the management of these areas are developed and adhered to.

The SWEK and property owners alongside roads have a responsibility to improve the management of roadside verges to ensure they are not acting as a source for weeds, or transferring feral animals etc.

5.4.7 References

Derrick Chan, Department of Land Administration, *pers comm*, August 1999.

Ross Currie, Land Matters Administrator –NWR, Water Corporation, 12 October 1999.

5.5 Bush Corridors

5.5.1 Goals

- **Preserve the remaining areas of native vegetation that have the potential to act as wildlife corridors**
- **Within 5 years identify where new corridors are required for the conservation of biodiversity.**

5.5.2 Background

A corridor is a linear feature of vegetation, which differs from the surrounding vegetation and connects at least two patches that were connected in historical time (Hussey *et.al*, 1989)

Frequently, corridors link one or more patches of habitat in the landscape and may be a pathway for animal movement, but they may also occur as isolated lines of habitat (Bennett, 1990).

The preservation of existing corridors, or the establishment of new corridors to link isolated habitats, has been widely proposed as practical conservation measures that can ameliorate the effects on wildlife of habitat loss and fragmentation (Bennett, 1990).

Corridors are important where large areas of land have been cleared of native vegetation, leaving isolated pockets of vegetation which does not "connect" to other areas – this is sometimes called fragmentation. Fragmentation can lead to loss of species diversity of both plant and animal species.

The function of corridors is to facilitate the movement of plants and animals along the corridor and between isolated populations, to act as habitat for some species, and to act as a barrier to the movement of certain species through a landscape (a river may be a natural barrier).

5.5.3 Current Knowledge

Corridors have many positive values in nature conservation and general land management. They may be habitat in their own right for native plants and animals, permit species to move between isolated areas of vegetation, and enable gene flow to occur between different members of a population. They can increase the diversity of the landscape, provide a tool to help control rising ground water levels, provide shelter for wildlife, improve aesthetics and help to create a more "integrated" system.

On the other hand, corridors can have negative impacts. They may channel species into areas where they face increased risk of mortality from human pressures or other predators. If corridors are open disturbed areas they can be ideal for weed establishment (Hussey *et.al*, 1989) and can be utilised by feral animals.

There are no areas in the ORIA that are designated as wildlife corridors (March 2000). However, there are areas around the irrigation area that may be able to be utilised as corridors. These areas may not be native vegetation but may be able to be used as managed corridors. These include sections of the D2 Drain, the M1 Channel – all the way through the irrigation area (*note: the area alongside the M1 Channel is a reserve for the M2 Channel) and the Farm Hill area (Dumas Lookout). However, there are a number of issues related to these areas including the size of the areas and possible conflicts with current surrounding land uses.

5.5.4 Knowledge Gaps

- Is the irrigation area large enough to warrant wildlife corridors?
- What is the extent of habitat fragmentation in the irrigation area?
- What would be the aim of the corridors – ie. what community/species are we trying to conserve?
- Are there sections of the irrigation area that are more important in terms of corridors than others?
- How do species currently found in the irrigation area move through it?
- Do they move through fields, along channels and drains, along roads?
- What species have reduced habitat or migration corridors that are blocked by the irrigation area.

5.5.4 Strategies

Strategy 1

Encourage the preservation of existing remnant vegetation areas by:{*}

1. Identifying the location of areas of remnant vegetation.
2. Working with the landholders to help manage these areas.

Strategy 2

Conduct research on the geography and scale of the ORIA and its possible requirements for wildlife corridors.

5.5.6 Responsibilities

The SWEK has a responsibility to develop guidelines for management of areas of remnant vegetation and integrate research results into these management guidelines.

Water Corporation has a responsibility for managing the channels and drains that have the potential to act as corridors. This responsibility may change once the irrigation distribution system is privatised.

Community groups such as the LCDC and COVE have a responsibility to help identify areas that may act as corridors and help to source funding to have research done in this area. This may include working with agencies to encourage research with Universities and other organisations.

5.5.7 References

Bennett, A.F., (1990), *Habitat Corridors- Their Role in Wildlife Management and Conservation*, Department of Conservation and Environment, Victoria, Arthur Rylah Institute for Environmental Research.

Hussey, B.M.J., Hobbs, R.J., Saunders, D.A., (1989), *Guidelines for Bush Corridors*, from workshop/conference on "Nature Conservation: the Role of Corridors" held in Western Australia.

Saunders, D.A. & Hobbs, R.J. (Eds.) (1991), *Nature Conservation II: The role of corridors.* Surrey Beatty & Sons Pty. Ltd.

5.6 National Parks and Conservation Reserves

5.6.1 Goals

- **Increase the area in the reserve system by incorporating currently proposed areas (Packsaddle Swamp, Carr Boyd ranges, Cambridge Gulf Marine Reserve).**
- **Within two years develop a plan to manage the impact of visitors on popular recreational areas that are outside national parks.**

5.6.2 Background

Mirima National Park (Hidden Valley) is close to Kununurra. This park has facilities such as walk trails and information boards and is utilised by local people and visitors to the area.

There are also two Nature Reserves located along the Lower Ord River, Parry Lagoons Nature Reserve and the Ord River Nature Reserve. These areas are managed primarily for nature conservation.

There is a proposed Cambridge Gulf Marine Park, which includes the Ord River Nature Reserve, portions of Carlton Hill Station, Unallocated Crown Land and the waters of the Cambridge Gulf.

5.6.3 Current Status

It has been proposed that the islands of Lake Argyle and the Carr Boyd Ranges to the west and north-west of Lake Argyle be declared a class C Reserve, for the purpose of a National Park (Burbidge, McKenzie and Kenneally, 1991). See attached map.

The Packsaddle Swamps area is also an area of proposed reserve with joint vestige in the Water Corporation and the National Parks and Nature Conservation Agency (Burbidge, McKenzie and Kenneally, 1991). See attached map.

The Department of Conservation and Land Management (CALM) manage these areas of national parks and reserves. This management includes fire management, public access management, as well as managing the native flora and fauna found in these areas. Comments from the public on park management are invited by CALM.

5.6.4 Strategies

Strategy 1

Encourage joint planning on fire and weed management around National Parks and Conservation Reserves by:

1. Involving CALM, SWEK, DOLA, fire brigades, the Kimberley Bush Fire Service and Traditional Owners in a joint planning initiative.

Strategy 2

Reduce the impacts of visitors on popular recreation areas (outside the National Parks) by: {*}

1. Education and awareness.
2. Appropriate signage.
3. Provision of facilities.
4. Involving the landholder (station management, traditional owners, DOLA (for areas of UCL) etc) and the SWEK in the management of the area.

5.6.5 Responsibilities

CALM has the principal responsibility for managing areas that are within their estate. Landholders surrounding national parks and conservation reserves have a responsibility for reducing their impacts on national parks by working with CALM on joint initiatives.

The community (including tourists and local residents) has a responsibility to minimise their impacts on national parks and other popular recreational areas. SWEK has a responsibility to help community organisations (such as LOCAC) maintain popular visitation areas.

5.6.6 References

Burbidge, A.A., McKenzie, N.L., Kenneally, K.F., (1991), *Nature Conservation Reserves in the Kimberley Western Australia,* Department of Conservation and Land Management, WA.

5.7 Native Plants and Animals

5.7.1 Goals

- **Maintain and protect the biodiversity of the plants and animals within the Ord River Irrigation area and surrounding areas included within this study.**
- **Increase the understanding of and interrelationships between native plant and animal species found in the area.**

5.7.2 Background

There have been a number of reports on native plants and native animals in the study area. These generally focus on one location, for example Mirima National Park or Lake Kununurra, but relate to the area as a whole.

5.7.3 Current Status

General

A list of plant species found in the area is located at the WA Herbarium (Perth). There may be other plants species in the area but they have not yet been recorded.

A survey of animals was carried out by the WA museum in 1971, prior to the flooding of the Ord River to form Lake Argyle. They found that there were 26 different species of native mammals in the area. This survey focussed on the areas that are now submerged by Lake Argyle (Kitchener, 1978).

Birds

There are approximately 200 different species of birds in the area. There are also records of large numbers of some bird species, for example, 4000 Brolgas and 500 Swamp Hens have been recorded at Lake Argyle (Steve Sharpe, Lake Argyle Cruises, *pers comm*). There are birds found in the area that have restricted distributions in other areas of the state, such as the Burdekin Duck, Green Pigmy Goose, White Browed Crake, Pied Heron and White Browed Robin. There are a number of species that have increased in numbers due to the permanent water supply now available. These include the Magpie Goose, Plumed Whistling Duck, Chestnut Whistling Duck, Jabiru, Brolga, and Swamp Hen (Jaensch, 1989).

Crocodiles

Crocodiles are found in all waterways around the area. Lakes Kununurra and Argyle are significant breeding areas for freshwater crocodiles, *Crocodylus johnstoni,* and the Lower Ord River is habitat for estuarine crocodiles. Lake Kununurra and Lake Argyle are designated crocodile control zones (CCZ), which means that immediate action is taken by CALM to remove any estuarine crocodiles that are confirmed to be present.

Photo 10: Crocodile sighted while boating on the Lower Ord River *(see central colour pages).*

CALM has conducted surveys on crocodile numbers in the Lower Ord River since 1986. These surveys have indicated that the crocodile population has not altered significantly over the survey period. Part of the reason for this is that significant numbers of crocodiles have been trapped for the Wyndham and Broome Crocodile Farms (Chris Done, CALM, *pers comm*).

Waterways

Lakes Kununurra and Argyle and the Ord River Floodplain are all listed as Ramsar wetlands. Being listed as Ramsar sites these areas are internationally recognised as "wetlands of international importance especially as waterfowl habitat". The key concept of the Ramsar convention is to encourage the wise use of these areas (where the *wise use* is their sustainable utilisation for the benefit of mankind in a way compatible with the maintenance of the natural properties of the ecosystem) (www.anca.gov.au).

Because of this Ramsar listing there have been a number of surveys focussing on the species found in the Lake. The following is a summary of the flora and fauna species for Lake Kununurra, therefore giving some indication of the species found in the study area.

Lake Kununurra

Flora

Riparian woodland has re-established along the banks (following flooding when the lake was created). Typical fringing and riparian woodland species include *Melaleuca species, Pandanus aquaticus, Eucalyptus microtheca, E. camaldulensis, Sesbania formosa, Nauclea orientalis* and *Lophostemon grandiflorus.* (Watkins *et. al* 1997).
Present conditions in the lake provide an ideal regime for growth of submerged aquatic plants. Common submerged or floating aquatic plants include floating pond weed *Potamogeton tricarinatus,* ribbon weed

Vallisneria spiralis, hydrilla *Hydrilla verticellata*, *Najas graminea, Myriophyllum verrucosum, Chara spp,* white snow flake lily *Nyphoides indica,* and blue waterlily, *Nymphaea gigantea* (Watkins *et. al* 1997).

One of the most successful aquatic plants associated with Lake Kununurra is cumbungi *Typha domingensis.* Since the lake was dammed cumbungi has moved along most of the banks of the lake and associated wetlands, and is continuing to expand into open water to depths of around 2m (Watkins *et. al* 1997).

None of the wetland plants associated with Lake Kununurra are considered to be rare, threatened or endangered (Australian Nature Conservation Agency, 1996). No exotic waterweeds are known to occur in Lake Kununurra. However, the riparian zones support an extensive array of terrestrial weed species.

Fauna

Animal species associated with Lake Kununurra and surrounds include an extensive array of invertebrate species (Ribbons of Blue sampling has located as many as 12 different species at one site at one time) and at least 15 species of freshwater fishes (mainly catfishes, grunters and gudgeons). Extensive populations of freshwater crocodiles and three species of freshwater turtles (one of which is only found in the Kimberley-Victoria River region). Colonies of flying foxes (with the black flying foxes *Pteropus alecto* being resident and the little red flying fox *Pteropus scapulatus* is only present in the wet season), and up to 160 species of birds (Watkins *et. al* 1997), of which there are ten listed under treaties (ANCA, 1996).

There are species of aquatic fauna which have had their area of population distribution reduced due to the construction of the Diversion Dam. These include a number of fish species, which have migration as a vital part of their life cycles.

Terrestrial

Much of this information relates to Mirima National Park and it's surrounds (once again as there has been study in this area and there is limited other information). This park is located on the edge of the town of Kununurra and therefore could be indicative of species found in the study area.

Flora

In the park area there have been 147 species of flora from 54 families recorded. Some examples of these species include Woollybutt (*Eucalyptus miniata)*, and Long-fruited Bloodwood (*E. polycarpa),* over shrubs such as *Cajanus reticulatus, Planchonia careya, Grevillia heliosperma, G. refracta* and *Pouteria sericea* on the valley floors. The rocky walls support the Boab (*Adansonia gregorii)* and the figs *(Ficus leucotricha and F. platypoda)* and Turkey Bush (*Calytrix exstipulata)* (Burbidge *et al*, 1991).

For more information on the species found in the area see *A Biological Survey of Mirima National Park Dec. 1993 – Jan. 1994.*

See the weeds Section 3.3 for the status of terrestrial weeds.

Fauna

There have been 15 species of frog, 45 reptile species and 22 mammal species found in the park (with four of the mammal species being introduced).

186 species of avifauna have been recorded in the boundaries of Mirima National Park. Birds found in the park that are seen as uncommon include the pacific baza, peregrine falcon, black tailed native-hen and barn owl. The little button quail, which is on the northern edge of its distribution has also been recorded (Graham, 1994).

5.7.4 Strategies

Strategy 1
Develop a local database for recording native plants and animals by:

1 Developing an easy to use recording system to catalogue this information (such as a local herbarium).
2 Encouraging local community groups to record their results from field trips, etc. (one idea is the duplicate log book system mentioned in Section 3.1.4 Strategy 1).
3 Encouraging cooperation and involvement with existing research and monitoring programs.
4 Publicising the local recording system to ensure interested people utilise it.

Strategy 2
Establish a corridor to allow the migration of aquatic fauna along the Ord River by:

1. Supporting the process that is already under way to investigate different options for developing an aquatic corridor.
2. Taking into account the safety concerns of river users on Lake Kununurra when developing options for a corridor.

5.7.5 References

Australian Nature Conservation Agency (1996), *A Directory of important Wetlands in Australia Second Edition.* ANCA, Canberra.

Burbidge, A., McKenzie, N.L., Kenneally K.F., (1991), *Nature Conservation Reserves in the Kimberley, Western Australia*, Department of Conservation and Land Management, Western Australia.

Graham, G (1994), *A Biological Survey of Mirima National Park, December 1993 – January 1994*, Department of Conservation and Land Management – Western Australia.

Jaensch, R. P., *Birds of Wetlands and Grasslands in the Kimberley Division, Western Australia: Some Records of Interest, 1981 – 1988,* Royal Australasian Ornithologists Union, RAOU Report No. 61, 1989.

Kitchener, D.J., (1978), *Mammals of the Ord River Area, Kimberley, Western Australia*, Rec.West.Aust. Mus., **6** (2).

Watkins, D., Brennan, K., Lange, C., Jaensch, R. P., Finlayson, M., (1997), *Planning for Ramsar Sites in the Kimberley Region of Western Australia,* Wetlands International – Oceania, Environmental Research Institute of the Supervising Scientist Consultant.

Chapter 6 - Town Issues

6.0 Introduction

The impacts of the community of Kununurra on surrounding land and water resources need to be managed and minimised.

Many of the strategies are aimed at encouraging the local community to take responsibility for the impacts they have and trying to reduce these impacts. It is important to highlight that the local residents have a responsibility for improving the management of town related impacts. The Shire of Wyndham East Kimberley (SWEK) has responsibility for leading and supporting improved management of the town rubbish tip, drainage from the town and taking a lead role with land use planning.

The Water Corporation is responsible to the community to ensure that the Waste Water Treatment Plant has minimal impact on the environment, residents and water users and that the health of members of the community is not compromised by their management of the facility.

** Please note - It is important to recognise that the strategies developed in this chapter will need to be built on as new knowledge is developed and targets are achieved. At this stage they provide a starting point and a framework for commitment from all the parties involved in Land and Water Management on the Ord.*

6.1 Land Use Planning

6.1.1 Goals

- **To ensure that recommendations from the Kununurra Wyndham Area Development Strategy are adhered to for the time frame of the plan (25yrs) and that any changes to this and other town planning schemes only occur through due process.**

6.1.2 Background

The town of Kununurra and the irrigation area are part of the Shire of Wyndham East Kimberley's Town Planning Scheme. This document determines the locations of new/different land uses, where subdivisions can occur, as well as planning for locations of future developments.

6.1.3 Current Status

The Town Planning Scheme No. 7 was reviewed in 1999. There was extensive public consultation and discussion on the document and the reviewed scheme is currently being finalised.

In addition to the Town Planning Scheme there is also a longer-term development strategy being developed for the area. This is the Kununurra-Wyndham Area Development Strategy (KWADS). This has been put together by the Kununurra-Wyndham Area Development Strategy Steering Committee.

The purpose of KWADS will be to provide long term (25 years) guidance to the relevant bodies that manage land use planning. It will ensure that environmental and heritage values are protected and that settlement expansion is managed and the need for new settlements investigated. It aims to promote tourism and development nodes, assess the need for further industrial land and coordinate the provision of transport and other service infrastructure.

This document incorporates the town-planning scheme, and is focused on a large area – taking in Wyndham, Kununurra, parts of the Northern Territory, and the land area extending to the coast. This document was out for public comment during November 1999.

The KWADS document covers areas of concern related to land use planning that were raised in the Issues Paper including: ensuring that the integrity of agricultural land is maintained, and minimising the potential for conflicting land uses to be located near one another.

To ensure that land use planning initiatives are successful in the future it will be necessary that those most involved both understand the process and actively participate in the development, review and implementation of land use planning initiatives.

6.1.4 Strategy

Strategy 1
Community participation in land use planning by:

1. Informing the community about the benefits of well planned development to reduce confusion and frustration often expressed during plan development and review.
2. Ensuring consultation with key community groups as well as informed individuals.
3. Ensuring adequate levels of advertising to provide the community with sufficient information to enable constructive participation in plan development and implementation.

6.1.5 Responsibilities

The Shire of Wyndham East Kimberley plays a lead role locally with land use planning. The Western Australian Planning Commission is responsible for planning at the state level.

6.1.6 References

Kununurra Wyndham Area Development Strategy Steering Committee, (1999) *Kununurra-Wyndham Area Development Strategy,* Western Australian Planning Commission.

6.2 Waste Water Treatment Plant

6.2.1 Goals

- **To ensure that waste water effluent is removed from the M1 channel and put to productive use within two years.**
- **To ensure that within two years potential ground water contamination around the waste water treatment plant is monitored.**
- **To ensure that all management information and monitoring data are freely and publicly available.**
- **To have deep sewerage available to 100% of the Kununurra town site in three years and 100% connection to deep sewerage in five years.**

6.2.2 Background

The Water Corporation manages the Kununurra Waste Water Treatment Plant. This plant is made up of a series of ponds and treats waste water from the town of Kununurra. Treated effluent from this plant is returned into the main irrigation delivery channel (M1) between Ivanhoe Road and the Victoria Highway. This plant is designed to service an estimated population of 7350 people.

The Water Corporation has a license from the Department of Environmental Protection that enables it to discharge water into the M1 channel. This license has a number of requirements and is given under the Environmental Protection Act 1986 (Department of Environmental Protection, WA, 1998).

- These requirements include:
- There is no loss of waste water through seepage or by overflow from rainfall events and no vegetation is allowed to grow on the banks of the ponds.
- Monthly flow volumes from the site must be measured.
- A sampling point in the outlet pipe must be maintained.
- A sample of treated waste water being discharged from the site shall be collected every three months.
- All samples shall be collected by, or under the instruction of a qualified chemist and in accordance with Australian Standard 5667.1, 1998, or other approved standard.

There are also requirements for the removal and disposal of sludge (bio-solids) from the ponds, including drying times, removal, on site storage, testing and disposal (Department of Environmental Protection, WA, 1998).

Following community pressure in 1998 (principally through the LCDC) there has been work done in an attempt to reduce the impact of treated effluent discharged to the M1 Channel. The community concern came from the fact that the water in the M1 channel (1km downstream of the outfall) is used by the Shire to irrigate some areas of the town. The school and a caravan park also use this water for irrigation, and farmers come into contact with the water while irrigating crops.

The Health Department of WA advised that if there is waste water being used to irrigate areas of the town, there are limits that need to be placed on the use of this water. There are guidelines for the direct reuse of waste water, however, the water leaving the WWTP is diluted in the M1 Channel and there are no guidelines for levels in diluted water.

The acceptable levels for using the water to flood irrigate crops is 1000cfu/100ml. From

the data provided by the Water Corporation the biggest problem occurs at the time of the year when irrigation water demand is low (January/February) when treated effluent entering the channel is not well diluted.

6.2.3 Current Knowledge

The water in the channel is tested monthly for thermotolerant coliforms and nematodes (the levels of nematodes can not exceed two larvae or eggs that resemble hookworm or Strongyloides). The water is also tested for nutrients – phosphorus and nitrogen (it should be noted that the coliform testing is not specifically on human coliforms – therefore the animal life in the channel may also be contributing to the levels).

These samples are gathered by the Water Corporation and sent to an independent laboratory for analysis. This data is then made freely available to the public – the LCDC receive copies of this monthly data.

The waste water in the treatment ponds has a residence time of 27 days (minimum) in high flow times and an average detention time of 35 days over the past 12 months (pers coms RD Becu, 1999).

The treatment plant treats most of the waste water from Kununurra, with the exception of Weaber Plains light industrial area, and some of the Ivanhoe Industrial area, and the plant is currently operating at approximately 55% capacity.

The plant has eight separate ponds that are clay lined. There are two sets of four ponds and half the waste water flows through one set of ponds and the other half through the other set of ponds. As the waste water flows through the series of ponds it is progressively treated and when it leaves the last pond it runs down a pipe and into the M1 Channel. This waste water is diffused through a PVC structure in the channel.

Since July 1998 thermotolerant coliforms have not been recorded above the current guideline of 1000cfu/100mls at any of the sampling sites, except for the site 6km downstream where this level was reached on one occasion (March 1999).
The levels of nitrogen and phosphorus are highest directly downstream of the outfall, but these levels are well diluted in the channel and have minimal impact on the downstream water quality.

The sampling in the M1 Channel has been extended to 6km downstream of the outfall and in consultation with the Health Department the Water Corporation is extending microbiological monitoring downstream.

6.2.4 Projects under way

The Water Corporation has completed planning for alternative effluent disposal options including discharge in the M1 Channel, establishing a tropical tree plantation, irrigation of a sugar cane crop, irrigation of the Kununurra Golf Course and improving the effluent quality through advanced treatment techniques. Local stakeholders considered these options during a workshop in September 1999. The recommendation from this meeting was to establish a tropical tree plantation on the area adjacent to the Waste Water Treatment Plant site.

6.2.5 Knowledge Gaps

- The Health Department guideline for the use of water from the M1 channel – downstream of the WWTP.

6.2.6 Strategies

Strategy 1

Reduce the impacts of the Waste Water Treatment Plant on downstream water users by:

1. Removing WWTP effluent from the M1 Channel, and;
2. Confining the excess effluent to a specific area.

Strategy 2

Monitor the impacts of the Waste Water Treatment Plant on downstream users by:

1. Regular sampling of the M1 Channel water for the nutrient and biological factors currently sampled by the Water Corporation.
2. Determining what the guidelines for microbiological activity in the M1 Channel water should be.

Strategy 3

Monitor the impact of Waste Water Treatment Plant on the immediate area by:

1. Regular sampling of ground water for changes in levels and nutrients using piezometers around the waste water treatment facility.

2. Record complaints about odours from the plant.

Strategy 4
Reduce the impact of waste water on ground water by:

1. Providing a deep sewerage service to those parts of the town currently not connected and using leach drains.

Strategy 5
Ensure awareness and understanding within the community about the Waste Water Treatment Plant and related issues by:

1. Ensuring that the information from the above strategies is made public through existing community groups (such as the LCDC) and the media.

6.2.7 Responsibilities

The Water Corporation has responsibility for managing the WWTP and the impacts of this plant. The community also has a responsibility to ensure that they utilise the information that is provided to them, to remain informed about the issue.

6.2.8 References

Gary Munns – *pers comm,* 20th February 2000

Kununurra Waste Water Treatment Plant – Options for Treated Waste water Disposal, August 1999, Water Corporation Infrastructure Branch.

Letter from R Becu, Manager Assets, North West Region, 21 July 1999.

Letter from the Health Department of Western Australia, Environmental Health Service, August 1998.

Department of Environmental Protection, WA (1998), Licence - Kununurra Waste Water Treatment Plant, Licence No. 6270/2, *Environmental Protection Act 1986*

6.3 Town Rubbish Tip

6.3.1 Goals

- **To ensure that inputs to and outputs from the rubbish disposal site are managed to Department of Environmental Protection requirements within 2 years.**
- **To increase the utilisation of recyclable refuse including green waste, aluminium, glass, etc by 50 % in four years**

6.3.2 Current Knowledge

The Kununurra Rubbish Tip is currently situated on the east side of town and is open 24hrs a day. The tip is not manned and therefore it is hard to control what is dumped there. More effective and environmentally sound practices are now required (which may require manning of the tip) to meet more stringent operating licence conditions introduced over the last two years (SWEK Council minutes 17th February).

The Shire has a waste disposal license from the Department of Environmental Protection (which was issued 18 months ago). The current location of the tip (about 1km from Lake Kununurra) was not cause for concern for the Environmental Protection Authority when they were issuing the license.

The current location has a life of about ten years. After this time a new location will be required where there will be much stricter controls on the inputs to the tip.

Recycling

Used Oil

Oil cannot be disposed of at the Rubbish Tip. Used oil can be recycled or refined into products for which there are environmentally sound markets (such as recovering the energy value of oil through high temperature incineration in cement or lime kilns) (Australian Institute of Petroleum Ltd, 1996). Most of the companies that provide oil have a responsibility to take back used oil. In Kununurra there are a number of different oil companies in business and most of them will take back their own customers used oil.

There are no legal requirements for any shire council to have an oil recycling station in their area (Ken Rain, *pers comm,* 1999). There are oil recycling plants in areas such as Karratha where there are large volumes of oil used by heavy industry. (Graham Cobby, *pers comm,* 1999)

Glass, Aluminium, etc.

The major difficulty with recycling glass, aluminium and other household products is the cost of transporting the recyclable products to an area where they can be recycled. The

collection of aluminium and glass would cost around $80 per household per annum.

Green Waste

SWEK is encouraging residents to recycle their green waste. Late in 1999 they were providing compost bins at a reduced cost to encourage their use. Other green waste generated (eg garden clippings) can also be composted.

Drum Muster

SWEK is looking at becoming involved in the nation wide program called Drum Muster (this was a recommendation from the August 19th 1999 council meeting). This involves the collection and recycling of agricultural chemical containers. This program is designed to be cash neutral and is funded by a levy on chemical drums purchased. It involves providing a collection place for clean containers and then having them recycled or reused.

6.3.4 Knowledge Gaps

- What is actually being dumped in the tip?
- Is the tip having any adverse off site impacts e.g. ground water contamination?

6.3.5 Strategies

Strategy 1

Reduce the risk of adverse effects from illegal dumping of rubbish by:

- Manning the tip – this will enable better control of what is dumped in the tip,
- Becoming involved in the Drum Muster program to encourage the responsible disposal of chemical containers.

Strategy 2

Reduce the amount of waste being generated by:

- Recycling green waste, plastics, glass, aluminium, etc.
- Reusing glass, aluminium, plastic and paper, etc.

Strategy 3

Increase the level of education and awareness about waste related issues by:

1. Encouraging educational programs, such as Ribbons of Blue, for local schools and community groups.
2. Utilising existing newsletters and media outlets such as: Ord Land & Water News, Shire newsletters, Kimberley Echo.
3. Investigating other avenues for awareness raising across cultural boundaries.

6.3.6 Responsibilities

The Shire of Wyndham East Kimberley plays a lead role in managing waste in the area. It is therefore the responsibility of the Shire and the residents (ratepayers) to support improvements in the management of waste in the area and awareness raising projects.

6.3.7 References

Australian Institute of Petroleum Ltd. (1996), *Code of Practice for The Management of Used Oil,* Melbourne.

Graham Cobby – Senior Assessor, Safety and Environment Branch, Petroleum Division, Department of Minerals and Energy, Western Australia.

Ken Rain – Department of Environmental Protection.

Shire of Wyndham East Kimberley Shire Council Minutes from 17th February 2000.

6.4 Town Drainage

6.4.1 Goals

- **To reduce the impacts of drainage from town areas on local water ways by 50% within five years.**
- **To ensure that industrial storage areas all comply with Australian and Western Australian standards within two years.**
- **Eliminate the risk of waterway contamination from surface water run-off from the airport within two years.**
- **Eliminate the risk of waterway contamination from fuel leakage or spills from sites within the town and at the airport within five years.**

6.4.2 Background

Most of the drainage water from the town of Kununurra runs into Lily Creek Lagoon (part of Lake Kununurra). There is a large drain that drains the Hidden Valley area, a number of large concrete drains that drain Lakeside, a large drain that runs alongside Ivanhoe Rd (past the Shell Roadhouse) as well as numerous other drains around the town that feed storm and run-off water into the lake.

The concern with the drains running into Lake Kununurra is that the water they transport has the potential to carry contaminants, for example: off road contaminants such as oil, grease, heavy metals etc, and from parks and gardens (including personal gardens) such as fertilisers. Gross pollutants such as beverage containers, plastic and paper are also a problem.

Some of the drains have the potential to act as weed seed sources if they are not properly managed.

The time when drainage off the urban areas is most important is generally the first run-off event of the wet season. This is due to the build up of oil and other hydrocarbons on the roads during the long dry season.

6.4.3 Current Knowledge

During 1998 the program to sample water quality picked up traces of a number of chemicals in Lily Creek Lagoon (the section of Lake Kununurra where most of the drainage water from the town enters).

The cumbungi in Lily Creek Lagoon may be acting as a biological filter for water entering Lake Kununurra. The Shire has cleared some areas of cumbungi in Lily Creek to "beautify" the area but they have not cleared areas where there are drain outlets.

Illegal dumping of waste into the drains is an offence and the Shire can prosecute offenders.

Airport

There is potential for a major fuel spill to pollute the M1 Channel, the Ord River, and Lake Kununurra as stormwater drainage from the airport discharges to these locations. Whilst the risk is low the consequences could be great and whilst there are emergency plans in place for minor incidents, there is a need for the Shire to address this issue in more detail.

6.4.4 Knowledge Gaps

- The amount of contaminants that actually enter the drainage system and the impacts that these are having.

6.4.5 Strategies

Strategy 1

Minimise the impacts of the urban area on surrounding waterways by:

1. Increasing education and awareness about urban impacts on waterways. The program would need to be ongoing and focus on the time of the year prior to the onset of the wet season. This could be done through:
    a) The Ribbons of Blue program (a community environmental education program),
    b) Ord Land & Water newsletters,
    c) Shire "Cyclone Cleanup" newsletters, and
    d) The Kimberley Echo.
2. Ensuring the contingency plan for dealing with fuel run-off from the airport is current and addresses all the issues associated with the location of the airport (proximity to Lake Kununurra, the Ord River and the M1 Channel) and the possibility of leakage and spills.

Strategy 2
Monitoring the impacts of the urban area on the waterways by:

1. Sampling drainage water flows during rainfall events to determine the level of contaminants in the water.

6.4.6 Responsibilities

SWEK has responsibility for the airport and contingency plans for accidents in the area. They also have a responsibility to support awareness about the issue of drainage off urban areas.

The Water and Rivers Commission has a responsibility to support awareness and to monitor the impacts of urban areas on the surrounding waterways.

Residents of the area have a responsibility to reduce the impacts that they are having on the waterways.

Appendix 1

Acronyms used in the document.

Acronym	Meaning
AGWEST	Agriculture Western Australia
APB	Agricultural Protection Board
BSES	Bureau of Sugar Experiment Stations
CALM	Department of Conservation and Land Management
CCZ	Crocodile Control Zones
CMZ	Crocodile Management Zones
COVE	Care of the Ord Valley Environment
CSIRO	Commonwealth Science & Industry Research Organisation
DEP	Department of Environmental Protection
DME	Department of Minerals and Energy
DOLA	Department of Land Administration
EKRFAC	East Kimberley Recreational Fishing Advisory
EPA	Environmental Protection Authority
FESA	Fire and Emergency Services Authority of WA
KDC	Kimberley Development Commission
KHPA	Kununurra Horticulture Producers Assoc.
KWADS	Kununurra Wyndham Area Development Strategy
LCDC	Land Conservation District Committee
LOCAC	Lower Ord Community Advisory Committee
NRA	National Registration Authority
OIC	Ord Irrigation Co-operative
ORIA	Ord River Irrigation Area
R&D	Research & Development
RFAC	Recreational Fishing Advisory Council
SEEKS	Save Endangered East Kimberley Species
SRDC	Sugar Research and Development Corporation
SWEK	Shire of Wyndham East Kimberley
UCL	Unallocated Crown Land
WA	Western Australia
WAP	Water Allocation Plan
WAPC	Western Australian Planning Commission
WC	Water Corporation
WRC	Water and Rivers Commission

Appendix 2

People contacted throughout the LWMP process.

First Name	Last name	Organisation / Group
Steve	Anderson	EKRFAC / LOCAC
Gavin	Anderson	Kununurra Horticulture Producers Association
Troy	Barbagello	Kununurra Rate Payers Association
Bob	Becu	Water Corporation
Richard	Beeck	Kununurra Rate Payers Association
Ray	Bland	Kununurra Rate Payers Association
Gabi	Bloecker	Ord River Cucurbit Growers Group
Matt	Bolam	Agriculture WA
Robert	Boshammer	
Bernard	Bowen	Environmental Protection Authority
Mick	Bowles	EKRFAC
Kevin	Bradley	Water Corporation
Ron	Brindley	Ord River Mango Growers Assoc
Bill	Brogmus	Ord River Mango Growers Assoc
John	Buchanan	Ord River District Co-op
Neil	Butcher	Ord River District Co-op
Derek	Causely	Ord River Cucurbit Growers Group
Colin	Chamers	Fisheries WA
Derrick	Chan	Department of Land Administration
Bruce	Commins	Kununurra Rate Payers Association
Kate	Commins	Kununurra Rate Payers Association
Eileen	Croot	Ord River Cucurbit Growers Group
Ian	Cross	LCDC
Greg	Cummings	Ord River District Co-op / TAT
Chris	Curtis	Kununurra Horticulture Producers Association
Spike	Dessert	Ord Irrigation Co-operative / TAT /SWEK / ODC
Kevin	Dixon	Shire of Wyndham East Kimberley
Lachlan	Dobson	TAT
Andrew	Dougall	LCDC
Rob	Doupe	EKRFAC
Cath	Elderton	Northern Land Council
Joanna	Embry	LCDC
Stephani	Eppler	Ord River Cucurbit Growers Group
Micheal	Eppler	Ord Irrigation Co-operative
Judy	Fairclough	Kununurra Rate Payers Association
Dick	Foster	Ord River Cucurbit Growers Group
Tony	Frisina	Kununurra Rate Payers Association
Elaine	Gardiner	KHPA / OIC
Fiona	Gardiner	Kununurra Horticulture Producers Association
Jim	Gill	Water Corporation
Jeff	Gooding	ODC / KDC / EKRFAC
Sue	Graham-Taylor	Conservation Council of WA
Di	Green	Ord River Mango Growers Assoc
David	Grosse	Lower Ord Management Committee
Tony	Hall	COVE
Roy	Hamilton	Kununurra Rate Payers Association
Andrew	Hammond	Shire of Wyndham East Kimberley
Glenda	Harding	Kununurra Horticulture Producers Association
Robert	Harris	Shire of Wyndham East Kimberley
Greg	Hayes	EKRFAC
Terry	Hill	Agriculture WA

Jim	Hughes	Ord River District Co-op
Lindsay	Innes	OIC / ODC / Ord River Cucurbit Growers Assoc
Kay	Ireland	Ord River Mango Growers Assoc
Kasey	Issacs	Kimberley Land Council
Brett	Jago	ODC
Brian	Jenkins	Department of Environmental Protection
Andrew	Kelly	Ord Irrigation Co-operative
Peter	Kimber	Sandgate Corporation
John	Kirby	Ord River Mango Growers Assoc
Terry	Ladbrook	Ord River Cucurbit Growers Group
Gill	Lefmann	Shire of Wyndham East Kimberley
Robert	Leonard	Ord River District Co-op
Rocky	Lerch	Ord River Cucurbit Growers Group
Deanne	Lerch	Ord River Cucurbit Growers Group
Barry	Lerch	Ord River Cucurbit Growers Group
Jim	Lewis	Shire of Wyndham East Kimberley
Ian	Longson	Agriculture WA
Mark	Lucas	COVE
John	Mack	TAT / KHPA
Jean	Mack	Kununurra Horticulture Producers Association
Al	Mason	Ord Irrigation Co-operative
Sharon	Mason	Kununurra Horticulture Producers Association
Andrew	Mc Ewan	LOCAC / EKRFAC
Adam	McKay	COVE
Alister	McKinnon	COVE
Peter	McKosker	ODC / TAT
Karen	Menzel	Ord River Cucurbit Growers Group
Dave	Menzel	Ord River Cucurbit Growers Group
Maxine	Middap	Shire of Wyndham East Kimberley
Gordon	Mock	Ord River District Co-op / Kununurra Ratepayers Assoc
John	Morris	COVE
Andy	Munro	Office of Monty House, Minister for Primary Industry and Fisheries
Michelle	Northover	TAT
Paul	Novelly	Agriculture WA
Roni	Oma	Water Corporation
Dick	Pasfield	EKRFAC / LCDC / Ord River Cucurbit Growers Group
Roger	Payne	Water and Rivers Commission
Matthew	Pope	COVE
Nick	Richards	Ord River Cucurbit Growers Group
Sue	Roberts	COVE
Graham	Robertson	Agriculture WA
Di	Robinson	Kununurra Horticulture Producers Association
Chris	Robinson	Ord River Cucurbit Growers Group / KHPA
Frank	Rodrigeuz	LOCAC / EKRFAC / SWEK
Mr	Rogers	Fisheries WA
Torben	Sass - Neilson	Ord Irrigation Co-operative
Lee	Scott-Virtue	Kimberley Specialists in Tourism
Herman	Sietz	Kununurra Horticulture Producers Association
Troy	Sinclair	EKRFAC
Noel	Smith	Ord Irrigation Co-operative
Carolyn	Stevens	Kununurra Rate Payers Association
Kirsten	Stodlt	Ord River Cucurbit Growers Group
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Allan	Thomson	LCDC
Trevor	Thomson	Department of Land Administration
Ivan	Thorley	Shire of Wyndham East Kimberley
Clinton	Vagg	Shire of Wyndham East Kimberley
Jeff	Warnock	Ord River Mango Growers Assoc
Richard	Watkins	Lower Ord Management Committee
Darren	Whelan	Kununurra Horticulture Producers Association
Bill	Withers	
Keith	Wright	Shire of Wyndham East Kimberley
Trevor	York	Kununurra Rate Payers Association
Howard	Young	Kununurra Rate Payers Association

We extend apologies to anyone who has been involved in the project and who is not listed here and to anyone whose name is incorrectly spelt.

Acknowledgments

Many people need to be acknowledged for their commitment to the Ord Land & Water Management Plan project. The Action Groups have committed many evenings to meetings over the 12 months leading up to the finalisation of the plan. The Steering Committee members have been committed to the project for over two years.

Steering Committee Membership

Tim Croot - Chairman
Wilhelm Bloecker
Tarnya Vernes
Geoff Lodge
Andrew Kelly
Jenny Hayley
Joe Sherrard
George Gardiner - Coordinator

Action Group Membership

Conservation Action Group

Iain Birnie
Ian Davies
Tarnya Vernes
Lincoln Heading
Dick Pasfield
Geoff Lodge
Julie Sutherland

Land Action Group

Wilhelm Bloecker
Lance Conley
Steve Anderson
Cindy Lethbridge
Barry Lerch
Joe Sherrard
Andrew McEwan
Chris Robinson
Michael Eppler
Spike Dessert

River Action Group

Fritz Bolten
Keeley Palmer

Stewart Dobson
Lachlan Dobson
Mike Vinnicombe
Debbie Nicholson
Jane Harman
Claire Warriner

Town Action Group

Andrew Kelly
Jenny Hayley
Jean Mack
Ian Cross
Kerry Love
Michael Moore

There are also a number of individuals and organisations who have been involved in the Ord Land & Water Management Plan project (though the Technical Advisory Committee) who have given their time (often after hours) to help the Action Groups and the Steering Committee understand some very complex issues.

Technical Advisory Committee

Name	Organisation
Chris Robinson	Agriculture WA
Joe Sherrard	Agriculture WA
Richard Watkins	Agriculture WA
Noel Wilson	Agriculture WA
Ben Tannock	CALM
Chris Done	CALM
David Grosse	CALM
Tony Start	CALM
Russel Kirk	CSR Ord Sugar
Peter Saint	FESA
Gary Bishop	FESA
Troy Sinclair	Fisheries WA
Robert Tregonning	Fisheries WA
Tony Brown	SWEK
Richard Brooks	SWEK
Robert Harris	SWEK
Leith Bowyer	Water & Rivers Commission
Susan Worley	Water & Rivers Commission
Tim McAuliffe	Water & Rivers Commission
Paula Deegan	Water & Rivers Commission
Scott Goodsen	Water & Rivers Commission
Phil Pyle	Water Corporation
Gary Munns	Water Corporation
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ORD LAND AND WATER MANAGEMENT PLAN 2000

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