1. Introduction

This document describes the mandatory Environmental Quality Monitoring results for 22 sites in the NCCMA dryland area in North Central Victoria from July 2002 to June 2003. It has been produced in response to the Victorian Statewide Salinity Monitoring Strategy.

This report is then distributed to the NCCMA Implementation Committees, Parks Victoria, Department of Primary Industries and Department of Sustainability and Environment Staff and other interested parties. The report is also able to be viewed on the Victorian Resources Online website at www.dpi.vic.gov.au/vro Follow the links to regional – select north central, click on land and water management, then environmental monitoring sites.

The long-term aim of the Environmental Quality Monitoring program is to assess the condition of remnant vegetation and wetland health to determine if salinity levels and salinity mitigation works are improving, stabilising or degrading the current condition of the environment.

This project is coordinated by the Department of Primary Industries in Bendigo. Environmental monitoring has been conducted as part of projects T091 Avon-Richardson, T068 Avoca, T067L Loddon and T067C Campaspe - environmental monitoring assistance in these four catchments.

2. Background

As a response to increasing problems associated with salinity, the Victorian Government Salinity Program released 'Salt Action: Joint Action' in 1988. The principal long-term goal of the Program was to manage salinity of land and water resources in order to maintain and where possible, improve the social well being, environmental quality and productive capacity of salt-affected catchments. One of the first steps of the Program was to instigate the production of Salinity Management Plans (SMPs) for catchments across Victoria.

The draft Avon-Richardson Land and Water Management Plan, Campaspe and Loddon SMP's were released in 1992 and the Avoca SMP released in 1993. These plans were developed with the common aims of successfully designing and implementing sustainable realistic actions to control salinity levels of soil and water and salt exports through the use of rain where it falls and establishment of perennial vegetation.

The Interim Government Response to the Plan (Government of Victoria 1994) stated that a comprehensive monitoring system needed to be established. This system was to monitor the effectiveness of land management measures for salinity control and their long-term trends on water quality, sustainable productivity and nature conservation.

Ongoing monitoring is fundamental to evaluate the success of the implementation of these catchment salinity plans. The Victorian Statewide Salinity Monitoring Strategy was released in March 1996 to provide guidelines for tracking the effectiveness of the Victorian Salinity Program. Monitoring of Environmental Quality was one component of the Strategy. It involves the assessment of the condition of significant wetlands and remnant vegetation in a Plan's area to determine if salinity levels and salinity mitigation works are improving, stabilising or degrading the current condition of the environment being monitored.

To meet the requirements of the Victorian Salinity Program, an Environmental Monitoring Program was developed and implemented for the four NCCMA dryland catchments between 1996-1997.

The Draft North Central Second-Generation Dryland Salinity Management Strategy was developed during 2002-2003, is almost finalised and will supersede the four SMPs when endorsed by State Government. Continuing the environmental monitoring program is very important for the collection of meaningful environmental trends and reporting on the health of key environmental assets across the North Central region.

This Report presents the results and limited interpretation of Environmental Monitoring information collected thus far across the NCCMA Dryland Catchment area.

3. Catchment Descriptions

3.1 Avon-Richardson

The Avon-Richardson catchment is located in the Eastern Wimmera of Victoria. It is a land-locked river system that rises in the Pyrennes foothills to the south-west of St Arnaud and flows northward into Lake Buloke, near Donald. The catchment covers an area of 330,000 hectares, stretches a distance of over 100 kilometres from north to south and spans 60 kilometres across east to west at its widest point (Avon-Richardson Land and Water Management Group 1992).

3.2 Avoca

The Avoca River catchment occupies an area of 690,000 hectares. The area can be split almost evenly between steep hill and rising country in the south, and plains country in the north. The catchment is long and narrow and includes areas of land divisions in the Western Uplands, Eastern Wimmera, Mallee and Riverine Plains. The Avoca River traverses a distance of 200 kilometres from south to north, arising at Mount Lonarch and draining into the Kerang Lakes System at Lake Bael Bael. The waters finally drain to the Murray River (Avoca Dryland Community Working Group 1993).

3.3 Loddon

The Salinity Management Plan area covers almost one million hectares, comprising the dryland area of the Loddon River catchment, extending from the Great Dividing Range in the south, to the edge of the Irrigation Districts of the Northern Plains of North Central Victoria (Loddon Community Working Group 1992). Towns include Creswick and Lexton in the south, Castlemaine in the east, Wedderburn to the west and Mitiamo in the north.

3.4 Campaspe

The Salinity Management Plan area covers some 443,100 hectares stretching from the Great Dividing Range up to the southern boundary of the Campaspe Irrigation District near Rochester. The Bendigo area is included within the Campaspe Catchment due to its total reliance on the Coliban water system, placed in the headwaters of the Coliban River. Similarly, the surface waters catchment of the Bendigo Creek, up to but not including Winghee Swamp is included in the Campaspe Catchment. Other population centres include Woodend, Kyneton, Heathcote and Elmore (Campaspe Community Working Group 1992)
(Taken from Davies 2003).

4. Methodology

The monitoring activities were undertaken according to the parameters and basic monitoring methods listed in Table 1. Methods had been developed according to recommendations of the Statewide Salinity Coordinator and technical experts within the Department of Primary Industries.

It is important that survey procedures are accurately documented and adhered to during each survey event. The success of this monitoring program relies on consistency in the methods used. Results for biological monitoring are tabulated in this report and are stored at DPI Epsom.
(Davies 2003).

4.1 Site Selection

Wetland and remnant vegetation monitoring sites are listed in Figure 1. Maps of each site can be found in appendix 10.1. These monitoring sites had been selected because they are:

- Located in high priority for salinity sub-catchments
- Currently affected or potentially threatened by rising groundwater,
- Currently or potentially influenced by salinity mitigation works, and/or
- Representative of wetland types and significant or threatened remnant vegetation communities in the catchment
- Accessible by four wheel drive vehicle all year

(Keleher 1997).

4.2 Site Description

Site descriptions have been incorporated into the results section of the report. Features include a description of the site's location in the landscape, vegetation composition and Ecological Vegetation Class (EVC), geomorphology, land use history and current status, habitat value, general health and salinity risk. Reference photographs of vegetation structure and health are also collected and stored at DPI Bendigo. Vegetation structure was described according to the definitions outlined in Specht (1981).
(Davies 2003).

4.3 Quadrat Location

Two quadrats of a standard size have been placed in a high quality area at each site. The quadrats are 10m x 10m for grasslands, 20m x 20m for Wetlands and 30m x 30m for Woodlands.

The four corners of most quadrats had been marked with star pickets coated on the top 20 cm with spray paint (refer Figure 2). Some quadrats have instead been marked with hardwood stakes painted red, outlining one or more corners to assist in detection. Where possible the quadrats were located close to access roads and had been arranged on the ground so that stake number one was closest to north. Maps showing the locations of quadrats are in Appendix 10.1 (Davies 2003).

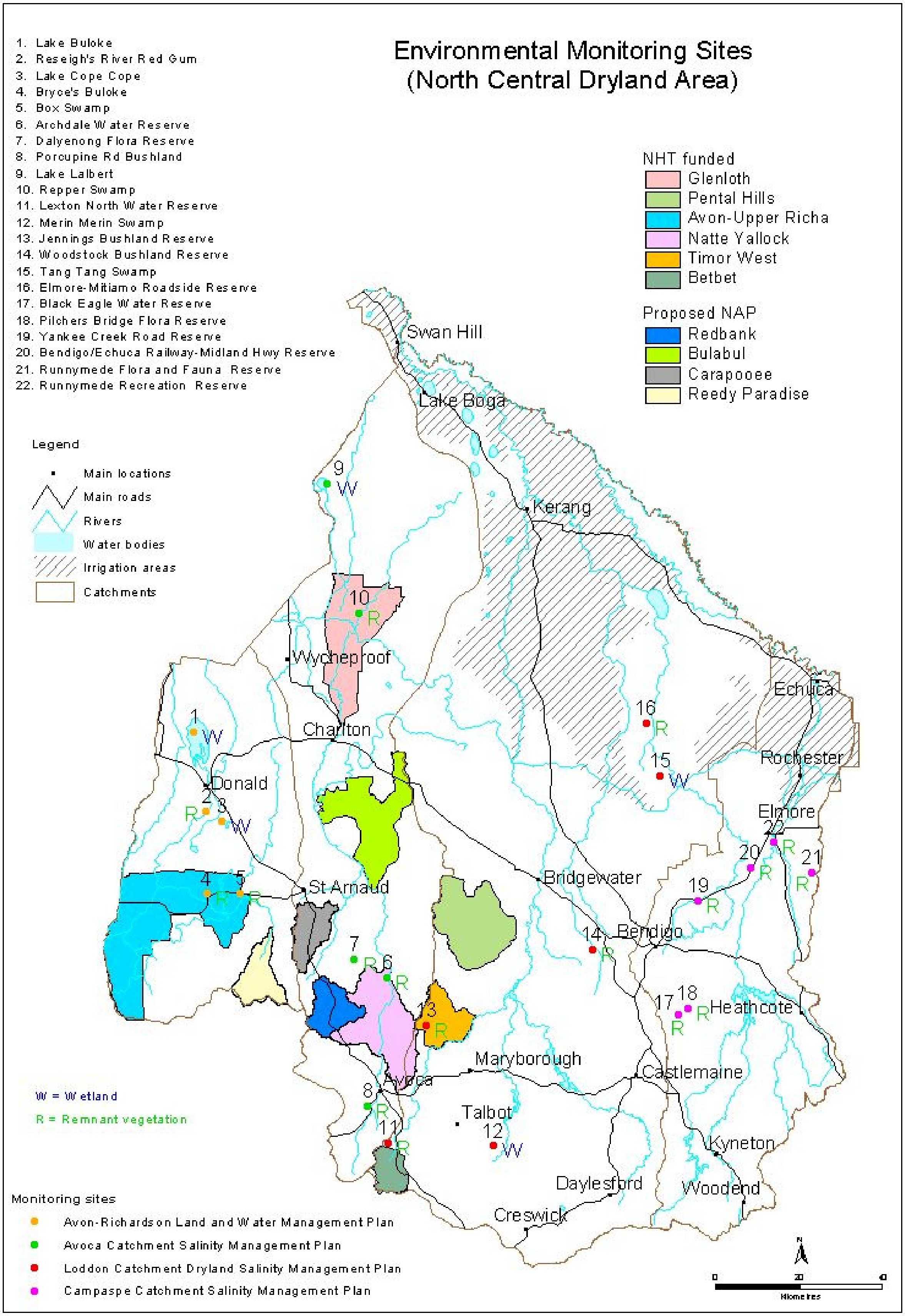

Figure 1. Location of environmental monitoring sites across the NCCMA dryland area

4.4 Vegetation Monitoring

Changes in vegetation community composition were monitored at each site. Community composition and abundance were monitored using quadrats of a standard size. Vegetation surveys commenced in mid October 2002 and were completed by mid November 2002. Ron and Dianne Davies Environmental Consultants, have provided the results from their vegetation surveys as an Excel database on IBM-formatted computer diskettes. Raw data can be found in appendix 10.2. Their reports also contain information about sites, methodology and bird sightings and are referenced as (Davies 2003).

4.4.1 Community Composition and Abundance

Community composition and abundance were monitored using two quadrats and nine sub-quadrats. However five sites in the Campaspe catchment only have one vegetation quadrat and there are three vegetation quadrats monitored at the Loddon's Tang Tang and Merin Merin Swamps due to additional funding supplied by Parks Victoria.

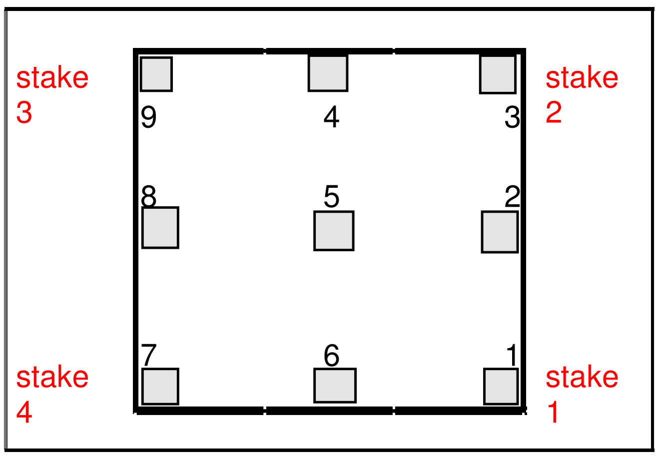

Figure 2. The layout of stakes (1-4) marking the permanent quadrats used for Braun-Blanquet abundance, and sub-quadrats (1-9) used to record presence/absence of individual species (Diez 1996).

4.4.2 Survey Methods

Ideally, vegetation surveys are undertaken when the majority of plants are flowering. For most remnant vegetation sites, this would be late spring (October-November). Very dry conditions in 2002 caused early or minimal flowering (Davies 2003). Vegetation at wetland sites should be surveyed when the water level has lowered, water temperature has risen and the plants are flowering (usually early summer). To ensure consistency, vegetation surveys at each site should be undertaken at the same stage of reproductive development each year (Keleher 1997).

All species present in each sub-quadrat were recorded and tallied for a total cover-rating in each vegetation quadrat using the Braun-Blanquet scale, (Table 2). Both scientific and common names are provided. Exotic (introduced) species are marked with an asterisk and salt indicator plants are marked with an *S* (Davies 2003).

Table 1.Monitoring Requirements for Wetlands and Remnant Vegetation Sites

Wetland	**Parameters**	**Methodology**	**Sampling Frequency**
Water Quality: Nutrients	Total Phosphorus Filterable Reactive Phosphorus Nitrogen - Nitrate/Nitrite Kjeldahl Nitrogen (TKN)	Field sampling and laboratory analysis. Laboratory must be NATA approved	Seasonal (Jan, April, July, Oct) *when applicable
Water Quality: Salinity, Turbidity, pH, Temperature, Dissolved Oxygen	Temperature, EC, pH, DO, Turbidity	Field survey/laboratory (using accurate equipment)	Monthly *when applicable
Hydrogeology	Groundwater	Depth to Groundwater Salinity EC	Monthly Yearly
Biota: macroinvertebrates	Community composition and abundance	Rapid Bioassessment Classification to at least Family level	Annually (late Spring/early Summer) *when applicable
Biota: Vegetation	Macrophytes and Terrestrial Vegetation-community Composition and abundance	Vegetation surveys using quadrats	Annually (late Spring/early Summer)
	Vegetation health	Photo points at selected sites	Bi-annually (Autumn Spring)
		Tree canopy health and regeneration	Annually (Spring)
Biota: Birds	Species identification and observations of note	20 min survey during tree health assessments	Annually (Spring)
Adjacent Land use	Surrounding Land use and Management Practices	Field inspection	Bi-annually (Autumn Spring)
Remnant Vegetation	**Parameters**	**Methodology**	**Sampling Frequency**
Biological Indicators	Weed invasion and regeneration-community composition and abundance	Vegetation surveys using quadrats	Annually (late Spring/early Summer)
	Vegetation health	Photo points at selected sites	Annually (Spring)
		Tree canopy health and regeneration	Annually (Spring)
		Leaf chloride analysis and insect attack	Annually (Spring)
Biota: Birds	Species identification and observations of note	20 min survey during tree health assessments	Annually (Spring)
Adjacent Land use	Surrounding Land use and Management Practices	Field inspection	Bi-annually (Autumn Spring)
Hydrogeology	Groundwater (CLPR)	Depth to Groundwater Salinity EC	Monthly Yearly

(Davies 2003).

Salt indicator species were defined using *Spotting Soil Salting, A Victorian Field Guide to Salt Indicator Plants* (Matters and Bozon 1995). The limitation of only using this method to assess salinity is this field guide includes some plants that are also found in non-saline environments. Some examples are *Lolium rigidum* (Wimmera rye grass), a very common agricultural weed found in a variety of conditions. Also many native saltbush species are found in saline and non-saline soils, often being a better indicator of arid conditions rather than salinity. The only way to determine whether dryland salinity is the reason that such species are present at sites is to conduct soil salinity tests in conjunction with the vegetation surveys.

The Victorian and Australian rare or threatened plant species are marked with “vrot” or “arot”. These species were taken from a list of species and codes provided by Andrea Keleher.
(Davies 2003).

Table 2. Modified Braun-Blanquet scale of cover abundance (Kent & Coker 1992).

Symbol	Cover
+	Sparsely or very sparsely present, foliage cover less than 5%
1	Plentiful, foliage cover less than 5%
2	5-25% foliage cover
3	25 - 50% foliage cover
4	50 - 75% foliage cover
5	75 - 100% foliage cover

Botanical names were taken from the Flora Information System list (2001) and previously from *A Census of the Vascular Plants of Victoria* (Ross 1996).
(Davies 2003).

4.4.3 Presence/Absence

To minimise variation in cover estimates between different observers, and to provide quantitative data that can be statistically analysed, nine subquadrats were assessed in each quadrat for presence/absence of species (Figure 2). Subquadrats were 2m x 2m for woodland/forest, 1.5m x l.5m for wetland and 1m x 1m for grassland.

For presence/absence monitoring the nine sub-quadrats were to be marked in each quadrat, using plastic stakes. However the ground was generally too hard to hammer in the plastic stakes, therefore the sub-quadrats were measured but not staked. These methods must be closely followed to ensure that data obtained is comparable to Victorian-wide environmental monitoring.
(Davies 2003).

4.4.4 Vegetation Health

Recording the presence and cover of plant species at a site is useful for indicating changes in composition over the long term, but this method alone can not answer

questions about the likely cause of the changes. To overcome this problem, extra data relating to tree
canopy health, levels of insect attack, leaf chloride levels, and habitat use by fauna were collected.

Photographs

To record visible changes, photos were taken from designated points at the site. One photo was taken at each stake moving from stake 1 to stake 4 (appendix 10.1), facing across the quadrat to photograph the area around the stake diagonally opposite (ie. four photos). Wetlands were photographed Bi-annually (to detect wetting/drying cycle) and the remnant vegetation sites annually.

Tree Health

Trees respond to changes in the environment and show stress in a variety of ways. They may become more susceptible to parasites (eg. mistletoes) and diseases, the crown may begin to die off, branches may die, and the foliage may become infested with insects (Platt 1995). Trees are often the first plants at a site to show signs of salt or water stress because their root systems penetrate much deeper underground. Although dieback can be attributed to a wide variety of factors (eg. breakdown in soil structure, loss of insect eating predators), trees are considered suitable indicators of the health of a site. If any decline in tree health is observed, these results must be carefully interpreted considering all possible information sources before making decisions about the causes.

Trees monitored at each site contain small numbered tags nailed into the trunk at the standard height measurement of 130cm and are clearly marked on a site map to ensure easy location for future monitoring events. They are assessed for tree canopy health and regeneration using a method described by Clifton (1988) detailed in appendix 10.4. This is a 20 point system that describes structure of the crown, branches and distribution of epicormic growth throughout the tree. Diameter at breast height (dbh) of each tree was also measured (Diez 1996).

The amount of regeneration occurring was also recorded as an indicator of vegetation health.

Regeneration was described as

- None (0% of the stand)
- Slight (<5% of the stand)
- Moderate (5-25% of the stand)
- High (>25% of the stand)

(Kelly 1992).

Leaf chloride analysis and insect attack

(NOTE: 2002 was the first year that the Avon-Richardson, Avoca and Loddon catchments have been sampled for leaf analysis, therefore comparative analysis is only possible for Campaspe sites).

Measuring the amount of chloride in leaves is a relatively new technique that can provide an indication of tree health and thus the state of the local environment. Recent research on the response of trees exposed to irrigated water (Morris *et al.* 1994) has shown that foliar chloride analysis may be a useful means of measuring the exposure of a tree to saline conditions. Collopy pers. comm. (2003) has indicated that because leaf chloride levels fluctuate throughout the year, the data should only be used as a diagnostic tool in conjunction with other information such as water table levels.

A sample of 20 newly formed mature leaves from the outer portion of each canopy was collected using five metre pole-pruners. The batches of 20 leaves were placed in pre-labelled paper bags (showing date and individual tree number). Before processing, a sub-sample of these leaves was used to determine levels of insect attack.

Trees may be more vulnerable to insect attack when they are stressed in some way (Landsberg & Wylie 1988, Landsberg *et al*. 1990). Assessing the state of leaves may provide another indication of tree health. Grey (1995) notes that there are several forms of leaf damage which can be measured, including leaf miners, blemishes, eggs and chewing. A very simple method has been described here, and although the results are likely be subjective to some extent, they will be useful to provide an immediate impression of the state of the vegetation.

Six leaves from each batch were selected randomly and a score ranging from zero (no leaf damage) to ten (total defoliation or lerp[1]cover) were assessed (Appendix 10.4). Sample leaves were returned to the labelled paper bags.

Leaves were then oven dried at 35°C for 24 hours, and sent to the Centre for Forest Tree Technology (CFTT) for leaf chloride analysis. The final results (in % form) were transferred to the vegetation health data sheets (appendix 10.4).
(Some text for Vegetation Health quoted from Diez 1996 pages 11-12).

4.5 Bird Surveys

Vegetation health may also be assessed by examining the diversity of fauna, which are using the site as habitat. Birds are used as the key indicator group because they are

- Relatively easy to see and hear during the daytime.
- The more common species are relatively easy to identify (by sight or sound).
- They can be recorded casually (whilst doing other things) or strategically (by doing a specific search)
- No complex equipment (other than binoculars and identification books) is required and time-consuming trapping is not necessary.

Most importantly, birds may be considered good indicator species for habitat health and complexity and so may be seen as an adjunct to measurements of tree health (Landsberg *et al*. 1990).

Birds respond to environmental changes, and in some cases they may cause them. Research by Grey (1995) and Loyn *et. al.* (1983) discusses the impacts on Eucalypt remnants where Noisy Miners have increased in numbers. Noisy Miners are aggressive honeyeaters that harass smaller nectar feeders and foliage gleaners thereby excluding them from some areas. Clarke *et al.* (1995) discussed the effects of removing Noisy Miners from woodlots which were experiencing dieback. The numbers of small birds visiting the site increased and although they found no immediate changes in tree health following the experiment, long term changes may occur as a result of the change in

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[1] Lerps are the protective carbohydrate scales produced by *Cardiaspina spp.* - psyllid bugs.

avifaunal composition.

If the intention of monitoring is to separate the effects of dryland salinity from all other pressures, it is crucial that additional information such as (large population of Noisy Miners at Site X; few small bird species noted; large amounts of leaf insect damage) is collected.

According to results of work by Slater (1994), the total time spent surveying for birds at each site is a more important factor than the duration of individual surveys. Loyn (1986) suggested that 20 minute searches in woodland are an efficient method of recording the majority of species present. Bird counts should be carried out before noon if possible. Recher (1988) recommends that vocalisations as well as sightings should be used in Eucalypt forest where some birds may be heard but not seen. Naturally, vocalisations alone should only be used by competent listeners.

Birds seen or heard, in or near the study site were recorded opportunistically whilst undertaking tree health and vegetation surveys. This method is recognised as not ideal because the time of the day and conditions were often not idyllic for bird surveying, ie. after midday, windy, hot and dusty etc.
(Some text for birds quoted from Diez 1996 pages 13-14).

The Avon Richardson and Avoca catchments had not been surveyed for birds until 2002 and now will be in concordance with monitoring regimes in the Campaspe and Loddon catchments. Bird surveys have been performed in those two catchments since the program's commencement in 1996 and 1997.

4.6 Groundwater and salinity

The Centre for Land Protection Research (CLPR) undertook most groundwater monitoring. However, Ron Davies (BRIT) and the Author collected groundwater data from the bores at Repper Swamp and Lake Lalbert. The Author also collected bore data from one Avoca and the southern Loddon sites. Along with recording fluctuations in groundwater levels, these trends are important for the interpretation of leaf chloride results.

4.7 Water quality monitoring

All measurements and samples were collected from open water, away from fringing vegetation to avoid any influences that vegetation may have on water quality readings.

Field Measurements

A Horiba U-10 (electronic water quality checker) is calibrated monthly and was used to measure

- Temperature (°C)
- Electrical Conductivity (mS/cm) – multiply by 1000 to get EC value
- Dissolved oxygen (mg/l)
- pH
- Turbidity (NTU)

Laboratory Measurements

Samples were collected in bottles supplied by Central Highlands Water; to be analysed at their NATA accredited laboratory for

- Total Phosphorus
- Kjeldahl Nitrogen
- Nitrate/Nitrite-Nitrogen
- Filterable Reactive Phosphorus (FRP)*

(Davies 1998).

*A separate bottle is used to collect for FRP and filtered on site using a 47mm Sartorius vacuum pressure polycarbonate filter holder. Whatman GF/C paper is placed on top of Millipore HA membrane filter paper (0.45µm) and the sample is pushed through the papers by an air compressor attached to the top of the filter holder. Care must be taken to avoid skin contact on the filter papers to ensure that the sample remains uncontaminated by extraneous phosphorus sources.

4.8 Macroinvertebrate monitoring [2]

A rapid bioassessment method of analysis is used to monitor long-term changes in the macroinvertebrate communities at each wetland.

Five permanent quadrats have been selected at each wetland. They are located in fringing vegetation and each covers an area of approximately $400m^2$ (quadrat locations are illustrated in appendix 10.1).

Macroinvertebrate sampling should occur when the populations are most abundant. The most suitable time for sampling is late spring/early summer when the wetland has contained water for some time, is close to full and the water temperature has begun to rise. Sampling should also occur at approximately the same depth/stage of flooding each year as well.

Sampling involves sweeping a triangular dip net (250µm mesh) through $1m^2$ of vegetation for 30 seconds at least 20cm off the bed of the wetland. Five random samples are taken at each quadrat. The five samples are then combined and the bulked sample for each quadrat sorted to family level at the Marine and Freshwater Resources Institute (MAFRI).

To reduce variability in sampling effort, a standard procedure is used for sorting and identification of macroinvertebrates. The first 300 individuals encountered during sorting for each sample is identified to at least family level. Both scientific and common names are supplied. Interpretation of results is based on the indicator organism approach and number of taxa present. Taxa present that are likely to be sensitive, moderately tolerant and tolerant of increases in salinity have been highlighted.

A voucher collection with representative specimens of each family identified is kept at the DPI office Epsom.
(Taken from Davies 1998).

4.9 Surrounding land use

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[2] Due to the dry seasonal conditions no macroinvertebrate samples have been collected since 1998 from Lake Lalbert, Lake Buloke and Lake Cope Cope and since 2001 from Tang Tang Swamp.

Adjacent land use and management activities around each of the monitoring sites are noted by conducting a vehicular inspection. This occurs annually at the remnant vegetation sites at the time of the tree health surveys and biannually at the wetland sites when vegetation quadrat photos are taken. Surrounding land use is important to note because it could impact on the site through weed invasion (particularly pasture weed species), recharge control (tree planting / perennial pasture establishment) and other factors.

5. Results

Only limited interpretation of results can be given at this early stage. The long period of below average rainfall and very dry conditions has influenced the outcome of the analysis of the data collected. This data can provide some limited indication of trends but it is important to note that the purpose of the monitoring program is to provide long-term data collection and a sound basis for ongoing comparative analysis. The appendices provide detailed information about the raw data collected.

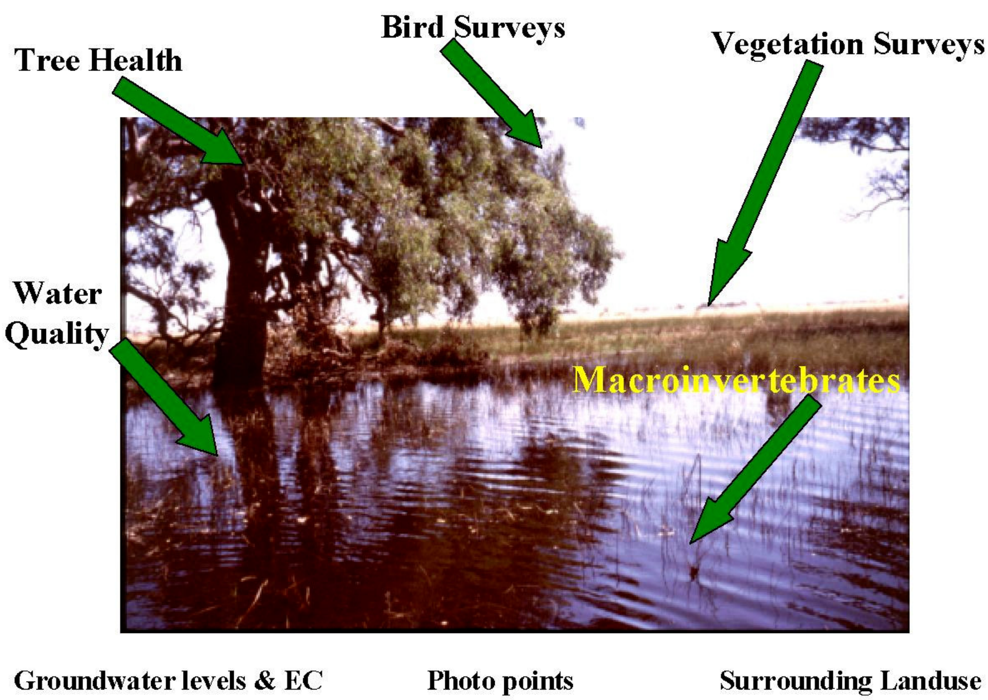

Figure 3. Promotional slide that has been used to describe some of the information that the environmental monitoring program collects