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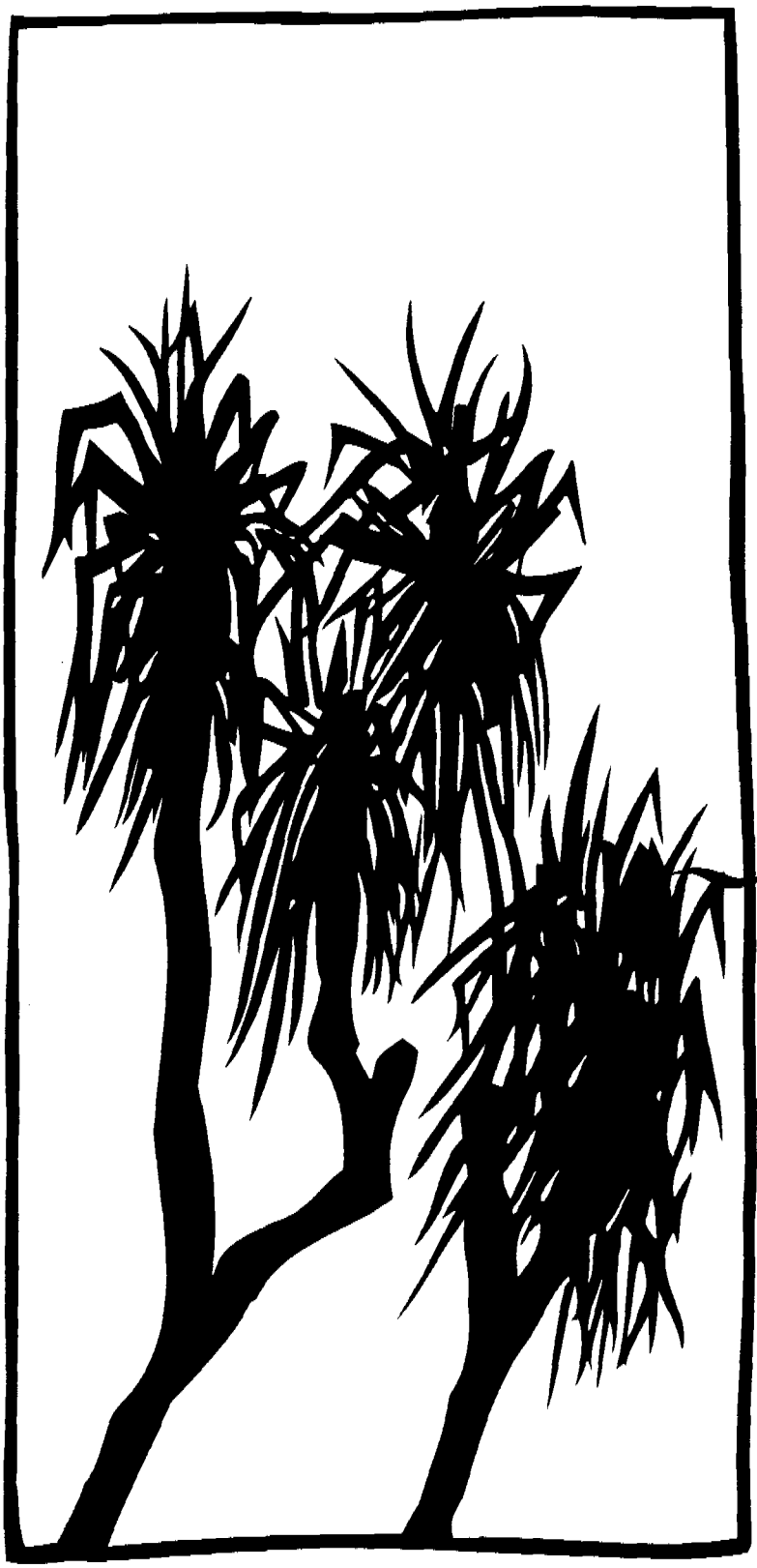

Environmental Research Institute of the Supervising Scientist Research Plan 1997-1998

Environmental Research Institute
of the Supervising Scientist

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ENVIRONMENTAL RESEARCH INSTITUTE

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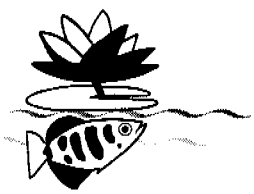
RESEARCH PLAN 1997–1998



1 INTRODUCTION

The Environmental Research Institute of the Supervising Scientist (***eriss***), formerly the Alligator Rivers Region Research Institute, was established under the *Environment Protection (Alligator Rivers Region) Act 1978*. Its primary function is to carry out research on the impact of uranium mining in the Region to enable the development of standards, practices and procedures for the protection of the environment.

Under amendments to the Act in 1994, this role was broadened to enable the Institute to carry out more general environmental research. Following consideration of the recommendations of the Barrow review of research in 1994 and an assessment of the fields in which the Institute could best make a significant contribution to environmental research, it was decided that the focus of the broadened program should be in the protection and management of wetlands. Apart from wetlands research, the Institute conducts general environmental research projects on topics nominated by the Commonwealth Government.

Thus, there are now three research programs carried out by ***eriss***:

- impact of mining on the environment,
- protection and management of wetlands, and
- general environment protection research.

The Alligator Rivers Region Technical Committee (ARRTC) was established under the 1994 amendments to the Act to review the nature and extent of mining related research necessary to protect and restore the environment in the region and to make recommendations on the most appropriate organisations to undertake the research. At the meeting of the ARRTC on 7 December 1995, ***eriss*** and ERA presented four review papers requested by ARRTC on (i) ERA and ***eriss*** strategic research directions, (ii) Rehabilitation research in the ARR, (iii) Radiological protection research in the ARR and (iv) Research issues related to constructed wetland filters. The committee endorsed the thrusts of the programs proposed and agreed with the priority identification allocated to individual topics. The ***eriss*** research plan for 1996–97 reflected these priorities agreed by ARRTC; work on these projects continues into 1997–98.

The principal outcomes for the ***eriss*** program arising out of the ARRTC meeting on 5 December 1996 were recommendations that ***eriss*** should undertake social impact research, that the biological monitoring program should be reviewed and the outcomes of the review implemented, and that, should the Jabiluka mine be approved, ***eriss*** should undertake work on radon dispersal and on the impact on aquatic ecosystems in the streams near the mine site. Implementaion of the first of these recommendations awaits Government decisions following the Kakadu Region Social Impact Study. The other recommendations have been implemented in the preparation of the 1997–98 Research Plan.

A draft research plan for 1997–98 was reviewed by the Supervising Scientist and members of staff of the ***oss*** in early August 1997. The current research plan takes into account the comments received at that review. The plan will be implemented during 1997–98 and will be submitted to the meeting of ARRTC in December 1997 as part of the planning process for 1998–99.

2 IMPACT OF MINING PROGRAM

The objective of the ***eriss*** program on the impact of mining is:

> ***through research on the environmental impact of mining, particularly uranium mining, enable the development of standards, practices and procedures that will ensure protection of the environment both during mining operations and following rehabilitation.***

The 1997–98 program includes some areas of additional new project work, and heralds the conclusion of a number of projects. Work on the effect of soil ripping as a rehabilitation tool to reduce erosion has been completed. Also completed is work on radionuclide concentrations in Magela Creek, and phase 2 of the laboratory scale bioreactor which removes uranium and radium from water. Major project work on Mount Lyell has been completed and the new ANZECC water quality guidelines are nearing completion. Significant work time expended on the Jabiluka EIS is also nearing completion. The commitment that ***eriss*** has made to the Kakadu Region Social Impact Study is largely completed, with the study report having been presented to the Commonwealth and Northern Territory Governments.

New work to be undertaken in the 1997–98 year includes projects related to Jabiluka. Baseline radionuclide, chemical and biological data from swift creek will be gathered, and baseline work will be undertaken on associated billabongs. Because the Jabiluka project entails higher concentrations of radionuclides, dose rates to both members of the public and to workers will become a more important issue. Monitoring of atmospheric radon and its daughters will receive greater attention in 1997–98 with expansion of a district radon monitoring program. Because some concern has been raised by Aboriginal people on the concentrations of radionuclides in bush tucker, further research involving the collection and radioisotope analysis of bush tucker has been initiated.

Other new research includes collaborative work on sediment toxicity testing. Work will also be undertaken in remote sensing and use of Geographic Information System (GIS) for evaluation of environmental impacts of uranium mining. Airborne radiometric data will be obtained from the Ranger Jabiluka and Nabarlek mines, and digital spectral data will also be collected. These data will be analysed in a GIS which will be developed in 1997–98 in collaboration with NTU and the ***oss***.

Much of the 1997–98 research program builds upon research efforts of the previous year particularly in the fields of the radiological impact assessment of radon emanation and dust resuspension, the performance and function of wetland filters, biological monitoring, and landscape evolution modelling. In determining the program, the Institute has taken into account the priorities for research that were agreed at the meeting of the Alligator Rivers Region Technical Committee on 5 December 1996.

2.1 Assessing the impact of mining on people

Mining has the potential to impact on people by a number of means, both physically and socially. Of particular importance in uranium mining is radiological exposure, which may arise via the following basic pathways:

- inhalation of the progeny of the radioactive gas radon-222,
- inhalation of radioactive dust particles,

- direct irradiation from outside the body, primarily by gamma rays or in some cases beta radiation, and
- ingestion of radionuclides (eg uranium or radium) in food or water.

For *workers* at an open cut mine such as Ranger, exposure to radon progeny is less significant than exposure from dust or gamma radiation. However, exposure to radon progeny is important in the case of underground mine workers.

For *members of the public*, the most important pathways for an *operating* mine are radon transport and, in some cases, ingestion following surface water transport. For a *rehabilitated* mine over the short-term, the most important pathways are dust resuspension, radon emanation and direct irradiation, though for a well-rehabilitated site these exposures should all be low. Over the long term, groundwater and surface water transport and/or bioaccumulation into edible plants may become more significant.

Following the recommendations of the Alligator Rivers Region Technical Committee, a major emphasis will be placed on further refining radiological dose assessment models with emphasis on predicting radon emanation and dust dispersion from rehabilitated land surfaces. In this regard, Nabarlek, which has been recently rehabilitated, provides a unique opportunity as a study site within the Alligator Rivers Region to provide data input for an atmospheric transfer model developed by ***eriss***, for radon, radon progeny and dust. Importantly, data from Nabarlek will help to construct near-field, long-term model predictions which will then be used in the radiological dose assessment of options for tailings repositories at Ranger. This work, which started in 1996–97, will continue through 1997–98.

The principal radiological concern of Aboriginal people relates to bush foods. A project to identify traditional Aboriginal foods and food preparation techniques will be started in 1997–98. It is intended that this project will provide a means of two-way communication between Aboriginal people of the region and the scientists who are carrying out the measurements. This project will need to be continued over a longer period in order to allow for any future changes in demography and Aboriginal food consumption practices and as well as to maintain information exchange. In addition, a project to publish the results of past research on radionuclide uptake by freshwater mussels will be started in 1997–98. Mussels are predicted to account for about 90% of the dose to people following release of contaminated water from Ranger. Consequently, improvements to the present dose assessment model will rely on incorporation of the results obtained from the studies of the mussel studies.

A project dealing with a study of the signature of the uranium isotopes 234 and 238 in groundwater of the deep aquifer at Ranger will be continued through 1997–98. This project aims to determine the hydrodynamics of uranium which is important in predicting long-term movement in groundwater, and is a component part to radiological dose assessment of the final tailings repository.

Work started during 1996–97 to examine the chemistry of tailings. More specifically, the research is concerned with addressing the possible future dispersal of eroded tailings from an above-grade structure to estimate effects on the radionuclide concentration in waters of Magela Creek and to provide input for a dose assessment model. The first part of the work has been completed which determined the importance of the potentially soluble fraction of tailings as a source of radionuclides. Preliminary results indicate that nearly all the radionuclide load reporting in the solution phase is already dissolved in interstitial water. The second part has started in which the interaction of tailings with sediments under oxidised and reduced conditions is being simulated. This study will allow estimates to be made of how the

biogeochemistry of the depositional environment influences the lability of radionuclides and their potential availability for biological uptake.

The Kakadu Region Social Impact Study was largely completed in 1996–97, and the report of the Study Advisory Committee, to which ***eriss*** provided executive support, was completed in July 1997. The issue of whether or not eriss should be the body that conducts the future social impact research and monitoring program will be decided by Government.

The projects that ***eriss*** will carry out in this sub-program during 1997–98 are listed in table 1.

Table 1 Projects for 1997–98 in the Impact of Mining Program - Assessing the impact of mining on people

Project and aims	Staff commitment (pw)	Indicator
Identification of traditional Aboriginal foods for radiological assessment		
Aims 1 Identification and cataloguing of traditional Aboriginal foods collected in the Alligator Rivers Region. 2 Recognition of the preparation techniques used with traditional foods. 3 Measurement of radionuclide content of traditional foods for estimation of radiological significance. *Project leader:* B Ryan	*Res staff:* 4	Internal Report June 1998. *Commence:* 1997 *Expected completion:* 2000
Radiological impact arising from uptake by freshwater mussels		
Aim: Analyse and publish the data currently available on uptake of radionuclides by freshwater mussels in the Alligator Rivers Region. *Project leader:* P Martin	*Res staff:* 8	Internal Report 'Freshwater mussels as environmental monitors of natural-series radionuclides'. December 1997. *Commenced:* July 1997 *Expected completion:* December 1998
Aim: Develop a method for rapid assessment of the radiological impact of waters discharged from uranium mines. *Project leader:* P Martin	*Res staff:* 8 *Tech staff:* 2	Internal Report 'The use of live mussels in the monitoring of release of uranium mine effluent'. November 1997. *Commenced:* 1995 *Expected completion:* November 1997
Radiological impact arising from dispersion of dust		
Aim: Determine dust dry and wet deposition factors to enable prediction of the transport of radionuclides on dust from rehabilitated minesites. *Project leader:* P Martin	*Res staff:* 15 *Tech staff:* 6	Internal Report 'Grain size distribution of radioactivity in the vicinity of the Ranger Mine'. August 1997. *Commenced:* 1992 *Expected completion:* December 1998
Radiological impact arising from dispersion of radon and radon progeny		
Aim: Develop and validate a model for the atmospheric dispersion of radon and radon progeny. *Project leader:* P Martin	*Res staff:* 4	Supervising Scientist Report 'Validation of a radon dispersion model over a five year period'. September 1997. *Commenced:* 1988 *Expected completion:* September 1997
Aim: Assess the importance of unattached radon progeny for public and employee radiation exposure at the Ranger mine. *Project leader:* P Martin	*Res staff:* 2	Supervising Scientist Report 'Two stage diffusion battery measurements from Jabiru and Jabiru East'. January 1998. *Commenced:* 1993 *Expected completion:* January 1998

Project and aims	Staff commitment (pw)	Indicator
Establishment of a regional radon measurement network		
Aims: 1 Establish a network of radon and meteorological stations in the Alligator Rivers Region. 2 Collect time-series data; establish background radon levels and determine the effect of uranium mining on regional radon concentrations. *Project leader:* S Tims	*Res staff:* 10 *Tech staff:* 10	Establish a second radon/meteorological station at JaJa December 1997. *Commenced:* 1997 *Expected completion:* 2000
Uranium in groundwater seepage at ERA - Ranger		
Aim: Determine uranium retardation factors in the groundwater aquifer at Ranger. *Project leader:* P Martin	*Res staff:* 10	Internal Report July 1997. Supervising Scientist Report June 1998. *Commenced:* 1996 *Expected completion:* June 1998
Radiological impact assessment of the rehabilitated Nabarlek site		
Aims: 1 To validate presently-used models for radionuclide transport in the environment. 2 To obtain information to assist in planning for the rehabilitation of uranium minesites. 3 To enable a prediction of radiological dose in the vicinity of the Nabarlek site. *Project leader:* P Martin	*Res staff:* 45 *Tech staff:* 20	Internal Report 'Radiological impact assessment of the rehabilitated Nabarlek site: Phase 1'. September 1997. *Commenced:* 1996 *Expected completion:* 1999
Long term erosion of tailings from a above-grade repository		
Aim: Assess the potential for radionuclides in eroded tailings to disperse in solution. *Project Leader:* C leGras	*Res staff:* 3	Internal Report 'Long-term tailings erosion: Leaching and dispersal of labile radionuclides' September 1997 *Completion:* September 1997
Aim: Determine the potential effects of deposition of eroded tailings in wetlands and the influence of the chemistry of wetland systems on the release of radionuclides into solution. *Project Leader:* D Klessa	*Res staff:* 10 *Tech staff:* 10	Internal Report 'Radionuclide concentration in the water column arising from the deposition of dispersed tailings'. *Completion:* December 1997
Kakadu Region Social Impact Study (KRSIS)		
Aims: 1 To participate in the study through membership of the KRSIS Advisory Group. 2 To provide secretariat support to the KRSIS Advisory Group. *Project Leader:* M Andrews	*Res staff:* 4	Report of the KRSIS Advisory Group - 'Aboriginal Action Plan'. *Commence:* October 1996 *Completion:* July 1997

2.2 Assessing the impact of mining on ecosystems

The objectives of this subprogram are to investigate processes which might give rise to off-site impacts on ecosystems and to develop practical methods for detecting and assessing the short- and long-term impact of mining operations on aquatic and terrestrial ecosystems.

The emphasis of past research has been on the development of biological monitoring systems that can be transferred to mining companies to become part of their routine monitoring programs. The Institute's program in this field has had three major components: the use of creekside testing procedures to provide early warning of any adverse effects, community structure studies of benthic macroinvertebrates and community structure and migration studies of fish. The community structure components are directed at assessing the long-term ecological integrity of downstream aquatic ecosystems using endpoints that are consistent with the aim of conserving biological diversity.

The research aspects of the creekside testing program directed at protocol development are now complete and draft protocols were successfully used by ERA staff during the 1996–97 Wet season under the supervision of ***eriss*** staff. This transfer of knowledge and expertise will result in finalisation of the protocols in 1997–98. The need for a sensitivity analysis will be evaluated.

Macroinvertebrate community structure data for sites above and below Ranger on Magela Creek are now available for the period 1990–1996. A review of this program during 1997 is being used to refine and modify the monitoring techniques so that sensitivity of the method for detecting impact, availability and timeliness of data and results, usefulness of the data and acceptability of current approaches to regulators and industry are best assured. This review, and comments by major stakeholders, will determine the future direction of this part of the ***eriss*** program in 1997–98 and beyond.

The main thrusts of the research on monitoring methods using fish have involved the study of fish community structure in lowland billabongs and the migration of fish in Magela Creek. These projects have been underway for some years and the potential of the monitoring methods for use in practical routine programs is being reviewed. Progress with the monitoring program will be summarised for the ARRTC meeting in 1997.

The review of the macroinvertebrate and fish monitoring projects will provide a basis for developing a demonstration monitoring project including comprehensive documentation of all techniques and procedures, stakeholder consultation, and review and reporting schedules. This will provide and endpoint for ***eriss***' investment in the development of stream monitoring techniques and further develop our interaction with stakeholders, including the local Aboriginal communities. We will also assess the need for development of alternaive monitoring techniques.

Work continues to address the potential problem of impact on the Magela Creek system from an increasing sulphate and magnesium load loss from the mine site. This has entailed the development of a model to predict changes in sulphate and magnesium concentrations in the RP1 catchment in response to the development of Ore Body #3 and expansion of the waste rock dump, and the irrigation of RRZ water on to land within the catchment. Findings from this work are important to developing future mine water management strategies since the conditions imposed on the release of retention pond water depend on water quality. Work during 1997–98 will further refine a sulphate budget for the RP1 catchment and test model predictions of the sulphate content of RP1 over the Wet season.

A collaborative project with the University of Stirling, UK began during 1996–97 to develop a sediment toxicity test suitable for tropical conditions and the Alligator Rivers Region (ARR). A postgraduate PhD student will be based half time at ***eriss***. Importantly, this work recognises the priority that has been given both nationally and internationally to seeking quick, accurate and reproducible bioassays in the quantification and prediction of ecotoxicological impact to the benthos arising from sediment contamination. The work is at an early stage but has already produced promising results. A local (to the ARR) species of chironomid with a short life cycle has been successfully cultured and will now be used in laboratory-based experiments to measure response to metal contamination of backflow billabong and floodplain sediments initially under controlled conditions.

A new project will start during the 1997–98 Wet season to typify temporal and spatial variations in the water chemistry and ecology of Swift Creek, the major catchment draining the proposed site for Jabiluka mine. This will help provide important baseline data of the water characteristics of the area and habitat, aspects which have been found to be deficient from a recently conducted environmental impact statement of proposed uranium mining by ERA.

Marked changes have taken place in many of the billabongs of the Magela system over the last decade in response to weed invasion and buffalo eradication with implications to the chemistry, limnology and trophic status of these waterbodies. Consequently, a new project has been proposed which will reassess the findings of the last major study undertaken on this topic over 15 years ago. The study will initially be confined to four key waterbodies to take account of downstream impact scenarios from Ranger and Jabiluka (if the proposal for mining is approved). Data will be used to re-establish 'baseline' conditions which will allow natural events and their effects on the aquatic environment to be separated from anthropogenic influences. In addition, data will be used to establish reference sites, a key component of water quality criteria assessment in the draft revised ANZECC water quality guidelines.

Work in 1997–98 will include an assessment of the environmental implications of the design of the final landform at Ranger, which will depend on a number of factors including the choice between above-grade and below-grade disposal of the tailings. Whichever choice is made, the final design will, within the concept of Best Practicable Technology, need to incorporate features that minimise off-site impact following rehabilitation. The assessment of off-site impact will require knowledge of solute and particulate loads leaving the site and knowledge of the fate of this material once it leaves the site. Earlier work by ***eriss*** established the fate of material after it entered Magela Creek and some work has been completed on the movement of material in the immediate catchments of the Ranger Project Area. This work will be reviewed to establish whether or not adequate information is available for off-site impact assessment. A research program will be developed during 1997–98 aimed at assessing the off-site geomorphic impacts of uranium mining on Magela Creek.

Remote sensing work will be undertaken in 1997–98 to assess the effectiveness of mine rehabilitation. The work entails collaborative arrangements between ERA, NTU and DME. Airborne radiometric and magnetic surveys will be undertaken over Ranger, Jabiluka and Nabarlek. Groundtruthing will be undertaken in 1997–98 for the Ranger and Nabarlek studies with more detailed ground measurements and analysis to be undertaken at Nabarlek. The data will be analysed in a GIS to assess the potential for increasing the power of remote sensing to detect ground anomalies. Digital video will be a flown in September. The radiometric and spectral data will be analysed by a PhD student from NTU, with this program beginning in October '97.

The full list of projects to be carried out by ***eriss*** in this sub-program during 1997–98 is given in table 2.

Table 2 Projects for 1997–98 in the Impact of Mining Program - Assessing the impact of mining on ecosystems

Project and aims	Staff commitment (pw)	Indicator
Early detection of mine-related effects using creekside testing procedures		
Aim: Transfer knowledge and expertise on ***eriss*** creekside protocols to ERA. *Project leader:* C Humphrey	*Res staff:* 3 *Tech staff:* 5	Internal Reports and ***eriss***notes on ***eriss*** creekside monitoring protocols: baseline data, data analysis procedures and maintenance procedures; January 1998. Reports on joint ERA/***eriss*** biological monitoring program, Wet season 1995–1996 & 1996–1997; December 1997. Review need for further testing: November 1997. *Commenced:* 1985 *Completion:* protocols January 1998; review of further testing November 1997.
Community structure of macroinvertebrates in streams		
Aim: Develop a biological monitoring program based on the community structure of benthic macroinvertebrates in streams of the ARR. *Project leader:* R O'Connor & C Humphrey	*Res staff:* 37 *Tech staff:* 24	Internal Reports: 1) Macroinvertebrates of 'macrophyte-edge' habitat in Magela Creek, 1988–1996; August 1997. 2) Analysis of 5-stream, 'macrophyte-edge' data set, 1995–96, for selection of future control streams; December 1997. 3) Determine within-site sampling effort for future monitoring of macrophyte-edge habitat; April 1998. 4) Evaluation of live-sorting procedures for Magela Creek study; Jun 1998. Sampling of Magela Creek and control streams; May 1998. 5) Complete internal review and develop a proposal for a demonstration monitoring project. May 1998 *Commenced:* 1988 *Review:* June 1998 *Completion:* Ongoing
Community structure monitoring: fish		
Aim: Develop a monitoring program to detect effects of mining on Magela Creek ecosystems using fish in lowland billabongs. *Project leader:* R Pidgeon	*Res staff:* 10 *Tech staff:* 19	Report on evaluation of monitoring procedure and status of research program; November. Sampling program for completed; June 1998 Protocol for monitoring procedure: June 1998 *Commenced:* 1984 *Completion:* Review June 1998
Aim: Develop a monitoring program to detect effects of mining upon recruitment and migration of fish in Magela Creek. *Project leader:* R Pidgeon	*Res staff:* 8 *Tech staff:* 7	Report on evaluation of monitoring procedure and status of of research; November 1997 Sampling completed may 1998 Protocol for monitoring using chequered rainbowfish; June 1998 *Commenced:* 1984 *Completion:* Review June 1998

Project and aims	Staff commitment (pw)	Indicator
Aim: Assess the recovery of the fish community in Gadjarigamundah Creek near the Nabarlek uranium mine. *Project leader:* R Pidgeon	*Res staff:* 4 *Tech staff:* 3	Data analysed and internal report submitted; December 1997. Draft external publication submitted; February 1998 *Commenced:* January 1995 *Completion:* February 1998
General biological monitoring		
Aim: Publish proceedings of Workshop to review ARRRI Biological Monitoring program. *Project leader:* M Finlayson & C Humphrey	*Res staff:* 3	Draft proceedings submitted; August 1997. *Commenced:* January 1994 *Completion:* Jan 1998
Sediment toxicity test		
Aims: The development of a sediment toxicity test for tropical conditions. *Project Leader:* D Klessa	*Res staff:* 5 *Tech staff:* 5	Six monthly Internal Report: June 1997. *Commenced:* 1996 *Completion:* October 1999
Limnological characteristics of Swift Creek		
Aim: Determine temporal and spatial water chemical, biological and radiological characteristics in the Swift Creek catchment. *Project Leader:* D Klessa	*Res staff:* 12 *Tech staff:* 12	Internal Report: 'Characteristics of water in the Swift Creek catchment' June 1998. *Completion:* June 1998
Source of sulphate in surface and ground waters at Ranger		
Aim: Test a predictive model for sulphate flux in the RP1 catchment. *Project Leader:* C leGras	*Res staff:* 6 *Tech staff:* 1	Internal Report: 'Model predictions of sulphate import and export in the RP1 catchment' June 1998. *Completion:* June 1998
Limnological characterisation of waterbodies in the ARR		
Aim: Provide a physico-chemical and biological baseline for billabongs in the ARR and investigate seasonal variations. *Project leader:* R Pidgeon & D Klessa	*Res staff:* 14 *Tech staff:* 16	Project proposal with options for sampling parameters and sites: March 1998. *Commenced:* November 1997 *Completion:* October 1998 and then reassessed
Quantification of solute and particulate loads discharged from rehabilitated landforms at Ranger Uranium Mine		
Aim: To develop methodologies for assessing off-site impacts due to erosion products from mining which can be used in the rehabilitation planning process and management of mine sites. *Project Leader:* M Saynor & K Evans	*Res staff:* 30 *Tech staff:* 20	Supervising Scientist Report, Review of previous work - Consultancy by W Erskine, December 1997. Finalise a research proposal, February 1998. Plain English summary - April 1998 *Commenced:* June 1997 *Expected completion:* Ongoing
Use of remote sensing in the assessment of rehabilitation success		
Aims: 1 Carry out radon and gamma spectrometry measurements in the field during and after the aerial survey for quality control purposes. 2 Assess the usefulness of the technique for radiological impact assessment. *Project leader:* P Martin	*Res staff:* 8 *Tech staff:* 2	Internal Report March 1998. *Commenced:* 1997 *Expected completion:* February 1998

2.3 Development of environment protection mechanisms

The broad objective of this subprogram is to assess and develop standards, practices and procedures for the protection of people and ecosystems both during mining operations and following rehabilitation.

Research into the role and performance of constructed wetland filters in treating mine effluent continues with projects investigating sulphate reduction and the distribution of contaminants, principally uranium, between biota and sediments. The sulphate reduction study, which is being undertaken as a collaborative project with the Northern Territory University, is concerned with translating the high rate of sulphate reduction which is achievable under controlled laboratory conditions to maximising reduction rates in wetland systems. This would bring advantages to the management of RRZ water at Ranger.

The opinion of traditional owners is that radionuclides should be removed from mine waters prior to discharge. While research may show that wetland filters perform this function adequately, it was decided that low cost investigations of alternative active methods of radionuclide removal should be carried out. Phase 2 of a project to evaluate a bioreactor based upon manganese-oxidising bacteria to attenuate radionuclides, especially radium and uranium, in mine waste waters was carried out in 1996–97. This is a collaborative project with the University of Queensland and CSIRO Division of Molecular Science. Write-up of this project will be completed in 1997–98. Discussions will be held with ERA and other stakeholders on further development of the method, as this would require trials using a pilot plant on site.

Research on the development of the landform evolution model SIBERIA is now at an advanced stage and is being applied to assess various options for rehabilitation of the Ranger mine site. The experimental part of the study of the effect of vegetation on erosion is now complete and results are being used in the modelling of options. Similarly, the investigation of the effect of long-term temporal change in erosion parameters is nearing completion. It is, however, essential that both the short- and the long-term predictions of the model are validated. Based on the results of a consultancy carried out in 1996, ***eriss*** has commenced a collaborative project with the University of Newcastle to validate SIBERIA. The project comprises three sub-projects: (1) monitoring gully and slope erosion at Scinto 6, an abandoned mine in the South Alligator River valley, from which SIBERIA parameters will be derived to hindcast the original landform of 40 years ago; (2) initiation and monitoring of a gully on a batter slope at Ranger to test the capability of SIBERIA in the prediction of gully formation; and (3) analysis of the Tin Camp Creek catchment to test SIBERIA's ability to predict the geomorphic statistics of a natural system. Completion of this project is scheduled to meet the deadline for ERA's proposed submission on the final repository for tailings in December 1997.

The full list of projects to be carried out by ***eriss*** in this sub-program during 1996–97 is given in table 3.

Table 3 Projects for 1997–98 in the Impact of Mining Program - Development of environment protection mechanisms

Project and aims	Staff commitment (pw)	Indicator
The treatment of mine waters by constructed wetland filters		
Aims: 1 Assess the role of carbon cycling in contaminant retention in constructed wetland filters.	*Res staff:* 6 *Tech staff:* 4	Internal Report 'Carbon supply as a factor influencing the fate of contaminants in constructed wetland filters', March 1998. *Completion*: March 1998
2 Evaluate the performance of the RP1 constructed wetland filter.	*Res staff:* 6 *Tech staff:* 4	Internal Report 'The performance of the RP1 constructed wetland filter', May 1998. *Completion*: May 1998
3 Optimise methods for the reduction of sulphate in Ranger mine waters. *Project Leader*: D Klessa	*Res staff:* 10 *Tech staff:* 4	Internal progress reports: October 1997 & April 1998 *Completion*: January 1999
Bioremediation of radionuclides from contaminated effluent		
Aim: Develop a method for removal of radium and uranium from mine waters. *Project leader:* P Martin	*Res staff:* 4	Supervising Scientist Report summarising results of the Phase 2 bioreactor studies, October 1997. *Commenced (Phase 1):* 1995 *Expected completion (Phase 2):* October 1997
Validation of the SIBERIA landform evolution model		
Aims: 1 To test the predictions of the long-term landform evolution model, SIBERIA 2 Implement changes where necessary to improve model predictions. *Project Leaders:* K Evans	*Res staff.:* 15 *Tech staff:* 8	Draft Supervising Scientist Report. December 1997. Plain English summary, September 1997. *Commenced:* April 1996 *Expected completion:* December 1997
The effect of vegetation on erosion of the Ranger waste rock dump		
Aims: 1 To compare hydrology and erosion parameters derived from experiments on vegetated areas of the Ranger waste rock dump with parameters derived from unvegetated areas, and 2 To assess, using a long-term erosion model, several alternative proposals for rehabilitated landforms based on unvegetated and vegetated surfaces. *Project Leader:* K Evans	*Res staff*: 24 *Tech staff:* 6	Journal paper; Sediment transport model and rainfall-runoff model parameters for a mine site, September 1997. Journal paper; Effect of fire on erosion and runoff from mine soils, September 1997. Conference paper; Incorporation of landform evolution modelling in mine site rehabilitation planning, October 1997. Plain English summary, November 1997. SSR; Effect of vegetation and surface amelioration on landform at Ranger, Dec 1997. *Commenced:* July 1994 *Expected completion:* December 1997
Temporal changes in the hydrology and erosion of rehabilitated landforms		
Aim: To determine and compare the erosion rates and hydrology of waste rock dumps at Ranger and undisturbed schist terrains at an analogue site and identify and interpret temporal trends in model parameters. *Project Leader:* K Evans	*Res staff:* 9 *Tech staff:* 5	SSR; Temporal effects on landscape evolution modelling, February 1998. Plain English summary, August 1997. *Commenced:* 1992 *Expected completion:* February 1998

3 WETLANDS PROTECTION AND MANAGEMENT PROGRAM

The objective of the ***eriss*** program on the protection and management of wetlands is:

> ***through research on tropical freshwater and estuarine ecosystems, provide advice on the conservation and sustainable development of wetlands in northern Australia.***

The 1997–98 program builds on extensive community consultation conducted over the past three years. Taking into account international initiatives to further bridge the gap between wetland research and management practice, we have taken many steps to consult with wetland owners, users and managers. The first major initiative was holding a wetland workshop in Jabiru during March 1995 with a broad cross section of wetland stakeholders in attendance. The papers from this workshop were published as a Supervising Scientist Report. The feedback from the workshop and the report were positive and indicated a general requirement for management oriented wetland research in the wet-dry tropics of Australia.

The conclusions of the workshop discussions were taken forward and incorporated into two major reviews of wetland research and management needs in northern Australia. The first was carried out for LWRRDC as part of a national R&D identification program for wetlands. We reviewed R&D needs for wetlands in the wet-dry tropics and then summarised R&D needs for wetland invasive species at a national level. The second review was carried out for the Parks and Wildlife Commission of the NT and concentrated on the conservation status of wetlands of the NT. As such, it will serve as a resource document for the development of a NT wetland management strategy. Both reviews will be published, the first by LWRRDC and the second as a Supervising Scientist Report.

A further major scene-setting study was a vulnerability assessment of wetlands in the Alligator Rivers Region to climate change and sea level change. This was a multi-disciplinary study conducted under contract to DEST as part of a national program. Importantly, it indicated the linkage between wetland management and carefully planned monitoring of environmental change with due regard to jurisdiction and social factors. It led to the establishment of a coastal monitoring node at ***eriss***, in collaboration with Environment Australia and others, which has added to our list of national programs. It also provided substantial support to continuation of research by ***eriss*** as part of the National River Health Initiative and the ANZECC funded assessment of biological criteria for setting water quality guidelines. These activities were very much linked to the ***eriss*** input to a workshop held by ANSTO and CSIRO to develop a national approach to ecological risk assessment.

Consultation at the local community level continued with active participation in Landcare meetings and an advisory role to the Northern Land Council's program for wetlands on Aboriginal land. Such consultation is providing a major communication channel for ***eriss*** staff as they seek to become further involved in providing management advice to wetland managers. Collaboration and communication have also been advanced through active participation in the Centre for Tropical Wetland Management at the Northern Territory University. At the other extreme, technical advice on interpreting change in the ecological character of wetlands was given to the Conference of the Contracting Parties to the Ramsar Convention. A member of staff participated in the Australian delegation to the Conference and continues to provide technical advice to the Convention. A second member of staff is an active participant on the technical panel providing guidance to the river health initiative.

The above initiatives have resulted in an enhanced profile of ***eriss***' wetland research potential in local, national and international fora. It is highly evident that ***eriss*** has an opportunity not

only to contribute to the research base for wetland management at all three levels, but to provide scientific leadership.

Throughout this developmental period we have attempted to identify a philosophical basis for wetland research that supports national agreements on ecological sustainable development and conservation of biological diversity. As a consequence, our three research directions have been assessed and past projects are being reviewed and placed into a holistic framework for wetland management. This review process will continue as we seek ways of being even more flexible and responsive to community needs for advice on crucial wetland issues. We are adopting a modular approach to our research planning to enable both urgent short-term and highly targeted issues to be addressed alongside longer-term strategic issues. The current projects reflect this mixture and we fully anticipate further changes in the existing balance as we extend our activities under programs such as that being developed by the NLC.

The above linkages and emphasis on transferring our knowledge base on wetlands is expected to stand us in good stead as we face changing operating procedures for the future. The wetland program is being critically reviewed with the intent of developing a far greater commercial basis. It is expected that will extend our activities internationally and into supporting training exercises. Towards the end of 1996–97 we developed an initial wetland management training module that will form the base for further exercises of this nature. In the same vein we are seeking further external grants to complement the tasks that we can currently undertake and further our expertise as a provider of timely and quality information for wetland management.

3.1 Description of the ecological character of wetlands

Primary research needs for managers of wetlands in northern Australia are adequate description of the ecological character (or health) of these ecosystems and then understanding of the critical processes that enable this character to be maintained (or to evolve naturally). Whilst over the past 15 years ***eriss*** staff have undertaken extensive research on the biology, chemistry and physical processes of the streams, billabongs and floodplains within Kakadu National Park, targeted research is still required to either obtain or improve the necessary information base for effective management. An ancillary goal to describing the ecological character of wetlands is identification of current and future threats to these systems. Finally, the sub-program is able to contribute to national wetland programs by way of developing techniques to enhance national and regional inventories (eg GIS, remote sensing) and in developing data and information management systems to assist wetland managers.

During 1997–98 it is planned to design several multi-faceted sampling programs to describe the ecological character of specific wetland habitats (eg deep billabongs on the Magela floodplain and estuarine and freshwater habitats on the Liverpool and Mann Rivers). These projects will provide experience in survey design and rapid ecological assessment as well as providing the baseline or reference state for further monitoring. Whilst they will address specific habitats they will also provide the basis for undertaking multi-faceted ecological survey in response to specific requests and consultancies (such as that conducted in the coastal lagoons of Ghana during 1996).

Participation in the Northern Land Council's *Top End Indigenous People's Wetland Program* will continue with the development of systematic ecological surveys and the compilation of information in readiness for the development of a management plan for the Djelk wetlands near Maningrida. This will also allow ***eriss*** to contribute to a review of the Ramsar Convention guidelines on management planning and ecological characterisation. In this manner we are able

to link local initiatives to international programs and even provide leadership on specific ecological issues.

Table 4 Projects for 1997–98 in the Wetlands Protection and Management Program - Description of the ecological character of wetlands

Project and aim	Staffing commitment (pw)	Indicator
Survey and management planning for wetlands on Aboriginal lands in the NT		
Aim: Assess the ecological status and uses of key wetlands on Aboriginal lands and assist with developing management plans. *Project leader:* M Finlayson	*Res staff:* 20 *Tech staff:* 20	IR; Survey of freshwater fish and wetland vegetation. Reference collections prepared for BAC laboratory, Nov 1997. IR; Survey proposals for estuarine mangroves and macro-invertebrates. IR; Draft management plans in collaboration with Aboriginal groups and NLC; April 1998. *Commenced:* July 1996 *Completion:* July 1999
Underlying reasons for change in ecological character of Australian wetlands		
Aim: Assess the underlying reasons for wetland loss and degradation in Australian wetlands. *Project leader:* M Finlayson	*Res staff:* 5	Paper on general reasons, climate change and monitoring issues and jointly edit special issue of the journal *Wetland Ecology and Management* : October 1997. *Commenced*: July 1996 *Completion*: October 1997
Preliminary investigation into temporal and spatial patterns of spread of *Mimosa* in northern Australia		
Aim: To use landsat TM to investigate temporal and spatial spread of *Mimosa pigra* in selected areas of northern Australia. *Project leader:* A Bull	*Res staff:* 12 *NTU staff:* 3	Acquisition of imagery; end July 1997 Digital spatial datasets on mimosa areas at different time intervals compiled. Report; January 1998. *Commenced:* June 1997 *Completion:* February 1998
Scales of freshwater fish of the ARR		
Aim: Provide an identification key for fish on the basis of scale description for users. *Project leader:* D Walden	*Res staff:* 1 *Tech staff:* 5	Draft completed, end June 1997. Internal report, July 1997. SSR Jan 1998. *Commenced:* 1995 *Completed*: Jan 1998
Field key to the trees and shrubs of the Jabiru area		
Aim: To provide an identification key to the trees and shrubs of the Jabiru area based on the use of perennial vegetative plant features. *Project leader:* K Brennan	*Res staff:* 3	Internal Report: May 1997. SSR publication MS submitted to publications officer; December 1997 *Commenced:* August 1995 *Completion:* June 1998
The impact of Wet season burning on herbaceous vegetation in eucalypt woodland		
Aim: Describe the short and longer term effects on herbaceous vegetation of Wet season burning practices in lowland eucalypt woodland. *Project leader:* K Brennan	*Res staff:* 5	Journal paper on short term effects of Wet season burning submitted; May 1998. *Commenced:* 1992 *Completion:* May 1998

Project and aim	Staffing commitment (pw)	Indicator
Technique development and databases for enhanced wetland inventory in northern Australia		
Aim: 1. Enhance capability for inventory through RS and GIS technology for hydrologyl and vegetation 2. Provide an information base for early warning and predictive monitoring of adverse change 3. Provide database techniques for information on annual and seasonal extent of wetlands to assess natural varaiation and changes due to global change *Project leader:* M Finlayson	*Res staff:20* *Tech staff:* 5	Progress reports to NPW. September 1997 & January 1998 Final report May 1998 *Commenced:* June 1997 *Completion:* June 1998

eriss is approaching the issue of data and information management required by managers in two ways. The first addresses the question of the adequacy of data capture techniques for the purposes of wetland management. In this case we have identified the application of recent advances in remote sensing as a key step in improving the range and quality of information that is required by managers. A project is being developed in collaboration with the UNSW to address this issue whilst we have received funding from the National Wetlands Program to develop protocols for a possible national wetland inventory and expect to undertake a review of the extent of wetland inventories on behalf of the Ramsar Convention and in collaboration with Wetlands International. The second approach adopted by ***eriss*** is to provide further information on specific topics of interest to managers or as a resource for other researchers. We will also provide advice and support to wetland users and researchers based on the further development of our GIS capability, herbarium colection, and capability to provide both general and specialised wetland training courses. Specific attention will be given to developing linkages with other institutions both within Australia (eg NTU, UWA, JCU) and overseas to develop our assessment and survey consultancy capabilities. Thus, the provision of advice to specific groups (eg Ghana national Wetland program, Porgera stakeholder environmental komiti) will be encouraged and developed.

3.2 Risk assessment and restoration of wetlands

Environmental management decisions are increasingly based on the results of ecological risk assessments that require data and models to establish the likelihood that adverse ecological effects may occur, or are occurring, as a result of exposure to one or more stressors. In the past, ***eriss*** was concerned only with evaluating risks associated with release of mining waste waters using results of laboratory toxicity tests. However, ecological risk assessment principles and techniques may now be applied to other issues for northern wetlands: eg evaluation of risks associated with climate change and sea-level rise, invasive animals and plants, as well as risks associated with any of the mitigation measures in place for control and restoration themselves (eg off-site effects of herbicidal control of weed species).

The first aim of the ***eriss*** program on risk assessment is to assess the probable ecological impact of specific threats. During 1997–98, the principal threat being assessed continues to be the invasion of wetlands by weeds. One project is a study of the effect of the invasive exotic paragrass (*Brachiaria mutica*) on the character of the floodplains. Another aspect of the weed issue is the threat to non-target organisms arising from the use of herbicides to control weed infestation, for example, Graslan is used to control *Mimosa pigra* in the

wetlands of northern Australia, however, little is known of the risks associated with the exposure of the herbicide's active ingredient, Tebuthiuron, to local aquatic species. The last year has seen ***eriss*** evaluate the toxicity of Tebuthiuron to non-target aquatic organisms native to the region, in collaboration with ANSTO and the University of Stirling (UK). Further research will be conducted during 1997–98 on the effects of the herbicide on a native aquatic plant and algal species.

The second aim of the program is to develop standards and procedures to ensure the maintenance of ecological processes and functions in aquatic ecosystems. In 1995–96, ***eriss*** collaborated with ANSTO on a project that aimed to provide a more relevant and comprehensive ecotoxicological database for the derivation of water quality guidelines for uranium (U) and copper (Cu) in tropical freshwater environments. With the aid of funding from ANZECC, a new phase of this research has commenced, and will continue into 1997–98, in which factors modifying the toxicity of U and Cu, namely pH and water hardness, will be assessed. ANZECC Trust funds have also been allocated to an Honours project on the development of a toxicity bioassay using a local green alga, not only for assessing the toxicity of U and Cu, but also for herbicides, whole effluents, and other pollutants of concern. Both projects will provide more relevant ecotoxicological data for the derivation of water quality guidelines for tropical freshwater ecosystems.

Further, collaboration between ***eriss*** and the University of Stirling (Scotland) during 1997–98 will investigate the development of a rapid toxicity bioassay protocol based on observations of feeding inhibition of cladocerans over ≤24 h, using the local species *Moinodaphnia macleayi*. The project will be carried out as a minor research project by a Masters by coursework student from Stirling. The protocol development phase in 1997–98 also includes preliminary investigations into the use of tropical estuarine/mangrove species for toxicity assessment purposes, in order to increase the range of wetland habitats represented, and potentially to address pollutant-related issues facing our coasts.

The third aim of the risk assessment sub-program is to develop procedures to restore degraded wetlands and replace lost wetlands. In 1997–98, a procedure will be developed for undertaking an ecological risk assessment for *Mimosa* and *Salvinia*, two major weed species that are found in the wetlands of Kakadu and elsewhere in northern Australia. The aim is to provide guidance on the management of these weeds.

The full list of projects to be carried out by ***eriss*** in this sub-program during 1997–98 is given in table 5.

Table 5 Projects for 1997–98 in the Wetlands Protection and Management Program - Risk assessment and restoration of wetlands

Project and aim	Staffing commitment (pw)	Indicator
Risk assessment of herbicide impacts on tropical Australian wetlands (1)		
Aim: Assess the toxicity of the herbicide Tebuthiuron, used to control the woody shrub Mimosa, on 3 non-target tropical aquatic species. *Project leader:* R van Dam	*Res staff:* 4 *Tech staff:* 1	Supervising Scientist Report: August 1997. *Commenced:* April 1996 *Completion:* December 1997
Risk assessment of herbicide impacts on tropical Australian wetlands (2)		
Aim: To assess the toxicity of the herbicide, tebuthiuron, to two native, non-target aquatic phytotrophs. *Project leader:* R van Dam	*Res staff:* 10 *Tech staff:* 24	Supervising Scientist Report, April 1998. Paper presentation at ASE, July 1998. *Commenced:* July 1996 *Completion:* April 1998
Effects of speciation on water quality guidelines for uranium and copper		
Aim: Investigate the influence of key physico-chemical parameters on the toxicological responses of hydra and gudgeon to uranium and copper. *Project leader:* R van Dam & S Markich	*Res staff:* 2 *Tech staff:* 5	Progress Report November 1997, May 1998. Progress Report to ANZECC, May 1998. Presentation at ASE, July 1998. Final report/SSR, June 1999. *Commenced:* July 1997 *Completion:* June 1999
Copper speciation and toxicity in estuarine water		
Aim: To relate copper toxicity to copper speciation in estuarine water. *Project leader:* R van Dam	*Res staff:* 1 *Tech staff:* 0	Presentation at metal speciation symposium in September 1997. Final Report (SSR), June 1998. *Commenced:* May 1997 *Completion:* May 1998
Development of an algal toxicity testing protocol		
Aim: Develop a toxicity test to assess the sensitivity of primary producers to toxicants. *Project leader:* R van Dam	*Res staff:* 2 *Tech staff:* 0	Supervising Scientist Report, December 1997. *Commenced:* January 1997 *Completion:* November 1997
Development of rapid waterflea toxicity test using feeding inhibition as an endpoint		
Aim: Develop a rapid waterflea toxicity test to meet regulatory needs. *Project leader:* R van Dam	*Res staff:* 1 *Tech staff:* 2	Internal Report; July 1998. *Commenced:* March 1998 *Completion:* June 1998
Implementation of a regular reference toxicity testing program		
Aim: To implement and maintain a regular program of toxicity testing using reference toxicants, to monitor the status of laboratory test organisms. *Project leader:* C Camilleri	*Res staff:* 3 *Tech staff:* 16	Internal Report, June 1998. *Commenced:* July 1997 *Completion:* Ongoing

3.3 Monitoring of changes in the ecological character of wetlands

This sub-program addresses the regular assessment or monitoring of the environment to see how effective management is in keeping impacts within acceptable limits, the interpretation and feedback of monitoring results to management. ***eriss*** has been involved with development of a biological monitoring program to assess possible impact upon aquatic ecosystems arising from mining in the Alligator Rivers Region since 1987. This program is ongoing and specific tasks to be conducted in this program are outlined in the Impact of Mining program. The same key principles that have dictated the development of this program will also be considered in programs developed for other management issues in the wetlands of tropical northern Australia.

During 1997–98, final reports and a conference paper will be prepared for three ***eriss*** research projects funded as part of the national Monitoring River Health Initiative and administered by the Land and Water Resources Research and Development Corporation (LWRRDC). The first project has evaluated the influence of temporal variability in Australian stream macroinvertebrate communities on the development of the predictive modelling of community composition, the basis of state/territory monitoring programs. The other two projects are providing external quality control and assurance (QA/QC) of identifications and sorting procedures, respectively, used by different state/territory agencies for the MRHI.

In 1995–96, ***eriss*** was commissioned by DEST to carry out an assessment of the likely impact of climate change on the wetlands of Kakadu National Park as part of a broader program to make such an assessment on a national scale. One of the outcomes of the national program was a proposal to establish a network of monitoring stations at key sites in Australia. In 1996–97, ***eriss*** received funding to develop a framework for assessing biophysical changes on the floodplains of the ARR and to identify appropriate management responses. This project is being conducted in collaboration with the University of WA.

Major new initiatives include a collaborative project with the Northern Territory and Griffith Universities to assess the impact of the introduced paragrass on the wetlands of Kakadu National Park and to investigate the effectiveness of herbicide control measures. The project is funded by LWRRDC and Environment Australia National Wetland Program. Further collaboration is underway with the University of New South Wales to assess the usefulness of radar imagery for monitoring wetlands and to link this to GIS capability. Funding support has been also provided by the National Wetland Program. Our international activities continue with funded assistance being given for the provision of advice on wetland monitoring in Ghana and Papua New Guinea.

The full list of projects to be carried out by ***eriss*** in this sub-program during 1997–98 is given in table 6.

Table 6 Projects for 1997–98 in the Wetlands Protection and Management Program - Monitoring of changes in the ecological character of wetlands

Project and aims	Staff commitment (pw)	Indicator
Temporal variability in macroinvertebrate communities of Australian streams		
Aim: Evaluate the influence of temporal variability in Australian stream macroinvertebrate communities on the development of the predictive models for the national monitoring programs. *Project leader:* C Humphrey	*Res staff:* 4 *Tech staff:* 3	Final report to LWRRDC; October 1997. *Commenced:* January 1995 *Completion:* October 1997
Quality assurance and quality control of identifications conducted in Australian macroinvertebrate monitoring programs		
Aim: Provide quality control and assurance of macroinvertebrate identifications of different agencies involved in national monitoring programs. *Project leader:* R O'Connor	*Res staff:* 2	Final report to LWRRDC; September 1997. *Commenced:* January 1995 *Completion:* September 1997
Quality assurance and quality control of sample processing procedures in Australian macroinvertebrate monitoring programs		
Aim: Provide quality control and assurance of macroinvertebrate sample processing procedures of different agencies involved in national monitoring programs. *Project leader:* C Humphrey	*Res staff:* 2	Final report to LWRRDC; October 1997. *Commenced:* January 1995 *Completion:* October 1997
Influence of temporal variability and sample processing errors on development of AUSRIVAS predictive models		
Aim: Present results of MRHI studies on influence of temporal variability and sample processing errors on development of AUSRIVAS predictive models. *Project leader:* C Humphrey	*Res staff:* 6	RIVPACS International conference attendance (Oxford, UK); September 1997. *Completion:* Submission of paper, November 1997
A monitoring framework for investigating coastal processes and climate change in the ARR		
Aim: Develop a monitoring framework for assessing biophysical changes on the floodplains of the ARR and identifying appropriate management responses. *Project leader:* M Finlayson	*Res staff:* 25 *Tech staff:* 30	DGPS operating with Auslig GPS base station, August 1997. Remote reference stations established within ARR coastal zone, October 1997. 4 staff trained in use of DGPS and in-house training manual prepared as Internal Report, Mapping of salt flat and salt water intrusion area at 3 locations. GIS for ARR established, October 1997. Outline of the status of available information, management issues and potential monitoring strategies for ARR Coastal zone (12 sub projects), October 1997. Metadatabase for all information compiled, October 1997. Saline intrusion monitoring undertaken June 1998. *Commenced:* July 1996 *Completion:* October 1997
Monitoring of Ghanaian coastal wetlands		
Aim: Provide advice to the Ghanaian Government on the ecological integrity and sustainable use of Ghana's coastal wetlands. *Project leader:* M Finlayson	*Res staff:* 6 *Tech staff:* 4	Provide report to Wildlife Department of Ghana, December 1997. *Commenced:* October 1996 *Completion:* December 1997

Project and aims	Staff commitment (pw)	Indicator
Weed management and the biodiversity and ecological processes of tropical wetlands		
Aims: 1 To assess the impact of Para Grass on faunal biodiversity and ecosystem processes of wetlands in KNP. 2 To assess effectiveness of herbicide control and effects on biodiversity and ecosystem processes. *Project leader:* M Douglas, NTU ***eriss** contact:* R Pidgeon	*Res staff:* 11 *Tech staff:* 6	Research associate appointed, October 1997. Experimental sites selected and sampling methods finalised, November 1997. Sampling and sample analysis for first year completed, June 1998. *Commenced*: October 1997 *Completion:* April 2000
Identifying and monitoring change in wetland inundation and vegetation patterns , ARR		
Aims: 1 To use radarsat to monitor changes in wetland inundation to delineate freshwater from tidal wetland areas. 2 Use SAR to monitor wetland vegetation change as either degradation or success of conservation practice. 3 Establish a GIS to develop predictive modelling capable of assessing impact of future change. 4 Develop routine procedures for mapping wetland change over northern Australia. *Project leader:* AK Milne UNSW ***eriss** contact:*: A Bull	*Res staff:* 40 *Tech staff:* 12	Research staff appointed, October 1997. By June 1998: Acquisition of radarsat data, Fieldwork (groundtruthing) undertaken, GIS set up, Relational data encoded, Wetland workshop undertaken. *Commenced:* October 1997 *Completion:* March 2000

3.4 Provision of management advice and services

About twenty percent of wetlands staff time will be devoted to the provision of advice on the management of wetlands and the provision of services that are of value to others in the wetlands field. Some of these activities arise in an ad hoc manner during the year. Others can be identified in advance. Some of the activities in the latter category for 1997–98 are listed in table 7.

Table 7 Planned management advice and service provision in the Wetlands field during 1997–98

Project and aim	Staffing commitment (pw)	Indicator
Providing information to Ramsar Convention		
Aims: 1 Provide guidance to Ramsar Convention and site managers on guidelines on interpreting ecological change.	*Res staff:* 4	Establish case studies to test guidelines for site description and provide recommendations to Ramsar Convention on possible changes to these: May 1997. *Commenced:* October 1997 *Completion:* November 1998
2 Provide advice to Ramsar Convention on appropriate techniques for monitoring wetlands.	*Res staff:* 8	Prepare paper for Ramsar Convention; September 1997. *Commenced:* November 1996 *Completion:* September 1997
3 Provide an update on the information available in international and national wetland inventories for the Ramsar Convention. *Project leader:* M Finlayson & Wetlands International	*Res staff:* 20 *Tech staff* 15	Negotiate joint arrangements with Wetlands International offices and NTU; August 1997. Prepare report for Ramsar Convention; December 1997.
Alligator Rivers Region Herbarium		
Aim: Provide a reference source, identification service and repository for voucher specimens for botanically based projects in the ARR. *Project leader:* K Brennan	*Res staff:* 3	Checklist of ARR flora completed July 1996 and proposal for developing a key to wetland plants, December 1997. *Commenced:* 1981 *Completion:* Biennial Revision
Tropical Wetland Management unit for NTU MSc		
Aim: To transfer information to assist wetland managers and/or policy makers develop skills and understanding about wetland processes, surveys and threats. *Project Leader:* M Finlayson	*Res staff:* 8 *Tech staff:* 12	Course to be held at ***eriss*** on 7–18 July, 1997. The information base for the course to be collated and published as an SSR by November, 1997.

4 GENERAL ENVIRONMENTAL RESEARCH PROGRAM

The objective of the ***eriss*** general environmental research program is to

> ***undertake environmental research that meets specific needs identified by the Australian Government or in collaboration with other environmental research organisations which would benefit from the unique location of eriss or its specialised knowledge and expertise.***

The Commonwealth, State and Territory Governments, through ANZECC and ARMCANZ, have developed a National Water Quality Management Strategy for the sustainable use of Australia's water resources. An important component of that strategy is the *Australian Water Quality Guidelines for Fresh and Marine Waters* released by ANZECC in 1992. ***eriss*** has been given the task of managing the first review of the Guidelines on behalf of ANZECC and will report to a Project Committee consisting of representatives from the key groups. The review of the guidelines will be comprehensive requiring a number of the tasks to be contracted out to expert consultants.

One of the key recommendations of the Project Committee at its first meeting in Jabiru in February 1996 was that the next version of the Guidelines should place much greater emphasis on biological indicators of ecosystem health. Two specific projects are being carried out by ***eriss*** staff to achieve this. The first reviews the use of whole effluent testing as a control measure for protection of aquatic ecosystems and will recommend protocols for use in Australia. The second project reviews the use of biological indicators and will give guidance on the adoption of suitable biological monitoring programs. The final ***eriss*** project associated with the revision is a review of the methods and protocols used for physico-chemical assessment of water quality. The need for this work was clearly identified in the feedback obtained from users of the Guidelines.

The full list of projects to be carried out by ***eriss*** in the program on General Environmental Research during 1997–98 is given in table 7.

Table 7 Projects for 1997–98 in the General Environmental Research Program

Project and aims	Staff commitment (pw)	Indicator
Review of Australian Water Quality Guidelines		
Aim: Review, and incorporate the latest scientific information on, water quality guidelines relevant to Australian and New Zealand conditions for use by appropriate authorities in both countries. *Project Leader:* K McAlpine	*Res staff:* 52	Draft released for public comment by March 1998, with the final revised document ready for SCEP endorsement in October 1998. *Commenced:* June 1996 *Completion:* October 1998
Aim: Collate and review protocols for 'Direct Toxicity Assessment' and recommend an approach suitable for use in Australia and New Zealand. *Project Leader:* R van Dam	*Res staff:* 3	Report on whole effluent testing incorporated into chapter on toxicants in water, July 1997. Some on-going involvement responding to feedback required. *Commenced:* January 1997 *Completion:* July 1997
Aim: Review, assess and collate biological indicators and monitoring methods and recommend indicators and protocols appropriate to Australia and New Zealand. *Project Leader:* C Humphrey	*Res staff:* 4	Final chapters on biological indicators and monitoring, July 1997. All protocols and examples completed October 1997. On-going involvement responding to feedback required. *Commenced:* December 1996 *Completion:* October 1997
Aim: Review and recommend appropriate methods and protocols for physico-chemical assessment of water quality. *Project Leader:* C IeGras	*Res staff:* 4	Final chapter on physico-chemical methods and protocols, July 1997. Some on-going involvement responding to feedback required. *Commenced:* October 1996 *Completion:* July 1997
Maritime Continent Thunderstorm Experiment		
Aim: Assist in an international project on lightning strike frequency in the Top End of the Northern Territory. *Project leader:* S Tims	*Res staff:* 2	Successful collection of data for the yearly cycle. *Commenced:* 1995 *Expected completion:* 1999