

**ALLIGATOR RIVERS REGION TECHNICAL COMMITTEE  
MEETING 21, 6 – 7 MARCH 2008  
MEETING OUTCOMES**

**ATTENDANCE**

**MEMBERS**

Mr Ray Evans - Independent Scientific Member (Chair)  
Dr Carl Grant - Independent Scientific Member  
Prof Peter Johnston – Independent Scientific Member  
Dr Simon Barry – Independent Scientific Member  
Dr Terry Hillman - Independent Scientific Member  
Dr Jenny Stauber - Independent Scientific Member  
Mr Howard Smith - Northern Land Council  
Mr Alan Hughes – Supervising Scientist  
Mr Russell Ball – DPIFM  
Mr Alan Puhlovich – Energy Resources of Australia Ltd

**APOLOGIES**

Prof Jon Nott - Independent Scientific Member  
Ms Anne-Marie Delahunt – Parks Australia North  
Mr Mark Foy - Northern Land Council  
Dr Tony Milnes – Energy Resources of Australia Ltd  
Mr Mike Ellsmore – Hanson Ltd

**PRESENTERS/OBSERVERS**

Mr Geoff Kyle - Gundjei'mi Aboriginal Corporation  
Ms Shelly Iles - EWL Sciences Pty Ltd  
Dr Ping Lu – EWL Sciences Pty Ltd  
Dr Jeff Turner – CSIRO Land & Water  
Dr John MacIntosh – Water Solutions Pty Ltd  
Dr Matt Daws – World Seed Bank, Kew  
Dr David Jones - Environmental Research Institute of the Supervising Scientist  
Dr Andreas Bollhoefer - Environmental Research Institute of the Supervising Scientist  
Dr Chris Humphrey - Environmental Research Institute of the Supervising Scientist  
Dr Ken Evans - Environmental Research Institute of the Supervising Scientist  
Dr Peter Bayliss - Environmental Research Institute of the Supervising Scientist  
Dr Rick van Dam - Environmental Research Institute of the Supervising Scientist  
Dr Renee Bartolo – Environmental Research Institute of the Supervising Scientist  
Mr Bruce Ryan - Environmental Research Institute of the Supervising Scientist  
Ms Jenny Brasier – Environmental Research Institute of the Supervising Scientist  
Mr Mike Saynor - Environmental Research Institute of the Supervising Scientist  
Ms Kate Turner - Environmental Research Institute of the Supervising Scientist  
Mr Richard McAllister – Office of the Supervising Scientist  
Ms Michelle Bush - Office of the Supervising Scientist  
Ms Jennene Marum – Office of the Supervising Scientist

**SECRETARIAT**

Mr Scott Parker – Office of the Supervising Scientist

## Day 1 – Thursday 6 March 2008

### 1 Introductory Session

#### 1.1 Welcome and Overview

Mr Evans formally opened the meeting and welcomed members and observers.

Mr Evans advised that, as agreed at last meeting, ARRTC members had undertaken a field trip to Ranger mine on Wednesday 7 March 2008 to observe various aspects of the mine's wet season operations and examine current and future water management issues associated with the proposed extensions to the mine. He advised that members were provided a tour of the mine including Pit#3 and Pit#1, the western stockpile, TSF, RP1, CCLAA, and the WTP. He advised that members had found the field trip very worthwhile and thanked the Secretariat and ERA staff for their assistance in arranging and hosting the field trip.

Mr Puhlovich advised that there have been a number of recent staff changes at EWL Sciences Pty Ltd including the resignation of Dr David Klessa from, and appointment of Ms Shelly Iles to, the position of Manager – Water Sciences. He advised that Dr Mark Gardener has also resigned and recruitment action is underway to fill this position. Mr Smith advised of recent staff changes at NLC including the resignation of Mr Mark Foy. He advised that he would likely be nominated as the NLC member on ARRTC and that a letter to this effect was being drafted. Mr McAllister advised that Ms Davis-Hall has resigned from the position of Director, Supervision and Assessment, OSS, and that recruitment action is underway. He also noted Ms Iles's resignation. Mr Ball advised that he had recently assumed the position of Director, Mining and Petroleum Compliance, DPIFM, following the resignation of Mr Mike Delosa. Mr Ball noted that he has been nominated as the DPIFM member on ARRTC.

#### 1.2 Apologies and Observers

Mr Evans noted apologies from Prof Jon Nott (who is in the process of formally resigning from the Committee), Mr Mike Ellsmore from Hanson Pty Ltd; Ms Anne-Marie Delahunt (Parks Australia) and Mr Mark Foy (who has resigned from the NLC).

#### 1.3 Conflict of Interest Declarations

No conflicts of interest were declared. Prof Johnston advised that he had submitted an ARC linkage grant proposal which was related to a research project being presented by EWL Sciences later in the meeting. It was noted that SSD is also a collaborator on this project.

#### 1.4 Correspondence

Mr Evans noted outgoing correspondence included his letter to Minister Garrett following the last meeting and his letter to ERA regarding aspects of the proposed rehabilitation trial. Mr Evans advised he would be writing to Minister Garrett regarding the outcomes of this meeting. Mr Hughes suggested that Mr Evans may wish to raise the issue of environment NGO membership of ARRTC in his letter to the Minister. It was noted that this matter had been raised with a previous Minister who, while generally supportive, did not accept the nominee that was put forward by the NECF at that time. Members agreed it would be good to ascertain Minister Garrett's views on the matter. Mr Evans noted that ARRTC had previously supported the proposal for environment NGO representation and Mr Hughes suggested that ARRTC indicate its support for this to Minister Garrett. Mr Kyle noted that Dr Hart had also suggested that ARRTC would benefit from having a social scientist as a member. He advised that GAC is currently considering whether to seek to upgrade its current observer status on ARRTC to being a full member and is in the process of writing to Minister Garrett on this and other matters.

Prof Johnston suggested that Minister Garrett be invited to attend a future ARRTC meeting. Members agreed this would be a good way to raise the Minister's awareness of the work of the Committee. Mr Kyle advised that Minister Garrett may be attending the opening of GAC's new building and that this could present an opportunity for ARRTC members to meet with the Minister. He suggested that ARRTC consider aligning one of its meetings so the Minister could do both events. Mr Evans advised that ARRTC could also use this opportunity to meet with Traditional Owners. Prof Johnston noted the importance of confirming timing and getting a date into the Minister's diary as soon as possible.

Dr Stauber asked what confidentiality arrangements apply to information discussed in ARRTC meetings noting that there had been a major breach in another committee she is involved with. Mr Evans noted that ARRTC deals with two types of information that may be sensitive and require protection – commercial-in-confidence information and off-the-record comments. Prof Johnston advised that he is a member of another government committee where members have to sign a non-disclosure agreement and suggested this approach may be useful for ARRTC. He advised the key issue is that members understand the relevance

and confidentiality of information when raised. Mr Hughes noted this would require members to identify information that is confidential and the level of protection it requires. Mr Kyle advised that he shares some of his notes with consultants and asked whether members objected to this. No members indicated they had an issue with this. It was agreed that the Secretariat would ascertain what confidentiality provisions apply to ARRTC and advise members out-of-session.

**ARRTC21 Action/Outcome - 1A**

**ARRTC Secretariat to ascertain what confidentiality provisions apply to ARRTC and advise members out of session.**

## **2 Actions and Outcomes**

### **2.1 ARRTC20 - Draft Summary Record**

Mr Evans asked members for comments on or changes to the draft ARRTC20 Summary Record. Dr Stauber and Dr Grant advised that they had a number of minor typographical changes which they would provide the Secretariat. Members approved the draft ARRTC20 Summary Record with these changes.

**ARRTC21 Action/Outcome - 2A**

**ARRTC approved the ARRTC20 Summary Record with a number of minor changes.**

### **2.2 ARRTC20 – Actions Arising**

In relation to ARRTC20 Action/Outcome 5N, Dr Stauber noted the implications of the recent staff changes at EWL Sciences and expressed concern that the results of the work on sediments at Ranger were not being presented at this meeting as previously requested. Mr Puhlovich noted Dr Stauber's concerns and advised that ERA regretted the delay in presenting the results, which was mainly due to the work not being completed prior to the departure of the relevant staff member. He advised that EWL Sciences was currently working on the interpretation of the results. Dr Jones noted that **eriss** was also waiting for the data to assist with its work on developing closure criteria for site water bodies.

Mr Evans asked what steps ERA could take to address Dr Stauber's concerns. Mr Puhlovich suggested that the minutes record that EWLS is currently working to finalise the project outputs as soon as possible. Dr Stauber suggested that the minutes should also record ARRTC's concerns about the delay to date, and that ARRTC formally request ERA to provide the information as soon as possible. This was agreed.

Mr Puhlovich agreed that ERA would aim to provide the report by the end of May 2008 and provide a presentation on the outcomes at the next ARRTC meeting. Prof Johnston thought this was a reasonable timeframe but suggested that if there was further delay, the Chair should write to the Minister raising ARRTC's concerns. This was agreed.

**ARRTC21 Action/Outcome – 2B**

**ARRTC agreed to record its concerns that finalisation of EWLS' sediment monitoring report has been further delayed despite ARRTC's requests for information.**

**ARRTC21 Action/Outcome – 2C**

**ARRTC agreed that EWLS would provide the report on sediment monitoring work by end of May 2008, and failing this, the Chair would write to the Minister outlining ARRTC's concerns about the continuing delay.**

Dr Jones asked whether members were happy with the current length and appropriateness of the ARRTC minutes. Mr Evans indicated he thought the style of the minutes was appropriate but they could be shorter. Prof Johnston noted that as ARRTC only meets twice a year, having more detailed minutes was useful in terms of providing necessary context to the Committee's decisions. Mr Kyle indicated he thought the minutes were about right in terms of level of detail and length.

### **2.3 Outstanding Actions**

Apart from the matter of the ERA sediment monitoring project covered under 2.2 above, there were no other outstanding actions discussed.

### 3 ARRTC KKN Review

Mr Evans noted that all ARRTC members had had the opportunity to review and comment on the revised KKNs. He suggested that ARRTC seek to finalise the KKNs this meeting and minimise any outstanding tasks. Mr Evans stressed the need for ARRTC to be clear on the priority of the KKNs in both absolute and timing terms, and to consider how the KKNs align with the current **eriss** and ERA work programs. He suggested that if members were happy with text in left column of the KKN table then the wording would be taken as agreed.

Dr Hillman suggested that KKN 1.2.3 needs to reflect three scales and offered to provide the necessary words.

**ARRTC21 Action/Outcome – 3A**  
**Dr Hillman to provide additional words for KKN 1.2.3.**

Mr Evans indicated he was happy with KKN 1.2.5 but noted the ARRTC20 actions proposing a new KKN dealing with model validation to address the need for near and far term datasets for validation of scenarios and model outputs. Dr Jones noted there are a various types of models and the key issue is to ensure that models are being developed and used. Prof Johnston suggested the issue of developing the necessary technical capacity to do the required modelling also needs to be addressed. Mr Evans suggested a new KKN 1.2.6 titled *Models and Model Validation*. Dr Jones queried whether the new KKN would deal with models *per se* or the validation of models. Prof Johnston suggested this could be put under a KKN dealing with knowledge management. Dr Barry queried the value of having a KKN focused on model validation as he expected that all models currently in use would already be subject to some level of validation.

There was general agreement that all models should be validated and that the key need is for an agreed dataset underpinning these models. Mr Puhlovich queried whether the need is for baseline or background datasets. Dr Jones suggested good temporal datasets are also required. Mr Puhlovich noted that differences in datasets between various stakeholders could potentially lead to arguments in the future, for example, in relation to climate change impacts. Dr Barry suggested that specific reference datasets be identified for specific work areas. Mr Evans noted that this is more a process and quality control issue than a fundamental knowledge gap. Dr Jones noted that there have already been instances where different datasets have been presented and used, which has led to some uncertainty. Dr Jones suggested that when results are presented to ARRTC, presenters should specify what primary dataset has been used. Mr Puhlovich suggested there may be issues with identifying background data for water quality and radiation, but agreed there is a need for agreed reference or baseline datasets. Mr Evans suggested ARRTC consider whether this could be covered under an existing KKN. Dr Jones suggested that ARRTC could identify which key datasets it would like to see developed, validated and agreed between the various stakeholders. Dr Hillman suggested that having agreed key datasets will be absolutely vital for developing agreed closure criteria.

Mr Evans suggested the development of a new KKN dealing with defining the reference state and baseline data for Ranger rehabilitation. Mr Puhlovich advised EWL Sciences is currently looking at reference data from the 1970s and noted that current detection limits vary across various datasets. Dr Barry suggested there may also be a need for a KKN dealing with incomplete datasets. Mr Puhlovich noted a range of techniques can be used depending on the types of data involved and agreed it is critical for closure criteria that data integrity is tightened up now. Dr Barry suggested that the knowledge need may be to determine appropriate reference benchmarks.

Mr Evans suggested that a new KKN 2.1 be created and titled *“Defining the reference state and baseline data”*. Dr Stauber noted this KKN has relevance to a number of other KKNs. Dr Hillman agreed and suggested this KKN be acknowledged in other KKNs. Dr Barry asked whether the KKN should be more explicit in defining which types of reference data. Mr Puhlovich suggested keeping the KKN at a high level as there will be a range of stakeholder consultation processes that will inform. Mr Evans noted this KKN would provide a basis for other interested organisations to develop targeted research proposals. Dr Jones noted that **eriss** had already identified the need for agreed reference datasets to inform and guide future research work.

**ARRTC21 Action/Outcome – 3B**  
**ARRTC agreed to create a new KKN 2.1 titled “Defining the reference state and baseline data”.**

**ARRTC21 Action/Outcome – 3C**

**ARRTC agreed to create a new sub-heading of 2.2 Landform under Section 2. Ranger rehabilitation.**

In relation to **KKN 1.3.1**, Dr Stauber suggested adding "...techniques and models" to KKN 1.3.1. This was agreed.

In relation to **KKN 2.1.1**, Dr Grant queried whether the importance of rehabilitation demonstration areas at Ranger is sufficiently stressed. It was noted that this is already captured under other KKNs.

In relation to **KKN 2.6.2**, Mr Puhlovich suggested that the current wording "*downstream ecosystems*" be replaced with "*beneficial use attributes*". It was agreed to replace "*the downstream environment*" with "*potentially impacted ecosystems*". Dr Hillman suggested that on and off-site monitoring needs should be informed by risk assessment. It was agreed to add "*The monitoring regime should address the key issues identified by the ecological risk assessment of the rehabilitation phase (KKN 2.7.1)*".

In relation to **KKN 2.7.1**, Prof Johnston suggested changing the wording to "...*effect of extreme events and climate change*". This was agreed.

In relation to **KKN 2.8**, Prof Johnston suggested inclusion of words "*ownership*" and "*caring for land*" to recognise the issue of longer term management of the rehabilitated landform. This was agreed. Mr Puhlovich suggested that longer term management of the site post rehabilitation was not really an issue for ARRTC and would be resolved through other processes. Mr Kyle agreed but thought it important that ARRTC highlight the scientific research that will underpin this process. Mr Smith noted KKN 2.8 deals with a range of future processes. ARRTC agreed to retain this KKN with the suggested changes.

In relation to **KKN 4.2**, Dr Stauber agreed with Dr Grant that the KKN contained too much detail and could be made shorter. ARRTC agreed to delete the entire second paragraph except for the last sentence "*Additional monitoring of ground water plumes is required to allow assessment of potential future groundwater surface water interaction and possible environmental effects.*"

In relation to **KKN 5.1.1**, Dr Stauber suggested replacing "*effectively*" with "*and should be*". This was agreed.

In relation to **KKN 5.4.1**, the current wording was agreed.

In relation to **KKN 6.0**, Mr Hughes advised that the presentation by Ms Webb on communication of research outcomes would be held over to another ARRTC meeting. Dr Hillman indicated that he wouldn't want to see this KKN drifting into general communication issues and that it should deal with specific issues such as data management. Mr Puhlovich asked if all documents produced by SSD related to KKNs. Mr Evans advised that it was originally intended to link all SSRs to KKNs but this was probably more difficult now given changes to KKNs arising from the review.

Mr Evans suggested the intent of KKN 6.0 was to focus on how research outcomes are reviewed and translated into information, and how this information is communicated to stakeholders. Dr Jones suggested it is also about how this information becomes knowledge. Mr Evans noted the need to also capture the grey literature. He stressed the importance of having effective mechanisms in place to ensure that information generated is able to be accessed and used by regulators and others.

Dr Jones suggested that KKN 6.0 essentially deals with the effectiveness of SSD communication activity in meeting the needs of a range of external stakeholders and queried the extent to which ARRTC should be involved in these issues.

Mr Puhlovich suggested there is an ongoing need for tracking of the research outputs for each KKN. Mr Hughes noted this was done as part of the KKN gap analysis but it had proved to be a detailed and convoluted process. Dr Stauber suggested that perhaps KKN 6.0 could be retained but refocused on knowledge management. Dr Barry indicated he had no problems with retaining the KKN but suggested it should be consistent with the other knowledge needs. Dr Hillman agreed that ARRTC should assure itself that knowledge generated from the range of research activity is being communicated to relevant stakeholders in the most efficient and effective way, but suggested it wasn't ARRTC's role to get involved in determining how this communication should be done.

Prof Johnston suggested that it would be good to see more *eriss* and EWL Sciences research being published in the literature but acknowledged that this is already happening. Mr Evans agreed and wondered whether a knowledge base should be included in the KKNs. Prof Johnston suggested it probably wasn't an issue for ARRTC. Mr Puhlovich noted the potential value in having this research information in a knowledge

base but questioned whether it would be used. Dr Hillman noted that having a good knowledge base would assist in identifying critical paths for research needs. Mr Kyle agreed this would assist stakeholders to better understand the scientific basis for decisions and the various lines of evidence supporting these decisions. Mr Smith noted that potential duplication could be avoided by having a central repository for scientific knowledge but agreed the mechanism is not ARRTC's concern.

ARRTC members agreed there was scope for having a publications and report documentation system in place and that this would remove the need for KKN 6.0. Dr Jones noted that many of the key references are very large documents. Mr Smith suggested that ARRTC's role is to recommend that these references be available and leave it up to others to work out how. Mr Ball suggested there is a need to substantiate the need for such an integrated knowledge base and asked if there have been any failings identified to date in communications. Dr Hillman asked if having such a system in place would have avoided the current issue regarding the lack of closure for the Metal's in Sediments project. Dr Jones suggested that having such a system probably wouldn't have avoided the current situation as the research outputs still would not have been available to put into the system.

Dr Stauber suggested that another issue related to communication is knowing what ARRTC is currently doing. Mr Ball suggested that there should be a list of relevant scientific reference material maintained somewhere and that this probably already exists. Dr Jones suggested that real issue is the large volume of scientific information bound up in the grey literature. Mr Kyle indicated that he hasn't found access to be a problem but rather the problem is knowing that particular information exists in the first place. Mr Evans suggested that this is more a principle than knowledge need.

Dr Stauber suggested that perhaps KKN 6.0 could have a high level statement similar to that for Stewardship. Mr Evans noted that communications with and between stakeholders has significantly improved since this KKN was developed.

Dr Stauber indicated that she was unsure about deleting KKN 6.0 given her current concerns about the reduced number of peer reviewed publications coming out over the past few years. Dr Barry asked why this couldn't be addressed through another process. Mr Evans noted the views of members that ARRTC was more interested in ensuring that the outputs from research are being communicated to relevant stakeholders rather than the processes employed to do this. He proposed that ARRTC agree to delete the KKN and create a new standing item on the ARRTC agenda called *Communication and Knowledge Management*. This was agreed. It was further noted that the committee requires an outcomes focussed summary – not a detailed presentation of all details.

**ARRTC21 Action/Outcome – 3D**

**ARRTC agreed to delete KKN 6.0 and add a new standing item on the ARRTC agenda titled "Communications and Knowledge Management".**

Mr Evans outlined the next steps for finalising the KKN review. He suggested that the current table be converted back to page format with changed numbering, and that KKNs be prioritised based on the views of stakeholders and included in a separate table. Dr Jones noted that some of the KKNs have changed in priority as a result of recent extensions to the mine life. Dr Barry asked if ARRTC should set the KKN priorities or should *eriss* and ERA do this and provide it to ARRTC for comment. Mr Puhlovich advised that ERA's priority focus is on getting agreement on surface and groundwater closure criteria for Pit#1. Dr Jones noted ARRTC is aware of the relevant timetables and planning priorities and can provide useful comment. Mr Hughes agreed that some operational priorities are not ARRTC's responsibility, but there may be instances where ARRTC may believe there is a problem with the priorities and would want to raise this with the Minister. Prof Johnston suggested that ARRTC seek advice from stakeholders on priorities. Mr Puhlovich advised that ERA's focus is on operational knowledge needs and suggested that perhaps ARRTC could take a longer term view on strategic research needs.

**ARRTC21 Action/Outcome – 3E**

**ARRTC agreed the ARRTC Secretariat would seek advice from SSD, ERA and stakeholders on the prioritisation of the KKNs for short, medium and long term issues with supporting information, and to consider this at the next meeting.**

**ARRTC21 Action/Outcome – 3F**

**ARRTC agreed the revised KKNs would be circulated with the draft ARRTC21 minutes.**

**ARRTC21 Action/Outcome – 3G**

**ARRTC agreed the Chair and Mr Hughes would review, and update where necessary, the preamble to the KKNs and this be circulated with the draft Minutes following ARRTC21.**

**ARRTC21 Action/Outcome – 3H**

**ARRTC agreed that the Chair would attach the revised KKNs to his letter to the Minister on the outcomes of ARRTC21.**

## **4 Activity Updates**

### **4.1 Energy Resources of Australia (Ranger & Jabiluka)**

#### **4.1.1 Update on Ranger operations (Mr Alan Puhlovich - EWL Sciences)**

Mr Puhlovich provided a presentation on Ranger operations. Key matters covered included current water inventory and recent and current applications to the MTC, which include:

- (Removal of the Ferric-Floc “front end” from the Water Treatment Plant (December 2007, under consideration);
- Pit #3 Extension – commence preparatory earthworks (July 2007, approved);
- Proposal to extend Pit #3 (December 2007, under consideration); and
- Application for Osmoflo plant construction (March 08, under consideration).

Mr Puhlovich outlined status of key operations projects including the western stockpile, seepage management, interim catchment management arrangements, and arrangements for addressing the factors (escape of water to Magela Creek via an under road culvert) which contributed to the action limits in Magela Creek being exceeded. He also detailed water management works associated with the Pit#3 extension and works associated with the raise of the TSF to RL+51. Mr Puhlovich identified the key issues ahead for ERA as being:

- progress with process water treatment upgrade, planned commissioning Q3 2008
- increased water treatment capacity for pond water Q2 2008 (Osmoflow units)
- tailings deposition to TSF in Q3 2008, additional wall raise
- preparation for the closure of Pit #1
- increased numbers of site personnel, equipment and infrastructure
- Pre-Feasibility Study for Ranger Expansion — study is progressing, first assessment due Q2 2008.

#### **Discussion**

Mr Evans asked whether there is still potential for additional ore resources to be identified in the pre-feasibility study that could affect the current end dates for mining (2012) and processing (2020). Mr Puhlovich indicated this could be a possibility.

#### **4.1.2 Calibration and use of OPSIM at Ranger (Dr John McIntosh - Water Solutions)**

Dr Macintosh provided a presentation on the calibration and use of the site water balance model OPSIM and its capabilities, and described the setup and validation of OPSIM at Ranger. Dr Macintosh outlined the key insights from the June 2007 update of the model which included Magela Creek seepage/backflows into Pit#3; identification of errant runoff into Pit#1; efficacy of increased use of pond water for dust suppression on mine roads; increasing groundwater inflows into Pit#3; and the importance of rainfall intensity and duration signatures. Dr Macintosh also detailed how the OPSIM model was assisting ERA with forecasting in terms of wet season recovery and changes in life-of-mine. OPSIM also has capacity to accommodate solutes but that has not yet been implemented at Ranger.

#### **Discussion**

Dr Macintosh advised that when flow in Magela Creek reaches a specific level, water is presumed to enter the connected sand aquifer and backflows into Pit #3. Mr Evans asked how the two recent extreme events were simulated by the calibrated model. Dr Macintosh advised that the calibration assumed periods of total runoff based on field capacities of 100% - i.e. fully saturated. He indicated it was not absolutely certain backflow is coming from Magela Creek. Mr Puhlovich indicated that there is not enough catchment for this water to come from anywhere else other than from Magela Creek. Mr Puhlovich advised ERA is drilling the sand beds to determine hydrogeological conditions and prove that a pathway exists from Magela Creek to the Pit. Mr Evans asked whether this could be due to a model artefact. Dr Macintosh advised he didn't believe this was the case. Mr Evans asked whether the model has any unaccounted losses and Dr Macintosh indicated there were none. Mr Evans asked if there is a residual between nodes when the model is run and Dr Macintosh indicated this wasn't the case. Dr Macintosh advised that the model utilises more than 100 years of rainfall data to develop a large number of water balance scenarios or realisations. Dr

Turner asked whether water comes from Pit walls or from some other pathway. Mr Puhlovich noted there are photos showing erosion of sands in the wall of Pit #3 but advised that quantifying groundwater inflows into the Pit is very difficult. Dr Macintosh noted this could be separated out from baseflow because it's seasonal. Dr Turner asked whether this could be just displaced groundwater. Dr Macintosh advised that the water was flowing like it is under constant head. Dr Macintosh noted that the water comes in like a waterfall from the Pit wall. Dr Turner asked if there is potential for reversal of this process when the pit is backfilled and groundwater levels recover. It was noted that this was not possible under current Pit 3 conditions.

Dr Barry noted the overall OPSIM approach but suggested there is still a question over the representativeness of historical rainfall versus future rainfall scenarios for forecasting. Dr Macintosh advised that as it's a transparent process the outputs are open and replicable.

Mr Evans asked if calibration statistics were produced for the model. Dr Macintosh advised that he does not report calibration statistic but uses goodness of fit and noted that, in general, the fit was very good. Mr Evans noted that in some graphs there appeared to be a difference of 5-10%. Mr Evans advised that in groundwater modelling, calibration stats are generally used and it would be useful to objectively quantify a statistic, even if it just involved plotting modelled against observed and measuring goodness of fit. Dr Barry queried what fitting procedure was used. Dr Macintosh advised that no fitting procedure was used. Dr Barry noted the approach is science-based but suggested there may be value in incorporating error into the trace, if this can be quantified. Dr Macintosh advised the model is updated every year incorporating previous outputs. Mr Evans indicated he is sceptical about perfect models and confused about how the model is calibrated if not using historical data. Mr Evans noted that most internodal models used in streamflows have error of approx 20% and wondered how OPSIM compared. Mr Evans and Dr Macintosh resolved this matter out of session.

#### **4.1.3 Assessment of radiological conditions in the LAAs and rehabilitation planning (Dr Ping Lu - EWL Sciences)**

Dr Lu provided a presentation on a proposed project for assessment of radiological conditions in the land application areas and implications for rehabilitation planning. Dr Lu advised that ERA is currently committed to ceasing irrigation of unpolished pond water to LAAs by the end of the 2009 dry season. He advised that ERA is required to develop a rehabilitation plan for the LAAs with aim of having it agreed with stakeholders prior to end of the 2009 dry season. Dr Lu advised that for the whole Ranger Project Area, after closure, total dose of radiation exposure to the critical group over natural background must be <1 mSv/a. He noted that doses from all important pathways to critical group have not yet been worked out, including LAAs. Dr Lu noted that screening thresholds for other contaminants are well established (NEPM, 1999, Schedule B1).

Dr Lu advised that the rehabilitation of LAAs of about 340ha represents a major potential liability for ERA. TOs requested scraping of the top 10 cm of the whole MLAA and are highly concerned about the status of the other LAAs. He advised that the definition of radiation exposure pathways in the LAAs and the estimation of radiation doses to the critical group using a Dose Model will determine the level of rehabilitation that ERA will need to undertake. Dr Lu advised the objectives of the project are to develop a comprehensive knowledge of: the current distribution and concentrations of contaminants; the condition of the vegetation, as well as predicted conditions at the end of 2009 and beyond; and a radiation exposure dose model for the LAAs which predicts exposure doses to a critical group from all important realistic pathways.

Dr Lu advised the key tasks for the project were to undertake:

- a general survey of current status in all LAAs of vegetation and contaminants (in surface soil and leaf litter) and their spatial distribution;
- measurement and assessment of site for radiation exposure doses from important pathways (direct irradiation, radon progeny, inhalation of dust, ingestion of soil and food) and development of a dose model for the LAAs to guide the design of the rehabilitation plan; and
- development of a rehabilitation plan for all LAAs that will include risk management measures and a clear understanding of ERA's rehabilitation liability.

This project will be done in collaboration with **eriss** (providing specialist radioanalytical services) and an external consultant engaged by EWLS.

#### **Discussion**

Mr Evans asked whether dose was the only factor driving rehabilitation. Mr Puhlovich advised radiation is the key driver as relates to human health exposure post closure. He noted that U content in soil was currently at around the same level as the cut off for mine waste (0.02% U). Prof Johnston asked what the levels of natural background radiation are. Mr Puhlovich indicated he wasn't sure. Mr Evans suggested

there is a need to define background radiation levels. Mr Smith suggested there is also a need to consider whether using unpolished water raises potential for uranium to be leached out of the landform through time.

Dr Jones asked whether a vulnerability assessment of existing vegetation will be undertaken on the new LAAs given the prospect of change in vegetation type through time as a result of the continued wetting. Dr Lu advised that pre application vegetation surveys would be carried out as well as contamination surveys of surface soil and leaf litter. Dr Stauber asked if depth studies will be undertaken and Dr Lu advised there will be systematic study of depth beyond 10cm. Mr Kyle noted that Dr Hollingsworth's work identified that contamination was moving downwards in the soil profile and that further work should be undertaken. Dr Lu advised that radionuclides in water have different characteristics so it was proposed to look at whether the higher concentration of radionuclides measured below 10cm is due to long term irrigation or other natural processes. Mr Puhlovich advised that further work will be undertaken to determine the concentrations of individual key radionuclides whereas Hollingsworth looked only at gross radioactivity through the profile.

Dr Stauber asked if there is an issue with particle sizes in measuring metals & radionuclides. Dr Lu indicated that the work by Hollingsworth showed that contamination is not evenly distributed across the irrigation areas so there is a need to base the sampling regime on the known annular distribution field from sprinklers. Dr Lu indicated the objective was to link dose to quality of applied water.

It was noted that this specific project was approved by the ERA Board in March 2008 and was related to an ARC linkage project on developing a site dose model led by Prof Peter Johnston. Mr Evans suggested that ARRTC record its support for the LAA project.

**ARRTC21 Action/Outcome – 4A**

**ARRTC supports Dr Lu's project on radiological characterisation of the LAAs and is pleased that ERA has funded the project.**

Dr Jones noted that the sampling of exhalation of radon will have to be undertaken after the end of the wet season and queried whether the soil would be sufficiently dried out to enable measurements to be done prior to the restarting of land application. Dr Bollhoefer advised that measurements will be undertaken in the laboratory on soil samples collected from the field. Dr Jones queried this, noting that it is very difficult to obtain an intact soil sample that replicated the soil porosity in the field. Ms Varris advised that there may be some areas that wouldn't be subject to irrigation and that these may be able to be used for radon measurements. Mr Smith asked if all LAAs were to be sampled. Dr Lu advised that direct radiation exposure and radon release would be measured across all of the LAA areas, although most effort would be on the MLAA. Dr Bollhoefer noted the focus is on the Magela Creek LAA because it's the most contaminated. Dr Jones noted that the CCLAAs will have the lowest exposure but the vegetation aspect will likely be the biggest future rehabilitation issue.

Mr Evans expressed concern that rehabilitation of vegetation may be required on all LAAs. Mr Evans noted the assumption that appears to underpin the project is that radiological issues alone will be the determinant of whether an LAA needs to be rehabilitated and that it could be risky spending half a million dollars on solely the radiological aspects without looking at vegetation. Mr Evans noted there is an assumption that LAAs can revert back to natural vegetative state without active management. Prof Johnston asked where the requirement that the area has to be rehabilitated back to a certain level came from. Mr Puhlovich indicated that this requirement came from ARPANSA that part of the dose model exercise is to determine appropriate closure limits. Dr Lu advised that, as part of the work, the relevant international and national limits will be reviewed. Dr Jones asked whether the site dose model would be sufficiently developed by the end of 2009 to provide this level of assessment. Mr Kyle noted that previous studies have highlighted the issue of acid sulfate soils and asked whether the work would also look at this issue, given that levels of potentially leachable manganese naturally present in the soil profile may also be a factor in determining whether soil needs to be scrapped. Mr Kyle suggested it was important to take samples from the same spots in the vicinity of MC20 where previous elevated levels of Mn had been measured in the groundwater. Dr Hillman asked whether the soil characterisation work involved measurement of organic material and Dr Lu confirmed this is the case.

Dr Turner asked whether sampling of dust (e.g. by wind action) was planned. Dr Lu advised that under each pathway it is proposed to do extensive studies including dust. Dr Lu advised that there also will be an analogue site sampled. Dr Stauber asked whether dust and particle size data would be used in determining exposure pathways for human health. Dr Bollhoefer indicated that given the limited time available there would not be any specific analysis of particle size.

#### **4.1.4 Update on the Ranger surface water – groundwater interaction study (Dr Jeff Turner - CSIRO Land & Water)**

Dr Turner provided a presentation on status of the surface-groundwater interaction study for Georgetown Billabong (GTB) at Ranger. Key issues covered included instrumentation and approach for 2007-2008; framework of eight potential model types for surface/groundwater interaction in shallow lakes and wetlands; mass balance equations for each of the eight models, and preliminary chloride and stable isotope mass balances. Dr Turner advised that field data collection has been underway for six to eight months but the project hasn't yet looked at the full hydrologic cycle. He identified the field sites for 2007/08 which included new observation bores west and south of GTB. Dr Turner reviewed the eight water balance conditions and the predicted solute balance seasonal timelines for each case. He advised that it was planned to use the time trajectory of water and tracer balances in GTB during its hydrologic recession to identify the specific model that applied to this waterbody. Dr Turner advised that his preliminary interpretation suggests that:

- in its hydrologic recession phase, GTB trends can be largely accounted for as being Case 1 (i.e. essentially a bathtub in which the water evaporatively concentrates during the dry season);
- inclusion of small components of groundwater inflow or outflow (Case 2, Case 5) cause deviation from observed water mass, solute and (to a lesser extent) isotope balances;
- GTB appears to become increasingly decoupled from groundwater during its recession – likely due to low permeability lakebed sediments; and
- the onset of the wet appears to generate a condition where groundwater gradient crossover occurs such that if groundwater levels are  $\geq$  to GTB levels, one could expect a wet season groundwater input.

Dr Turner suggested that the hydraulic behaviour of the onset of recession will be the key for improved understanding and noted that tracer signals are “wiped out” during the wet season as a result of backflow flushing from Magela Creek. He also indicated that as the recession has been monitored for only half of the annual hydrological cycle, continued monitoring of another full hydrologic cycle is recommended.

#### **Discussion**

Mr Evans queried whether the significant differences in head levels shows that the two monitoring bores are not receiving water from GTB and noted the relationship between surface area and evaporation rate was not linear. Dr Macintosh asked whether evaporation was being monitored. Dr Turner advised that only pan evaporation was being monitored. Dr Macintosh asked how this compared with observed evaporation. Dr Turner advised probably about 5mm/day but he hadn't compared to pan evaporation rates. Dr McIntosh suggested the difference was probably double.

Mr Evans noted the groundwater conditions appear to suggest some influence from Pit#3 dewatering and asked how representative the gradients of non Pit #3 influences are. Mr Puhlovich suggested taking this on notice and waiting until the data are available. Mr Evans asked whether based on the modelling work done by Frans Kalf it would be expected that there would be a groundwater component to the GTB at the start of the dry season recession. Mr Evans asked whether the data could therefore be used to infer whether there is a signature coming in at the early recession period. If these data show there is little surface and groundwater interaction would this change the thinking regarding the outputs of Dr Kalf's Pit #3 model. Dr Turner suggested that during the wet season some interaction between surface and groundwater would be expected. Mr Puhlovich advised there is more potential to see such interaction now compared to previously due to stabilisation of groundwater that has occurred over time following the recovery of groundwater levels since pumping of MBL ceased in 2006.

Mr Evans asked what timeframe was being followed and Dr Turner advised that officially the work was to be completed by the end of the financial year but it was proposed that some monitoring would continue past this to look at what happens in the next recession. Mr Evans assumed that ARRTC would have access to project outputs once the report has been completed. Ms Iles advised there are some studies also planned for the Corridor Creek wetland filter to look at interaction between the surface and the groundwater beneath the wetland. The purpose of this work is to assess the potential for groundwater accession of ammonia present in process water permeate.

#### **4.1.5 Demonstration Landform: planning update (Mr Alan Puhlovich - EWL Sciences)**

Mr Puhlovich provided a presentation on status of planning for the demonstration landform. He noted this is an important project for ERA and advised that the laterite/waste rock mixing trial had been completed and work was almost complete on the order-of-magnitude construction design, schedule and costing. He noted that managing surface water runoff from the trial landform area was potentially a major issue.

The site for the trial is located on a ridgeline (aligned with and abutting the NW corner of the tailings dam) so it will integrate well with final landform, was not in a boggy area which should minimise potential water logging of the root zone, is well away from future stockpile areas and is able to be accessed separately from

current operational mining areas. The majority of the landform will be within the Gulung Creek catchment. The issues to be considered during the vegetation design phase would include: aesthetics; erosion control-pioneer species; suitability of tree/shrub species for substrate based on subset from analogue; understorey establishment; establishment from seedlings/seed; physical and biological needs of trees/shrub and understorey (e.g. water, nutrients, mycorrhiza); weed and fire management; and succession and biodiversity issues.

Mr Puhlovich advised that the current revegetation strategy was taking account of the species list collated by Dr Gardener. He noted that Kakadu Plant Supplies had advised they would require one year's notice to ensure sufficient stock of seed and to get the species grown. He also noted that there is some concern that laterite on the surface will result in erosion and increased turbidity. Mr Puhlovich advised that given previous problems with revegetation at Jabiluka, it was proposed to look at using irrigation to assist initial establishment. He advised that there are currently no agreed trajectories for ecosystem reestablishment at Ranger and that the approach tended to use end points. Mr Puhlovich advised the next steps would be (i) approval from ERA Investment Committee, (ii) finalise species list, commission plant supplier(s), experimental design, (iii) construction and water monitoring approach (Application), (iv) complete construction, revegetation & monitoring plan, and (v) syndicate with stakeholders (incl. water, weed & fire management).

Mr Evans asked if the base of the landform is to be specially prepared with a compacted layer as this would be very useful to assist with monitoring water balance later. Mr Puhlovich indicated that this aspect hadn't been considered at this stage. Mr Puhlovich advised that rock for the project would start being produced in April 2008, with planting of overstorey and understorey vegetation scheduled to commence in Jan 2009. He noted the need to put an application to the MTC and undertake necessary consultation with stakeholders.

#### **Discussion**

Dr Barry indicated he thought the approach looked good but stressed the need to maximise opportunities from the trial. Mr Puhlovich agreed but noted the need to also keep the trial simple. Mr Puhlovich advised the key aim is to lock in species lists as soon as possible and then have further discussion on how to measure turbidity in runoff and other details. He noted that **eriss** will be participating in some aspects of design and noted that more discussion was obviously required. Dr Barry asked how the risk in the project would be managed in the event it doesn't work and whether there will be experimentation to reduce risk of failure. Dr Jones noted there is some pre-knowledge that will inform the rehabilitation trial design. Mr Puhlovich noted that if aspects of the trial don't work then this will still be useful information.

Dr Jones suggested that although irrigation may be useful to assist establishment, the major downside is that this would be an artificial construct that would not be replicating the risks for rehabilitation of the final landform, where widescale irrigation would not be practicable. Ms Varris noted that, based on observations from rehabilitation work elsewhere around Australia, irrigation doesn't work. She suggested that use of irrigation may have some use in testing responses of particular species but was not appropriate as a long term rehabilitation strategy. She suggested the best approach was to ensure the best species selection and timing of planting. Dr Jones suggested the need to also look at issues associated with using seeds or tube stock. Ms Varris noted that Australian mining companies use bulk seeds for rehabilitation and that tube stock was generally used for establishing difficult species.

Mr Evans asked what the timeframe was for species selection. Mr Puhlovich indicated around April 2008. Mr Evans asked whether ERA would be consulting with Dr Grant, and Mr Puhlovich confirmed this. Ms Varris noted that species selection was also dependent on seasonal conditions, as weather impacts on germination. She noted that a non-soil replicate (i.e. waste rock only) would also be required and, if not done on the current landform, this would need to be done somewhere else. Dr Jones agreed this was important.

Mr Evans noted the approach being followed by ERA and reconfirmed that ARRTC remains very supportive of the work and will continue to follow progress with interest.

#### **ARRTC21 Action/Outcome – 4B**

**ARRTC noted ERA's proposed approach for the landform planning, was fully supportive of progress so far and requested that ARRTC be formally consulted by ERA in relation to the design and implementation of the demonstration landform project.**

## 4.2 Supervising Scientist Division

### 4.2.1 Summary of 2007-08 *eriss* research program (Dr David Jones – *eriss*)

Dr Jones provided a presentation on the summary of the 2007-08 *eriss* research program. He advised that the 2007-08 wet season was looking like being only slightly above average - 1320 mm to date compared with totals of 2540mm for 06/07 and 2100mm for 05/06. Dr Jones advised that the “red tide” of iron-rich sediments observed in Magela Creek during the current wet season was due to sheet erosion from a number of landslips which occurred upstream following the extreme rainfall event ( 800 mm over three days) in the previous 06/07 wet season. He noted although erosion from the landslips had resulted in a number of peaks in turbidity within Magela Creek, no corresponding elevations in EC and U were detected. Dr Jones noted that the recent land slips have implications for erosion rates and perhaps these types of events contribute to the apparently higher contemporary rates of erosion in the region.

Dr Grant asked whether there is a feedback loop to ERA with real-time monitoring. Dr Jones advised that data are currently downloaded daily so this is not a continuous live feed. He noted, however, if significant differences are observed between upstream and downstream stations, or if water quality action limits are exceeded at GS009, then *eriss* does consult with ERA to compare data sets to see if the changes are due to a real event or data corruption/sample contamination. Dr Grant advised that Alcoa has a real-time monitoring system in place so events are investigated once they are detected. He queried the value of having a continuous data recording system if you are not able to detect events immediately. Dr Grant also asked whether the missing data in the presentation were due to problems with equipment. Ms Turner advised there have been some technical problems with equipment that are currently being worked out. Dr Jones noted that *eriss* has a degree of redundancy in their equipment but equipment failure has resulted in some data loss and the need to infill the missing record as best as possible by interpolation.

### **Research Topics**

#### **Monitoring (1)**

Dr Jones advised that the weekly water quality monitoring was operating well and was consistent with last year's results. He advised that a monitoring station had been established midway down Gulungul Creek. Comparative biological monitoring in Magela Creek using creekside and in-situ methods was continuing with stage 3 testing and validation of in-situ testing snails upstream/downstream and fish larvae upstream. He noted that in-situ snails tend to produce more eggs than the snails in the creekside tanks, and that there is no significant difference between upstream and upstream snail production for both methods. Dr Jones advised that *eriss* proposed to discontinue creekside monitoring and go for full deployment of the insitu snail monitoring in the 08/09 wet season.

#### **Monitoring (2)**

Dr Jones advised that continuous physicochemical monitoring in Magela and Gulungul Creek had been reinstated with reconstruction of Gulungul gauging stations and associated instrumentation. Mr Evans commended Dr Jones on *eriss*'s efforts in getting equipment back online after the extreme weather event. Mr Evans asked if the new gauging stations need to be re-rated and Dr Ken Evans advised this was an ongoing process.

#### **Monitoring (3)**

Dr Jones advised that auto samplers had been reinstalled in Magela Creek to collect discrete samples of fine suspended sediments. He noted this would provide capability to define the correlation between turbidity and TSS by automatic triggering of sample collection during periods of higher turbidity, and calculate individual event and annual loads of fine suspended sediments and associated U and Ra loads. The system is also programmed to sample at higher EC values and these results will both improve correlation between EC and Mg and also determine if there is higher U associated with these events. Mr Evans noted the relatively low levels of ECs in these systems and asked whether the equipment is able to reliably measure these low values. Ms Turner advised that the equipment dealt well with such low values, as demonstrated by the close correspondence between continuous data and independently measured data obtained at the same time using a calibrated field portable instrument.

#### **Bioaccumulation/Bushtucker**

Dr Jones outlined progress in the work to assess suitability of reference sites to establish contribution of the mine to levels of U and Ra in mussels in Mudginberri Billabong, and to investigate the relationship between Ra levels in mussels and percentage of fine grain sediments in substrate and concentrations of Ca in water. He noted the work on updating the traditional diet of TO was ongoing. Dr Hillman asked if relative organic

material in sediments was being measured as this is where contaminants will be bound. Dr Jones confirmed this was the case.

Dr Hillman noted that bioaccumulation in fish hadn't been mentioned and asked if this was still happening. Dr Jones advised that work is ongoing and the latest round of sampling was still being analysed.

### **Uranium in Sediment/Mussels**

Dr Jones noted that upstream levels of U in fine sediment were consistently low, higher at the Georgetown Confluence site and decreasing downstream. He noted that levels of U in mussels were very low. Prof Johnston asked if the low values were natural or mine related. Mr Evans asked whether there are any other exposed ore bodies further up the catchment. Dr Jones advised there are a number of other streams (eg 7J Creek) that feed into Magela Creek downstream of the minesite that have radiological anomalies/signatures. Prof Johnston asked if the quoted 1981 data were pre-mining and Dr Humphrey confirmed this to be the case.

### **Radium in sediment**

Prof Johnston asked what the radium activities were like in the samples. Dr Bollhoefer advised that Radium levels were five times higher than uranium but this varied. Prof Johnston suggested it would be useful to report the uranium levels in comparison with radium levels as the variation in uranium may be sitting on top of underlying source of radium. Dr Jones welcomed any advice ARRTC could provide on how to analyse the figures. Mr Evans indicated he thought that groundwater would be reasonably radiogenic. Dr Jones noted that uranium doesn't bioaccumulate in mussels but radium does, so the data are complicated. He noted that Bowerbird has about a six times higher slope in uptake of radium in mussels. Prof Johnston asked if this was due to previous exploration in the area. Dr Bollhoefer advised that the rate of uptake in mussels was related to the size of mussels. Dr Hillman noted that if the mussels are living in a cleaner environment they will have to be processing particles at a higher rate to obtain sufficient food. Prof Johnston agreed that the differences could be related to how clean the surrounding aquatic environment is.

### **Source fingerprinting**

Dr Jones presented source fingerprinting data on whether lead isotopes in mussels are of Uranium origin or Thorium origin. Prof Johnston asked whether the levels observed are due to the natural signature of the area or mine related. Dr Jones suggested that the signature showed that radioactivity comes from mine material. Mr Evans noted that it would be difficult to determine the actual source. Dr Bollhoefer noted the line between the ratio for downstream data and the ore body ratio. Dr Bollhoefer indicated that the signal showed U mineralisation as the source as the lead isotope ratio in the tailings is similar to the ore body. Prof Johnston asked why the sediment data are different to the mussel data. Dr Jones noted it was interesting that data from Mudginberri Billabong indicate that the mine is only contributing in a minor way to the Ra being taken up by the mussels.

### **Closure criteria**

Dr Jones outlined work related to development of closure criteria. In relation to water quality, Dr Jones advised that a macroinvertebrates survey of impacted and reference sites had been conducted to provide a biological basis for derivation of water quality closure criteria for Georgetown Billabong and Coonjimba Billabong. He noted that there was much lower benthic macroinvertebrate diversity in GTB compared to reference billabongs but it wasn't clear whether this was natural or mine related. Dr Jones noted that GTB has a different substrate (hard compacted clay) compared to other billabongs in the ARR.

In relation to vegetation, Dr Jones advised that data acquisition for the vegetation analogue areas had been finalised. Dr Grant asked whether analysis of soil samples has been undertaken. Dr Humphrey advised that the actual physical and chemical analysis was complete but that these data had not yet been integrated with the physiographic and vegetation data sets for overall statistical analysis.

Dr Grant commented that the work is of high priority and that it is important that the characteristics of waste rock mixed with laterite material also be looked at in the context of comparison with the data from the analogue sites. Mr Puhlovich advised the delay in finalising the work on the EWLS was due to recent staff changes (notably the departure of Mark Gardener). Dr Humphrey suggested that Dr Grant may wish to review the results of the work once the analyses were completed.

Mr Evans asked what the project timeline is and Mr Puhlovich advised the project should be completed by June 2008. Dr Jones asked whether the results of the project would affect the selection of vegetation species. Mr Puhlovich advised this was something that ERA intended opening up to discussion with stakeholders. Dr Grant suggested that a more fundamental issue was whether the vegetation at the chosen analogue site is similar to what will grow on weathered laterite/waste rock. Mr Puhlovich noted that work by

Dr Gardener had included species that may not survive. Dr Grant stressed the need to ensure that species selected will be able to survive on the final landform. Dr Jones suggested that nutrient status will also be very important and will determine whether growth is restricted or satisfactory.

ARRTC agreed that it would like to be formally consulted in relation to the design and implementation of the demonstration landform project.

**ARRTC21 Action/Outcome – 4C**

**ARRTC agreed eriss would contact Dr Grant for further input once the additional soil analyses have been completed and will report this at next meeting.**

**Ecological Risk Assessment of Magela Floodplain**

Dr Jones advised that writing up and publishing the results of this work would be a high priority over next few months. He noted that there would be ongoing collaborative work with Kakadu-PAN related to mangroves, climate change, fire and invasive species, and that mining and non-mining risks would be communicated to all stakeholders primarily through the Kakadu landscape symposia series (with emphasis on fire and weeds). He noted that fire and invasive species could have a significant negative impact, unless appropriately managed, on revegetation success on the final landform,

Dr Grant asked if the Ecological Risk Assessment outcomes would be presented to ERA management noting that this could lead to ERA funding some activities on weed management around the Ranger lease. Dr Jones advised that there had been some discussion with ERA regarding biodiversity offsets. Dr Grant asked whether the information had been communicated to the right people. He noted there are two issues: (i) the impact of the mine relative to other risks and (ii) the opportunities this provides to address a broader range of threats. Mr Evans noted this comes back to issues of communication and knowledge flow and asked whether there is a different model that could more explicitly communicate the outcomes of the Ecological Risk Assessment work to stakeholders.

Mr Puhlovich advised that Dr Milnes usually reports back to ERA management on implications of ARRTC outcomes so this means that information is getting to the right people. Dr Jones advised that **eriss** intends communicating outcomes through the landscape symposia series. Dr Grant asked whose role it is to propose that ERA could fund some activities in KNP. Mr Evans suggested ARRTC could propose that **eriss** present the outcomes of the Ecological Risk Assessment process to ERA management including recommendations. Mr Puhlovich suggested that ARRTC could recommend that ERA initiate discussions and report back to next meeting on how it intends to collaborate with stakeholders. He wasn't sure that having external scientist presenting to ERA management would be appropriate or effective. ARRTC agreed that Mr Puhlovich should report back to ERA management on the Ecological Risk Assessment work.

**ARRTC21 Action/Outcome – 4D**

**ARRTC agreed that Mr Puhlovich would take recommendations arising from the Ecological Risk Assessment work to ERA management and report back to next meeting.**

**Ecotoxicology**

*Effect of Organics on U toxicity to water Flea*

Dr Jones referred to an outstanding question from ARRTC20 regarding the effect of the lack of DOC in treated pond water on apparently anomalous (with respect to U) toxicity of treated pond water to the Water Flea. Pilot screening data obtained using Magela Creek water as diluent showed that natural DOC in Magela Creek is capable of providing a strong protective effect against U toxicity.

Prof Johnston asked if the very low organic content of the treated pond water would limit the discharge of treated pond water to catchment lines. Dr Jones advised that this would probably not be the case as the discharged RO permeate passes through several wetland filters, where it will pick up DOC, prior to entering more sensitive receiving waters (for example, Georgetown Billabong). The extent to which the DOC does increase as the water passes through the wetland should perhaps be quantified to confirm that this is indeed the case.

*Effect of DOC (Swanee river fulvic acid) on U toxicity to purple spotted gudgeon*

Dr Stauber asked what the reason was to do arsenic as one of the metal suite for the effects of DOC on metal toxicity PhD project. Dr van Dam advised that the UQ collaborators had a long history of working with biological impacts of arsenic, and an international reputation in this field and that this was especially relevant since As is a characteristic constituent in mine drainage from the Pine Creek geosyncline mineral belt of the NT. Dr Stauber noted that in relation to arsenic the critical issue is the levels of phosphate (which competes with arsenate for binding sites) and suggested there may be a need to look at the effects of different levels of phosphate. This would be especially important for the plant-based tests where phosphate is added as a nutrient to maintain growth. Mr Puhlovich strongly recommended that groundwater supplies in KNP be tested for arsenic. Mr Kyle noted that no one is currently testing groundwater quality in KNP and there could be concerns because Mudginberri used to be a cattle yard, and arsenical pesticides were historically used in cattle dips.

### **Ranger Trial Landform**

Dr Jones advised that *eriss* was defining with ERA/EWLS the scope and objectives of the long term plot trial to evaluate revegetation establishment and test management strategies. He noted the recent decision of ERA to proceed with the 8ha demonstration plot adjacent to the NW corner of the tailings dam. He advised that other collaborative projects were being developed addressing erosion, hydrology, water quality and vegetation establishment.

### **South Alligator Valley**

Dr Jones outlined activities *eriss* is undertaking in collaboration with PAN including determining the radiological conditions and volume of material to be removed from Rockhole mine residue area, assessing time series water quality data for Rockhole Mine Creek, and monitoring groundwater levels and radionuclide activity concentrations in the El Sherana bores. Dr Jones presented data on the Rockhole tailings footprint, tailings profiles and volume versus selected radiological cut-off thresholds leading to the decision to remove top 70cm of material.

Dr Grant noted the level of cut-off usually depends on the rehabilitation technique being used. Dr Jones advised that it is proposed to excavate to a certain depth and that there appears to be a peak in the top 10 cm of the soil profile. Dr Bollhoefer noted that based on radiological standards there was no need to do dose modelling. Dr Jones noted that airborne gamma surveys (AGS) provide a broad overview of extent of contamination but there is always the need to ground truth in the field to derive conversion factors to convert the raw AGS data to quantitative gamma values. He also noted that the soil profile is iron rich so has high binding capacity for radionuclides, hence limiting the depth of penetration of radionuclides leached from the originally overlying tailings. Mr Evans noted the key issue is at what depth the 1.25uSv/hr cut-off occurs. Dr Jones advised that it had been decided that a max of 1.5m depth of excavation and then backfill with clean material would be sufficient. Prof Johnston noted the reasons for rehabilitating the sites were more related to social/political issues than radiological factors. Dr Jones agreed that based on international codes of practice for protection of members of the general public, the level of radiation at the site wouldn't warrant rehabilitation.

### **Rockhole Mine Creek**

Dr Jones advised that a previous risk assessment showed that as long as the levels of radionuclide inputs from the old mine adit did not increase from that measured in the early 2000's there would be no significant risk to the South Alligator River, and that specific rehabilitation works would therefore not be required. He advised that *eriss* had undertaken monitoring of metals and radionuclides downstream over the past 3 years which shows that inputs of U and Ra to the creek do not appear to be getting any worse. Dr Stauber asked whether metals are total or dissolved. Dr Jones advised metals are measured as dissolved. Both U and Ra are attenuated (absorbed by precipitated ferric hydroxide) downstream from the source. Dr Jones advised that as the traditional owners do not use the area for cultural or other purposes it was proposed to leave the site as it is.

#### **4.2.2 Proposed *eriss* projects against ARRTC KKNs 2008-09 (Dr David Jones – *eriss*)**

Dr Jones provided a presentation on proposed *eriss* research projects for 2008-09 against selected ARRTC KKNs.

#### **Ecotoxicology (KKN 1.2.4)**

Dr Jones advised that the work on the effects of fine suspended sediment complements other work on development of turbidity triggers and fine suspended sediment management guidelines. He advised it was proposed to initially use laboratory testing to determine direct and indirect effects. He advised there would also be an ongoing PhD project on the effects of dissolved organics on modifying metal toxicity and a pilot study of the toxicity of Mn to three freshwater species.

Prof Johnston asked whether the project on suspended sediment had commenced. Dr van Dam advised that the project hadn't commenced but some initial discussions have been held and the next steps were to determine program of work and testing required. Dr van Dam indicated that a number of different experiments will be required in addition to the straightforward ecotox approach. Dr Jones indicated that work on the sediment trigger values was currently looking at variance from natural background to see if this is appropriate.

### **Monitoring (KKN 1.3)**

Dr Jones advised that the operational deployment of the in-situ snail test method would occur in the 08/09 wet season following three seasons of validation comparison with the reference creekside monitoring method. Dr Jones advised that work in relation to the continuous monitoring in Magela and Gulungul Creeks would involve interpretation of 06/07 and 07/08 wet season data. Dr Jones advised that the current weekly grab sampling for water quality was biased to low turbidity values as samples are taken early in the day prior to storm activity. The advent of continuous monitoring means that all of the hydrograph is now covered and that an autosampler can be triggered to collect samples during high turbidity periods, thereby providing more data points for the higher end of the suspended sediment vs turbidity correlation. Dr Jones indicated the work was also looking at loads coming off the site and comparing these with the loads being derived for the downstream station. Mr Puhlovich suggested it would be good to also look at the Georgetown Billabong backflow work being done by Dr Turner. He noted that a hydraulic dam exists at RP1 so that when Magela Creek flow decreases, discharge from the RP1/Coonjimba system occurs and consequently there is a corresponding spike in downstream EC. Dr Jones noted that given the size and importance of the continuous monitoring project resourcing will need to be carefully looked at.

### **Landform evolution**

Dr Jones advised that the work on suspended sediments was very important in determining the relationship between slope of the correlation line between fine sediment and turbidity and for developing techniques to fingerprint sediments to sort out different origins.

Dr Evans noted that the CAESAR model currently did not allow for differences in landform surface treatments and that further development work was needed on the model code to address this shortcoming. He noted that all modelling on landform stability to date has been based on a waste rock surface rather than mixed waste rock/laterite cover. Dr Grant asked whether a consistent waste rock – laterite mix was being applied. Mr Puhlovich suggested there is a need to qualify what is meant by laterite (not ferricrete) and that this is really the heavily weathered and leached upper 20-30m zone which has properties similar to soil, but still contains fragments of the original rock matrix. Dr Grant queried whether the proposed proportion 30% was based on how much of this material was available on site. Dr Jones commented that the 30% is based on the mass of laterite required to infill the voids in the waste rock matrix. Mr Puhlovich advised that ERA doesn't have a site inventory that shows that sufficient laterite would be present for closure in the case of a 5m mixed cover thickness. He also advised that ERA hasn't done the calculations to confirm the laterite availability and suggested that it is probably premature. Dr Grant disagreed and suggested that ERA should have some estimate of the volumes of laterite required and the level of availability on site. He suggested this is essential to ensure that the scenarios being tested by the landform trial are realistic in the context of the amounts of material that will ultimately be available for rehabilitation of the site. Mr Puhlovich noted that ERA already has an estimate of laterite based on the Shell 50 design so it probably wouldn't be too difficult an exercise to calculate.

### ***ARRTC21 Action/Outcome – 4E***

***ARRTC requested ERA to calculate likely volumes of laterite available between now and closure in terms of future cover requirements and to ensure that these calculation inform future projects.***

Dr Jones suggested that if a heavy reliance was going to be placed on fines to create water retention substrate in the final landform then this is key information. Prof Johnston asked whether any scrapping of the LAAs will be required and whether this could be a source of laterite. Mr Puhlovich advised that this wasn't currently included in closure planning and that ERA has consistently stated that scraping material from the surface of the LAAs may not be the best option for protecting downstream water quality. He advised that ERA always retained the option of scraping and disposing in the Pit. Dr Jones noted that rehabilitation of the LAAs could be done progressively to avoid disturbance of large areas and consequent erosion risk.

### **Landform Evolution**

There is a need to determine geochemical fingerprints of natural sources of sediment in Magela Creek catchment to be able to distinguish mine material from these natural sources. Dr Grant asked if **eriss** was monitoring erosion rates at land slips. Dr Ken Evans advised that access to the slip areas was difficult so

some remote sensing work has been done but no direct monitoring. He advised that the day the first major erosion event occurred an intense rainfall event happened which would've made access even more difficult. He advised that a rain gauge with dial in telemetry had been installed. As the area is in Arnhem Land access approvals had to be obtained from the NLC. He advised that the work will be focussing on the suspended sediment load that passes the continuous monitoring stations located in Magela Creek.

Dr Ken Evans noted that Prof Nott raised the issue of long term erosion rates at a previous meeting. He advised that the project would be looking at possible reasons for the difference in rates. He suggested that this could be due to the faults and gorges in the area or perhaps that major movements of sediments occur during extreme events. Mr Evans thought that the issue raised by Prof Nott was that if you applied overall erosion rates the surface of the region should be 200m lower than what it is currently. Dr Evans suggested it's the link between current measurements and the long term rate. He suggested the key question is why there are different erosional rates to the long term. He noted there are a range of processes happening within a relatively small area but it's not clear why there may be different erosion rates across the region.

### **Ecosystem Establishment**

It was suggested that macroinvertebrate sampling frequency in on site natural waterbodies be every few years unless there is an event on the mine site that causes a pulse and then the need to conduct a sampling exercise would be reassessed. Not looking like this is required this wet season. Dr Jones noted the project has a multitude of objectives. Dr Jones also noted the need to finalise the chemical waste rock and laterite mix work and commence analysis of vegetation analogue data. Mr Puhlovich noted the other issue is that the current demonstration landform is likely to have a waste rock base compared to other rehab areas. It was suggested the nine year old "heritage" revegetation site located in the landform integration in fill area adjacent to the SE wall of the tailings dam be examined using trenches to see how rock has broken up and to see dynamics of nutrients. Dr Jones suggested also looking at tree root morphology between different cover types because depth of tree root penetration is critical. Mr Puhlovich suggested it would be good to also look at sites after cyclones and other extreme events. Dr Grant suggested also looking at overstorey and understorey vegetation on the site.

### **Radio nuclides in Groundwater**

Dr Jones advised that this project has been affected by staff changes at both DPIFM and EWLS and that Bruce Ryan from **eriss** was talking to DPIFM with a view to obtaining the relevant datasets. Mr Evans asked if the project was limited to radionuclides. Dr Jones advised that the project was aiming to develop a baseline dataset for closure and included general solutes in addition to radionuclides. He noted that sampling needed to be refined to better define the distribution of radionuclides and gather the data required for inferring what the pre-mining radiological state was.

### **Ecosystem Establishment (KKN 2.2)**

Dr Jones noted the need to look at extensive data on fire and weeds to enable a vegetation response model to be developed. He indicated that it is important for rehabilitation that vegetation response is better understood. He noted that this research would probably continue past 08/09.

### **Ecological Risk Assessment**

Dr Jones advised that the current work was being finalised but this would support further work. He advised that collaborative work with CDU was continuing looking at Para grass which poses a major threat to ecological values in the Magela Creek floodplain. Dr Jones noted the need to formulate a conceptual framework for the decommissioning and post decommissioning phases at Ranger. He referred to the Mg and Ca time series data from monitoring point 009 and noted that waste rock on the surface at Ranger has led to raised Ca levels which ameliorate the toxicity of Mg. However, Dr Jones noted that current modelling suggests that post rehabilitation the groundwater will have Mg levels much higher than current levels but there will be a much lower amount of Ca to counteract this (reflecting the very high Mg/Ca ratio in tailings pore water). He suggested that the potential effects of this on the post mining composition of seepage from the site need to be assessed. Mr Puhlovich suggested that ERA would probably look to use more carbonate rock on the surface of the final landform to provide the required Ca to buffer the Mg. He noted that this may require that waste rock be selectively positioned on site so that it can be used in the rehabilitation process.

### **South Alligator Valley (KKN 5.2.1)**

Dr Jones advised that the Slesbeck site has been rehabilitated by backfilling the small open cut with the material from the nearby truck dumps and covering this with clean fill.

### **Discussion**

Dr Grant indicated that he thought the way **eriss** research was now being presented was excellent although he noted it had taken a while to get to a level of reporting that is appropriate. He thought the approach of linking objectives with the results was good and suggested that ERA consider adopting a similar presenting format for reporting to ARRTC.

Dr Grant suggested it would probably be useful to undertake some leaching tests on the demonstration landform to understand nutrient dynamics and related issues. Mr Puhlovich suggested that quite a bit of relevant data may already exist (eg with ANSTO). Dr Jones noted that existing data may not include chemistry. Mr Evans asked whether there is an opportunity for **eriss** to look at what data exists and cost and benefits of looking at column leaching. Mr Puhlovich undertook to provide Dr Grant with further information on what data ERA understands exists.

Mr Evans suggested that ARRTC request **eriss** and ERA to provide a report to the next meeting on the work by ERA on characterising leachate from waste rock. This was agreed.

**ARRTC21 Action/Outcome – 4F**  
**ARRTC asked eriss and ERA to provide a report on ERA work on characterisation of leachate from waste rock at next meeting.**

Prof Johnston suggested it would be useful to have some information on what is known about anomaly 1 and 3 at Ranger. Mr Hughes advised that he suspected these have never been drilled due to cultural sensitivity issues. Mr Puhlovich noted that there may be some shallow auger holes in these locations. Prof Johnston advised he would like a presentation on this issue at some stage. Dr Bollhoefer advised that the area was being investigated in terms of its value as an analogue for estimating gamma dose rates and noted that groundtruthing had shown the gamma readings were 130m out from the location indicated by the airborne survey so more detailed groundtruthing is required. Mr Puhlovich asked if the airborne data presented were pre mining. Dr Bollhoefer advised the data were from 1976 and had been reprocessed in 2003 but that the original line data could probably still be obtained. Prof Johnston suggested that ARRTC ask EWL Sciences to advise what data currently exists. Mr Puhlovich suggested there may be implications in terms of risk management associated with constraining knowledge to existing data and looking ahead to dose models and community access. Dr Bollhoefer noted existing data included average gamma signature pre mining. Prof Johnston noted that at the end of the day these data may not be that useful but they should be pursued.

Dr Barry noted the **eriss** presentation and indicated that he is generally happy with the approach. He stressed the need to ensure that the experimental design of projects is being based on what needs to be known.

Mr Puhlovich suggested that it is inevitable that surface water quality closure criteria will be based on the GTB analogue but indicated that ERA will be looking at other sites including groundwater in terms of potential compliance points for rehabilitation. He noted there will be problems developing groundwater closure criteria based on old data and expects that developing appropriate closure criteria will be challenging.

Mr Smith asked if he could obtain a copy of the proposal of the **eriss** work looking at the landslips. Dr Evans advised that he is currently working on this and would provide further advice in due course. Mr Kyle noted that it is by no means certain that 009 will be the primary compliance point after closure given the confluence of Gulungul Creek is downstream of 009. He indicated he was pleased to see that ERA is recognising that one compliance point will not be sufficient. He noted also that any other compliance points will not have the level of baseline data 009 has.

Dr Hillman raised a concern regarding the timeliness of closure projects and suggested that a critical path analysis overlay on timeline for closure may assist setting priorities. He also asked how the extension of mining affects the research needed to inform the closure plan. Mr Puhlovich advised that he has been requested by ERA management to map out all closure-related projects to 2020, and noted ERA's closure liability includes all costs right through to 2026. Dr Jones noted that significant work will be involved in setting the closure criteria and much of this work will be collaborative. He also noted that ERA would be embarking on specific closure workshops with stakeholders and that until this conversation has been held, getting agreed perspectives would be difficult.

Dr Hillman stressed the need for ARRTC to be thinking ahead of the process in terms of the data and knowledge needed to inform decision making. Dr Hillman suggested in relation to the decision to expand the LAA, for example, there may have been a range of data that ARRTC could have suggested be collected if it had anticipated this. Mr Evans agreed and noted this is why ARRTC is looking at setting priorities on the

revised KKNs. Dr Grant noted that previous attempts to prioritise the KKNs didn't work very well due to the complexity of the projects. Mr Evans asked when the updated ERA closure plan will be available. Mr Puhlovich advised that he had left this out of his report to allow the inclusion of Shell 50 considerations. Mr Evans suggested that ARRTC request an updated timeline for closure from ERA and that this inform the prioritisation of the revised KKNs. This was agreed.

**ARRTC21 Action/Outcome – 4G**

**ARRTC requested ERA to provide an updated closure timeline out of session as soon as is available and that this inform the prioritisation of the ARRTC KKNs.**

Mr Kyle raised his concerns about investing too many resources into the current closure model given this will obviously change with further proposals for expansion of the mine. Dr Jones noted that the need for scientific research will be ongoing and the focus of this research will change as the mining operation changes.

Dr Stauber advised she thought the *eriss* reporting approach was working well and that she found the update information very useful in keeping ARRTC members informed. She indicated that in relation to the toxicology projects she would like to see the planning for the Mn and sediments work. Dr Stauber also expressed concern regarding the reduced international publications from *eriss* over past few months but noted the time and resources required for this. She suggested the need to look at how ARRTC can assist in getting more of *eriss*'s work published. Dr Stauber noted that while ERA reporting has improved she would like to also see more results presented from ERA research – perhaps in a similar format to *eriss*. She noted that ARRTC may not always get to see the results of each project but does get the list of SSD publications at each meeting.

Mr Evans indicated he was pleased with the general level of reporting by *eriss* and ERA noting the need to cover a lot of detail at each meeting. He suggested that ARRTC commend *eriss* on the high quality of reporting and evolution over time and encouraged further cooperative work between ERA and *eriss*.

**ARRTC21 Action/Outcome – 4H**

**ARRTC commended *eriss* staff on the high quality of their reporting and general progress in their work.**

**ERA Work Program**

Mr Evans suggested that ARRTC note the improved timeliness and quality of ERA reporting and request ERA to adopt the reporting format current being used by *eriss*. He also suggested that ARRTC request that future ERA reports to March meetings include progress on current projects, and reports to October meetings include details of proposed projects for the following year. This was agreed.

**ARRTC21 Action/Outcome – 4I**

**ARRTC noted the improved quality and timeliness of ERA reporting and requested that ERA adopt the reporting format currently used by *eriss*.**

**ARRTC21 Action/Outcome – 4J**

**ARRTC requested that ERA reports to March meetings include progress on current projects and reports to October meetings include details of proposed projects.**

In relation to the work on ammonium removal as part of treatment of process and pond water, Mr Puhlovich advised that ERA was currently consulting CSIRO and other stakeholders in relation to the selection of suitable conservative ions for use as tracers to quantify seepage losses to groundwater from the CCWLF. He also advised that ERA was currently looking at installing a new water treatment plant.

Mr Evans asked whether the work on whole of mine site hydrogeology has been overtaken. Mr Puhlovich advised that ERA is keen to document the hydrology at Ranger and a report is currently being finalised. He indicated that the work had been difficult due to the amounts of data that needed to be sorted out.

Mr Evans asked Mr Puhlovich to identify the top five outputs from Ranger in terms of projects. Mr Puhlovich advised that work on the investigation of contaminated sites around Ranger was continuing and a position paper on status had been done. He advised that another wet season monitoring run was planned and the work had progressed to the stage where the project could commence. He advised that ERA is aware there is hydrocarbon contamination under the maintenance workshops and there is a plume of sulfate under the acid plant but these are of less concern because groundwater is flowing to Pit #3. Mr Puhlovich noted

that groundwater is moving slowly and there is a need for a strategy dealing with plumes. He advised that ERA made an assumption in the current version of the closure plan on the amount of contaminated soil to be stripped in the plant areas. Site assessment data are now available and will be incorporated into the next iteration of the closure model.

Mr Puhlovich advised that over the next six months, ERA would look to finalise the geo-tech study of the tailings in Pit#1. He advised that ANSTO has written a draft report which documents an important set of investigations which will guide the next stage of assessing long term closure requirements. He advised that Dr Turner was looking at surface/groundwater interactions and currently doing data review, and will commence development of a geochemical model in the second half of 2008 which will assist with predictions of long term seepage from the Pit. Mr Puhlovich advised that significant effort was being directed into progressing work on the demonstration landform which had involved difficult and complex interactions between stakeholders. He advised ERA was looking to get contractors to provide quotes to commence work in early April. Mr Puhlovich also advised that ERA has completed test pumping of groundwater bores downstream of the TSF to evaluate the possibility of recovery of the groundwater mound beneath the TSF. He noted that ERA has considerable data from tracer tests looking at the vertical extent of plume and has already got good knowledge of the horizontal movement. Mr Puhlovich noted the new LAA proposal was a big achievement and the work should be completed by next year.

Mr Evans asked whether there is a requirement for ERA to remediate the contamination of plant area immediately or later. Mr Puhlovich advised that ERA is under pressure from RioTinto to remediate it as soon as possible. Mr Evans asked whether there is an obligation under the Ranger ERs for ERA to clean up hydrocarbon spills as soon as possible. Mr Puhlovich advised that regardless of any statutory requirements, as a good corporate citizen ERA will clean up the contamination. Mr Hughes suggested that it could be argued that the Fox report and the ERs together place a requirement on ERA to clean up any contamination. Mr Puhlovich advised that the contamination may be difficult to totally clean up and that the key issue will be ensuring any risks to the environment are appropriately mitigated.

Mr Evans noted that Traditional Owners may have an expectation that any contamination be totally cleaned up. Mr Kyle advised that he generally advises TOs that if there is hydrocarbon contamination and it has been cleaned up, and there are no potential for impacts in the future, there should be no grounds for concern. He noted that any residual contamination would probably be self remediating due to soil microbial activity over the timeframes involved. Mr Kyle noted that as usual TOs probably wouldn't be concerned as long as decisions have been based on good science. Mr Puhlovich advised that some of the groundwater plumes require further modelling to ascertain what remedial actions will be required ranging from engineering intervention through to natural attenuation.

ARRTC noted the importance of science based regulatory decision making and agreed to include a standing agenda item for future meetings for DPIFM to present the scientific basis for regulatory decisions in the period since the last meeting.

**ARRTC21 Action/Outcome – 4K**  
**ARRTC agreed to include presentation by DPIFM on the science underpinning regulatory decisions since last meeting as a standing agenda item for future meetings.**

### **4.3 Hanson Pty Ltd (Nabarlek)**

Mr Ellsmore did not attend the meeting but tabled a brief report advising that Hanson Pty Ltd has completed the planting of 2000 trees during January 2008. Plant locations have been logged with a GPS and stakes. The supervisor for Demed Inc who managed the project has left that organisation and a replacement has not yet been appointed. Hanson Pty Ltd has contracted Mr Peter Christophersen from Kakadu Native Plants to oversee the site weed management plan going forward.

### **4.4 Department of Primary Industry, Fisheries & Mines**

Mr Ball advised that he had reviewed previous ARRTC minutes and sought advice on the form of report required. He suggested that there was little to report other than the changes in responsibilities between Worksafe and DPIFM has occurred and there is still some work required to resolve outstanding issues. In relation to current exploration activity, Mr Ball advised he wasn't aware of any new entrants in the north and most of the exploration focus is still on the south of the Territory.

Mr Hughes noted that DPIFM also normally reports on the science underpinning decisions by the MTC. Mr Ball referred members to the minutes of the Ranger, Jabiluka and Narbalek MTCs in the meeting papers. He noted that items included the change in date of the Ranger environment report, approval for raising the MOL

of the TSF to RL+48 and changes in the frequency and nature of data collected at Jabiluka. Mr Ball noted the Shell 50 application had been through MTC which had accepted advice from SSD and was awaiting further information from ERA. He noted the application for the WTP had been through the MTC and was with the Minister for decision, and the application to construct a new MF/RO plant was in the process of being considered by the MTC.

Mr Kyle noted that the Ranger authorisation was amended after Shell 12 and was approved with the proviso that any further change to the mine shall be subject to a Public Environmental Review. He noted that given DPIFM has provided undertaking that stakeholder comments will be reflected in future changes to Authorisations, stakeholder comments on the Shell 50 application will be reflected in the conditions attached to any approval to change the Authorisation. Mr Puhlovich suggested that it wasn't DPIFM's call whether it accepts or not. It was noted that a number of *eriss* scientists were also not happy about the proposal. Mr Hughes indicated that he wasn't sure what the basis for concern is given Shell 12 was approved in 2006. Mr Kyle advised that the main issue was that there were strong feelings put forward by stakeholders as part of the MTC process and these don't appear to be reflected in the paperwork. Mr Ball noted that the MTC has an important role to play but is only one of a number of sources of advice taken into account by the NT Minister in making his decisions. He advised that the Minister can and does seek advice from a variety of sources in making his decision including from stakeholders and scientific and policy advisors within his Department.

Mr Evans noted the relationship between ARRTC and MTC and level of reporting from MTC are two separate issues. Mr Kyle advised that he doesn't find MTC minutes very helpful. Mr Ball indicated that he also had some concerns about the level of detail of MTC minutes and is looking at instigating a different process for signing off on MTC decisions. For example, he suggested that it may be useful to append some of the comments received by DPIFM on MTC business to the minutes. Mr Evans noted that ARRTC's role is not to be a Board of Management for the MTC; however, as ARRTC's prime interest is in the science that underpins MTC decisions, the committee needs to be provided with sufficient detail to be able to formulate informed questions. Mr Puhlovich suggested that ARRTC would get more information from reading applications to the MTC and ERA/Stakeholder comments. He noted that a table with these details is generated for each MTC. Dr Stauber asked whether ARRTC gets to see applications to the MTC. It was noted that ERA was providing applications to ARRTC up until a year ago.

Mr Evans suggested there would be merit in exploring how to improve the relationship between ARRTC and the MTC. Prof Johnston suggested that someone like Mr McAllister could provide a short presentation to each meeting on the science underpinning each recommendation of the MTC. Mr Hughes suggested that it's up to DPIFM as the regulator to decide how to address ARRTC's information needs. Dr Barry asked how ARRTC would know when to ask for information. Mr Hughes noted that ARRTC currently sees information after regulatory decisions have been made. He suggested if DPIFM provides ARRTC with information on the science underpinning MTC decisions ARRTC can form a view regarding the quality and appropriateness of this science. Mr Evans noted that ARRTC's role is to advise the Federal Minister of the validity of the science underpinning regulatory decisions and has a limited if any formal role in the NT regulatory process. He noted that ARRTC gets good information on research projects but not on the regulatory decisions. Dr Barry noted that ARRTC is not currently able to see the underlying scientific research and the related regulatory decisions in an integrated way.

Mr Ball reminded members that the regulatory decision making body is not MTC but the NT Minister. He asked how ARRTC members would like to be more engaged in this process. Dr Stauber noted she found seeing the applications very useful in identifying the relevant scientific issues. Mr Hughes stated that it is ultimately up to ERA whether they are happy for ARRTC to see their applications to the MTC.

#### **4.5 Northern Land Council**

Mr Smith advised that NLC has sent a letter to DPIFM indicating that it would prefer to see further environmental assessment for Shell 50 approval. He advised that NLC has had to deal with the applications for the stockpile and possible expansion of the tailings dam separately. He advised that NLC does not have any specific concerns regarding the Shell 50 expansion, but believes that any expansion beyond that would start to pose a potential issue for the integrity of the Magela Creek. Mr Smith advised that if the mine is to expand further then there may be a need for a PER. He acknowledged that these matters were not directly an issue for ARRTC.

Mr Smith advised that most of the period since the ARRTC October meeting has been spent on statutory business. He mentioned that NLC had been involved in a survey of bores at Jabiluka and had developed a plan to use some of these bores for monitoring. Mr Puhlovich advised that there was general agreement about the merits of the groundwater monitoring project but this was subject to approvals from TOs. He

advised that ERA was currently developing a concept plan to monitor groundwater quality in the vicinity of the decline. Mr Smith advised that he understood this would form part of annual rehabilitation plan for Jabiluka and provide further useful data on groundwater movement at the site. Mr Smith advised that NLC has proposed closure criteria for Nabarlek and this was a matter for NLC and Hanson Pty Ltd to resolve, and the Nabarlek MTC.

Mr Smith advised that he was looking to address Traditional Knowledge as part of his Masters Thesis and he would also be looking at closure criteria, environmental impacts and legal aspects. Mr Smith asked ARRTC to indicate what it would like to get from this work. Mr Evans suggested that ARRTC would be interested in Mr Smith's views on concrete actions to move the process forward. Mr Smith advised the main thrust of his studies will be to look at how to better integrate traditional knowledge into the regulatory process and offered to provide some feedback at the October meeting. Mr Kyle noted that the TOs see this work as a translation tool.

**ARRTC21 Action/Outcome – 4L**

**ARRTC agreed that Mr Smith would provide a presentation on activities to integrate Traditional Knowledge into the regulatory process at a future meeting.**

#### **4.6 Parks Australia North**

No representative from PAN attended the meeting and no report was tabled. Mr Hughes noted that it was agreed at the last ARRTC meeting that PAN would provide a report to the October 2008 meeting. PAN has done works at Coronation Hill and Guratba by removing drill benches and has almost completed removing primary rock and putting it back into Pit. Mr Hughes advised he had inspected the project and looked like a good job. He advised that other minor bunding work was being completed to make the site safe which didn't require any higher level of remediation.

#### **4.7 Minesite Technical Committee (MTC) informed regulatory decisions - DPIFM**

Mr Ball advised members that the minutes of the Ranger, Narbalek and Jabiluka Minesite Technical Committees were in the meeting papers provided by DPIFM.

### **5 SSD Communication Activities**

Dr Stauber expressed concern about the need for more international peer review and publishing of *eriss* research. Dr Jones noted Dr Stauber's concerns and indicated that *eriss* staff needed to strike a balance between allocating time and resources to doing the required operational monitoring and research and writing up papers for journal publication. Mr Hughes indicated that he was not aware that this was an issue but thanked ARRTC for raising and agreed that this would assist in maintaining *eriss*'s scientific credibility.

Mr Evans noted ARRTC was generally of the view that international publishing of papers is a good measure of the quality of *eriss* science. Prof Johnston suggested that a greater level of publishing in international journals would assist *eriss* in winning and attracting government grant funding. Dr Barry suggested the need to be strategic in terms of research topics to ensure credibility and underpin the perception of *eriss* as a world class scientific research institute. Dr Jones suggested the work on radium uptake by mussels was a case in point of world class research.

Mr Evans suggested the need to publish in international journals applies equally to EWL Sciences and asked whether there is scope for EWL Sciences to do more publishing in the international literature. Mr Puhlovich indicated that the value of publishing the result of its scientific endeavors was well recognised internally but commercial factors would always be an overriding consideration. Prof Johnston noted it is clear that the new Australian Government sees the quality of publications as a key measure of the quality of science being done.

### **6 Other Business**

There was no other business raised.

### **7 Next Meeting**

Mr Kyle advised that he wasn't able to make a commitment about linking next meeting with Minister Garrett's visit. Mr Hughes suggested having a fall-back date for the next meeting. ARRTC agreed that the next meeting would be held in Darwin, 22 – 24 October 2008, starting lunchtime Wednesday and finishing

lunchtime Friday. Mr Evans thanked all SSD and ERA staff for their efforts in ensuring the success of the meeting and ARRTC fieldtrip to Ranger.

***ARRTC21 Action/Outcome – 7A  
ARRTC thanked all SSD and ERA staff responsible for arranging the March meeting and fieldtrip for their efforts.***

Meeting was closed at 5.00pm

ARRTC21 Draft Actions/Outcomes

No.	Action/Outcomes	Responsibility
1A	ARRTC Secretariat to ascertain what confidentiality provisions apply to ARRTC and advise members out of session.	ARRTC Secretariat
2A	ARRTC approved the ARRTC20 Summary Record with a number of minor changes.	ARRTC
2B	ARRTC agreed to record its concerns that finalisation of EWLS' sediment monitoring report has been further delayed despite ARRTC's requests for information	ARRTC
2C	ARRTC agreed that EWLS would provide the report on sediment monitoring work by end of May 2008, and failing this, the Chair would write to the Minister outlining ARRTC's concerns about the continuing delay.	ERA – Mr Puhlovich
3A	Dr Hillman to provide additional words for KKN 1.2.3.	Dr Hillman
3B	ARRTC agreed to create a new KKN 2.1 titled "Defining the reference state and baseline data".	ARRTC
3C	ARRTC agreed to create a new sub-heading of <u>2.2 Landform</u> under <u>Section 2. Ranger rehabilitation</u>	ARRTC
3D	ARRTC agreed to delete KKN 6.0 and add a new standing item on the ARRTC agenda titled "Communications and Knowledge Management".	ARRTC
3E	ARRTC agreed the ARRTC Secretariat would seek advice from SSD, EWLS and stakeholders on the prioritisation of the KKNs for short, medium and long term issues with supporting information, and to consider this at the next meeting.	ARRTC Secretariat
3F	ARRTC agreed the revised KKNs would be circulated with the draft ARRTC21 minutes.	ARRTC Secretariat
3G	ARRTC agreed the Chair and Mr Hughes would review, and update where necessary, the preamble to the KKNs and this be circulated with the draft Minutes following ARRTC21.	Mr Evans; Mr Hughes
3H	ARRTC agreed that the Chair would attach the revised KKNs to his letter to the Minister on the outcomes of ARRTC21.	Mr Evans
4A	ARRTC supports Dr Lu's project on radiological characterisation of the LAAs and is pleased that ERA has funded the project.	ARRTC
4B	ARRTC noted ERA's proposed approach for the landform planning and requested that ARRTC be formally consulted by ERA in relation to the design and implementation of the demonstration landform project.	ERA – Mr Puhlovich
4C	ARRTC agreed eriss would contact Dr Grant once the additional soil analyses have been completed and will report this at next meeting.	Eriss – Dr Jones
4D	ARRTC agreed that Mr Puhlovich would take recommendations arising from the Ecological Risk Assessment work to ERA management and report back to next meeting.	ERA – Mr Puhlovich
4E	ARRTC requested ERA to calculate likely volumes of laterite available between now and closure in terms of future cover requirements and ensure that these calculation inform future projects.	ERA – Mr Puhlovich
4F	ARRTC asked eriss and ERA to provide a report on ERA work on characterisation of leachate from waste rock to next meeting.	Eriss – Dr Jones; ERA – Mr Puhlovich
4G	ARRTC requested ERA to provide an updated closure timeline and that this inform the prioritisation of the ARRTC KKNs.	ERA – Mr Puhlovich
4H	ARRTC commended eriss staff on the high quality of their reporting and general progress in their work.	ARRTC
4I	ARRTC noted the improved quality and timeliness of ERA reporting and requested that ERA adopt the reporting format currently used by eriss.	ERA – Mr Puhlovich
4J	ARRTC requested that ERA reports to March meetings include progress on current projects and reports to October meetings include details of proposed projects.	ERA – Mr Puhlovich
4K	ARRTC agreed to include presentation by DPIFM on the science underpinning regulatory decisions since last meeting as a standing agenda item for future meetings.	ARRTC
4L	ARRTC agreed that Mr Smith would provide a presentation on activities to integrate Traditional Knowledge into the regulatory process at a future meeting.	Mr Smith
7A	ARRTC thanked all SSD and ERA staff responsible for arranging the March meeting and fieldtrip for their efforts.	ARRTC

## ALLIGATOR RIVERS REGION TECHNICAL COMMITTEE

### **Key Knowledge Needs 2008-2010 – Uranium Mining in the Alligator Rivers Region**

#### **Overall objective:**

To undertake relevant research that will generate knowledge leading to improved management and protection of the ARR and monitoring that will be sufficiently sensitive to assess whether or not the environment is protected to the high standard demanded by the Australian Government and community.

#### **Background**

In assessing the Key Knowledge Needs for research and monitoring in the Alligator Rivers Region, ARRTC has taken into account current mining plans in the region and the standards for environmental protection and rehabilitation determined by the Australian Government. The assumptions made for uranium mining operations in the region are:

- mining of uranium at Ranger is expected to cease in about 2012. Extraction of ore at Pit#3 will be restricted to the current 2008 plan controlled by the Shell 50 application. This will be followed by milling until about 2020 and final rehabilitation is expected to be completed by about 2026;
- Nabarlek is decommissioned but has not reached a status where the NT Government will agree to issue a Revegetation Certificate to the mine operator. Assessment of the success of rehabilitation at Nabarlek is ongoing and may provide valuable data for consideration in the design and implementation of rehabilitation at Ranger;
- Jabiluka will remain in a care and maintenance condition for some years. ERA, the project owner, has stated that further mining will not occur without the agreement of the traditional owners; and
- grant of an exploration title at Koongarra is required under the terms of the *Aboriginal Land Rights (Northern Territory) Act 1976* before the mining company can apply for a mining title. As such, any future activity at Koongarra is subject to the agreement of the traditional owners and the Northern Land Council.

This scenario is considered to be a reasonable basis on which to base plans for research and monitoring, but such plans may need to be amended if mining plans change in the future. ARRTC will ensure the research and monitoring strategy is flexible enough to accommodate any new knowledge needs.

The Australian Government has specified Primary and Secondary environmental objectives for mining at Ranger in the Ranger Environmental Requirements. Similar standards would be expected for any future mining development at Jabiluka or Koongarra.

Specifically, under the Ranger Environmental Requirements (ERs):

*The company must ensure that operations at Ranger are undertaken in such a way as to be consistent with the following primary environmental objectives:*

- (a) maintain the attributes for which Kakadu National Park was inscribed on the World Heritage list;*
- (b) maintain the ecosystem health of the wetlands listed under the Ramsar Convention on Wetlands (i.e. the wetlands within Stages I and II of Kakadu National Park);*
- (c) protect the health of Aboriginals and other members of the regional community; and*
- (d) maintain the natural biological diversity of aquatic and terrestrial ecosystems of the Alligator Rivers Region, including ecological processes.*

With respect to rehabilitation at Ranger, the ERs state that:

*The company must rehabilitate the Ranger Project Area to establish an environment similar to the adjacent areas of Kakadu National Park such that, in the opinion of the Minister with the advice of the Supervising Scientist, the rehabilitated area could be incorporated into the Kakadu National Park.*

The ERs go on to specify the major objectives of rehabilitation at Ranger as follows:

- (a) revegetation of the disturbed sites of the Ranger Project Area using local native plant species similar in density and abundance to those existing in adjacent areas of Kakadu National Park, to form an ecosystem the long term viability of which would not require a maintenance regime significantly different from that appropriate to adjacent areas of the park;*

*(b) stable radiological conditions on areas impacted by mining so that, the health risk to members of the public, including traditional owners, is as low as reasonably achievable; members of the public do not receive a radiation dose which exceeds applicable limits recommended by the most recently published and relevant Australian standards, codes of practice, and guidelines; and there is a minimum of restrictions on the use of the area;*

*(c) erosion characteristics which, as far as can reasonably be achieved, do not vary significantly from those of comparable landforms in surrounding undisturbed areas.*

A secondary environmental objective applies to water quality and is linked to the primary ERs. This ER states:

*The company must not allow either surface or ground waters arising or discharging from the Ranger Project Area during its operation, or during or following rehabilitation, to compromise the achievement of the primary environmental objectives.*

While there are many possible different structures that could be used to specify the Key Knowledge Needs, ARRTC has chosen to list the knowledge needs under the following headings:

- Ranger – current operations;
- Ranger – rehabilitation;
- Jabiluka;
- Nabarlek; and
- General Alligator Rivers Region.

***Key Knowledge Needs 2008 – 2010 – Uranium Mining in the Alligator Rivers Region*** is based on and supersedes a predecessor document, ***Key Knowledge Needs 2004 – 2006 – Uranium Mining in the Alligator Rivers Region***. KKNs 2004 – 2006 remained the operative set during their review and the development of KKNs 2008 – 2010.

While some KKNs remain essentially unchanged, others contain revised elements or are new in their entirety. Care should be exercised if using KKN numbers alone as a reference because some continuing KKNs have changed numbers in the revised document.

## 1. RANGER – CURRENT OPERATIONS

### 1.1 Reassess existing threats

#### **1.1.1 Surface water transport of radionuclides**

Using existing data, assess the present and future risks of increased radiation doses to the Aboriginal population eating bush tucker potentially contaminated by the mining operations bearing in mind that the current Traditional Owners derive a significant proportion of their food from bush tucker.

#### **1.1.2 Atmospheric transport of radionuclides**

Using existing data and atmospheric transport models, review and summarise, within a risk framework, dose rates for members of the general public arising from operations at the Ranger mine.

### 1.2 Ongoing operational issues

#### **1.2.1 Ecological risks via the surface water pathway**

Off-site contamination during mine operation (and subsequent to decommissioning – refer KKN 2.6.1) should be placed in a risk-based context. A conceptual model of the introduction, movement and distribution of contaminants, and the resultant biotic exposure (human and non-human) has been developed, and the ecological risks (i.e. probability of occurrence x severity of consequence) of some of the contaminant/pathway sub-models have been estimated. This process should be completed for all the contaminant/pathway sub-models, noting, however, that the level of effort for each needs to be proportionate to the level of concern of the issue- It is critical that robust risk assessment methodologies are used, and that they explicitly incorporate uncertainty in both the assessment and subsequent decision making processes. Where ecological risk is significant, additional information may be required (eg. mass-balance and concentration dynamics, consideration of possible interactive effects, field data). Further, knowledge gaps preventing reasonable estimation of potential risks (i.e. with unacceptable uncertainty) must be filled.

The Magela floodplain risk assessment framework developed to estimate and compare mining and non-mining impacts should be revisited periodically, and updated to the current risk profile. It should be revised in the event that either **(i)** the annual monitoring program or other sources indicate that the inputs from mining have significantly increased relative to the situation in 2005, or **(ii)** an additional significant contaminant transport pathway from the minesite is identified, or **(iii)** there is a change in external stressors that could result in a significant increase in likelihood of impacts from the site.

#### **1.2.2 Land irrigation**

Investigations are required into the storage and transport of contaminants in the land irrigation areas particularly subsequent to decommissioning. Contaminants of interest/concern in addition to radionuclides are magnesium, sulfate and manganese. Results from these investigations should be sufficient to quantify the role of irrigation areas as part of satisfying KKN 1.2.1, and form the basis for risk management into the future.

#### **1.2.3 Wetland filters**

The key research issue associated with wetland filters in relation to ongoing operations is to determine whether their capacity to remove contaminants from the water column will continue to meet the needs of the water management system in order to ensure protection of the downstream environment. Aspects of contaminant removal capacity include (i) instantaneous rates of removal, (ii) temporal performance – including time to saturation, and (iii) behaviour under 'breakdown' conditions - including future stability after closure. Related to this is a reconciliation of the solute mass balance particularly for the Corridor Creek System (see KKN 1.2.5).

#### **1.2.4 Ecotoxicology**

Past laboratory studies provide a significant bank of knowledge regarding the toxicity of two of the major contaminants, uranium and magnesium, associated with uranium mining in the ARR. Further studies are scheduled to assess (i) the toxicity of manganese and, potentially, ammonia (in the event that permeate produced by process water treatment will contain potentially toxic ammonia concentrations), and (ii) the relationship between dissolved organic matter and uranium toxicity. This knowledge should continue to be synthesised and interpreted, within the existing risk assessment framework (refer KKN 1.2.1), as it comes to hand.

An additional issue that needs to be addressed is the direct and indirect effects on aquatic biota of sediment arising from the mine site. In the first instance, a conceptual model needs to be developed (building on the relevant components of the conceptual model developed under KKN 1.2.1) that describes the movement of sediment within the creek system, including the associated metal-sediment interactions and biological implications. Studies likely to arise from the outcomes of the conceptual model include:

- the effects of suspended sediment on aquatic biota;
- the relationship between suspended sediment and key metals, and how this affects their bioavailability and toxicity; and
- the effects of sediment-bound metals on benthic biota, including, initially, a review of existing information on uranium concentrations in sediments of waterbodies both on- and off the Ranger site, and uranium sediment toxicity to freshwater biota.

Whilst of relevance at present, the above issues will be of additional importance as Ranger progresses towards closure and rehabilitation (refer KKN 2.6.1). Finally, the need for studies to assess the toxicity of various mine waters (treated and untreated) in response to specific supervisory/regulatory or operational requirements is likely to continue.

### **1.2.5 Mass Balances and Annual Load Limits**

With the expansion of land application areas and the increase in stockpile sheeting that has occurred in concert with the expansion of the footprints of the waste rock dumps and low grade ore stockpiles, it is becoming increasingly important to develop a solute mass balance for the site – such that the behaviour of major solute source terms and the spatial and temporal contribution of these sources to water quality in Magela Creek can be clearly understood. Validated grab sample and continuous data records are needed to construct a high reliability solute mass balance model.

Related to mass balance is the issue of specifying allowable annual load limits from the site – as part of the site's regulatory requirements. The technical basis for these load limits needs to be reviewed since they were originally developed decades ago. There has since been significantly increased knowledge of the environmental geochemistry of the site, a quantum increase in knowledge about ecotoxicological sensitivity of the aquatic systems and updated data on the diet profile of traditional owners.

## **1.3 Monitoring**

### **1.3.1 Surface water, groundwater, chemical, biological, sediment, radiological monitoring**

Routine and project-based chemical, biological, radiological and sediment monitoring should continue, together with associated research of an investigative nature or necessary to refine existing, or develop new (promising) techniques and models. A review of current water quality objectives for Ranger should be conducted to determine if they are adequate for future water management options for the whole-of-site, including the closure and rehabilitation phase (KKN 2.2.1 and KKN 2.2.2).

ARRTC supports the design and implementation of a risk-based radiological monitoring program based on a robust statistical analysis of the data collected over the life of Ranger necessary to provide assurance for Aboriginal people who source food items from the Magela Creek system downstream of Ranger.

## **2. RANGER – REHABILITATION**

### **2.1 Reference state and baseline data**

#### **2.1.1 Defining the reference state and baseline data**

There is a requirement to define the baseline data/reference state that existed at the Ranger site prior to development. This will inform the process of the development of closure criteria which is compatible with the Environmental Requirements. The knowledge need is to develop and perform analysis to generate agreed reference data that cover the range of pre-mining and operational periods.

### **2.2 Landform**

#### **2.2.1 Landform design**

An initial design is required for the proposed final landform. This would be based upon the optimum mine plan from the operational point of view and it would take into account the broad closure criteria, engineering considerations and the specific criteria developed for guidance in the design of the landform. This initial landform would need to be optimised using the information obtained in detailed water quality, geomorphic, hydrological and radiological programs listed below.

Current and trial landforms at Ranger and at other sites such as Nabarlek should be used to test the various models and predictions for water quality, geomorphic behaviour and radiological characteristics at Ranger. The detailed design for the final landform at Ranger should be determined taking into account the results of the above research programs on surface and ground water, geomorphic modelling and radiological characteristics.

#### **2.2.2 Development and agreement of closure criteria from the landform perspective**

Closure criteria from the landform perspective need to be established at both the broad scale and the specific. At the broad scale, agreement is needed, particularly with the Traditional Owners and within the context of the objectives for rehabilitation incorporated within the ERs, on the general strategy to be adopted in constructing the final landform. These considerations would include issues such as maximum height of the landform, the maximum slope gradient (from the aesthetic perspective), and the presence or absence of lakes or open water. At the specific scale, some criteria could usefully be developed as guidance for the initial landform design such as slope length and angle (from the erosion perspective), the minimum cover required over low grade ore, and the minimum distance of low grade ore from batter slopes. Specific criteria are needed that will be used to assess the success of landform construction. These would include, for example, maximum radon exhalation and gamma dose rates, maximum sediment delivery rates, maximum constituent concentration rates in runoff and maximum settling rates over tailings repositories.

#### **2.2.3 Water quality in seepage and runoff from the final landform**

Existing water quality monitoring and research data on surface runoff and subsurface flow need to be analysed to develop models for the quality of water, and its time dependence, that would enter major drainage lines from the initial landform design. Options for adjusting the design to minimise solute concentrations and loads leaving the landform need to be assessed.

There is a need to develop and analyse conceptual models of mine related turbidity and salinity impacts following closure. These models could be analysed in a variety of ways, as a precursor to the development of a quantitative model of potential turbidity and salinity impacts offsite caused by surface and subsurface water flow off the rehabilitated mine site. This analysis should explicitly acknowledge knowledge uncertainty (e.g. plausible alternative conceptual models) and variability (e.g. potential for Mg/Ca ratio variations in water flowing off the site) and explore the potential ramifications of the off-site impacts. (see also KKN 2.6.1)

#### **2.2.4 Geomorphic behaviour and evolution of the landscape**

The existing data set used in determination of the key parameters for geomorphological modelling of the proposed final landform should be reviewed after consideration of the near surface characteristics of the initial proposed landform. Further measurements of erosion characteristics should be carried out if considered necessary. The current site-specific landform evolution models should be applied to the initial proposed landform to develop predictions for long term erosion rates, incision and gully rates, and sediment delivery rates to the surrounding catchments. Options for adjusting the design to minimise erosion of the landform need to be assessed. In addition, an assessment is needed of the geomorphic stability of the Ranger mine site with respect to the erosional effects of extreme events.

#### **2.2.5 Radiological characteristics of the final landform**

The characteristics of the final landform from the radiological exposure perspective need to be determined and methods need to be developed to minimise radiation exposure to ensure that restrictions on access to the land are minimised. Radon exhalation rates, gamma dose rates and radionuclide concentrations in dust need to be determined and models developed for both near-field and far-field exposure.

The use of potential analogue sites for establishing pre-mining radiological conditions at Ranger should be further investigated to provide information on parameters such as pre-mining gamma dose rates, radon exhalation rates, and levels of radioactivity in dust. This information is needed to enable estimates to be made of the likely change in radiation exposure when accessing the rehabilitated site compared to pre-mining conditions.

### **2.3 Groundwater dispersion**

#### **2.3.1 Containment of tailings and other mine wastes**

The primary method for protection of the environment from dispersion of contaminants from tailings and other wastes will be containment. For this purpose, investigations are required on the hydrogeological integrity of the pits, the long-term geotechnical properties of tailings and waste rock fill in mine voids, tailings deposition and transfer (including TD to Pit #3) methods, geochemical and geotechnical assessment of potential barrier materials, and strategies and technologies to access and 'seal' the surface of the tailings mass, drain and dispose of tailings porewater, backfill and cap the remaining pit void.

#### **2.3.2 Geochemical characterisation of source terms**

Investigations are needed to characterise the source term for transport of contaminants from the tailings mass in groundwater. These will include determination of the permeability of the tailings and its variation through the tailings mass, strategies and technologies to enhance settled density and accelerate consolidation of tailings, and pore water concentrations of key constituents.

There is a specific need to address the existence of groundwater mounds under the tailings dam and waste rock stockpiles. Models are needed to predict the behaviour of groundwater and solute transport in the vicinity of these mounds and options developed for their remediation to ensure that on-site revegetation can be achieved and that off-site solute transport from the mounds will meet environmental protection objectives. Assessment is also needed of the effectiveness (cost and environmental significance) of paste and cementation technologies for increasing tailings density and reducing the solubility of chemical constituents in tailings.

#### **2.3.3 Aquifer characterisation and whole-of-site model**

The aquifers surrounding the tailings repositories (Pits 1 & 3) need to be characterised to enable modelling of the dispersion of contaminants from the repositories. This will involve geophysics surveys, geotechnical drilling and groundwater monitoring and investigations on the interactions between the deep and shallow aquifers.

#### **2.3.4 Hydrological/hydrogeochemical modelling**

Predictive hydrological/hydrogeological models need to be developed, tested and applied to assess the dispersion of contaminants from the tailings repositories over a period of 10 000 years. These models will be used to assess whether all relevant and appropriate factors have been considered in designing and constructing an in-pit tailings containment system that will prevent environmental detriment in the long term.

### **2.4 Water treatment**

#### **2.4.1 Active treatment technologies for specific mine waters**

Substantial volumes of process water retained at Ranger in the tailings dam and Pit 1 must be disposed of by a combination of water treatment and evaporation during the mining and milling phases of the operation and during the rehabilitation phase. Research priorities include treatment technologies and enhanced evaporation technologies that can be implemented for very high salinity process water. A priority should be evaluation of the potential impact of treatment sludge and brine streams on long term tailings chemistry in the context of closure planning and potential post closure impacts on water quality.

#### **2.4.2 Passive treatment of waters from the rehabilitated landform**

Sentinel wetlands may form part of the final landform at Ranger. Research on wetland filters during the operational phase of mining will provide information relevant to this issue. Research is needed to establish the effect of wet-dry seasonal cycling on contaminant retention and release, since this aspect will influence design criteria and whether such wetlands should be maintained as ephemeral or perennial waterbodies. There is also the need to assess the long-term behaviour of the physical and biotic components of the wetlands, their ecological health, and the extent of contaminant accumulation (both metals and radionuclides) in the context of potential human exposure routes.

### **2.5 Ecosystem establishment**

#### **2.5.1 Development and agreement of closure criteria from ecosystem establishment perspective**

Closure criteria need to be established for a range of ecosystem components including surface water quality, flora and fauna. The environmental requirements provide some guidance but characterisation of the analogue ecosystems will be an important step in the process. Consultation on closure criteria with the traditional owners has commenced and it is important that this process continues as more definitive criteria are developed.

#### **2.5.2 Characterisation of terrestrial and aquatic ecosystem types at analogue sites**

Identification and characterisation of analogue ecosystems (target habitats) can assist in defining the rehabilitation objective and developing robust, measurable and ecologically-based closure criteria. The concept of using analogue ecosystems for this purpose has been accepted by ARRTC and the traditional owners. Substantial work has been undertaken on the Georgetown terrestrial analogue ecosystem while there is also a large body of information available on aquatic analogues, including streams and billabongs. Future work on the terrestrial analogue needs to address water and nutrient dynamics, while work on the aquatic analogue will include the development of strategies for restoration of degraded or removed natural water bodies, Coonjimba and Djalkmara, on site.

#### **2.5.3 Establishment and sustainability of ecosystems on mine landform**

Research on how the landform, terrestrial and aquatic vegetation, fauna, fauna habitat, and surface hydrology pathways will be reconstructed to address the Environmental Requirements for rehabilitation of the disturbed areas at Ranger is essential. Trial rehabilitation research sites should be established that demonstrate an ability by the mine operator to be able to reconstruct terrestrial and aquatic ecosystems, even if this is at a relatively small scale. Rehabilitation establishment issues that need to be addressed include species selection; seed collection, germination and storage; direct seeding techniques; propagation of species for planting; fertiliser strategies and weathering properties of waste rock. Rehabilitation management issues requiring investigation include the stabilisation of the land surface to erosion by establishment of vegetation, return of fauna; the exclusion of weeds; fire management and the re-establishment of nutrient cycles. The sustainable establishment and efficiency of constructed wetland filters, reinstated waterbodies (e.g. Djalkmara Billabong) and reconstructed waterways also needs to be considered (see KKN 2.3.2).

#### **2.5.4 Radiation exposure pathways associated with ecosystem re-establishment**

Radionuclide uptake by terrestrial plants and animals on the rehabilitated ecosystem may have a profound influence on the potential utilisation of the land by the traditional owners. Significant work has been completed on aquatic pathways, particularly the role of freshwater mussels, and this now forms part of the annual monitoring program. The focus is now on the terrestrial pathways and deriving concentration factors for Bushtucker such as wallabies, fruits and yams. A project investigating the contemporary diet of traditional owners has commenced and needs to be completed. Models need to be developed that allow exposure pathways to be ranked for currently proposed and future identified land uses, so that identified potentially significant impacts via these pathways can be limited through appropriate design of the rehabilitation process.

### **2.6 Monitoring**

#### **2.6.1 Monitoring of the rehabilitated landform**

A new management and monitoring regime for the rehabilitated Ranger landform needs to be developed and implemented. It needs to address all relevant aspects of the rehabilitated landform including ground and surface water quality, radiological issues, erosion, flora, fauna, weeds, and fire. The monitoring regime should address the key issues identified by the ecological risk assessment of the rehabilitation phase (KKN 2.7.1).

#### **2.6.2 Off-site monitoring during and following rehabilitation**

Building upon the program developed and implemented for the operational phase of mining, a monitoring regime is also required to assess rehabilitation success with respect to protection of potentially impacted ecosystems and environmental values. This program should address the dispersion of contaminants by surface water, ground

water and via the atmosphere. The monitoring regime should address the key issues identified by the ecological risk assessment of the rehabilitation phase (KKN 2.7.1).

## **2.7 Risk assessment**

### **2.7.1 Ecological risk assessments of the rehabilitation and post rehabilitation phases**

In order to place potentially adverse on-site and off-site issues at Ranger during the rehabilitation phase within a risk management context, it is critical that a robust risk assessment framework be developed with stakeholders. The greatest risk is likely to occur in the transition to the rehabilitation phase, when active operational environmental management systems are being progressively replaced by passive management systems. A conceptual model of transport/exposure pathways should be developed for rehabilitation and post rehabilitation regimes and the model should recognise the potential that some environmental stressors from the mine site could affect the park and vice versa. Implicit in this process should be consideration of the effects of extreme events and climate change.

Conceptual modelling should be followed by a screening process to identify and prioritise key risks for further qualitative and/or quantitative assessments. The conceptual model should be linked to closure criteria and post-rehabilitation monitoring programs, and be continually tested and improved. Where appropriate, risk assessments should be incorporated into decision making processes for the closure plan. Outputs and all uncertainties from this risk assessment process should be effectively communicated to stakeholders.

## **2.8 Stewardship**

The concept of Stewardship (including ownership and caring for the land) is somewhat broader and applies to all phases of, in this case, uranium mining. In this context it is considered to be the post closure phase of management of the site, i.e. after relinquishment of the lease. If the rehabilitation phase is successful in meeting all objectives then this stewardship will effectively comprise an appropriate level of ongoing monitoring to confirm this. Should divergence from acceptable environmental outcomes be detected then some form of intervention is likely to be required. The nature, responsibility for, and duration of, the monitoring and any necessary intervention work remains to be determined.

### 3. JABILUKA

#### **3.1 Monitoring**

##### **3.1.1 Monitoring during the care and maintenance phase**

A monitoring regime for Jabiluka during the care and maintenance phase needs to be implemented and regularly reviewed. The monitoring program (addressing chemical, biological, sedimentological and radiological issues) should be commensurate with the environmental risks posed by the site, but should also serve as a component of any program to collect baseline data required before development such as meteorological and sediment load data.

#### **3.2 Research**

##### **3.2.1 Research required prior to any development**

A review of knowledge needs is required to assess minimum requirements in advance of any development. This review would include radiological data, the groundwater regime (permeabilities, aquifer connectivity etc), hydrometeorological data, waste rock erosion, assess site-specific ecotoxicology for uranium, and additional baseline for flora and fauna surveys.

### 4. NABARLEK

#### **4.1 Success of revegetation**

##### **4.1.1 Revegetation assessment**

Several assessments of the revegetation at Nabarlek have been undertaken; the most recent being completed by ERISS. There is now general agreement that the rehabilitated areas require further work. Revised closure criteria are currently being developed through the mine-site technical committee and these should be reviewed by relevant stakeholders, including ARRTC. The required works should then be completed on site with further monitoring leading to the relinquishment of the lease.

##### **4.1.2 Development of revegetation monitoring method**

A methodology and monitoring regime for the assessment of revegetation success at Nabarlek needs to be developed and implemented. Currently, resource intensive detailed vegetation and soil characterisation assessments along transects located randomly within characteristic areas of the rehabilitated landform are being undertaken. Whilst statistically valid, these assessments cover only a very small proportion of the site. Remote sensing (satellite) data are also being collected and the efficacy of remote sensing techniques for vegetation assessment in comparison to ground survey methods should continue. The outcomes of this research will be very relevant to Ranger.

#### **4.2 Assessment of radiological, chemical and geomorphic success of rehabilitation**

##### **4.2.1 Overall assessment of rehabilitation success at Nabarlek**

The current program on erosion, surface water chemistry, groundwater chemistry and radiological issues should be continued to the extent required to carry out an overall assessment of the success of rehabilitation at Nabarlek. In particular, all significant radiological exposure pathways should be identified and a comprehensive radiation dose model developed. Additional monitoring of ground water plumes is required to allow assessment of potential future groundwater surface water interaction and possible environmental effects.

### 5. GENERAL ALLIGATOR RIVERS REGION

#### **5.1.1 Develop a landscape-scale ecological risk assessment framework for the Magela catchment that incorporates, and places into context, uranium mining activities and relevant regional landscape processes and threats, and that builds on previous work for the Magela floodplain**

Ecological risks associated with uranium mining activities in the ARR, such as current operations (Ranger) and rehabilitation (Nabarlek, Jabiluka, future Ranger, South Alligator Valley), should be assessed within a landscape analysis framework to provide context in relation to more diffuse threats associated with large-scale ecological disturbances, such as invasive species, unmanaged fire, cyclones and climate change. Most key landscape processes occur at regional scales, however the focus will be on the Magela catchment encompassing the RPA. A conceptual model should first be developed to capture links and interactions between multiple risks and assets at multiple scales within the Magela catchment, with risks associated with Ranger mining activities made explicit. The spatially explicit Relative Risk Model will be used to prioritise multiple risks for further qualitative and/or quantitative assessments. The conceptual model and risk assessment framework should be continually tested and improved as part of Best Practice. Where appropriate, risk assessments should be incorporated into decision making processes using advanced risk assessment frameworks such as Bayesian Networks, and all uncertainties made explicit. This risk assessment process should integrate outputs from KKN 1.2.1 (risks from the surface water pathway – Ranger current operations) and the new KKN 2.6.1 (risks associated with rehabilitation) to provide a landscape-scale context for the rehabilitation of Ranger into Kakadu National Park, and should be communicated to stakeholders.

## **5.2 South Alligator River valley rehabilitation**

### **5.2.1 Assessment of past mining and milling sites in the South Alligator River valley**

SSD conducts regular assessments of the status of mine sites in the SAR valley, provides advice to Parks Australia on technical issues associated with its rehabilitation program and conducts a low level radiological monitoring program. This work should continue.

## **5.3 Develop monitoring program related to West Arnhem Land exploration activities**

### **5.3.1 Baseline studies for biological assessment in West Arnhem Land**

ARRTC believes there is a need to determine a baseline for (a) rare, threatened and endemic biota and (b) indicator species or groups such as macroinvertebrates in areas where advanced exploration or proposed mining projects are identified and in line with the current approvals process under the Aboriginal Land Rights Act.

## **5.4 Koongarra**

### **5.4.1 Baseline monitoring program for Koongarra**

In line with the current approvals process under the Aboriginal Land Rights Act, a low level monitoring program should be developed for Koongarra to provide baseline data in advance of any possible future development at the site. Data from this program could also have some relevance as a control system for comparison to Ranger, Jabiluka and Nabarlek.