supervising scientist report 171

Evaluation of alleged deficiencies in management of the Ranger Uranium Mine between 1996 and 1998

Supervising Scientist &
Northern Territory Department of Business, Industry and Resource Development

Environment Australia
Department of the Environment and Heritage

supervising scientist

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Executive summary

On 5 April 2002, Mr Geoffrey Kyle, a former employee of Energy Resources of Australia Limited (ERA) at Ranger Uranium Mine's Environmental Laboratory, wrote to the Commonwealth Minister for Environment and Heritage, the Northern Territory Minister for Resource Development and a number of Commonwealth and Northern Territory officials. In his letter and attached report, Mr Kyle expressed concern about a number of issues relating to environmental management and reporting by ERA at the Ranger mine between 1996 and 1998.

At the request of the above Ministers, an investigation of the issues raised by Mr Kyle has been carried out.

The investigation was undertaken jointly by the staff of the Supervising Scientist Division (SSD) and of the Northern Territory Department of Business, Industry and Resource Development (NTDBIRD). A detailed search of files and reports held by SSD, Energy Resources of Australia (ERA) and NTDBIRD was conducted to establish, as far as is now possible, the circumstances surrounding the events referred to by Mr Kyle. Field visits were also conducted to determine the current situation at the relevant sites and discussions were held with current ERA staff. In addition, interviews were conducted with a number of former staff of ERA and with one former ***oss*** employee to determine their recollections and account of events. Mr Kyle was also interviewed to allow him to present further information and to clarify information presented in his report.

Tailings spill in Corridor Road

In December 1997, a tailings spill occurred at Ranger. With respect to this incident, Mr Kyle alleged in his report that ERA under-reported and mis-reported the extent of the spillage outside the Restricted Release Zone (RRZ), failed to clean up in a timely manner the spilled tailings material within the RRZ, and, by its inaction, probably caused an increase in uranium in Retention Pond 2 (RP2).

This report concludes that:

- It has not been possible to be conclusive about the extent of the spill outside the Restricted Release Zone but is no evidence that ERA under-reported or misreported the incident. Records show that ERA acted very quickly to remove this material and may have removed more soil than was strictly necessary, possibly resulting in a conclusion that more tailings was spilled than had been reported.
- Remedial action within the RRZ could not be completed until the dry season, many months after the incident. During this period, ERA took appropriate action, with the NT Minister's approval, to ensure protection of water quality.
- The tailings spill was not responsible for the increase in uranium in RP2.

Discharge of water from the Restricted Release Zone into a tributary of Gulungul Creek

In his report, Mr Kyle alleged that ERA routinely discharged from the RRZ water containing high concentrations of uranium from the southern external walls of the tailings dam, into the headwaters of Gulungul Creek, that the ERA Laboratory Manager refused permission for Mr Kyle to investigate the effects of this discharge, and that he instructed Mr Kyle not to record a higher than normal result for uranium in Gulungul Creek waters. Mr Kyle claims that this result was obtained from two separate samples, each of which was analysed in triplicate.

This report concludes that:

- ERA did not discharge RRZ or tailings water from the mine to the external environment but acted properly in accordance with the requirements of the NT Minister for Resource Development with respect to water shedding from the outside walls of the tailings dam and the area south of the dam.
- ERA did conduct an investigation of the likely impact of these discharges on the water quality of Gulungul Creek and the results indicated that the uncontrolled discharge of these waters did not pose a threat to the creek. Mr Kyle, being unaware of this study, conducted a second separate study but appears not to have informed his manager of the results obtained.
- The ERA laboratory records only reveal the analysis of a single sample for uranium from the Gulungul Creek monitoring point on the date in question. This sample was not subject to triplicate analyses but was subject to three sequential analyses to obtain a reliable result.
- The ERA Laboratory Manager was on leave at the relevant time and could not have given the instruction at that time that the result not be recorded or that Mr Kyle should not proceed with his proposed investigation.
- The uranium concentration currently entered in the ERA water quality data base for the Gulungul Creek sample in question is 0.1 µg/L not 7.4 µg/L as measured by Mr Kyle. However, the data base contained the latter result in February 1997, one month after the analysis was obtained indicating that the result has been changed. ERA procedures should have required a reanalysis of the sample prior to a change of result in the data base but we have found no evidence of such a reanalysis.
- Examination of the ERA data base indicates that ERA's policy of not deleting unusual results until a reanalysis has been carried out has normally been adhered to by the company and its employees.

Procedures in ERA's Environmental Laboratory

Mr Kyle raised a number of issues related to the performance of ERA's chemical analysis laboratory. Specifically, he claims that laboratory management consistently refused to address technical issues that compromised the performance of the laboratory, that this led to an inability to honour the conditions of its licence to operate the mine, and that ERA did not rectify problems even when it was demonstrated that the problems were valid.

Our assessment of the laboratory related issues raised by Mr Kyle has been, to some extent, superficial in that we have relied heavily upon the assessment of ERA's performance in these areas by the appropriate authority, the National Association of Testing Authorities (NATA).

This report concludes that:

- There is no doubt that many of the deficiencies identified by Mr Kyle were present and that corrective action was needed.
- It appears that, in the cases described by Mr Kyle, a dispute arose between Mr Kyle and the Laboratory Manager on what would constitute the best way to overcome the problems. Mr Kyle clearly did not accept the conclusions of his manager, then or now.

- We are satisfied that the analytical issues raised by Mr Kyle did not lead to the lack of detection of environmental detriment although, if fully correct, they may have led to inconsistent or incorrect analyses. We are also satisfied that there is no evidence that ERA adopted a policy towards its analytical laboratory that would have undermined its environmental protection responsibilities or compromised its reporting responsibilities.
- ERA, in accordance with the Environmental Requirements, maintained a NATA registered laboratory. Following NATA inspections and recommendations, ERA responded to NATA providing details on steps taken to implement the recommendations.

Overall conclusion and recommendations

The overall conclusion of this report is that, apart from the previously reported breach of the Ranger Authorisation arising from the spillage of tailings outside the Restricted Release Zone on 19 December 1997, no evidence has been found that ERA has operated otherwise than in accordance with its Authorisation and the Commonwealth's Environmental Requirements.

The report recommends that the Ranger Minesite Technical Committee:

1. Should, in its current review of the Ranger monitoring program, assess the need for load estimation in the chemical monitoring of the Ranger mine, taking into account existing biological monitoring programs.
2. Should consider, within the context of Best Practicable Technology, whether or not uncontrolled discharges of water from the region south of the tailings dam to the Gulungul Creek system should continue.

Evaluation of alleged deficiencies in management of the Ranger Uranium Mine between 1996 and 1998

1 Introduction

On 5 April 2002, Mr Geoffrey Kyle, a former employee of Energy Resources of Australia Limited (ERA) at Ranger Uranium Mine's Environmental Laboratory, wrote to the Commonwealth Minister for Environment and Heritage, the Northern Territory Minister for Resource Development and a number of Commonwealth and Northern Territory officials. Mr Kyle expressed concern about a number of issues relating to environmental management and reporting by ERA at the Ranger mine between 1996 and 1998. Mr Kyle's complete submission is included as Appendix 1.

In his report, Mr Kyle grouped these issues into the following three principal topics:

- Tailings Spill in Corridor Road
- Discharge of water from the Restricted Release Zone into a tributary of Gulungul Creek
- Procedures in ERA's Environmental Laboratory

This report assesses the issues raised by Mr Kyle under the same topics.

The Assistant Secretary of ***oss*** responded to Mr Kyle on 8 April 2002, advising that the Supervising Scientist was immediately commencing an investigation into his allegations. A team of senior officers of the ***oss*** and the Environmental Research Institute of the Supervising Scientist (***eriss***) commenced these investigations on 9 April 2002.

The Chief Executive Officer of the Northern Territory Department of Business, Industry and Resource Development (NTDBIRD) wrote to Mr Kyle on 15 April 2002, acknowledging his letter on behalf of the department, and confirming that the matters raised would be investigated.

The ***oss*** investigation was undertaken in conjunction with staff of NTDBIRD. A detailed search of files and reports held by ***oss***, ERA and NTDBIRD was conducted to establish, as far as is now possible, the circumstances surrounding the events referred to by Mr Kyle. Field visits were also conducted to determine the current situation at the relevant sites and discussions were held with current ERA staff. In addition, interviews were conducted with a number of former staff of ERA and with one former ***oss*** employee to determine their recollections and account of events. The people interviewed were as follows with their former affiliation indicated: Dr P Woods (ERA), Mr A Jackson (ERA), Mr A Ryan (ERA), Mr A Martin (ERA), Mr M Nolan (ERA) and Mr M Wilson (***oss***). Mr Kyle was also interviewed to allow him to present further information in support or clarification of his claims. The full co-operation of all interviewees is appreciated and acknowledged. Each allegation was investigated to the maximum extent practicable given the relatively long time (usually over five years) since the alleged incidents.

The Restricted Release Zone

In the following discussion of the incidents many references are made to a Restricted Release Zone (RRZ). At the time of the incidents described by Mr Kyle, the RRZ concept was a key component of the Ranger mine water management system. Water releases, other than unavoidable seepage, were not permitted from the RRZ except with the specific approval of the NT Minister and any transgressions constituted infringements of Ranger's Authorisation. Boundaries of the RRZ were clearly delineated on plans which the mine operator maintained and lodged copies of with the supervising authorities. Changes in the Ranger Authorisation in 2000 saw the RRZ concept abandoned in favour of water management according to water quality. The location of the RRZ in 1997-98, the corridor road and sump (included in the RRZ), RP2, the tailings dam and south wall toe loading area are shown in figure 1.

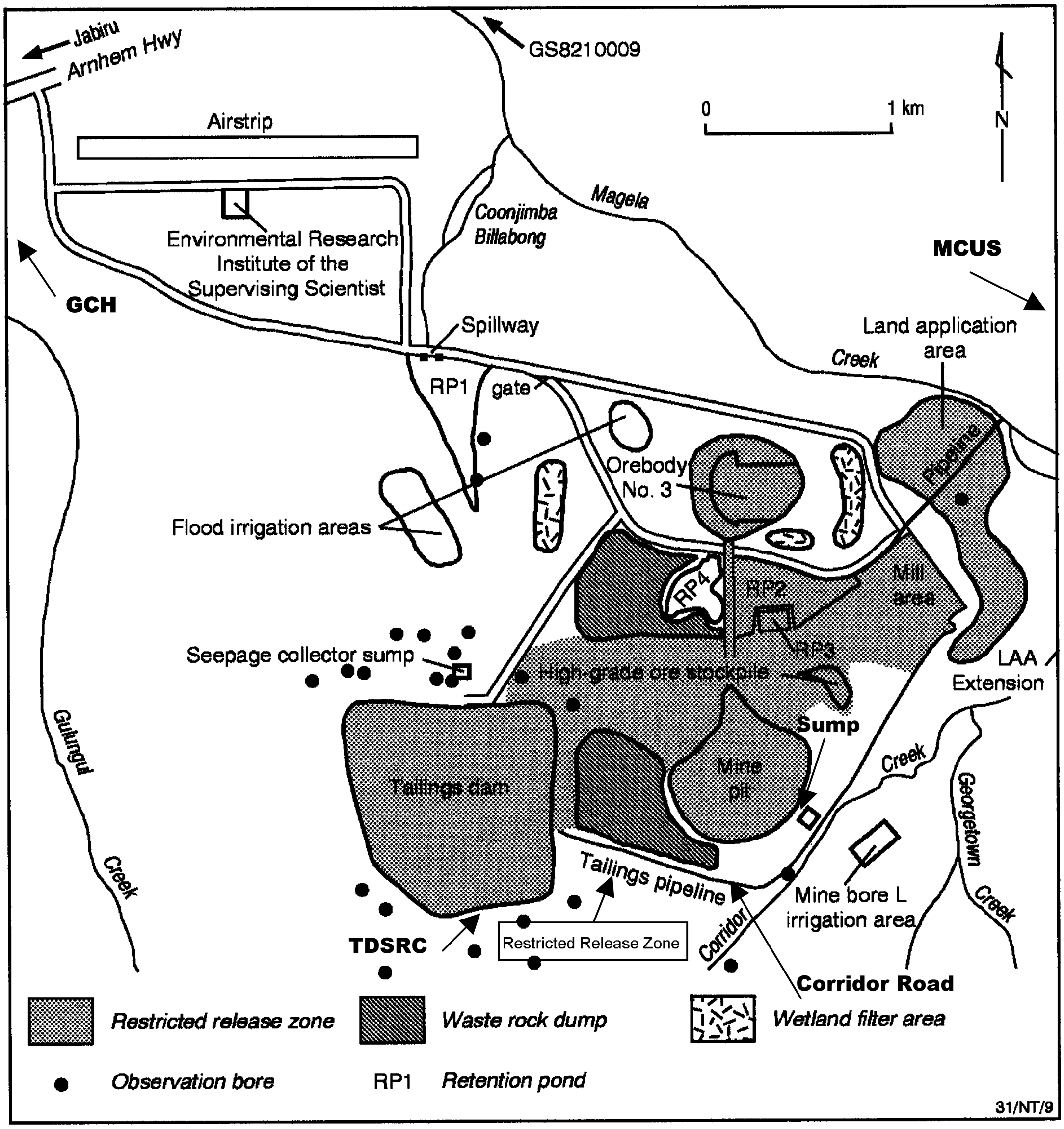


Figure 1 Location map of the sites referred to at ERA Ranger mine. The tailings pipeline is located in a completely bunded Restricted Release Zone. Water quality monitoring sites are G8210009 (Magela Creek at gauging station), MCUS (Magela Creek upstream of Ranger), GCH (Gulungul Creek at Arnhem Highway Bridge) and TDSRC (culvert on road at south wall of the tailings dam).

2 Tailings Spill in Corridor Road

In December 1997, an incident took place at the Ranger mine in which the tailings pipeline leaked. Tailings spilled on to the Tailings Corridor Road and into drainage structures designed to receive such spills, all of which lie within the Restricted Release Zone (RRZ). Tailings also sprayed beyond the southern edge of the Corridor Road, landing outside the RRZ. With respect to this incident, Mr Kyle alleged in his report that ERA:

- Under-reported and mis-reported the extent of the incident,
- Failed to clean up [in a timely manner] the spilled tailings material that occupied the Corridor Road Sump and its feeder drains, and
- Employed an *ad hoc* water management strategy that resulted in over 300 kg of uranium being lost to Retention Pond No. 2 (RP2) from which water is released into the Magela Creek system.

The incident and the allegations related to it are discussed below.

2.1 Background

At the Ranger Mine, ore is processed in the Mill circuit to extract uranium (see figure 1) and the residue material (tailings) is pumped in pipes to the tailings dam (prior to August 1996) or to the mined out Pit No 1 (after August 1996). The tailings pipeline is contained within a bunded corridor along which runs a roadway that connects the Mill area to the Tailings Dam. The road and the bunded area were, at the time of the incident in 1997, within the then Restricted Release Zone. Any spillage of tailings water or tailings material within the corridor drains into a sump (see figure 1). Water collected in this sump could, depending on its quality, be pumped to RP2 or to Pit 1. Any overflow drained to Pit 1.

Failures of pipeline joints or the pipeline itself have not been uncommon over the life of the Ranger mine. ERA was only formally required to report a leak in the tailings pipeline if tailings or water escaped the bunded area. Process water or tailings leaving the bunded system and hence escaping the RRZ would constitute an infringement of the Ranger Authorisation. ERA was required to take immediate steps to clean up the affected area and report the incident to the NT authorities and the Supervising Scientist.

2.2 Reporting of the tailings spill in December 1997

Most of the spilled material from the tailings pipeline leak of 17 December 1997 was released onto the tailings corridor road and into the RRZ drain and corridor road sump (figures 2 & 3). ERA's then Senior Environmental Scientist, Dr P. Woods, reported the leak to both ***oss*** and the then NT Department of Mines and Energy (DME), now NTDBIRD, by fax at 1822 hours on 19 December 1997. The leak was thought to have occurred between 1600 and 1700 hours from a joint failure due to partial blockage of the pipe near the Pit 1 offtake pipe.

It was also reported, however, that approximately 1 m^3 of tailings sprayed outside the RRZ into the Corridor Creek catchment, covering an area of about 100 m^2 (10 m x 10 m) to a depth of 0.01 m and that a similar volume of process water infiltrated into the ground outside the RRZ at the same site as the tailings spill.

ERA did not provide, and was not required to do so, a report on the extent of the spillage within the RRZ because no material could be transported from this fully contained area to the external environment.

ERA immediately instigated a cleanup operation and all tailings and contaminated soil from outside the RRZ were removed to Pit 1. However, as reported by Mr Kyle (see next section), all the tailings within the RRZ were not removed immediately because they were wet and because some had been washed into the tailings corridor road sump (figure 3).

Mr M Wilson, the then Senior Environmental Scientist with ***oss***, inspected the site on Tuesday 23 December 1997 and reported to the Assistant Secretary of ***oss*** on the same day that, in his opinion, the impact of the above spill was localised and not significant with respect to off-site environmental impact. He reported that the spill was probably caused by the failure of a non-return valve and occurred over a period of approximately 45 minutes. The area affected outside the RRZ was approximately 100 m^2 but up to 400 m^2 had been disturbed by the clean up operations to ensure that all contaminated material had been removed. He estimated that 2 kBq (kilo Becquerel) of ^{226}Ra (radium 226) may have been released which was trivial with respect to the permissible annual load. Mr Wilson concluded that any process water which discharged into Corridor Creek would have been diluted by the high wet season flows at that time. Furthermore, metals and radionuclides would be attenuated by infiltration through the soil profile (see Willett et al 1993) as well as by passage through the mine bore L constructed wetland (see Klessa 2000).

Mr A. Jackson, ERA's then Manager for Environment, Safety and Health, faxed the Director of Mines on 23 December 1997 with a further report on the incident. A copy was faxed to ***oss*** on 2 January 1998. He stated that the time of the incident was 1650 hrs and was caused by a joint failure in a pressurised side line of the main tailings line. The clean up of the tailings outside the RRZ and on the corridor road was completed by 2200 hrs on the night of the incident. ERA stated that all water from the tailings corridor sump would be retained in the process circuit [rather than being pumped to RP2] until the clean up could be completed.

The 1997-1998 Annual Report of the Supervising Scientist for the Alligator Rivers Region (Environment Australia 1998, 289), NTDBIRD files and ERA's Annual Environment Report 1997/98 (Energy Resources of Australia Ltd 1998a, 111) summarised the above incident and their accounts of these events are consistent with that outlined above.

A principal issue raised by Mr Kyle with respect to this incident is the volume of tailings and process water that sprayed outside the RRZ. The affected area outside the RRZ is not in significant dispute. The ***oss*** officer who inspected the site, Mr Wilson, assessed that the area disturbed by the clean up operations was about 20m x 20m. This is in reasonable agreement with Mr Kyle's estimate of 25m x 25m. The ***oss*** report stated that this area was larger than the area directly affected by the spill because ERA wanted to be sure that all contaminated material had been removed. At interview, Mr Wilson stated that he would have reached this conclusion on the basis of discussions with ERA staff during his inspection.

ERA reported the depth of tailings slurry in the area affected by the spill outside the RRZ to be about 0.01m. Mr Wilson's report referred to 'a thin layer of solids' outside the RRZ. Former ERA staff contacted by the ***oss*** during this investigation could not recall the basis of the depth estimate. They suggested that a crude measurement or assessment would have been made (eg scraping the slurry away from the land surface at several locations and noting the approximate depth). The main concern of ERA at the time, according to former ERA staff interviewed, was to clean up the area as quickly as possible. Current ERA staff have indicated that the depth of material removed would have been significantly greater than the depth of slurry partly because of the size of machinery used but partly to ensure that any soil contaminated by infiltration of water would also be removed.

Figure 2 Tailings corridor road in April 2002 near the site of the spill on Friday 19 December 1997. The sump shown in figure 3 is located to the middle left of the photograph (WD Erskine photograph).

Figure 3 Sump for the tailings corridor road in April 2002. This sump was the immediate sink for the tailings spilt onto the tailings corridor road and drain on 19 December 1997 before they were finally transferred to, and permanently stored in, pit #1 (WD Erskine photograph).

It is impossible after the lapse of almost 5 years from the incident to come to firm conclusions on the quantity of tailings slurry that sprayed on to areas outside the RRZ. It can be concluded with some confidence that the amount of material removed (slurry and soil) was considerably greater than 1 m^3 but this has never been in dispute. ERA staff, past and present, state that it was necessary to remove this larger quantity of material to ensure that no contaminated material remained outside the RRZ. The extent of disturbance may have been excessive but it is difficult to criticise the adoption of this precautionary approach.

2.3 Removal of spilled tailings in the corridor road sump and its feeder drain

The second issue raised by Mr Kyle about the tailings incident in 1997 was that, although ERA acted quickly to remove tailings spilled outside the RRZ, the affected area inside the RRZ was left for nine months before any serious effort was made to remove the tailings material and that this delay exposed staff and the environment to toxic materials.

The tailings trapped in the original corridor road sump could not be removed until the material was dry and capable of being removed as a solid by earth moving machinery. This took some months after the end of the wet season. The rainfall at Jabiru Airstrip for the 1997-98 water year (ie September to August) was 1667 mm (average 1483 mm at that time) and was the fifth above average rainfall year in the preceding six years. The highest monthly rainfall was 520 mm in January 1998 and was associated with major flooding of the Katherine and Daly rivers. This event occurred about one month after the above spill. Furthermore, pan evaporation was marginally below average for the 1997-98 water year at 2621 mm. All of these factors would have delayed the drying and consolidation of the tailings and their subsequent removal from the sump by ERA.

This situation was one that needed to be managed by ERA. To address the issue, ERA wrote to the Northern Territory Minister for Mines and Energy on 13 January 1998 requesting permission to redefine the RRZ boundary. The request entailed the construction of a new sump on the corridor road to the west of the original sump that contained the spilled tailings. Permission was granted on 21 January 1998 (Environment Australia 1998). The water collected in the new sump was pumped to RP2 but all overflow was directed into the original sump which, in turn, overflowed into Pit 1. The new sump did not receive runoff from the section of the tailings corridor that had been contaminated by the tailings spill.

This action was consistent with ERA's undertaking, contained in Mr Jackson's letter to the Director of Mines on 23 December 1997, to retain within the process water system all water collected in the original sump until all tailings had been removed. This could not occur until the sump and tailings dried out during the 1998 dry season. ERA reports of 2 November 1998 and 14 December 1998 notified authorities that when subsequent minor tailings spills occurred within the RRZ on 31 October 1998 and 13 December 1998 the original corridor road sump overflow was directed to Pit 1. This is still the case.

According to the 1998-99 Annual Report of the Supervising Scientist (Environment Australia 1999) and NTDBIRD files, approval for the excision of the temporary sump in the tailings corridor from the RRZ was granted on 4 November 1998. This means that the tailings in the original sump must have been removed before this application could have been approved. Mr Kyle, in his supporting documents (Appendix 1), recorded that the tailings in the original sump were being excavated on 9 September 1998. Therefore, it would appear that the tailings in the original corridor road sump were removed on or about 9 September 1998 and certainly before 4 November 1998.

The question of worker safety raised by Mr Kyle was an appropriate one. Mr A Martin, a former ERA radiation safety officer, said at interview that he recollected that radiological checks of the tailings corridor road had been completed at the time of the spill and that they had revealed that it was safe for ERA employees to undertake the clean-up operation. Furthermore, subsequent radiological checks also revealed that the area was safe for workers, despite the continued presence of tailings. Mr Martin did not recall passing this information on to Mr Kyle. Thus, it would appear that ERA did not inform Mr Kyle of the results of its radiological testing despite his concerns on this issue raised in his reported verbal requests to the Alan Ryan and others and his written request of 9 September 1998.

The above information demonstrates that the delay in removing the tailings from areas within the RRZ was caused by the need to wait until the dry season for a successful removal operation and that ERA took appropriate action to ensure that the affected area was isolated within the process water circuit. However, although ERA made an assessment of the risk to worker health arising from the spilled tailings and concluded that the risk was very small, it appears that the company did not inform Mr Kyle of this conclusion.

2.4 The effect of the tailings spill on RP2 water quality

The third issue raised by Mr Kyle about the tailings incident in 1997 was that the failure to clean up the tailings spill within the RRZ promptly probably did, in his view, cause or contribute to water management problems in RP2. Mr Kyle refers to the fact that water from the tailings road sump is usually pumped to RP2 and he alleges that *ad hoc* water management strategies resulted in over 300 kg of uranium being lost to RP2 from which, he states, water is released into the Magela Creek system.

The water management system at Ranger is outlined in detail by ERA in a manual (Water Management System Operation Manual) which is produced annually [see Energy Resources of Australia Ltd (1998b) for the relevant version for the period under consideration here] and which is reviewed by the supervising authorities. The tailings spill did not have any impact on RP2 water quality because the contaminated water in the tailings corridor sump was never transferred to RP2. As outlined in the previous section, a new temporary sump was constructed in the tailings corridor system to collect runoff from those sections of the corridor that had not been affected by tailings. Water from the new temporary sump, which was not contaminated, was pumped to RP2 but water from the old sump was contained within the process water system.

The origin of the high uranium concentrations in RP2 in 1998 was an issue of concern and was discussed extensively by ERA, the NT authorities and the ***oss*** at the time. ERA, in its Environmental Annual Report for 1999, described and explained the high uranium concentrations in RP2 in late 1998 as follows:

> In most years RP2 experiences a sudden increase in uranium concentration early in the wet season. This expected first flush effect was greater this year than the last few years. The uranium concentration peaked at 7300 μg/L on 29 October 1998, a similar level to that of the 1987/88 wet season. By November values of 5000 μg/L were measured and the downward trend continued through the wet season (see figure 3.5)…
>
> The principal reason for this higher level was transfer of water from Ranger #3 pit which had leached through approximately 1,000,000 tonnes of blasted broken material including some high grade ore. This material was still located in the base of the pit when heavier than normal early rains fell in October.

> …this material is drawn primarily from the halo of the deposit and contains more mobile minerals such as uraninite, coffinite and brannerite. With large quantities of broken rock these minerals were even more susceptible to leaching (Energy Resources of Australia Ltd 1999, 34–5).

Figure 3.5 from Energy Resources of Australia Ltd (1999) is reproduced here as figure 4. As ERA stated, similar high values had been found on previous occasions but were not included in the data presented for RP2 by Mr Kyle in his submission (his figure 2.3). While such previous high uranium values in RP2 do not make such occurrences acceptable, they do highlight that ERA was continuously monitoring the situation and understood what was happening.

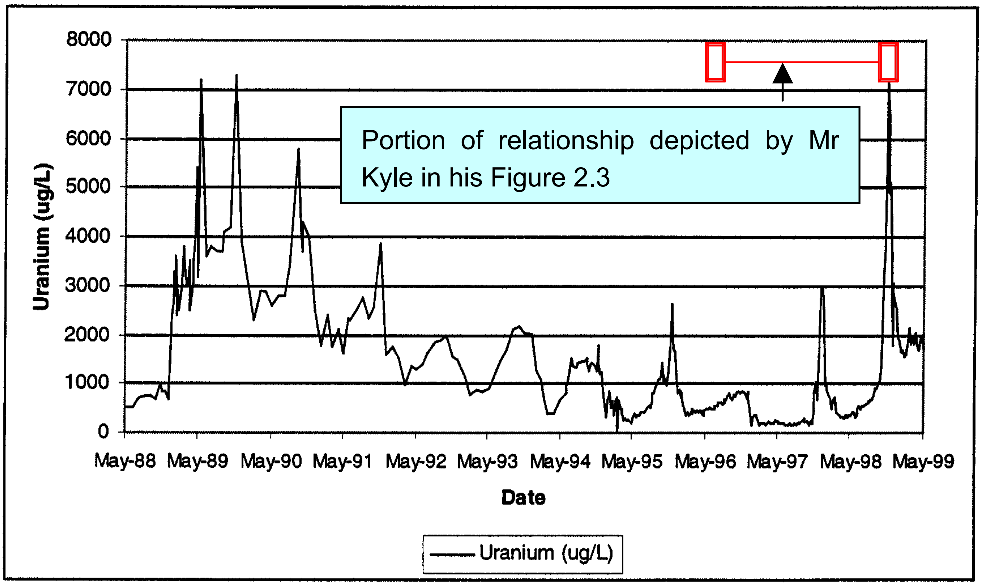


Figure 4 Uranium concentrations in RP2 between 1988 and 1999 (Source: Energy Resources of Australia 1999, figure 3.5 on p 35)

The implication that contaminated water from RP2 may have been disposed of in Magela Creek is also in error. No water has ever been transferred directly from RP2 into Magela Creek and it is not possible for RP2 water to enter Magela Creek without active intervention. The Ranger General Authorization Number A82/3 issued under the *Uranium Mining (Environment Control) Act 1979 (NT)* stipulates in Schedule 7 that RP2 water must be disposed of by irrigation unless Ministerial approval has been granted. Such approval was not granted at that time.

Thus, Mr Kyle's implication that overflow or pumping from the tailings road sump to RP2 was the source of the high uranium in the pond is in error for two reasons. Firstly, overflow or pumping from the tailings corridor sump to RP2 did not occur at this time. Secondly, the source of the high uranium concentrations in RP2 was clearly identified by ERA at the time. It was caused by the transfer of water from Ranger Pit 3 which had leached through approximately 1,000,000 tonnes of blasted broken material including some high grade ore. This material was still located in the base of the pit when heavier than normal early rains fell in October 1998.

3 Discharge of water from the Restricted Release Zone into a tributary of Gulungul Creek

In his report, Mr Kyle describes the uncontrolled discharge of water from the Ranger mine site into a tributary of Gulungul Creek via the Tailings Dam South Road Culvert (TDSRC). With respect to this issue, Mr Kyle claims that:

- ERA routinely discharged from the RRZ water containing up to 10 000 ppb uranium from the toe loading of the tailings dam, via the TDSRC, into the headwaters of Gulungul Creek, and
- When an indication was recorded that an effect attributed to this discharge had been found at Gulungul Creek, ERA refused permission for field staff to investigate the matter, attempted to suppress the datum, and described it as spurious in a statement to shareholders. The offending result came from two separate samples, each tested in triplicate by the same experienced analyst [Mr Kyle] who acquired the samples.

These issues are discussed below after the provision of background information on water management in the southern region of the Tailings Dam and on issues related to the stability of the tailings dam.

3.1 Background

3.1.1 Water management on the south wall of the tailings dam

Prior to 1990 when the fourth stage of the tailings dam was constructed, there was a seepage collection system around the southern perimeter of the dam. This consisted of a pipeline contained within the toe of the dam which was designed to intercept seepage and direct it to a sump located south of the south wall of the dam (the Southern Sump — see fig 6). Water collected in this sump was retained within the RRZ by being pumped back into the tailings dam.

The intent of this system was to intercept water that seeped from within the dam; that is, tailings water. It was not designed to intercept water which resulted from rainfall incident upon the dam wall and which either infiltrated the wall or simply ran off the wall. Because the dam wall was constructed from waste rock (ie less than 0.02% uranium by weight), such water was considered suitable for unrestricted discharge to the surrounding environment. However, a considerable quantity of such water was collected by the system and was pumped into the dam.

In planning the Stage IV tailings dam lift, ERA argued that such a seepage collection system did not constitute Best Practicable Technology because, in its view, the system was very inefficient in collecting seepage from the tailings dam and that it resulted in the contamination of relatively clean water by pumping it to the dam. The NT Minister did not require ERA to include a seepage collection system on the southern wall of the tailings dam in the Stage IV lift. The Southern Sump was decommisioned.

Thus, following the Stage IV lift of the tailings dam, the approved water management system for Ranger included unrestricted flow to the surrounding environment of all water from the southern exterior walls of the tailings dam.

ERA constructed a perimeter drain around the southern part of the dam to direct water arising from surface runoff and any surface expression of water which had infiltrated the dam wall to a pipe which passes under the perimeter road around the dam through a culvert. From this pipe the water flows through a small sump (the Tailings Dam South Road Culvert, TDSRC) and then overland towards a tributary of Gulungul Creek. ERA regularly collects and analyses water samples from TDSRC as part of its internal, non-statutory monitoring program.

3.1.2 Stability of the Tailings dam

The tailings dam at Ranger was designed as a multi-zoned earth- and rock-fill ring dyke dam and has been constructed mainly from mine waste rock and earth from borrow areas near the tailings dam (Supervising Scientist for the Alligator Rivers Region 1990, 1991). The tailings dam wall has been increased in height in several stages (figure 5) and was lifted to the current crest level of RL 44.5 m (Stage IV) during the 1990 dry season (Supervising Scientist for the Alligator Rivers Region 1990). Construction of stage IV commenced on 19 March 1990 and was essentially completed by November 1990 although minor work persisted until December 1990 (Supervising Scientist for the Alligator Rivers Region 1990, 1991).

Each stage of the raising of the Ranger tailings dam has been a major construction project and the design and construction has been supervised by a Quality Control Committee (QCC). The QCC was chaired by ERA and had representatives from DBIRD and the ***oss***. The members were each advised by their own consulting engineer expert in dam design.

The Ranger tailings dam was assessed by the QCC as being the equivalent of an ANCOLD (Australian National Committee on Large Dams) Type 1 dam which warranted particular design and monitoring features. Stability of the dam is monitored by a series of wall settlement plates plus a series of downstream piezometers which measure groundwater pressure. The dam is subject to an annual assessment by ERA, the authorities and their consulting engineers. All the monitoring data relevant to dam stability are examined and a site inspection is undertaken.

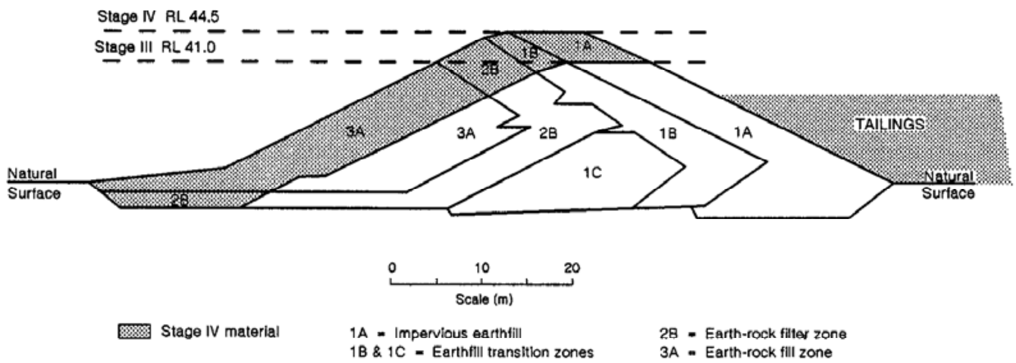


Figure 5 Tailings dam showing the area changed by the stage IV lift in 1990

As part of this annual assessment process, it was proposed (Coffey Partners International Pty Ltd 1997) that toe loading of the south wall of the tailings dam should be undertaken as a stability measure to reduce artesian pressures observed in the piezometer data for the south wall region of the dam. Similar toe loading of the west wall area of the tailings dam prevented a rise in piezometric pressures to the point where they became artesian (Coffey Partners International Pty Ltd 1997).

The toe loading of the south wall was carried out by ERA before the 1997-98 wet season (Coffey Geosciences Pty Ltd 1998) and was constructed from grade 1 stockpile material, sourced from Pit 1 (H Topp, ERA, personal communication, 2002) and, therefore, was characterised by a U_3O_8 content of <0.02%. Mr Burgess reported that the south wall toe loading changed the piezometric pressures so that they were no longer artesian, as intended (Coffey Geosciences Pty Ltd 1998).

Seepage at the south wall and at other areas had been noted in periodic dam inspections (Coffey Geosciences Pty Ltd 1998). The explanation for surface expression of seepage water was given as:

> These occurrences were mainly observed during the middle of the wet season and occurred in low ground or poorly drained sections of the dam foundation. The seepages appear to be a combination of rainwater infiltration to the dam embankment, high seasonal, regional groundwater levels and possibly elevated groundwater due to groundwater mounding around the dam. The seepages occur during the wetter months of the year (December to March) when all these levels are highest and the rockfill shell of the dam is draining (Coffey Geosciences Pty Ltd 1998, 4).

3.2 Routine discharges of RRZ water into the headwaters of Gulungul Creek

With respect to the statement by Mr Kyle that there have been routine discharges of RRZ water into the headwaters of Gulungul Creek, it must first be stated that there have never been routine discharges of water from the RRZ at the Ranger mine. As explained in the previous section, the water to which Mr Kyle referred in his report, and which discharged into the Gulungul Creek catchment, was not RRZ water but water which drained from the outside walls of the tailings dam and the dam toe loading area. Both areas consist of waste rock, material which has never been included in the Restricted Release Zone at Ranger.

A second point of clarification is also warranted. Mr Kyle, on page 5 of his report, refers to the water leaving the TDSRC as 'toe loading seepage of tailings water'. This may just have been loose terminology but it must be stressed that the water being considered was not tailings water or seepage of tailings water. All of the major chemical ion concentrations in TDSRC water are, on average, about a factor of 50 lower in TDSRC water than in tailings water, manganese is lower by a factor of about 1500, and uranium is greater in TDSRC water by about a factor of 2.

Water draining from the outside walls of the tailings dam or the toe loading area (see fig 6) arises from rainfall that either runs off the surface of these areas or which infiltrates the surface and emerges further downslope. As noted by Coffey Geosciences above, a contribution can also arise from elevated ground water due to groundwater mounding around the dam. Natural groundwaters in the region of the dam do not have concentrations of constituents, particularly uranium, as high as those found in the TDSRC. However, water which passes through the dam wall or the toe loading area has the opportunity to interact with the constituents contained in the rock and thus to leach out constituents that are chemically available. The concentrations of uranium in water that comes in contact with fresh waste rock are generally higher than in water in contact with rock that has been exposed for some years. This is because the first contact of water with fresh rock removes most of the available uranium.

Thus, the toe loading of the south wall of the tailings dam during the 1997 dry season directly resulted in an increase of uranium concentration in water that passed through TDSRC, as concluded by Dr Woods in his email to Mr Kyle on 23 February 1998 (figure 1.6 in Mr Kyle's supporting documents). Water from the toe loading areas to the east and west of TDSRC passes through small sharp-crested V-notch weirs before mixing and being piped under a roadway to TDSRC (figures 7 and 8).

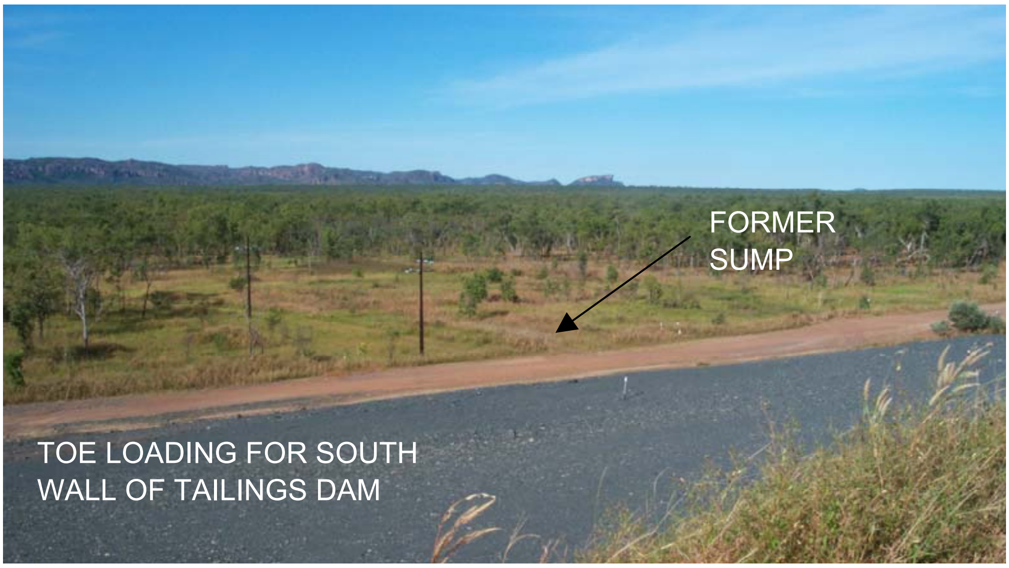


Figure 6 Area immediately below the south wall of the Tailings Dam on 4 May 2000 showing the toe loading and remains of the tailings dam south wall sump. Seepage from this area may flow into Gulungul Creek. When inspected on 17 April 2002 conveyance losses resulted in seepage water extending only 50 m downstream of the former sump before all surface flow had infiltrated and hence stopped (OSS photograph).

Figure 7 Weir discharging seepage from the south wall toe loading area of the tailings dam generated to the east of TDSRC in April 2002 (WD Erskine photograph)

Figure 8 Weir discharging seepage from the south wall toe loading area of the tailings dam generated to the west of TDSRC in April 2002 (WD Erskine photograph)

Figure 9A shows all the uranium concentrations measured by ERA at TDSRC and clearly demonstrates that a substantial increase occurred on 10–11 December 1997 (about 8500 and 9100 µg/L respectively) immediately after the completion of toe loading. The first flush effect was very short-lived (one week at most) and uranium concentrations rapidly declined. They did not exceed 4600 µg/L for the remainder of the 1997-98 Wet season and have not exceeded 3300 µg/L during subsequent Wet seasons (figure 9A). This first flush event occurred 11 months after Mr Kyle's record of 7.4 µg/L uranium at GCH (figure 9B) and was not causally related, as the reader might infer from Mr Kyle's report.

The above discussion demonstrates that:

- ERA did not discharge RRZ or tailings water from the mine to the external environment but acted properly in accordance with the requirements of the NT Minister for Resource Development with respect to water shedding from the walls of southern region of the tailings dam, and
- ERA was aware of the higher than normal concentrations of uranium in this region in December 1997 and understood that their origin was the recent toe loading of the dam.

While ERA's actions were clearly legal, an issue raised by Mr Kyle is whether ERA managers, who were aware of these high concentrations from the internal ERA monitoring program, should have allowed water with concentrations of uranium often exceeding 2000 µg/L to leave the mine site and enter a creek system which subsequently enters Kakadu National Park. An appropriate approach for the mining company to take would have been to question whether or not the discharge of these waters was having any adverse effect on the waters of Kakadu National Park. It is clear from the minute from Dr Woods dated 23 February 1998 (figure 1.6 of Mr Kyle's report in Appendix 1) that that is the approach that he adopted.

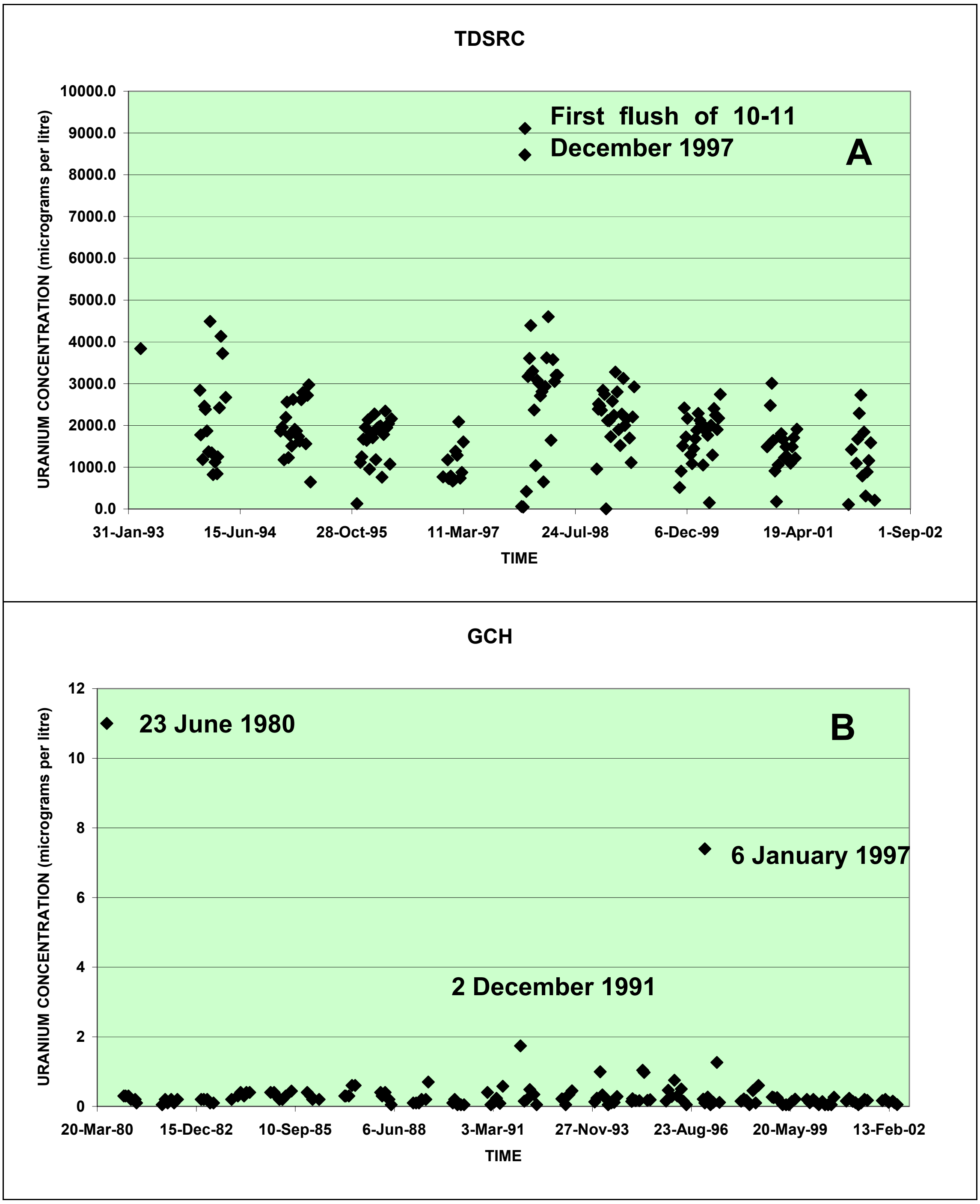


Figure 9 Complete data on uranium concentrations at TDSRC **(A)** and GCH **(B)**. ERA data and reproduced with permission. All values below the detection limit were set at 0.05 μg/L. Compare **(A)** with figure 1.3 in Appendix 1.

The full data set of uranium concentrations at the downstream monitoring point in Gulungul Creek (1980–2002) are shown in figure 9B. Apart from the first measurement recorded in June 1980 and the measurement on 6 January 1997 (discussed in the next section), all measurements gave results that were below the Supervising Scientist's recommended receiving water standard at the time (10 µg/L) and the NT Minister's Maximum Allowable Addition for Magela Creek (3.8 µg/L). In his interview, Mr Ryan outlined the internal procedures adopted by ERA in regularly reviewing all environmental data. ERA was (and is) also required to provide interpretative annual reports on these data. In addition, when discussing at interview the uranium result at the Gulungul Creek monitoring point for 6 January 1997 (see next section) both Mr Ryan and Mr Nolan immediately referred to a possible result of 7.4 µg/L as a 'high result' for Gulungul Creek that would need to be checked thoroughly. It is clear, therefore, that senior ERA environmental staff were well aware that the historical uranium concentrations for Gulungul Creek had always been low throughout the period when results at TDSRC were often greater than 2000 µg/L.

It is also clear from ERA files that ERA staff were aware of the uranium concentrations at TDSRC and had decided to investigate any potential impact on the waters of Gulungul Creek prior to the concerns expressed by Mr Kyle. ***oss*** officers investigating the issues in this report found a minute on ERA's files dated 2 January 1997 by Mr Surkitt to Dr Woods. The minute outlined the results of an investigation into the reduction in uranium concentrations as a function of distance downstream from TDSRC as water flowed overland towards a tributary of Gulungul Creek. The results are shown in figure 10A. They illustrate that uranium concentrations were reduced by dilution and absorption from over 700 µg/L at TDSRC to less than 10 µg/L over a distance of 200 m. The distance to the Gulungul Creek tributary is about 2000 m. A reasonable interpretation of these data would have been that, while concentrations of uranium in TDSRC were relatively high, they did not pose a threat to Gulungul Creek itself.

It is puzzling, therefore, that Mr Kyle states in his report that he was refused permission by Mr Ryan to conduct such an investigation and that he did not obey Mr Ryan's instruction and conducted a study on two occasions; firstly on the same day as the 7 ppb uranium result was obtained at Gulungul (the uranium result was obtained 10 January 1997) and secondly on 21 January 1997. Mr Kyle has not presented the results of his first survey and no record can be found of the results in the ERA chemical log nor the results data base. The results of Mr Kyle's survey of 21 January, presented in his report, do exist in the ERA data base but none of the other relevant staff of ERA (Dr Woods, Mr Ryan or Mr Nolan) were aware of these measurements.

We are drawn to the conclusion that, since Mr Kyle conducted his survey without the approval of his supervisor, he did not reveal the results obtained to senior staff. It is also noteworthy that, when the existence of Mr Surkitt's results were brought to Mr Kyle's attention at interview on 13 May 2002, he stated that he was unaware that the survey had been carried out and was unaware of the results obtained. It would appear, therefore, that tensions existed between Mr Kyle and other staff of the ERA Environment Department and this may have led to distrust and poor communication.

The results of Mr Kyle's survey of 21 January downstream of TDSRC are shown in figure 11B. A rapid decrease in concentrations of uranium is observed over the first 200 m from TDSRC similar to that in the data in figure 11A. However, there is an indication that attenuation beyond that point is less severe and that a residual concentration of uranium, about 9 µg/L, remains when the overland flow enters the tributary of Gulungul Creek at a distance of 2000 m from TDSRC.

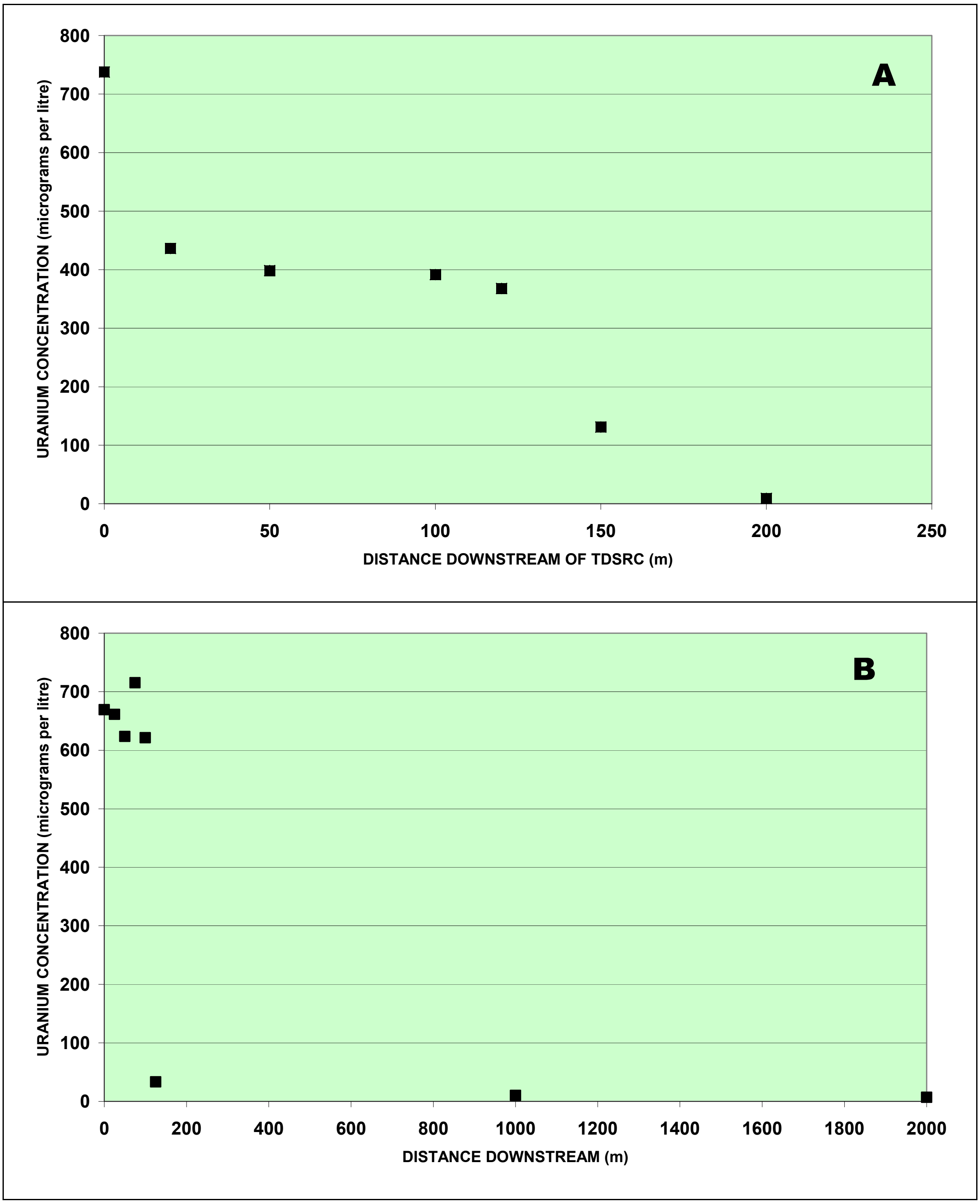


Figure 10 Downstream reductions in uranium concentration below TDSRC on 2 January 1997 **(A)** and 21 January 1997 **(B)**

According to the watercourse information shown on the 'Mount Brockman' 1:50000 topographic map produced by the Army Topographic Support Establishment in 1997, the drainage feature at TDSRC flows into two channels before reaching an anabranch of Gulungul Creek. It is then 5 km by channel to the GCH sample site. Clearly, dilution by flows in Gulungul Creek and attenuation would further greatly reduce the uranium concentration at the GCH sample site. Gulungul Creek between the tailings dam tributary and GCH is characterised by a single sand-bed main channel and by a series of shallower anabranches on a wide, well vegetated floodplain. Overbank flows would also provide significant opportunities for substantial uranium attenuation. The ratio of catchment area of Gulungul Creek to the total for the whole southern tailings dam tributary at their junction is about 16:1 and this can be used as an estimate of dilution.

On the basis of this minimum (because it ignores absorption) dilution factor, the concentration of uranium at the Gulungul Creek sampling site GCH could have been as high as 0.5 µg/L at the time that Mr Kyle observed 9 µg/L at the entry to the Gulungul Creek tributary. While this concentration is much lower than the recommended standards at the time of observation or at the present time, these data indicate that the occurrence of concentrations of about 10 000 µg/L at TDSRC on 10–11 December 1997 could have been more significant, up to 7 µg/L. As stated above, this concentration represents the maximum value that could have been expected to occur at the Gulungul monitoring point and the monitoring data at the time did not record a concentration of this magnitude. Nevertheless, the knowledge that such a concentration was in principle possible might have led ERA management to reconsider the importance of the observations on uranium concentrations at TDSRC. However, ERA management appears to have been unaware of the measurements taken by Mr Kyle and could not act upon them. ERA management was, however, aware of the results of Mr Surkitt's investigation which indicated that the continuing discharge of these waters to the Gulungul Creek system did not pose a threat to Gulungul Creek.

In his report, Mr Kyle questioned the adequacy of the monitoring program at Ranger and, in particular, its inability to reliably measure loads of chemical components and pulses of rain event-driven contaminant exports.

The determination of loads requires simultaneous analyte concentrations and discharge measurements. Therefore, water sampling sites must be located at gauging stations if loads are to be accurately determined. Detailed research on suspended sediment transport has demonstrated that monthly and weekly sampling frequencies at river gauging stations are usually associated with very large errors for load estimates when determined by rating curves (Walling 1977a, 1977b, 1978, Rieger & Olive 1988, Walling & Webb 1988). Other methods of load estimation based on infrequent sampling of concentrations are even less accurate and should not be used. Furthermore, bias-correction procedures (Ferguson 1986, 1987) do not improve the accuracy of load estimates by rating curves, indicating that there are other sources of error (Walling & Webb 1988).

If load estimation is the objective of monitoring, then Mr Kyle's concerns are well founded. If event-based water sampling at river gauging stations is considered essential, automatic pump water samplers should be used (Walling & Teed 1971, Thomas & Lewis 1995). The method of water sampling could be selection-at-list-time (SALT), time-stratified or flow-stratified (Thomas & Lewis 1995). All three methods produce unbiased estimates of load and variance, and can be used to estimate event yields or to estimate mean concentrations in flow classes for detecting change over time or differences from water quality standards (Thomas & Lewis 1995). Time-stratified sampling generally gives the smallest variance of the three methods for estimating storm yields (Thomas & Lewis 1995).

The review of the Ranger monitoring program that is currently underway should determine whether load estimation is be one of the objectives and, if it is, how best to achieve it. It needs to be recognised that chemical sampling cannot and should not be considered in isolation from biological monitoring. There were two principal reasons for the introduction of biological monitoring in the ARR by the Supervising Scientist. These were:

- The need to ensure that monitoring addresses the key issue, that is, the protection of animals and plants, and
- The use of biological monitoring is a method of integrating the potential impact arising from increases in chemical concentrations in both space and time.

It is recommended that the Ranger Minesite Technical Committee, in its current review of the Ranger monitoring program, assesses the need for load estimation in the chemical monitoring of the Ranger mine, taking into account existing biological monitoring programs.

It is also recommended that the Ranger MTC consider, within the context of Best Practicable Technology, whether or not uncontrolled discharges of water from TDSRC to the Gulungul Creek system should continue.

Apart from the above two recommendations, our conclusions on the issue of routine discharges of RRZ water into the headwaters of Gulungul Creek are as follows:

- ERA did not discharge RRZ or tailings water from the mine to the external environment but acted properly in accordance with the requirements of the NT Minister for Resource Development with respect to water shedding from the walls of southern region of the tailings dam.
- ERA was aware of the higher than normal concentrations of uranium in this region in December 1997 and understood that their origin was the recent toe loading of the dam. ERA investigated any potential impact on the waters of Gulungul Creek prior to the concerns expressed by Mr Kyle. The results of this investigation to a distance of 200 m from TDSRC indicated that the uncontrolled discharge of these waters did not pose a threat to Gulungul Creek.
- Mr Kyle, unaware of the first investigation, conducted a second similar investigation but extended the survey to 2000 m from TDSRC. He did not inform ERA environmental managers that he was conducting the survey and apparently did not provide them with his results. Had ERA management been aware of the results, it might have reconsidered the importance of the observations on uranium concentrations at TDSRC. Since ERA management was, however, unaware of the measurements taken by Mr Kyle, it cannot be held responsible for not acting upon them.

3.3 Analysis of Gulungul Creek sample dated 6 January 1997

As stated above, Mr Kyle, in his report, claims that, when an indication was recorded that an effect attributed to the discharge of TDSRC waters had been found at Gulungul Creek, ERA refused permission for field staff to investigate the matter, attempted to suppress the datum, and described it as spurious in a statement to shareholders. The offending result was reported to have come from two separate samples, each tested in triplicate by the same experienced analyst (Mr Kyle) who acquired the samples. These issues are addressed in this section.

In the previous section, we have assessed the issues associated with investigation of the potential downstream effects of discharges into the Gulungul Creek catchment. Two principal issues arise with respect to the analysis of the water sample collected at the downstream Gulungul Creek monitoring point (GCH) on 6 January 1997. These are:

- The number of samples collected and analysed for uranium
- The alleged instruction by Mr Ryan to Mr Kyle not to record the uranium result in the ERA database.

3.3.1 Number of samples collected and analysed

In his report, Mr Kyle claims that he collected duplicate samples at GCH (Gulungul Creek at the Arnhem Highway Bridge) on 6 January 1997 and that he made triplicate determinations of the uranium concentration using ERA's kinetic phosphorescence analyser (KPA). We have attempted to establish the sample record for that day from ERA's laboratory record. The following information was obtained:

- ERA's monthly checklist for January 1997 shows that duplicate samples were not collected at GCH. Instead, one sample was collected for the analysis of general parameters and two acidified water samples were collected. One of the acidified samples was collected for uranium analysis (sample 52917) and one for analysis of ^{226}Ra.
- Three sequential analyses of sample 52917 were required before a reliable result could be obtained. This involved increasing the dilution until a phosphorescence life time greater than 220 was obtained, this value being required before a reliable result could be claimed using the KPA technique.

Thus the laboratory records only reveal the analysis of a single sample for uranium and that this sample was not subject to triplicate analyses but was subject to three sequential analyses to obtain a single reliable result.

Mr Kyle, at the interview on 13 May 2002, explained that he used the general parameters water bottle and the uranium acidified sample as the duplicates for uranium analyses. Only acidified samples should be used for such analysis. However, there is no independent confirmatory record that these two samples were analysed by Mr Kyle because no permanent record was kept. Routine duplicate samples are currently being collected by ERA as part of their monitoring protocol (Mr O Fisher, ERA, personal communication, 2002). Similarly, while only one uranium result was entered by Mr Kyle for sample 52917 at GCH on ERA's uranium results sheet (File L04.151) on 10 January 1997, Mr Kyle explained that he undertook triplicate analyses but only entered one result. A permanent record of the results of all analyses should have been kept.

3.3.2 Recording of the result in the database

In his report, Mr Kyle stated that Mr Ryan issued an instruction that the uranium result for sample 52917 not be recorded in the data base. (It should be noted that the word 'suggested' is used in one sentence and 'instruction' in another.)

The timing of this alleged incident is uncertain from Mr Kyle's report but it is linked to Mr Ryan's alleged refusal to grant permission to investigate uranium concentrations downstream from TDSRC. Mr Kyle states that he refused to comply with either part of the instruction and entered the result on the data base and undertook the first survey downstream on the day that the 7ppb result was acquired. From the laboratory log, this latter date was 10 January 1997.

Mr Ryan, in his interview on 10 May 2002, had no recollection of such a refusal to sample the additional sites or of his supposed instruction to delete data from ERA's database. He maintained that his policy was that all data should be entered and the reasons for any unusual values should be subsequently investigated to determine their reliability. Mr M Nolan, a former Senior Technical Officer in ERA's Environmental Laboratory in his interview of 24 July 2002, confirmed the veracity of Mr Ryan's stated policy. Mr Ryan also said that 7.4 ppb uranium was a high value for GCH and was totally unexpected. He suggested that the sample may have been contaminated during collection or during subsequent analysis. A re-analysis of the sample should have been undertaken although he could not remember requesting it.

Because Mr Ryan's memory on these issues was vague, the investigation team decided to check ERA's records of staff movements. It was then discovered that the records show that Mr Ryan was on annual leave from 9 December 1996 to 20 January 1997. Thus, he was not on site when the uranium analysis for sample 52917 was obtained and could not have given an instruction at that time that the result not be recorded or that Mr Kyle should not proceed with the investigation of uranium concentrations downstream from TCSRC which Mr Kyle claims he carried out, contrary to instructions, on the day that the 7ppb result was obtained.

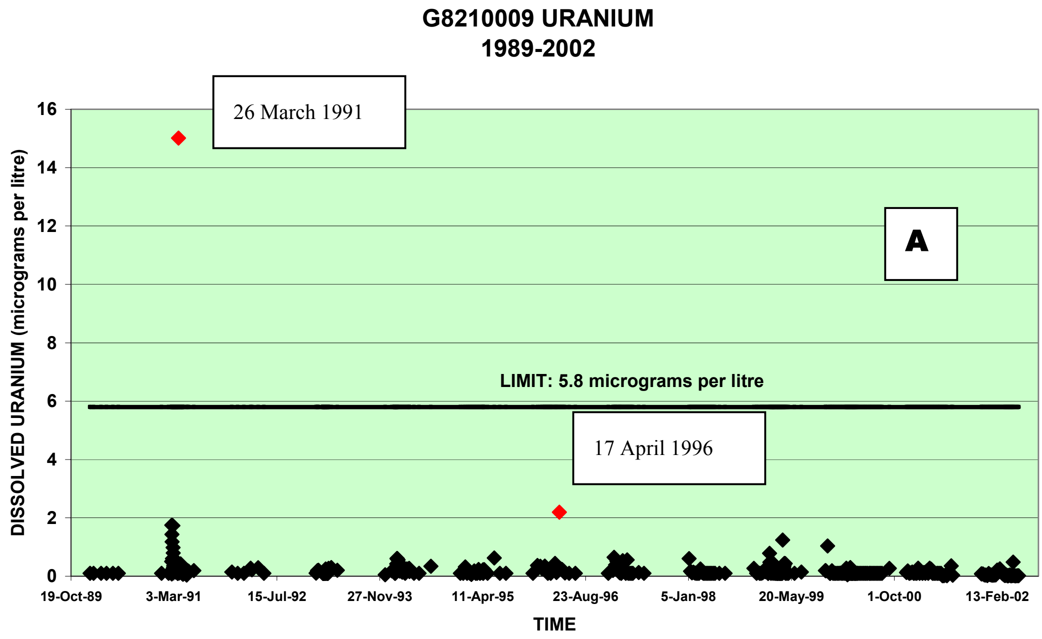
The value of uranium entered for sample 52917 on ERA's water quality database is currently 0.1 µg/L not 7.4 µg/L. At interview, Mr Kyle presented to ***oss*** officers the record of uranium concentrations at the Gulungul Creek monitoring point GCH in support of his claim that there were historically high values of uranium at this point. The date of the printout was 6 February 1997. The value recorded for GCH on 6 January 1997 was 7 µg/L (only one significant figure was printed for all results). Thus, the result reported by Mr Kyle was recorded at that time and the change must have been made at some later time.

Both Mr Ryan and Mr Nolan stated that the later figure (0.1 µg/L) is most likely the result of a re-analysis of the sample. Mr Ryan suggested that sample 52917 would have been re-analysed if he was aware of the original result but he had no recollection of it. Mr Nolan stated that ERA's standard practice at that time was that sample 52917 should have been re-analysed to check the original result. The value of the re-analysis should have been entered next to the original result on the work sheet with a line drawn through the original entry. Mr Nolan thought that the re-analysis was probably undertaken and the result entered directly onto the database without the original result being annotated on the work sheet.

We have checked ERA's laboratory records and have found no evidence of such a reanalysis of sample 52917. We have also checked ***eriss***'s laboratory records in case ERA had requested that ***eriss*** carry out an independent check. No such record was found. ERA did send some samples to external laboratories for analysis at that time but no such record has yet been found. Thus at the time of writing this report, no fully satisfactory explanation has been found for the discrepancy between the 7.4 µg/L result reported by Mr Kyle and the 0.1 µg/L result currently recorded for sample 52917.

Because our investigation of the alteration of the results in the database was inconclusive, we have examined the full ERA database to determine whether there is evidence to support Mr Ryan's claim that it is ERA's policy to retain outlier points unless a reanalysis demonstrates that they are in error.

Examples of extracts from the current ERA water quality database for uranium analyses in Magela Creek downstream of Ranger (G8210009) are shown in figure 11. There are two high uranium values recorded (highlighted in red in figure 11A), one of which exceeds the current limit of 5.8 µg/L (figure 11). These high values are believed, by ERA and the authorities, to have arisen from sample contamination.



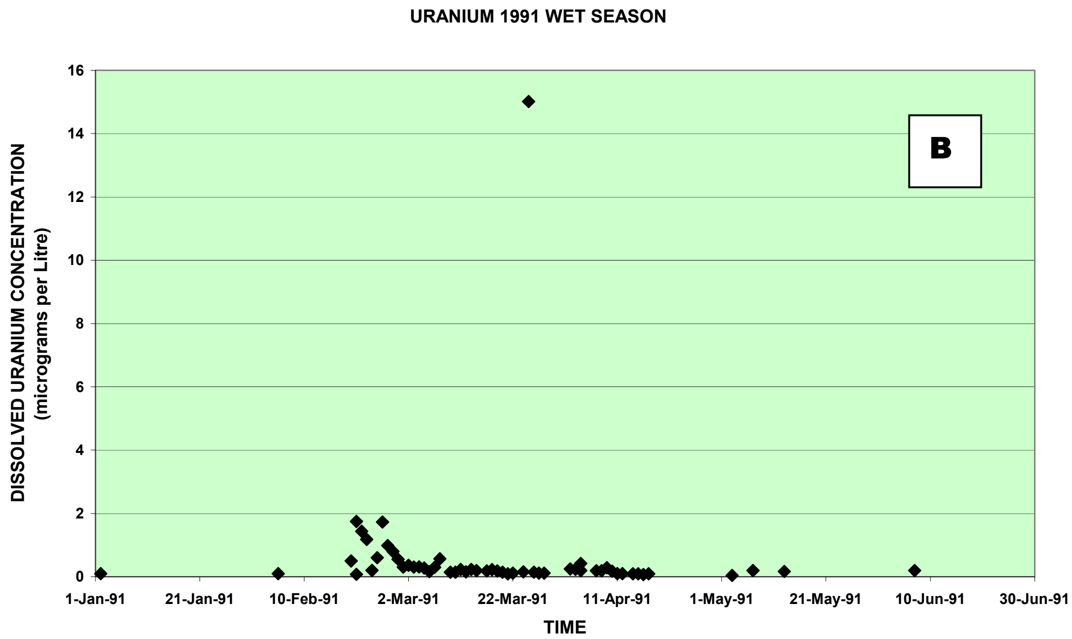


Figure 11 Dissolved uranium values at GS8210009, downstream of Ranger mine (A) Full data set 1989-2002 and (B) Expanded data set for the 1991 Wet season. The values highlighted in red are high values which are discussed in the text.

For example, the data for the 1991 Wet season are expanded in figure 11B. The value of 15 µg/L on 26 March 1991 is clearly an outlier with results obtained immediately before and after this date being very low. The 1991 uranium data were discussed in detail in the Supervising Scientist's Annual Reports for 1990–1991 and 1991–1992 within the context of investigation of the unplanned disharge of water originating from the Ranger high grade ore stockpile. In both reports, the Supervising Scientist quotes the maximum value for the uranium concentration for the 1990–91 Wet season as being 1.7 µg/L which occurred on two occasions on 20 and 25 February 1991. Thus the Supervising Scientist, in making his assessment of the significance of uranium concentrations in Magela Creek during 1991, did not consider the value of 15 µg/L on 26 March 1991 because it was considered to have arisen from sample contamination. Nevertheless, this value and the less high value of 2.2 µg/L on 17 April 1996 have not been deleted from ERA's database.

Thus, we have not been able to find any evidence that indicates that ERA had a culture of altering monitoring data. On the contrary, results for samples considered to have been contaminated have been retained in the current database.

The principal conclusions we have reached with respect to the analysis of the water sample collected at the downstream Gulungul Creek monitoring point (GCH) on 6 January 1997 are:

- The ERA laboratory records only reveal the analysis of a single sample (52917) for uranium for the Gulungul Creek monitoring point and that this sample was not subject to triplicate analyses but was subject to three sequential analyses to obtain a single reliable result. Nevertheless, Mr Kyle has advised that he recorded only one result following triplicate analysis of two samples.
- The ERA Laboratory Manager, Mr Allan Ryan, was on leave when the uranium analysis for the relevant sample was obtained and could not have given an instruction at that time that the result not be recorded or that Mr Kyle should not proceed with the investigation of uranium concentrations downstream from TCSRC which Mr Kyle claims he carried out, contrary to instructions, on the day that the 7 ppb result was obtained.
- The value of the uranium concentration currently entered for sample 52917 on ERA's water quality database is 0.1 µg/L not 7.4 µg/L as reported by Mr Kyle. The latter result was recorded in the data base in February 1997, one month after the analysis was obtained. ERA procedures should have required a reanalysis of the sample prior to a change of result in the data base but we have found no evidence for such a reanalysis.
- Examination of the ERA data base indicates that ERA's policy of not deleting unusual results until a reanalysis has been carried out has normally been adhered to by the company and its employees.

3.4 Environmental impact

Because of the uncertainty about the validity of the uranium concentration at the downstream monitoring point in Gulungul Creek on 6 January 1997 and also because of the broader issue of the drainage of water containing relatively high uranium concentrations towards Gulungul Creek, we have reviewed the existing data to assess the likelihood of adverse environmental impact in the Gulungul Creek system.

The overall chemical analysis results for uranium in Gulungul Creek have already been discussed. The results are presented in figure 9. Throughout the entire period of mining at Ranger, only two data points have exceeded the current recommendation of the Supervising Scientist for uranium in freshwaters of the Alligator Rivers Region, namely 5.8 µg/L.

According to the analysis presented in the Australian and New Zealand guidelines for fresh and marine water quality (ANZECC & ARMCANZ 2000), adherence to this figure should result in protection of 99% of local species. The two results higher than this value were 11 µg/L in June 1980 as the mine was being constructed and 7.4 µg/L on 6 January 1997. These results may have been caused by sample contamination but, even if they are valid numbers, it is clear that any adverse effect would have been small. First, the extent to which the recommended limit was exceeded was small in both cases. Second, the high values did not persist for extended periods. For example, routine check sampling by NT DBIRD at GCH on 20 February 1997 reported 0.13 µg/L uranium and ERA monthly samples collected on 19 December 1996 and 2 February 1997 were 0.21 µg/L and 0.27 µg/L uranium, respectively. These results indicate that the 7.4 µg/L result, even if correct, did not represent a trend to, or persistent, high values.

eriss has only recently begun to undertake a routine monitoring program in Gulungul Creek as part of the new Supervising Scientist monitoring program. However, ***eriss*** has conducted long-term studies of the fish communities in Gulungul Creek as part of its research program on the establishment of appropriate monitoring programs for the Ranger mine.

In the period 1978 to 1990, ***eriss*** collected information on fish at various sites along the creek, from just upstream of the Arnhem Highway to escarpment sites in Radon Springs. The information was collected by diving and snorkelling in pools, and recording the types and numbers of different fish for each month of the year. In May 2001, a former ***eriss*** employee, Dr K Bishop, who initiated the fish study in 1978 and collected the original data (Bishop et al 1986, 1990, 2001) was engaged by ***eriss*** as a consultant to revisit the sites originally sampled and conduct a modern survey. Dr Bishop recorded the types and numbers of different fish in the same places that he had originally sampled, to see whether any changes to the fish communities had occurred between 1978–1990 and 2001. If changes had occurred, he also wanted to determine whether the changes could possibly be related to the mine.

Dr Bishop used two approaches to compare and assess Gulungul Creek fish communities between the early (1978–90) and recent (2001) periods:

1. Comparison of fish communities in pools upstream of the tailings dam with those in pools downstream of the tailings dam, over time; and
2. Comparison of fish communities in the whole creek between the early and recent periods. If there were differences, it might indicate either natural or general mine-related changes that have been occurring in the catchment and perhaps causing a gradual change over time.

The preliminary results include:

1. The differences in number of species, total counts of fish and types of fish species between pools upstream of the tailings dam with those in pools downstream of the tailings dam over time were very minor. This indicates that the very small quantities of mine wastes reaching the creek downstream of the tailings dam are not directly harming the fish communities there.
2. The differences in types of fish species and their relative numbers between the early and recent periods were small for a given location in the creek. Fish communities have remained very similar over time. The numbers of archerfish (*Toxotes chatareus*) and spangled grunters (*Leiopotherapon unicolor*) in the creek (figures 12 and 13) have declined over time (1978 to the present). ***eriss*** has other data to show that long-term declines and increases in certain fish species, such as archerfish and spangled grunters,

are not unusual in the creeks of Kakadu National Park, including creeks unaffected by mining (eg in Sandy Billabong on Nourlangie Creek).

3. The greatest change to the fish communities of Gulungul Creek that has occurred over time and between different sites was observed in 1981, after natural flood disturbance caused by Cyclone Max.

Further analyses are being conducted but no indication of subtle mine-related changes in the fish communities of Gulungul Creek have been detected. Therefore, detailed long-term biological monitoring indicates that the uranium passing through TDSRC has not impacted on the fish communities in Gulungul Creek between the junction with the tailings dam tributary and the GCH sampling location.

Figure 12 *Toxotes chatareus* sampled from Nourlangie Creek at the Kakadu Highway bridge in May 2002 (WD Erskine photograph)

Figure 13 *Leiopotherapon unicolor* sampled from Gulungul Creek at the Arnhem Highway bridge in February 2002 (WD Erskine photograph)

4 Procedures in ERA's Environmental Laboratory

In his report, Mr Kyle raised a number of issues related to the performance of ERA's chemical analysis laboratory. Specifically he states in his covering letter that:

> Laboratory management consistently refused to address technical issues that compromised the performance of the laboratory. This failure led to an inability to honour the conditions of its licence to operate the mine, especially in terms of the NATA registration of certain critical test procedures and equipment. Even when it was demonstrated that the points raised were valid, Ranger did not rectify the problem.

ERA does not currently maintain an Environmental Laboratory but contracts all its chemical analyses to an external laboratory. Therefore, these complaints are not contemporary issues relating to mine performance and compliance.

It must be recognised that it is extremely difficult after the passage of about five years to establish the detail of what happened in an analytical laboratory that no longer exists. Moreover, the laboratory in question was subject to external inspection and ratification procedures by the competent national authority. It is normal practice for regulatory authorities to rely on the thoroughness of the independent inspection authorities in such matters. Nevertheless, we have investigated the claims made by Mr Kyle primarily to assess whether or not there is any evidence that ERA adopted a policy towards its analytical laboratory that would have undermined its environmental protection responsibilities or compromised its reporting responsibilities. The outcome of our investigation of these issues is summarised below.

A condition of NATA (see below) accreditation is that the records system is generally traceable and that all raw data should be retained for at least three years. ERA, in its response to NATA of 14 March 1997, agreed to retain all raw data, including transcribed data to electronic media, for at least three years. Since this minimum time has now been exceeded, it is fortunate that the completeness of ERA's laboratory records greatly exceeds the conditions of NATA accreditation and we were able to examine the records during this investigation.

4.1 Background

Under the Environmental Requirements that governed ERA's operations at the time, ER36 stated that:

> The Joint Venturers shall ensure that their monitoring standards and methods are conducted in such a way that the laboratory could obtain registration with the National Association of Testing Authorities, Australia and in accordance with the quality control program required by the Supervising Authority.

Thus, the laboratory operated by ERA at Jabiru East had to be capable of NATA registration to comply with this ER. At the time covered by Mr Kyle's allegations, ERA's Environmental Laboratory was NATA accredited (Accreditation No. 1516).

Following a revision of the Environmental Requirements under which, *inter alia*, the condition specified in the old ER36 was removed, ERA formally requested that NATA accreditation of its site Environmental Laboratory be withdrawn on 23 July 2001. All such laboratory analyses are now externally contracted.

On 28 November 1996, NATA conducted an audit of ERA's Environmental Laboratory. Accreditation was continued in the field of chemical testing and ERA was notified of the continuation by letter on 24 December 1996. Accreditation covered:

1. Waters (7.66) including analyses by ion chromatography, ion selective electrode, UV-vis spectrophotometry, AES/ICP, alpha spectrometry and Scintrex laser induced fluorimetry by the methods of American Public Health Association and in-house for, among other things, alkalinity, bicarbonate, carbonate, conductivity, chloride, pH, sulfate and radium-226. Waters for potable and domestic purposes (.01) and trade wastes (.05) were also covered.
2. Constituents of the environment (7.81) including waters other than saline (.11), soils (.31), sediments (.32), biota (.51) and sampling (.71). The methods for specific properties or samples were also listed.
3. Residues in constituents of the environment (7.84) including elements (.01) and nutrients (.51). Methods for specific properties were also listed.

The following five issues were raised by Mr Kyle and are discussed below:

- The balance,
- Radium analysis,
- Alkalinity,
- ICP performance and detection limits, and
- Zinc and deionised water.

Because NATA inspections and reports are widely accepted as providing the most appropriate independent assessment of a laboratory's performance, we refer, wherever possible, to NATA's assessment of the issues raised.

4.2 The Balance

Mr Kyle maintained that the balance was 'condemned by a NATA-certified calibration engineer'. This was not the case. Queensland Traceable Calibrations, a NATA accredited laboratory (Accreditation No. 12329) for specific tests in metrology, completed a calibration report for ERA's Sartorius Model A200S balance (Serial Number 36120003) on 16 August 1996 (Calibration 0042D). It was recommended that the balance be used where the required accuracy was not smaller than 1 mg. The errors were not adjustable.

A balance capable of measuring to four decimal places (0.1 mg) is appropriate where small masses are measured. For highly quantitative work, a balance of this accuracy would be necessary for directly weighing samples in the range 10-100 mg (when an imprecision of 0.1%–1% would result). A mass quantified in this way could be quoted to three significant figures (xx.x mg). If less than three significant figures were required, then a less accurate balance could be used.

The NATA audit did conclude that the balances must be serviced annually and that the week of the month when the single point check of the balance was conducted needed to be shown on the laboratory schedule. ERA responded to NATA on 14 March 1997 and stated that a maintenance schedule for the balances had been initiated with the NATA accredited laboratory, Queensland Traceable Calibrations.

The balance in question was replaced by ERA before Mr Kyle resigned from ERA. Mr B Matthews, ERA's Technical Officer, made inquiries about a replacement balance as soon as capital expenditure was approved for the 1997/1998 financial year. He sought advice from ERA's service technician on 10 July 1997 and quotes for AND balances models HR200, HR300 and HR120 were obtained from Laboratory Supply (S.A.) Pty Ltd on 16 July 1997. The capital expenditure application form for the new analytical balance (AND balance model

HR300, the most expensive of the models for which quotes were obtained) was completed on 28 July 1997. The new balance was installed in October 1997.

Replacement of the balance was apparently delayed until the capital expenditure budget contained the item. This took until the financial year following the detection of the problem with the fourth decimal place.

The issue, therefore, seems to be whether or not the purchase of a new balance was an urgent issue or could be delayed until the new capital equipment program was approved. Mr Kyle clearly believed that it was an urgent matter and the Laboratory Manager, believing that alternative procedures could overcome immediate problems, did not. The NATA inspectors did not recommend immediate replacement, merely limitation of its use, so we must conclude that the Laboratory Manager's action was consistent with NATA's requirements.

4.3 Radium analysis

Mr Kyle's concern about inaccurate Ra determinations is a direct result of the faulty balance. The usual procedure for preparing the barium tracer was to weigh a sample for spiking to four decimal places. To overcome the inability of the balance to measure the fourth decimal place precisely, the amount of tracer weighed was increased by ten, and the resulting solution diluted by ten. In principle there is nothing wrong with this approach as long as the volumetric equipment is properly calibrated, the dilution performed competently and the procedure is validated and documented in laboratory records. Of course, the introduction of an additional step into the testing method increases the possibility of an error being made and it appears that an error did occur in the additional dilution step.

The NATA audit concluded that:

> A system must be implemented to check the calculation software for the radium method on a regular basis, eg by entering a dummy set of data (National Association of Testing Authorities Australia Report on Assessment of Energy resources of Australia Ltd – Ranger Mine Environmental Chemistry Laboratory dated 24 December 1996).

ERA addressed this issue by complying with NATA's request, as outlined in the response to NATA on 14 March 1997.

4.4 Alkalinity

Mr Kyle's allegation that the autotitrator used to measure alkalinity did not accurately measure each component contributing to alkalinity is technical and not highly significant. In essence, alkalinity in natural waters is almost exclusively derived from the conjugate bases of carbonic acid (HCO_3^- and CO_3^{2-}). The pKa values for HCO_3^- and CO_3^{2-} (bicarbonate and carbonate) are ~6.4 and 10.3. These are the pH values where, respectively 50% of 'total carbonate' is present as H_2CO_3 and HCO_3^- (pH 6.4) and HCO_3^- and CO_3^{2-} (pH 10.3). For most natural waters, alkalinity is present virtually entirely as HCO_3^-. However, at pH values greater than ~8.3, CO_3^{2-} becomes a significant contributor. Mr Kyle's allegation apparently relates to a high pH standard (>8.3), which calculated an inaccurate distribution of total alkalinity between HCO_3^- and CO_3^{2-}. The miscalculation derived from inaccurately programmed machine-resident constants.

It is doubtful whether this error produced results that were unreliable in any meaningful way. The main application of alkalinity measurements is to determine the buffering capacity of certain waters. The measurement of pH alone does not do this adequately because it gives no insight into the concentrations of water constituents that contribute to pH. Alkaline buffering is relevant to RP1, for example, where an acidification event caused by oxidation of sulfidic minerals in the sediment would be substantially ameliorated by significant alkalinity in the overlying water. Some waters generated by ERA's activities return pH values where CO_3^{2-} may be present in low concentrations and, therefore, inaccurately quantified under the circumstances described. However, it is important to note that the degree of partitioning between HCO_3^- and CO_3^{2-} does not affect the total alkalinity of the sample, and consequently does not alter its buffering capacity. This point is apparently conceded by Mr Kyle. It may be the case that accurate measurement of the distribution between HCO_3^- and CO_3^{2-} was important to some of ERA's external clients, but is probably not relevant to ERA's statutory obligations.

The NATA audit concluded that:

> The laboratory needs to run a QC sample with each batch of samples for alkalinity determinations, eg a certified reference material or control sample (National Association of Testing Authorities Australia Report on Assessment of Energy resources of Australia Ltd – Ranger Mine Environmental Chemistry Laboratory dated 24 December 1996).

ERA's response to NATA of 14 March 1997 stated that suitable QC standards had been obtained, an internal standard had been produced and both had been used and results recorded.

Spex Certiprep Inc was contracted to conduct a check analysis of ERA's measured alkalinity, among other things. ERA obtained a value of 11.0 mg/L in November 1996. The check result was:

Mean = 11.1 mg/L

σ = 1.38 mg/L

95 % Confidence Interval = 8.34-13.86 mg/L

This is acceptable agreement with ERA's result. While such inter-laboratory comparisons are important for demonstrating accurate results, they do not specifically address Mr Kyle's complaint. From a regulatory and supervisory perspective, Mr Kyle's concern about alkalinity is not significant.

4.5 ICP performance and detection limits

Mr Kyle alleged that ERA did not perform regular checks of the detection limits and performance levels of the ICP spectrometer.

This issue is also highly technical. Most instrument manufacturers quote 'instrumental detection limits' in promotional material for their equipment. This is, broadly speaking, the minimum concentration of an analyte that a testing method can qualitatively observe, without being able to measure with precision. Such values, which are invariably lower than *quantitation limits* that can be reliably measured in practice, should never be used by a laboratory as an indication of the sensitivity of its tests. The accepted procedure is to perform multiple determinations (10–20 would be appropriate) of an analyte at a low but measurable concentration (10 times the quoted detection limit is sometimes used). Four times the standard deviation of these multiple measurements is then used as the operational quantitation limit for that test in that laboratory. Quantitation limits can and do vary from laboratory to laboratory, and need to be rechecked periodically to ensure that performance has not changed. The nature and concentration of matrix species in samples can alter practical quantitation limits significantly, and provides an additional reason for site-specific sensitivity checks.

In the case of ERA's Environmental Laboratory, the instrument in question is an ICP-OES similar to ICP-MS except that an optical-emission spectrometer rather than a mass spectrometer is used to measure atomic ions generated by the plasma. The instrument determines many elements simultaneously and the task of performing multiple-element sensitivity checks on a regular basis would be an onerous one. It is a task that is unavoidable, however, for a laboratory undertaking commercial work or providing results for statutory purposes.

Whether this alleged practice would produce unreliable results depends on how close to the detection limit measured concentrations were. Any values less than a factor of ten greater than the instrumental detection limit would be unlikely to be valid, in the absence of specific evidence from machine-specific sensitivity checks. NATA inspectors are usually quite vigilant in examining records of sensitivity checks and any departure from good practice would be dealt with severely. There is no evidence that NATA found this to be an issue.

4.6 Zinc and deionised water

Mr Kyle alleged that the deionised water system in ERA's Environmental Laboratory was contaminated by brass fittings and that blank-corrections were performed routinely on the zinc results from the ICP, unlike at other laboratories.

Zinc is a challenging element to measure at the trace level (µg/L concentration and equivalent) for all laboratories. This is because low-level contamination can be introduced from many sources. No high-purity water system should contain brass components in contact with the product stream. Mr A Ryan believed that the main source of zinc contamination in ERA's Environmental Laboratory was analytical grade nitric acid and Dr D Jones, Earth Water and Life Sciences, concluded in an email to Mr A Ryan on 29 April 2002, that the major source of zinc contamination in the Jabiluka samples was from the 50 ml sample bottles. In particular, the liner of the bottle caps was the probable source. Nevertheless, ERA took the tap that Mr Kyle suspected of causing the contamination in the deionised water system out of service and installed a bench top purification system to polish deionised water before use in the laboratory.

In principle, all sample analyses should be blank corrected. The process of blank correction should only be performed with a complete understanding of the source of any Zn signal in a blank. This is how the problem with the analytical grade nitric acid and sample bottles at Jabiluka was detected. Laboratories sometimes observe the phenomenon of Zn blank concentrations being greater than sample concentrations (in which case the adjusted concentration is negative). This is invariably a case of gross contamination of the blank. A blank should ideally be procedural, with the high-purity water (previously verified as analyte-free) being subjected to all processes experienced by samples (especially but not limited to filtration and acidification). This procedure was followed by ERA. For Zn, it is important that the blank not be consistently the first sample filtered. This is because inadequately prepared filtration apparatus can contain traces of Zn which reports mostly to the first sample filtered, often resulting in a Zn blank higher than the concentration in samples, where samples have very low levels of this element. The NATA assessor did not highlight ERA's treatment of blanks as being inappropriate in the audit report.

4.7 Summary of laboratory issues

Our assessment of the laboratory related issues raised by Mr Kyle has been, to some extent, superficial in that we have relied heavily upon the assessment of ERA's performance in these areas by the appropriate authority, NATA. NATA carried out inspections of the ERA

Laboratory and, where deficiencies were found, made recommendations to ERA on appropriate procedures to overcome the deficiencies. ERA responded to NATA providing details on steps taken to implement NATA's recommendations.

There is no doubt that many of the deficiencies identified by Mr Kyle were present and that corrective action was needed. This is clear both from the NATA reports and from the acknowledgment provided in the Minute from Mr Jackson dated 3 December 1998. ERA formally assessed its response to Mr Kyle's complaints on 25 May 1998 in a memorandum between Mr Jackson and Mr Ryan, and concluded that appropriate action had been taken in relation to each of the five claims. Furthermore, the relevance of these issues to compliance by ERA with the terms of its authorisation is minimal because some (in particular, ICP performance and detection limits, and Zinc and deionised water) only relate to very low to low concentrations which do not cause environmental impacts. The other issues (the balance, radium analysis and alkalinity) were either addressed by ERA or only affected very infrequent samples which did not result in any significant off-site environmental impact.

It is our experience that analytical issues of the type described by Mr Kyle arise in any laboratory, even the best managed laboratories. A piece of equipment may malfunction or even fail; an existing well developed practice may need to be changed to adapt to new circumstances; etc. Staff, in consultation with management, need to develop procedures to overcome the deficiency or change in the short term while putting in place plans for a permanent solution. What seems to have occurred in the cases described by Mr Kyle is that a dispute arose between Mr Kyle and the Laboratory Manager on what would constitute the best way to overcome the problem. Mr Kyle clearly did not accept the conclusions of his manager, then or now. It is perhaps for this reason that ERA decided that the issue between Mr Ryan and Mr Kyle needed to be dealt with via a 'conflict resolution' process.

We are satisfied that the analytical issues raised by Mr Kyle did not lead to the lack of detection of environmental detriment although, if fully correct, thay may have led to inconsistent or incorrect analyses. We are also satisfied that there is no evidence that ERA adopted a policy towards its analytical laboratory that would have undermined its environmental protection responsibilities or compromised its reporting responsibilities. On the contrary, ERA ensured that it maintained NATA registration of its analytical laboratory and responded appropriately to any recommendations made by NATA inspectors.

5 Conclusions and Recommendations

This report contains the results of an investigation into a number of allegations and issues raised by Mr Geoffrey Kyle related to the management of the Ranger uranium mine. These issues were raised by Mr Kyle in a report and covering letter submitted to the Commonwealth Minister for Environment and Heritage, the Northern Territory Minister for Resource Development and a number of Commonwealth and NT officials on 5 April 2002. The investigation has been carried out jointly by staff of the Supervising Scientist Division and the NT Department of Business, Industry and Resource Development.

The investigation failed to identify any instance where ERA had operated otherwise than in accordance with its Authorisation and the Commonwealth's Environmental Requirements. The detailed findings are summarised below.

Tailings Spill in Corridor Road

In December 1997, an incident took place at the Ranger mine in which the tailings pipeline leaked. Tailings spilled on to the Tailings Corridor Road and into drainage structures designed to receive such spills, all of which lie within the Restricted Release Zone (RRZ). Tailings also sprayed beyond the southern edge of the Corridor Road, landing outside the RRZ. With respect to this incident, Mr Kyle alleged in his report that ERA:

- Under-reported and mis-reported the extent of the incident,
- Failed to clean up [in a timely manner] the spilled tailings material that occupied the Corridor Road Sump and its feeder drains, and
- Employed an *ad hoc* water management strategy that resulted in over 300 kg of uranium being lost to Retention Pond No. 2 (RP2) from which water is released into the Magela Creek system.

With respect to these issues, this investigation has concluded:

- It is impossible after the lapse of almost 5 years from the incident to come to firm conclusions on the quantity of tailings slurry that sprayed on to areas outside the RRZ. It can be concluded with some confidence that the amount of material removed (slurry and soil) was considerably greater than 1 m^3 but this has never been in dispute. ERA staff, past and present, state that it was necessary to remove this larger quantity of material to ensure that no contaminated material remained outside the RRZ, allowing for infiltration of the process water. The extent of disturbance may have been excessive but it is difficult to criticise the adoption of this precautionary approach.
- The decision by ERA to delay removal of the tailings from areas within the RRZ until the Dry season was based on a consideration of the practical difficulties in achieving an effective cleanup during the Wet season. To prevent the spread of contamination from the tailings, ERA took appropriate action to ensure that the affected area was isolated within the process water circuit under a specific approval of the NT Minister. ERA also made an assessment of the risk to worker health arising from the spilled tailings and concluded that the risk was very small, but it appears that the company did not inform Mr Kyle of this conclusion.
- Contaminated water from the tailings corridor sump was not the source of the additional load of 300kg received by RP2. The source was the well-documented transfer of water from Ranger Pit 3 which had leached through approximately 1,000,000 tonnes of blasted broken material including some high grade ore. All water associated with the spilled tailings was retained within the process water system.

Discharge of water from the Restricted Release Zone into a tributary of Gulungul Creek

In his report, Mr Kyle describes the uncontrolled discharge of water from the Ranger mine site into a tributary of Gulungul Creek via the Tailings Dam South Road Culvert (TDSRC). With respect to this issue, Mr Kyle claims that:

- ERA routinely discharged from the RRZ water containing up to 10,000 ppb uranium from the toe loading of the tailings dam, via the TDSRC, into the headwaters of Gulungul Creek, and

- When an indication was recorded that an effect attributed to this discharge had been found at Gulungul Creek, ERA refused permission for field staff to investigate the matter, attempted to suppress the datum, and described it as spurious in a statement to shareholders. The offending result came from two separate samples, each tested in triplicate by the same experienced analyst [Mr Kyle] who acquired the samples.

With respect to these issues, this investigation reached the following conclusions:

- ERA did not discharge RRZ or tailings water from the mine to the external environment but acted properly in accordance with the requirements of the NT Minister for Resource Development with respect to water shedding from the walls of southern region of the tailings dam.
- ERA was aware of the higher than normal concentrations of uranium in this region in December 1997 and understood that their origin was the recent toe loading of the dam wall. ERA investigated any potential impact on the waters of Gulungul Creek prior to the concerns expressed by Mr Kyle. The results of this investigation to a distance of 200 m from TDSRC indicated that the uncontrolled discharge of these waters did not pose a threat to Gulungul Creek.
- Mr Kyle, unaware of the first investigation, conducted a second similar investigation but extended the survey to 2000 m from TDSRC. He did not inform ERA environmental managers that he was conducting the survey and apparently did not provide them with his results. Had ERA management been aware of the results, it might have reconsidered the importance of the observations on uranium concentrations at TDSRC. Since ERA management was, however, unaware of the measurements taken by Mr Kyle, it cannot be held responsible for not acting upon them.
- It would appear that tensions existed between Mr Kyle and other staff of the ERA Environment Department this may have led to distrust and poor communication.
- The ERA laboratory records only reveal the analysis of a single sample (sample 52917) for uranium from the Gulungul Creek monitoring point on 6 January 1997 and that this sample was not subject to triplicate analyses but was subject to three sequential analyses to obtain a reliable result. Nevertheless, Mr Kyle has advised that he recorded only one result following triplicate analysis of two samples.
- The ERA Laboratory Manager, Mr Allan Ryan, was on leave when the uranium analysis for the relevant sample was obtained. Consequently, he could not have given an instruction at that time that the result not be recorded or that Mr Kyle should not proceed with the investigation of uranium concentrations downstream from TCSRC which Mr Kyle claims he carried out, contrary to instructions, on the day that the 7ppb result was obtained.
- The value of the uranium concentration currently entered for sample 52917 on ERA's water quality database is 0.1 µg/L not 7.4 µg/L as reported by Mr Kyle. The latter result was recorded in the data base in February 1997, one month after the analysis was obtained. ERA procedures should have required a reanalysis of the sample prior to a change of result in the data base but we have found no evidence for such a reanalysis.
- Examination of the ERA data base indicates that ERA's policy of not deleting unusual results until a reanalysis has been carried out has normally been adhered to by the company and its employees.

Following consideration of the above issues, we recommend the following actions:

1. The Ranger Minesite Technical Committee, in its current review of the Ranger monitoring program, should assess the need for load estimation in the chemical monitoring of the Ranger mine, taking into account existing biological monitoring programs.
2. The Ranger Minesite Technical Committee should consider, within the context of Best Practicable Technology, whether or not uncontrolled discharges of water from TDSRC to the Gulungul Creek system should continue.

Procedures in ERA's Environmental Laboratory

In his report, Mr Kyle raised a number of issues related to the performance of ERA's chemical analysis laboratory. Specifically he states in his covering letter that:

- Laboratory management consistently refused to address technical issues that compromised the performance of the laboratory. This failure led to an inability to honour the conditions of its licence to operate the mine, especially in terms of the NATA registration of certain critical test procedures and equipment. Even when it was demonstrated that the points raised were valid, Ranger did not rectify the problem.

Our assessment of the laboratory related issues raised by Mr Kyle has been, to some extent, superficial in that we have relied heavily upon the assessment of ERA's performance in these areas by the appropriate authority, the National Association of Testing Authorities (NATA). The conclusions of our investigation on this issue are:

- Following NATA inspections of the ERA Laboratory and, where deficiencies were found, the provision of recommendations to ERA on appropriate procedures to overcome the deficiencies, ERA responded to NATA providing details on steps taken to implement NATA's recommendations.
- There is no doubt that many of the deficiencies identified by Mr Kyle were present and that corrective action was needed. This is clear both from the NATA reports and from internal ERA documentation. The relevance of these issues to compliance by ERA with the terms of its authorisation is minimal.
- It appears that, in the cases described by Mr Kyle, a dispute arose between Mr Kyle and the Laboratory Manager on what would constitute the best way to overcome the problems. Mr Kyle clearly did not accept the conclusions of his manager, then or now.
- We are satisfied that the analytical issues raised by Mr Kyle did not lead to the lack of detection of environmental detriment although, if fully correct, thay may have led to inconsistent or incorrect analyses. We are also satisfied that there is no evidence that ERA adopted a policy towards its analytical laboratory that would have undermined its environmental protection responsibilities or compromised its reporting responsibilities. On the contrary, ERA ensured that it maintained NATA registration of its analytical laboratory and responded appropriately to any recommendations made by NATA inspectors.

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Appendix 1

Letter and report from Mr Geoffrey Kyle dated 5 April 2002