Part 3: Jabiluka

Monitoring sediment movement in Ngarradj

K Evans, K Turner & M Saynor

Background

During the 2008–09 wet season, continuous rainfall, stream discharge, turbidity and electrical conductivity (EC) data were collected from the Swift Creek (SC) continuous monitoring station, located immediately downstream of the Jabiluka project area within the Ngarradj catchment. Baseline suspended sediment and hydrology data have now been monitored at this site over a 11 year period. Data collection at two stations upstream of Jabiluka (ET and UM) ceased after the 2006–07 wet season, following discussion and agreement with both the Jabiluka Minesite Technical Committee and ARRTC. The locations of the three monitoring stations are shown in Figure 1.

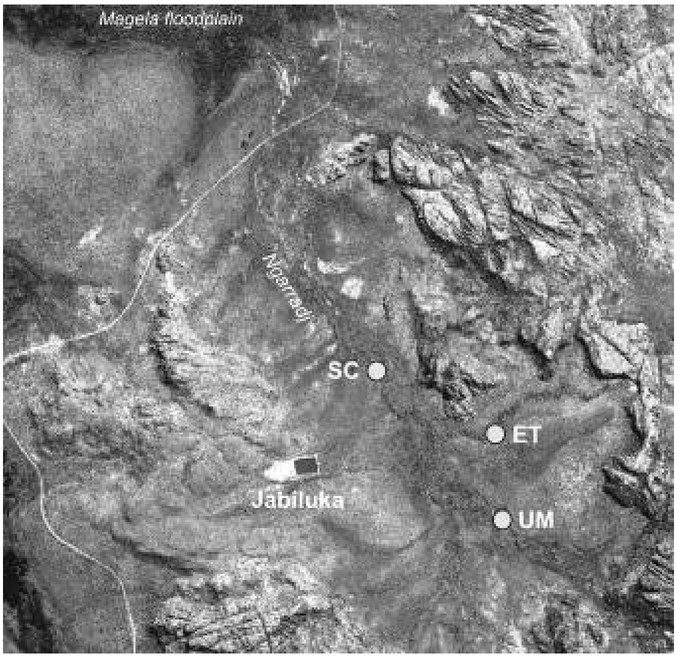

Figure 1 Location of the monitoring stations along Ngarradj

The fine suspended sediment (FSS) data, measured indirectly from turbidity, together with hydrology data collected from the sites, will be used to derive indicators for minesite impact in the event that the Jabiluka project proceeds. Data collected since the 2006–07 wet season are especially important in the context of Cyclone Monica, which occurred in April 2006. In particular, comparison between the suspended sediment load data collected before and after this event may indicate whether there has been a change in 'pre-mining' sediment transport characteristics as a result of this catchment-wide impact.

Progress

An extraordinary rainfall event occurred over a 3-day period between 27 February and 2 March 2007, which resulted in the highest flood levels recorded within the Ngarradj catchment since monitoring commenced in 1998. The SC station was submerged by floodwaters, resulting in damage to monitoring equipment and loss of data during the peak and subsequent recession of the flood. Consequently, the SC continuous monitoring station underwent an upgrade which included installation of new instruments and elevation of the instrument platform to at least 1 m above the peak water level recorded during the March 2007 flood. This upgrade was similar to that described for the Gulungul Creek stations in Moliere et al (2009). As a result of the upgrade, the SC station is now integrated into SSD's continuous monitoring program which also includes Gulungul and Magela Creeks. Due to the location of the SC station, dial up telemetry access is not possible up to an including 2008–2009 as it lies outside mobile network coverage.

The continuous monitoring data collected at SC during the 2008–09 wet season have not yet been analysed, owing to staffing changes and competing commitments. However, all indications from the water quality grab sampling program are that measured parameters remained within the baseline range of values for this wet season. The hydrograph and rainfall over the 2008–09 wet season are shown in Figure 2.

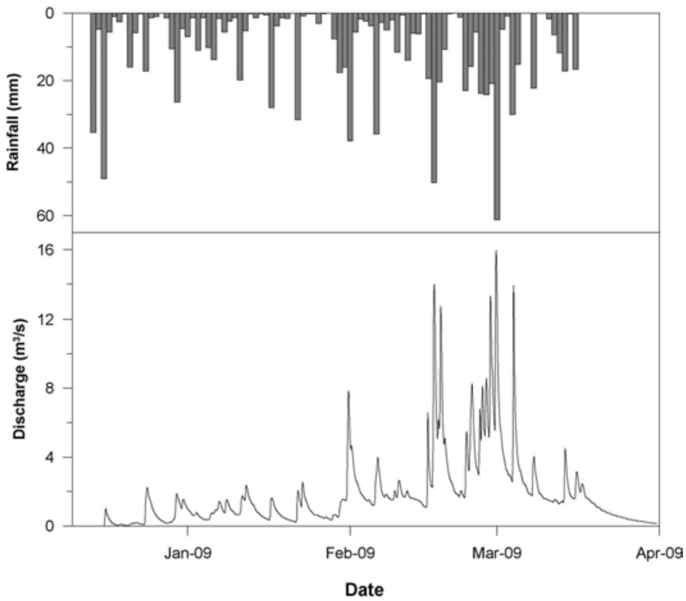

Figure 2 Discharge (m³/s) and rainfall (mm) measured at the SC continuous monitoring station during the 2008–09 wet season

Future work

Event FSS load data collected during the 2008–09 wet season will be plotted against the relationship between FSS load and discharge characteristics derived using data from previous years (Moliere & Evans 2010) to assess the sediment load characteristics for the 2008–09 wet season.

References

Moliere DR & Evans KG 2010a. Development of trigger levels to assess catchment disturbance on stream suspended sediment loads in the Magela Creek, Northern Territory, Australia. *Geographical Research* DOI: 10.1111/j.1745-5871.2010.00641.x

Moliere D, Staben G, Saynor M & Houghton R 2009. Development of catchment geomorphic characteristics of Gulungul Creek – gauging station upgrades. In ***eriss*** *research summary 2007–2008*. Supervising Scientist Report 200, Supervising Scientist, Darwin NT, 170–171.

Part 4: Nabarlek

There are no research papers this year in the Nabarlek key knowledge needs theme. The taking over of management of the site by Uranium Equities Limited and the requirement for conduct of monitoring and progressive rehabilitation activities as part of the mine management plan have meant that the involvement of SSD has been reduced following completion of the suite of projects that had been initiated to define for stakeholders the rehabilitation status of the site.

Part 5: General Alligator Rivers Region

Remediation of the remnants of past uranium mining activities in the South Alligator River Valley

A Bollhöfer, B Ryan, M Fawcett[1], K Turner & D Jones

Introduction

The upper South Alligator River valley in the south of Kakadu National Park is both a popular tourist destination and a region in which past uranium exploration, mining and milling activities have occurred. The locations of these former uranium mine sites are marked on Figure 1.

Mining in the area started with the discovery of the Coronation Hill deposit in 1953, and continued through to 1964. During that time, approximately 877 tonnes of U_3O_8 were produced from 13 small scale uranium mines (Waggitt 2004). When mining ceased, no substantial effort was made to clean up and rehabilitate the mine and mill areas or camps.

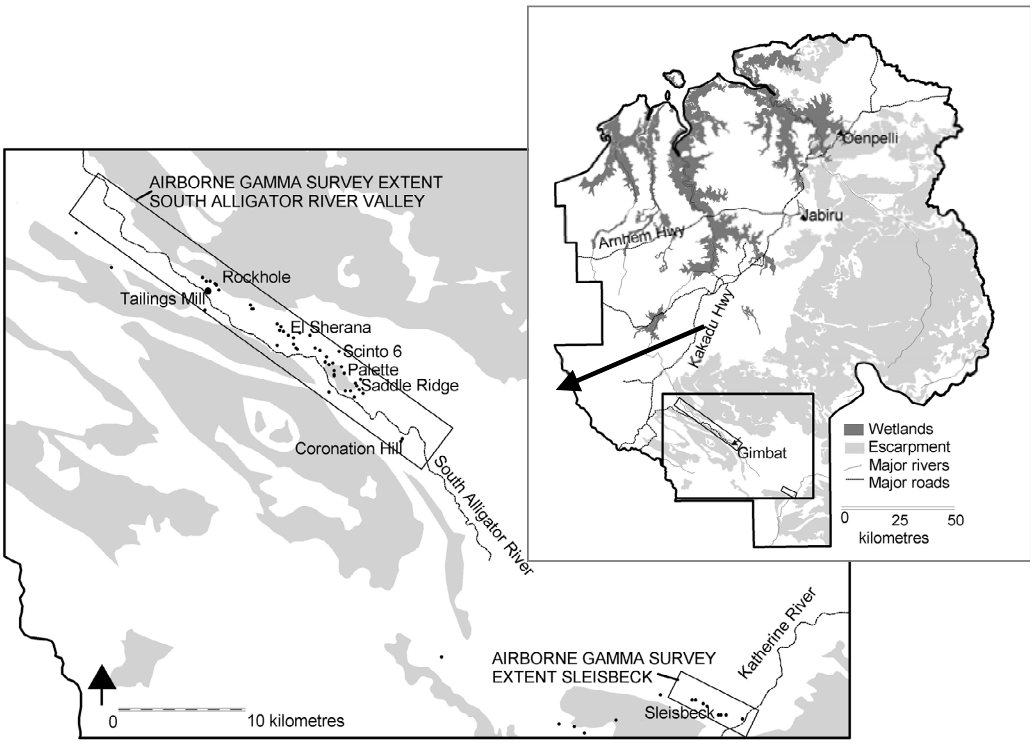

Figure 1 Alligator Rivers Region, with a detailed excerpt of the southern area showing the extent of two airborne gamma surveys conducted in 2000 and 2002, the location of known uranium anomalies (from MODAT database) and some historic mining and milling areas (Supervising Scientist 2003)

Radioactive tailings were discovered by staff from SSD in 1984 next to the road to the Gunlom waterfall, and close to the South Alligator River, during a ground gamma radiation survey. The fine-grained tailings originated from the Rockhole mill, where over 13 400

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tonnes of high-grade uranium ore were processed in the 1950s and 1960s. Subsequently, rehabilitation works were conducted in 1990–92, with most of the tailings removed. Residuals of the tailings subsequently found to be located on erodable terrain adjacent to the river (Tims et al 2000) were covered with rock armour (in 2000) to prevent erosion of the material into the river. Other small historic mining sites were, at that stage, not considered a priority for rehabilitation because they were either largely inaccessible to the public, relatively stable and/or did not contain radioactive tailings.

In 1996, land granted to the Gunlom Aboriginal Land Trust was leased back to the Director of National Parks to be managed as part of Kakadu National Park. The lease agreement required the Director of National Parks to implement an environmental rehabilitation plan for the historic minesites and associated workings in the South Alligator River valley. This plan is managed by Parks Australia. SSD is providing specialist assistance with the radiological assessment of the sites.

Airborne gamma surveys were flown over the South Alligator River valley in 2000 (Pfitzner & Martin 2000, Pfitzner et al 2001) and over the Sleisbeck area in 2002 (Bollhöfer et al 2008). The results from these surveys were used to identify the location, extent and magnitude of residual radiological contamination. Areas exhibiting radiation levels above local background values were subsequently surveyed in more detail by ground measurements (Bollhöfer et al 2002, Bollhöfer et al 2007). The results of these investigations have aided the development of a rehabilitation strategy for the South Alligator River valley. The works for this are nearing completion.

Radiological assessment of the area continued through 2008–09 to provide final details of those sites that may require additional attention to remove remaining above-background materials. Two historic minesites, Palette and El Sherana, were investigated by grid-surveys. In addition, a post-remediation radiation survey was conducted at the Sleisbeck mine in the Katherine River catchment to document the success of the works that were carried out during the 2007 dry season. The Sleisbeck site is approximately 30 km south-east of Guratba. Figure 1 shows the location of these sites.

Results

Status of Palette mine

Palette mine was worked from 1956 to 1961 and produced ~120 tonnes U_3O_8 from high grade uranium ore (Fisher 1968). While mining occurred mainly in open stopes, there are also a number of adits in the area. The mine area is difficult to access. It is located less than 1 km to the east of the Koolpin access track, approximately 220 m above sea level.

The highest pre remediation gamma dose rate at Palette was 5 $\mu Gy \cdot hr^{-1}$, measured on the top bench, with typical values ranging between 1.4 and 1.7 $\mu Gy \cdot hr^{-1}$. During a meeting between Parks Australia, the Supervising Scientist and consultants involved in the rehabilitation works, a guideline value for the gamma dose rate applicable to the rehabilitation of historic mining and milling sites in the South Alligator River valley was set at 1.25 ± 0.25 $\mu Gy \cdot hr^{-1}$ (which is approximately 10 times higher than background levels). This guideline value was derived purely on the basis of being able to distinguish the radiological signal from the regional background, and it should be regarded as a screening value. Application of this value as a cleanup threshold will result in annual effective doses to members of the public being well below the 10 mSv dose constraint recommended by the International Commission for Radiological Protection (ICRP 2007) for the rehabilitation of existing exposure situations.

This applies even in the unlikely case that the remediated areas were permanently occupied for a couple of months per year.

About two thirds of the surveyed area at Palette mine, in particular the top bench, showed gamma dose rates above the screening guideline value. The top bench has been remediated and scraped in September 2009. The material has been buried at the new containment at the El Sherana Airstrip.

Status of El Sherana mine

The El Sherana mine area was worked from 1956 to 1964 and produced ~400 tonnes U_3O_8 (Fisher 1968). The ore grade was lower than at Palette but was still comparatively high at up to 0.82%. Two areas were worked: the El Sherana pit on the hill top and El Sherana West in the valley located approximately 500 m north-east of the El Sherana camp. The airborne gamma survey from 2000 indicated that the El Sherana pit was the main source of above-background radiation in the area and so ground surveys focused on that area.

The highest dose rate on top of the El Sherana pit was 14 µGy/hr, measured over a concrete pad that had supported a battery used to crush some of the high grade ore mined at the site. The next highest readings were obtained from an area without noticeable infrastructure but containing a number of rock and rubble piles. Figure 2 shows a contour plot of dose rates measured on top of the pit. It appears that some radiological material was eroding towards the northwest, coincident with flow lines established from the local topography. Approximately 7000 m^2 were surveyed within the fenced area; approximately 4800 m^2 was found to exceed the 1.25 µGy/hr threshold value.

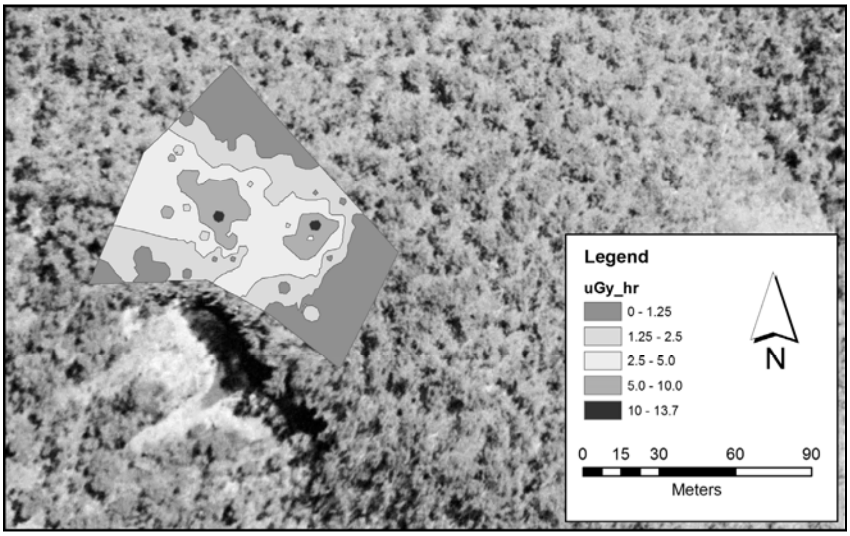

Figure 2 Dose rate contours [µGy/hr] on top of the El Sherana pit

In addition, the bottom of the El Sherana pit and associated workings, consisting of two waste piles and four benches in the pit wall to the south-east of the pit, were surveyed in December 2008. The bench on top of the pit wall exhibited gamma dose rates of approximately 1 µGy/hr. The remaining three benches, the bottom of the pit, and the two waste piles exhibited average gamma dose rates of about 2 µGy/hr and above. There was a small area of mineralisation accessible from one of the benches that exhibits gamma dose rates of above 7 µGy/hr. To cover the mineralisation and to reduce average gamma dose rates in the area, the material from the two waste piles was shifted and pushed against the benches to the south-east of the pit, and subsequently covered with background material. The area has now been remediated and the contaminated material has been transported to the new containment at the El Sherana Airstrip.

Assessment of the rehabilitated Sleisbeck minesite

The Sleisbeck mine was worked in 1957 but only a little over 2 tonnes of U_3O_8 was produced before the mine was abandoned. The rehabilitation of this site, comprising a water-filled open pit and surface waste dumps with a substantially above background radiological signature was undertaken in the dry season of 2007. The waste rock and low grade material from the truck dumps to the south of the pit were removed and placed into the pit. The pit backfill was shaped to cover a mineralised area in the pit wall that exhibited very high external gamma dose rates of above 30 µGy/hr.

Top cover material with background radiological signature was sourced from old spoil piles located to the east of the Sleisbeck pit. This material was spread over the surface of the backfilled pit in a single layer to a nominal depth of 700 mm. The second source of cover material was from a disused track to the north-east of the pit, which provided material for the final upper 300 mm cover layer (Waggitt & Fawcett 2008). Rehabilitation works were finalised in December 2007.

A detailed ground survey of the rehabilitated footprint was carried out in 2008 to confirm that the radiological objectives of the works had been achieved (Bollhöfer & Fawcett 2009). Figure 3 shows a probability plot of the gamma dose rates. Geometric and arithmetic averages measured across the 7.6 ha surveyed are 0.14 and 0.23 µGy/hr, respectively. Assuming a lognormal distribution, the plot shows that 99% of the area surveyed has gamma dose rates below the screening value of 1.25 µGy/hr. There is a small area immediately to the east of the old access track to the rehabilitated pit where gamma dose rates of above 3 µGy/hr were measured. This area is part of an old access track to the pit, and mineralised material may have been used as road fill. It comprises less than 0.01% of the area.

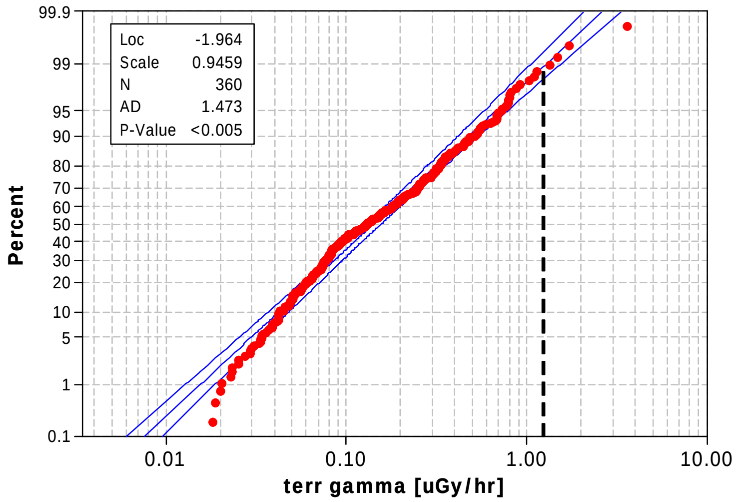

Figure 3 Probability plot of terrestrial gamma dose rates at Sleisbeck post rehabilitation. The probability plot shows that ~99 % of the area surveyed exhibits terrestrial gamma dose rates below 1.25 µGy/hr.

The successful rehabilitation of the old truck dumps and pit area at the Sleisbeck mine has reduced the average terrestrial gamma dose rates in the area by about threefold. Assuming the unlikely scenario that the site is occupied for one month per year, the average terrestrial gamma dose rate on site will lead to an effective dose from exposure to terrestrial gamma radiation of ~ 0.1 milli Sievert. Approximately half of this dose will originate from exposure to natural background radiation. These doses are well below the annual dose constraint for the public for existing exposure situations of 10 mSv, and even lower than the 0.3 mSv dose constraint recommended in current ICRP (2007) guidelines for prolonged exposure from planned exposure situations.

Assessment of rehabilitation requirements for Rockhole Mine Creek

In contrast to the situations described above where the primary rehabilitation requirements relate to solid materials produced by mining, Rockhole Mine Creek is a case of a receiving waterway receiving contaminated drainage originating from abandoned mine workings.

Rockhole Mine Creek (RMC) is a small tributary of the upper South Alligator River that receives low level inputs of acidic and metal-rich seepage water from the former Rockhole minesite. The water is flowing at a low rate (0.2–0.4 L/s) from the lower adit draining the abandoned Rockhole mine workings (see Figure 4).

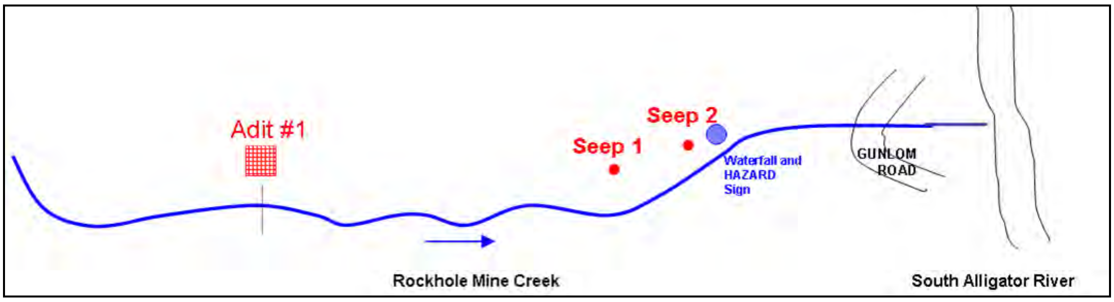

Figure 4 Schematic (not to scale) of Rockhole Mine Creek showing the location of Adit 1 and two downstream seeps

SSD has completed an assessment of the downstream effects of this input to advise Parks Australia on whether specific remediation is needed. The review draws upon a long history (since 1988) of field investigations, an earlier SSD review prepared for the NT World Heritage Ministerial Council in 2000, the results of field investigations conducted for Parks in 2000 and 2001 by Earth Water Life Sciences (EWLS) Pty Ltd, and a subsequent program of stream monitoring undertaken by SSD between 2002 and 2009.

The earlier reviews and reports by SSD and EWLS in the early 2000s concluded that: (i) there were no significant radiological issues in the creek; (ii) although there was substantial iron staining (an aesthetic issue) along the channel of the creek, this iron was also coming from seeps further downstream of the adit (see Figure 4); (iii) though there were detrimental effects on the ecology of RMC, these effects did not extend to the South Alligator River; and (iv) RMC was not considered to be of significant cultural value to Traditional Owners. Given this background, it was concluded that unless the risk to the downstream environment could be shown to be increasing through time (viz increasing loads of potentially toxic metals, or inputs of radionuclides), there would be no justification for carrying out specific remediation works at the adit. In particular, and given the multiple inputs of iron to RMC, there was no guarantee that remedial works such as plugging the adit or treating the adit waters would necessarily lead to removal of the iron staining and deposition of iron precipitates.

To determine if contaminant loads were increasing through time, an extended program of monitoring to track the composition of the adit water was carried out by SSD between 2002 and 2009.

The recently-completed review (Turner et al 2009) found that over the 20-year water quality record (1988–2009), iron and manganese are the only contaminants that have systematically increased (manganese only slightly) in concentration in the RMC adit outflow. In contrast, the concentrations of the potentially toxic metals, aluminium, copper, lead, zinc and uranium have, overall, decreased significantly on a year by year basis. Subsequent and complementary work conducted by SSD (Ryan et al 2008) has also shown no significant bioaccumulation of ^{226}Ra in mussels in the South Alligator River as a result of input of adit water to RMC.

Given that concentrations of metals of greatest concern to ecosystem health have declined over time, this finding supports earlier recommendations that no remedial action is required in RMC. While iron concentrations have increased in the adit water, this needs to be considered in the context of substantial amounts of iron also being contributed by seeps downstream of the adit. Given that it will not be possible to stop the flow from these distributed downstream sources, there would be no benefit to be gained by remediating the adit source of iron. SSD has recommended future opportunistic sampling of adit waters to confirm on an ongoing basis that iron continues to be the only contaminant in the water that is significantly affecting RMC.

Steps for completion

Post remediation surveys need to be conducted at the Rockhole Residues site in 2009, and at the remediated Palette and El Sherana sites in the dry season 2010.

Acknowledgments

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References

Bollhöfer A, Ryan B, Pfitzner K, Martin P & Iles M (2002). A radiation dose estimate for visitors of the South Alligator River valley, Australia, from remnants of uranium mining and milling activities. In *Uranium Mining and Hydrogeology III*, eds BJ Merkel, B Planer-Friedrich & C Wolkersdorfer. Technical University, Bergakademie Freiberg, 931–940.

Bollhöfer A, Dunn L, Ryan B & Sellwood J 2007. Radiological field investigations at the Rockhole Residue Site, South Alligator River Valley, Australia. Internal Report 529, September, Supervising Scientist, Darwin. Unpublished paper.

Bollhöfer A, Pfitzner K, Ryan B, Martin P, Fawcett M & Jones DR 2008. Airborne gamma survey of the historic Sleisbeck mine area in the Northern Territory, Australia, and its use for site rehabilitation planning. *Journal of Environmental Radioactivity* 99, 1770–1774.

Bollhöfer A & Fawcett M 2009. Results of a gamma dose rate survey at the rehabilitated Sleisbeck mine, Northern Territory, Australia. Internal Report 561, April, Supervising Scientist, Darwin. Unpublished paper.

Fisher WJ 1968. Mining practice in the South Alligator Valley. In: *Proceedings of a Symposium 'Uranium in Australia'*. AusIMM Rum Jungle Branch, 16–21 June 1968, AusIMM, Melbourne.

ICRP 2007. *The 2007 Recommendations of the International Commission on Radiological Protection*. Publication 103, International Commission on Radiological Protection, Elsevier Ltd.

Pfitzner K & Martin P 2000. Airborne gamma survey of the South Alligator River valley: First report. Internal Report 353, Supervising Scientist, Darwin. Unpublished paper.

Pfitzner K, Martin P & Ryan B 2001. Airborne gamma survey of the upper South Alligator River valley: Second Report. Internal Report 377, Supervising Scientist, Darwin. Unpublished paper

Ryan B, Bollhöfer A & Martin P 2008. Radionuclides and metals in freshwater mussels of the upper South Alligator River, Australia. *Journal of Environmental Radioactivity* 99, 509–526.

Supervising Scientist 2003. *Annual report 2002–2003*. Supervising Scientist, Darwin NT.

Tims S, Ryan B & Waggitt P 2000. γ Radiation survey of exposed tailings in the area around Rockhole mine. Internal report 332, Supervising Scientist for the Alligator Rivers Region, Darwin.

Turner K, Jones D & Humphrey C 2009. Changes in water quality of Rockhole Mine Creek associated with historic mining activities. Internal Report 560, June, Supervising Scientist, Darwin. Unpublished paper.

Waggitt P 2004. Uranium mine rehabilitation: The story of the South Alligator Valley intervention. *Journal of Environmental Radioactivity* 76, 51–66.

Waggitt P & Fawcett M 2008. Small scale uranium mine remediation in northern Australia. In *Uranium mining and hydrogeology V*, eds BJ Merkel & A Hasche-Berger, Springer-Verlag Berlin & Heidelberg New York, 243–250.