

# CONTENTS

---

<b>LETTER OF TRANSMITTAL</b>	<b>III</b>
<b>FOREWORD</b>	<b>XII</b>
<b>SUPERVISING SCIENTIST'S OVERVIEW</b>	<b>XIII</b>
<b>ABBREVIATIONS</b>	<b>XX</b>
<b>GLOSSARY</b>	<b>XXI</b>
<b>1 INTRODUCTION</b>	<b>1</b>
1.1 Role and function of the Supervising Scientist	1
1.2 Performance summary	1
1.3 Business planning	2
1.4 The Alligator Rivers Region and its uranium deposits	2
1.4.1 Ranger	2
1.4.2 Jabiluka	3
1.4.3 Nabarlek	3
1.4.4 Koongarra	4
1.4.5 South Alligator Valley mines	4
<b>2 ENVIRONMENTAL ASSESSMENTS OF URANIUM MINES</b>	<b>5</b>
2.1 Supervision process	5
2.1.1 Minesite Technical Committees	5
2.1.2 Audits and inspections	5
2.1.3 Assessment of reports, plans and applications	6
2.2 Ranger	6
2.2.1 Developments	6
2.2.2 On-site environmental management	9
2.2.3 Off-site environmental protection	17
2.3 Jabiluka	36
2.3.1 Developments	36
2.3.2 On-site environmental management	36
2.3.3 Off-site environmental protection	38
2.4 Nabarlek	41
2.4.1 Developments	41
2.4.2 On-site conditions	41

2.4.3	Off-site environmental protection	43
2.5	Other activities in the Alligator Rivers Region	43
2.5.1	Rehabilitation of the South Alligator Valley uranium mines	43
2.5.2	Exploration	45
2.6	Radiological issues	45
2.6.1	Background	45
2.6.2	Radiation at and from Ranger	46
2.6.3	Jabiluka	50
2.7	EPBC assessment advice	51
<b>3</b>	<b>ENVIRONMENTAL RESEARCH AND MONITORING</b>	<b>52</b>
3.1	Enhancements to SSD’s stream monitoring program for Ranger	54
3.2	Results from continuous monitoring of water quality in Magela Creek	58
3.3	Review of solute selection for water quality and bioaccumulation monitoring	67
3.4	Effects of magnesium pulse exposures on aquatic organisms	73
3.5	Amelioration of uranium toxicity by dissolved organic carbon from a tropical Australian billabong	76
3.6	A study of radionuclide and metal uptake in mussels from Mudginberri Billabong	79
3.7	Investigating radium uptake in <i>Passiflora foetida</i> (bush passionfruit)	84
3.8	Design and construction of erosion plots on the Ranger trial rehabilitation landform	88
3.9	Remediation of remnants of past uranium mining activities in the South Alligator River valley	90
<b>4</b>	<b>STATUTORY COMMITTEES</b>	<b>97</b>
4.1	Introduction	97
4.2	Alligator Rivers Region Advisory Committee	97
4.3	Alligator Rivers Region Technical Committee	98
<b>5</b>	<b>COMMUNICATION AND LIAISON</b>	<b>101</b>
5.1	Introduction	101
5.2	Research support and communication	101
5.2.1	Indigenous employment and consultation	102
5.2.2	Research protocols for Kakadu National Park	103
5.2.3	Internal communication	103
5.2.4	Communication with technical stakeholders and the general community	104

5.2.5	Australia Day awards	104
5.3	National and international environmental protection activities	105
5.3.1	Environmental radiation protection	105
5.3.2	Revision of National Water Quality Guidelines	105
5.3.3	Basslink	105
5.3.4	Northern Australian Water Futures Assessment	106
5.3.5	Tropical Rivers and Coastal Knowledge Research Program	106
5.3.6	Special Issue of the Australasian Journal of Ecotoxicology	107
5.3.7	EPBC Compliance Audits	107
5.3.8	Rum Jungle collaboration	107
5.3.9	Global Acid Rock Drainage Guide	108
5.3.10	Best practice study tour of Canada and Brazil	108
5.4	Science communication (including conferences)	109
<b>6</b>	<b>ADMINISTRATIVE ARRANGEMENTS</b>	<b>112</b>
6.1	Human resource management	112
6.1.1	Supervising Scientist	112
6.1.2	Structure	112
6.1.3	Investors in People	113
6.1.4	Occupational Health and Safety	114
6.2	Finance	115
6.3	Facilities	116
6.3.1	Darwin facility	116
6.3.2	Jabiru Field Station	116
6.4	Information management	117
6.5	Interpretation of Ranger Environmental Requirements	117
6.6	Ministerial directions	117
6.7	Environmental Performance	117
6.8	Social and community involvement	118
6.9	National Centre for Tropical Wetland Research	118
6.10	Animal experimentation ethics approvals	118
	<b>APPENDIX 1 ARRTC KEY KNOWLEDGE NEEDS 2008–2010: URANIUM MINING IN THE ALLIGATOR RIVERS REGION</b>	<b>120</b>
	<b>APPENDIX 2 PUBLICATIONS FOR 2008–2009</b>	<b>133</b>
	<b>APPENDIX 3 PRESENTATIONS TO CONFERENCES AND SYMPOSIA, 2008–2009</b>	<b>138</b>
	<b>INDEX</b>	<b>141</b>

## Tables

Table 2.1 Ranger production activity for 2008–2009 by quarter	7
Table 2.2 Ranger production activity for 2004–2005 to 2008–2009	7
Table 2.3 Audit and RPI	12
Table 2.4 Grading System	13
Table 2.5 Ranger Minesite Technical Committee meetings	15
Table 2.6 RPI Focus during the reporting period	37
Table 2.7 Jabiluka Minesite Technical Committee meetings	38
Table 2.8 Annual radiation doses received by workers at ranger mine	47
Table 2.9 Radon decay product concentrations at Jabiru and Jabiru East, and total and mine derived annual doses received at Jabiru in 2006–08	49
Table 3.1 Jabiru rainfall and Magela creek wet season flow conditions since 2005	59
Table 3.2 Estimated Mg loads exported from Coonjimba and Corridor Creeks for the 2005–06 to 2008–09 wet seasons	62
Table 3.3 Mg loads applied to the Magela, Jabiru East and Djalkmara LAAs	63
Table 3.4 Mg loads measured in Magela Creek (upstream and downstream of the mine) and mine waters and applied to LAAs	63
Table 3.5 Comparison of the difference between measured and predicted downstream Mg loads	64
Table 3.6 Sampling sites	69
Table 3.7 Sampling occasions	69
Table 3.8 Mean and standard deviation of pH, EC and turbidity from each site	70
Table 3.9 Summary of results from one-way anovas and Tukey's <i>post hoc</i> tests on differences in element concentrations measured in mine waterbodies and in Magela Creek	71
Table 3.10 Toxicity of pulse exposed magnesium compared with continuous exposure	74
Table 3.11 Effect of two different forms of dissolved organic carbon on the toxicity of uranium to three local freshwater species	78
Table 3.12 <sup>226</sup> Ra concentration factors for <i>Passiflora foetida</i> measured relative to the various leach fractions	86
Table 5.1 International conferences, seminars and workshops, 2008–09	111
Table 6.1 Staffing numbers and locations	113
Table 6.2 Summary of cost of outputs	116
Table 6.3 Animal Experimentation Ethics Approvals	119

## Figures

Map 1 Alligator Rivers Region	xvii
Map 2 Ranger minesite	xviii
Map 3 Sampling locations used in SSD's research and monitoring programs	xix
Figure 2.1 Annual rainfall Jabiru Airport 1971–72 to 2008–09	10
Figure 2.2 Electrical conductivity measurements in Magela Creek between November 2008 and June 2009	20
Figure 2.3 Electrical conductivity and discharge measurements in Magela Creek between December 2008 and April 2009 – continuous monitoring data	20
Figure 2.4 Uranium concentrations measured in Magela Creek by SSD between November 2008 and June 2009.	21
Figure 2.5 Uranium concentrations in Magela Creek since the 2000–01 wet season	21
Figure 2.6 Radium-226 in Magela Creek 2001–09	22
Figure 2.7 Electrical conductivity measurements in Gulungul Creek for the 2008–09 wet season	23
Figure 2.8 Electrical conductivity and discharge in Gulungul Creek 2005–2009 – continuous monitoring	23
Figure 2.9 Uranium concentrations in Gulungul Creek between 2000 and 2009	24
Figure 2.10 Uranium concentrations measured in Gulungul Creek by SSD and ERA during the 2008–09 wet season	24
Figure 2.11 A. In situ toxicity monitoring results for freshwater snail egg production for past three wet seasons. B. Toxicity monitoring results by way of the average freshwater snail egg production for each wet season between 1992 and 2009	26
Figure 2.12 Mean concentrations of uranium measured in mussel soft-parts, sediment and water samples collected from Mudginberri Billabong and Sandy Billabong since 2000	28
Figure 2.13 <sup>226</sup> Ra activity concentrations in the dried flesh of freshwater mussels collected from Mudginberri Billabong 2000–2008 and Sandy Billabong 2002–2008	28
Figure 2.14 Paired upstream-downstream dissimilarity values calculated for community structure of macroinvertebrate families in several streams in the vicinity of Ranger mine for the period 1988 to 2009	30
Figure 2.15 Ordination plot of macroinvertebrate community structure data from sites sampled in several streams in the vicinity of Ranger mine for the period 1988 to 2009	31

Figure 2.16 Paired control-exposed dissimilarity values calculated for community structure of fish in Mudginberri ('exposed') and Sandy ('control') Billabongs in the vicinity of Ranger mine over time	32
Figure 2.17 Relative abundance of chequered rainbowfish in Mudginberri and Sandy billabongs from 1989 to 2009 with associated total discharge in Magela Creek (gauging station G8210009)	34
Figure 2.18 Paired control-exposed site dissimilarity values calculated for community structure of fish in 'directly-exposed' Magela and 'control' Nourlangie and Magela Billabongs in the vicinity of Ranger mine over time	35
Figure 2.19 Uranium concentrations in Ngarradj since the 1998–99 wet season	39
Figure 2.20 Uranium concentrations measured in Ngarradj by SSD and ERA in the 2008–09 wet season	40
Figure 2.21 Radium-226 in Ngarradj 2001–09	40
Figure 2.22 Radon decay product concentration measured by SSD and ERA in Jabiru and Jabiru East from January 2004 to March 2009	48
Figure 2.23 Radon decay product and long lived alpha activity concentrations measured at SSD's Mudginberri Four Gates Rd radon station from July 2004 to June 2009	50
Figure 3.1 Upstream and downstream monitoring sites used in the SSD's water chemistry (grab sampling and continuous) and toxicity monitoring programs	55
Figure 3.2 Time-series plot showing validated discharge and electrical conductivity data measured at the upstream site on Magela Creek from February to April	58
Figure 3.3 Relationships between EC and Mg concentration and upper and lower 95% confidence limits for the upstream and downstream sites on Magela Creek, in the Coonjimba Creek catchment, and in the Corridor Creek catchment	61
Figure 3.4 Discharge measured in the western channel at MCDW against total Magela Creek discharge measured at G8210009	66
Figure 3.5 Percentage of discharge travelling along the western channel as a function of total Magela Creek discharge measured at G8210009	66
Figure 3.6 Toxicity of magnesium to the green hydra, <i>Hydra viridissima</i> , the duckweed, <i>Lemna aequinoctialis</i> and the cladoceran, <i>Moinodaphnia macleayi</i>	75
Figure 3.7 Effect of increasing DOC on U toxicity to <i>Mogurnda mogurnda</i> , <i>Hydra viridissima</i> and <i>Chlorella</i> sp	77
Figure 3.8 Mudginberri Billabong and location of 2008 sampling sites	80

Figure 3.9 $^{226}\text{Ra}$ activity concentrations and $^{228}\text{Ra}/^{226}\text{Ra}$ activity ratios measured in mussels collected in 2008, and a comparison with results from previous end of the dry season collections	81
Figure 3.10 $^{206}\text{Pb}/^{207}\text{Pb}$ plotted versus $^{208}\text{Pb}/^{207}\text{Pb}$ isotope ratios measured in mussel tissue from Mudginberri Billabong, and previous data from Magela Creek	83
Figure 3.11 <i>Passiflora foetida</i>	85
Figure 3.12 Concentration factors based on the bioavailable fraction plotted versus soil $^{226}\text{Ra}$ activity concentration	87
Figure 3.13 Location of the elevated trial landform at Ranger mine	88
Figure 3.14 Layout of the plots on the trial landform	89
Figure 3.15 Plastic half pipe trough and boundary	90
Figure 3.16 Reservoir and flume at the outlet of the erosion plot	90
Figure 3.17 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	91
Figure 3.18 Dose rate contours on top of the El Sherana pit	93
Figure 3.19 Probability plot of terrestrial gamma dose rates at Slesbeck post rehabilitation	94
Figure 3.20 Schematic of Rockhole Mine Creek showing the location of Adit 1 and two downstream seeps	95
Figure 4.1 ERA staff explaining to ARRTC and SSD visitors wet season management of runoff from waste rock stockpiles during a field trip to Ranger mine	99
Figure 5.1 Fieldwork with local Aboriginal people	102
Figure 5.2 <i>oss</i> staff inspecting the discharge compliance point at Cameco's Rabbit Lake operations, Saskatchewan, Canada	109
Figure 5.3 Stockpiling of ore on the heap leach pad at Caetite uranium mine, Bahia, Brazil	109
Figure 6.1 Organisational structure of the Supervising Scientist Division (as at 30 June 2009)	112
Figure 6.2 JFS site following demolition and removal of buildings	116