APPENDICES

Appendix 1: ERA Social Impact Monitoring

The Ranger Environmental Requirements under the 'new' *Atomic Energy Act 1953* (Cth) s.41 Authority (conferred on ERA in 1999) oblige the company to include a section on social impact monitoring in its Annual Environmental Management Report. The complete inadequacy of the company's consideration of social impact monitoring is illustrated with the following extracts from the 2000 and 2001 Annual Environmental Management Reports, the social impact monitoring text of which is exactly the same in both years.

ERA Ranger Uranium Mine Annual Environmental Management Report,
1 May 1999 – 31 August 2000.
Section 10.2 - Social Impact Monitoring:

> ERA has contributed to the social impact monitoring work being undertaken throughout the Kakadu region by Mr Bob Collins. ERA continues to support the implementation of the Kakadu Region Social Impact Study (KRSIS) recommendations, particularly those that impact on ERA operations. Senior ERA Aboriginal employees represent the company at various forums and have been involved in the KRSIS committee as well as the Bining Working Committee and the Gunbang Action Group. ERA continues to strive to provide meaningful opportunities for local Aboriginal people to resolve issues associated with community dysfunction.

ERA Ranger Uranium Mine Annual Environmental Management Report,
1 September 2000 – 31 August 2001.
Section 12.4 - Social Impact Monitoring:

> ERA has contributed to the social impact monitoring work being undertaken throughout the Kakadu region by Mr Bob Collins. ERA continues to support the implementation of the Kakadu Region Social Impact Study (KRSIS) recommendations, particularly those that impact on ERA operations. Senior ERA Aboriginal employees represent the company at various forums and have been involved in the KRSIS committee as well as the Bining Working Committee and the Gunbang Action Group. ERA continues to strive to provide meaningful opportunities for local Aboriginal people to resolve issues associated with community dysfunction.

Appendix 2 - Operational data and financial performance of Energy Resources of Australia Ltd

Annual mining (Mt)

Fin. Year	Ore Mined			Cut-Off	Low-Grade Ore		Waste	Const.	Total
	Pit	SP	Mill	$\%U_3O_8$	(Mt)	$t\,U_3O_8$ [1]	Rock	Material	Mined
2001 [2]	3	1.207	0.166	0.12	1.483	1,038	1.001	-	3.857
2000-01	3	1.539	0.259	0.12	3.392	2,374	2.443	-	7.633
1999-00	3	2.053	0.305	0.12	2.867	2,007	1.657	-	6.882
1998-99	3	1.974	0.522	0.12	4.158	2,911	1.185	-	7.839
1997-98	3	2.210	0.100	0.12	4.141	2,899	1.730	-	8.181
1996-97	3	0.709	-	0.12	2.772	1,940	1.849	-	5.330
1995-96	1	0.00035	-	0.20	0.014	15	0.245	-	0.259
1994-95	1	0.841	-	0.20	1.324	1,456	0.404	-	2.569
1993-94	1	0.712	-	0.20	1.771	1,948	0.980	-	3.463
1992-93	1	0.826	0.004	0.20	1.942	2,136	1.102	-	3.874
1991-92	1	0.337	0.098	0.10	0.792	475	-	1.316	2.543
1990-91	1	0.439	0.222	0.10	0.569	341	1.002	0.553	2.785
1989-90	1	0.617	0.468	0.10	0.862	517	0.957	1.203	4.107
1988-89	1	1.923	0.477	0.10	1.735	1,041	1.399	0.440	5.974
1987-88	1	1.972	0.158	0.10	2.840	1,704	1.160	0.240	6.370
1986-87	1	1.253	0.461	0.075	0.920	437	2.120	0.290	5.044
1985-86	1	1.05	0.45	0.10	0.87	522	1.59	0.76	4.700
1984-85	1	0.4034	0.500	0.10	1.269	761	1.8187	0.551	4.5421
1983-84	1	0.7799 (total)		0.10	0.711	427	0.9745	0.632	3.097
1982-83	1	0.3744 (total)		0.10	0.6	360	1.8	1.0	3.8
1981-82	1	2.0853 (total)		0.10	-	-	1.786 [4]	-	3.871
1979-81 [5]	1	1.5467 (total)		0.10	-	-	5.0 [4,6]	-	6.547

Total	**3**	**11.044 Mt Ore**	0.12%	**18.813 Mt LGO** (~13,169 $t\,U_3O_8$)	**9.865 Mt** [4]	**39.722**
	1	**17.998 Mt Ore** **[19.78 Mt Ore]** #	~0.11%	**16.219 Mt LGO** (~12,142 $t\,U_3O_8$) **[4.5 Mt LGO]** #	**29.303 Mt** **[55.5 Mt]** [7] #	**63.520** **[79.78]** #

[1] Assuming an average $\%U_3O_8$ of the economic and low-grade ore cut-offs (ie. 0.10% and 0.02%);
[2] December half-year only;
[3] No mining was undertaken from December 1994 to April 1996 due to the switch from Pit #1 to #3;
[4] Includes some low-grade ore;
[5] Includes from the start of construction with large quantities of construction material and secondary (weathered) ore;
[6] Assumes 2.0 t/m^3;
[7] Includes 'very low-grade ore', which is classified as >0.02% but <0.05% U_3O_8.

Reference : ERA (1999). No attempt has been made to reconcile the differences between the totals for Pit #1 calculated from the table above and ERA (1999). This is the same as that predicted for the Ranger Inquiry of 20 Mt ore and 60 Mt waste rock (see pp 75, Fox *et al.*, 1977).

Notes : SP - Stockpiled ore; Low-Grade Ore (LGO) is that below the economic cut-off grade but above 0.02% U_3O_8 (ie. - uneconomic ore to mill); Waste Rock is unmineralised material (<0.02% U_3O_8); Const. - Construction material (unmineralised).

References : ERA-AR (various); Danielson (1993); OSS-AR (various).

Annual mine production by ore type (Mt)

Financial Year	Primary		Weathered		Lateritic		Below Cut-Off [1]	
	Mt	%U_3O_8	Mt	%U_3O_8	Mt	%U_3O_8	Mt	%U_3O_8
2001 [2]	1.869 [T]	-	-	-	-	-	6.094 [3]	<0.12
2000-01	1.798 [T]	-	-	-	-	-	3.392	<0.12
1999-00 [4]	2.504 [T]	-	-	-	-	-	6.944 [5]	<0.12
1998-99	1.085 [T]	-	-	-	-	-	3.022	<0.12
-	-	-	-	-	-	-	-	-
1988-89	2.40 [T]	0.28	-	-	-	-	3.57	<0.10
1987-88	2.13 [T]	0.292	-	-	-	-	4.24	<0.10
1986-87	1.71 [T]	0.365	-	-	-	-	3.30	<0.10
1985-86	1.50 [T]	0.318	-	-	-	-	3.20	<0.10
1984-85	0.8041	0.314	0.0778	0.189	0.0215	0.167	3.6387	<0.10
1983-84	0.4089	0.408	0.2273	0.281	0.1437	0.231	2.3175	<0.10
1982-83	0.2436	0.313	0.0647	0.543	0.0661	0.301	3.3511	<0.10
1981-82	0.6708	0.450	0.8451	0.386	0.5694	0.447	1.7858	<0.10
1980-81	0.2146	-	0.7202		0.6119		1.1511	<0.10

[1] May include both low grade ore and waste rock;
[2] Data from September 1, 2000, to August 31, 2001 (ERA-RAER, 2001);
[3] Low-grade ore (0.05-0.12% U_3O_8) - 783,579 t; very low grade ore (0.02-0.05% U_3O_8) - 2,397,525 t (ERA-RAER, 2001);
[4] Data from May 1, 1999, to August 31, 2000 (ERA- RAER, 2000);
[5] Low-grade ore (0.05-0.12% U_3O_8) - 810,725 t; very low grade ore (0.02-0.05% U_3O_8) - 3,581,979 t (ERA-RAER, 2000).

[T] Total ore production (only, although once well developed, the quantities of weathered and lateritic ore from each pit would be minimal).

References : OSS-AR (various).

Annual milling by ore type (Mt)

Ore to Mill	Primary		Weathered		Lateritic		Below Cut-Off	
	Mt	%U_3O_8	Mt	%U_3O_8	Mt	%U_3O_8	Mt	%U_3O_8
1996-97	1.52	0.31%	-	-	0.052	0.25%	-	-
1995-96	0.980	0.35%	-	-	0.220	0.35%	-	-
1994-95	0.500	0.336%	-	-	0.078	0.362%	-	-
-	-	-	-	-	-	-	-	-
1984-85	0.6974	0.346%	0.2556	0.257%	-	-	0.0181	0.086%
1983-84	0.4150	0.409%	0.5310	0.309%	0.0171	0.417%	0.0587	0.086%
1982-83	0.3653	0.358%	0.6197	0.307%	0.0033	0.372%	0.0456	0.095%
1981-82	0.6983	0.287%	0.3425	0.287%	0.0016	0.287%	0.0429	0.287%

References : ERA-AR (various); OSS-AR (various).

Annual milling and uranium production

Fin. Year	Ore Milled Mt	Grade $\%U_3O_8$	Uranium Oxide (t U_3O_8) Contained	Uranium Oxide (t U_3O_8) Production	Mill Efficiency%	Residual tU_3O_8
2002 [1]	0.764	0.27% ?	??	1,863	??%	~230 ??
2000-01	1.840	0.287%	5,277.9	4,612	87.4%	665.9
1999-00	1.468	0.299%	4,390.8	4,144.0	94.4%	245.0
1998-99	1.827	0.267%	4,878.1	4,375.0	89.7%	503.2
1997-98	1.843	0.269%	4,957.7	4,162.0	83.9%	795.8
1996-97	1.571	0.311%	4,885.8	4,236.9	86.7%	648.9
1995-96	1.201	0.349%	4,191.5	3,453.3	82.4%	738.2
1994-95	0.578	0.345%	1,994.1	1,548.2	77.6%	445.9
1993-94	0.437	0.389%	1,699.9	1,461.8	86.0%	238.1
1992-93	0.426	0.348%	1,482.5	1,335.1	90.1%	147.4
1991-92	0.986	0.324%	3,194.6	2,980.0	93.3%	214.6
1990-91	1.090	0.295%	3,215.5	2,908.3	90.4%	307.2
1989-90	1.089	0.314%	3,419.5	3,084.0	90.2%	335.5
1988-89	0.975	0.408%	3,978.0	3,595.5	90.4%	382.5
1987-88	0.782	0.423%	3,307.9	3,041.5	91.9%	266.4
1986-87	0.869	0.379%	3,293.5	3,123.8	94.8%	169.7
1985-86	0.968	0.350%	3,388.0	3,067.0	90.5%	321.0
1984-85	1.021	0.317%	3,236.6	3,037.0	93.8%	199.6
1983-84	1.003	0.343%	3,440.3	3,098.7	90.1%	341.6
1982-83	1.044	0.318%	3,319.9	3,000.0	90.4%	319.9
1981-82 [2]	0.859	0.308%	2,645.7	2,322.5	87.8%	323.2
Total	**23.306**	**0.318% ??**	**74,115.9 ??**	**66,401.6**	**89.5% ??**	**7,598.4 ??**

[1] December half-year only (ore grade not stated by ERA in the December Quarterly production report).
[2] September 1981 to June 1982 only.

Notes - Efficiency calculated as the percentage extracted over that contained. Residual is the amount of uranium left in the mill tailings (giving an average grade of about 0.034% U_3O_8).

References : ERA -A R (various) and Quarterly Reports, Edwards (1993) , OSS-AR (various).

Quarterly milling and uranium production 1996 to 2002

	3 Months To End of	kt Ore	Grade %U_3O_8	t Uranium Oxide (U_3O_8) Contained	Production	Efficiency	t U_3O_8 Residual
2002	Dec.						
	Sept.						
	June	399	~0.26 ?	~1,049 ?	934	??	~115
	March	365	~0.29 ?	~1,044 ?	929	??	~115
2001	Dec.	393	0.32 ?	1,258 ?	1,154	~92 ?	~104 ?
	Sept.	272	0.301	818.7	798	97.5%	20.7
	June	344	0.302	1,038.9	973	93.7%	65.9
	March	501	0.290	1,452.9	1,278	88.0%	174.9
2000	Dec.	498	0.296	1,474.1	1,232	83.6%	242.1
	Sept.	497	0.264	1,312.1	1,129	86.0%	183.1
	June	308	0.308	948.6	910.7	96.0%	37.9
	March	408.0	0.309	1,260.7	1,165.0	92.4%	95.7
1999	Dec.	422.0	0.297	1,253.3	1,159.0	92.5%	94.3
	Sept.	330.3	0.281	928.1	909.3	98.0%	18.8
	June	334.3	0.262	875.9	736.2	84.1%	139.7
	March	429.9	0.264	1,134.9	1,052.7	92.8%	82.2
1998	Dec.	494.0	0.277	1,368.4	1,191.0	87.0%	177.4
	Sept.	568.3	0.264	1,500.3	1,395.1	93.0%	105.2
	June	395.7	0.236	933.9	732.6	78.4%	201.3
	March	301.4	0.252	759.5	730.9	96.2%	28.6
1997	Dec.	617.0	0.268	1,653.6	1,454.4	88.0%	199.2
	Sept.	528.9	0.274	1,449.2	1,244.1	85.8%	205.1
	June	438.6	0.306	1,342.1	1,104.8	82.3%	237.3
	March	366.5	0.318	1,165.5	988.5	84.8%	177.0
1996	Dec.	380.1	0.318	1,208.7	1,100.3	91.0%	108.4
	Sept.	385.6	0.302	1,164.5	1,043.3	89.6%	121.2
	June	419.9	0.351	1,473.8	1,137.2	77.2%	336.6
	March	-	-	-	857.4	-	-

(1) Estimate only (ore grade not stated by ERA in the December Quarterly production report).

References : ERA quarterly reports. H Half year only.

Quarterly & half-yearly production 1981 to 1995 (t U_3O_8)

1995	Dec.	410.4
	Sept.	1,048.3
	June	843.1
	March	705.1
1994	Dec.	0.0
	Sept.	0.0
	June	912.4
	March	549.4
1993	Dec.	0.0
	Sept.	0.0
	June	700.5
	March	634.6
1992	Dec.	0.0
	Sept.	0.0
	June	686.4
	March	663.9

1991	Dec.	715.9
	Sept.	913.6
	June	827.6
	March	663.7
1990	Dec.	564.7
	Sept.	852.3
	June	872.8
	March	604.9
1989	Dec.	778.4
	Sept.	827.9
	June	976.1
	March	707.3
1988	Dec.	993.8
	Sept.	918.3
	June	588.3
	March	1,212.0

1987	Dec.^{H}	1,241.2
	June^H	1,020.3
1986	Dec.^{H}	2,103.5
	June^H	1,393.1
1985	Dec.^{H}	1,673.9
	June^H	845.2
1984	Dec.^{H}	2,191.8
	June^H	1,583.8
1983	Dec.^{H}	1,514.9
	June^H	1,065.7
1982	Dec.^{H}	1,934.3
	June^H	1,200.3
1981	Dec.	776.8
	Sept.	345.4

References : Mudd (2002); ABARE (various) & BMR (various). H Half year only.

Annual reagent consumption in milling

Year	Pyrolusite	Sulfuric Acid	Lime [1]	Ammonia	Kerosene	Amine
96-97	6,751 t [2] (4.3 kto)	56,363 t (35.9 kto)	18,369 t (11.7 kto)	1,884 t (1.2 kko)	1,336,928 L (0.32 lko)	41,779 L (0.010 lko)
95-96	2,904 t [3] (5.6 kto)	64,087 t (53.4 kto)	21,978 t (18.3 kto)	1,568 t (0.44 kko)	1,424,829 L (0.41 lko)	52,275 L (0.015 lko)
94-95	3,261 t (5.64 kto)	28,563 t (49.4 kto)	9,543 t (16.5 kto)	794 t (0.49 kko)	674,769 L (0.44 lko)	36,080 L (0.023 lko)
93-94	2,975 t (6.81 kto)	21,610 t (49.5 kto)	7,165 t (16.4 kto)	873 t (0.6 kko)	552,400 L (0.38 lko)	44,690 L (0.031 lko)
92-93	2,592 t (6.08 kto)	17,417 t (40.9 kto)	5,828 t (13.7 kto)	653.37 t (0.48 kko)	555,700 L (0.42 lko)	1,980 L (0.001 lko)
91-92	4,106 t (4.14 kto)	46,507 t (47.2 kto)	18,744 t (19.0 kto)	1,311.70 t (0.44 kko)	420,930 L (0.14 lko)	16,490 L (0.006 lko)
90-91	4,657 t (4.27 kto)	52,930 t (48.6 kto)	19,039 t (17.5 kto)	1,447.54 t (0.498 kko)	849,831 L (0.29 lko)	40,590 L (0.014 lko)
89-90	5,394 t (4.95 kto)	51,825 t (47.6 kto)	21,945 t (20.2 kto)	1,492 t (0.48 kko)	895,344 L (0.29 lko)	33,147 L (0.011 lko)
88-89	4,822 t (4.95 kto)	41,822 t (42.9 kto)	17,311 t (17.8 kto)	1,636 t (0.45 kko)	-	-
87-88	3,789 t (4.85 kto)	27,981 t (35.8 kto)	13,251 t (17.0 kto)	1,299 t (0.43 kko)	-	-
86-87	5,324 t (6.13 kto)	37,064 t (42.7 kto)	17,545 t (20.2 kto)	1,306 t (0.43 kko)	-	-
85-86	6,530 t (6.75 kto)	43,653 t (45.1 kto)	20,041 t (20.7 kto)	1,352 t (0.44 kko)	-	-
84-85	4,477 t (4.38 kto)	43,860 t (43.0 kto)	17,290 t (16.9 kto)	1,368 t (0.46 kko)	-	-
83-84	4,180 t (4.17 kto)	44,918 t (44.8 kto)	21,900 t (21.8 kto)	1,260 t (0.41 kko)	-	-
82-83	-	-	-	-	-	-
81-82	10,383 t (12.09 kto)	55,473.7 t (64.6 kto)	18,359 t [4] (21.4 kto)	-	-	-

[1] Neutralising agent used is generally magnesium oxide (MgO) or lime (as CaO equivalent);
[2] Includes 2,355 t at 1.5 kg/t ore of hydrogen peroxide (H_2O_2) introcuded in the Ranger mill in December 1995;
[3] 948 t of H_2O_2 at 4.38 kg/t ore;
[4] 8,445 t of hydrated lime also used.

Pyrolusite - MnO_2; Sulfuric Acid - H_2SO_4; Ammonia - NH_3; kto - kg/t ore milled; kko - kg/kg U_3O_8 produced; lko - L/kg U_3O_8 produced.

References : OSS-AR (Various).

ERA financial and corporate performance 1981 to 2001

Financial Year	Produced (tU_3O_8)	Sales (tU_3O_8)			Revenue	Costs [1]	Profit [2]	
		Ranger	Exports [3]	Foreign	$million	$million	$million	Jobs
2002 [4]	1,952	1,915	??	0	83.7	??	10.3	??
2000-01	4,612	3,997.9	??	408.2	149.096	??	26.2	248
1999-00	4,144.3	4,514	??	3.0	181.847	135.5	46.3	257
1998-99	4,374.9	4,006.0	??	0	172.93	127.1	43.15	272
1997-98	4,161.9	4,635.3	??	292.5	201.34	152.5	47.62	255
1996-97	4,236.9	3,956.3	??	1,464.3	230.56	156.8	71.57	246
1995-96	3,453.3	3,363.9	??	867.6	180.35	119.6	58.56	215
1994-95	1,548.2	2,012.8	??	1,418.4	140.03	102.0	35.42	198
1993-94	1,461.8	1,934.9	??	1,510.3	152.18	106.1	44.28	193
1992-93	1,335.1	2,250.3	??	848.0	159.51	84.5	72.53	198
1991-92	2,980.0	2,230.1	3,469.1	1,328.4	170.46	96.9	69.09	191
1990-91	2,908.3	2,598.5	2,648.3	802.3	210.41	108.4	101.60	339
1989-90	3,084.0	2,716.1	2,995.3	47.6	206.90	97.9	125.83	340
1988-9	3,595.5	2,633.4	3,869.0	0	177.52	86.9	80.63	354
1987-88	3,041.5	3,274.0	3,656.9	0	251.30	102.0	131.06	374
1986-87	3,123.8	3,048.0	2,796.9	0	234.26	??	108.09	414
1985-86	3,067.0	2,810.2	2,724.9	0	222.51	??	98.42	409
1984-85	3,037.0	2,682.0	2,755.6	0	233.80	??	109.85	421
1983-84	3,098.7	2,668.7	2,307.1	0	246.10	??	113.02	429
1982-83	3,000.0	3,152.2	2,857.2	0	261.20	??	113.36	404
1981-82 [5]	2,322.5	1,976.9	1,518.1	0	146.00	??	45.58	414
Total	**64,538.6**	**62,373.6**	**>31,598**	**8,990.6**	**4,012.61**	**>1,476**	**1,552.5**	**-**

[1] Costs are ERA's reported "Net Expenses".
[2] Profit before abnormal items and tax.
[3] Presumably does not include uranium borrowed from the AAEC between 1977-1980.
[4] Data from for September quarter only. ERA, however, have changed their financial year to the calendar year, to allow co-ordination with latest parent company, Rio Tinto Ltd.
[5] Data from September to June only.

References : ERA -A R (various), ACIL (1993). (Financial data unadjusted).

Appendix 3: Extracts from the Ranger General Authorisation 82/3

RANGER GENERAL AUTHORIZATION
Number A82/3

Issued under the

Uranium Mining (Environment Control) Act 1979 (NT)

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SCHEDULE 1 DEFINITIONS

1.1 In this Authorization, unless a contrary intention appears:

1.1.1 "the Act" means the *Uranium Mining (Environment Control) Act (NT) 1993*;

1.1.2 "the Minister" means the Minister of the Northern Territory responsible for the Act;

1.1.3 "the Director" means the Director of Mines appointed under the *Mine Management Act (NT) 1996*;

1.1.4 “the Commonwealth Minister” means the Minister administering the *Atomic Energy Act 1953*;

1.1.5 “the Authority” means the Authority issued under section 41 of the *Atomic Energy Act 1953* by the Commonwealth Minister on 14 November 1999;

1.1.6 “the Environmental Requirements” mean the requirements attached as Appendix A to the Authority;

1.1.7 “the Supervising Scientist” means the person performing the duties of Supervising Scientist under the *Environment Protection (Alligator Rivers Region) Act 1978*;

1.1.8 "the Supervising Authority" means the person having responsibility under an applicable law or if there is no applicable law the person performing the duties of Supervising Scientist under the *Environment Protection (Alligator Rivers Region) Act 1978*.

1.1.9 "Ranger project area" has the same meaning as it does under the Act;

1.1.10 "owner", in relation to a mine, has the same meaning as it does under the Act, and, in relation to the mine that lies within the Ranger project area, means Energy Resources of Australia Ltd (ACN 008 550 865), and having its registered office at C/- Mallesons Stephen Jaques, 10th Floor Advance Bank Centre, 60 Marcus Clarke Street, Canberra City, ACT 2601;

1.1.11 "manager" has the same meaning as it does under the Act;

1.1.12 "Inspector" has the same meaning as it does under the Act;

1.1.13 "mine" has the same meaning as it does under the Act;

1.1.14 "mining" has the same meaning as it does under the Act

1.1.15 "operator of the mine" means the owner or the manager of the mine;

1.1.16 "mine site employees" means employees of the operator of the mine whose usual place of work is in the Ranger project area;

1.1.17 "the Code " means the Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores (1987);

1.1.18 "designated employees" has the same meaning as it does in the Code;

1.1.19 “controlled area” has the same meaning as it does in the Code;

1.1.20 “supervised area” has the same meaning as it does in the Code;

1.1.21 "Radiation Safety Officer" has the same meaning as it does in the Code; and

1.1.22 "site" has the same meaning as "Ranger project area".

SCHEDULE 2 AUTHORIZED OPERATIONS AT THE RANGER MINE

2.1 The operator of the mine is authorised to:

2.1.1 mine Ranger #3 in general accordance with the provisions of SCHEDULE 3;

2.1.2 operate an ore treatment facility for the production of uranium oxide in general accordance with the provisions of SCHEDULE 4;

2.1.3 operate the tailings dam and Pit#1 tailings repository and to carry out such associated activities as may be required for their operation, in general accordance with SCHEDULE 5;

2.1.4 carry out ancillary works and services necessary for the conduct of mining and the continuing operation of ore treatment facilities in general accordance with SCHEDULE 6;

2.1.5 dispose of water by direct release from Retention Pond 1 and Djalkmarra Billabong in general accordance with SCHEDULE 7;

2.1.6 dispose of water from Retention Pond 2 by irrigation within areas which are approved by the Director, in general accordance with SCHEDULE 7;

2.1.7 dispose of water from pit dewatering bores by flood irrigation within areas which are approved by the Director;

2.1.8 pump water from Magela Creek to Retention Pond 2 subject to the approval of the Director and subject to the conditions of SCHEDULE 7; and

2.1.9 to construct and operate a dolomite treatment plant in accordance with the provisions of SCHEDULE 4;

2.1.10 operate a hydrogen peroxide storage facility, and operate a Caro's acid production facility, in general accordance with the document titled "Application for Approval Construction and Operation of a Hydrogen Peroxide Storage Facility Including the Production of Caro's Acid" dated October 1995;

SCHEDULE 3 MINING OPERATIONS

Environmental Protection

3.1 The operator of the mine shall ensure that mining operations at Ranger are undertaken in such a way as to be consistent with the following Primary Environmental Objectives for Kakadu National Park.

3.1.1 maintain the attributes for which Kakadu National Park was inscribed on the World Heritage list;

3.1.2 maintain the ecosystem health of the wetlands listed under the Ramsar Convention on Wetlands (i.e. the wetlands within Stages I and II of Kakadu National Park);

3.1.3 protect the health of Aboriginals and other members of the regional community; and

3.1.4 maintain the natural biological diversity of aquatic and terrestrial ecosystems of the Alligator Rivers Region, including ecological processes.

3.2 In particular, the operator of the mine shall ensure that operations do not result in:

3.2.1 damage to the attributes for which Kakadu National Park was inscribed on the World Heritage list;

3.2.2 damage to the ecosystem health of the wetlands listed under the Ramsar Convention on Wetlands (i.e. the wetlands within Stages I and II of Kakadu National Park);

3.2.3 an adverse effect on the health of Aboriginals and other members of the regional community by ensuring that exposure to radiation and chemical pollutants is as low as reasonably achievable and conforms with relevant Australian law, and in particular, in relation to radiological exposure, complies with the most recently published and relevant Australian standards, codes of practice, and guidelines;

3.2.4 change to biodiversity, or impairment of ecosystem health, outside of the Ranger Project Area. Such change is to be different and detrimental from that expected from natural biophysical or biological processes operating in the Alligator Rivers Region; and

3.2.5 environmental impacts within the Ranger Project Area which are not as low as reasonably achievable, during mining excavation, mineral processing, and subsequently during and after rehabilitation.

Conditions

3.3 In order to meet the Primary Environmental Objectives and the primary environmental objectives for rehabilitation described in 8.1.2, the operator of the mine shall:

3.3.1 develop and update to the approval of the Director, the Ranger Mining Manual;

3.3.2 conduct the mining in general accordance with the latest approved revision of the Ranger Mining Manual insofar as that document does not conflict with the Schedules contained herein; and

3.3.3 dump and stockpile ore and waste material:

3.3.3.1 in general conformity with the Ranger Mining Manual; and

3.3.3.2 without passing through the discriminator if the material is from an area which has been probed or scanned and ascertained to be waste; or

3.3.3.3 according to the uranium content determined by the discriminator, which has a nominal accuracy of plus or minus 50% at the 0.02% uranium level, and which is to be calibrated in accordance with the procedure approved by the Director; and described in the Mining Manual.

3.3.4 minimise, to the maximum extent practical and to the satisfaction of the Director:

3.3.4.1 the disturbance of soil, vegetation and fauna within the Ranger Project Area; and

3.3.4.2 the risk to fauna as a result of drinking contaminated water.

3.3.5 ensure that the operations at Ranger will not result in any adverse impact on Kakadu National Park through the introduction of exotic fauna or flora.

3.4 All mining operations shall be implemented in accordance with Best Practicable Technology, defined as that technology from time to time relevant to the Ranger Project which produces the minimum environmental pollution and degradation that can reasonably be achieved having regard to:

- the level of effluent control achieved, and the extent to which environmental pollution and degradation are prevented, in mining and milling operations in the uranium industry anywhere in the world,
- the total cost of the application or adoption of that technology relative to the environmental protection to be achieved by its application or adoption,
- evidence of detriment, or of lack of detriment, to the environment after the commencement of the Ranger Project,
- the physical location of the Ranger Project,
- the age of equipment and facilities in use on the Ranger Project and their relative effectiveness in reducing environmental pollution and degradation, and
- social factors including possible adverse social effects of introducing new technology.

SCHEDULE 5 OPERATION OF TAILINGS REPOSITORIES

5.1 During mining operations and prior to final placement, covering and rehabilitation of the tailings, tailings shall be securely contained in a manner approved by the Director which prevents detrimental environmental impact.

5.2 In order to protect the environment, the operator of the mine shall:

5.2.1 to the maximum extent possible, deposit tailings in tailings repositories in such a way as to result in the maximum practicable dry density;

5.2.2 minimise dusting from the surface of the tailings by ensuring that exposed surfaces of tailings are maintained in a coherent near-saturated condition; and

5.2.3 ensure that the water level in the tailings dam does not exceed RL 43.5 m AHD. Subject to the availability of such capacity to transfer water from the tailings dam to Pit#1 that the addition of the volume of water that would be expected during a 72 hour, 1 in 100 rainfall event would not cause the level to rise above RL 43.5 m AHD, the target operating level in the tailings dam will, from 1 December until 30 March each year, be RL 43.0 m AHD.

5.3 The operator of the mine shall submit a report on proposed actions to manage the water level in the tailings dam to the Director within three days of the target operating level being exceeded by more than 0.1 m.

5.4 Final disposal of tailings shall be undertaken to the satisfaction of the Minister on the basis of best available modelling, in such a way to ensure that:

5.4.1 the tailings are physically isolated from the environment for at least 10,000 years;

5.4.2 any contaminants arising from the tailings will not result in any detrimental environmental impact for at least 10,000 years

5.4.3 radiation doses to members of the public will comply with relevant Australian law and be less than limits recommended by the most recently published and relevant Australian standards, codes of practice and guidelines effective at the time of the final disposal.

5.4.4 By the end of operations all tailings must be placed in the mined out pits.

5.5 The operator of the mine shall submit reports on each tailings repository in accordance with the requirements of Annex C.

5.6 By the end of operations all tailings must be placed in the mined out pits.

SCHEDULE 6 OTHER SERVICES, OPERATIONS AND REQUIREMENTS

Infringements

6.1 The operator of the mine shall notify the Minister as soon as is practicable, of any infringement of the conditions and requirements of this Authorization or the Environmental Requirements.

Staffing and Induction

6.2 The company shall employ adequate numbers of competent, appropriately qualified and experienced staff to ensure that it can provide the required level of protection to the environment, human health, and Aboriginal culture and heritage.

6.3 All mine site employees shall attend an induction course, which shall explain the environment protection and monitoring programs, radiation protection and responsibilities, Aboriginal culture, and the plan of management of Kakadu National Park.

6.4 All mine site employees shall be issued with a radiation protection manual explaining the nature of the hazards associated with the handling of uranium ores and concentrates and the safe working procedures to be adopted.

Air Quality

6.5 Emissions of gaseous and particulate contaminants shall conform with Australian law, and, taking into account the most recently published and relevant Australian standards, codes of practice, and guidelines, be managed to minimise the effects of particulate and gaseous contaminants from the point of view of all possible radiological, physical and chemical hazards.

6.6 Air quality shall be managed in such a way that there is no physical or chemical detriment to any known sites of Aboriginal culture or heritage.

Extraction of Sand and Gravel for Ancillary Purposes

6.7 All excavated material shall be managed such that there is no detrimental environmental impact outside the Ranger Project Area, and that environmental impacts within the Ranger Project Area are as low as reasonably achievable.

6.8 The operator of the mine shall ensure that:

6.8.1 prior to the commencement of extraction operations, a plan of the proposed operations is submitted to an Inspector for approval. This plan shall depict the extent of the proposed borrow areas and the location of associated roads or other developments. It shall also include details of proposed rehabilitation; and

6.8.2 rehabilitation measures specified by an Inspector are carried out as soon as is reasonably practicable.

Explosives Manufacture and Blasting Operations

6.9 The company shall ensure that detonation of explosives cannot damage the environment outside of the Ranger Project Area, or any sites significant to Aboriginal culture and heritage.

6.10 In the conduct of blasting operations, in order to protect the environment, the operator of the mine shall ensure that no blast is fired in which the weight of explosive per millisecond delay interval exceeds the maximum weight determined from time to time by an Inspector and noted in the Mining Manual.

SCHEDULE 7 WATER MANAGEMENT

7.1 The operator of the mine shall not allow either surface or ground waters arising or discharged from the Ranger Project Area during its operation, or during or following rehabilitation, to compromise the achievement of the Primary Environmental Objectives as described in 3.2 and 8.1.

7.2 In order to protect the environment, the operator of the mine shall operate a water management system in general accordance with the latest approved revision of the Water Management System Operation Manual insofar as that document does not conflict with the Schedules contained herein.

7.3 The operator of the mine shall, to the extent necessary to achieve the Primary Environmental Objectives as described in 3.2, take steps to: minimise the volume of contaminated water that is required to be managed on site; minimise the load of contaminants within that water; and concentrate and contain contaminants within the site.

7.4 Process water shall be totally contained within a closed system except for:

7.4.1 losses through natural or enhanced evaporation;

7.4.2 seepage of a quality and quantity that will not cause detrimental environmental impact outside the Ranger Project Area; and

7.4.3 subject to 7.1 and 7.3, process water which has been treated to achieve a quality which:

7.4.3.1 conforms to a standard practice or procedure recommended by the Supervising Scientist; and

7.4.3.2 is not less than that of the water to which it is to be discharged.

7.5 The operator of the mine shall:

7.5.1 within two weeks of the end of October each year submit for the approval of the Director, a revision of the Water Management System Operation Manual, including:

- a complete explanation of the operation and maintenance of the water management system;
- the contingency procedures for disruptions in the operation and maintenance of the water management system;
- the surface water monitoring program; and
- details of the proposed wet and dry season operating levels and limits for Retention Pond 2.

Note: the basis for the calculation of the Wet season operating level for Retention Pond 2 shall be that sufficient freeboard is maintained to accommodate runoff from a 72 hour, 1 in 100 Annual Exceedance Probability Storm.

7.5.2 maintain up-to-date versions of drawings depicting the current surface runoff drainage system; and

7.5.3 instruct all personnel involved in the operation of the water management system in the details of its operation and in the implementation of contingency procedures.

7.6 In order to protect the environment, the operator of the mine:

7.6.1 shall ensure that any discharge of waters from waterbodies other than Retention Pond 1 or Djalkmarra Billabong is made only with the approval of, and in accordance with conditions set by, the Minister;

7.6.2 shall, in relation to the disposal of Retention Pond 2 water by irrigation, ensure that flood irrigation is used as the primary irrigation option and spray irrigation is used only as a backup option during periods when demand for irrigation capacity exceeds that available through flood irrigation, subject to the following conditions:

7.6.2.1 runoff from the irrigation areas is monitored in accordance with the requirements of Annex A;

7.6.2.2 the volume of water discharged by each section of the irrigation system, the times of commencement and of cessation of irrigation, and any observed adverse effects of irrigation, are recorded daily in a log book kept specifically for this purpose;

7.6.2.3 during irrigation, a daily inspection of the irrigation areas is made to detect any waterlogging, seepage, or other visible adverse effects; and

7.6.2.4 during irrigation, a monthly inspection of vegetation is carried out by a suitably qualified person to detect any recognisable physiological responses resulting from irrigation.

7.7 The operator of the mine shall maintain to the satisfaction of the Minister and for examination by an Inspector, all records and data associated with the operation and monitoring of the water management system for the life of the mine up to and including rehabilitation.

7.8 With reference to the pumping of water from Magela Creek to Retention Pond 2, the operator of the mine shall ensure that:

7.8.1 such pumping is carried out by pumps having their intake situated just north of the confluence of the main channel of the Magela with the Georgetown Branch;

7.8.2 such water is conveyed by pipeline laid on surface from the pumping station to the north-east corner of the plant fenced area and shall have an "open" discharge to Retention Pond 2, so that water cannot syphon back from the pond into the creek;

7.8.3 the rate and cumulative quantity of water extracted is measured and reported weekly and this rate shall not exceed 25,000 m^3 per day. The rate of flow of the Magela immediately upstream of the point of extraction shall be measured and similarly reported; and

7.8.4 the pump installation shall be constructed in a manner which will prevent pollution of the surrounding environment by fuel, lubricants or other foreign matter.

7.9 The operator of the mine shall submit reports in accordance with the requirements of Annex C.

SCHEDULE 8 DECOMMISSIONING AND REHABILITATION

Rehabilitation

8.1 In order to protect the environment the operator of the mine shall plan rehabilitation in accordance with the following Primary Environmental Objectives for rehabilitation:

8.1.1 Goal

Subject to 8.1.2 and 8.1.3, the operator of the mine shall rehabilitate the Ranger project area to establish an environment similar to the adjacent areas of Kakadu National Park such that, in the opinion of the Commonwealth Minister with the advice of the Supervising Scientist, the rehabilitated area could be incorporated into Kakadu National Park.

8.1.2 Objectives

To revegetate the disturbed sites of the Ranger project area using local native plant species similar in density and abundance to those existing in adjacent areas of Kakadu National Park, to form an ecosystem the long-term viability of which would not require a maintenance regime significantly different from that appropriate to adjacent areas of the Park.

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

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

8.1.3 Facilities that may remain following rehabilitation

Where all the major stakeholders agree, a facility connected with Ranger may remain in the Ranger Project Area following the termination of the Authority, provided that adequate provision is made for eventual rehabilitation of the affected area consistent with principles for rehabilitation set out in 8.1.2 and 7.1.

8.2 At the end of every twelve month period, the operator of the mine shall prepare a rehabilitation plan for the approval of the Minister and the Commonwealth Minister with the advice of the Supervising Scientist, the implementation of which will achieve the major objectives of rehabilitation of the Ranger Project Area and will include:

8.2.1 a detailed specification of all progressive rehabilitation works which are proposed to be undertaken in the 12 months following the preparation of the report;

8.2.2 a conceptual specification covering decommissioning and rehabilitation for the remaining life of the project.

8.3 The work estimate to be included with the specifications to be submitted under 8.2 shall encompass forecasts of the extent of works, the resources to be applied in the execution of those works, and the likely cost and time required for completion. These aspects shall take into account:

8.3.1 removal of all plant, equipment, buildings and other structures;

8.3.2 removal of civil works and facilities that are not required for other purposes;

8.3.3 dewatering of the water management system;

8.3.4 disposal of tailings.

8.3.5 removal of all unnecessary water-retaining structures and other earthworks;

8.3.6 backfilling of the open pits;

8.3.7 revegetation of all disturbed areas; and

8.4 The obligations on the operator of the mine imposed by SCHEDULE 8 will cease in respect of any part of the Ranger project area over which a close-out certificate is issued by the Minister subject to the Supervising Scientist and the NLC agreeing that the specific part of the Ranger Project Area has met the aims and objectives for rehabilitation.

SCHEDULE 9 ENVIRONMENTAL AND RADIATION MONITORING AND REPORTING

9.1 The operator of the mine shall implement a system to control the radiological exposure of people and the environment arising from its mining and milling activities. The system and the dose limits applied shall comply, at the minimum, with relevant Australian law taking into account the most recently published and relevant Australian standards, codes of practice, and guidelines. Subject to 9.2, the company shall achieve the following outcomes:

9.1.1 Radiation doses to company employees and contractors shall be kept as low as reasonably achievable and shall always remain less than the dose limit for workers.

9.1.2 Radiation doses to people who are not company employees or contractors shall be kept as low as reasonably achievable and shall always remain less than the dose limit for members of the public.

9.1.3 Ecosystems surrounding the Ranger Project Area shall not suffer any significant deleterious radiological impacts.

9.2 Radiation doses received from natural background sources or as the result of undergoing medical procedures are not subject to the system and are not to be included in the calculation of radiation doses.

9.3 In order to protect the environment, and in compliance with Environmental Requirements 13.1 and 13.2 relating to monitoring and analysis, the operator of the mine shall:

9.3.1 implement the environmental and radiation monitoring programs included in Annex A and Annex B;

9.3.2 conduct contingency monitoring in a manner approved by the Director in the event of the malfunction of monitoring equipment; and

9.3.3 submit to the Director, reports in accordance with the requirements of Annex C.

9.4 The company shall carry out a monitoring program approved by the Director following cessation of operations until such time as a relevant close-out certificate is issued under 8.4.

ANNEX A ENVIRONMENTAL MONITORING PROGRAM

A.1 Groundwater	Measurement	Frequency
Designated bores	L	January, February, March, April, May, July, September, November, December
Primary sites		
Tailings dam area 1A, 7A, 17A, 19A, 20, 24, 30, 41, 42A, RN23551	EC, magnesium, and sulfate	Every two months
	W1, W2, W7	May and November
	W8	Every two years
RP2 area RN23560	EC and sulphate	Every two months
	W1, W2, W7	May and November
	W8	Every two years
Secondary sites		
Tailings dam area 21A, 23, 28, 43	EC and magnesium	Every two months
	W1, W2, W7	May and November
RP2 area 79/6A	EC	Every two months
	W1, W2, W7	May and November
	W8	Every two years
Tertiary sites		
All areas 2A, 4A, 6A, 9A, 10A, 13A, 44, RN23552 29, 79/2	W1, W2, W7	May and November
	W8	Every two years
Piezometers	L	Dependent on situation
Dewatering bores MBL, DW3A	EC, pH and Uranium	Every two months

Designated observation bores, with corresponding Registration No.:

OB	RN	OB	RN	OB	RN
1A	22902	20	22934	41	26590
2A	22904	21A	22935	42A	28431
4A	22908	23	22937	43	26592
6A	22912	24	22938	44	26593
7A	22914	28	22939	79/2	9329
10A	22920	29	22940	79/6A	22901
13A	22924	29	22940		RN23551
17A	22931	30	22941		RN23552
19A	22933				RN23560

A.2 Potable Water	Measurement	Frequency
Mine site (Jabiru East supply)	W1 plus uranium and radium-226	Monthly
	W6	Quarterly
	W2, W4 plus sulfate	November

A.3 Impounded water	Measurement	Frequency
RP1		
Weir	L	Weekly, or during overflow, a frequency that will allow estimation of the daily volume of overflow.
	W1 except sulfate	Weekly October to May, and prior to overflow
	W1, W7, W8	Monthly October to May
RP2		
Gauge board	L, EC, and pH	Weekly
	W2, W7, W8, W9 plus NH4 and sulfate	Quarterly
Tailings dam		
Return water pontoon	W2, W7, W8 plus NH4 and sulfate	Quarterly
Tailings dam seepage collection system		
North wall manhole	W1, W2, W7, W9 plus NH4	Quarterly
Return pipes to tailings dam	Flowmeter volumes	Monthly
RP2 seepage collector system		
Return pipe to RP2	W1, W2, W7, and flowmeter volume	Monthly

A.4 Spray irrigation	Measurement	Frequency
Bores (all bore numbers have the prefix MC)		
6, 32, 33, 34	L	Weekly during irrigation, otherwise monthly
35,36,37,38	L	Weekly during irrigation
19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31	L, pH, and EC	Weekly during irrigation, otherwise monthly
	Sulfate, Mn, U	Monthly during irrigation, otherwise every two months
21 and 24	Radium-226	Monthly during irrigation, otherwise every two months
35,36,37,38	pH, EC and sulfate	Monthly during irrigation and once during the month immediately following the cessation of irrigation
Irrigation water	pH, EC, sulfate, Mn, U	Weekly

A.4 Spray irrigation	Measurement	Frequency
Seepage sites	pH, EC	Weekly April to December

Land application area bores (with numbers having the prefix MC), with corresponding Registration No.:

MC	RN	MC	RN	MC	RN
6	25394	19	25406	20	25407
21	25408	22	25409	23	25465
24	25466	25	25467	26	25468
27	25469	28	25470	29	25471
30	25472	31	25473	32	25474
33	25475	34	25476	35	29460
36	29461	37	29462	38	29463

A.5 Releases	Measurement	Frequency
RP2		
Prior to release		
Waters to be released (at point of discharge)	W1, W2, W7, W8, W10 plus NH4 and PO4	At least once within one week of release
Magela Creek (upstream of pipeline outlet)	W1, Mg, Ca, Mn, U	At least once just prior to release
GS8210009	W1, Mg, Ca, Mn, U	At least once just prior to release
During release		
Waters to be released (at point of discharge)	W1, Mg, Mn, U	Daily during release
	W1, W7 plus Mg and alkalinity	Weekly during release if period of release exceeds one week
Magela Creek (upstream of pipeline outlet)	W1, Mg, Mn, U	Daily during release
GS8210009	W1, Mg, Mn, U	Daily during release
After release		
Magela Creek (upstream of pipeline outlet)	W1, Mg, Ca, Mn, U	Once within seven days since the end of any release
GS8210009	W1, Mg, Ca, Mn, U	Once within seven days since the end of any release
RP1 and Djalkmarra Billabong		
Prior to first release (in any Wet season)		
Waters to be released (at point of discharge from pond)	W1, W2, W7, W8, W10 plus NH4 and PO4	At least once within one week of first release
Magela Creek (upstream of outlet)	W1, Mg, Ca, Mn, U	At least once just prior to first release

A.5 Releases	Measurement	Frequency
GS8210009	W1, Mg, Ca, Mn, U	At least once just prior to first release
During release (to be sampled on the same day)		
Waters to be released (at point of discharge from pond)	W1, Mg, Mn, U	Weekly during release
Magela Creek (upstream of outlet)	W1, Mg, Mn, U	Weekly during release
GS8210009	W1, Mg, Mn, U	Weekly during release

A.6 Creeks and billabongs	Measurement	Frequency
Magela Creek		
Water/GS8210009	W1 plus Mg, uranium and radium-226	Monthly
Gulungul Creek		
Water/Highway	W1 plus uranium and radium-226	Monthly
Georgetown Creek		
Water/Upstream GS	W1 plus uranium and radium-226	Monthly
Georgetown Billabong		
Water/GB	W1 plus radium-226	Monthly
	W9	Quarterly
Bottom sediment/one site (0-5 cm)	SED	Yearly
Djalkmarra Billabong		
Water	W1 plus uranium and radium-226, W2	Monthly
Water/GB	W9	Quarterly
Bottom sediment/one site (0-5 cm)	SED	Yearly
Coonjimba Billabong		
Water/GB	W1 plus uranium and radium-226	Monthly
Water/GB	W9	Quarterly
Bottom sediment/one site (0-5 cm)	SED	Yearly
Gulungul Billabong		
Water/GB	W1 plus uranium and radium-226	May and November
Bottom sediment/one site (0-5 cm)	SED	Yearly
Mudginberri Billabong		
Water/GB	W1 plus uranium and radium-226	May and November
Mussel, 40-60 mm (flesh)	B	Yearly
Bottom sediment/one site (0-5 cm)	SED	Yearly

A.7 Soil monitoring	Measurement	Frequency
Project Area		
Soil/Sites No. R82, R80, R27, R28, R79, R52, R4, R10, R1, R77, R95 (0-5 cm)	SOIL	3-yearly
Land application area		
Soil Site Nos.: R85 and R86, R90 and R91, R87 and R96, R88 and R89, R92A and R93, and R94 and R101	S	Yearly in April
For each site five soil cores are to be bulked for 0-5, 40-50, 90-100 and 140-150 cm depths (or to depth of refusal of auger).		

A.8 Atmospheric monitoring	Measurement	Frequency
Calciner stack emissions	Uranium	Monthly
Product packing area stack emissions	Uranium	Monthly
Sulfuric acid plant stack emissions	SO_2	A frequency that will allow reliable quarterly maxima and averages to be reported
	H_2SO_4	Quarterly
Power house stack emissions	SO_2	A frequency that will allow reliable quarterly maxima and averages to be reported

Notes

Abbreviations

The following abbreviations are used in this Annex:

EC	-	Electrical Conductivity
L	-	level
RP	-	retention pond
W1	-	EC, pH, turbidity, and sulfate
W2	-	sodium, potassium, calcium, magnesium, alkalinity, chloride, and nitrate
W4	-	copper, lead, manganese and zinc
W6	-	total coliform, E. coli, and faecal Streptococci
W7	-	manganese, uranium, and radium-226
W8	-	copper, lead, and zinc
W9	-	magnesium (filtrate); copper, lead, zinc, uranium, manganese, radium-226 (all filtrate + residue); residues are to be digested prior to analysis
W10	-	thorium-230, lead-210, and polonium-210
B	-	copper, lead, manganese, zinc, uranium, and radium-226
S	-	pH, EC, sulfate, exchangeable sodium, potassium, magnesium, calcium, cation exchange capacity, uranium, manganese, and radium-226
Uranium	-	uranium determined in filtered sample
SED	-	copper, lead, manganese, zinc, uranium, and radium-226
SOIL	-	uranium, radium-226, sulfate, pH, and EC
Mussel	-	Velesunio angasi

GB - Gauge board

GS - Gauging station

U - natural uranium

A.9 Criteria for direct release of water from RP2 to Magela Creek

A.9.1 The flow rate in Magela Creek at GS8210009 shall be greater than 20 m^3/s before water may be released.

A.9.2 The water release rate shall be restricted so that any increase in the value in Magela Creek at GS8210009 of the individual water quality parameters listed in Table 1 is limited to the maximum allowable increases specified in Table1.

This implies that the water to be released must be of such a quality that the formula

$C < A \times F / D$

is satisfied, where:

C is the concentration of a constituent in the water being released;

A is the maximum allowable addition of that constituent as in Table 1;

F is the Magela Creek flow rate at GS8210009; and

D is the discharge rate of water being released.

A.9.3 The water release rate shall also be restricted so that the total load of those constituents listed in Table 2 does not exceed the additional annual load limits specified in Table 2 in any twelve-month period commencing in September.

A.9.4 In addition to the monitoring program specified in this Annex, if any other parameter in the water being released is found to limit the water release rate in order that the formula given above is satisfied, then that parameter shall be monitored daily at the point of discharge, upstream of the pipeline outlet to Magela Creek, and at GS821009.

A.9.5 Results of analyses performed for the water release monitoring program are to be forwarded weekly to the Director.

A.9.6 Within six weeks of the end of releases for a season, a full report is to be submitted to the Director, detailing:

- release quantities and timing;
- monitoring results;
- calculations of loads;
- analysis of trends; and
- demonstration of compliance with the receiving water standards for Magela Creek.

A.10 Criteria for releases of water from RP1 and Djalkmarra Billabong

A.10.1 The water release rate shall be restricted so that any increase in the value in Magela Creek at GS8210009 of the individual water quality parameters listed in Table 1 is limited to the maximum allowable increases specified in Table1.

A.10.2 The water release rates shall also be restricted so that the total load of those constituents listed in Table 2 does not exceed the additional annual load limits specified in Table 2 in any twelve-month period commencing in September.

A.10.3 Results of analyses performed for the water release monitoring program are to be forwarded weekly to the Director, in conjunction with monthly routine monitoring reports.

TABLE 1 Standards for release of water to Magela Creek.

Constituent	**Unit**	**Maximum Allowable Addition**
Turbidity	NTU	15
Calcium	mg/L	1.3
Magnesium	mg/L	10
Sulfate	mg/L	19
Nitrate/nitrite (as N)	mg/L	0.6
Phosphate (as PO_4)	mg/L	0.01
Copper, total	µg/L	0.6
Lead, total	µg/L	0.7
Zinc, total	µg/L	5
Manganese, total	µg/L	24
Uranium, total	µg/L	3.8

TABLE 2 Additional annual load limits for release of water to Magela Creek

Constituent	**Unit**	**Additional Annual Load Limit**
Uranium-(238+234)	GBq/y	88
Thorium-230	GBq/y	170
Radium-226	GBq/y	13
Lead-210	GBq/y	8
Polonium-210	GBq/y	7
Copper	t/y	90
Lead	t/y	8
Manganese	t/y	6
Zinc	t/y	200
Phosphate	t/y	2.8
Nitrate	t/y	4.4

ANNEX B RADIATION MONITORING PROGRAM

	Frequency	Dosimetry
External Gamma		
All designated employees Non-designated employees (see B.1.2)	Quarterly	Dose to be assessed from the TLD reading
Radon Decay Products		
Controlled areas:		
Pit area Stockpiles Inside mine offices Outside mine offices Primary crusher Secondary crusher Secondary crusher control room Grinding CCD SX Grinding control room SX control room	Monthly	Average level to be assessed and used to calculate the effective dose equivalent to designated employees
Supervised areas:		
Tailings circuit	Monthly	
Acid plant (outdoors) Acid plant (indoors)	Monthly	Refer to B.1.2
Environmental areas		
Jabiru Jabiru East	Monthly	Refer to B.1.4
Long Lived Alpha Activity (dust)		
Controlled areas		
Designated employees	Refer to B.1.5	Average levels to be assessed and used to calculate the effective dose equivalent to designated employees
Stockpiles Secondary crusher	Monthly	No dosimetry required
Supervised areas		
Tailings circuit	Quarterly	No dosimetry required
Acid Plant (outdoors) Acid Plant (indoors)	Quarterly	Refer to B.1.2
Environmental areas		

	Frequency	Dosimetry
Jabiru and Jabiru East	Monthly	No dosimetry required
Surface contamination		
Accessible surfaces (including ore crushing areas, drumming and packing area, control rooms, crib and ablution rooms, and sample preparation areas)	Monthly	No dosimetry required

Meteorology		
Ranger Project Area	Wind speed and direction	The percentage wind frequency and average wind speed in 22.5^{o} sectors, are to be recorded and reported. This wind information is to be used to assess doses to members of the public in Jabiru and Jabiru East.

B.1 Notes

B.1.1 Abbreviations used are:

CCD	Counter-current Decantation
SX	Solvent Extraction
TD	Tailings Dam (down-wind wall)
TLD	Thermoluminescent Dosimeter

B.1.2 Doses to non-designated employees are to be calculated using the most exposed group for each source on a quarterly and annual basis and reported in the quarterly and annual reports. The dose to this most exposed group consists of the gamma exposure to Emergency Services Officers and dust and radon decay product exposure to employees working in the acid plant and power station area.

B.1.3 The average radon decay product levels are to be determined from measured levels and the dose is to be calculated in accordance with the current revision of the Code. The effective dose conversion factors are:

- 0.0012 mSv/(μJhm^{3}) for Radon-222 decay products;
- 5.7×10^{-3} mSv/alpha disintegration per second for ore dust;
- 5.3×10^{-3} mSv/alpha disintegration per second for mill tailings dust; and
- 6.2×10^{-3} mSv/alpha disintegration per second for uranium product dust.

B.1.4 The dose to inhabitants of Jabiru is to be calculated annually.

B.1.5 The monitoring frequencies to be adopted are to be sufficient to allow reliable monthly averages to be calculated.

B.1.6 The Radiation Safety Officer must maintain a list of designated employees in accordance with the Code.

B.1.7 During the non-operational periods of the mine or mill, monitoring will be carried out as deemed necessary by the Radiation Safety Officer and approved, as soon as practicable after its introduction, by the Director.

ANNEX C REPORTING REQUIREMENTS

Annual Environmental Management Report

C.1 The operator of the mine shall prepare an Environmental Management Report which is approved by the Minister. The Environmental Management Report must be prepared in accordance with guidelines as determined by the major stakeholders. The report shall provide details of:

- the company's environmental management over the preceding 12 month period; and
- the company's proposals for complying with the Environmental Requirements and all applicable environmental laws over the following 12 months.

C.1.1 The report required shall cover the period 1 September to 31 August and be submitted by 16 October each year, and shall provide details of the following matters the operation and performance of the Water Management System;

- tailings management;
- excavated material management;
- land management;
- air quality management;
- hazardous substances and industrial waste management;
- radiation monitoring and management;
- environmental monitoring;
- environmental research;
- protection of cultural sites and social impact monitoring;
- environmental planning and operating systems, including employment and training programs;
- counter disaster and emergency procedures; and
- rehabilitation.

C.2 The operator of the mine shall comply with the proposals set out in each Environmental Management Report as approved and subject to any conditions set by the Director.

Quarterly Reports

C.3 The operator of the mine shall submit, for approval by the Director, trend and monitoring data summary reports as follows:

C.3.1 Trend and monitoring data summary reports shall contain, at least, the following:

- a comparison of corresponding data reported over the immediately preceding three months;
- identification of any trends evident from the data comparison; and
- a statement of any conclusions to be drawn from monitoring in the summary period, together with comments on any unusual measurements or events affecting the performance of the monitoring programs.

C.3.2 The trend and monitoring data summary report for the period commencing 1 March each year shall include details of water releases that may have occurred throughout the preceding Wet season.

C.3.3 Trend and monitoring data summary reports shall be submitted for the quarterly periods commencing 1 September, 1 December and1 March each year. The report for the period commencing 1 June is subsumed by the Annual Environmental Management Report.

C.3.4 Trend and monitoring data summary reports shall be submitted within one month after the end of each reporting period.

Monthly Reports

C.4 The operator of the mine shall submit, for approval by the Director, preliminary environmental monitoring data reports as follows:

C.4.1 Preliminary monitoring data reports shall include water management data (rainfall and pond levels) and available water quality data without analysis or interpretation.

C.4.2 Preliminary monitoring data reports shall be submitted monthly, except where subsumed by quarterly or annual reports.

C.4.3 Preliminary monitoring data reports shall be submitted within one month of the end of each reporting period.

Annual Radiation and atmospheric monitoring interpretive report

C.5 The operator of the mine shall submit, for approval by the Minister, radiation and atmospheric monitoring interpretive reports as follows:

C.5.1 The interpretive report shall contain, at least, the following information:

- a statement of the results of the monitoring measurements taken over the report period;
- a comparison with data included in the corresponding preceding report period;
- where appropriate, a comparison of the average and maximum values with the derived limits and pre-mining baseline values for items in the monitoring programs;
- where appropriate, an illustration of trends through graphs or histograms showing spatial, temporal or other trends evident from the data;
- where appropriate, notes on errors in the data, including systematic, random and total, and a statement on the level of confidence to be found in the reported data;
- a statement of the conclusions drawn from the results, and an assessment of the performance of the monitoring program;
- a summary of any significant or unusual results in the operation of the monitoring program, giving the reasons and contributing factors in those results;
- a summary of any infringements in the operation of the monitoring program and of events which have impinged on the operation or results of that program; and
- an explanation of changes or proposed changes in the technology or techniques applied in carrying out the monitoring programs.

C.5.2 The interpretive report should be submitted for the period 1 January to 31 December each year, by 31 March in the following year.

Radiation and atmospheric monitoring data summary reports

C.6 The operator of the mine shall submit, for approval by the Director, radiation and atmospheric monitoring data summary reports as follows:

C.6.1 Radiation and atmospheric monitoring data summary reports shall contain, at least, the following information:

- the number and site of measurements taken;
- the results of measurements (where the measurements comprise a range or series of values, the range and the average shall be given);
- identification of any trends evident from the data; and
- a statement of any conclusions to be drawn from monitoring in the summary period, together with comments on any unusual measurements or events affecting the performance of the monitoring programs.

C.6.2 Radiation and atmospheric monitoring data summary reports shall be submitted for the quarterly periods ending 31 March, 30 June, 30 September and 31 December each year.

C.6.3 Radiation and atmospheric monitoring data summary reports shall be submitted within six weeks after the end of each reporting period.

Tailings dam surveillance reports

C.7 A report on the integrity and stability of the tailings dam embankments, written in accordance with the specifications set out in the document entitled "Ranger Uranium Mines Pty. Ltd. - Stage IV/RL 44.5 - Construction, Quality Control and Monitoring" approved by the Quality Control Committee on 13 December 1990, and amended with the approval of the Director, shall be submitted by 30 September each year.

Appendix 4 : Select List of 'Incidents' at Ranger, 1979-2002

2002

- **April 11-15** - It was discovered that further runoff from the Low Grade Ore stockpile - which was supposed to have been remediated - had uranium at 13,785 µg/L and was entering the headwaters of Corridor Creek. Despite being a considerably higher and more significant concentration, ERA (and regulators) do not investigate to find the source. NLC advise that it is unlikely source will identified.
- **Feb. 26** - It was discovered that Low Grade Ore had been dumped in the wrong area, with contaminated runoff containing uranium in excess of 2,000 µg/L entering the headwaters of Corridor Creek. Subsequent investigations revealed that the incorrect dumping had been occurring for some six weeks from January 14. The total quantity involved 80,900 t of 'Grade 2' material (0.02-0.08% U_3O_8) plus 3,600 t of 'Grade 3' material (0.08-0.12% U_3O_8). It was also discovered that runoff from an adjacent medium grade stockpile ('Grade 4') was failing to report to RP2 as intended and was mixing with the contaminated runoff from the incorrect stockpiling and entering Corridor Creek. Remedial works were undertaken immediately.
- **Feb. (early)** - The 'focus' level of 0.20 µg/L for uranium concentration was exceeded in Magela Creek, with sampling showing 0.211 µg/L. ERA fail to notify stakeholders according to requirements.
- **Feb. (early)** - of high uranium concentrations in water discharging uncontrolled from RP1 to Coonjimba and Magela Creeks. This year the concentrations have increased back to as high as the first episode in 1998/99 (about 70 µg/L). In order to try and reduce the flow going into the Magela, ERA simply placed sandbags across the spillway – an action heavily criticised by many. In response, ERA promises to 'completely re-engineer' the RP1 catchment (though this is four wet seasons too late).

2001

- **Jan. 31** - Re-occurrence of high uranium (26 µg/L) in water discharging uncontrolled from RP1 to Coonjimba and Magela Creeks. Although concentrations were not as high as the previous wet season, the source of the uranium remained uncertain and questions the remedial works undertaken by ERA in the 2000 dry season.

2000

- **Sep. 9** - About 20,000 L of tailings leaked following the failure of a pressure gauge tapping point adjacent to one of the tailings pumps in the mill. The failure resulted in tailings spraying over the bunds surrounding the pipe and associated infrastructure into an area which drains to RP2. No tailings left the mill area.
- **April 28** - A major leak of about 2,000,000 L was announced from the tailings water return pipeline, between Pit #1 and Georgetown Creek. ERA first detected the problem on April 4, but failed to notify the authorities until April 28. The leak, from late December 1999 to April 5, 2000, originated from 2 flanges on the tailings water return pipeline (which pumps water from the tailings dam in Pit #1 to the mill for process use). The burial of the flange joints in silt and moist conditions for up to 6 months of the year allowed three bolts to rust and allow the joint to develop a slow leak. After breaching the bund surrounding the pipeline, about 85,000 L of tailings water was estimated to have reached the adjacent wetlands in Corridor Creek, from where water discharges through Georgetown and into Magela Creek. Exactly how the leak was discovered remains unclear but appears to have been by visual inspection. Follow-up investigation by OSS discovered evidence of a similar leak during the 1998/99 wet season. Tailings water has concentrations of Mn around 1,000,000 µg/L and NH_4 at 530 mg/L. ERA's monitoring was not required to analyse for these species in sampling in the Corridor Creek area. The OSS report on the issue identified 2 breaches of the Environmental Requirements. DBIRD fails to acknowledge breaches and sanction ERA.
- **Feb. 2** - Re-occurrence of high uranium (41 µg/L) in water discharging uncontrolled from RP1 to Coonjimba and Magela Creeks. Although concentrations were not as high as the previous wet season, the source of the uranium remained uncertain and questions the remedial works undertaken by ERA in the 1999 dry season to prevent this problem again.

1999

- **General** - The uranium contamination of RP1 during the 1998/99 Wet Season is the closest ERA has yet come to exceeding its operating requirements. Although the total mass of uranium discharged is below (high) legal limts, the low flows in Magela Creek during the early discharges from RP1 almost led to ERA increasing the U concentration in the Magela greater than the 3.8 µg/L allowed. The U and SO_4 levels in the Magela at the Kakadu National Park border are higher than background. ERA states that : *"Analysis of water quality and sediments in surrounding billabongs and creeks indicate the presence of the mine is apparent, as was expected by the Ranger Uranium Environmental Inquiry. Whilst the levels are detectable chemically, they are not ecologically significant and no deleterious effects on downstream flora and fauna or downstream users of the creek and its resources have been detected."* This is in contrast to the evidence and earlier OSS comments on such increases.

- **Mid (Dry Season)** – To try and better control future discharge from RP1, ERA construct a short retaining wall on the spillway about 30 cm in height.
- **Feb. 17** - ERA attempts to minimise the discharge from RP1 by sandbagging the spillway - in order to avoid the Magela exceeding its allowable uranium concentration.
- **Jan. 27** - The concentration of uranium in water discharging uncontrolled from RP1 to Coonjimba Creek and on to the Magela Creek was found to be approximately 70 µg/L - up to 100 times higher than normal. The RP1 sediment control bund, with uranium at 600 µg/L, was identified as the likely source.

1998

- **Oct. (late) to Nov. (early)** - The RP2 Wetland filter had been allowed to dry out during the Dry Season. The first rains of the Wet led to acidification of the wetland waters, with pH around 2.6 and uranium as high as 4,000 to 6,000 µg/L.
- **March 16** - To remove rainwater which had collected on the haul road, an ERA employee broke a bund which resulted in about 100,000 L of water escaping from the RRZ.

1997

- **Dec. 19** - About 2,000 L of tailings slurry escaped from the RRZ due to a leak in the tailings pipeline.
- **Feb. 24** - 50,000 L of Very Low Grade/Low Grade (VLG/LG) ore spilled outside the RRZ zone into the RP1 catchment.

1996

- **Nov. 19** - A segment of the perimeter drain around new extensions to the VLG/LG stockpile washed out during a heavy storm. About 100,00 L of RRZ water and some sediment was released into RP1 catchment.
- **Nov. 6** - Fatal work accident involving a contractor. The worker died when the excavator he was operating collapsed into the excavation.
- **Sep. 21** - A bush fire on the mine site placed significant demand on accessible non-RRZ water for fire fighting. To speed up the turnaround times for water tankers, a decision was made to use RRZ water to create a wet perimeter and to dampen facilities under threat. Approximately 585,000,000 L was applied to areas outside the RRZ.

1995

- **Dec. 13** - An administrative error resulted in a repeat of the incident of 6 Dec. when 8,000 L of the residual diesel/water mixture was spilled back to RP2. There were no further bird deaths associated with this incident.
- **Dec. 6** - 12,000 L of diesel spilled from tanks at the power station and ran into RP2. Although the spill was cleared up the spill was responsible for the **DEATH OF 40 WATER BIRDS** (36 Little Black Cormorants, 3 Australasian Grebe and 1 Australian Darter). ***The OSS regarded this incident as the first example of an unacceptable environmental impact at Ranger since operations began***.
- **Aug. 1** - About 120,000 L of RP2 water was accidentally discharged outside the RRZ due to a failure in a pipeline carrying water to the constructed wetland filter adjacent to RP1.
- **July 31** - An asbestos cement pipe failed and about 120,000 L of water from RP2 was released. The water was pumped over the spillway into Djalkmara Creek.

1994

- **May 10** - About 50,000 L of RP2 water was accidentally discharged outside the RRZ during the installation of a new section of pipe at the RP2 pumping station. The pipe was part of the network that serves the Magela irrigation area.
- **April 13** - About 60,000 L of combined rainfall-runoff and seepage from the high-grade ore stockpile discharged outside the RRZ following a pipe joint failure. The pipe ran alongside the drain downstream of the RRZ boundary at the bund in the high-grade ore stockpile drain. Samples taken along the flow path showed an increase in U concentration in Georgetown Creek but no change in U concentration could be detected in Georgetown Billabong. The pipe has since been relocated wholly inside the RRZ.

1993

- **Jan. 25** - During heavy rainfall a blocked drain caused a small volume (less than 100,000 L) of water to escape from the RRZ. The OSS assessed this event as being an infringement of the Ranger Authorisation and a breach of ER27.

1992

- **Sep. 27** - About 430,000 L of RP2 water was transported by mine trucks to locations outside the RRZ for use by the Ranger emergency fire crew in containing and controlling a bushfire burning in and near the Magela LAA. The fire, fanned by strong winds and burning on a number of fronts, threatened infrastructure including monitoring installations and powerlines close to RP2 and also threatened to move towards the light industrial area and the Jabiru East site. There were no alternative sources of water in sufficient quantity available to fight the fire. The OSS assessed the transfer of water from the RRZ as constituting an infringement of the Ranger Authorisation and a breach of the ERs.
- **Feb. 26 to 27** - During a high rainfall event, water from the high grade ore stockpile, which contained significant U concentrations, escaped from its containment sump and flowed into Georgetown Creek, then into Magela Creek. As a result increased concentrations of U were detected in Georgetown Creek and in Magela Creek. The available information did not enable an accurate assessment to be made of the effect of this uncontrolled release. The OSS estimated that about 25 kg of U was released.

1991

- **General** - "At Ranger, the expected environmental effects of a large operating uranium mine are beginning to be discernible outside the immediate environs of the mine site ... The water quality of Magela Creek close to the boundary of the Project area and Kakadu National Park deteriorated in the 1991 Wet season to the extent that uranium and sulphate reached concentrations higher than background values ... this is the first recorded instance since Ranger commenced mining that the water quality in Magela Creek has deteriorated to the point where it has the potential to cause observable effects on aquatic organisms. Ranger is now a mature mine; losses of contaminants to the environment are increasing and their presence is measurable in local waterbodies and streams. The company has introduced a number of practices which result in the deliberate release of water whose quality will modify the chemistry of nearby natural waterbodies. While each of these sources contributes only minor quantities of contaminants, the resultant effect on water quality is readily measurable and more importantly, the evidence shows it to be increasing. The environmental implications of this trend should be assessed and water management practices re-evaluated to ensure that all sources contributing to losses to the environment have been minimised as required under the definition of Best Practicable Technology (ER 44)."
- **Aug. 24 to 25** - Approximately 1,300,000 L of RRZ water (from RP2) was inadvertently used on the perimeter road of the tailings dam to suppress dust.
- **March 27** - About 320,000 L of additional water were applied to the land application area following equipment malfunction, leading to a 9% increase in irrigation rate. The water fully infiltrated and there was no runoff.
- **Feb. 26 to 27** - Uranium enriched water draining from the Ranger high grade ore stockpile was accidentally released to Georgetown Creek and subsequently Magela Creek. The event was not classified as an infringement by NTDME. The OSS estimated that about 25 kg of U was discharged to Magela Creek during this event and, based upon the flow conditions at the time, assessed that the concentration of uranium could have been comparable to the receiving water limit for a short period.

1989

- **Aug. 13 to 14** - About 315,000 L of RP2 water was used for fire fighting when a bush fire threatened both the Ranger and Alligator Rivers Region Research Institute laboratories.

1988

- **Nov.** - Following a malfunction of ore discriminators material containing low grades of uranium was being dumped incorrectly on the waste rock dump; up to 500,000 t of material may have been involved, possibly for as long as six months. The area of the waste rock dump was redesignated as RRZ. Criticising Ranger's attitude to the incident, Dr Glen Riley, OSS Director at Jabiru wrote "I regard this situation as the most serious deficiency shown by Ranger in a long series of malfunctions and operational shortcomings since the mine opened ... rather than achieve better (or more sure) environmental control as they gain more experience, Ranger are moving the operation into a more hazardous situation".

1987

- **March** - 500,000 L of RP4 water was inadvertently released via the pipeline to Magela Creek following a valve malfunction and when the creek's flow rate was below the minimum approved rate.

1985

- **Oct. 3-7** - Valve failure in the tailings line resulted in 500,000 L of tailings and process water being inadvertently applied to land application plots within the RRZ.
- **Sep. 18** - Another tailings pipeline failure resulted in about 25,000 L of tailings water being released from the RRZ.
- **Sep. 17** - Tailings pipeline failure resulted in about 25,000 L of tailings water being released from the RRZ.
- **Feb. 14 to 16** - Fish kill in RP2 was reported after water was pumped from RP4.

1984

- **July 11** - 200,000 L of water from within the RRZ leaked outside the RRZ from a joint in a pipe carrying tailings dam seepage back to the dam.
- **Jan. 25** - 100,000 L of RP2 water escaped from a pipeline within the RRZ; all water contained.

1983

- **Sep. 20** - 40 t of low grade dumped outside the RRZ. Clean up was carried and material returned to RRZ.
- **July** - Drinking water at the mine was contaminated by radioactive water used in the processing of the plant. The processing water and drinking water were connected accidentally. It is uncertain how long this situation went undetected. When the contamination was eventually discovered the system was flushed out and workers were examined for radioactive contamination. Tests on the workers and in the contaminated area indicated 'no danger'; however subsequently a plumber found residue in the pipes which was revealed to have been the radioactive substance ammonium diuranate.
- **Feb. 9** - 200 L of diesel spilt at a borefield 800 m south of pit #1.

1982

- **April 20** - 30,000 L pregnant organic liquor solution overflowed from an overflow sump into stormwater system thence to RP2. Operation was stopped; sump modified.
- **Jan. 22 to 23** - About 40 dead fish were found in Coonjimba Billabong considered part of natural processes (no abnormal water quality indicators were found).

1981

- **July 29** - Recycle tank overflowed spilling process water from RP3 into the neutral thickener area. Some of the water and a minor amount of tailings solids were pumped into the stormwater collection pond which discharges to RP2 during the wet season. The estimated volume pumped was 40,000 L.
- **April 9** - Small volume of water and silt flowed from RUM's organic dump tank to Georgetown Creek. (Ranger reported the incident to the OSS on April 29).

1980-81 Wet Season

- **General** - Sewer at old mess site became surcharged at times and sewage entered Coonjimba Billabong; necessitating remedial works.

1980

- **June 6** - Release of 1,000,000 L of silty water discharged from Borrow D to Georgetown Creek.
- **Feb.** - The tailings dam floor and walls were identified by the Ranger Uranium Environmental Inquiry as major pathways by which contaminants could enter the Magela Creek. 245 mm of rain fell on the Ranger mine site in five hours. A rapid rise in water level occurred in both RP1 and the partially complete tailings dam. The company was forced to make a four metre breach in the tailings dam wall and about 9,000,000 L and possibly up to 64,000,000 L was discharged into Djalkmara Creek.

1979

- **Nov. 22** - 20 L of diesel spilled into a drain in Jabiru.
- **Feb. 28** - Spillage of diesel into Coonjimba Billabong.

Appendix 5 : List of Ranger Reports Requested to be Public

1977

Clark, G H, 1977, *Assessment of the Meteorological Data and Atmospheric Dispersion Estimates in the Ranger 1 Uranium Mining Environmental Impact Statement*. Australian Atomic Energy Commission, AAEC/E407, March 1977, 103 p.

1978

Davy, D R & O'Brien, B, 1978 (In Preparation), *Radon Survey at the Ranger I Orebody I Uranium Deposit, Northern Territory*. Australian Atomic Energy Commission, AAEC/E4??. [Quoted in Davy, D R, Dudaitis, A & O'Brien, B, 1978, Radon Survey at the Koongarra Uranium Deposit, Northern Territory. Australian Atomic Energy Commission, AAEC/E459, November 1978, 56 p.].

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Sinclair, G, 1992, *Hydrological and Geochemical Assessment of the Tailings Dam Seepage Collector System*. Energy Resources of Australia Ltd, November 1992.

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Davy, D R, 1988, *The Attenuation of Solute (Chemical & Radioactive Species) in Tailings Water by Adsorption on Soil and Rock Down Gradient of the Ranger Tailings Dam*. Australian Nuclear Science & Technology Organisation, November 1988.

Milnes, A R & Fazey, P G, 1988, *Acid Leaching From Ore Stockpiles and Waste Dumps in the Ranger Project Area, East Jabiru*. RUM Technical Paper 2, RAN-197 #2.

Turner, J V & Dillon, P J, 1988, *Migration of Solutes From the Ranger Mines Tailings Dam in Relation to Seepage Collection and Groundwater*. Division of Water Resources, Commonwealth Scientific & Industrial Research Organisation, May 1988.

1990

Reid, P D, Brown, P L & Huang, J C, 1990, *Geophysical Delineation of Groundwater Seepage Pathways - Electromagnetic Imaging of Apparent Terrain Conductivity*. Environmental Science Division, Australian Nuclear Science & Technology Organisation, Report ANSTO/C198, November 1990.

RUM, 1990, *Amelioration of Retention Pond Water by Wetland Filtration*. Ranger Uranium Mines Pty Ltd, 14 November 1990.

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Ross, B J & Noller, B N, 1992, *Monitoring of Ranger Wetland Filtration Trial 1990*. Environment Directorate, Internal Report, Commonwealth Scientific & Industrial Research Organisation, November 1991.

Unger, C, 1992, *Trial Release Through Wetland Filter*. Energy Resources of Australia Ltd.

1994

Lowson, R T & Reid, P, 1994, *The Formation of Epsomite - [$MgSO_4.7H_2O$] - Down Gradient of the Land Application Site*. Australian Nuclear Science & Technology Organisation, March 1994.

McAllister, R, 1994, *Review of the Monitoring of the Wetland Filter in RP1 Catchment 1993/94 Wet Season*. Energy Resources of Australia Ltd.

1997

Hatton, T, 1997, *Review of Evaporation Estimates, Ranger Mine*. CSIRO Research Project 82BG, August 1997.

Sheng, Y, Peter, P, Youzhi, W, Nefiodovas, A & Wright, M, 1997, *Field Trials of the Capping Techniques in the Tailings Dam at Ranger Mine*. CSIRO Division of Exploration and Mining Report No. 423C.

1998

Agnew, M, Nefiodovas, A & Peter P, 1998, *Particle Size Determination of Ranger #1 Pit Tailings*. CSIRO Minesite Rehabilitation Research Pr ogram Division of Land and Water Report No. 98-45, July 1998. 5pp plus 3 figures.

Buselli, J & Lu, K, 1998, *Ranger Geophysics Progress Report - October 1998*. Cooperative Research Centre for Australian Mineral Exploration Technologies. 5pp plus 9 figures. Project 93BI.

Craig, M S, 1998, *A Conceptual Model for the Prediction of Consolidation of the Ranger Tailings*. CSIRO Minesite Rehabilitation Research Program, June 1998. Report No 502C, 40pp.

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- *Annual Water Management Report.*
- *Annual Water Management Systems Operation Manual Report.*
- *Annual Environmental Management Plan Report.*
- *Annual Radiation and Atmospheric Monitoring Report.*
- *Annual Tailings Dam Surveillance Report.*

Important Specific Issues :

- *Studies/Reports Relating to Long-Term Tailings Management at Ranger.*
  - projections of filling of Pit #1 (to 'RL 0 metres'), current storage capacity of the above ground dam, timing of filling dam and Pit #1, when Pit #3 will be available / ready, alternative tailings storage and management regimes studied, timing of removing and rehabilitation of above ground dam, long-term rehabilitation plan.
  - groundwater contamination and protection, fracture behaviour, high permeability pathways such as fault and fracture zones, techniques to remediate already contaminated groundwater.

- *Studies Relating to Long-Term Contaminant Retention in Wetlands.*
  - studies examining the retention by soils and plants, the eventual rates at which contaminants could be released, effect of varying conditions.

Appendix 6 : Mudd, G.M. 2001m Review of Water Management at Jabiluka: Environmental Issues and Recommendations. Research Report to Gundjehmi Aboriginal Corporation, December 2001.

Review of Water Management at Jabiluka :

Environmental Issues and Recommendations

December 2001

Dr Gavin M. Mudd

Environmental Science Consultant to Gundjehmi Aboriginal Corporation

Executive Summary

- Water management at Jabiluka has historically – and currently – been promoted as a 'no-release' operation, but due to unnecessary project risks taken by current owner ERA, the Jabiluka project is facing a continually escalating water management crisis;

- The use of "Best Practicable Technology" (BPT), as practised by ERA, fails to account for the legitimate concerns of the Mirrar, generally being an exercise in assuring approvals of the lowest cost option;

- The Mirrar and their representatives from Gundjehmi Aboriginal Corporation have not been adequately informed and consulted about water management issues at Jabiluka, especially prior to approvals;

- Groundwater behaviour around and discharge into the decline is still poorly understood and analysed, despite this being the major contaminant source for water management at Jabiluka;

- Inadequate reporting of critical water management aspects by ERA, OSS and NT authorities, especially :

    - water level and quantity over time of the IWMP;
    - Reverse Osmosis treatment quality and irrigation quantities (and performance of Jabiluka soils from this irrigation);
    - groundwater sources, both quantity and quality, remain poorly reported.

- The Northern Land Council (NLC) and Office of the Supervising Scientist (OSS) need to pro-actively support the legitimate concerns of the traditional owners, the Mirrar, and argue for active rehabilitation over 2002 and 2003 to alleviate water management strains;

- Water treatment should be continued on-site at Jabiluka in the short-term to ensure that contamination levels are not further increased in areas outside of the IWMP.

1 Introduction

The proposed uranium mining project at Jabiluka has been consistently opposed by the region's traditional owners the Mirrar since its discovery in the early 1970s. In mid 1998, current owner Energy Resources of Australia Ltd (ERA) began construction of mining and associated facilities at the Jabiluka site, with the intention of mining ore at Jabiluka and trucking it 22 km south to their Ranger mill for processing – despite the clear opposition from the Mirrar. The facilities built and operated between June 1998 and September 1999 are :

- an underground decline for access, mine development and exploration;
- office and workshop facilities, including diesel storage tanks;
- an 'Interim Water Management Pond', intended for 1-2 wet seasons until permission could be sought to truck Jabiluka ore to Ranger;
- a 'mineralised' stockpile, which includes uranium ore ≥0.02% U_3O_8 and potentially acid-forming rock (contains reactive sulfide minerals);
- an inert or 'non-mineralised' stockpile (ie. below the mineralised criteria);
- ventilation shaft (for the underground decline);
- sediment traps for erosion and drainage control.

All development and exploration work ceased at the site in September 1999. A current site map is shown in Figure 1. By November 2001, the 'interim' pond has been subjected to 3 heavy wet seasons and is facing its fourth. This report briefly examines the history of water management at Jabiluka, and examines current management practices being used by ERA to try and minimise unacceptable environmental impacts. Based on this analysis, options and recommendations for water management at Jabiluka are presented to help achieve the best possible environmental and community outcomes for the Mirrar.

2 Climate and Hydrology

The first measurements of rainfall and evaporation at Jabiluka were taken in the early 1970s, although monitoring has not been continuous since. The climate varies between a monsoonal wet season from November to April and a dry season between May and October. A compilation of the available climate data is presented in Table 1, including nearby Jabiru East (airstrip) and Gunbalanya (Oenpelli) for comparison. The rainfall over the past three wet seasons has been well above average, amongst the highest recorded rainfall for the East Alligator region over the past 30 years whilst evaporation has been considerably lower than average (see Appendix 1 for data).

Table 1 – Rainfall and Evaporation Data (mm)

	Jabiluka		**Jabiru East**		**Gunbalanya**	
	Rainfall	Evaporation	Rainfall	Evaporation	Rainfall	Evaporation
30 Year Average [(1)]	NA	NA	1,483 [(1)]	NA	1,500 [(1)]	NA
May 1998 – April 1999	1,915	1,266 [(2)]	1,893	2,307	NA	NA
May 1999 – April 2000	1,862.2	1,935.8	1,917	2,301	NA	NA
May 2000 – April 2001	1,953.6	1,980.4	1,946	2,270	NA	NA

[(1)] - data from September 1971 to August 1998; [(2)] - data for Sept. 1, 1998 to April 1, 1999 only.

References : NTSA (various); NTS (1999); Johnston & Prendergast (1999), ERA (2000 & 2001).

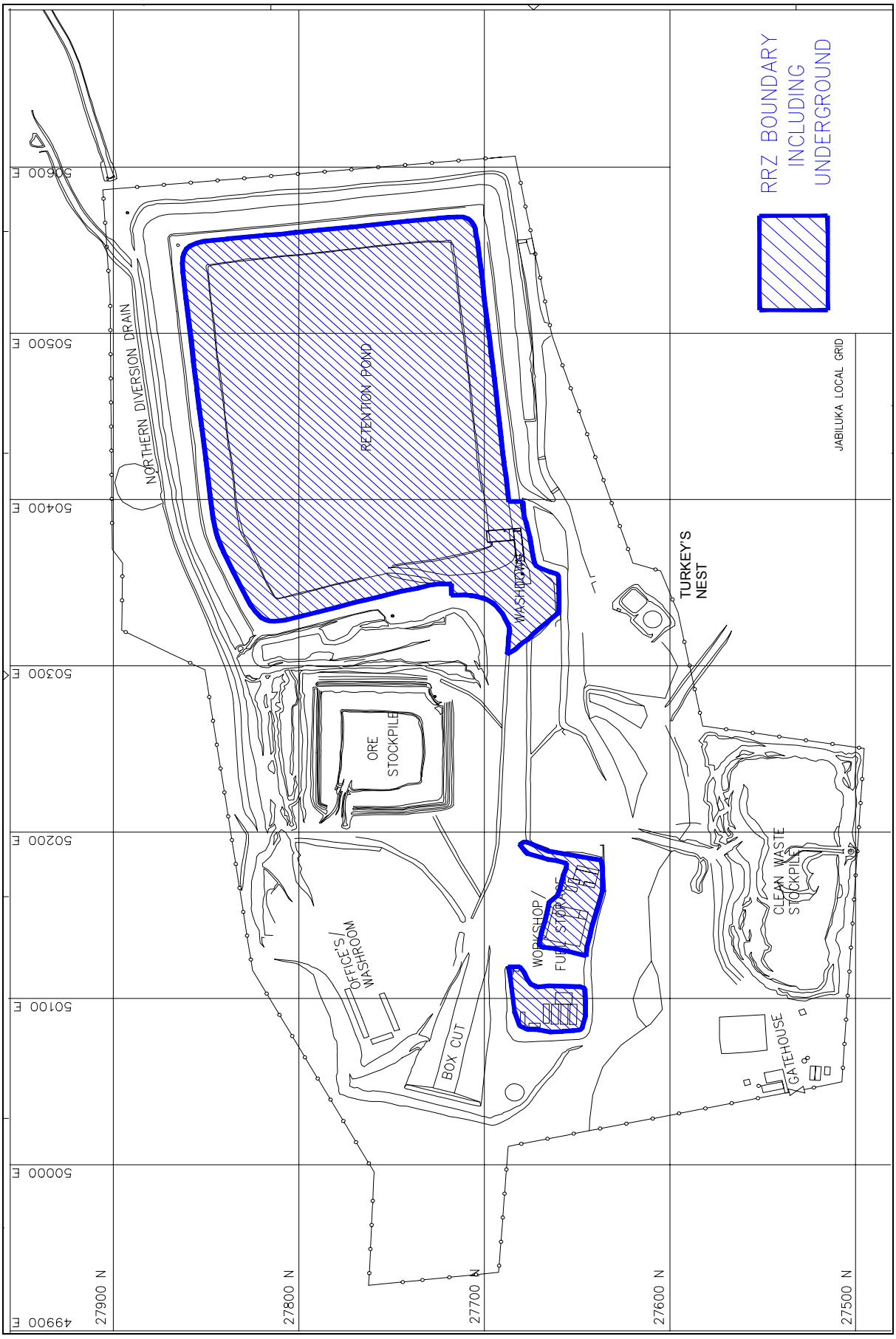


Figure 1 – Site Layout of Jabiluka Facilities, November 2001 (ERA, 2001)

3 Water Management at Jabiluka

3.1 History of Water Management Proposals

In the 1970s, Pancontinental Mining Ltd presented two major proposals for the development of the Jabiluka project. The first proposal, as outlined in the Draft Environmental Impact Statement (EIS) (Pancon, 1977), included a water management regime which allowed the controlled release of contaminated mine waters through dilution with clean water. This was contrary to the recommendations of the Ranger Uranium Environmental Inquiry (Fox *et al.*, 1977), which argued against water release and urged the adoption of a 'no-release' water management system for all proposed uranium mines of the Alligator Rivers Region. In July 1979, Pancontinental presented the second proposal for Jabiluka, a major overhaul of the earlier Draft EIS, which, as well as shifting from an open cut to an underground mine, included the adoption of a 'no-release' water management system (Pancon, 1979).

After failing to develop the Jabiluka project in the 1980s [1], Pancontinental were forced into selling Jabiluka to Energy Resources of Australia Ltd (ERA) in August 1991. ERA, who operated the Ranger uranium project to the south, went about re-designing the entire Jabiluka project. Under a deed of transfer agreed to and signed on December 24, 1991, ERA and the Northern Land Council (NLC) agreed that in order for Jabiluka ore to be milled at Ranger, the consent of the NLC shall be required, which may be refused or given subject to conditions. With the election of the Howard Coalition Government in March 1996, the previous restriction on uranium mine development was lifted and ERA began a new environmental impact assessment process to develop Jabiluka (ie. Kinhill, 1996 & 1997).

The key change in concept was to operate a 'small' underground mine and truck the ore for milling at Ranger - the 'Ranger Mill Alternative' (RMA). The RMA was to maintain a 'Total Containment Zone' for water management at Jabiluka, essentially a different wording of no-release. The Commonwealth and Northern Territory (NT) approvals for development of the RMA option were given by late 1997. As per the 91 deed of transfer, this change in mine plan required the express consent NLC and therefore the traditional owners. Since the Mirrar have continued to clearly oppose any development at Jabiluka, this consent has never been given.

After belated recognition of Mirrar opposition, ERA was forced to reconsider their development options for Jabiluka and were then required to undertake a lower level of environmental assessment, a Public Environment Report (PER), on the potential for a major uranium mill onsite at Jabiluka (in addition to the underground mine facilities) (ie. Kinhill, 1998). This was due to serious deficiencies identified in the Draft EIS and Supplement concerning ERA's contingency for a milling operation at Jabiluka. The new proposal was taking advantage of the earlier Pancontinental agreement with the traditional owners [2] for a mill onsite at Jabiluka – and hence is known as the 'Jabiluka Mill Alternative' (JMA). The draft guidelines for the PER were released in May 1998, with the final guidelines adopted on June 3, 1998 – though not publicly acknowldged until June 9 - the same day the JMA PER was released.

[1] - due to the Hawke Labour Government's 'Three Uranium Mines Policy' from 1983 to 1996, which recognised community and traditional owner opposition to uranium mining, especially in Kakadu National Park.
[2] - the Mirrar have always maintained this agreement was negotiated under extreme duress.

Despite the significant uncertainties surrounding the Jabiluka project by mid-1998 (namely where to mill the ore and the impending federal election in October), ERA sought and (eventually) won court approval for construction of facilities in June 1998 which were 'common' to both the RMA and JMA – principally the decline and an 'interim water management pond' (IWMP). The PER did not gain federal approval until late August 1998. Further to this, there was no discussion of staged construction in the Draft EIS (Sections 4.3.4 and 4.9.3) or the Supplement (Section 5.4). The (later) approved PER [3] proposes a schedule whereby construction of water management facilities would start in July 1998 and be completed by November 1998 (pp 4-11, Kinhill, 1998).The original JMA proposal in the Draft EIS included a 'raw water pond' of 4.0 ha, however, this was excluded in the JMA as proposed in the PER in favour of using the tailings pits as part of the water management system (pp 4-8, Kinhill, 1998). For comparison, the RMA water management pond was proposed to be 9.0 ha in the Draft EIS (pp 4-67, Kinhill, 1996). It is generally assumed that the IWMP was to last for one wet season until the RMA could proceed in 1999 [4].

It is curious that NTSA (1999) states that the IWMP "… will be incorporated into the WMS [water management system] constructed for the production phase" (pp 61).

Given that approval of the RMA included a specific recommendation [5] that the design of the water management pond obtain the approval of the Supervising Scientist before proceeding, it would seem that ERA were keen to proceed with the risks of construction at Jabiluka with no clearly defined project future. This leaves a limited scientific or engineering basis upon which to design the pond and encourages little confidence in ERA's approach to water management.

Development of the underground decline and further exploration drilling continued at Jabiluka until September 1999. Since this time the site has been on an 'environmental management and standby phase', until such time as ERA and/or its latest parent company Rio Tinto Ltd either proceed with the JMA, abandon the entire Jabiluka project as wished by the Mirrar, or seek to renegotiate from January 2005 for the potential milling of Jabiluka ore at Ranger.

A chronology of water management proposals is compiled in Box 1.

3.2 Water Management Regime – Late 1998 to Early 2000

As part of the various approvals and conditions from both the Commonwealth and Northern Territory governments, ERA was committed to a 'Total Containment Zone' for water management at Jabiluka. As shown in Figure 1, the main features of the facilities, as constructed, are supposedly common to both the RMA and JMA proposals, although the actual basis for this appears slight at best. The excavation for the IWMP was completed in August 1998 and the pond liner system installed in September (concurrently with work starting on the decline) (OSS, 1998).

[3] - no date for completion of the water management pond at Jabiluka is given in NTS (1999).
[4] - eg. talk by Brendan Lewis, NLC, at Gundjehmi Governing Committee, April 10, 2001 (NLC, 2001a).
[5] - Recommendation 28, Minister for the Environment, August 1997 (see pp 82, EA, 1997).

Box 1 : Chronology of Water Management Proposals for Jabiluka	
May 1977	• Ranger Uranium Environmental Inquiry (Fox Inquiry) recommends that all proposed uranium mines in the Alligator Rivers Region adopt a 'no-release' water management regime.
Dec. 1977	• Pancontinental Mining Ltd releases its Draft EIS, proposing release of contaminated minesite waters diluted with clean waters.
July 1979	• Pancontinental Mining Ltd releases its Final EIS, proposing a 'no-release' water management system.
Aug. 1991	• Energy Resources of Australia Ltd (ERA) gain ownership of Jabiluka, and redesign the entire Jabiluka Project.
Oct. 1996	• ERA releases its Draft EIS for a completely new Jabiluka proposal, presenting a 'Total Containment Zone (TCZ)' for the underground mine infrastructure (ore would be trucked to ERA's Ranger mill for processing). Pond size is 9.0 ha.
June 1997	• ERA release their Supplementary EIS, with no change to water management.
Oct. 1997	• Commonwealth government gives final approvals to ERA's development of the Ranger Mill Alternative (RMA) for Jabiluka.
May 1998	• After steadfast opposition from the Mirrar, ERA is forced to undertake a Public Environment Report (PER) for developing a mill at Jabiluka ('JMA').
June 2, 1998	• NT approval to start construction, the Mirrar block with court action.
June 3, 1998	• PER guidelines finalised but not released - PER already sent for printing.
June 9, 1998	• ERA release the PER on the revised JMA. No retention ponds included in project design, instead using tailings pits.
June 15, 1998	• ERA win court approval to begin construction of 'common elements' to both the RMA and revised JMA, despite no approval for the revised JMA and no mention of 'staged' construction in the RMA. The Mirrar remain opposed.

By the start of the Jabiluka site's first wet season in November 1998, the major water management features were (totalling about 8 ha in area [6]) :

- an underground mine decline and groundwater collection system;
- the 'Interim Water Management Pond' (IWMP);
- a 'non-mineralised' stockpile;
- sediment traps for erosion and drainage control.

As noted, the IWMP was apparently built to approximately the RMA design and function, although the construction was staged to allow time for the gaining of consent from the Mirrar for this proposal. The IWMP covered an area of 3.27 ha and collected all water from the working areas of the Jabiluka site (about 8 ha [7]), mainly the underground decline, workshops, pond and mineralised stockpile. Although the authorisation which allowed ERA to proceed in June 1998 did not allow the release of water [8], a 'Restricted Release Zone' (RRZ) was not declared until 'mineralised' rock (see below) was encountered in the construction of the underground decline on April 26, 1999 (OSS, 1999a). On this date the RRZ was officially declared [9].

There is no discussion of this detail in NTS (1999), despite it being absolutely pivotal in water management at Jabiluka. It would also seem that the phrase of 'Total Containment Zone' was no longer preferred, although OSS (2001a) maintains that the RRZ is still a TCZ (pp 25 & 29).

[6] - based on Restricted Release Zone as outlined in Map 3 in NTS (1999); map dated April 1999.
[7] - total site area is about 17 ha, courtesy of ERA, www.energyres.com.au, printed November 25, 2001.
[8] - Item 6.3, Schedule 6, Jabiluka Authorisation 98/2 (Appendix G), NTS (1999).
[9] - see Figure Map 3, NTS (1999). OSS (1999b) states approval of the RRZ as May 10, 1999.

The principal change to occur after the 1998-99 wet season was that construction and development work in the underground decline encountered 'mineralised' material on April 26, 1999, introducing contaminated rock into the surface environment at Jabiluka. It should be noted that the first annual environmental report for Jabiluka (ie. NTS, 1999), did not mention this development although it was within its reporting period. Mineralised material is classified as rock which contains ≥0.02% U_3O_8 (low grade uranium ore) and/or sulfidic minerals [10] and was stockpiled on a separate pad with a double-layered impermeable liner. The total quantity of mineralised material placed on the pad was 47,000 tonnes [11], after a further expansion in late June 1999 to accommodate the extra material encountered (OSS, 1999a). Based on criteria for assessing the sulfides in extracted material, the mineralised rock was classified as non-sulfidic since the average sulfide concentration was 0.12% S, with the maximum sulfur grade being 0.48% S. The average uranium grade is 0.123% U_3O_8, including 10,000 t at 0.27% U_3O_8.

If exposed to excessive rainfall and infiltration, this could lead to significant leaching of contaminants from the mineralised rock into the water management system. The principal contaminants were considered to be uranium (U), lead (Pb), magnesium (Mg), manganese (Mn), radium-226 (^{226}Ra) and sulfate (SO_4). All drainage through this stockpile goes to the IWMP. It is worth noting that there was about 150 mm of rainfall in April 1999 (NTS, 1999), although the timing of this rainfall is not clear from avaliable reports.

All development and underground exploration work ceased at Jabiluka in September 1999, with the site converting to an 'environmental management and standby phase'. In November 1999, a tarpaulin was placed and weighed down over the mineralised stockpile to prevent infiltration and also to excise this area from the RRZ (down to 4.95 ha; ERA, 2001), thereby reducing the flow of contaminated water into the pond (approved on December 14, 1999). The IWMP was maintained for the 1999-2000 wet season, which was again a near-record at 1,862 mm of rainfall.

3.3 Water Management Regime – Mid 2000 to Late 2001

By early 2000, there was serious concern that the IWMP would be retaining too much water which could not be lost through evaporation before the 2000-01 wet season. Under the various approvals, ERA is required to maintain enough capacity in the IWMP to hold a 1-in-10,000 year wet season of about 2,460 mm [12].

A 'Best Practicable Technology' (BPT) process was initiated in late March 2000 (NLC, 2000a) which investigated numerous options for treatment and/or disposal of the excess contaminated water. The outcome of the BPT assessment, undertaken by ERA and then presented to regulators and the NLC [13] at an informal meeting on March 29, pointed to two prime options for water treatment – land application and reverse osmosis treatment (or RO, followed by land application or direct discharge).

[10] - based on ≥0.5% sulfides, Net Acid Producing Potential of 20 kg H_2SO_4 per tonne and Net Acid Generation pH <4 (pp 23, NTS, 1999). The Jazbiluka authorisation was changed on February 27, 2001, to alter the criteria for sulfide mineralisation (reasons unknown) (see OSS, 2001a).
[11] - Fax from Allan Wade, ERA, to Geff Cramb, NLC, November 27, 2001, 1 p.
[12] - using the recommended figure of Johnston & Prendergast (1999).
[13] - who are statutorily required to represent the interests of the traditional owners, the Mirrar.

A BPT assessment has to take into account age and effectiveness of equipment, location, environmental benefits and risks, social factors and cost [14]. Since land application scored marginally higher than RO, combined with the fact that it was considerably cheaper, land application (ie. direct irrigation) was ERA's preferred choice. This indicates that social concerns, particularly the legitimate concerns of traditional owners, are not adequately considered by ERA into its BPT assessments.

When water management options were discussed at an informal Jabiluka Minesite Technical Committee (JMTC) on March 29, 2000, ERA argued strongly for land application, however, the NLC and Office of the Supervising Scientist (OSS) argued convincingly for RO followed by land application of the treated water within the Jabiluka site (ie. no external release as per the approvals). ERA established and ran a series of apparently successful RO laboratory trials at Ranger, which were discussed at a further informal JMTC meeting held on July 19.

Following JMTC support for RO from this meeting, ERA applied to the NT Minister for Mines and Energy to install and operate an RO water treatment system followed by land application over 3.76 ha. The irrigation was to provide an extra buffer (through contaminants, primarily uranium, being retained within soils) should the quality of the RO output vary over time, as argued by the NLC and others. The Minister's approval was given on August 17, 2000, with the approval amended on August 24 for irrigation limits. The water quality limits set for irrigation were required to be met for samples taken from the 'Turkey's Nest' (see Figure 1), a small pond in the southern part of the site where RO output water would be temporarily stored until irrigated.

The first RO unit began operation followed by irrigation on August 28, 2000 [15], with a second unit arriving in October but wasn't commissioned until late November 2000 due to delays in the delivery of the microfiltration membranes (ERA, 2001). The cost of the RO system was apparently in the order of some $500,000 (NLC, 2001a). The units were supplied by O'Donnell Griffin [16] but their performance has been much less than satisfactory, however, with problems including biological fouling of the membranes, chemical compatibility (requiring the dosing of input water with sulfuric acid) and questionable quality in the supplied equipment and its operation. A compilation of the performance of the RO units is presented in Section 6.

Further drainage modifcations were made in late 2000 to further reduce the RRZ area, to allow clean runoff to be diverted and the quantity of inflow to the IWMP. The reduced RRZ of 4.1 ha was approved in January 2001 (see Figure 1) (ERA, 2001).

In December 2000, ERA claimed that they were able to meet the 1-in-10,000 year rainfall contingency for the 2000-01 wet season [17], although this included storage in the decline (not preferred but seen as safe). The near-record rainfall of 1,954 mm led to emergency pumping of IWMP water into the underground decline on February 13, 2001 (ERA, 2001). From 11:00 on February 13 to 14:00 on February 15, approximately 12 million litres (ML [18]) was pumped from the IWMP into the decline. This reduced the level of water in the IWMP sufficiently not to require further underground storage for the remainder of the wet season.

[14] - see clause 12 of the Environmental Requirements for the Ranger uranium mine (in Appendix 2).
[15] - NTSA, 2000b, Report N0. 40.
[16] - NLC, 2001a2-&&&.
[17] - see minutes from the Alligator Rivers Region Advisory Committee meeting, December 2000.
[18] - 1 million litres = 10^6 L = 1 ML = 1,000 m^3 (1 m^3 = 1,000 L).

By March 22, 2001, the quantity of water stored in the decline was 17.7 ML, including groundwater inflow, with up to 30 ML expected to be stored by the mid dry season when pumping out of the decline was to commence (NLC, 2001b). The dewatering of the decline, totalling approximately 20 ML, commenced in early May 2001 and was completed on June 19, 2001 (OSS, 2001a).

By mid 2001, it was apparent that the RO units were not maintaining performance expectations (0.4 ML per day), and would not be likely to last until the end of the 2001-02 wet season. Before consultation and formal meetings between the NTDME, NLC and OSS, ERA applied on September 20, 2001, for an expanded irrigation area with increased load limits (ie. IWMP water). At an informal JMTC meeting on October 1, 2001, it was agreed that land application was needed on a larger scale than currently being practiced (NLC, 2001c). ERA subsequently sought approval for a modified water management regime at Jabiluka, including combined irrigation of RO-IWMP water and direct irrigation of IWMP water during the dry season. Approvals were forthcoming on October 11, 2001, only specifying load limits and concentrations for Mg, SO_4 and U. This approval did not specify whether the irrigated water would be RO, IWMP or mixed, nor did it differentiate between irrigation during the wet and dry season. Critically, the OSS was not party to the derivation of these criteria, although they appear to reluctantly accept that their appropriateness (OSS, 2001c).

It would appear that some debate followed this approval, as a further informal Jabiluka MTC was held in late October 2001 to address the deficiencies in the approval criteria from the NT authorities. As the NT approval also stated that any further directions from the JMTC would apply, it is disappointing that the meeting was only an informal meeting (meaning its enforcement is perhaps questionable). Following this meeting, ERA agreed that only RO treated water could be irrigated during the wet season but that mixed RO-IWMP water could be irrigated for the subsequent dry season. Other conditions included no visible run-off, stopping irrigation after enough capacity in the IWMP has been reached for the 1-in-10,000 year rainfall (including an appropriate buffer), meeting water quality criteria for Swift Creek downstream and an overall review of water management at Jabiluka starting in February 2002. The available area for irrigation was increased to 6.34 ha. Given the timing of these events, it is likely that the refusal to inspect Jabiluka on October 30 was in part due to this lack of formal clarity for water management criteria.

The approved limits for irrigation, such as flow rate, load and concentrations, were based on a 3-tiered approach for the monitoring of Swift Creek, as discussed and agreed to by stakeholders at the September 21, 2001, Jabiluka MTC meeting. Three separate trigger values were set, based on statitsical analyses of background data : focus, action and limit. An analysis of these trigger values and comparisons to the natural water quality variation within Swift Creek will be presented in Section 7.

Although ERA apparently started combined RO-IWMP water irrigation by the end of October, neither the OSS nor NLC were informed, which subsequently led to the incorrect advice provided to Gundjehmi Aboriginal Corporation by the OSS on October 30, 2001 [19] (cf. OSS, 2001b). Another feature of current operations is the use of 'enhanced evaporation' by spray irrigation on the sides of the IWMP, although it is unclear when this practice began [20]. A chronology of recent water management issues is given in Box 2. Recent aerial photos are shown in Box 3.

[19] - this advice was corrected by OSS on November 14, 2001 (OSS, 2001c).
[20] - see for example OSS (2001c).

Box 2 : Recent Chronology of Water Management at Jabiluka

June 15, 1998	• Start of construction for infrastructure 'common' to the RMA or JMA. Pond designed as an 'Interim Water Management Pond' (3.27 ha).
August 1998	• Excavation work completed for the IWMP.
Sept. 1998	• IWMP liner installed, work on decline commences.
Wet 1998-99	• Wet season rainfall of 1,915 mm.
April 26, 1999	• Mineralised material (≥0.02% U_3O_8) encountered within the decline, stored on specialised pad, not classified as sulfidic rock (<0.5% S). Restricted Release Zone (RRZ) declared, totalling about 8 ha.
Sept. 14, 1999	• Construction of 'Stage I' completed, site enters 'Environmental Management and Standby' phase.
Dec. 14, 1999	• Mineralised stockpile excised from RRZ.
Wet 1999-00	• Wet season rainfall of 1,862 mm, evaporation of 1,936 mm.
March 2000	• ERA, realising that the IWMP would not maintain enough storage for 1-in-10,000 year rainfall in the next 2000-01 wet season, begin a process of identifying options for dry season treatment of IWMP water.
March 29, 2000	• Jabiluka Minsite Technical Committee (informal meeting) considers urgent need for intervention, with ERA pushing for land application though OSS and NLC argue for Reverse Osmosis (RO) treatment.
July 19, 2000	• Jabiluka Minsite Technical Committee (informal meeting) considers lab scale results from RO tests at Ranger. ERA then aaply for RO units at Jabiluka, followed by land application.
Aug. 17, 2000	• RO treatment approved by NT Minister for Mines & Energy, the treated water from the RO plant was to be irrigated within the Jabiluka site.
Aug. 24, 2000	• Irrigations loads and limits amended NT Minister for Mines & Energy. Area of irrigation 3.76 ha.
Aug. 28, 2000	• RO treatment begins followed by irrigation within the Jabiluka site.
Late Oct. 2000	• Second RO unit arrives at Jabiluka, not installed due to delays in some parts arriving.
Late Nov. 2000	• Second RO unit commissioned.
Wet 2000-01	• Wet season rainfall of 1,954 mm, evaporation of 1,980 mm.
Jan. 2001	• Restricted Restricted Release Zone reduced to 4.1 ha, following further modifications to drainage patterns on-site.
Feb. 13, 2001	• Maximum Operating Level (wet season) reached in IWMP (RL 25.23 m), pumping to decline initiated at 11:00, continuing until 14:00 February 15, 2001. Total of 12 ML stored in decline).
March 22, 2001	• Decline storing about 17.7 ML.
Early May 2001	• Dewatering of the decline begins, pumping water back to the IWMP.
June 19, 2001	• Decline emptied of excess water, total pumped about 20 ML (including groundwater inflow)
Sept. 20, 2001	• ERA apply for direct irrigation of IWMP water.
Oct. 1, 2001	• Land application of direct IWMP water considered at an (informal) Jabiluka Minsite Technical Committee, as well as the continued use of RO treatment.
Oct. 11, 2001	• Approval given for enlarged irrigation including IWMP water. Limits set by NTDME without input from the OSS. Area of irrigation increased to 6.34 ha.
Late Oct. 2001	• After an informal Jabiluka MTC, further conditions agreed to, including mixed RO-IWMP water for remainder of 2001 dry season, irrigation of RO water only during 2001-02 wet season and no runoff. A major Best Practice Technology (BPT) review of water management is scheduled for February 2002.
Late Oct. 2001	• ERA begin combined RO-IWMP land application. RO unit expected to fail by mid-December 2001.
Oct. 30, 2001	• Representatives of the Mirrar and environment groups denied access to visit Jabiluka and witness the RO-IWMP water management regime.
Nov. 16, 2001	• Representatives of the Mirrar and environment groups visit Jabiluka and witness the RO-IWMP water management regime.

Box 3 : Recent Aerial Photos of the Jabiluka Site

(courtesy of ERA's website, www.energyres.com.au)

(author, July 2001)

(author, July 2001)

3.4 Water Management – Summary

Water manegement for the Jabiluka project has been based, for more than 20 years, on the principle of 'no-release'. Current approvals continue to enforce this, however, due to unnecessary risks taken by current owner ERA, acute water management problems have developed. Despite the acknowledged seriousness of the water management problems at Jabiluka, ERA is now able to operate the site without *"stringent operational criteria"* [21], providing that there is no direct water release off-site and that the end environmental result dopwnstream in Swift Creek is acceptable to regulators. The Mirrar have had no direct rights or participation in this process. Thus, some impacts on the Jabiluka site – above pre-mining levels – are therefore considered acceptable by ERA, OSS and the NLC, providing there is no impact downstream. The critical concern is that by the time monitoring detects potential impacts downstream in Swift Creek it will be too late. This will be further discussed in Section 7.

4 Water Quantity – IWMP & Groundwater

4.1 Interim Water Management Pond (IWMP)

The 'Interim Water Management Pond' first began receiving water in late 1998, and by November 16 contained about 20,000 litres (0.02 ML), presumably derived from groundwater inflows from the decline and initial wet season rains. A compilation of the water levels and contained volumes within the IWMP for the three wet seasons to date is given in Table 2, including maximum operating levels (MOL) and volumes for the wet and dry seasons. Although not acknowledged elsewhere, the MOL is currently stated by ERA as 25.36 m for a contained volume of 167.0 ML [22].

The first use of IWMP water began in late December 1998 for underground drilling and decline development work (NTS, 1999). There was no further use of IWMP water beyond September 1999, until RO treatment began in mid 2000 followed by combined RO treatment and direct IWMP irrigation in late 2001.

Overall, due to the three heavy wet seasons to date, the capacity of the IWMP has been streteched to its absolute limit, though ERA has managed to avoid overtopping or overflowing of the IWMP. As noted in Section 3.3, the wet season MOL was reached on February 13, 2001, which led to pumping of 12 ML of IWMP water into the decline for temporary storage, as shown in Figure 2.

[21] - emphasis added, minutes of the Jabiluka Minesite Technical Committee, September 21, 2001 (pp 3).
[22] - Fax from Allan K Wade, ERA, November 27, 2001, 1 p.

Table 2 – IWMP Water Levels and Contained Volumes

	Water Level – RL [1]	**Contained Volume**
Dry Season MOL	25.40 m	168.339 ML
Wet Season MOL	25.23 m (25.36 m ? [2])	162.658 ML (167 ML? [2])
IWMP Maximum [3]	25.90 m	185.378 ML

	Minimum – Wet Season				**Maximum – Wet Season**		
Date	RL (m)	Vol. (ML)	%WMOL	Date	RL (m)	Vol. (ML)	%WMOL
Nov. 16, 1998	19.96	0.020	0.012%	April 14, 1999	19.96	83.769	51.5%
Oct. 21, 1999	22.19	67.515	41.5%	April 27, 2000	25.00	154.976	95.3%
Nov. 16, 2000	24.215	129.423	79.6%	Feb. 13, 2001 #	25.23	162.658	100%
				Feb. 15, 2001 D	-	12 ML D	~20% D (4)
Nov. 16, 2001 [2]	23.20	97.5					

– pumping to decline initiated (incl. date pumping finished), pond level not reached again; D – decline.

(1) - RL is 'relative level', and is referenced to sea level at 0 m;
(2) - Fax from Allan K Wade, ERA, November 27, 2001, 1 page;
(3) - level of overflow or overtopping of the walls of the IWMP;
(4) - assuming total capacity of decline at 61 ML; agreed storage capacity below the unconformity is 25 ML.

References : NTS (1999); ERA (2000 & 2001).

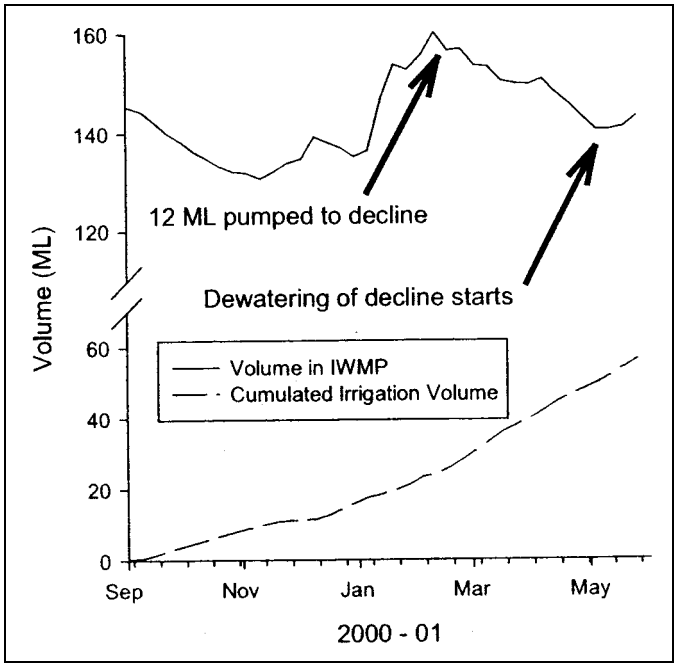


Figure 2 – Water Volume in the IWMP for the 2000-01 Wet Season (OSS, 2001a)

4.2 Groundwater Inflow

The second major source of water at the Jabiluka site is groundwater inflow to the decline. A simplified geological cross-section showing the major sources of groundwater is shown in Figure 4. Although further detailed groundwater studies were a major recommendation from the Minister for the Environment's approval of the Jabiluka Project (the Draft EIS, Supplement and PER) as well as a legal requirement from the Minister for Resources' development approvals [23], the majority of this additional baseline groundwater research has yet to be completed or even initiated [24]. Thus, the understanding of groundwater behaviour, and therefore existing and potential impacts from the Jabiluka project to date, is difficult to estimate accurately.

In general, a simplified interpretation has been adopted whereby groundwater is considered to be derived from two main aquifer systems – shallow and deep. The shallow aquifers include surficial soils, sands and the Kombolgie sandstones, while the deeper aquifers mainly consist of the Cahill Formation fractured rock sequence, which also contains the uranium orebody, though the Kombolgie at depth can also be included as part of the deep aquifer.

Based on recent information, groundwater inflows to the decline have been lower than that predicted for the environmental assessment process, although there have been times during construction of the decline that significant quantities of groundwater were required to be pumped out until an aquifer was pumped dry (eg. NTS, 1999). The average inflows during the wet and dry seasons is about 1.5 and 0.75 litres per second (0.13 and 0.065 ML/day; 32 ML per year in total), respectively (NLC, 2001c).

Although these flow rates are not large *per se* for an underground decline of the size of Jabiluka, it does illustrate some degree of response to infiltration of rainfall with higher inflows in the wet season compared to the dry season. This could be related to old exploration bores (many of which have been recently capped by ERA), disturbance from blasting and excavation works during decline construction or existing connections between the deep and shallow aquifers. The annual environmental reports by ERA (NTS, 1999; ERA, 2000 & 2001) do not adequately address physical factors controlling groundwater flows around the decline area and therefore the respective contaminant loads from the shallow and deep aquifers. Thus a high degree of caution is still required in interpreting groundwater data for the decline.

[23] - see EA, 1997 & 1998.
[24] - NLC at Gundjehmi Governing Committee, March 27, 2001.

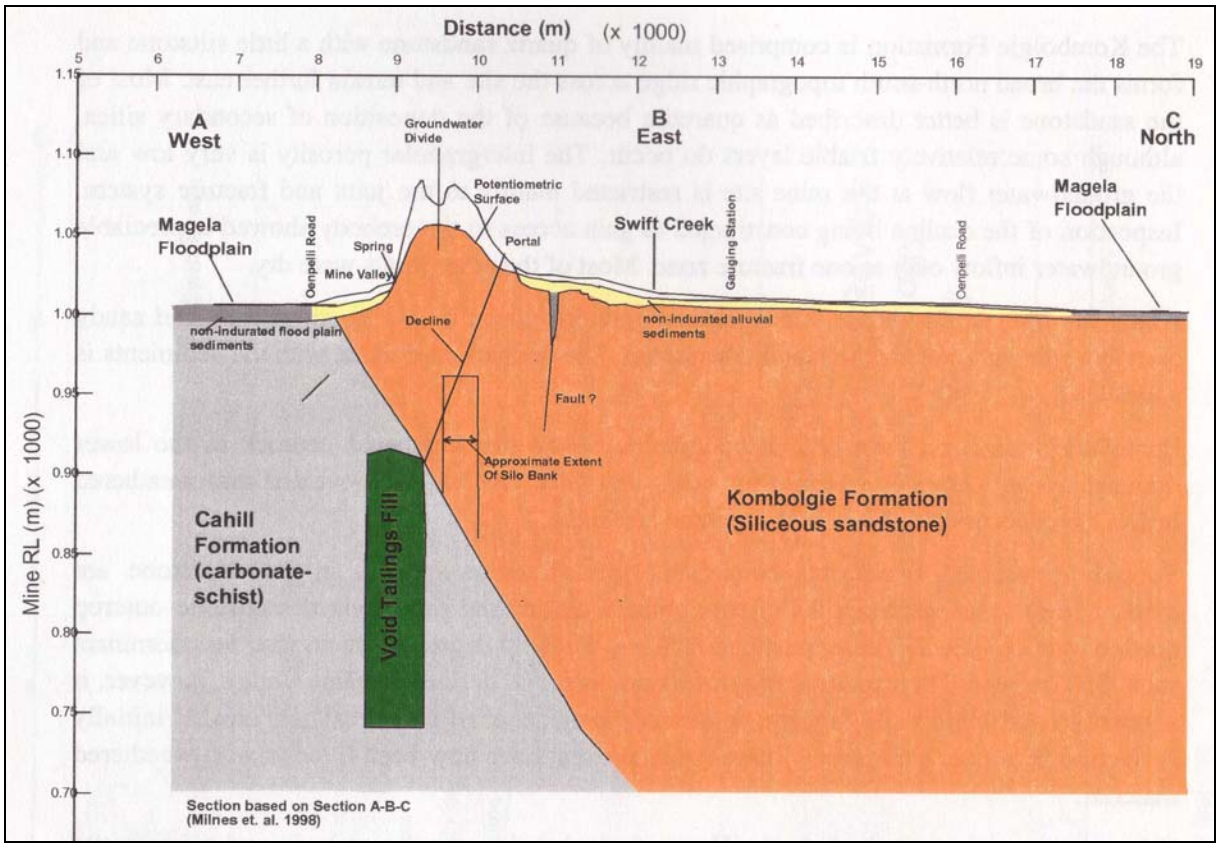


Figure 4 – Geological Cross-Section for Groundwater Sources
(from Kalf & Dudgeon, 1999)

5 Water Quality – IWMP, Groundwater and Mineralised Stockpile

One of the most critical issues in water management at Jabiluka is the quality of the water stored within the Interim Water Management Pond. There are three major sources of solutes entering the IWMP :

- surface runoff (derived from rainfall and its interaction with surface sediments);
- decline (especially groundwater inflows from the deep aquifer hosting the orebody);
- seepage from the mineralised stockpile (slightly sulfidic, low grade uranium ore).

Due to the nature of the Jabiluka site at present, the water quality in the IWMP is generally of a low salinity but it does contain very high uranium concentrations. The quantity of water in the IWMP is chiefly derived from rainfall and surface runoff, while the uranium and solute loads are largely derived from the inflow of groundwater to the decline (a minor portion of solutes also derive from the mineralised stockpile). A compilation of the water quality of the IWMP is shown in Table 3, with a graph in Figure 5. The water quality of groundwater inflow to the decline and seepage from the mineralised stockpile is presented in Table 4.

From the various tables and graphs, the major events in the history of Jabiluka to date can be discerned. For example, the intersection of mineralised material in April 1999 led to a very significant increase in uranium concentrations in the IWMP, with another major increase in June 2001 following the pumping out of the water stored in the decline from earlier in the year.

Overall, the monitoring does seem to be adequately covering the main contaminants present and potentially present in site waters due to operations. There remains, however, some points of concern about the water quality data, as presented by ERA, NTDME and OSS in their respective reports (eg. NTS, 1999; ERA, 2000 & 2001; OSS, 2001a & c; NTSA, various) :

- the mineralised stockpile contains 47,000 t of low grade uranium ore (and low sulfur grades) – this will remain a pollution source as long as it is above ground. Importantly, the stockpile is already being noted as a source of acidic drainage (eg. NLC, 2001d);
- based on single samples each year collected in April and analysed in detail (ERA, 2000 & 2001 [25]), heavy metal concentrations in the IWMP appear low (except U);
- most contaminants are in a dissolved form;
- salinity has steadily increased due to reverse osmosis treatment [26], continuing inputs of solutes and evaporation, though not dramatically;
- radium (^{226}Ra) is only analysed quarterly but shows significant activities (up to 1,000 mBq/L) and is often late in being reported – as a major component of radioactive risk, it should be routinely monitored in IWMP and other waters (preferrably fortnightly);
- radon (^{222}Rn) does not appear to be analysed at all – since radon is often present in groundwater from uranium orebodies in much higher activities than its parent radium, real data is needed to substantiate low radon levels;
- quality control issues are not sufficiently highlighted and investigated (eg. uranium in sediments [27]). This prevents full confidence in the monitoring data presented by ERA;
- if RO treatment is continued, this will lead to higher salinity and uranium concentrations over time but the rate of this increase is difficult to predict

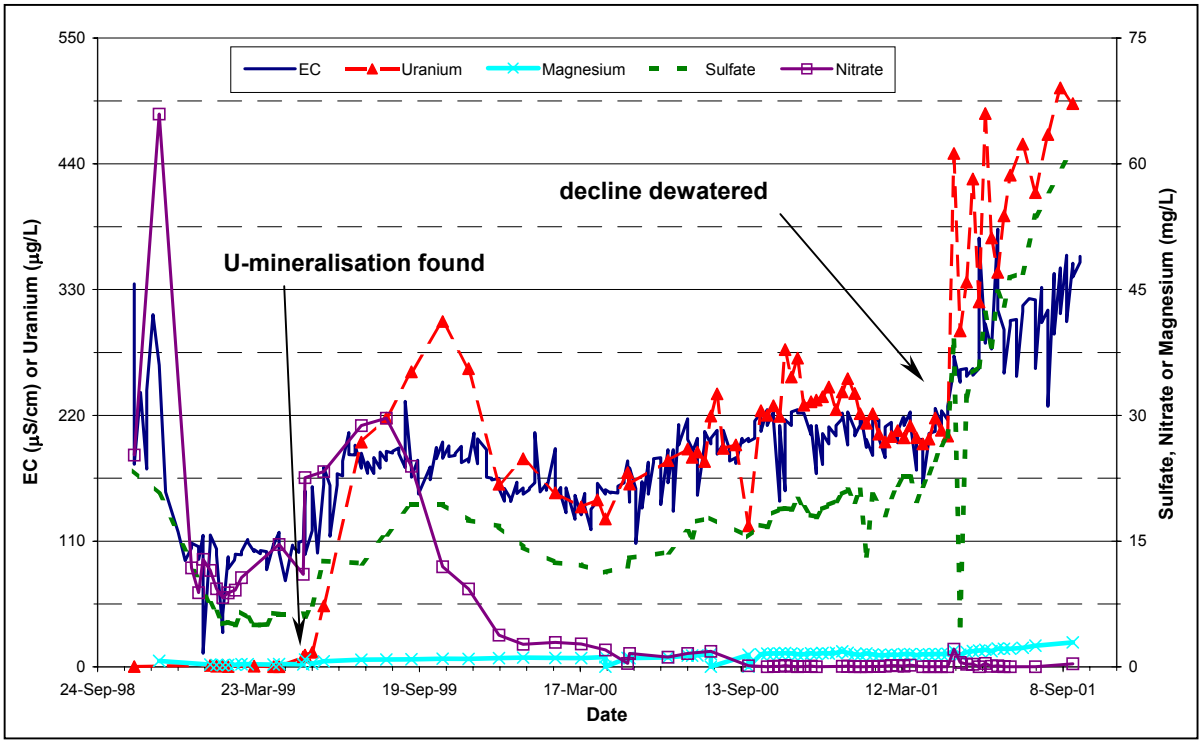


Figure 5 – IWMP Water Quality Over Time

[25] - no full analyses of heavy metals in IWMP water appears in the 1999 report (NTS, 1999).
[26] - reverse osmosis produces a high quality treated water output as well as a degraded, more saline output (or brine) which is discharged back to the IWMP.
[27] - pp 27-28, ERA (2001) and pp 28, ERA (2000), for significant differences between tested and expected uranium concentrations from analytical standard samples.

Table 3 – IWMP Water Quality Over Time

10th Percentile - Mean - 90th Percentile

	pH	**EC** (μS/cm)	**SS** (mg/L)	**Turb.** (NTU)
May 1998 – April 1999 (1)	5.7 - 8.5 - 9.7	70 - 115 - 335	38 - 102 - 235	1.1 - 119 - 546
1999 Dry	8.8 - 9.2 - 9.7	100 - 170 - 190	NA	NA
May 1999 – April 2000	8.5 - 9.0 - 9.5	140 - 160 - 190	3 - 19 - 46	3 - 14 - 34
2000 Dry	8.8 - 9.2 - 9.5	150 - 180 - 200	NA	NA
May 2000 – April 2001	8.3 - 8.6 - 9.0	180 - 200 - 220	3 - 10 - 11	2 - 4 - 5
2001 Dry	7.7 - 8.4 - 8.7	210 - 290 - 350	NA	NA

EC – Electrical Conductivity; SS – Suspended Solids; Turb. - Turbidity.

	Ca (mg/L)	**Mg** (mg/L)	**SO_4** (mg/L)	**NO_3** (mg/L)
May 1998 – April 1999 (1)	NA	1.6 - 1.9 - 3.3	5.0 - 5.6 - 19	8.8 – 16 - 25 (2)
1999 Dry	NA	2.3 - 5.0 - 6.6	12 - 16 - 18	12 - 23 - 29
May 1999 – April 2000	12 - 15 - 17	5.3 - 6.8 - 8.0	8.2 - 14 - 19	2.7 - 3.4 – 11
2000 Dry	NA	0.12 - 8.4 - 10	12 - 15 - 17	0.30 - 1.6 – 1.9
May 2000 – April 2001	19 - 20 - 22	10 - 11 - 12	16 - 19 - 23	<0.023 - 0.063 - 0.15
2001 Dry	NA	11 - 14 - 17	23 - 37 - 49	<0.023 - <0.023 - 0.46

	Cu (μg/L)	**Mn** (μg/L)	**Pb** (μg/L)	**U** (μg/L)	**^{226}Ra** (mBq/L)
May 1998 – April 1999 (1)	<2 - <2 - 2	<1.0 - 2.3 - 5.1	0.17 - 0.22 - 0.28	<0.1 - 0.4 - 1.6	16 - 17 - 18
1999 Dry	<2 - <2 -2	<1.0 - 1.1 – 5	0.14 - <1.0 - 1.0	0.21 - 13 - 226	38 - 192 (3)
May 1999 – April 2000	0.69 - 0.98 - 1.9	<1 - <1 - 2.4	0.035 - 0.095 - 0.16	29 - 170 - 280	68 - 82 (3)
2000 Dry	0.81 - 1.5 - 1.9	<1 - 0.80 - 2.9	<0.05 - <0.05 - 0.14	130 - 180 - 212	175 (3)
May 2000 – April 2001	1.8 - 3.6 - 4.8	0.40 - 1.3 - 3.2	<0.05 - <0.05 - 0.16	190 - 220 - 240	<2 - 9 - 248 (3)
2001 Dry	2.3 - 6.7 - 11	0.44 - 0.9 - 5.4	<0.05 - 0.08 - 0.16	200 - 385 - 485	190 (3)

(all μg/L)	**Al**	**Fe**	**Cu**	**Mn**	**Pb**	**Zn**	**U**	**^{226}Ra** #
Feb. 2000	865	320	4.0	9.5	0.5	13.5	206	900
Oct. 18, 2000	-	-	-	-	-	-	-	250 a
Dec. 5, 2000	-	-	-	-	-	-	-	240 b
April 17, 2001	-	-	-	-	-	-	-	190 c
April 20, 2001	-	-	-	-	-	-	-	193 d
Sep. 18, 2001	-	-	-	-	-	-	490 e	-

– units mBq/L; a – residue 13 mBq/L; b – residue 88 mBq/L; c – residue 19 mBq/L; d – residue 19 mBq/L; e – residue 1 μg/L.

Note : dissolved concentrations unless specified; (1) – median not mean. NA – not available; (2) –maximum NO_3 was 66 mg/L; (3) – insufficient number of analyses for statistical analyses.

References : NTS (1999); ERA (2000 & 2001); NTSA (various); NLC (2000a & b, 2001a to e).

Table 4 - Water Quality in the Jabiluka Decline and Mineralised Stockpile
(ERA, 2001)

Decline	%10TH	Mean	%90TH
pH	8.0	8.4	9.0
EC (μS/cm)	280	360	530
SO_4 (mg/L)	26	47	75
NO_3 (mg/L)	0.59	2.7	4.2
Mg (mg/L)	18	26	30
U (μg/L)	360	800	1,400

Stockpile	Min.	Mean	Max.
pH	3.5	3.8	4.5
EC (μS/cm)	5,100	6,400	7,200
SO_4 (mg/L)	530	800	1,400
NO_3 (mg/L)	950	2,500	4,100
Mg (mg/L)	380	450	510
U (μg/L)	4.0	6.3	9.0

6 Performance of the Reverse Osmosis Units at Jabiluka

As noted previously, the Reverse Osmosis water treatment plants that have been installed and operated at Jabiluka have been far less than satisfactory, mainly from a volume and commercial basis. There has been some periods where the regulatory criteria for water quality have failed to be met, with the water subsequently pumped back into the IWMP. For example, during the 2001 dry season, the electrical conductivity (or EC, a measure of salinity) of RO output was satisfactory with calcium and uranium "occassionally exceeding instantaneous targets" (pp 71, NTSA, 2001b). A compilation of RO performance is presented in Tables 5 and 6 and Figure 6.

According to NTSA (2001b), 48 ML was irrigated from RO treated water in the six months to the end of September 2001. The quantity of uranium was 0.156 kg (pp 71), giving an average uranium concentration in the irrigated water of 3.25 μg/L. This represented some 70% of the authorised load limits (ie. the load limit must be about 0.225 kg for the 3.76 ha area under irrigation). Other metals in RO output were less than 10% of their authorised irrigation load limits. Based on single samples from each RO unit in April 2001 and presented in Table 32 of ERA (2001), the concentration of most heavy metals in RO output appears to be low. The actual water quality limits set by the regulators (NT Department of Mines & Energy, NTDME) for operation of the RO units from August 2000 till October 2001 have still not been released.

As discussed earlier, ERA began irrigation of mixed RO-IWMP water from late October 2001. The maximum daily volume of mixed RO-IWMP water allowed to be irrigated is 0.6 ML, which equates to 9.5 mm per day. The basis for this appears to be irrigation rates at Ranger, which are of a similar daily quantity. Based on analyses of daily evaporation versus infiltration rates at Ranger (eg. Akber *et al.*, 1991) and, it can be expected that the majority of irrigated water will infiltrate the soils at Jabiluka. Given the lower salinity of IWMP water, however, this is not likely to lead to significant salt impacts, as the case has been at Ranger's land application areas, where salts have migrated to the banks of the Magela Creek (see Mudd, 2001).

The initial load and concentration limits were derived and approved through the NTDME without input from the OSS, and are shown in Table 7. These limits were further refined by the JMTC in late October, with the main changes being that the use of RO water only was clarified for the 2001-02 wet season and criteria to determine when the wet season 'proper' is considered to have started [28]. This was mainly to minimise the risk of irrigated water becoming runoff and entering Swift Creek.

[28] - eg. wet season has started when 24 hours of continuous rainfall or 7 consecutive days of rainfall occurs.

Table 5 – Reverse Osmosis Treated Water Quality : May 2000 – April 2001

(based on Jabiluka water quality database in ERA, 2001)

	Min.	Mean	Max.
pH	5.27	6.21	8.74
EC (μS/cm)	2	11.25	42
Ca (mg/L)	<0.1	0.51	1.3
Mg (mg/L)	<0.1	0.36	0.8
Cl (mg/L)	0.1	0.32	1.9
SO_4 (mg/L)	<0.1	0.66	1.8
NO_3 (mg/L)	<0.022	0.19	0.99

	Min.	Mean	Max.
Al (μg/L)	<0.1	1.74	8.0
Cu (μg/L)	<0.05	1.45	5.84
Fe (μg/L)	<20	<20	20
Mn (μg/L)	0.05	0.26	2.51
Pb (μg/L)	<0.05	0.34	0.77
^{226}Ra (mBq/L)	<2 #	<2 #	17 #
U (μg/L)	0.15	2.60	10.87
Zn (μg/L)	<0.5	4.69	21.4

Note : mean excludes values below detection. # - only four samples analysed for ^{226}Ra, three were <2 mBq/L.

Table 6 – Performance Over Time of the RO Units and Irrigated Volumes

Period	Daily RO Volume Treated	Total RO Volume	Irrigated IWMP	Total Area
August 28 to Sept. 30, 2000	up to 0.150 ML/day	3.9 ML	0	3.27 ha
Nov. 22 to Dec. 4, 2000	0 (breakdown)	0	0	3.27 ha
January 2001	~0.199 ML/day		0	3.27 ha
February 2001	~0.262 ML/day		0	3.27 ha
Oct. 1, 2000 to March 31, 2001	up to 0.377 ML/day (average 0.2 ML/day)	36 ML	0	3.27 ha
April 1 to September 30, 2001	up to 0.330 ML/day	48 ML	0	3.27 ha
Early October 2001	~0.22 ML/day		0	3.27 ha
October 2001	0.20 to 0.25 ML/day		??	6.34 ha
Late October to November 12, 2001		3.2 ML	0.3 ML	6.34 ha
November 16, 2001	~0.05 ML/day	0.05 ML	~0.15 ML	6.34 ha
November 2001 - planned #		1.5 ML	6 ML	6.34 ha
December 2001 - planned #		1.5 ML	9 ML	6.34 ha
	Total (to end 2001)	~94 ML	~16.5 ML	

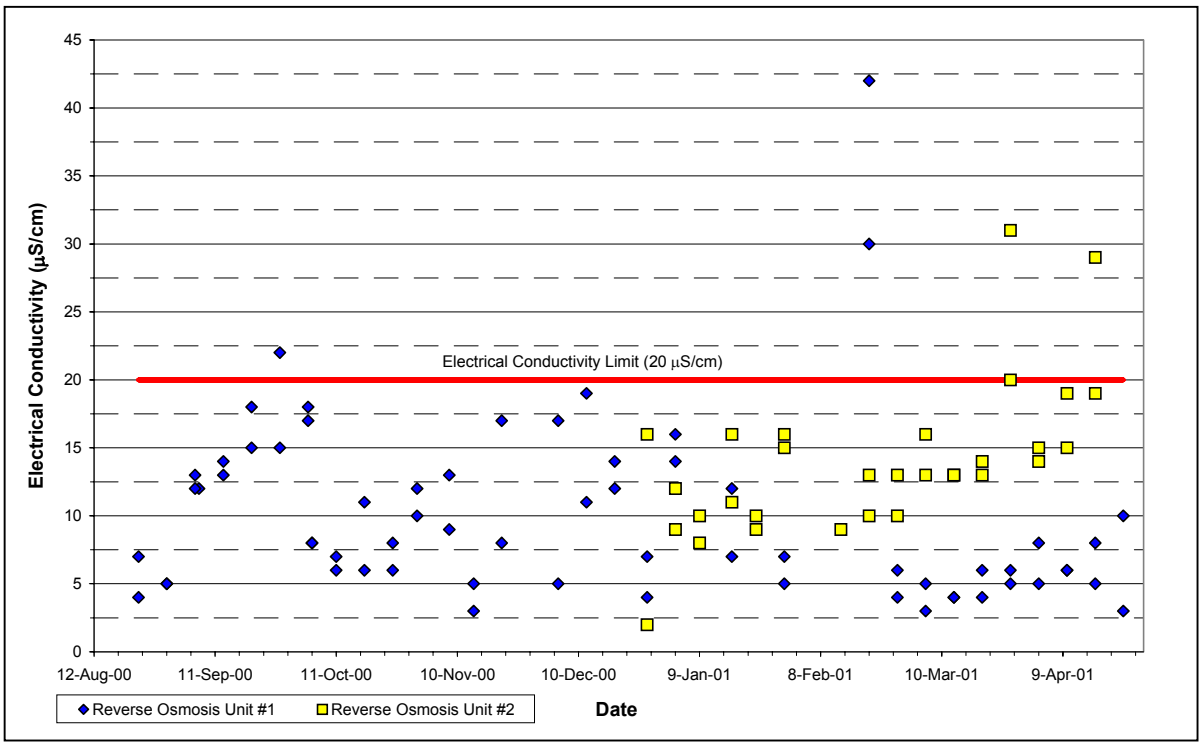
- over 15 days each period, assuming RO output of 0.05 ML/day.

References : NTSA (various); OSS (2001a & 2001c), ERA (2001).

Table 7 – Regulatory Limits for Irrigation From Late October 2001 [29]

	EC	Mg	SO_4	U
Maximum Concentrations	600 μS/cm	40 mg/L	80 mg/L	1,000 μg/L
Maximum Monthly Loads	-	700 kg	1,400 kg	40 kg
Maximum Yearly Loads	-	4,200 kg	8,400 kg	240 kg
IWMP (Sept. 2001)	360 μS/cm		60 mg/L	500 μg/L

[29] - Letter from Minister for Resources Development, Hon. Paul Henderson MLA, to R Weston (ERA), Oct. 11, 2001, 2 p.



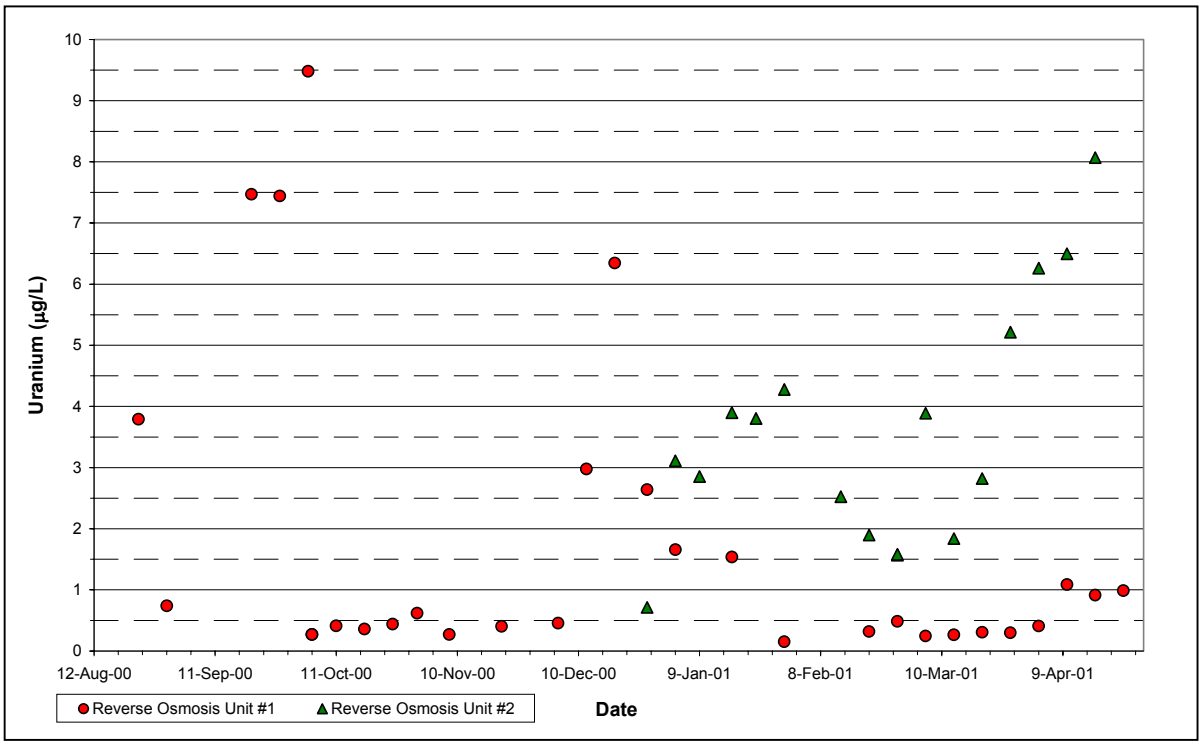


Figure 6 - Trends of Electrical Conductivity and Uranium in RO Treated Water
(data adpated from ERA, 2001)

A map of the enlarged irrigation areas (now 6.34 ha) within the Jabiluka site area is shown in Figure 7, including the 8 points for visual monitoring of runoff [30]. A number of points need to be made concerning irrigation areas :

- there is no future room for expansion if current loads are found to be excessive and irrigation loads need to be diluted;
- the basis for suitability of irrigation has been its extensive use at Ranger, which has been irrigating contaminated Retention Pond 2 (RP2) water on an area adjacent to the Ranger mill (also adjacent to Magela Creek) since 1985 – there have been no studies conducted on the contaminant retention characteristics of Jabiluka's sandier soils (which would likely have a lower ability to retain uranium), as well as potential rates of infiltration;
- the previous irrigation of RO-treated water should have been investigated for the U-retention capabilities to provide a more scientific basis for the current, increased loadings now approved;
- the uranium loadings, initially about 0.06 kg per hectare from RO treated water, have now been increased to 37.9 kg/ha – compared to average annual uranium loadings at Ranger of about 11.3 kg/ha, with the cumulative to date about 169 kg/ha [31] (a total of 6,722 kg over 53 ha).

The average uranium concentration in the earth's crust is about 2.7 parts per million (ppm or mg/kg) (eg. Langmuir, 1997; Mudd, 2001). The soils in the vicinity of the Jabiluka site are generally well below this value, varying from <0.10 to 0.5 mg/kg (eg. Kinhill, 1998; Hollingsworth *et al.*, 1998; NTS, 1999; ERA, 2000 & 2001). It is rare for soils to exceed 20 mg/kg uranium in the region [32], with most generally less than 5 mg/kg (see Mudd, 2001). According to Hollingsworth *et al.* (1998), the average uranium concentration around the Jabiluka site is 0.2 mg/kg (Appendix 2).

It is often claimed that irrigation is environmentally acceptable since the uranium (and radium-226) are retained or 'sorbed' onto the upper 5 cm of soil (eg. Akber *et al.*, 1991) and this will not lead to uranium concentrations which are significantly above background. No data is presented publicly by ERA, such as iron, clay or organic content in Jabiluka soils, to substantiate claims that such behaviour could be reasonably expected at Jabiluka.

Based on these claims, it is possible to calculate the increase in uranium concentrations expected from the high uranium loading rates approved at Jabiluka, assuming some average properties for a sandy soil :

- dry density of 1,800 kg/m^3 (porosity about 0.32)
- soil thickness of 5 cm (or 0.05 m)
- irrigation area 6.34 ha (or 63,400 m^2)

  $\Rightarrow$ gives mass of dry soil of 1,800 x 0.05 x 63,400 = 5,706,000 kg (or 5,706 t)

- based on 240 kg U :

  $\Rightarrow$ gives increase in concentration as 240,000,000 / 5,706,000 = 42 mg/kg

[30] - adapted from irrigation map supplied by ERA to NLC and Gundjehmi, November 27, 2001.
[31] - based on preliminary data in Mudd, G M, 2001, Ranger Research Report, due for release in early 2002.
[32] - upstream in Swift Creek often has uranium between 2.5 and 16 mg/kg (see above references).

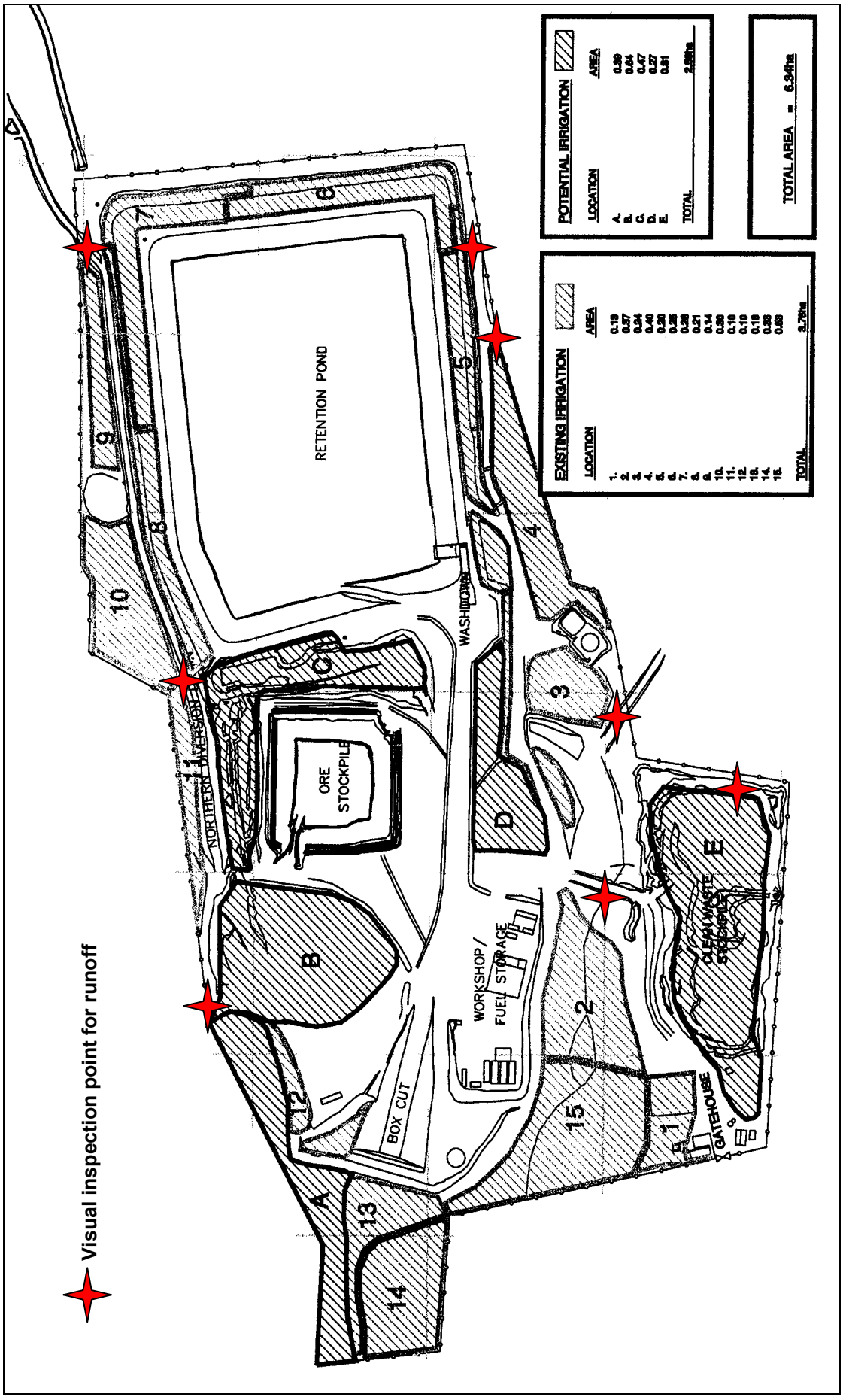


Figure 7 – Location of Irrigation Areas and Visual Monitoring Points for Runoff

If one assumes that all of the IWMP water (about 168.339 ML) is to be irrigated at the maximum uranium concentration (1,000 μg/L), this equates to some 168.339 kg U over the 6.34 ha or 26.6 kg/ha. Alternatively, if one assumes the 240 kg U limit, then this allows the uranium concentration to reach 1,425 μg/L (assuming the entire IWMP is to be irrigated). As noted for Ranger's land application, the uranium loadings are cumulative, with the annual average and cumulative uranium loadings being about 11.3 and 169 kg/ha, respectively. These figures can be compared with some realistic estimates for Jabiluka.

The maximum daily application rate is 0.6 ML, equivalent to 9.5 mm per day (which does not appear to be based on evaporation or infiltration rates of Jabiluka soil). This flow rate also allows the entire IWMP to be irrigated in one year – 168.4 ML in 365 days. If it is assumed that current IWMP water is irrigated at the approved rate, this gives rise to 0.6 kg per day, 219 kg in a full year or 34.5 kg/ha (remembering that irrigation of direct IWMP water will not be taking place during the wet season 'proper', and this figure is therefore likely to be less over a year).

Assuming the current uranium concentration in the IWMP (~500 μg/L) and only eight months irrigation (dry season), this gives an annual figure of 73 kg uranium irrigated or 11.5 kg/ha. The increase in uranium concentrations in Jabiluka site soils can be estimated as 12.8 mg/kg. Compared to natural uranium concentrations of 0.2 mg/kg, this represents a 64-fold increase compared to pre-mining conditions. For 0.4 ML per day of IWMP water over eight months, this gives a load of 49 kg of uranium and a concentration increase of 8.5 mg/kg (43-fold increase). If only RO water is irrigated (using the original 3.76 ha), this would represent an increase of just 0.05 mg/kg, or well within the range of natural concentrations on the Jabiluka site. A compilation of the various load estimates, including those for Mg and SO_4, is presented in Table 8. The quality of irrigated RP2 water from Ranger is also shown.

Table 8 – Estimates of Annual Mg, SO_4 and U Loads in Irrigation at Jabiluka

	Mg			**SO_4**			**U**		
	mg/L	kg	kg/ha	mg/L	kg	kg/ha	μg/L	kg	kg/ha
Approved Limits	40	4,200	662	80	8,400	1,325	1,000	240	37.8
Current IWMP [(1)]	21	3,066	484	62	9,052	1,428	~500	73	11.5
Current IWMP [(2)]	21	1,533	242	62	4,526	714	~500	36.5	5.8
Typical RO	0.36	-	-	0.66	-	-	2.6	-	-
Ranger RP2 [(3)]	88	133 t	2,515	437	2,315 t	43,680	1,500	6,722	169

[(1)] – based on 8 months irrigation at 0.6 ML per day (or 146 ML per year), concentration data from NTSA (2001b) (based on electronic data provided by Gretel Parker, NTDME);
[(2)] – based on 8 months irrigation at 0.3 ML per day (or 73 ML per year), concentration data from NTSA (2001b);
[(3)] – average concentrations and cumulative loads to date (15 years) over 53 ha (Mudd, 2001).

The above estimates are somewhat speculative without access to actual irrigation data, that is – the water quality and respective quantities of RO and IWMP waters. Depending on the extent of RO treatment during late 2001, the actual increase in uranium in Jabiluka soils could be lower, but if higher proportions of IWMP water are used (which is considered likely), then the increase may be even higher than 64-fold. It is clear that current irrigation practices and approvals allow for significant increases in uranium concentrations in soils far in excess of pre-mining concentrations.

The irrigation concentration and load limits therefore appear designed to ensure that irrigation at Jabiluka can proceed without "stringent operational criteria" since the current loads and concentrations of Mg, SO_4 and U are such that the IWMP should not reach values approaching the load and concentration limits. However, given recent increases in contaminant concentrations, this may not hold true if several years are allowed to pass and both ERA and NT regulators would be forced to reconsider load limits accordingly.

7 Water Quality Issues for Swift Creek

As alluded to earlier in Section 3.3, the three trigger levels or water quality criteria that ERA are required to meet downstream in Swift Creek were based on statistical analyses of background concentrations. The methodology was based on the recently released National Water Quality Management Strategy guidelines [33], which allow for site-specific data to be set based on local toxicity data and statistical analysis techniques (ANZECC & ARMCANZ, 2000). During the site visit on November 16, 2001, ERA and OSS were claiming that this is probably the first application of the new guidelines in Australia, or at the very least for the mining industry. However, the suitability of the derived values for Jabiluka do require comparison to the new recommended guideline values, plus the typical background values in Swift Creek, as compiled in Table 9.

Table 9 – Trigger Levels for Water Quality Criteria in Swift Creek

	Focus	Action	Limit	NWMQS	Swift Creek (1)	
					Upstream	Downstream
EC (µS/cm)	15	18	21	20 – 250 (2)	9 – 17	7.4 – 17
pH	4.61 – 5.31	4.27 – 5.65	3.92 – 6.00	6.0 – 8.0 (3)	4.5 – 6.4	5.2 – 6.0
Mg (mg/L)	0.37	0.50	0.76	no data	<0.1 – 0.56	<0.1 – 0.65
NO_3 (mg/L)	0.30	0.63	1.26	0.005 (3)	<0.022 – 0.034	<0.022 – 0.05 (4)
SO_4 (mg/L)	0.60	0.91	1.50	no data	<0.1 – 0.60	<0.1 – 0.74
U (µg/L)	0.02	0.03	5.8	0.5 (5)	<0.005 – 0.015	<0.005 – 0.017

Notes :
- Focus – mean plus 1 standard deviation (80th percentile) [34];
- Action – mean plus 2 standard deviations (95th percentile);
- Focus – mean plus 3 standard deviations (99.7th percentile) or the 'No Observable Effect Concentration' (NOEC) [35].

(1) – based on 10TH and 90TH percentiles in NTSA (2001b) (based on NTS, 1999; ERA, 2000 & 2001);
(2) – recommended values for 'slightly disturbed' NT tropical upland and lowland rivers;
(3) – recommended values for 'slightly disturbed' NT tropical wetlands, freshwater lakes and reservoirs, and lowland rivers (though pH is clearly not applicable to Swift Creek);
(4) – some potential impacts from blast residues (high in nitrate) leaching from non-mineralised waste rock (values over 0.35 mg/L were observed);
(5) – considered a 'low reliability' toxicity-based guideline.

References : ANZECC & ARMCANZ (2000); NTSA (2001b); OSS (2001c).

[33] - developed by the Australian & New Zealand Environment & Conservation Council (ANZECC) and the Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ). (see www.ea.gov.au/water/quality/nwqms/) [ERISS/OSS had significant input into these guidelines.]
[34] - a standard deviation and percentile are measures of the statistical variation in a data set.
[35] - when no toxic effects are observed in biological tests on various organisms at this concentration.

As can be seen, the natural water quality of Swift Creek is quite pure and of very high quality with low salinity (such as Mg and SO_4) and extremely low uranium [36]. Compared to the new NWQMS guidelines, the trigger values are generally low and reasonable from a ecotoxicity or environmental risk – except uranium. The 'limit' of 5.8 μg/L is some 12 times higher than the NWQMS value, although the data used to derive this figure is considered of low reliability. This also compares to the proposed World Health Orgtanisation guideline of 2 μg/L, the USA and Canadian guidelines of 20 μg/L [37]. Based on these figures, the limit value of 5.8 μg/L is therefore in the lower range of global guideline values, but is still about 580 times higher than the typical median values in Swift Creek of 0.01 μg/L (see NTSA, 2001b).

The 5.8 μg/L limit for uranium allows significantly increased loads to be discharged through the Swift Creek before ERA could be considered to have potentially breached the Environmental Requirements for the Jabiluka project. It is perhaps academic whether or not the concentrations are sufficient to induce toxic responses in various organisms, as this represents a demonstrable environmental impact if it is indeed reached. If this value is reached, there would be serious risk of further increases, since it would suggest the failure of irrigation and uranium being retained by soils, as well as other management regimes at the Jabiluka site.

For NO_3, the amount of non-mineralised rock on the surface exposed to weathering and leaching has not increased since late 1999. This should see a decrease in the NO_3 being leached into the tributaries of Swift Creek over time, as can be seen in the North Tributary over the past three wet seasons (which was mainly impacted by NO_3 in the 1998-99 wet season). The Central Tributary, on the other hand, experienced an increase in NO_3 in the 1999-2000 and 2000-01 wet seasons, indicating a slower leaching due to flow through the stockpile attenuating diretc discharge into the creeks. Over time NO_3 would be expected to return to background levels, however, the trigger levels for NO_3 do allow for substantial increases (which would likely require further mining and placing of waste rock on the surface). As a major component of nutrients in aquatic ecosystems, sustained increases in NO_3 are of concern.

The basis for trigger values for Swift Creek for EC, pH, Mg and SO_4, as variation from background, should not see noticeable effects in the aquatic ecosystems. The main concern is that such increases could point to failure of management regimes at Jabiluka and the potential for increases in uranium associated with such failures. Given that experience at Ranger shows that Mg and SO_4 in irrigated RP2 water is not retained by soils (and has been shown to migrate to Magela Creek), the irrigation of IWMP water at Jabiluka is likely to lead to an increase in Mg and SO_4 in Swift Creek, though small in magnitude. Prolonged irrigation of IWMP could lead to the trigger levels being approached, though how many wet seasons this might take is unclear and speculative.

[36] - such low concentrations of uranium have only become analytically detectable in recent times.
[37] - see www.antenna.nl/wise/uranium/utox.html

In summary, the trigger values set for downstream water quality in Swift Creek are mostly conservative and should not see significant environmental effects arise, however the values for nitrate and uranium do allow substantial increases over background concentrations. A further concern is that by the time monitoring detects these impacts in Swift Creek, a significant quantity of contaminants would already have been leached or flushed from the Jabiluka site and therefore not amenable to remediation through management changes at Jabiluka. Assuming that appropriate changes are made promptly on-site, this would mean that over the next few wet seasons, this load of contaminants would be flushed through the system, leading to slow decreases in concentrations in Swift Creek [38].

8 Summary and Recommendations

Water management at proposed and operating uranium mines in the Alligator Rivers Region has always been a contentious indigenous, public and scientific issue. The various regimes approved for water management have always been on the basis of 'no-release' of contaminated mine site waters. When current owner of the Jabiluka site, Energy Resources of Australia Ltd, began construction – against the wishes of the traditional owners – they clearly took the risk of building staged facilities that support the Ranger Mill Alternative (RMA) (trucking Jabiluka ore to Ranger for processing). The subsequent veto over this proposal has seen Jabiluka stalled and the small 'Interim Water Management Pond' (IWMP) being forced to operate as a medium-term solution, contrary to its design and function. The IWMP has now been through 3 heavy wet seasons and is now preparing for its fourth.

From mid-2000 to late 2001, emergency action saw two Reverse Osmosis (RO) water treatment units installed but they have failed to meet performance expectations (mainly on a volume basis, although some water quality targets, such as EC, were being occassionally exceeded).

In late 2001 ERA sought and received approval for direct irrigation of IWMP water, with loads which will significantly increase the uranium concentrations around the Jabiluka site. The loads approved for magnesium and sulfate are already close to beign exceeded, though they are still much lower than those used in irrigation at Ranger.

The trigger levels for water quality downstream in Swift Creek should not lead to any significant environmental effects, although the maximum 'limit' value does allow substantive increases in uranium and nitrate. If the highest trigger limits are exceeded, it is likely that it will take a period of time to recover typical background concentrations.

There are still several unknowns in quantifying the medium- to long-term effects, as this would depend on the actual quantity and quality of RO and IWMP waters irrigated by the end of 2001, the nature of the 2001-02 wet season and the contribution from the decline.

[38] - eg. uranium contamination in RP1 at Ranger, once occurred, has taken three wet seasons to flush through, despite active changes in the catchment for uranium sources (low grade ore). After the third wet season, the uranium concentrations are still above those prior to the start of the contamination.

A detailed review of water management is scheduled to begin in February 2002, which should lead to consideration of future options at Jabiluka. There are two clear options shown by this to be preferrable – continued use of active water treatment (such as RO or a functionally equivalent technology like ion exchange columns) and action to reduce inflow from the decline (the major source of uranium contamination).

In the short-term, RO treatment capacity (or equivalent) needs to be maintained on-site at Jabiluka to minimise the increasing spread of contaminants through irrigation and help to manage the water balance and quality within the IWMP. However, it is clear that the use and need for such options would be negated if the principal source of uranium – decline inflow – was rehabilitated in a fashion which stops the need for dewatering. This would involve the placement of most of the mineralised stockpile back into the decline with appropriate lining or sealing. The major difficulties or uncertainties in this approach relate to the small quantity of mineralised material which would not fit into the decline plus the poorly understood groundwater behaviour in this region. Further work is needed to more clearly refine understanding of these uncertainties.

Water management at Jabiluka has clearly not been systematically planned, and is now regularly disposing of excess contaminated water outside of the 'Restricted Release Zone' (though this is still within the current footprint of the site). If the past four years is a guide to the future directions of ERA's management of the site, the current difficulties are not likely to be overcome to the satisfaction of the traditional owners.

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10 Chronology of Jabiluka Minesite Technical Committee Meetings

• May 6, 1998 • May 19, 1998 • June 17, 1998 • August 26, 1998 • October 8, 1998 • November 24, 1998	• January 20, 1999 • March 3, 1999 • May 21, 1999 • September 10, 1999 • November 3, 1999	• Febuary 3, 2000 • March 19, 2000 # • July 19, 2000 #
		• January 23, 2001 • September 7, 2001 • September 21, 2001 • October 1, 2001 # • October (late), 2001 #

- informal meeting only.

11 Common Acronyms & Units

EIS	Environmental Impact Statement
ERA	Energy Resources of Australia Ltd
ERISS	Environmental Research Institute of the Supervising Scientist
IWMP	Interim Water Management Pond
JMA	Jabiluka Mill Alternative
MOL	Maximum Operating Level
MTC	Minesite Technical Committee
NLC	Northern Land Council
NTDME	Northern Territory Department of Mines and Energy
NTS	North Technical Services (division of North Ltd)
NTSA	Northern Territory Supervising Authorities (part of NTDME)
OSS	Office of the Supervising Scientist
RMA	Ranger Mill Alternative
RO	Reverse Osmosis
RRZ	Restricted Release Zone
TCZ	Total Containment Zone

12 Abbreviations for Elements, Chemical Units & Measurements

EC	Electrical Conductivity (measured in 'μS/cm')
g	gram (1 kg = 10^3 or 1,000 g)
ha	hectares (100x100 metres, or 10,000 m^2)
L	litre (mass of 1 kg)
mg/L	milligrams per litre (or parts per million, ppm)
ML	mega litre (1,000,000 litres or 10^6 L)
mm	millimetres (10^{-3} metres)
SS	Suspended Solids (measured in 'mg/L')
Turb.	Turbidity (measured in 'NTU')
t	tonnes (1,000 kg)
U_3O_8	Uranium Oxide ('Yellowcake')
μg/L	micrograms per litre (or parts per billion, ppb)

Al	Aluminium	Pb	Lead
Ca	Calcium	pH	acidity / alkalinity
Cu	Copper	^{226}Ra	Radium-226
Fe	Iron	^{222}Rn	Radon-222
Mg	Magnesium	SO_4	Sulfate
Mn	Manganese	U	Uranium
NO_3	Nitrate	Zn	Zinc

Appendix 1 – Monthly Rainfall and Evaporation at Jabiluka (mm)

	Rainfall	Evap'n	Rainfall	Evap'n	Rainfall	Evap'n	Rainfall	Evap'n
	1998	1998	1999	1999	2000	2000	2001	2001
January			388	145	202.2	143.2	626.4	161.6
February			344	109	396.2	116.6	518.8	110.2
March			363	144	403.8	136.2	263.8	130.4
April					224.0	117.4	102.8	150.6
May			0.0	166.0	30.2	172.2	0.0	178
June			0.4	167.0	0.0	159.4	0.0	163
July			0.0	189.0	0.0	165.6	0.0	181
August			0.0	192.4	0.0	183.6	0.0	191
September			0.0	184.0	0.0	212.0	0.0	210
October	167	218	83.2	200.8	50.4	206.6		
November	121	161	225.6	165.8	149.2	194.6		
December	388	135	326.8	157.4	212.0	133.6		

Rainfall	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Minimum	405.5	419.7	343.5	163.4	10.1	0.1	0.0	0.0	0.0	100.2	165.3	308.9
Average	202.2	344.0	263.8	102.8	0.0	0.0	0.0	0.0	0.0	50.4	121.0	212.0
Maximum	626.4	518.8	403.8	224.0	30.2	0.4	0.0	0.0	0.0	167.0	225.6	388.0

Evap'n	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Minimum	149.9	111.9	136.9	134.0	172.1	163.1	178.5	189.0	202.0	208.5	173.8	142.0
Average	143.2	109.0	130.4	117.4	166.0	159.4	165.6	183.6	184.0	200.8	161.0	133.6
Maximum	161.6	116.6	144.0	150.6	178.0	167.0	189.0	192.4	212.0	218.0	194.6	157.4

Appendix 2 – Definition of 'Best Practicable Technology' (BPT)

From OSS (1999b)

12. BEST PRACTICABLE TECHNOLOGY

12.1 All aspects of the Ranger Environmental Requirements must be implemented in accordance with BPT.

12.2 Where there is unanimous agreement between the major stakeholders that the primary environmental objectives can be best achieved by the adoption of a proposed action which is contrary to the Environmental Requirements, and which has been determined in accordance with BPT, that proposed action should be adopted. Where agreement can not be reached the Minister will make a determination with the advice of the Supervising Scientist.

12.3 All environmental matters not covered by these Environmental Requirements must be dealt with by the application of BPT.

12.4 BPT is defined as : That technology from time to time relevant to the Ranger Project which produces the maximum environmental benefit that can be reasonably achieved having regard to all relevant matters including :

a) the environmental standards achieved by uranium operations elsewhere in the world with respect to :
i) level of effluent control achieved; and
ii) the extent to which environmental degradation is prevented;
b) the level of environmental protection to be achieved by the application or adoption of the technology and the resources required to apply or adopt the technology so as to achieve the maximum environmental benefit from the available resources;
c) evidence of detriment, or lack of detriment, to the environment;
d) the physical location of the Ranger Project;
e) the age of equipment and facilities in use on the Ranger Project and their relative effectiveness in reducing environmental pollution and degradation; and
f) social factors including the views of the regional community and possible adverse effects of introducing alternative technology.

12.5 Proposals to amend or introduce operational approaches, procedures or mechanisms must be supported by a BPT analysis. The rigour of the BPT analysis must be commensurate with the potential environmental significance of the proposal.The BPT analysis must involve consultation with and having regard to the views of the major stakeholders and copies of the BPT analysis must be provided to each of the major stakeholders.

12.6 A precautionary approach is to be exercised in the application of BPT in order to achieve outcomes consistent with the primary environmental objectives.

Appendix 7: Extracts from the Jabiluka General Authorisation 98/2

Jabiluka Authorization

A98/2

TABLE OF CONTENTS

SCHEDULE 1 DEFINITIONS

1.1 In this authorization, unless a contrary intention appears:

1.1.1 "the Act" means the Northern Territory Uranium Mining (Environment Control) Act;

1.1.2 "the Minister" means the Minister of the Northern Territory responsible for the Act;

1.1.3 "the Director" means the Director of Mines Division of the Northern Territory Department of Mines and Energy;

1.1.4 "Jabiluka Lease Area" has the same meaning as it does under Northern Territory Mining Lease N1 (MLN1);

1.1.5 "owner", in relation to a mine, has the same meaning as it does under the Act, and, in relation to the mine that lies within the Jabiluka Lease Area, means Energy Resources of Australia Ltd (ACN 008 550 865), and having its registered office at C/- Mallesons Stephen Jaques, 10th Floor Advance Bank Centre, 60 Marcus Clarke Street, Canberra City, ACT 2601;

1.1.6 "manager" has the same meaning as it does under the Act;

1.1.7 "Inspector" has the same meaning as it does under the Act;

1.1.8 "mine" has the same meaning as it does under the Act;

1.1.9 "mining" has the same meaning as it does under the Act

1.1.10 "operator of the mine" means the owner or the manager of the mine;

1.1.11 "mine site employees" means employees of the operator of the mine whose usual place of work is in the Jabiluka Lease Area;

1.1.12 "designated employees" has the same meaning as it does in the Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores (1987);

1.1.13 “controlled area” shall have the same meaning as it does in the Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores (1987);

1.1.14 “supervised area” shall have the same meaning as it does in the Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores (1987);

1.1.15 "Restricted Release Zone" has the same meaning as it does in ER9(b) of MLN1 1;

1.1.16 "Radiation Safety Officer" has the same meaning as it does in the Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores (1987); and

1.1.17 "site" has the same meaning as "Jabiluka Lease Area".

1.1.18 "sulfide mineralisation" means natural rock having Net Acid Producing Potential (NAPP) of greater than –20 kg H_2SO_4 per tonne.

SCHEDULE 2 AUTHORIZED OPERATIONS

2.1 The operator of the mine is authorized to:

2.1.1 construct a portal and access decline at the Jabiluka Project and construct associated infrastructure in accordance with the provisions of SCHEDULE 5;

SCHEDULE 6 WATER MANAGEMENT

6.1 In order to protect the environment, the operator of the mine shall operate a water management system in conformance with the latest approved revision of the Water Management System Operation Manual.

6.2 The operator of the mine shall:

6.2.1 within four weeks of the end of October each year submit for the approval of the Director a revision of the Water Management System Operation Manual, including:

6.2.1.1 a complete explanation of the operation and maintenance of the water management system;

6.2.1.2 the contingency procedures for disruptions in the operation and maintenance of the water management system;

6.2.1.3 the surface water monitoring program; and

6.2.1.4 details of the proposed Wet and Dry season operating levels and limits for the Retention Pond;

6.2.2 maintain up-to-date versions of drawings depicting the currently approved boundaries of the Restricted Release Zone; and

6.2.3 instruct all personnel involved in the operation of the water management system in the detailed operation of the system and in the implementation of contingency procedures.

6.3 In order to protect the environment, the operator of the mine shall ensure that water from the approved Restricted Release Zone is not released without the approval of the Supervising Authority.

6.4 In order to protect the environment, the operator of the mine shall dispose of water from dewatering bores that are located between the portal and the S1 raise in areas and in the manner approved by the Director.

6.5 The operator of the mine shall maintain to the satisfaction of the Minister and for examination by an Inspector, all records and data associated with the operation and monitoring of the water management system for the life of the mine up to and including the rehabilitation of all disturbed areas.

6.6 The operator of the mine shall submit reports in accordance with the requirements specified in the document annexed hereto and marked "ANNEXURE D".

SCHEDULE 7 DECOMMISSIONING AND REHABILITATION

7.1 In order to protect the environment the operator of the mine shall:

7.1.1 plan rehabilitation in accordance with the following goal and objectives:

7.1.1.1 Goal

To establish an environment in the Jabiluka Lease Area that reflects, to the maximum extent that can reasonably be achieved, the environment existing in the adjacent areas of Kakadu National Park, so that the rehabilitated area could be incorporated into Kakadu National Park without detracting from Park values of adjacent areas.

7.1.1.2 Objectives

To revegetate the disturbed sites of the Jabiluka Lease Area with local native plant species in similar density and abundance to that existing in adjacent areas of Kakadu National Park, in order to form an ecosystem the long-term viability of which would not require a maintenance regime significantly different from that appropriate to adjacent areas of the Park.

To establish stable radiological conditions on disturbed sites of the Jabiluka Lease Area so that, with a minimum of restrictions on use of the area, the public dose limit will not be exceeded and the health risk to members of the public, including traditional owners, will be as low as is reasonably achievable.

To limit erosion in rehabilitated areas, as far as can reasonably be achieved, to that characteristic of similar landforms in surrounding undisturbed areas.

7.1.2 at the end of every twelve month period, or of such other period as the Minister may determine, submit for the approval of the Minister an amended plan of rehabilitation detailing specifications for the physical decommissioning and rehabilitation of the mine, the uranium treatment plant and all ancillary works and services, which specifications shall include:

7.1.2.1 a detailed specification of all rehabilitation works which are proposed to be undertaken in the 12 months following the preparation of the report; and

7.1.2.2 a conceptual specification covering decommissioning and rehabilitation for the remaining years of life of the project.

7.2 The work estimate to be included with the specifications to be submitted under 7.1.2 shall encompass forecasts of the extent of works required, the resources to be applied in the execution of those works, and the likely cost and time required for completion. These aspects shall take into account:

7.2.1 removal of all plant, equipment, buildings and other structures, including mine and support facilities;

7.2.2 removal of civil works and facilities that are not required for other purposes;

7.2.3 dewatering of the water management system;

7.2.4 removal of all unnecessary water-retaining structures and other earthworks; and

7.2.5 revegetation of all disturbed areas.

SCHEDULE 8 ENVIRONMENTAL AND OCCUPATIONAL HEALTH MONITORING

8.1 In order to protect people and the environment, the operator of the mine shall:

8.1.1 implement the environmental and occupational health monitoring programs included in the documents annexed hereto and marked "ANNEXURE B" and "ANNEXURE C";

8.1.2 conduct contingency monitoring in a manner approved by the Minister in the event of the malfunction of monitoring equipment;

8.1.3 determine the average Net Acid Generating (NAG) pH of the product of each blast for mined rock not specifically exempted by the Director of Mines or material which is described in Environmental Requirement 9(a)(i). Each sample which reports a NAG pH of less than 4.5, and in any case at least every tenth NAG sample, will be submitted to a recognised Net Acid Producing Potential (NAPP) test.

8.1.4 keep a record of animal deaths and these are to be reported in the environmental annual report, and any unusual death must be reported immediately to the Supervising Authority and Parks Australia; and

8.1.5 present reports in accordance with the requirements specified in the document annexed hereto and marked "ANNEXURE D".

ANNEX B JABILUKA ENVIRONMENTAL MONITORING PROGRAM

Note: all coordinates in the tables below are based on the AMG 66 datum, grid number 53.

B.1 Monitoring of groundwater

B.1.1 Designated Regional Downgradient Bores

Location	Frequency	Parameters
RN031998 RN031999 RN032001 RN032002 RN032003 RN032004 RN032005	Quarterly	pH, EC, water level, Na, K, Ca, Mg, Cl, SO_4, HCO_3/CO_3, NO_3 and NO_2, NH_4, filtered (acidified) trace elements (Al, Mn, U, Fe, Pb, Cu, Zn, Ra^{226})
	Annually	ICP-MS scan of trace elements

B.1.2 Seepage Monitoring Bores

Location	Frequency	Parameters
RN031990 RN031991 RN031992 RN031993 RN031994 RN031995 RN031996 RN031997	Quarterly	pH, EC, water level, Na, K, Ca, Mg, Cl, SO_4, HCO_3/CO_3, NO_3 and NO_2, NH_4, filtered (acidified) trace elements (Al, Mn, U, Fe, Pb, Cu, Zn, Ra^{226})
	Annually	ICP-MS scan of trace elements

B.1.3 Dewatering bore water

Location	Frequency	Parameters
All active bores	Monthly	pH, EC, Na, K, Ca, Mg, Cl, SO_4, HCO_3/CO_3, NO_3 and NO_2, residue and filtered (acidified) trace elements (Al, Mn, U, Fe, Pb, Cu, Zn,)
	Quarterly	residue and filtered (acidified) Ra^{226}
	Annually	ICP-MS scan of trace elements

B.1.4 Potable Bore Water

Location	Frequency	Parameters
All active bores	Monthly	EC, pH, turbidity, SO_4, total coliform, E. Coli and faecal streptococci
	Monthly for first 6 months, then quarterly	Na, K, Ca, Mg, Cl, NO_3, HCO_3/CO_3, and total trace elements (Cu, Pb, Zn, U, Ra^{226})
	Initially, then annually	Ra^{228} and Gross-β

B.2 Monitoring of site waters

B.2.1 Total containment zone pond

Frequency	Parameters
Weekly	Field measurements of pH, EC and water level
Monthly	Na, K, Ca, Mg, Cl, SO_4, HCO_3/CO_3, NO_3 and NO_2, NH_4, soluble reactive P, residue and filtered (acidified) trace elements (Al, Mn, U, Fe, Pb, Cu, Zn,)
Quarterly	residue and filtered (acidified) Ra^{226}
Before the commencement of the Wet season	TOC, DOC, Hydrocarbons in the following fractions : C6-C9; C10-C14; C15-C28; and C29-C36
Annually	ICP-MS scan of trace elements

B.3 Creek and billabong monitoring

B.3.1 Swift Creek:

Location	Frequency	Parameters
GS8215127 GS8215131 GS8215132 GS8215120	Weekly	Grab samples for turbidity and suspended solids, and field measurements of pH, EC and flow rate (GS8215127only)
	Monthly commencing with first flush	Na, K, Ca, Mg, Cl, SO_4, HCO_3/CO_3, NO_3 and NO_2, NH_4, soluble reactive P, residue and filtered (acidified) trace elements (Al, Mn, U, Fe, Pb, Cu, Zn)
	Quarterly commencing with first flush	residue and filtered (acidified) Ra^{226}
	First flush event and 1 month thereafter	TOC, DOC, Hydrocarbons in the following fractions: C6-C9; C10-C14; C15-C28; and C29-C36
	Annually	ICP-MS scan of trace elements

B.3.2 Tributaries to Swift Creek

Location	Frequency	Parameters
GS8215105 GS8215106 GS8215130	Weekly	Grab samples for turbidity and suspended solids, and field measurements of pH and EC
	Monthly commencing with first flush	Na, K, Ca, Mg, Cl, SO_4, HCO_3/CO_3, NO_3 and NO_2, NH_4, soluble reactive P, residue and filtered (acidified) trace elements (Al, Mn, U, Fe, Pb, Cu, Zn)

B.3.3 Sediment Sampling:

Location	Frequency	Parameters
Bottom sediment (one upstream and one downstream site, 0-5 cm)	Yearly	U, Pb, Cu, Zn, Mn, and Ra^{226}

B.3.4 North Magela and 7J Creeks

Location	Frequency	Parameters
GS8215125 (North Magela) GS8215126 (7J Creek)	Weekly	Grab samples for turbidity and suspended solids, and field measurements of pH and EC
	Monthly commencing with first flush	Na, K, Ca, Mg, Cl, SO_4, HCO_3/CO_3, NO_3 and NO_2, NH_4, soluble reactive P, residue and filtered (acidified) trace elements (Al, Mn, U, Fe, Pb, Cu, Zn)

B.4 Soil monitoring

B.4.1 Lease Area:

Location	Frequency	Parameters
JSOIL1 JSOIL2 JSOIL3 JSOIL4 JSOIL5 JSOIL6 JSOIL7 JSOIL8	Annually (in April)	pH, EC, SO_4, U, Pb, Cu, Zn, Ra^{226}

B.5 Meteorology

Frequency	Parameters
Continuous	Wind speed and direction, temperature, rainfall and evaporation

B.6 Emissions from blasting

Northing	Easting	Frequency	Parameters
8617542	272085	Every blast	ground vibration, airblast overpressure
8616360	272872		

ANNEX D REPORTING REQUIREMENTS

Reports required under this authorization shall be produced and submitted in accordance with the following conditions:

D.1 Water management

D.1.1 Description

The report shall describe the operation and performance of the Water Management System.

D.1.2 Reporting periods

The reporting period shall be 1 September - 31 August each year.

D.1.3 Due date

The report shall be submitted within eight weeks after the end of the reporting period.

D.2 Environmental monitoring

D.2.1 Preliminary monitoring data reports

D.2.1.1 Description

Preliminary monitoring data reports shall include water management data (rainfall and pond levels) and available water quality data without analysis or interpretation.

D.2.1.2 Frequency

Preliminary monitoring data reports shall be submitted monthly, except where subsumed by quarterly or annual reports.

D.2.1.3 Due date

Preliminary monitoring data reports shall be submitted within one month of the end of each reporting period.

D.2.2 Trend and monitoring data summary reports

D.2.2.1 Description

Trend and monitoring data summary reports shall contain, at least, the following:

- the time, number and site of measurements taken;
- the results of measurements (where the measurements comprise a range or series of values, the range and the average shall be given);
- a comparison of corresponding data reported over the immediately preceding three months;
- identification of any trends evident from the data comparison; and
- a statement of any conclusions to be drawn from monitoring in the summary period, together with comments on any unusual measurements or events affecting the performance of the monitoring programs.

D.2.2.2 Reporting periods

Trend and monitoring data summary reports shall be submitted for the quarterly periods ending 31 July, 31 October and 31 January each year. The report for the period ending 30 April is subsumed by the annual interpretative report.

D.2.2.3 Due date

Trend and monitoring data summary reports shall be submitted within one month of the end of each reporting period.

D.2.3 Interpretative report

D.2.3.1 Description

The interpretative report shall contain, at least, the following information:

- a statement of the results of the monitoring measurements taken over the report period;
- a comparison with data included in the corresponding preceding report period;
- where appropriate, a comparison of the average and maximum values with the derived limits and pre-mining baseline values for items in the monitoring programs;
- where appropriate, an illustration of trends through graphs or histograms showing spatial, temporal or other trends evident from the data;
- where appropriate, notes on errors in the data, including systematic, random and total, and a statement on the level of confidence to be found in the reported data;
- a statement of the conclusions drawn from the results and an assessment of the performance of the monitoring program;
- a summary of any significant or unusual results in the operation of the monitoring program, giving the reasons and contributing factors in those results;
- a summary of any infringements in the operation of the monitoring program and of events which have impinged on the operation or results of that program; and
- an explanation of changes or proposed changes in the technology or techniques applied in carrying out the monitoring programs.

D.2.3.2 Reporting period

The interpretative report shall be submitted for the period 1 May - 30 April each year.

D.2.3.3 Due date

The interpretative report shall be submitted within eight weeks of the end of each reporting period.

D.3 Radiation and atmospheric monitoring

D.3.1 Radiation and atmospheric monitoring data summary reports

D.3.1.1 Description

Radiation and atmospheric monitoring data summary reports shall contain, at least, the following information:

- the number and site of measurements taken;
- the results of measurements (where the measurements comprise a range or series of values, the range and the average shall be given);
- identification of any trends evident from the data; and
- a statement of any conclusions to be drawn from monitoring in the summary period, together with comments on any unusual measurements or events affecting the performance of the monitoring programs.

D.3.1.2 Reporting periods

Radiation and atmospheric monitoring data summary reports shall be submitted for the quarterly periods ending 31 March, 30 June, 30 September and 31 December each year.

D.3.1.3 Due date

Radiation and atmospheric monitoring data summary reports shall be submitted within eight weeks of the end of each reporting period.

D.3.2 Interpretative report

D.3.2.1 Description

The interpretative report shall contain, at least, the following information:

- a statement of the results of the monitoring measurements taken over the report period;
- a comparison with data included in the corresponding preceding report period;
- where appropriate, a comparison of the average and maximum values with the derived limits and pre-mining baseline values for items in the monitoring programs;
- where appropriate, an illustration of trends through graphs or histograms showing spatial, temporal or other trends evident from the data;
- where appropriate, notes on errors in the data, including systematic, random and total, and a statement on the level of confidence to be found in the reported data;
- a statement of the conclusions drawn from the results, and an assessment of the performance of the monitoring program;
- a summary of any significant or unusual results in the operation of the monitoring program, giving the reasons and contributing factors in those results;

- a summary of any infringements in the operation of the monitoring program and of events which have impinged on the operation or results of that program; and
- an explanation of changes or proposed changes in the technology or techniques applied in carrying out the monitoring programs.

D.3.2.2 Reporting period

The interpretative report should be submitted for the period 1 January to 31 December each year, by 30 April in the following year.

D.4 Environmental Management Plan

D.4.1 Description

Using the Environmental Impact Statement as the interim plan, the operator shall develop and submit an Environmental Management Plan by 1 November 1999.

The operator shall submit annual updates of the Environmental Management Plan.

The Environmental Management Plan shall include summaries of the conclusions of, and detail actions to manage any deficiencies identified in, the reports described in D.1 to D.3.

D.4.2 Reporting periods

The reporting period for the plan shall be 1 September - 31 August each year.

D.4.3 Due date

The plan shall be submitted within eight weeks of the end of the reporting period.

Appendix 8 : List of 'Incidents' at Jabiluka, 1998-2002

A list of "technical divergences" from Jabiluka Authorisation 98/2 and other incidents of concern to the Mirrar. Compiled from ERA-JAER (1999, 2000, 2001); Mudd (2001).

May 2000 to April 2001

- Water quality monitoring of the 2000-01 wet season showed even higher nitrate (NO_3) in Central Tributary, which was sourced back to the non-mineralised stockpile.
- Total of 57 individual missing chemical analyses for Jabiluka over the 2000/01 reporting period – all but 1 relate to ^{226}Ra due to technical difficulties. Radium now analysed externally.
- Technical equipment failure for radon measurement.
- Air velocity measurements in the decline during maintenance were below the minimum specified in the Authorisation, which was subsequently changed to remove the need for measurement during maintenance.
- Potable bores were not sampled during April (2001) due to lack of adequate staff.
- No sample obtained for ^{226}Ra in the IWMP in July 2000.
- Sample obtained from 7J Creek not analysed for turbidity in December 2000.
- During 2000, a number of samples were collected for ^{226}Ra, however the results are missing from the database and the samples are no longer available for analysis.
- Total of 32 fauna deaths on the Jabiluka Mineral Lease, of which 25 were not related to Jabiluka activities. Includes ***6 quolls*** who drowned in the IWMP.

May 1999 to April 2000

- Water quality monitoring of the 1999-2000 wet season still shows elevated turbidity (ie. sediment) and nitrate (NO_3) in waters of the Swift Creek catchment, though not as high as the previous year.
- March 2000 – ERA begin investigating ways to dispose of or treat water within the IWMP due to the 2 wet seasons being well above average and the predicted lack of capacity of the IWMP to retain water from the 2000-01 wet season.
- Total of 49 individual missing chemical analyses for Jabiluka over the 1999/2000 reporting period. Of these, 36 relate to ^{226}Ra due to technical difficulties (due to be finished by July 2000).
- Total of 19 fauna deaths on the Jabiluka Mineral Lease, of which 13 were not related to Jabiluka activities. Includes 1 crow and 1 quoll who drowned in the IWMP.

May 1998 to April 1999

- Water quality monitoring of the 1998-99 wet season shows elevated turbidity (ie. sediment) and nitrate (NO_3) in waters of the Swift Creek catchment.
- Failure to renew proper permits at the end of May 1998 meant that ERA staff did not have correct access permits for Area's A, B and C. Weekly samples from 4 sites were not collected.
- Uranium contamination of samples taken on 3 February 1999.
- Ground vibration and air-blast overpressure were not monitored for the first nine portal development blasts, due to delays in approval of permanent locations and access to those sites.
- During December 1998 the solar panels powering blast monitors failed to record for a period of 8 days, covering a total of 9 blasts.
- Total of 40 fauna deaths on the Jabiluka Mineral Lease, of which 21 were on the Oenpelli Road. Includes 1 quoll and 1 frill neck lizard who drowned in the IWMP.

Appendix 9 : DBIRD check monitoring program for Ranger and Jabiluka (Proposed)

RANGER BORE RUN

RUN DATES...../ ..../ 00....

REGESTERED No	NAME	DATUM	AQUIFER	TOTAL DEPTH	MARCH	JUNE	SEPTEMBER	DECEMBER	SWL	TOC	COMENTS
TAILINGS DAM AREA											
9329		16.85	DEEP		1.3	1	1.3	1			
22934	OB20	21.68	DEEP		1.3	1	1.3	1			
23569		27.86	SHALLOW	5.40	1.3	1	1.3	1			
22912	OB6A	30.96	DEEP		1,3,4	1.3	1,3,4	1.3			
~~22918~~	~~OB9A~~	~~30.06~~	~~DEEP~~		~~1,3,4~~	~~1.3~~	~~1,3,4~~	~~1.3~~			~~INSIDE PIT AREA unable to pump~~
~~22920~~	~~OB10A~~	~~26.23~~	~~DEEP~~		~~1,3,4~~	~~1.3~~	~~1,3,4~~	~~1.3~~			~~INSIDE PIT AREA unable to pump~~
~~22927~~	~~OB16~~	~~21.9~~	~~DEEP~~		~~1,3,4,5~~	~~1,3,4,5~~	~~1,3,4,5~~	~~1,3,4,5~~			~~DESTROYED~~
~~22926~~	~~OB15~~	~~20.62~~	~~DEEP~~		~~1,3,4,5~~	~~1,3,4~~	~~1,3,4,5~~	~~1,3,4~~			~~DESTROYED~~
22902	OB1A	30.08	DEEP		1.3	1.3	1.3	1.3			
23554		27.47	SHALLOW	5.05	1.3	1	1.3	1			
22904	OB2A	30.33	DEEP		1.3	1.3	1.3	1.3			
23533		29.69	SHALLOW	5.35	1.3	1	1.3	1			
23552		18.45	SHALLOW	4.06	1,3,4	1.3	1,3,4	1.3			TOTAL DEPTH NOW 3.5M
RP1/ COONJIMBA/ MAGELA AREA											
23551		16.49	SHALLOW	5.30	1.3	1.3	1.3	1.3			
23525		16.15	SHALLOW	5.00	1.3	1.3	1.3	1.3			ACCESS DIFFICULT
7243	B11	12.95	DEEP		1.3	1	1.3	1			
23524		11.72	SHALLOW	6.40	1.3	1	1.3	1			
9248	77/11	11.36	DEEP		1.3	1	1.3	1			
PIT AREA											
22941	OB30	18.82	DEEP		1.3,4	1	1.3,4	1			
RP2/ DJALKMARRA AREA											
20091	79/2	17.17	DEEP		1,3,4,5	1.3	1,3,4,5	1.3			
22940	OB29	14.64	DEEP		1.3	1.3	1.3	1.3			
23560		14.19	SHALLOW	5.47	1.3	1.3	1.3	1.3			
23558		13.59	SHALLOW	4.73	1.3	1.3	1.3	1.3			
23561		13.18	SHALLOW	6.60	1.3	1	1.3	1			ACCESS DIFFICULT
~~23011~~	~~82/4~~	~~13.75~~	~~DEEP~~		~~1.3~~	~~1~~	~~1.3~~	~~1~~			~~DESTROYED~~
GEORGETOWN AREA											
22930	OB27	14.17	DEEP		1.3	1	1.3	1			
23939		14.87	SHALLOW	5.66	1.3	1	1.3	1			
25406	MC19	20.04	SHALLOW	4.77	1,3,4,5	1.3,4	1,3,4,5	1.3,4			
25466	MC24	15.42	SHALLOW	6.21	1,3,4,5	1.3,4	1,3,4,5	1.3,4			

1. FIELD PARAMETERS EC,Ph,TEMP,Eh

3. GENERAL PARAMETERS, SiO_2

4. T&F Al,Mn,U

5. R&F Ra

RANGER SURFACE WATERS

GS No	SITE LONG NAME	JAN	FEB	MAR	APR	MAY	JUN
8210009	MAGELA CREEK D/S JABIRU	1 TO 5	1 TO 5	1 TO 5	1 TO 5	1 TO 5	1 TO 5
8210017	JABILUKA B/BONG		1		1		
8210018	MUDGINBERRI B/BONG		1		1		
8210028	MAGELA CREEK ARNHEM BORDER		1, & 3.		1, & 3.		1, & 3.
8210201	GEORGETOWN B/BONG	1	1 TO 5	1	1 TO 5	1	1 TO 5
8210205	DJALKMARRA B/BONG	1	1 TO 5	1	1 TO 5	1	1 TO 5
8210208	COONJIMBA B/BONG	1	1 TO 5	1	1 TO 5	1	1 TO 5
8210211	GULUNGUL B/BONG	1	1, & 3.	1	1	1	1
8210210	GULUNGUL CREEK ARNHEM HWY	1	1, & 3.	1	1		
8211026	RP1 GAUGE BOARD	1 TO 5	1 TO 5	1 TO 5	1	1	1
8211032	RP2 GAUGE BOARD	1 TO 5	1	1	1	1	1
8211125	TAILINGS DAM WEST WALL	1	1	1 TO 5	1		
8211038	TAILINGS DAM CENTRAL MAN HOLE	1 TO 5	1	1	1		
8211086	RP2 SEEPAGE RETURN	1	1, & 3.	1	1		

1 field, 3 general parameters, 4 heavy metals, 5 radium

GS No	SITE LONG NAME	JUL	AUG	SEP	OCT	NOV	DEC
8210009	MAGELA CREEK D/S JABIRU	1 TO 5	1 TO 5	1 TO 5	1 TO 5	1 TO 5	1 TO 5
8210017	JABILUKA B/BONG				1		1
8210018	MUDGINBERRI B/BONG				1		1
8210028	MAGELA CREEK ARNHEM BORDER						1, & 3.
8210201	GEORGETOWN B/BONG	1	1	1	1	1	1 TO 5
8210205	DJALKMARRA B/BONG	1	1	1	1	1	1 TO 5
8210208	COONJIMBA B/BONG	1	1	1	1	1	1 TO 5
8210211	GULUNGUL B/BONG	1	1	1, & 3.	1	1	1
8210210	GULUNGUL CREEK ARNHEM HWY						1
8211026	RP1 GAUGE BOARD	1	1	1 TO 5	1	1	1 TO 5
8211032	RP2 GAUGE BOARD	1	1	1 TO 5	1	1	1
8211125	TAILINGS DAM WEST WALL	1	1	1 TO 5	1		
8211038	TAILINGS DAM CENTRAL MAN HOLE			1			
8211086	RP2 SEEPAGE RETURN	1		1			1, & 3.

1 field, 3 general parameters, 4 heavy metals, 5 radium

JABILUKA MONITORING PROGRAM (PROPOSED)

SITE	Parameters	Frequency
SC – Tributary North	pH, EC, Ca, Mg, Na, K, SO_4, Cl, NO_2, NO_3, SiO_2, Al(f,t), Cu(f,t), Fe(f,t), Mn(f,t), Pb (f,t), U(f,t), Zn(f,t)	Dec/Jan Mar Apr/May
SC – Tributary Central	pH, EC, Ca, Mg, Na, K, SO_4, Cl, NO_2, NO_3, SiO_2, Al(f,t), Cu(f,t), Fe(f,t), Mn(f,t), Pb (f,t), U(f,t), Zn(f,t)	Dec/Jan Mar Apr/May
SC – Tributary South	pH, EC, Ca, Mg, Na, K, SO_4, Cl, NO_2, NO_3, SiO_2, Al(f,t), Cu(f,t), Fe(f,t), Mn(f,t), Pb (f,t), U(f,t), Zn(f,t)	Dec/Jan Mar Apr/May
SC – Oenpelli Rd	pH, EC, Ca, Mg, Na, K, SO_4, Cl, NO_2, NO_3, SiO_2, Al(f,t), Cu(f,t), Fe(f,t), Mn(f,t), Pb (f,t), U(f,t), Zn(f,t)	Dec/Jan Mar Apr/May
SC – Lease Boundary (JSC)		Dec/Jan Mar Apr/May
SCUSB (Upstream Billabong)	pH, EC, Ca, Mg, Na, K, SO_4, Cl, NO_2, NO_3, SiO_2, Al(f,t), Cu(f,t), Fe(f,t), Mn(f,t), Pb (f,t), U(f,t), Zn(f,t)	Dec/Jan Mar Apr/May
Subsoil Drain	ICPMS Scan	Dec/Jan Mar Apr/May
IWMP	ICPMS Scan	Dec/Jan Mar Apr/May

DME will revise their check-monitoring program as the status of the Jabiluka Project evolves.

Appendix 10 : List of Jabiluka Reports Requested to be Public

1996

Taylor, G F, Hollingsworth, I D, Hignett, C F & Nefiodovas, A, 1996, *Characterisation of Soils From Potential Disposal Sites for Jabiluka Waste Water Management*. CSIRO prepared for ERA Environmental Services Pty Ltd, May 1996, 28 p.

1999

Farrar, V A, Hollingsworth, I D & Jones, D R, 1999, *Soluble Blast Residues in Waste Rock : Internal Discussion Paper.* Prepared by Earth Water Life Sciences Pty Ltd for ERA, November 1999.

Undated

Government legal advice to the Supervising Scientist regarding the revision of environmental conditions of the Jabiluka Mineral Lease MLN1. Cited by Supervising Scientist during Senate Environment, Communication, Information Technology and the Arts Legislation Committee Consideration of Supplementary Estimates, Thursday 30 May 2002.

Annual Reports (all existing and future) :

- *Annual Plan of Rehabilitation Report.*
- *Annual Water Management Report.*
- *Annual Water Management Systems Operation Manual Report.*
- *Annual Environmental Management Plan Report.*
- *Annual Radiation and Atmospheric Monitoring Report.*