Appendix 11

Potential Effects of Solute Loading to Magela Creek

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Assessment of Potential Effects of Solute

Loading to Magela Creek from Ranger 3 Deeps Closure Strategy

ERA Project 2-6253

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Executive summary

The objective of this project was to assess the risk to the ecosystem of Magela Creek and downstream wetlands, from potentially elevated concentrations of constituents of potential concern, magnesium, uranium, manganese, radium-226, total ammonia nitrogen, nitrate, total phosphorus and polonium-210), that may enter Magela Creek as a consequence of the Ranger 3 Deeps closure strategy.

The approach used in addressing the objective was to critically review relevant information, including, but not necessarily limited to;

- the groundwater modelling predictions for loads of constituents of potential concern that may enter Magela Creek after closure of the proposed Ranger 3 Deeps underground mine (the Project); and
- the toxicity of the contaminants entering the creek, particularly magnesium, manganese and uranium, to local specie; and
- existing water quality and biological results from the environmental monitoring programs.

The Supervising Scientist Division (SSD), via the Environmental Research Institute of the Supervising Scientist (ERISS), and ERA have extensive monitoring programs that have spanned the life of the Ranger mine. The SSD use an integrated monitoring program that provides multiple lines of evidence. This program has a range of biological monitoring, including in-situ toxicity monitoring and ecosystem level response with assessment of fish and macro-invertebrate communities, together with physicochemical monitoring, including surface water chemistry and continuous monitoring (pH, electrical conductivity, turbidity and flow).

These programs have been developed and implemented over nearly 30 years, and can be considered leading practice. The 30 years of multiple lines of evidence have shown that, during the operational phase, the mine derived constituents of potential concern have not had any adverse effect on water quality or the abundance and diversity of aquatic organisms downstream of the mine site. The results of the ERA monitoring programs are consistent with the SSD results and support the conclusion that there have been no measureable adverse effects.

The Supervising Scientist, through ERISS, has derived high reliability site specific water quality guidelines for 99% species protection for a number of constituents of potential concern, including magnesium, uranium and manganese. Their derivations were based on the ANZECC/ARMCANZ (2000) recommended methods that are considered to provide the most comprehensive guidance and are a leading practice approach. The six local species toxicity test methods have been developed at ERISS as part of their research and monitoring programs over the past 25 years. Further toxicity studies have derived high reliability site specific water quality guidelines for 99% species protection for 4h, 8h and 24h magnesium pulse exposures of 94, 14 and 8 mg/L, respectively.

These high reliability site specific water quality guidelines for 99% species protection provide guidance for interpreting and assessing potential impacts of the predicted concentrations of constituents of potential concern that may be expected in Magela Creek as a result of groundwater egress resulting from closure of the proposed Ranger 3 Deeps underground mine.

The closure of Ranger 3 Deeps involves backfilling of the stopes with cemented paste aggregate fill with tailings (comprising tailings, cement and aggregate generated from low-grade ore) and the vents and decline with cemented rock fill (a mixture of crushed waste rock and cement). The cemented paste aggregate fill with tailings and cemented rock fill are sources of constituents of potential concern.

The constituents of potential concern were modelled as conservative solutes that may result in 100% of the predicted loads entering Magela Creek being in the dissolved phase. Based on this approach, the INTERA solute transport modelling, predicted that the constituents of potential concern loads to Magela Creek from Ranger 3 Deeps sources will have a negligible effect on loadings of constituents of potential concern in Magela Creek.

The predicted loads from the INTERA modelling and resultant concentrations of constituents of potential concern in Magela Creek were assessed against operational loads, additional annual load limits, baseline concentrations and the trigger values for 99% species protection.

Assessment of loads

The predicted long term annual groundwater magnesium load (3.1kg) would be 0.0015% and 0.002% of the mean annual (2005-2012) mine derived magnesium load and background magnesium loads, respectively. Similarly, all other annual loads of constituents of potential concern from Ranger 3 Deeps would be between 0.04% to 4.1 x 10^{-7}% of mean annual mine derived loads. In comparison to the additional annual load limits, the predicted annual loads of constituents of potential concern would be between four and eight orders of magnitude lower than the additional annual load limits.

Assessment of concentrations

The predicted concentrations of constituents of potential concern for a worst case scenario would be:

- unmeasurable above the background concentrations for Magela Creek; and
- between two and four orders of magnitude below the corresponding trigger values.

On this basis the multiple lines of evidence, physical, chemical and biological, acquired from the research and monitoring programs of the Supervising Scientist, ERA and others over the past 30 years, demonstrate no detrimental impact, defined as *an impact which causes or is likely to cause a change to biodiversity or impairment of ecosystem health,* during the operational phase of the Ranger mine. This includes assessment of cumulative impacts from all constituents of potential concern.

The weight of evidence:

- multiple lines of evidence that demonstrate no detrimental impact during the operational phase of Ranger mine; and
- the negligible to unmeasurable contribution to the loads and concentrations of constituents of potential concern;

demonstrate that the egress of constituents of potential concern from the Ranger 3 Deeps site post-closure will not have any environmental impact in the aquatic environment and furthermore will not compromise the ecological and/or cultural values of Magela Creek and associated wetlands.

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Glossary of Terms

Additional annual load limit(s) - The additional load of constituents that can be released to the Magela Creek, above background levels. The limits are based on dietary uptake (for metals and radionuclides) for protection of human health and eutrophication risk for nutrients.

Base flow – The flow of groundwater to Magela Creek

Bq – Becquerel is a measure of the activity of a quantity of radioactive material.

Cemented paste aggregate fill with tailings - Comprises tailings, cement, and aggregate generated from low-grade ore.

Cemented rock fill - A mixture of crushed waste rock and cement.

Conservative solute - A dissolved chemical constituent in groundwater or surface water whose concentration is not affected by biogeochemical or physical processes occurring along the flow path.

Constituents of potential concern – Chemicals (element or salt species) present at concentrations that exceed background concentrations as a result of the mining operation.

Electrical conductivity – The capacity of water to conduct electrical current which is directly related to the concentration of salts, such as magnesium and sulfate, dissolved in water. It is measured in units of microsiemens/cm (µS/cm).

Exfiltration - Discharge of groundwater from the sub-surface to ground surface.

Macroinvertebrates – A group of animals that have no backbone, including insects, crustaceans, molluscs and annelids, and can be seen by the naked eye. They live in water for all or part of their lives and so their survival can be related to water quality.

Magela Creek downstream, MG009 - The Ranger downstream statutory or compliance surface water monitoring point. It is located on Magela Creek, downstream of Ranger operations.

Magela Creek upstream, MCUS - The upstream statutory surface water monitoring point, located on the Ranger Project Area.

Magnesium – The water soluble magnesium ion, Mg^{2+}.

µg/L – micrograms of a chemical dissolved in one litre of water.

mg/L - milligrams of a chemical dissolved in one litre of water.

Order of magnitude - A power of ten. An increase by one order of magnitude equals a tenfold increase, whereas a two order of magnitude increase equals a hundredfold increase.

Reactive solute - A dissolved chemical constituent in groundwater or surface water whose concentration is affected by biogeochemical and/or physical processes occurring along the flow path.

Tailings - The materials left after the process of removing the recoverable uranium from the ore.

Trigger Values – Numerical water quality objectives that, when exceeded, trigger a management response.

Waste rock - Mined rock that is stockpiled due to its low grade, i.e., material which does not enter the processing plant. For example, 1s waste rock typically has a grade of less than 0.02% U_3O_8; 2s waste rock (or very low-grade ore) typically has a grade between 0.02% and 0.05% U_3O_8.

Water quality objectives – Locally derived trigger values used to assess compliance and/or interpret changes in water quality.

Project Details

1. Background

Energy Resources of Australia Ltd (ERA) are proposing to construct and operate an underground mine (the Project) that will mine the Ranger 3 Deeps uranium ore body between 300 and 480 m below ground level, east of Pit 3. Mining will remove approximately 6.8 Mt of uranium ore, at an average grade of 0.25 % U_3O_8, plus 0.6 Mt of low grade ore and 0.5 Mt of waste rock. This resource is estimated to contain more than 32,000 t of uranium oxide and mining will be completed in five-years.

Ore will be transported to the surface using diesel trucks and ore processing will use the existing processing facilities at the Ranger mine. As ore is removed, the underground mine will be progressively backfilled and sealed with a paste, typically comprising tailings, crushed very low-grade ore[1] and cement binder. The paste will be pumped, or gravity fed, from the surface via a cased borehole.

The preferred design for closing Ranger 3 Deeps involves backfilling the stopes with cemented paste aggregate fill with tailings (comprising tailings, cement and aggregate generated from low-grade ore) and the vents and decline with cemented rock fill (a mixture of crushed waste rock and cement).

A closure strategy for the Project has been developed that fully aligns with closure planning for the current Ranger mine operations. Following approval of the Project, this strategy will be integrated into the overall Ranger closure plan. Integrated closure of the entire Ranger Project Area (RPA) requires removal of the tailings dam, all surface water storage structures, all surface infrastructure, and backfilling of Pit 1, Pit 3 and the proposed Ranger 3 Deeps workings by January 2026.

The key rehabilitation and closure risk identified for the Project related to the potential for solute transport into Magela Creek post closure.

The materials to be used to backfill Ranger 3 Deeps are sources of constituents of potential concern, which include magnesium, uranium, manganese, radium-226, total ammonia as nitrogen, nitrate as nitrogen, total phosphorus and polonium-210. ERA contracted INTERA to perform groundwater modelling to quantitatively predict the mass loads of constituents of potential concern that potentially may be carried from the Ranger 3 Deeps backfill by groundwater to Magela Creek over 10,000 years.

Specific objectives of the INTERA (2104) study included:

- Extending the hydrogeologic conceptual models for conservative and reactive transport at the mine site to include the Ranger 3 Deeps mine workings.
- Define the constituents of potential concern source terms for solutes leached from the cement and mine material mixtures to be used to backfill Ranger 3 Deeps.
- Construct a predictive three-dimensional numerical model of groundwater flow and conservative solute transport from the cemented paste aggregate fill with tailings backfill and the cemented rock fill backfill, and apply it to quantify estimates of loading rates of constituents of potential concern from the Ranger 3 Deeps backfill to Magela Creek.

Details of the groundwater modelling are contained in INTERA (2014).

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[1] Category 2 ore containing 0.02 – 0.05 wt% of U_3O_8

1.1 Ranger Environmental Requirements

The ERA Integrated Tailings Water and Closure (ITWC) study, has developed a fit-for-purpose closure strategy and closure management plan to meet the legislated requirements for the planned closure date of January 2026. The ITWC development is guided by relevant Rio Tinto/ERA policies and standards and the Ranger Environmental Requirements as prescribed in the Section 41 Authority. The primary environmental protection objectives defined under the Environmental Requirements are:

- Maintain the attributes for which Kakadu National Park was inscribed on the World Heritage list;
- 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);
- Protect the health of Aboriginals and other members of the regional community; and
- Maintain the natural biological diversity of aquatic and terrestrial ecosystems of the Alligator Rivers Region, including ecological processes.

For rehabilitation, the overall rehabilitation goal is stated in the Environmental Requirements:

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

In addition, there are specific requirements for tailings. All tailings at Ranger must be returned to the mined out pits and final disposal of tailings must be undertaken in such a way as to ensure that:

- The tailings are physically isolated from the environment for at least 10,000 years;
- Any contaminants arising from the tailings will not result in any detrimental environmental impacts for at least 10,000 years; and
- 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 tailings disposal.

Another Environmental Requirement relevant to closure and the ITWC study directs that:

- Surface or groundwater discharging during or following rehabilitation must not compromise the primary environmental objectives.

With respect to the primary environmental objectives the company must ensure that operations at Ranger do not result in:

- 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
- 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.

1.2 Project objective

The objective of this project was to assess the risk to the ecosystem of Magela Creek and downstream wetlands, from elevated concentrations of constituents of potential concern, magnesium, uranium, manganese, radium-226, total ammonia as nitrogen, nitrate as nitrogen, total phosphorus and polonium-210, predicted to enter Magela Creek as a consequence of the Ranger 3 Deeps closure strategy.

2. Methodology

The methods used to achieve the objective:

1. Critically review the relevant information, including, but not necessarily limited to;
   - existing results from Supervising Scientist Division and ERA environmental monitoring programs;
   - the solute transport modelling predictions of loads of constituents of potential concern entering Magela Creek resulting from closure of the proposed Ranger 3 Deeps underground mine;
   - the toxicity of constituents of potential concern entering Magela Creek, in relation to predicted concentrations, and
   - assessment against existing site specific water quality guidelines.

2. Consult with INTERA (via ERA) and Supervising Scientist Division staff on their areas of expertise as required to obtain any additional information or clarify existing data.

3. Review of Relevant Information

3.1 Environmental Monitoring Programs

ERA monitors and reports on water quality in Magela and Gulungul Creeks adjacent to Ranger mine with specific water quality objectives to be achieved in Magela Creek (Table 1). The trigger values have four tiers, Focus, Action, Guideline and Limit, with exceedance of trigger value tiers invoking specific responses as detailed in Iles (2004).

Each week during the wet season, ERA reports the water quality at key sites at Ranger, including Magela and Gulungul Creeks, to the Minesite Technical Committee (MTC).[2] A

[2] The MTC is the formal forum for key advisory and stakeholder groups, including representatives of the NT Department of Mines and Energy (Chair), Office of the Supervising Scientist, ERA, Gundjeihmi Aboriginal Corporation (GAC) and the Northern Land Council (NLC).

detailed interpretation of water quality across the site is provided at the end of each wet season in the ERA Ranger Annual Wet-season Report, confidentially provided to the MTC.

Table 1: Magela Creek Water Quality Objectives for 2013-14 (SSD, 2013)[1].

Parameter	Objective	Trigger Value			
		Focus	Action	Guideline	Limit
pH	To retain the natural distribution of pH in Magela Creek and report and act on any trigger value exceedances at MG009[2]	5.9 – 6.5	5.6 – 6.7	5.0 – 6.9	N/A
Turbidity (NTU)	To retain the natural distribution of turbidity in Magela Creek and report and act on any trigger value exceedances at MG009[2]	5.0	10	26	N/A
Electrical conductivity (µs/cm)	To (i) report and act on any exceedances of the focus, action and guideline trigger values, and (ii) to sustain the improved water quality seen in the last three wet seasons when practicable.	18	30	N/A	42 (≥ 72 hour limit)
Magnesium (mg/L)	To (i) report and act on any trigger value exceedances at MG009[2], and (ii) to sustain the lower magnesium concentrations measured in the last three wet seasons when practicable.	1.0	2.0	N/A	3.0 (≥ 72 hour limit)
Manganese (µg/L)	To report and act on any trigger value exceedances at MG009[2] when flow is dominated by surface flow (> 5 m^3/s)	35	45	N/A	75
Uranium (µg/L)	To (i) report and act on any exceedances at MG009[2], and (ii) to sustain the lower uranium concentrations measured in the last three wet seasons when practicable.	0.3	0.9	N/A	6.0
Total ammonium nitrogen (mg/L)	To report and act on any trigger value exceedances at MG009[2]	0.1	0.3	0.7	N/A
Radium-226 (mBq/L)	The median total radium-226 activity concentration for the wet season at the downstream site will not be more than 10 mBq/L greater than at the upstream site.	N/A	N/A	N/A	10mBq/L (wet season median difference)

[1] SSD, 2013. http://www.environment.gov.au/topics/science-and-research/supervising-scientist-division/environmental-monitoring/surface-water
[2] MG009 = downstream compliance point on Magela Creek as shown in Figure 1.

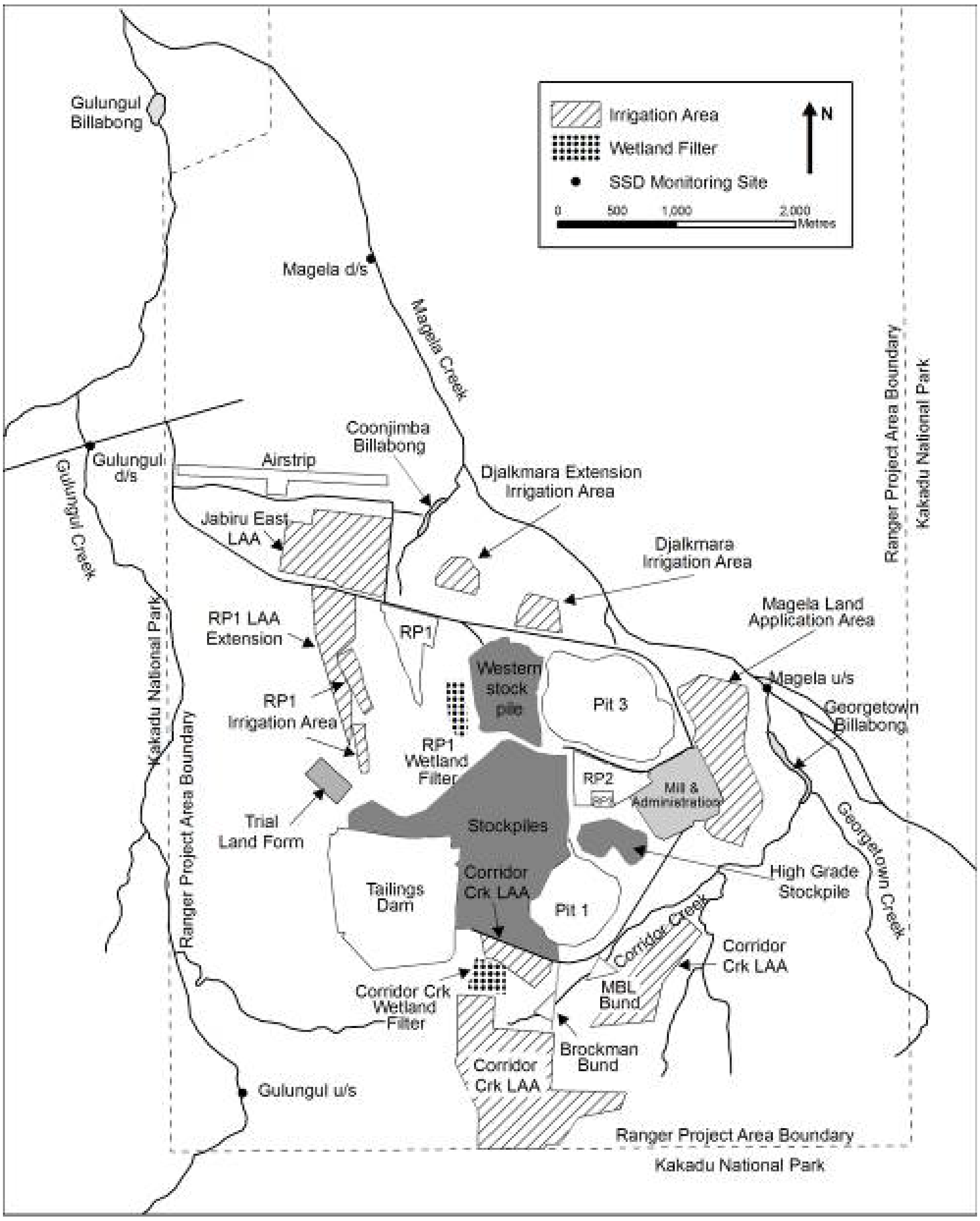


Figure 1: Ranger mine in relation to Magela and Gulungul Creeks.

Figure 1 shows the Ranger mine, with the downstream (d/s) compliance point (MG009) and upstream (u/s) continuous monitoring locations on Magela and Gulungul Creeks. Figure 1 also shows the proximity of Pit 3 to Magela Creek.

In addition to ERA's monitoring program, the Supervising Scientist conducts an independent surface water quality monitoring program that includes chemical, physical and biological measurements performed in Magela Creek, Gulungul Creek, and other reference water bodies in the region.

A key component of the surface water chemical monitoring program is the continuous monitoring of pH, electrical conductivity (EC), turbidity and flow at sites in Magela Creek upstream and downstream of the mine site (Figure 1). In addition, relationships between electrical conductivity and magnesium at each of the continuous monitoring locations both upstream and downstream of the Ranger mine have been derived by correlating magnesium concentrations in grab water samples with concurrent measurements of in-situ electrical conductivity. There are statistically very strong relationships between magnesium concentration and electrical conductivity at the continuous monitoring locations (Supervising Scientist, 2009).

The biological monitoring programs, developed and refined over the past 30 years by the Environmental Research Institute of the Supervising Scientist (ERISS), allow an assessment of impacts from the Ranger mine on downstream aquatic ecosystems. Two broad approaches are used: early detection and assessment of overall ecosystem-level responses.

Early detection techniques involve assessing the responses of the freshwater snail, *Amerianna cumingi,* exposed *in-situ* to Magela Creek water. This species is the most sensitive to uranium and magnesium of the six local species assessed by ERISS. The *in-situ* toxicity monitoring commenced in the 2008-09 wet season. Before this, in the 1990-91 to 2007-08 wet seasons, toxicity monitoring had been conducted using the creekside methodology. This involved pumping water from Magela Creek continuously through tanks of snails and fish on the creek bank.

Ecosystem-level responses are assessed using benthic macroinvertebrate and fish community data from Magela and Gulungul Creek sites, which are compared with historical data and data from control sites in streams unaffected by contemporary mining operations.

3.1.1 Supervising Scientist Division Programs

Biological monitoring: freshwater snail (Amerianna cumingi) (Humphrey et al 2013a)

The creek side monitoring from the 1991-92 to 2012-13 wet seasons showed that snail eggs production remained relatively constant over this time as indicated by the upstream-downstream difference values plot around the running mean (Figure 2). In 2012-13 there was overall lower egg production observed in Magela Creek downstream of Ranger, in contrast to previous years when there was higher egg production downstream. The differences in egg production are attributed to changes in water temperature regimes in the creeks, with higher temperatures having an inhibitory effect.

Humphrey & Ellis (2013) concluded that the toxicity monitoring results for 2012–13 reflected patterns associated with natural water quality (water temperature and electrical conductivity) conditions in Magela and Gulungul Creeks. There was no evidence of mine-related effects upon snail egg production over the wet season.

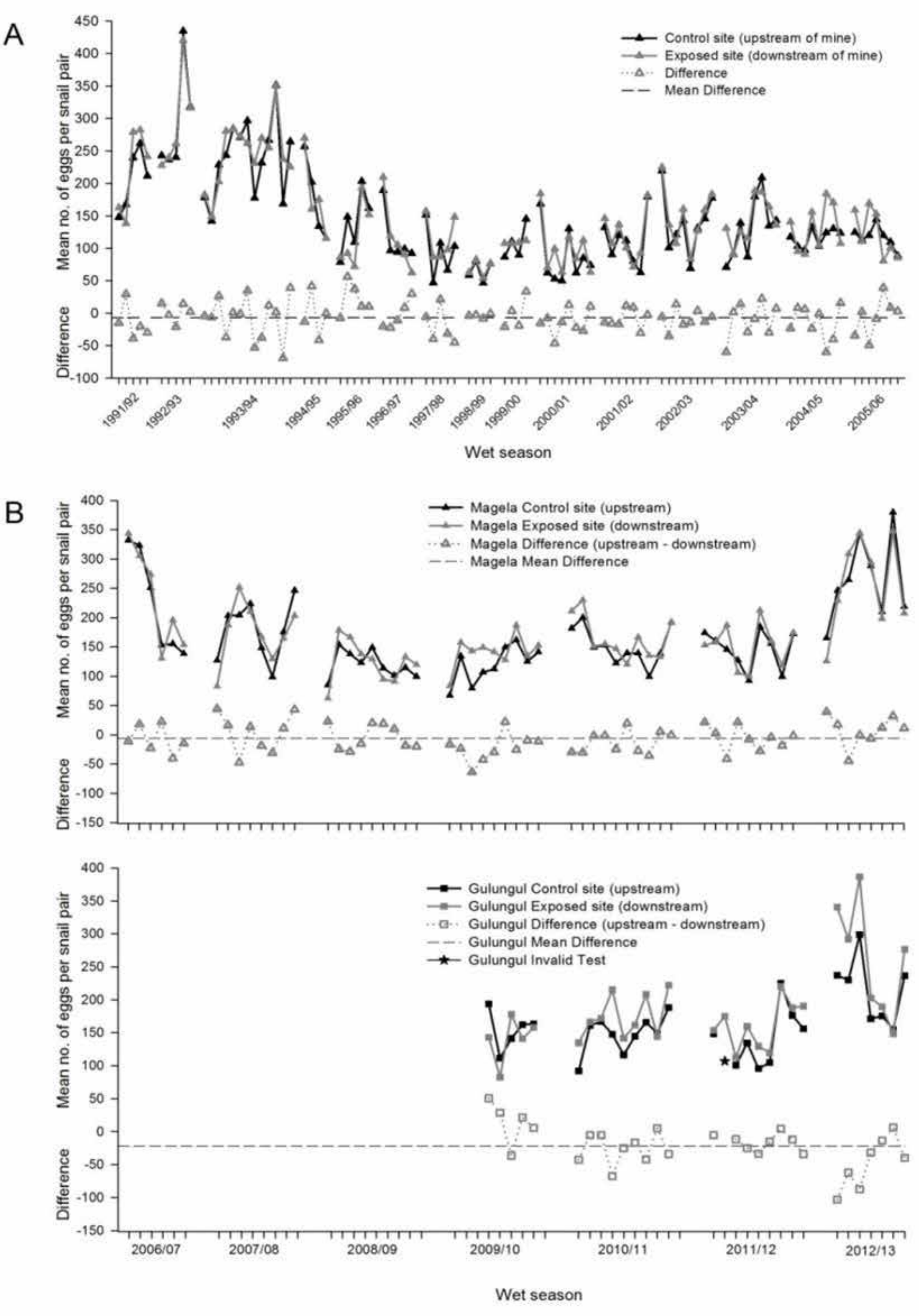


Figure 2 Time-series of snail egg production data from toxicity monitoring tests conducted in Magela Creek. A: creekside tests, and B: in-situ tests with Gulungul tests commencing in 2009–10 (from Humphrey, et al, 2013a).

Biological Monitoring: Fish Communities

Assessment of fish communities in billabongs is conducted between late April and July each sampling year, the precise time of the monitoring being dependent on flow regime, using non-destructive sampling methods at ‘exposed’ and ‘control’ locations. Two billabong types are sampled: deep channel billabongs every year and shallow lowland (mostly backflow) billabongs dominated by aquatic plants every two years (Supervising Scientist, 2012).

Across all tests (1991/92 to 2005/06) larval black banded rainbow fish survival at the upstream and downstream sites remained relatively constant over time (Figure 3) (Supervising Scientist, 2008).

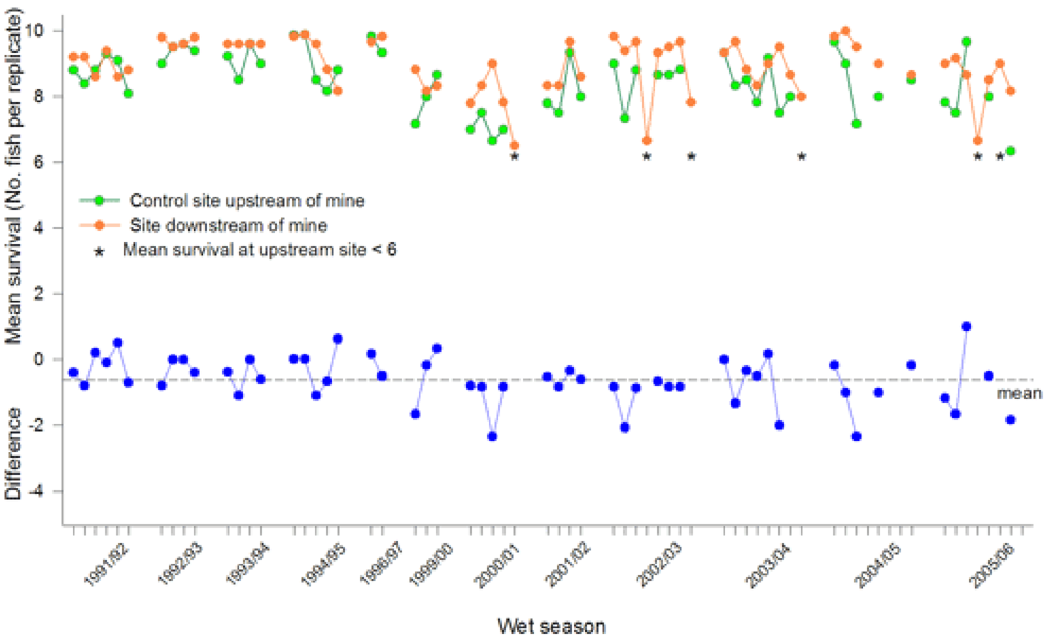


Figure 3: Toxicity monitoring results for larval black-banded rainbow fish survival for wet seasons between 1992 and 2006 (from Supervising Scientist, 2008).

The similarity of fish communities in Mudginberri Billabong (directly exposed site downstream of Ranger mine in Magela Creek catchment) to those of Sandy Billabong (control site in the Nourlangie Creek catchment) (Figure 4) is determined using multivariate dissimilarity indices calculated for each annual sampling occasion. A plot of the dissimilarity values from 1994 to 2013 is shown in Figure 5.

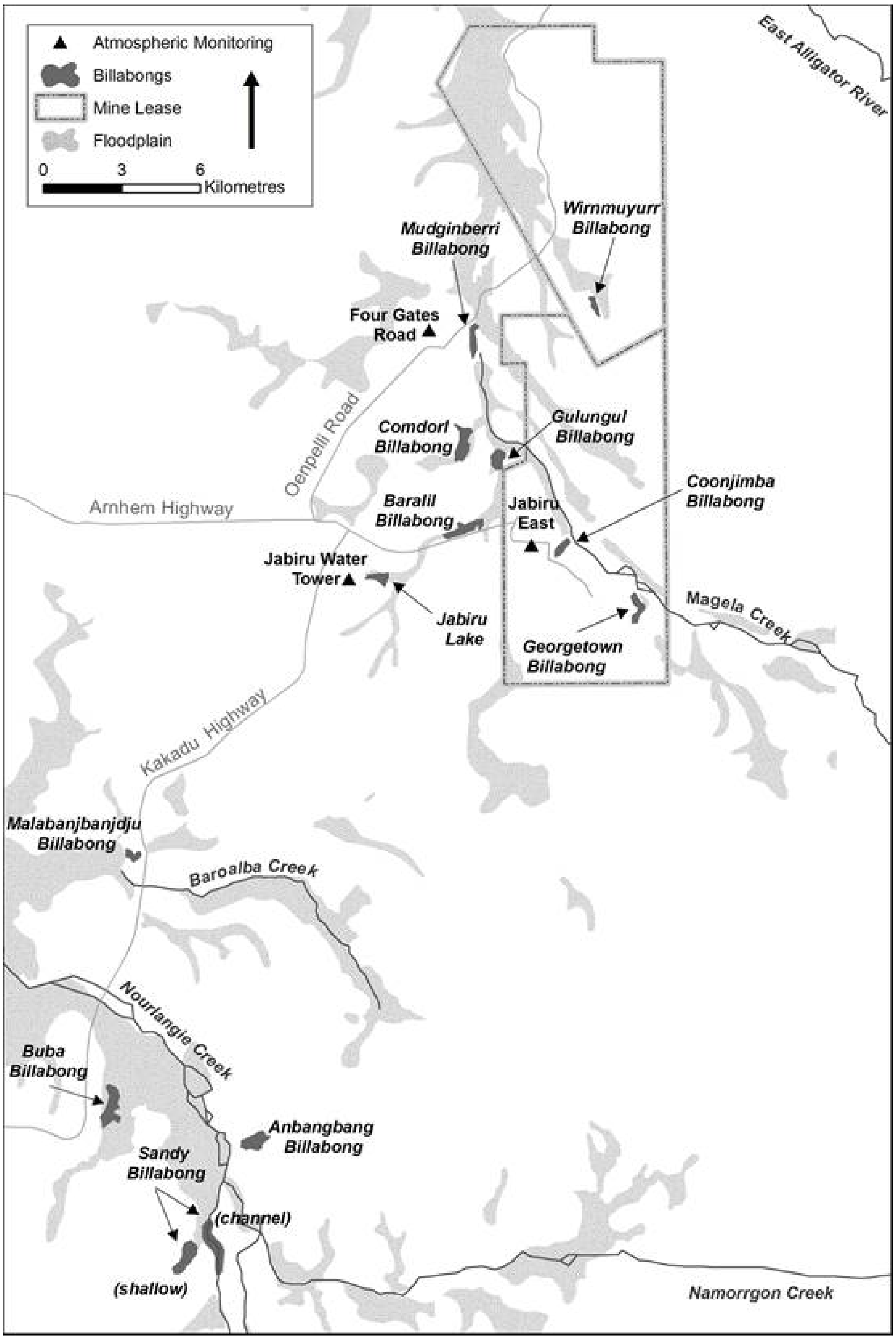


Figure 4: Billabongs used in SSD research and monitoring programs

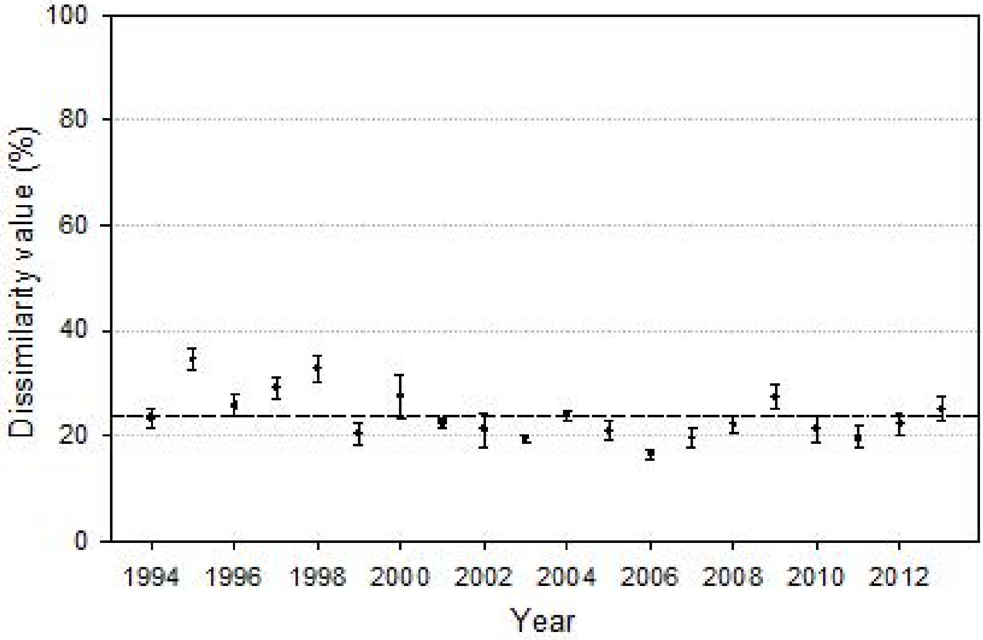


Figure 5: Paired control-exposed dissimilarity values (Bray-Curtis measure) calculated for community structure of chequered rainbowfish (Melanotaenia splendida inornata) in Mudginberri ('exposed') and Sandy ('control') Billabongs over time. Values are the mean dissimilarity (± standard error) of the 5 possible (randomly selected) pairwise comparisons of transect data between the two waterbodies. The dashed line is the mean dissimilarity over all years (1994-2013) (from Ellis & Humphrey, 2013).

The overall fish communities analyses **"*provide good evidence that changes to water quality downstream of Ranger as a consequence of mining during the period 1994 to 2013 have not adversely affected fish communities in channel billabongs*"** (Ellis & Humphrey, 2013)

Biological monitoring: macroinvertebrate community structure

Macroinvertebrate communities have been sampled from several sites in Magela Creek, after significant wet season flows, each year from 1988 to 2013. The design and methodology have been refined over this period (changes are described in Supervising Scientist, 2004). The present design is a balanced one comprising upstream and downstream sites at two 'exposed' streams (Gulungul and Magela Creeks) and two control streams (Burdulba and Nourlangie Creeks) (Figure 4). The dissimilarity values in Figure 6 shows there has been no change in community structure of macroinvertebrate families from 1988 to present.

Humphrey et al (2013b) concluded: ***"Collectively, the graphical and statistical results (for macroinvertebrate community structure) provide good evidence that changes to water quality downstream of Ranger as a consequence of mining during the period 1994 to 2013 have not adversely affected macroinvertebrate communities."***

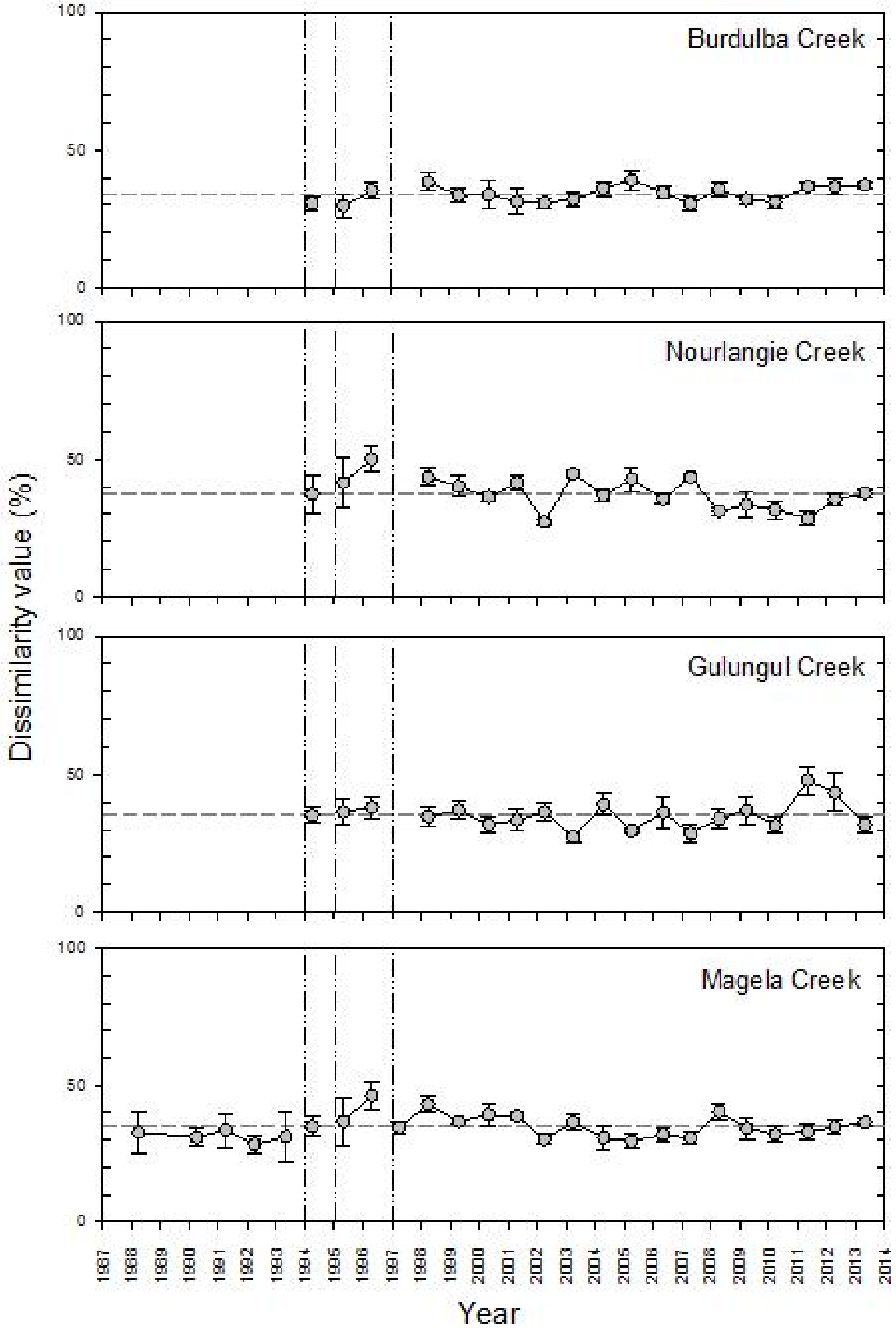


Figure 6: Paired upstream-downstream dissimilarity values (Bray-Curtis measure) calculated for community structure of macroinvertebrate families in several streams in the vicinity of the Ranger mine for the period 1988 to 2013. The dashed vertical lines delineate periods for which a different sampling and/or sample processing method was used. Dashed horizontal lines indicate mean dissimilarity across years. (Humphrey et al, 2013b).

Conclusions from biological monitoring programs:

The biological monitoring results from 1988 to present have shown that water quality downstream of Ranger mine has not adversely affected biological communities. The Supervising Scientist (2013) concluded: ***The measured responses of the snails during the 2012–13 wet season, combined with the results from monitoring of fish and macroinvertebrates conducted in the recessional flow period towards the end of the wet season, continue to confirm that the downstream aquatic environment remains protected from the effects of the mining of uranium at Ranger.***

Magela Creek Water Quality: electrical conductivity, magnesium, manganese, uranium and radium-226

Figure 7 shows the ranges of annual rainfall from 1971-72 to present. The annual average rainfall is 1,536 mm with the wettest during this period being 2006-07 and a relative dry period between 1985-86 and 1992-93, albeit the minimum rainfall was approximately 1,000 mm.

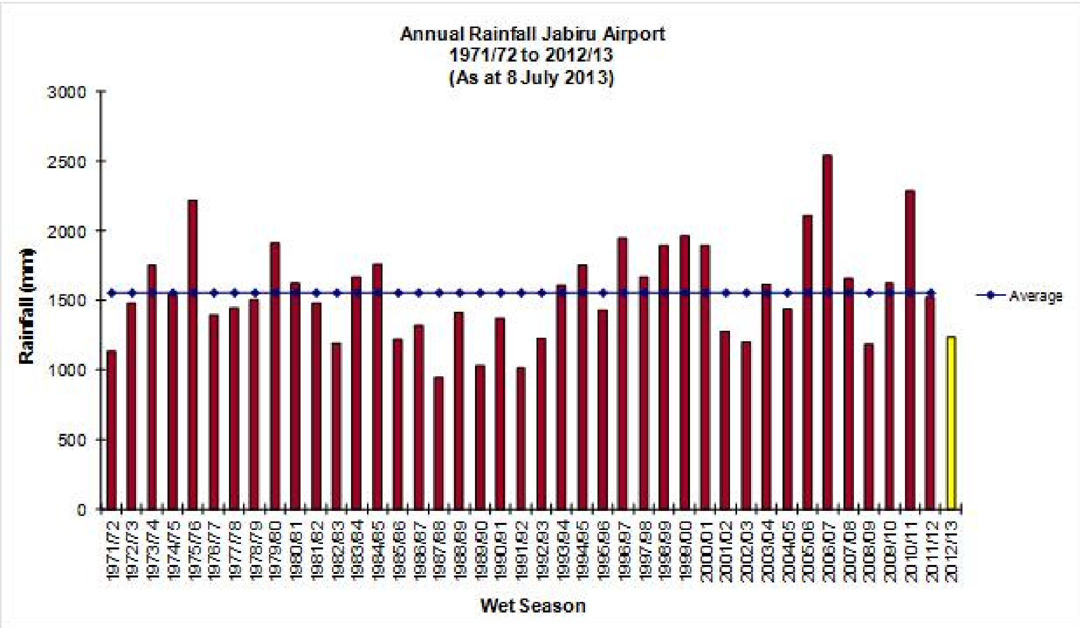


Figure 7 Annual rainfall Jabiru Airport 1971–72 to 2012–13 (data from Bureau of Meteorology) (Supervising Scientist, 2013)

Figure 8 shows the typical continuous electrical conductivity upstream and downstream in Magela Creek for the 2011-12 average wet season. The electrical conductivity downstream was generally higher than upstream and apart from a number of short term spikes downstream, the electrical conductivity remained below the electrical conductivity trigger value for continuous exposure of 42 µS/cm (equivalent to 3 mg/L magnesium). A peak in electrical conductivity of 54 µS/cm with a duration of 7 hours occurred at the downstream monitoring site on 4 December 2011 (refer Figure 1 Magela d/s). This was substantially lower than the 8 hour exposure duration trigger value of 174 µS/cm (14 mg/L magnesium) (Hogan et al, 2013). The electrical conductivity decreased during the wet season as a result of increased flows.

The falling hydrograph in Figure 8 shows recessional flow conditions that became established in Magela Creek during April 2012. This resulted in low and stable electrical conductivity upstream and downstream, with a slight rise approaching the cessation of flow in late June-July (Figure 8).

Figure 9 shows the electrical conductivity during one of the driest wet seasons on record with discharge <25 m^3/s except for a flood event on 31 March 2013. The low flows resulted in low electrical conductivity at the downstream site with a small increase following the flood event.

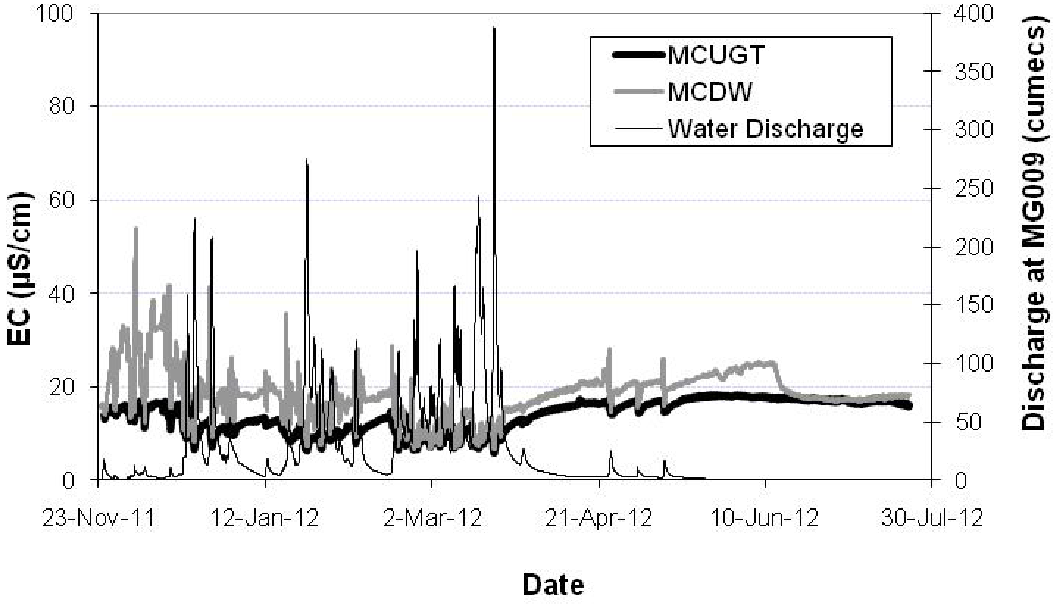


Figure 8: Continuous electrical conductivity and discharge in Magela Creek between November 2011 and July 2012 (Supervising Scientist, 2012)

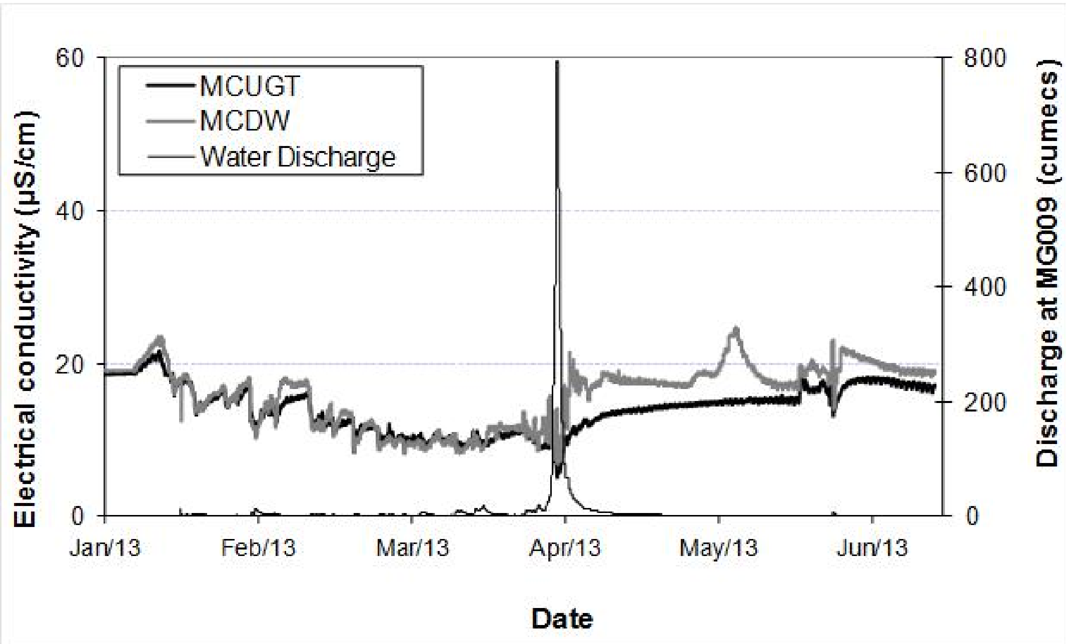


Figure 9: Continuous electrical conductivity and discharge in Magela Creek between January and June 2013 (Supervising Scientist 2013)

Figure 10 shows a comparison of electrical conductivity from 2008-09 to 2012-13 wet seasons. Overall, the electrical conductivity measured in Magela Creek was less than the trigger value of 42 µS/cm, with a few short duration exceedances of the trigger value.

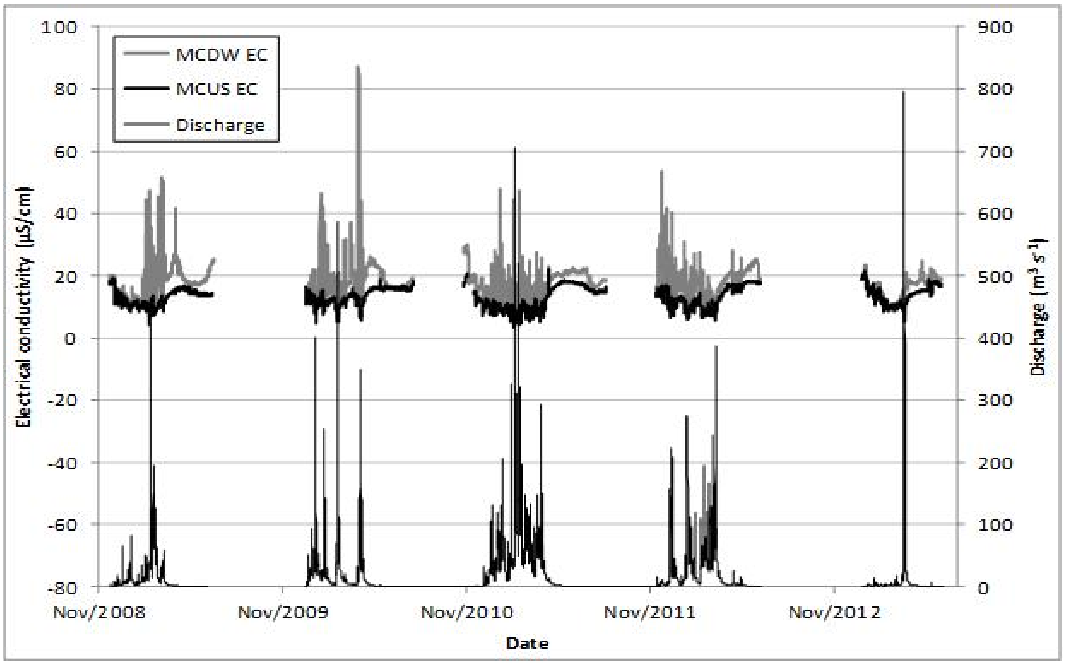


Figure 10: Continuous electrical conductivity measurements at the upstream (MCUGT) and downstream (MCDW) sites and discharge (lower trace) in Magela Creek between November 2008 and June 2013 (values averaged over a 90 minute period of measurement) (from Supervising Scientist, 2013.)

Magnesium concentrations, measured in automatically collected water samples closely followed the electrical conductivity continuous monitoring data with concentrations peaking during the electrical conductivity events at the downstream site (MCDW) (Figure 11). Except for the short duration peaks in electrical conductivity, the electrical conductivity remained around 20 µS/cm up and downstream of the mine site, well below the 42 µS/cm (corresponding to 3 mg/L magnesium) guideline.

Total manganese concentrations in water samples from Magela Creek upstream and downstream of Ranger mine for the past 3 wet seasons have been substantially lower than the trigger value Limit (75 µg/L) and below the action level of 45 µg/L even at the peak electrical conductivity events (Figure 12).

Total uranium concentrations are generally <0.2 µg/L downstream of Ranger mine with higher concentrations during peak electrical conductivity events, but concentrations were substantially lower than the uranium Limit of 6 µg/L Limit and below the Action level of 0.9 µg/L (Figure 13). These concentrations are similar to the filterable uranium concentration results from previous years (Supervising Scientist, 2012).

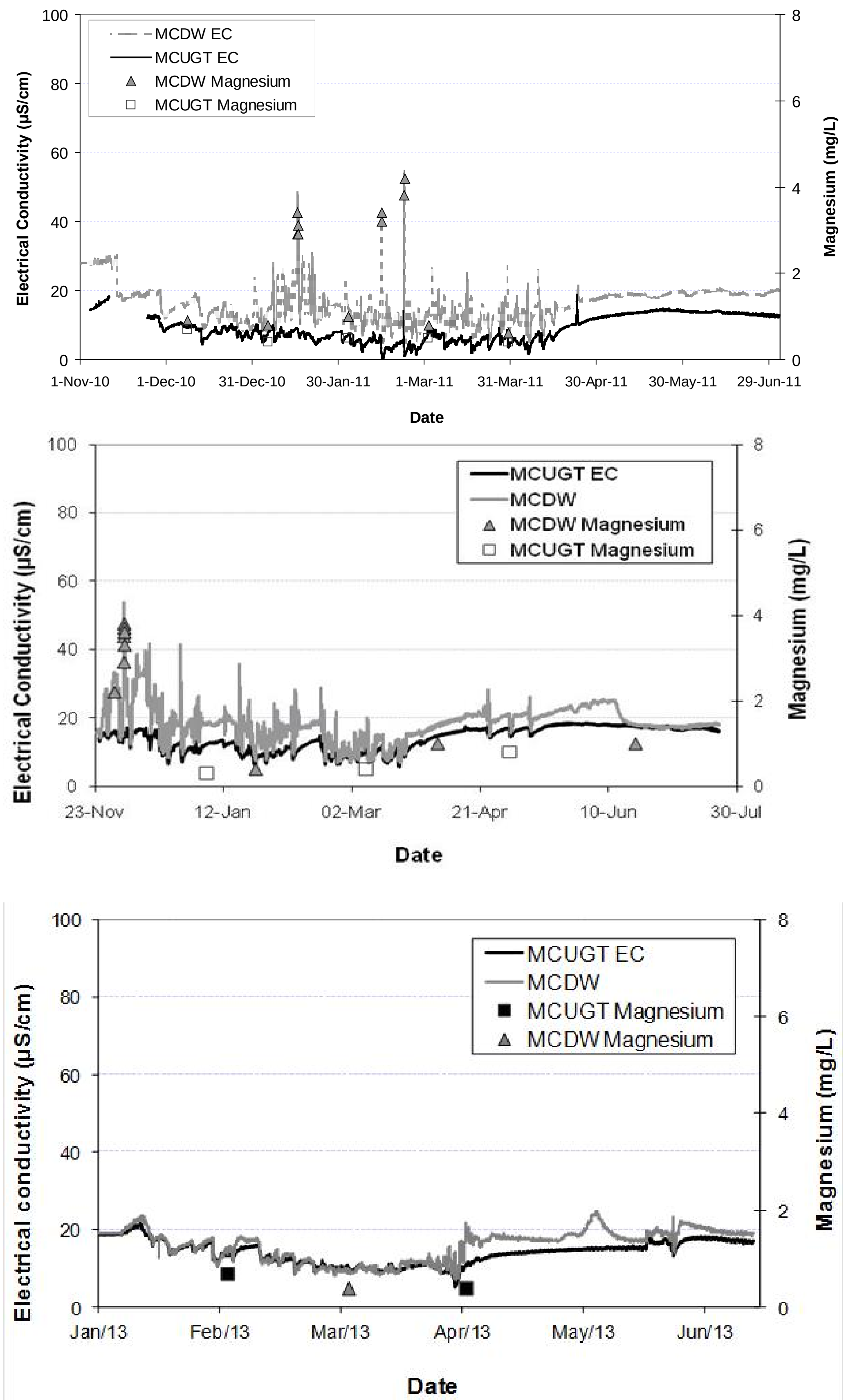


Figure 11: Total magnesium concentrations in triggered samples and continuous electrical conductivity in Magela Creek between November 2010 and July 2011 (Supervising Scientist, 2011), November 2011 and July 2012 (Supervising Scientist, 2012) and January and June 2013 (Supervising Scientist 2013)

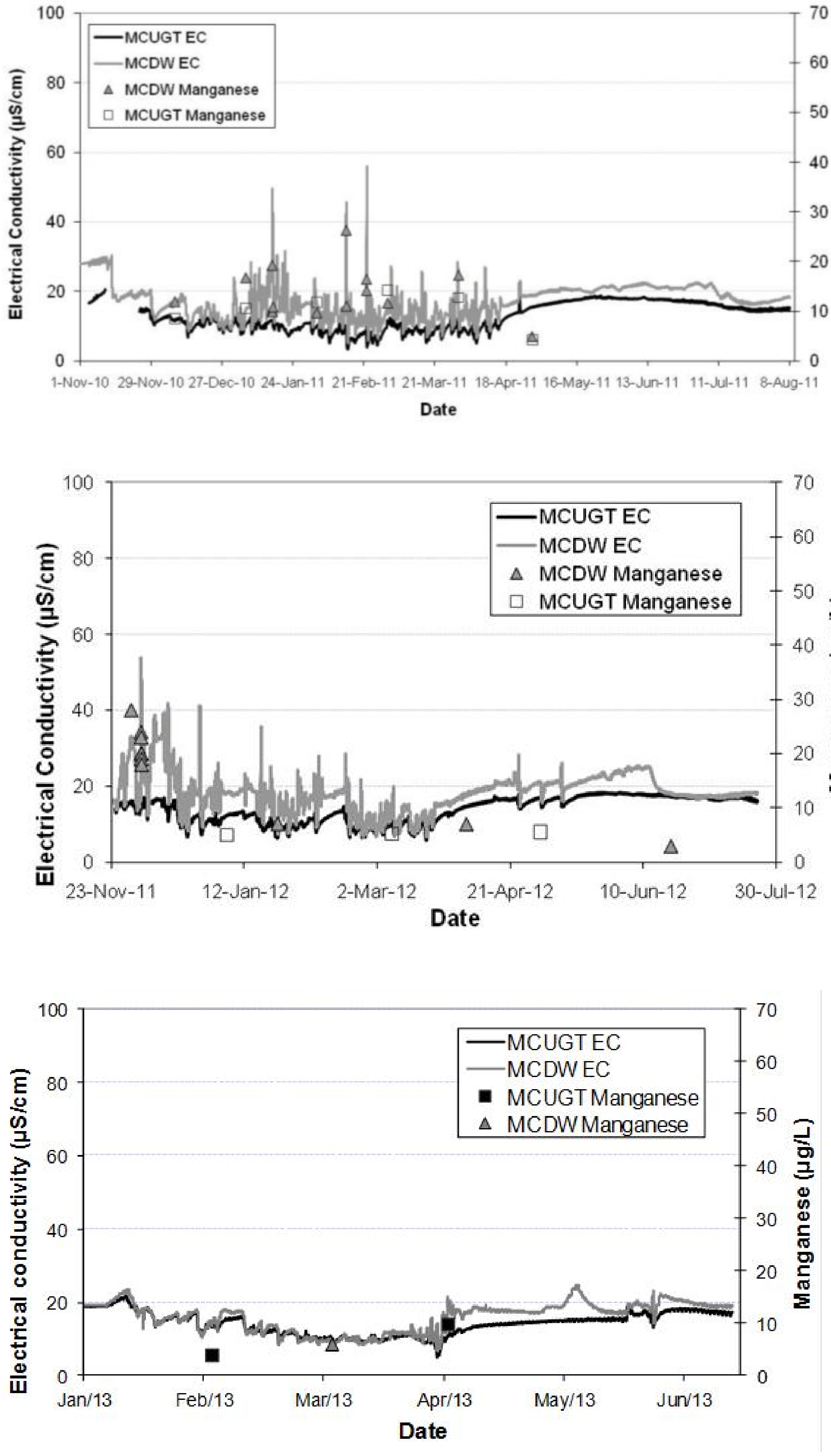
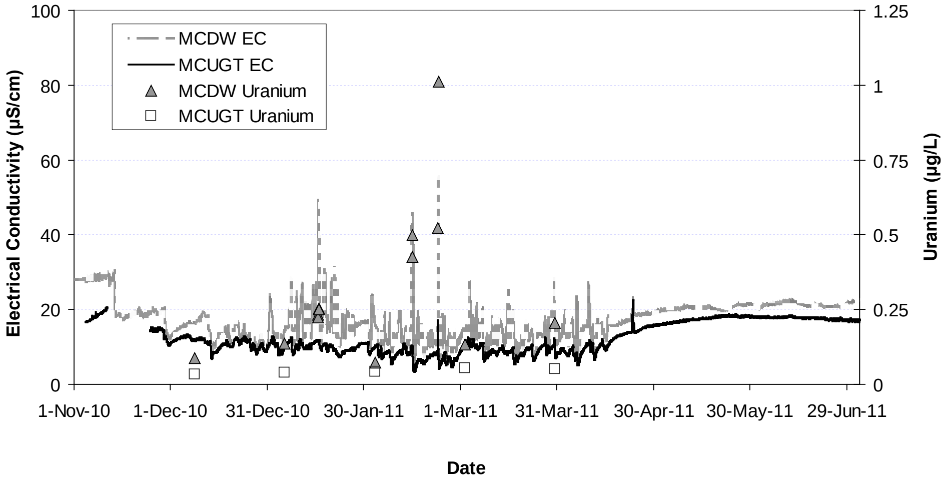
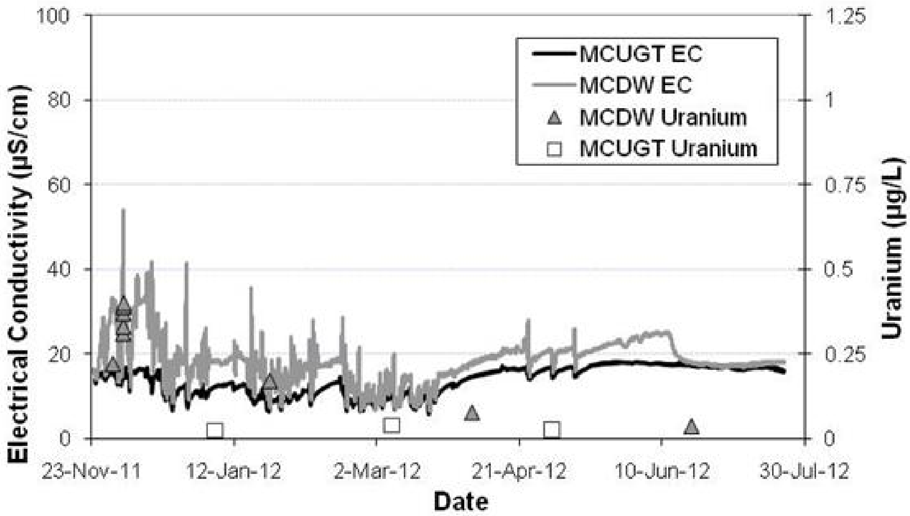


Figure 12: Total manganese concentrations in triggered samples and continuous electrical conductivity in Magela Creek between November 2010 and July 2011 (Supervising Scientist, 2011), November 2011 and July 2012 (Supervising Scientist, 2012) and January and June 2013 (Supervising Scientist 2013)





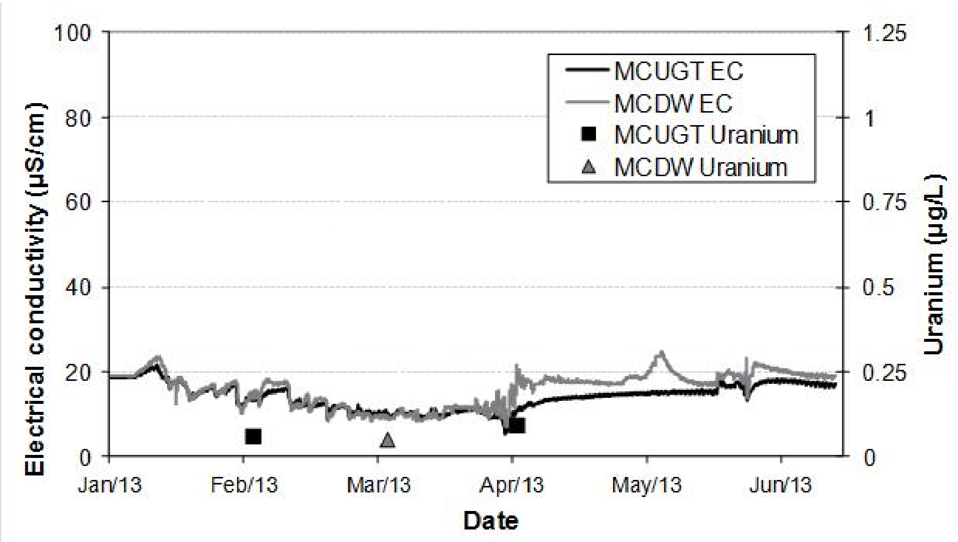


Figure 13: Total uranium concentrations in triggered samples and continuous electrical conductivity in Magela Creek between November 2010 and July 2011 (Supervising Scientist, 2011), November 2011 and July 2012 (Supervising Scientist, 2012) and January and June 2013 (Supervising Scientist, 2013)

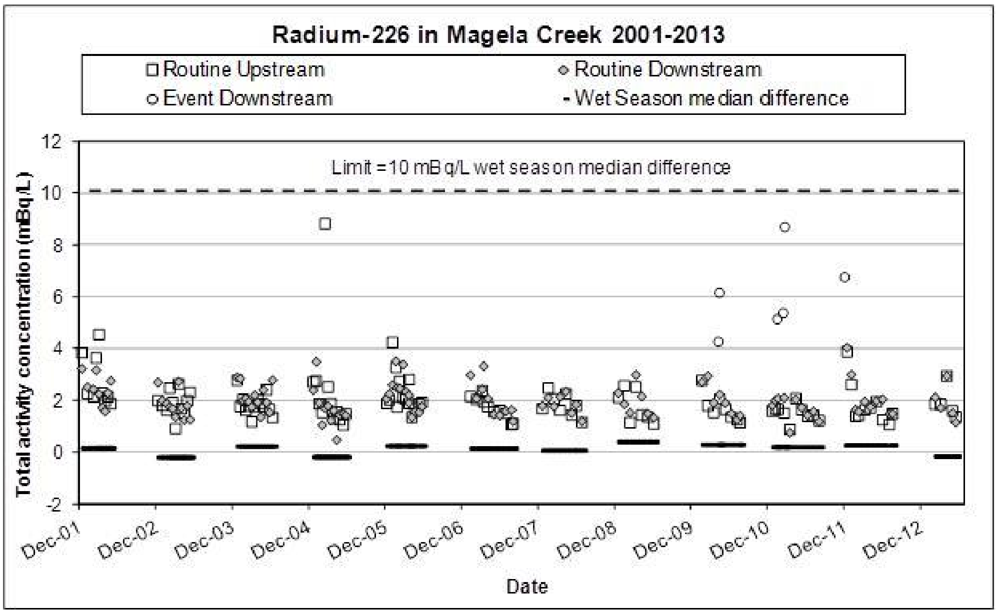


Figure 14: Radium-226 in Magela Creek 2001–2013 (Supervising Scientist 2013)

Wet season median differences for radium-226 (shown by the horizontal lines in Figure 14) from 2001 to 2013 are close to zero, indicating that the majority of radium-226 is coming from natural sources of radium located in the catchment upstream of the mine. The wet season median difference for the entire monitoring period (2001–2013) was only 0.1 mBq/L (Supervising Scientist, 2013).

Conclusion: Water Quality

The Supervising Scientist (2013) concluded, as in previous Annual Reports, that **"*the*** (water quality) ***results indicate that the aquatic environment in the creek*** (Magela and Gulungul) ***has remained protected from mining activities*"**.

Bioaccumulation in freshwater mussels (Supervising Scientist, 2013)

Local Aboriginal people harvest fish and mussels from Mudginberri Billabong, 12 km downstream of the Ranger mine (Figure 4). The concentrations of uranium in mussels from Mudginberri Billabong and a control billabong (Sandy Billabong) have been measured since 2000. The uranium concentration in the Mudginberri Billabong water has remained low and concentrations in mussels have been very similar from 2000 onwards, with no evidence of an increasing trend in concentration over time (Figure 15). Essentially constant and low levels were also observed between 1989 and 1995 (Supervising Scientist, 2013). Supervising Scientist (2013) concluded: ***the low and constant uranium concentrations up to the last sample taken in October 2012 indicate absence of any mining influence.***

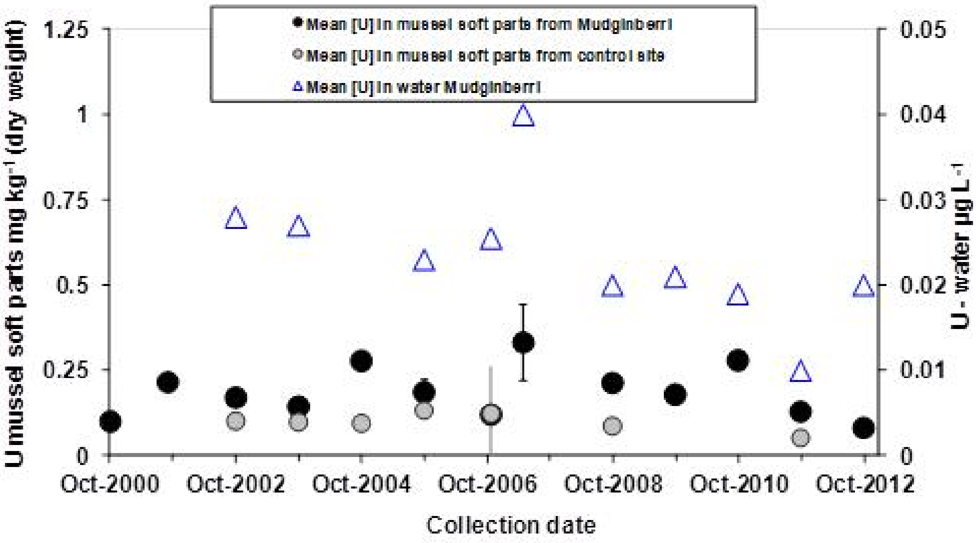


Figure 15: Mean concentrations of uranium measured in mussel soft-parts and water samples collected from Mudginberri and Sandy Billabongs since 2000 (Supervising Scientist, 2013).

Conclusions from SSD monitoring programs

The SSD use an integrated monitoring program that provides multiple lines of evidence. This program has a range of biological monitoring, including *in-situ* toxicity monitoring and ecosystem level response with annual assessment of fish and macro-invertebrate communities, together with physicochemical monitoring, including surface water chemistry and continuous monitoring (pH, electrical conductivity, turbidity and flow).

These programs have been developed over nearly 30 years and are leading practice. The 30 years of multiple lines of evidence show that during the operational phase, the mine derived constituents of potential concern (including magnesium, uranium, manganese and radium-226) have not adversely affected the water quality, or the abundance, diversity and quality of aquatic organisms, downstream of Ranger mine.

3.1.2 ERA Programs

ERA conducts a water quality monitoring program that is similar to the SSD monitoring program. Of particular relevance to the current assessment are the reviews of Klessa (2000 and 2005).

Klessa (2000) derived baseline water quality data for Magela Creek based on:

- Ranger water quality data base;
- NT Department of Mines and Energy (DME) check monitoring water quality database; and
- NT Water Resources Division (WRD).

The majority of water samples were taken upstream of Ranger mine from site GS8210067. In addition the DME data are independent of the Ranger mine data. The WRD data from site GS009 collected before the 1976-77 wet season is pre-mining data. The baseline data in Table 2 was derived from Ranger and DME data bases from sites GS028 and GS067 and WRD site GS009 data base.

Table 2 Baseline values at median, 20th and 80th percentiles and range (Klessa, 2000)

Parameter	20th percentile	80th percentile	Median	Minimum	Maximum
magnesium (mg/L)	0.41	0.88	0.64	0.05	8.10
uranium (µg/L)	0.05	0.30	0.10	0.013	24.95
radium-226 (mBq/L)	1.0	18.0	3.0	0.6	43.2
manganese (µg/L)	3.3	10.4	5.60	0.5	180.0
ammonia (mg/L)	0.01	0.025	0.01	0.01	0.18
nitrate (mg/L)	0.01	0.05	0.03	0.002	0.43

Klessa (2005) analysed the Magela Creek monitoring data to produce a balance sheet over 4 wet seasons (1999 – 2003) to account for magnesium sulfate entering Magela Creek from the Ranger site.

This review correlated the downstream water quality data with the corresponding upstream water quality data. These data showed that at the end of the wet season, upstream of Ranger mine, waters have elevated magnesium and electrical conductivity. This implies a base-flow water source with higher ionic strength than the predominantly allogenic surface water flow observed earlier in the wet season.

Upstream Magela Creek data (from 1993 to 2003) showed that magnesium concentrations varied from approximately 1mg/L at low flow to <0.1mg/L at flow rates that exceeded 100 m^3/s. Corresponding sulfate concentrations ranged from approximately 0.1 to 1 mg/L but did not show the same negative correlation with flow rate. Electrical conductivity showed the same trend as magnesium, with electrical conductivity decreasing with increasing flow rates from approximately 20 µS/cm to 5 µS/cm.

Generally electrical conductivity and magnesium variation follows the hydrological phases of flow, which is a decrease in concentration from start of wet season to a minimum near mid-wet season, followed by a subsequent increase to end of wet season. The electrical conductivity and magnesium concentrations in surface water at the start and end of the wet season are similar. This observation by Klessa (2005) is consistent with the outcomes of the Supervising Scientist Division monitoring program.

Downstream of the Ranger mine at MG009 (data from 1993 to 2003), the magnesium concentration and electrical conductivity were relatively constant (approximately 1mg/L and 15 µS/cm respectively) at flow rates <10m^3/s. At higher flow rates the magnesium concentration and electrical conductivity decreased to approximately 0.2mg/L and 5 µS/cm, respectively. Magnesium exceeded 3 mg/L (3-4mg/L) in 1993-94 and 1994-95 wet seasons, with corresponding electrical conductivity of 40-50 µS/cm, attributed to sub-optimal release of mine waters (Retention Pond 4 and Djalkmarra releases).

Loads:

Estimated downstream (MG009) loads of magnesium and sulfate were two and three times higher, respectively, than the estimated loads at the upstream site (MCUS) (Table 3). The average annual mine derived magnesium load (2005 – 2012) was 203 tonnes. The average annual mine derived magnesium load (1999-2012) was 179 tonnes. The data shows that the magnesium loads between 2005 and 2011 varied, generally correlated with wet season flows.

Use of ERA monitoring data from 1993 – 2003 from upstream (MCUS) and downstream (MG009) of Ranger showed variations in concentrations of dissolved salt (measured as electrical conductivity), magnesium, sulfate and manganese related to flow rate and temporal influences. The effects of mining activities were derived from correlations of downstream and upstream water quality data in relation to flow rate.

Klessa (2005) reconciled the total load export of magnesium and sulfate from Ranger lease at MG009, "whole of mine" influence, against point source inputs (Corridor Creek via Georgetown Billabong, RP1 release waters and Djalkmara release waters) and diffuse source inputs (runoff from the Magela and Djalkmara LAA). Klessa (2005) concluded that the mean incremental effect of the Ranger mine lease on solute concentration is small over the measured ranges of upstream solute concentrations. These results and the Supervising Scientist Division findings of no adverse impact of mining influence illustrate the capacity of the Magela Creek ecosystem to assimilate magnesium loads of this magnitude.

Table 3: Magnesium and sulfate loads (tonnes) in Magela Creek

Parameter	year	Load at MCUS (tonnes)	Estimated load at MG009 (tonnes)	Point + diffuse inputs (tonnes)***	Mine derived Load (tonnes)	Mine site contribution %
magnesium	1999-00#	181	363	354	182	50
	2000-01#	169	345	339	176	51
	2001-02#	76	148	269	72	49
	2002-03#	111	224	331	113	50
	2005-06*	168	377	348	209	55
	2006-07*	135	510	454	375	74
	2007-08*	*100*	*364*	*490*	*264*	*73*
	2008-09*	75	173	172	98	57
	2009-10*	*130*	*277*	*921*	*147*	*53*
	2010-11*	180	399	374	219	55
	2011-12*	160	268	276	108	40
sulfate	1999-00#	113	367	677		
	2000-01#	126	392	936		
	2001-02#	52	175	759		
	2002-03#	80	258	917		

#Klessa 2005;
* Turner et al 2013.
**Loads calculated using cross channel gradient (loads calculated using west channel discharge)
***Point + diffuse inputs = upstream, corridor Creek, RP1, Djalkmarra, MLAA, DLAA.

3.2 Derivation of site specific trigger values

The SSD has derived site specific water quality guidelines for magnesium, uranium and manganese in Magela Creek water (Supervising Scientist Division, 2013). The derivation was based on the ANZECC/ARMCANZ (2000) recommended methods which are considered to provide the most comprehensive guidance and can be considered a leading practice approach. Species sensitivity distributions based on a minimum of six local species toxicity data were used to derive the site specific water quality guidelines. The local species toxicity test methods were developed at ERISS as part of their research and monitoring programs.

van Dam et al (2010) assessed the toxicity of magnesium sulfate to six local freshwater species. Magnesium was found to be the toxic ion and that toxicity was reduced with increasing calcium concentration. A magnesium site specific water quality guideline for 99%

species protection of 2.5 mg/L was derived based on a magnesium/calcium mass ratio of ≤ 9:1. The value has subsequently been rounded up to 3 mg/L. Any increase in the magnesium/calcium ratio would result in an increased toxicity of magnesium.

Hogan et al (2013) conducted further toxicity studies of magnesium pulse exposures in Magela Creek water. The study derived site specific water quality guidelines for 99% species protection for 4 hour, 8 hour and 24 hour magnesium pulse exposures (Table 4). The data was used to generate a site specific water quality guideline versus exposure duration model (Figure 16).

The uranium trigger value for 99% species protection of 6 µg/L was derived using the same approach. A revised site specific uranium trigger value is presently being derived by ERISS using toxicity data from seven local species, and incorporating a dissolved organic carbon correction factor (Supervising Scientist Division, 2013).

A manganese ecotoxicology-based trigger value of 75 µg/L was derived using data from six local species and 3 non-local species (Supervising Scientist Division, 2013). This is a conservative value when compared to the existing biological effects literature and the proposed predicted no effect concentration of 123 µg/L for Europe (Peters et al, 2010).

The SSD has derived an interim site specific 99% species protection trigger value for total ammonia nitrogen in Magela Creek of 0.7 mg/L (Supervising Scientist Division, 2013). This is based on a large body of international literature on ammonia toxicity, including Australia and New Zealand (ANZECC/ARMCANZ 2000) Canada (Environment Canada, 2010), the UK (UKTAG, 2007) and the USA (USEPA, 2013).

The Trigger Values are summarised in Table 1 in Section 3.1 above.

Table 4: Water quality trigger values for magnesium and electrical conductivity for different exposure durations (source: Hogan et al. 2013).

Exposure duration	magnesium (mg/L)	Electrical conductivity (µS/cm)
4 hours	94	1140
8 hours	14	174
24 hours	8	102
Continuous (3-6 days)	3	42

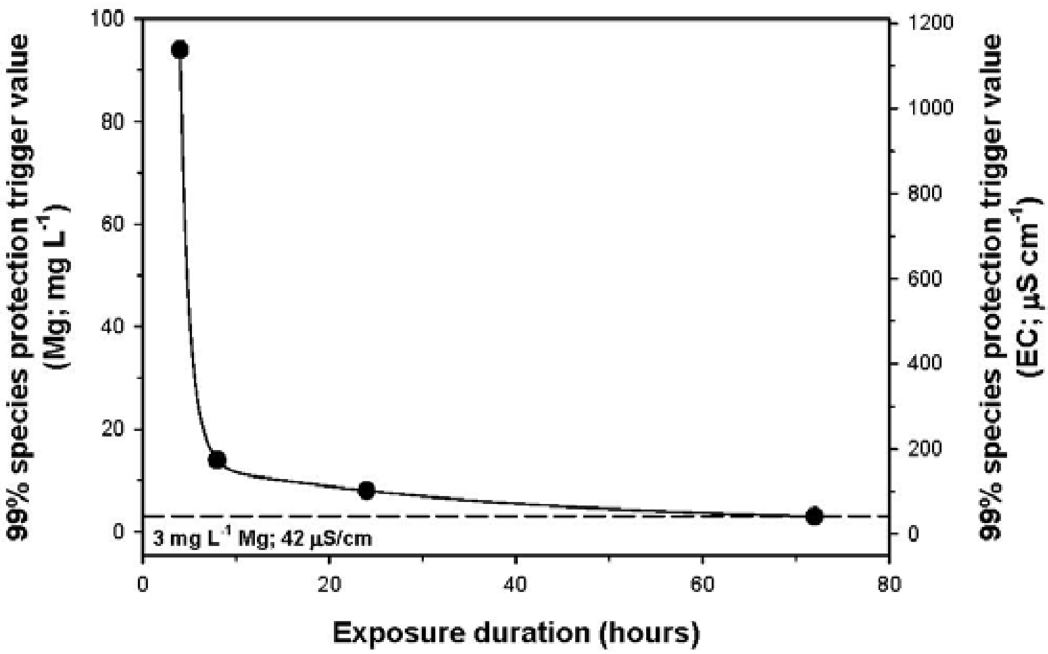


Figure 16: Relationship between water quality trigger value expressed as magnesium (mg/L) and electrical conductivity (µS/cm) and exposure duration. The chronic exposure trigger value of 3 mg/L or 42 µS/cm (horizontal broken line) is shown for comparison (source: Hogan et al. 2013).

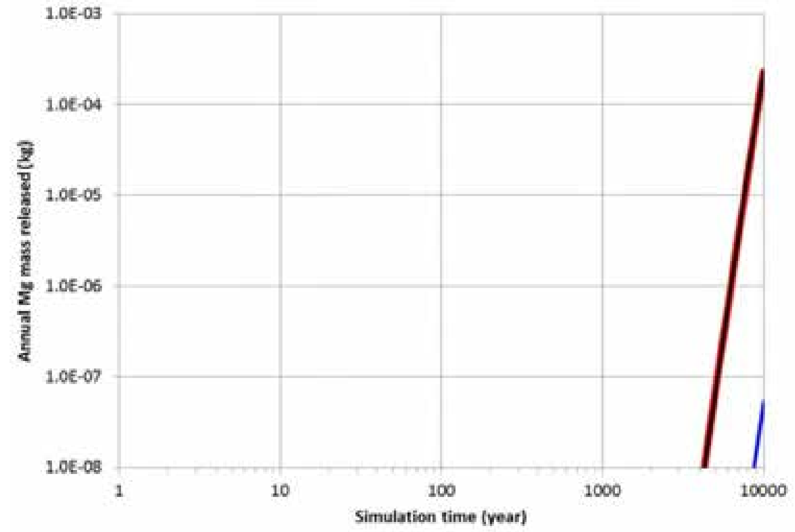
4. Groundwater – solute transport modelling for Ranger 3 Deeps

INTERA (2014) constructed a predictive three-dimensional numerical model of groundwater flow and conservative solute transport from the cemented paste aggregated fill with tailings backfill and the cemented rock fill, and applied it to quantify estimates of loading rates of constituents of potential concern from the Ranger 3 Deeps backfill to Magela Creek. The concentrations of constituents of potential concern predicted to leach from the cement and mineral mixtures that are proposed to be used in the Project backfill was conservatively assumed to leach at the same concentrations as the component mine wastes. This is a conservative assumption as the cement additives would be expected to lower the concentrations of the constituents of potential concern compared to crushed rock or tailings without cement.

The groundwater model provided a quantitative estimation of the magnesium load that may subsequently enter Magela Creek after closure of Ranger 3 Deeps. Figure 17 shows the annual magnesium mass predicted to be released from backfill in stopes, decline and vents via groundwater seepage (exfiltration) and groundwater discharge (base flow) up to 10,000 years after closure. The predicted concentrations of magnesium from all three sources are negligible.

In order to estimate the annual long-term loading of reactive solutes, uranium, manganese, radium-226, total ammonia nitrogen, nitrate, total phosphorus and polonium-210, a scaling factor was applied relative to the magnesium long-term source concentration (INTERA, 2014). The predicted loads are in Table 5.

A



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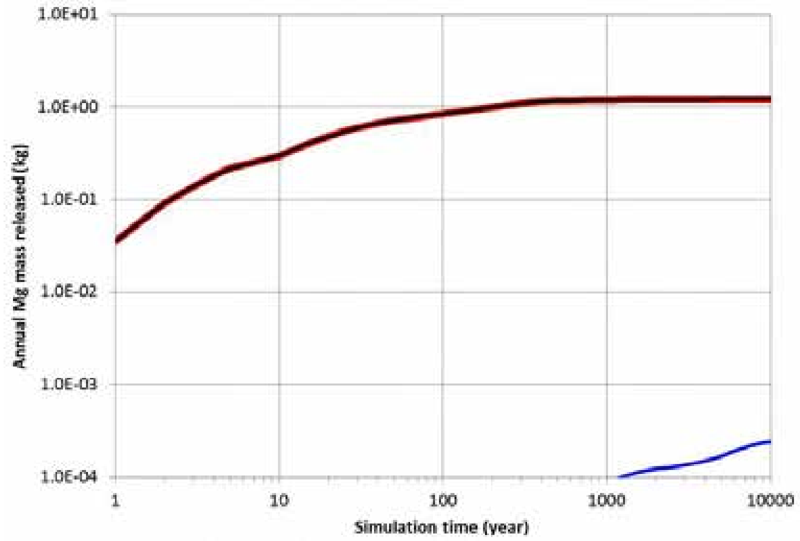

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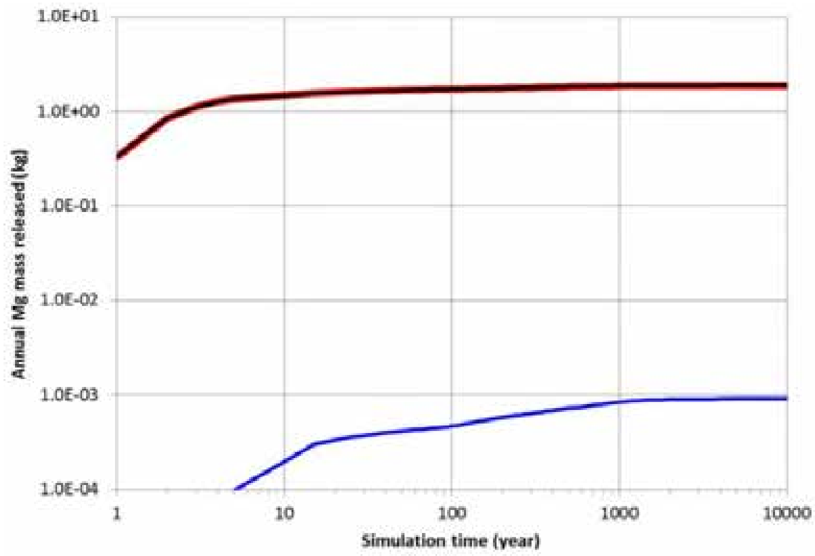

Figure 17: Magnesium loading from Ranger 3 Deeps to Magela Creek from: A: Cemented paste aggregated fill with tailings in stopes; B: cement rock fill in decline; C: cement rock fill in vent shaft. Exfiltration (blue) Base flow (red) (source: INTERA, 2014)

Table 5: Long term annual loading of reactive and non-reactive solutes to Magela Creek from Project sources (INTERA, 2014).

Constituents of potential concern	Unit	Project sources
Magnesium	kg/yr	3.1
Uranium	GBq/yr	1.2×10^{-5}*
Manganese	kg/yr	$2.3x10^{-3}$
Radium-226	GBq/yr	$4.4x10^{-6}$**
Total ammonia nitrogen as N	kg/yr	$7.1x10^{-3}$
Nitrate as N	t/yr	$2.4x10^{-5}$
Total phosphorus as P	t/yr	$3.1x10^{-6}$
Polonium-210	GBq/yr	$1.64x10^{-10}$***

*uranium = 4.6E-04 kg/yr; activity calculated from mass as 25 MBq/kg
**radium-226 = 1.2E-10 kg/yr; activity calculated from mass as 37 GBq/g
***polonium-210 = 9.9E-19 kg/yr; activity calculated from mass as 166 GBq/mg

5. Assessment of potential impacts of solutes entering Magela Creek from Ranger 3 Deeps closure

The Ranger Environmental Requirements define ***Detrimental environmental impact*** to mean *any impact arising from the mining operation, whether direct or indirect, which causes or is likely to cause a change to biodiversity, or impairment of ecosystem health. Such change is to be different and detrimental from that expected from biophysical or biological processes operating in the Alligator Rivers Region.*

If this is interpreted to mean no observable or measureable adverse effects, then the multiple lines of evidence acquired from the 30 years of research and monitoring programs of the Supervising Scientist, ERA and others, as detailed in Sections 3.1.1 and 3.1.2, demonstrate there has been no detrimental impact to the off-site environment during the operational phase of the Ranger mine. Several of these lines of evidence are based on measureable quantitative limits, including, additional annual load limits and trigger values for 99% species protection. These quantitative measures provide guidance for assessment of the potential impacts of constituents of potential concern that are predicted to enter Magela Creek in groundwater egress from Ranger 3 Deeps post-closure. Therefore this assessment is based on the acquisition of a number of lines of evidence, including solute loads and solute concentrations

Solute Loads

Table 6 compares the predicted loads of constituents of potential concern from all the Ranger 3 Deeps sources, with the measured operational loads and additional annual load limits. With the exception of magnesium operational loads, the reactive constituents of potential concern operational loads are calculated based on concentrations and volumes leaving the Ranger mine, not on concentrations passing a point in the creek.

The predicted long term annual groundwater magnesium load of 3.1kg would be 0.0015% and 0.002% of the mean annual (2005 – 2012) mine derived magnesium load that has been observed during the history of the current mine operation (Table 6), and the background magnesium load measured upstream of the mine influence (Table 3), respectively. Similarly, all other annual loads of constituents of potential concern from the Project would be between 0.04% to $4.1x10^{-7}$% of mean annual mine derived loads. In comparison to the additional annual load limits, the predicted annual loads of constituents of potential concern would be between four and eight orders of magnitude lower than the additional annual load limits. These constituents of potential concern loads will have a negligible impact on Magela Creek loads.

Table 6: Mean annual operational loads for constituents of potential concern from the RPA compared to predicted annual loads from the Project and Additional Annual Load Limits

Constituents of potential concern	Units	Annual loads: Project sources	RPA mean annual loads: 2002-2013	Additional Annual Load Limits
Magnesium	kg/yr	3.1	203,000*	N/A
Uranium	GBq/yr	$1.2x10^{-5a}$	1.87**	88
Manganese	t/yr	$2.3x10^{-6}$	0.064**	6
Radium-226	GBq/yr	$4.4x10^{-6b}$	0.13**	13
Total ammonia nitrogen as N	kg/yr	$7.1x10^{-3}$	ND	N/A
Nitrate	t/yr	$1.1x10^{-4}$	0.15**	4.4
Phosphate	t/yr	$3.1x10^{-6\#}$	0.008**	2.8
Polonium-210	GBq/y	$1.64x10^{-10c}$	0.04**	7

*Mean 2005 – 2012: calculated from continuous monitoring data
**calculated from concentrations and volumes from Retention Pond 1, Corridor Creek (GC2) and Djalkmarra Billabong/pumping station (Iles, 2014)
a. uranium = 4.6E-04 kg/yr; activity calculated from mass as 25 MBq/kg
b. radium-226 = 1.2E-10kg/yr; activity calculated from mass as 37 GBq/g
c. polonium-210 = 9.9E-19 kg/yr; activity calculated from mass as 166GBq/mg
#Total phosphorus

Solute Concentrations

Predictions of concentrations of the constituents of potential concern in Magela Creek can be made based on the loads predicted by INTERA (2014). This is a conservative approach that assumes all the constituents of potential concern behave conservatively. In other words they remain dissolved in groundwater and surface water, and the concentrations are unaffected by biogeochemical or physical processes along the flow path. However, some attenuation of at least the reactive constituents of potential concern, uranium, manganese, radium-226, total ammonia nitrogen and nitrate, are expected to occur.

Concentrations have been predicted based on two scenarios:

- Scenario 1: considered to be a worst case scenario, with the annual load discharged to Magela Creek in 24 hours at the start of the wet season flow in Magela Creek, with a low creek flow of 1m^3/s (24 hour flow of 86,400 m^3).
- Scenario 2: considered to be an average case, with the annual load discharging over an average Magela Creek wet season flow of 382 GL.

These two scenarios would result in the concentrations shown in Table 7. These concentrations are negligible, and would be unmeasurable above the baseline concentrations for both scenarios (Table 7).

Table 8 compares the predicted concentrations of the constituents of potential concern with the corresponding trigger values, for 99% species protection, albeit there are not trigger values for all constituents of potential concern. The predicted concentrations for the worst case scenario (scenario 1) are between two and four orders of magnitude below the corresponding trigger values (Table 8).

Table 7: Baseline values at median, 20th and 80th percentiles (Klessa, 2000), compared to predicted concentrations above background from Project sources

Parameter	20th percentile	Median	80th percentile	Project sources: Scenario 1*	Project sources: Scenario 2**
Magnesium (mg/L)	0.41	0.64	0.88	0.036	8.1×10^{-6}
Uranium (µg/L)	0.05	0.10	0.30	5.3×10^{-3}	1.2×10^{-6}
Radium-226 (mBq/L)	1.0	3.0	18.0	5.1×10^{-2}	1.2×10^{-5}
Manganese (µg/L)	3.3	5.60	10.4	2.66×10^{-2}	6.05×10^{-6}
Ammonia (mg/L)	0.01	0.01	0.025	8×10^{-5}	1.9×10^{-8}
Nitrate (mg/L)	0.01	0.03	0.05	2.8×10^{-5}	6.3×10^{-8}

*Scenario 1 = based on load discharged to Magela Creek in 24 hours with creek flow of 1 m^3/s (24 hour flow of 86,400 m^3).

**Scenario 2: based on load discharged to Magela Creek over a mean annual flow of 382 GL (Moliere et al, 2008)

Table 8: Predicted concentrations, above background, of constituents of potential concern in Magela Creek from Project sources compared to Water Quality Objectives (Trigger Values) for Magela Creek.

Constituents of potential concern	Project sources: Scenario 1*	Project sources: Scenario 2**	Trigger Values			
			Focus	Action	Guideline	Limit
Magnesium (mg/L)	0.036	8.1×10^{-6}	1.0	2.0	N/A	3.0 (≥ 72 hour limit)
Uranium (µg/L)	5.3×10^{-3}	1.2×10^{-6}	0.3	0.9	N/A	6.0
Manganese (µg/L)	2.66×10^{-2}	6.1×10^{-6}	35	45	N/A	75
Radium-226 (mBq/L)	5.1×10^{-2}	1.2×10^{-5}	N/A	N/A	N/A	10 mBq/L (wet season median difference)
Total ammonia nitrogen as N (mg/L)	8×10^{-5}	1.9×10^{-8}	0.1	0.3	0.7	N/A
Nitrate as N (µg/L)	2.8×10^{-2}	6.3×10^{-5}	NTV	NTV	NTV	10***
Total phosphorus as P (µg/L)	3.6×10^{-2}	8.1×10^{-6}	NTV	NTV	NTV	10***
Polonium-210 (Bq/yr)	1.9×10^{-9}	4.3×10^{-13}	NTV	NTV	NTV	NTV

*Scenario 1 = based on load discharged to Magela Creek in 24 hours with creek flow of 1 m^3/s (24 hour flow of 86,400 m^3).
**Scenario 2: based on load discharged to Magela Creek over a mean annual flow of 382GL (Moliere et al, 2008)
NTV = no trigger values
***ANZECC (2000) default trigger values for tropical Australia for slightly disturbed ecosystems; nitrate includes all oxides of nitrogen.

6. Conclusion

The INTERA (2014) groundwater solute model predicted that there will be negligible constituents of potential concern loads resulting from the backfilling of stopes, decline and vent shafts at Ranger 3 Deeps. The resultant concentrations in Magela Creek were also predicted to be negligible, to unmeasurable, even with the conservative approaches used for the modelling and assessment of potential impacts.

The multiple lines of evidence, physical, chemical and biological, acquired from the research and monitoring programs of the Supervising Scientist, ERA and others over the past 30 years, demonstrate no detrimental impact defined as, *an impact which causes or is likely to cause a change to biodiversity or impairment of ecosystem health,* during the operational phase of the Ranger mine. This includes assessment of cumulative impacts from all constituents of potential concern.

The weight of evidence:

- multiple lines of evidence that demonstrate no detrimental impact during the operational phase of Ranger mine; and
- the negligible to unmeasurable contribution to the loads and concentrations of constituents of potential concern;

demonstrates that any potential constituents of potential concern egress from the Ranger 3 Deeps closure will not result in any environmental impact in the aquatic environment, and consequently will not compromise the ecological and/or cultural values of Magela Creek and associated wetlands.

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