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## MEMORANDUM

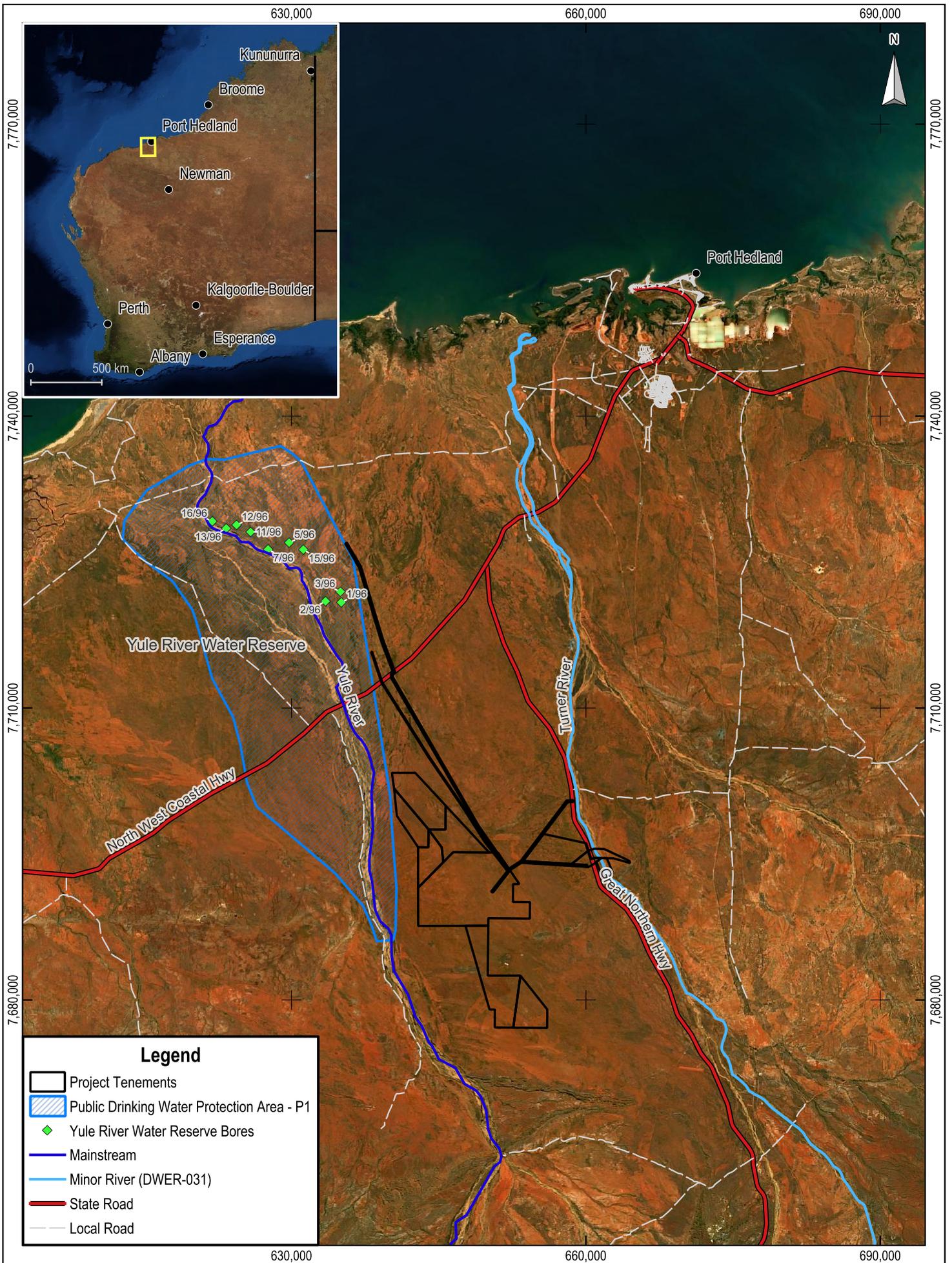
Attention:	Jonathan Barker	From:	Dr Elliott Duncan
Company:	De Grey Mining	Date:	30th July 2024
Subject:	EPBC MNES Memorandum	Project:	Hemi Dewater Discharge Assessment

### 1. BACKGROUND

The Hemi Gold Project (Hemi) is located within the larger Malina Gold Project (MGP) approximately 80 km south of Port Hedland in the Pilbara region of Western Australia (Figure 1).

In order to develop the Hemi project, significant pit dewatering is required; particularly during the first three (3) years of operations whereby a surplus of approximately 30 GL needs to be managed. Based on the characteristics of the Hemi site (volumes, shallow groundwater table, limited spatial extent), the most viable option to manage significant portions of this water was considered a controlled discharge into the nearby Turner River (approx. 14 km to the east).

Based upon survey results, the Turner River habitat type has been classified as potential critical habitat for the Northern Quoll (*Dasyurus hallucatus*). It also potentially provides habitat for the Pilbara Olive Python (*Liasis Olivaceus*) and Grey Falcon (*Falco hypoleucos*). These species are considered threatened under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*. This memorandum was prepared to detail whether the planned discharge has the potential to effect populations or habitat of these species (considered Matters of National Environmental Significance (MNES)) within the Turner River System under the EPBC Act.



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 Image: Copernicus Sentinel Data 2020  
 Grid: GDA94 / MGA zone 50

De Grey Mining Pty Ltd  
 Hemi Gold Project

**Figure 1**  
**Location Plan**

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## 2. DETAILS OF PLANNED DISCHARGE

### 2.1 DISCHARGE VOLUMES

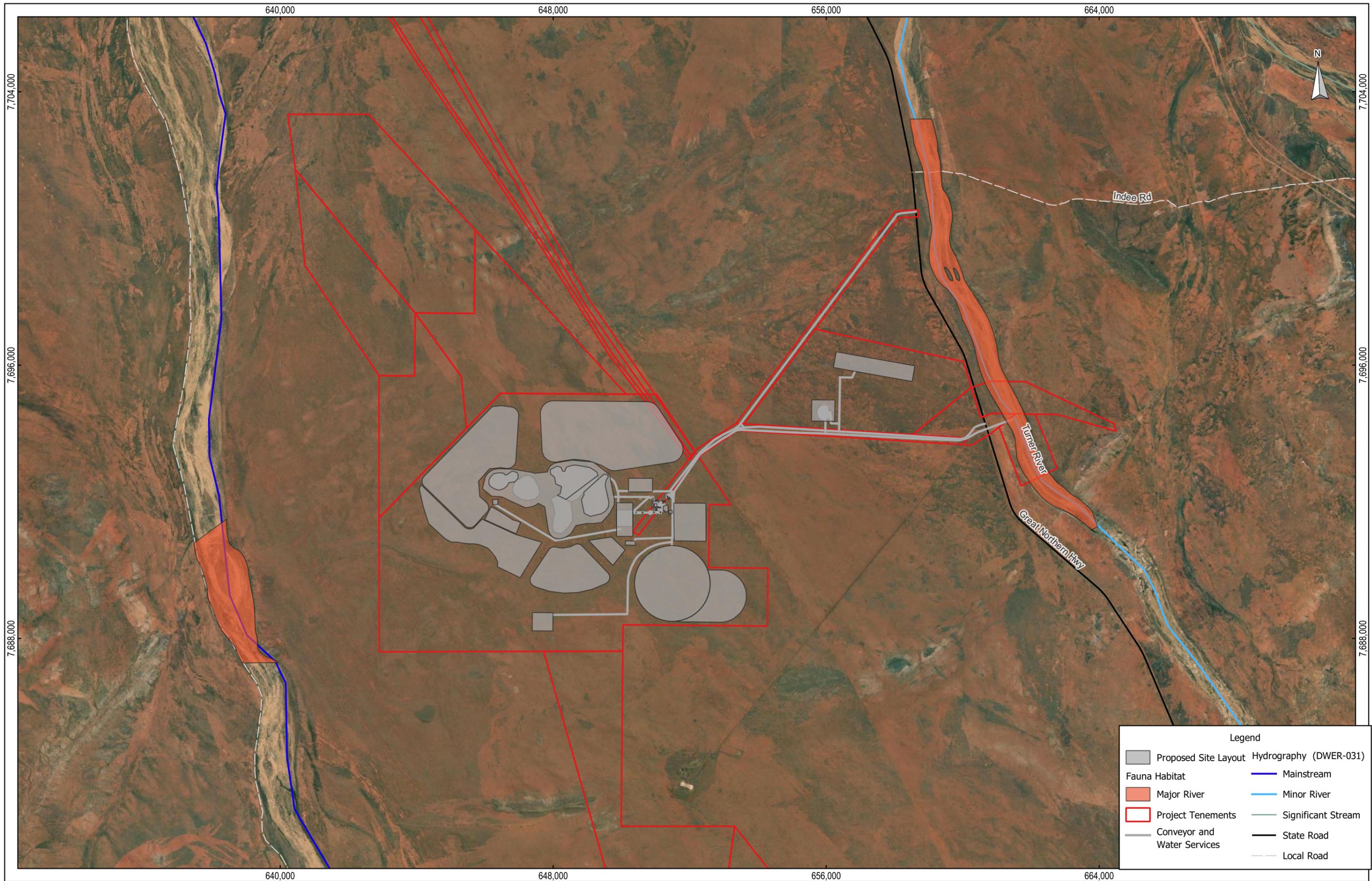
The Hemi project will utilise open cut mining to extract gold bearing ore from six (6) pits (Eagle, Crow, Aquila, Brolga, Diucon and Falcon) which will cover a combined area of approx. 289 ha. During mining development significant dewatering will be required given that groundwater is likely to be intercepted within the top 5 to 10 m of the profile. Over the life of mining (15 years), approximately 226 GL will be dewatered to allow development of the pit. Of this, approximately 91 GL will be reinjected. During the first three years of operations, however, a surplus of approximately 30 GL has been identified and will require discharge into the adjacent Turner River.

This discharge is to occur through a series of dewatering bores spread across the six proposed mining pits. The 30 GL will be discharged at a steady rate over the 3-year discharge period, which equates to approximately 0.83 GL being discharged monthly.

### 2.2 ENVIRONMENTAL CONSIDERATIONS

The major environmental considerations relevant to this assessment include:

- The area surrounding the Turner River (Major River habitat) is known to provide potential critical habitat for conservation significant (MNES) fauna including the northern quoll (*Dasyurus hallucatus*), Pilbara olive python (*Liasis Olivaceus*) and grey falcon (*Falco hypoleucos*) as outlined in Figure 2.
- The climate within the project area is variable with periods of high temperatures or high rainfall events relatively common. Consequently, the Turner River system often fluctuates between periods of high flow to times in which surface water is constrained in isolated pools. As a result of this variability, the chemical composition of the Turner River is known to undergo marked changes over time as a result of either evapo-concentration or dilution effects (from catchment rainfall).
- The water table within the area is very shallow (5 to 10 m below ground level) and thus the water abstracted from the surficial aquifer during dewatering is likely to be similar (in terms of chemical composition) to the water flowing within the Turner River.
- The proposed discharge has been modelled to be constrained to the main channel of the Turner River which is approximately 90 m wide. The river itself is approximately 1.5 km wide and therefore the discharge is expected to inundate approx. 6% of the river area at any one time.



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 0 2,500 5,000 m

De Grey Mining Pty Ltd  
 Hemi Gold Project

**Figure 2**  
**Potential Critical Habitat for Conservation Significant Fauna**

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## 2.3 COMPOSITION OF DISCHARGE WATER

In order to assess the possible risks to fauna who reside in or utilise the Turner River as a drinking water source, a groundwater quality assessment was conducted based largely on groundwater monitoring data collected since 2020 in the proposed mining pit areas. A summary of the groundwater monitoring data is presented below in Table 1, with the full dataset provided in Attachment 1.

**Table 1: Summary of Groundwater Monitoring Data**

Bore Data	pH	TDS	Total Alkalinity	Ca	Mg	Hardness	As	U	V
	SU	mg/L	mg/L CaCO <sub>3</sub>	mg/L		mg/L CaCO <sub>3</sub>	µg/L		
Mean	8.21	824	372	30	49	274	14	35	31
Minimum	8.05	673	315	23	41	237	6	19	21
Maximum	8.31	916	414	40	55	304	36	45	37
ANZECC (2000) Livestock Drinking Water	6.5–8.5	4,000	N/G	1,000	500	N/G	25	200	100

Based on the results of groundwater monitoring, the water to be discharged into the Turner River was likely to be alkaline pH, of low salinity, high alkalinity and very hard. Metal(loids) of key interest included arsenic, uranium and vanadium which (of all analytes screened for). Arsenic was the only element to exceed the ANZECC (2000) livestock (cattle) drinking water value whilst vanadium and uranium regularly exceeded the default (non-site specific) low-reliability freshwater species protection values (Attachment 1).

With respect to MNES fauna, the ANZECC livestock (cattle) drinking water criteria was utilised as default environmental criteria to assess whether the composition of discharge water is likely to have adverse effects if consumed. Based on the data presented in Table 1 and in Attachment 1, most potential metal(loid) contaminants were present in concentrations well below those that would warrant further investigation.

Given the presence of slightly (regionally) elevated uranium concentrations (19 – 45 µg/L) gross alpha, gross beta and radionuclides (Ra-226 and Ra-228) concentrations were also analysed in water samples from selected bores (Table 2).

**Table 2: Summary of Groundwater Monitoring Data — Radiation**

Bore ID	U	U-238	Total Activity	Gross Alpha	Gross Beta	Ra 226	Ra 228
	µg/L	Bq/L	Bq/L	Bq/L	Bq/L	Bq/L	Bq/L
Mean	41.3	0.51	0.55	1.91	0.46	0.04	<0.08
Minimum	8.9	0.11	0.11	0.43	0.29	0.01	<0.08
Maximum	84.1	1.05	1.14	3.34	0.87	0.10	<0.08
ANZECC (2000) Livestock Drinking Water	200	2.5	2.5	1	5	5	5

All bores tested contained gross beta values below the 5 Bq/L screening guideline value for Gross Beta and Ra-226 and Ra-228. Gross alpha values, however, in two bores (HMB025 and 035) exceeded the 1 Bq/L livestock drinking water quality guideline screening value (1.7 to 3.2 Bq/L) (Table 2). Calculated total activity of U-238, Ra-226 and Ra-228 were all well below the relevant ANZECC livestock drinking water guideline values.

In the context of fauna of conservation significance exceedances of the ANZECC 2000 Livestock gross alpha screening threshold values are of potential significance given that alpha emitters can have significant health effects if ingested (as drinking water). As a result of these exceedances, an environmental radiation risk assessment was conducted with the results summarised in Section 3.

## 2.4 TURNER RIVER COMPOSITION PRE- AND POST-DISCHARGE

The chemical composition of the Turner River pre and post proposed discharge are summarised in Tables 3 and 4 respectively for key analytes. Baseline or pre-discharge conditions for the natural state of the Turner River (Table 3) can be summarised as alkaline pH, low salinity, high alkalinity and hardness. Background arsenic (3.5 µg/L), uranium (3.9 µg/L) and vanadium (3.5 µg/L) concentrations were lower in the Turner River when compared to undiluted and untreated proposed discharge water means (11.2, 29 and 29.6 µg/L, respectively). However, concentrations of all analytes are below relevant default environmental criteria (i.e. ANZECC Livestock Drinking Water Guidelines).

Post discharge concentrations of arsenic, uranium and vanadium are likely to also be heavily influenced by rainfall within the catchment as outlined in Table 4, with resulting dilution and final concentrations determined by this. Irrespective of this variable dilution, concentrations post-discharge are well below relevant default environmental criteria (i.e. ANZECC Livestock Drinking Water Guidelines) and no impact to MNES from consumption of river water is expected.

**Table 3: Existing Surface Water Monitoring Data (17 Samples)**

Turner River Data	pH	TDS	Total Alkalinity	Ca	Mg	Hardness	As	U	V
	SU	mg/L	mg/L (CaCO <sub>3</sub> )	mg/L	mg/L	mg/L (CaCO <sub>3</sub> )	µg/L	µg/L	µg/L
Mean	8.50	763	225	21	31	163	3.5	3.9	3.5
Minimum	7.74	143	48	7	5	43	0.6	0.5	0.1
Maximum	9.41	2,490	496	50	77	383	9.8	16.0	11.2
ANZECC (2000) Livestock Drinking Water	6.5–8.5	4,000	N/G	1,000	500	N/G	25	200	100

**Table 4: Predicted Turner River Composition Post-Discharge**

Analyte	Turner River Flow Scenarios (per annum)					ANZECC (2000) Livestock Drinking Water
	0 GL	6.2 GL	28 GL	137 GL	No Discharge	
	Dry (Minimum Recorded, no Dilution)	Median	Average	Maximum Recorded		
As	11.2	8.7	6.4	5.2	3.5	25
U	29.6	20.2	11.7	7.0	3.9	200
V	29.0	19.4	10.7	5.8	3.5	100

### 3. ENVIRONMENTAL RADIATION RISK ASSESSMENT

Given the slightly elevated uranium concentrations in the discharge water and the exceedance of some radiological criteria (i.e. Gross alpha emissions) ecological radiation modelling using the ERICA (Environmental Risk from Ionising Contaminants: Assessment and Management) and RESRAD (Residual Radioactivity) programs were conducted to assess risks to organisms that use the Turner River as a drinking water source. Full results of the modelling are presented in Attachment 2. Key findings are presented below and include:

- Two scenarios were tested which included:
  - Discharge into the Turner River with no rainfall during discharge period — “worst-case scenario”.
  - No discharge occurs (i.e. background levels in the Turner River) — “best-case scenario”.
- An exposure dose screening value of 40  $\mu\text{Gy/h}$  terrestrial animals, birds, amphibians and reptiles was set for the model which is an estimate of the dose at which where measurable effects are noted at a population level.
- Exposure (via drinking water) was assessed for three main terrestrial organisms which included:
  - Cattle: beef cattle.
  - Large bird (similar to duck or chicken).
  - Reptile (similar to the Pilbara olive python which may inhabit the area).
- The results of the model are presented below in Table 5 and demonstrate that the modelled dose rates were below the relevant screening values in both scenarios for all organisms. No measurable individual or population level effects are likely to occur as a result of radiation impacts on any organism consuming water from the Turner River.

**Table 5: Summary of Modelled Dose Rates for Fauna and Livestock (Drinking Water Consumption)**

Organism	Weight (kg)	Water Intake Rate (L/day)	Screening Value ( $\mu\text{Gy/h}$ )	Scenario 1 No Catchment Rainfall (U = 30 $\mu\text{g/L}$ )	Scenario 2 Turner River Natural State (U = 4 $\mu\text{g/L}$ )
				Total Dose ( $\mu\text{Gy/h}$ )	Total Dose ( $\mu\text{Gy/h}$ )
Cattle: beef cattle	800	45	40	0.012	0.00044
Bird (large)	2.8	0.32	40	0.006	0.00019
Reptile	15	0.1	40	0.006	0.0002

### 4. BIOACCUMULATION OF URANIUM IN FRESHWATER AQUATIC SYSTEMS

As outlined in Section 2.3 metal(loid) concentrations in the discharge water and in the Turner River post-discharge are unlikely to impact fauna if directly consumed as drinking water given that concentrations are well below relevant default guidelines (i.e. ANZECC Livestock Drinking Water Guidelines). These guidelines, however, do not assess whether organisms are at risk as a result of accumulating metal(loids) as a result of consuming aquatic plants or animals as food. In order to assess whether the proposed discharge is likely to result in the accumulation of metal(loids) from food, a high-level review was conducted specifically for uranium to determine whether a) it bioaccumulates in the tissues of aquatic plants and animals and b) whether uranium biomagnifies as it moves up trophic levels within aquatic and terrestrial food-webs. Although considered to be slightly elevated in the discharge water, arsenic and vanadium were not assessed here based on:

- The intention to pass discharge water through earthen ponds which will significantly lower concentrations of arsenic and vanadium to similar levels to those in the Turner River naturally. This a process of sorption to iron oxide minerals in the soil.
- Significant lack of evidence for the bioaccumulation of arsenic (Saidon et al., 2024) and vanadium (Jardine et al., 2019) in food webs.

Within the literature there are numerous examples of aquatic organisms including fish (Barillet et al., 2007), invertebrates (Fortin et al., 2004; Simon and anzec-Laplace, 2004), crayfish (Simon et al., 2013), insects (Bergmann, 2019) and plants including algae (Cordeiro et al., 2016) being able to accumulate uranium if present (dissolved) in the water column. When present in elevated concentrations within the water-column, uranium has a tendency to accumulate in gill tissues (Barillet et al., 2007, Simon and Garnier-Laplace, 2004) rather than in visceral tissues (i.e. liver, hepatopancreas, muscle) (Simon and Garnier-Laplace, 2004). Under elevated uranium concentrations, much of the uranium accumulated in gill tissues is likely to be adsorbed rather than accumulated intracellularly (Schaller et al., 2009). Most aquatic animals are relatively inefficient in terms of accumulating uranium, with bioconcentration factors (BCF) (accumulated concentration / concentration in water-column/food) typically <100 (and many, especially higher trophic levels being significantly less than this). For context, the United Nations (UN) Globally Harmonised System for Hazard classification and labelling of chemicals details that a chemical requires a BCF value >500 to be considered bioaccumulating (UNECE, 2003).

In many studies, aquatic plants behave in a similar manner whereby uranium concentrations associated with plant tissues increase with increasing uranium exposure (Mahon, 1982). However, as is the case with many aquatic faunal species, under high uranium exposures the proportion of uranium accumulated intracellularly is low i.e. the bulk of uranium is adsorbed to tissue surfaces rather than taken internally (Mahon, 1982).

Many terrestrial plant species have been shown to accumulate uranium from soils in root tissues (Van Netten and Morley, 1983). The translocation of uranium from roots into leaves however in the majority of plant species is typically very low (Dreesen et al., 1982; Moffett and Tellier, 1977), which is consistent with their being no known biological function of uranium in plant tissues (Markich, 2002).

Studies on uranium accumulation in terrestrial fauna are limited, with most studies demonstrating that uranium accumulation is low (Muller et al., 2009, Johansen and Twining, 2010), particularly when transferred from food. There is some evidence to suggest that endemic Australian fauna have a higher capacity to accumulate uranium when compared with introduced species (Johansen and Twining, 2010). However, these observations have largely been generated from ex-uranium mining and/or weapons testing sites (Johansen and Twining, 2010) which are unlikely to be reflective of the Turner River environment.

Finally, most studies have demonstrated that uranium is unlikely to biomagnify within foodwebs with a number of studies demonstrating that the lowest uranium concentrations are present in higher trophic organisms (Mahon, 1982, Bergmann, 2019). This suggests that primary consumers (i.e. herbivores) are likely to excrete or remove much of the uranium accumulated by primary producers (i.e. plants/algae) which ensures that it is not transferred to higher trophic organisms. This is likely to be a consequence of uranium not having a biological function in plants or animals (Markich, 2002).

Thus, in the context of native fauna of conservation significance (MNES) present in the Turner River area it is highly unlikely that the proposed discharge will lead to an increased accumulation of uranium for the following reasons:

- Predation/consumption of aquatic organisms/plants that are potentially exposed to the elevated uranium concentrations are likely to represent at best a very minor food source for these species.
- Terrestrial plants are unlikely to be exposed to the discharge water given that it will be constrained to a subset of the existing river channels unless significant rainfall occurs. If significant rainfall were to occur this would have a dilutionary effect which would lower uranium concentrations to near background levels, which is also likely to negate any potential issue regarding possible uranium accumulation.

- All of the species of conservation significance are higher trophic organisms and thus as detailed above the transfer of uranium from food sources to these organisms across several trophic levels with losses at each level due to lack of accumulation is likely to be very low.
- Finally, although uranium concentrations are elevated (circa 30 µg/L) due to regionally elevated groundwater concentrations, they are not as high as concentrations in some published work (mg/L range) in which only limited accumulation of uranium was observed.

Thus, given that uranium accumulation (resulting from the proposed discharge) by fauna of conservation significance (MNES) is likely to be very low, toxicological effects (resulting from uranium accumulation) and impacts to MNES are considered not significant.

## 5. CONCLUSIONS AND SUMMARY

This memo was prepared to assess whether the proposed dewatering discharge from the Hemi gold project into the adjacent Turner River has the potential to impact populations of conservation significant fauna (MNES) that are within the area. Overall, the discharge was considered not significant to MNES populations for the following reasons:

- Concentrations of all potential metal(loid) contaminants in the Turner River post-discharge were well below ANZECC (2000) livestock drinking water values which were used as default environmental criteria for assessing risks to fauna via the consumption of river water post-discharge.
- Environmental radiation modelling suggested that modelled dose rates were below the relevant default screening values for all organism groups. Consequently, no measurable population effects are likely to occur as a result of radiation impacts on any of the conservation significant fauna species consuming water the Turner River.
- Uranium is highly unlikely to bioaccumulate in the tissues of these species via trophic transfer as it has a limited capacity to bioaccumulate and biomagnify — especially in higher trophic organisms. In addition, uranium exposed species (i.e. aquatic plants and animals) are a very minor food source for these species, making the risk of uranium accumulation via food negligible at worst.

Consequently, in the context of the above-mentioned MNES fauna of national conservation significance the management of uranium concentrations in the discharge water will not be required.

## 6. REFERENCES

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Yours sincerely  
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**Dr Elliott Duncan**  
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enc.  
Attachment 1: Groundwater Monitoring Dataset  
Attachment 2: Results of Environmental Radiation Risk Assessment

## Attachment 1: Groundwater Monitoring Dataset

BORE	DATE	pH Value pH Unit	EC µS/cm	TDS mg/L	TSS mg/L	OH Alkalinity mg/L as CaCO3	CO3 Alkalinity mg/L as CaCO3	HCO3 Alkalinity mg/L as CaCO3	Total Alkalinity mg/L as CaCO3	SiO2 mg/L	SO4 mg/L	Chloride mg/L	Calcium mg/L	Magnesium mg/L	Sodium mg/L	Potassium mg/L	Mercury µg/L	Aluminium µg/L	Iron µg/L	Antimony µg/L	Selenium µg/L	Arsenic µg/L	Barium µg/L	Beryllium µg/L	Boron µg/L	Bismuth µg/L	Cadmium µg/L	Chromium µg/L	Cobalt µg/L	Copper µg/L	Lead µg/L	Lithium µg/L	Manganese µg/L	Molybdenum µg/L	Nickel µg/L	Silver µg/L	Strontium µg/L	Tellurium µg/L	Thallium µg/L	Thorium µg/L	Tin µg/L	Titanium µg/L	Uranium µg/L	Vanadium µg/L	Zinc µg/L	Nitrate as N mg/L	Bromide mg/L		
HM0001	02/12/2020	8.35	1470	890	15	<1	8	358	366	91.0	63	233	32	56	197	13	<0.1	<5	<2	<0.2	3.0	15.8	122.0	<0.1	490	<0.05	<0.05	3.6	<0.1	<0.5	<0.1	17.8	1.2	6.7	<0.5	<0.1	614	<0.2	<0.02	<0.1	<0.2	<1	42.80	30.8	8	6.53	0.67		
HM0002	02/12/2020	8.41	1500	898	18	<1	9	346	355	88.5	66	238	30	54	197	14	<0.1	<5	<2	<0.2	3.2	15.3	116.0	<0.1	506	<0.05	<0.05	3.7	<0.1	<0.5	<0.1	18.1	0.9	6.6	<0.5	<0.1	624	<0.2	<0.02	<0.1	<0.2	<1	42.90	30.8	10	6.26	0.76		
HP0001	03/12/2020	8.30	1290	798	40	<1	3	331	335	91.1	62	187	30	41	161	13	<0.1	<5	<2	<0.2	3.1	6.5	63.0	<0.1	497	<0.05	<0.05	1.8	<0.1	<0.5	<0.1	<0.1	20.0	7.0	5.6	<0.5	<0.1	586	<0.2	<0.02	<0.1	<0.2	<1	27.70	27.1	15	7.62	0.43	
HM0003	03/12/2020	8.43	1500	898	49	<1	19	353	372	93.1	62	241	30	53	195	13	<0.1	<5	<2	<0.2	3.1	30.2	126.0	<0.1	506	<0.05	<0.05	2.9	<0.1	<0.5	<0.1	18.6	0.9	5.0	<0.5	<0.1	614	<0.2	<0.02	<0.1	<0.2	<1	44.60	34.3	8	6.75	0.58		
HM0004	03/12/2020	8.48	1530	929	173	<1	24	354	378	86.9	65	245	34	58	202	14	<0.1	<5	<2	<0.2	3.6	9.9	140.0	<0.1	592	<0.05	<0.05	3.2	<0.1	<0.5	<0.1	18.6	<0.5	6.3	<0.5	<0.1	664	<0.2	<0.02	<0.1	<0.2	<1	47.60	32.8	8	6.52	0.61		
HM0005	03/12/2020	8.48	1670	1030	754	<1	23	351	373	78.2	77	284	32	53	232	16	<0.1	<5	<2	<0.2	4.2	54.4	186.0	<0.1	695	<0.05	<0.05	3.5	0.4	<0.5	<0.1	15.6	48.7	6.2	<0.5	<0.1	606	<0.2	<0.02	<0.1	<0.2	<1	36.70	22.7	13	6.28	0.71		
HM0007	03/12/2020	8.47	1280	794	117	<1	22	340	362	90.3	39	191	34	44	160	13	<0.1	<5	<2	<0.2	3.0	6.1	170.0	<0.1	488	<0.05	<0.05	3.0	<0.1	<0.5	<0.1	20.6	4.1	5.7	<0.5	<0.1	581	<0.2	<0.02	<0.1	<0.2	<1	25.30	25.0	10	7.86	0.47		
HM0008	03/12/2020	8.44	1260	768	93	<1	18	314	332	93.7	36	183	35	43	155	13	<0.1	<5	<2	<0.2	2.9	5.5	157.0	<0.1	494	<0.05	<0.05	2.8	<0.1	<0.5	<0.1	21.0	2.2	5.4	<0.5	<0.1	597	<0.2	<0.02	<0.1	<0.2	<1	23.30	28.9	8	8.47	0.43		
HM0009	03/12/2020	8.45	989	598	257	<1	15	265	281	80.0	22	126	33	30	126	10	<0.1	<5	<2	<0.2	2.1	4.7	172.0	<0.1	342	<0.05	<0.05	3.1	<0.1	<0.5	<0.1	18.5	0.7	3.7	<0.5	<0.1	483	<0.2	<0.02	<0.1	<0.2	<1	7.37	24.0	10	7.13	0.30		
HM0010	03/12/2020	8.37	1450	866	24	<1	1	281	295	82.1	58	225	26	40	140	13	<0.1	<5	<2	<0.2	2.9	8.2	214.0	<0.1	484	<0.05	<0.05	2.7	<0.1	<0.5	<0.1	20.2	0.6	5.2	<0.5	<0.1	603	<0.2	<0.02	<0.1	<0.2	<1	42.20	39.7	19	8.58	0.39		
HM0006	04/12/2020	8.38	1780	1070	304	<1	14	345	359	102.0	43	176	42	61	225	19	<0.1	<5	<2	<0.2	5.5	5.0	257.0	<0.1	716	<0.05	<0.05	1.7	<0.1	<0.5	<0.1	18.5	1.6	1.9	<0.5	<0.1	804	<0.2	<0.02	<0.1	<0.2	<1	16.80	20.4	12	7.14	0.97		
HM0011	04/12/2020	8.40	1250	754	58	<1	14	311	325	81.0	43	183	36	44	157	13	<0.1	<5	<2	<0.2	3.0	3.0	3.4	124.0	<0.1	475	<0.05	<0.05	3.1	0.2	1.4	<0.1	14.9	13.8	5.3	1.1	<0.1	509	<0.2	<0.02	<0.1	<0.2	<1	19.30	17.9	52	7.07	0.45	
WP0001	05/12/2020	8.34	11400	6920	206	<1	11	456	468	26.1	740	3160	91	190	2180	32	<0.1	<5	12	1.0	2.3	1.1	52.3	<0.1	856	<0.05	0.36	<0.2	2.4	1.8	<0.1	<0.1	52.7	7.9	3.6	<0.1	<0.1	3130	<0.2	<0.02	<0.1	<0.2	<1	35.80	1.0	18	1.58	7.51	
HM0008	21/04/2021	8.08	1190	732	<5	<1	<1	316	316	95.7	34	185	33	41	157	13	<0.1	<5	<2	<0.2	2.7	4.7	180.0	<0.1	497	<0.05	<0.05	2.2	<0.1	<0.5	<0.1	18.1	<0.5	4.4	<0.5	<0.1	617	<0.2	<0.02	<0.1	<0.2	<1	19.30	28.1	14	11.30	0.53		
HM0009	21/04/2021	8.08	1020	614	<5	<1	<1	286	286	77.6	23	145	33	32	128	10	<0.1	<5	<2	<0.2	2.1	4.4	212.0	<0.1	352	<0.05	<0.05	2.5	<0.1	<0.5	<0.1	6.0	<0.5	6.0	<0.5	<0.1	520	<0.2	<0.02	<0.1	<0.2	<1	7.70	25.4	14	8.05	0.45		
HM0010	21/04/2021	8.07	996	616	<5	<1	<1	304	304	76.6	23	125	29	30	134	9	<0.1	<5	<2	<0.2	2.0	4.9	224.0	<0.1	344	<0.05	<0.05	2.4	<0.1	<0.5	<0.1	5.4	<0.5	4.1	<0.5	<0.1	525	<0.2	<0.02	<0.1	<0.2	<1	8.53	30.0	13	9.33	0.40		
HE00026	22/04/2021	8.26	1450	872	<5	<1	<1	369	369	85.5	60	253	29	54	188	12	<0.1	<5	<2	<0.2	2.7	6.7	186.0	<0.1	506	<0.05	<0.05	2.7	<0.1	<0.5	<0.1	0.7	0.2	20.4	<0.5	6.7	<0.5	<0.1	624	<0.2	<0.02	<0.1	<0.2	<1	43.90	33.9	18	7.16	0.76
HM0001	23/04/2021	8.04	1310	746	<5	<1	<1	348	348	89.3	46	204	26	46	183	12	<0.1	<5	<2	<0.2	2.8	10.3	177.0	<0.1	539	<0.05	<0.05	2.0	<0.1	<0.5	<0.1	10.0	<0.5	6.0	<0.5	<0.1	590	<0.2	<0.02	<0.1	<0.2	<1	34.20	34.0	13	7.17	0.60		
HM0002	23/04/2021	8.02	1450	829	5	<1	<1	361	361	86.5	61	245	30	56	189	12	<0.1	<5	<2	<0.2	3.1	56.0	128.0	<0.1	545	<0.05	<0.05	3.6	<0.1	<0.5	<0.1	20.6	<0.5	6.5	<0.5	<0.1	638	<0.2	<0.02	<0.1	<0.2	<1	45.50	31.3	13	6.76	0.73		
HM0003	23/04/2021	8.06	1440	865	<5	<1	<1	369	369	93.2	53	248	28	52	195	12	<0.1	<5	<2	<0.2	3.2	11.3	139.0	<0.1	595	<0.05	<0.05	2.4	<0.1	<0.5	<0.1	21.6	<0.5	6.0	<0.5	<0.1	605	<0.2	<0.02	<0.1	<0.2	<1	39.40	35.7	14	7.51	0.74		
HM0007	23/04/2021	8.04	1220	760	72	<1	<1	325	325	93.9	40	198	34	45	157	12	<0.1	<5	<2	<0.2	3.0	5.8	141.0	<0.1	513	<0.05	<0.05	3.0	<0.1	<0.5	<0.1	24.6	<0.5	5.6	<0.5	<0.1	582	<0.2	<0.02	<0.1	<0.2	<1	27.50	29.3	10	8.55	0.59		
HM0011	23/04/2021	8.05	1270	768	<5	<1	<1	335	335	90.7	43	205	32	44	165	12	<0.1	<5	<2	<0.2	3.0	6.7	159.0	<0.1	492	<0.05	<0.05	2.8	<0.1	<0.5	<0.1	21.9	<0.5	5.6	<0.5	<0.1	596	<0.2	<0.02	<0.1	<0.2	<1	30.50	28.8	14	8.05	0.62		
INDEE HOMESTEAD	23/04/2021	7.89	3420	1950	<5	<1	<1	377	377	50.2	178	861	66	114	469	13	<0.1	<5	<2	<0.2	2.6	2.4	242.0	<0.1	396	<0.05	<0.05	<0.2	<0.1	0.8	<0.1	0.9	<0.1	98.9	<0.5	4.9	<0.5	<0.1	1490	<0.2	<0.02	<0.1	<0.2	<1	84.10	5.3	17	3.46	2.81
HM0004	23/04/2021	7.98	1490	1030	<5	<1	<1	374	374	85.1	62	259	30	56	194	13	<0.1	<5	<2	<0.2	3.8	10.1	186.0	<0.1	666	<0.05	<0.05	3.1	<0.1	<0.5	<0.1	22.7	<0.5	6.5	<0.5	<0.1	663	<0.2	<0.02	<0.1	<0.2	<1	46.20						



Sample Location	River System	Date	pH	EC	TDS	TSS	DH Alkalinity	CO3 Alkalinity	HCO3 Alkalinity	Total Alkalinity	SiO2	SO4	Cl	Ca	Mg	Na	K	Hg	Al	Fe	Sb	Se	As	Ba	Be	B	Bi	Cd	Cr	Co	Cu	Pb	Li	Mn	Mo	Ni	Ag	Sr	Te	Tl	Th	Sn	Ti	U	V	Zn	NO3-N	Br			
			Unit	µS/cm	mg/L	mg/L	mg/L as CaCO3	mg/L as CaCO3	mg/L as CaCO3	mg/L as CaCO3	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L																			
TR01	Turner	05/11/2021	9.01	3830	2490	15	<1	140	355	496	N.D	56	988	19	77	679	17	N.D	<5	<2	N.D	<0.2	5	90	N.D	770.0	N.D	<0.05	<0.2	<0.1	13	<0.5	N.D	17	4	6	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	16	<0.2	45	<0.01	N.D
TR02	Turner	05/11/2021	8.25	754	490	17	<1	4	182	186	N.D	4	145	43	18	98	4	N.D	30	70	N.D	<0.2	1	86	N.D	140	N.D	<0.05	<0.2	<0.1	2	<0.5	N.D	35	<0.1	1	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	2	<0.2	<1	<0.01	N.D		
TRU1	Turner	06/11/2021	8.35	1830	1190	<5	<1	21	312	333	N.D	93	410	46	65	243	7	N.D	<5	160	N.D	<0.2	2	169	N.D	400	N.D	<0.05	<0.2	<0.1	2	<0.5	N.D	91	1	1	N.D	N.D	N.D	N.D	N.D	N.D	N.D	5	<0.2	5	<0.01	N.D			
TRD2	Turner	06/11/2021	9.05	1030	670	19	<1	55	200	256	N.D	6	216	16	38	158	9	N.D	60	60	N.D	<0.2	5	49	N.D	250	N.D	<0.05	<0.2	<0.1	1	<0.5	N.D	20	2	1	N.D	N.D	N.D	N.D	N.D	N.D	N.D	3	<0.2	<1	<0.01	N.D			
TR01	Turner	03/01/2022	9.27	3200	1800	147	<1	193	272	465	15.1	61	798	8	71	531	24	<0.1	<5	17	0.4	<0.2	8	101	<0.1	740	<0.05	<0.2	0.2	1.4	<0.1	10.2	16	3.4	1.6	<0.1	75	<0.2	<0.02	<0.1	0.2	1	4.84	8.6	9	0.01	2.25				
TR01	Turner	11/02/2022	9.41	3030	1690	53	<1	172	251	422	22.4	25	786	7	60	478	22	<0.1	<5	8	0.5	0.4	9.8	155	<0.1	807	<0.05	<0.2	0.4	1.4	<0.1	9.6	3.4	3.5	1.4	<0.1	62	<0.2	<0.02	<0.1	0.4	1	5.65	9.8	8	0.01	2.51				
TR01	Turner	11/03/2022	8.91	269	165	<5	<1	15	77	92	20.9	3	28	20	9	28	6	<0.1	9	17	<0.2	2.8	78.8	<0.1	68	<0.05	<0.2	0.3	1.2	<0.1	1.8	6.3	1	1.7	<0.1	181	<0.2	<0.02	<0.1	<0.2	1	1.39	4.8	4	0.01	0.012					
TR08	Turner	11/03/2022	8.49	888	663	128	<1	25	302	327	22.7	<5	112	50	30	113	17	<0.1	5	5	0.4	0.6	7.7	202	<0.1	440	<0.05	<0.2	0.3	2.7	4.5	<0.1	2.1	112	5.5	19.2	<0.1	490	<0.2	<0.02	<0.1	<0.2	1	8.45	11.2	17	0.01	0.399			
TR01	Turner	26/04/2022	8.07	236	146	13	<1	<1	112	112	16.0	2	11	26	7	13	4	<0.1	<5	13	<0.2	<0.2	1.4	106	<0.1	39	<0.05	<0.2	0.3	0.7	<0.1	1	42.5	0.8	1.6	<0.1	171	<0.2	<0.02	<0.1	<0.2	1	1.37	2.3	15	0.02	0.01				
TR south	Turner	03/06/2022	7.94	235	155	<5	<1	<1	53	53	11.6	16	33	10	5	30	2	<0.1	11	10	<0.2	0.4	0.7	92.9	<0.1	55	<0.05	<0.2	0.5	<0.1	1	<0.1	1.8	3.7	0.9	0.6	<0.1	64	<0.2	<0.02	<0.1	0.4	<1	0.65	1.9	30	1.08	0.071			
TR North	Turner	03/06/2022	7.74	225	143	<5	<1	<1	48	48	11.3	15	30	9	5	28	2	<0.1	<5	8	<0.2	0.2	0.7	73.7	<0.1	45	<0.05	<0.2	0.7	<0.1	0.8	<0.1	1.4	2.3	0.9	<0.5	<0.1	59	<0.2	<0.02	<0.1	0.6	<1	0.52	1.9	18	1	0.064			
TR South	Turner	06/06/2022	7.97	234	158	<5	<1	<1	53	53	12.6	15	31	10	6	30	2	<0.1	6	9	<0.2	0.3	0.6	83.8	<0.1	44	<0.05	<0.2	0.5	<0.1	0.7	<0.1	1.7	2.4	0.8	<0.5	<0.1	61	<0.2	<0.02	<0.1	<0.2	<1	0.71	2.3	12	1.2	0.065			
TR North	Turner	06/06/2022	8.04	258	158	<5	<1	<1	79	79	13.2	17	34	11	6	33	3	<0.1	7	8	<0.2	0.3	0.7	63.3	<0.1	44	<0.05	<0.2	0.6	<0.1	0.7	<0.1	1.5	1.8	0.8	<0.5	<0.1	66	<0.2	<0.02	<0.1	<0.2	<1	0.74	2.4	8	1.12	0.076			
TR Flow before Indee access rd	Turner	08/02/2023	7.94	276	175	<5	<1	<1	86	86	18.4	15	34	13	8	35	4	<0.1	6	9	<0.2	0.2	0.8	26.3	<0.1	73	<0.05	<0.2	0.5	<0.1	0.5	<0.1	2.3	<0.5	0.8	0.6	<0.1	104	<0.2	<0.02	<0.1	<0.2	<1	1.25	2.9	<1	<0.01	0.085			
TR Flow on Indee access rd	Turner	08/02/2023	8.10	274	166	<5	<1	<1	90	90	18.3	10	34	12	7	35	4	<0.1	6	7	<0.2	0.2	0.8	26.5	<0.1	76	<0.05	<0.2	0.4	<0.1	0.5	<0.1	2.4	<0.5	0.8	0.6	<0.1	104	<0.2	<0.02	<0.1	<0.2	<1	1.30	2.9	<1	<0.01	0.083			

## Attachment 2: Results of Environmental Radiation Risk Assessment

**RESRAD - Livestock and Native Fauna Exposure through Drinking Water**

Only source of drinking water - 100% of water consumption from here

Organism	Weight (kg)	Water Intake Rate (L/day)	Screening Value(µGy/h)	Scenario 1a No Flow		Scenario 2a Median Annual Flow 6.3 G/Ly		Scenario 3a Mean Annual Flow 28 GL/y		Background Turner River	Indee Homestead Indee Homestead Well	
				Total Dose (µGy/h)	Tissue Concentration (Bq/kg)	Total Dose (µGy/h)	Tissue Concentration (Bq/kg)	Total Dose (µGy/h)	Tissue Concentration (Bq/kg)	Total Dose (µGy/h)	Total Dose (µGy/h)	Tissue Concentration (Bq/kg)
Cattle - Beef Cattle	800	45	40	0.012	0.0699	0.00717	0.0434	0.00185	0.023	0.00044	0.055	0.536
Bird (Large)	2.8	0.32	40	0.006	0.0329	0.00345	0.0194	0.00183	0.013	0.00019	N/A	N/A
Reptile	15	0.1	40	0.006	0.0336	0.00349	0.0201	0.00378	0.0106	0.0002	N/A	N/A

**RESRAD - Livestock and Native Fauna Exposure through Drinking Water**

Other drinking water sources available - 50% of water consumption from here

Organism	Weight (kg)	Water Intake Rate (L/day)	Screening Value (µGy/h)	Scenario 1b No Flow		Scenario 2b Median Annual Flow 6.3 G/Ly		Scenario 3b Mean Annual Flow 28 GL/y		Background Turner River	Indee Homestead Indee Homestead Well	
				Total Dose (µGy/h)	Tissue Concentration (Bq/kg)	Total Dose (µGy/h)	Tissue Concentration (Bq/kg)	Total Dose (µGy/h)	Tissue Concentration (Bq/kg)	Total Dose (µGy/h)	Total Dose (µGy/h)	Tissue Concentration (Bq/kg)
Cattle - Beef Cattle	800	22.5	40	0.0064	0.0388	0.004	0.022	0.0019	0.00115	N/A	N/A	N/A
Bird	2.8	0.16	40	0.001	0.0054	0.002	0.01	0.0009	0.0051	N/A	N/A	N/A
Reptile	15	0.05	40	0.0063	0.0359	0.003	0.02	0.0018	0.0106	N/A	N/A	N/A

Attachment 2: Radiation Modelling Data

BIRD	Details	Scenario 1	Scenario 4
		No Flow	Turner River
		Total Dose (µGy/h)	Total Dose (µGy/h)
Occupancy	0.5 Water Surface	31.5	5.28
Water Intake (100%)	0.32 L/day	0.006	0.00019
Total Dose Rate		31.506	5.28019
Screening Dose Rate (µGy/h)		40	40

REPTILE (i.e. Olive Python)	Details	Scenario 1	Scenario 4
		No Flow	Turner River
		Total Dose (µGy/h)	Total Dose (µGy/h)
Occupancy	0.5 Water	14.2	2.38
Water Intake (100%)	0.1 L/day	0.006	0.0002
Total Dose Rate		14.206	2.3802
Screening Dose Rate (µGy/h)		40	40

Details		Total Dose (µGy/h)	
		Scenario 1	Scenario 4
<b>Large Bird</b>			
Occupancy	0.5 Water Surface	31.5	5.28
Water Intake (100%)	0.32 L/day	0.006	0.00019
Total Dose Rate		31.506	5.28019
<b>Reptile</b>			
Occupancy	0.5 Water	14.2	2.38
Water Intake (100%)	0.1 L/day	0.006	0.0002
Total Dose Rate		14.206	2.3802
Screening Dose Rate (µGy/h)		40	40