

Appendix C – Tailings Characterisation Results 2017, Proposed Albemarle Kemerton Plant (extract from Ramboll 2017)

1. WASTE CLASSIFICATION

The following is an excerpt from the Albemarle Kemerton Plant Waste Management Strategy (Tailings) prepared by Ramboll Environ in December 2017.

Samples of the tailings material were collected from Albemarle's Guorun lithium processing facility in the Sichuan Province, P.R. China. The plant in Guorun processes the same feedstock (spodumene ore) which will be used for the Kemerton plant, using a same methodology to that proposed for the Project.

Bulk samples of tailings material were collected in the plant twice a day, over a 10 day period, in order to gain representative samples. These bulk samples were subsequently subsampled and shipped to the ALS Environmental laboratory in Melbourne, Victoria, a National Association Testing Authorities (NATA, Australia) accredited laboratory, for analysis.

The samples of tailings material were characterised for total constituent concentrations, and leachable concentrations by the Australian Standard Leachate Procedure (ASLP) AS4439 for the chemical constituents detailed in Table 3 and Table 4 of WA DEC (2009) Landfill Waste Classification and Waste Definitions. Total and leachable lithium (by ASLP) was also analysed.

The following steps detail the waste classification that has been undertaken in accordance with WA DEC (2009) based on the USA EPA (2012) method:

1.1 Step 1 – Ensure that an assessment needs to be done

The tailings material does not fall into any of the waste types defined in Tables 2a, 2b, 2c, and 2d of WA DEC (2009), therefore further assessment was required.

1.2 Step 2 – Assess the waste

Since the material cannot be pre-classified, assessment was required. The concentration of the relevant contaminant constituents was determined by ALS Melbourne, a NATA accredited laboratory.

1.3 Step 3 – Compare total concentration values with CT criteria

The mean plus one standard deviation of the total concentrations were then compared to the contaminant threshold (CT) criteria from Table 3 of WA DEC (2009) as per the guidelines. The tailings material is provisionally classified as Class IV on the basis of elevated total concentrations of beryllium, and mercury. Statistical analysis (calculation of the 95% Upper Confidence Limit) of these results did not reduce the classification of the material. A summary of the provisional waste classification is provided below in **Table 1**.

1.4 Step 4 – Determine contaminant leachate concentrations

The leachable concentrations of the constituents were determined by ALS Melbourne. Leachate testing was carried out under the Australian Standard Leachate Procedure (ASLP) AS4439, as stipulated by WA DEC (2009). Leaching fluids to simulate the natural pH of rainwater (deionised water) and acidic conditions (pH 4.93) were used in the determination of leachable concentrations of constituents that exceeded the Class I CT criteria in Step 3, above.

1.5 Step 5 – Compare total and leachate concentrations with CL and ASLP criteria

The mean plus one standard deviation of the leachable concentrations determined in Step 4, along with the mean plus one standard deviation of the total concentrations determined in Step 2, were compared to the concentration limit (CL) and leachable concentration (ASLP) values in Table 4 of WA DEC (2009) for leachable constituents determined by ASLP under neutral and acidic (pH = 4.93) conditions. The tailings material is classified as Class I (with the exception of lithium) under both neutral conditions and when tested at pH 4.93. A summary of the waste classification is provided in **Table 2** and **Table 3**

Table 1 Provisional Waste Classification of Lithium Processing Tailings

Constituent	Unit	Maximum Values of Total Concentration for Classification Without the Requirements to Assess Leachability				No. of Samples	Min. Conc.	Max. Conc.	Mean Conc.	Standard Deviation, σ	Mean + σ	No. Above GL	Step 3: Provisional Waste Classification	95% UCL	Step 3: Provisional Waste Classification (95% UCL)
		CT1 (mg/kg)	CT2 (mg/kg)	CT3 (mg/kg)	CT4 (mg/kg)										
		Class I	Class II	Class III	Class IV										
<i>Metals</i>															
Arsenic	mg/kg	14	14	140	1,400	20	<5	11.0	7.7	2.0	9.7	0	Class I	-	Class I
Beryllium	mg/kg	2	2	20	200	20	42	58	50.2	3.5	53.6	20	Class IV	51.53	Class IV
Cadmium	mg/kg	0.4	0.4	4	40	20	0.4	0.5	0.4	0.0	0.5	5	Class III	0.442	Class III
Chromium (Hexavalent)	mg/kg	10	10	100	1,000	20	<0.5	0.7	0.6	0.1	0.7	0	Class I	-	Class I
Lead	mg/kg	2	2	20	200	20	1.4	2.8	1.7	0.4	2.1	4	Class III	1.877	Class I
Lithium	mg/kg					20	361	642	458.6	78.5	537.1	-	No Guidelines	489.7	No Guidelines
Mercury	mg/kg	0.2	0.2	2	20	20	<0.1	4.4	1.8	1.5	3.3	6	Class IV	2.859	Class IV
Molybdenum	mg/kg	10	10	100	1,000	20	<2	-	-	-	-	0	Class I	-	Class I
Nickel	mg/kg	4	4	40	400	20	5	12	7.7	2.0	9.7	20	Class III	8.474	Class III
Selenium	mg/kg	2	2	20	200	20	<1	-	-	-	-	0	Class I	-	Class I
Silver	mg/kg	20	20	200	2,000	20	<2	-	-	-	-	0	Class I	-	Class I
<i>Other Inorganic Species</i>															
Cyanide (amenable)	mg/kg	7	7	70	700	20	0	-	-	-	-	0	Class I	-	Class I
Cyanide (total)	mg/kg	16	16	160	1,600	20	<1	-	-	-	-	0	Class I	-	Class I
Fluoride	mg/kg	300	300	3,000	30,000	20	80	370	141.5	73	214.5	2	Class I	170.5	Class I
<i>Other metals</i>															
Aluminium	mg/kg	50,000	50,000	100,000	200,000	20	6,970.0	8,570.0	7,583.5	364.4	7,947.9	0	Class I	-	Class I
Barium	mg/kg	50,000	50,000	100,000	200,000	20	<10	-	-	-	-	0	Class I	-	Class I
Boron	mg/kg	50,000	50,000	100,000	200,000	20	180.0	250.0	205.0	15.3	220.3	0	Class I	-	Class I
Cobalt	mg/kg	50,000	50,000	100,000	200,000	20	<2	9.0	3.5	2.1	5.6	0	Class I	-	Class I
Copper	mg/kg	50,000	50,000	100,000	200,000	20	5.0	11.0	6.8	1.3	8.1	0	Class I	-	Class I
Manganese	mg/kg	50,000	50,000	100,000	200,000	20	147.0	284.0	211.6	36.9	248.5	0	Class I	-	Class I
Vanadium	mg/kg	50,000	50,000	100,000	200,000	20	6.0	9.0	7.3	0.8	8.0	0	Class I	-	Class I
Zinc	mg/kg	50,000	50,000	100,000	200,000	20	14.0	20.0	16.5	1.6	18.0	0	Class I	-	Class I
<i>Non-Chlorinated Organics</i>															
Benzene	mg/kg	0.2	0.2	2	20	20	<0.2	-	-	-	-	0	Class I	-	Class I
Cresols (total)	mg/kg	400	400	4,000	40,000	20	<1	-	-	-	-	0	Class I	-	Class I
2,4-D	mg/kg	0.02	0.02	0.2	2	20	<0.02	-	-	-	-	0	Class I	-	Class I
Ethylbenzene	mg/kg	60	60	600	6,000	20	<0.5	-	-	-	-	0	Class I	-	Class I
Petroleum hydrocarbons	mg/kg	N/A	N/A	N/A	N/A	20	<50	-	-	-	-	0	Class I	-	Class I
Phenol (total, non-halogenated)	mg/kg	28.8	28.8	288	2,880	20	<1	-	-	-	-	0	Class I	-	Class I
Polycyclic aromatic hydrocarbons (total)	mg/kg	N/A	N/A	N/A	N/A	20	<0.5	-	-	-	-	0	Class I	-	Class I
Styrene (vinyl benzene)	mg/kg	6	6	60	600	20	<0.5	-	-	-	-	0	Class I	-	Class I
Toluene	mg/kg	160	160	1,600	16,000	20	<0.5	-	-	-	-	0	Class I	-	Class I
Xylenes (total)	mg/kg	120	120	1,200	12,000	20	<0.5	-	-	-	-	0	Class I	-	Class I
<i>Chlorinated Organics</i>															
Organochlorine pesticides	mg/kg	N/A	N/A	N/A	N/A	20	<5	-	-	-	-	0	Class I	-	Class I
Polychlorinated biphenyls	mg/kg	N/A	N/A	N/A	N/A	20	<0.1	-	-	-	-	0	Class I	-	Class I

'-' indicates not calculated

WA DECC (2009) – Western Australia Department of Environment and Conservation, Landfill Classification and Waste Definitions 1996 (as amended 2009)

Table 2 Waste Classification by Leachable Concentration (ASLP) and Concentration Limit (CL) at neutral pH

Constituent	Unit	Leachable Concentration (ASLP) and concentration limit (CL) values for waste classification*								No. of Samples	Min. Conc.	Max. Conc.	Mean Conc.	Standard Deviation, σ	Mean + σ	No. Above Guidelines	Step 5: Waste Classification
		Leachable Concentration ASLP1 (mg/L) Class I	Concentration Limit CL1 (mg/kg) Class I	Leachable Concentration ASLP2 (mg/L) Class II	Concentration Limit CL2 (mg/kg) Class II	Leachable Concentration ASLP3 (mg/L) Class III	Concentration Limit CL3 (mg/kg) Class III	Leachable Concentration ASLP4 (mg/L) Class IV	Concentration Limit CL4 (mg/kg) Class IV								
<i>Metals</i>																	
Beryllium	mg/L	0.1	-	0.1	-	1	-	10	-	20	<0.01	-	-	-	-	0	Class I
	mg/kg	-	100	-	100	-	1000	-	4,000	20	42	58	50.15	3.48	53.63	0	Class I
Cadmium	mg/L	0.1	-	0.1	-	1	-	10	-	20	<0.005	-	-	-	-	0	Class I
	mg/kg	-	100	-	100	-	1000	-	4,000	20	0.4	0.5	0.425	0.04	0.47	0	Class I
Lead	mg/L	0.1	-	0.1	-	1	-	10	-	20	<0.01	-	-	-	-	0	Class I
	mg/kg	-	1,500	-	1,500	-	15,000	-	60,000	20	1.4	2.8	1.725	0.38	2.11	0	Class I
Lithium	mg/L	-	-	-	-	20 [^]	-	-	-	20	0.234	0.509	0.366	0.06	0.430	-	No Guidelines
	mg/kg	-	-	-	-	-	-	-	-	20	361	642	458.6	78.45	537.05	-	No Guidelines
Mercury	mg/L	0.01	-	0.01	-	0.1	-	1	-	20	<0.001	-	-	-	-	0	Class I
	mg/kg	-	75	-	75	-	750	-	3,000	20	<0.1	4.4	1.8	1.48	3.28	0	Class I
Nickel	mg/L	0.2	-	0.2	-	2	-	20	-	20	<0.01	-	-	-	-	0	Class I
	mg/kg	-	3,000	-	3,000	-	30,000	-	120,000	20	5	12	7.7	1.95	9.65	0	Class I

*- indicates no criteria or not calculated

[^]WA DECC (2009) – Western Australia Department of Environment and Conservation, Landfill Classification and Waste Definitions 1996 (as amended 2009)

[^]NZ MFE (2004). Module 2: Hazardous Waste Guidelines, Landfill Waste Acceptance Criteria and Landfill Classification, New Zealand Ministry for the Environment, May 2004

Table 3 Waste Classification by Leachable Concentration (ASLP) and Concentration Limit (CL) at pH=4.93

Constituent	Unit	Leachable Concentration (ASLP) and concentration limit (CL) values for waste classification*								No. of Samples	Min. Conc.	Max. Conc.	Mean Conc.	Standard Deviation, σ	Mean + σ	No. Above Guidelines	Step 5: Waste Classification
		Leachable Concentration ASLP1 (mg/L) Class I	Concentration Limit CL1 (mg/kg) Class I	Leachable Concentration ASLP2 (mg/L) Class II	Concentration Limit CL2 (mg/kg) Class II	Leachable Concentration ASLP3 (mg/L) Class III	Concentration Limit CL3 (mg/kg) Class III	Leachable Concentration ASLP4 (mg/L) Class IV	Concentration Limit CL4 (mg/kg) Class IV								
<i>Metals</i>																	
Beryllium	mg/L	0.1	-	0.1	-	1	-	10	-	20	<0.05	-	-	-	-	0	Class I
	mg/kg	-	100	-	100	-	1,000	-	4,000	20	42	58	50.15	3.48	53.63	0	Class I
Cadmium	mg/L	0.1	-	0.1	-	1	-	10	-	20	<0.05	-	-	-	-	0	Class I
	mg/kg	-	100	-	100	-	1,000	-	4,000	20	0.4	0.5	0.43	0.04	0.47	0	Class I
Lead	mg/L	0.1	-	0.1	-	1	-	10	-	20	<0.1	-	-	-	-	0	Class I
	mg/kg	-	1,500	-	1,500	-	15,000	-	60,000	20	1.4	2.8	1.73	0.38	2.11	0	Class I
Lithium	mg/L	-	-	-	-	20 [^]	-	-	-	20	1.76	4.21	2.750	0.72	3.470	-	No Guidelines
	mg/kg	-	-	-	-	-	-	-	-	20	361	642	458.6	78.45	537.05	-	No Guidelines
Mercury	mg/L	0.01	-	0.01	-	0.1	-	1	-	20	<0.001	-	-	-	-	0	Class I
	mg/kg	-	75	-	75	-	750	-	3,000	20	<0.1	4.4	1.8	1.48	3.28	0	Class I
Nickel	mg/L	0.2	-	0.2	-	2	-	20	-	20	<0.1	-	-	-	-	0	Class I
	mg/kg	-	3,000	-	3,000	-	30,000	-	120,000	20	5	12	7.7	1.95	9.65	0	Class I

*- indicates no criteria or not calculated

[^]WA DECC (2009) – Western Australia Department of Environment and Conservation, Landfill Classification and Waste Definitions 1996 (as amended 2009)

[^]NZ MFE (2004). Module 2: Hazardous Waste Guidelines, Landfill Waste Acceptance Criteria and Landfill Classification, New Zealand Ministry for the Environment, May 2004

1.6 Lithium assessment guidelines

WA DEC (2009) does not provide a waste classification guideline criteria for lithium.

NZ MfE (2004) provides guideline values for screening criteria and leachability limits for lithium for waste classification for acceptance into a 'Class A' landfill of total lithium of 400 mg/kg and TCLP leachate concentration of 20 mg/L and 'Class B' landfill of total lithium 40 mg/kg and TCLP leachate concentration of 2 mg/L. Under this guideline, if the waste reports a total lithium concentration of greater than the screening criteria (total concentration in mg/kg) then the leachability must be determined by TCLP (in mg/L) and be less than the leachability limits for disposal to landfill. The leachability limit is based on a dilution attenuation factor (DAF) applied to the New Zealand Drinking Water Standards. A 'Class A' landfill in New Zealand is defined as one that has been constructed in accordance with the New Zealand Centre for Advanced Engineering's Landfill Guidelines (2000). The Class A landfill description is roughly consistent with the requirements for a Class III landfill in WA (well sited, lined, leachate collection system, gas flaring for sites >1 000 000 m³, daily cover, licenced) (NZ MfE (2004)). Conversely, a 'Class B' landfill in New Zealand is a landfill that does not meet the site selection and design standards outlined in the NZ CAE 2000 Landfill Guidelines).

USEPA (1996) default DAF is 20, using the 'weight of evidence' approach based on 300 groundwater sites across the United States. By this method, if the target limit for a particular chemical constituent in the receiving environment, i.e. groundwater, is 1 mg/L, then using the DAF a guideline value of 20 mg/L for leachate can be adopted. USEPA (1996) also provides guidance and the methodology to calculate a site specific DAF based on the receiving environment, the size of the contaminant source, hydraulic conductivity of the underlying geology, the hydraulic gradient locally.

ANZECC (2000) provides a trigger value for lithium in irrigation waters and soils (long term) of 2.5 mg/L (0.075 mg/L for citrus crops). Applying the USEPA (1996) default DAF of 20 would yield a guideline limit for leachate 50 mg/L. No other trigger values applicable to lithium are referenced in ANZECC (2000).

It is proposed to adopt an interim guideline of 20 mg/L for lithium in leachate, pending the calculation of a site specific value based on environmental conditions at the site of storage / management. This is consistent with the value adopted by NZ MfE (2004) for a Class A landfill in New Zealand which is comparable to a Class III landfill in Western Australia.

1.7 Quality Assurance / Quality Control

The following quality assurance / quality control (QA/QC) measures were undertaken as part of the tailings sampling event at the lithium processing facility at Guorun, Sichuan, P.R. China:

- Sampling was undertaken by an experienced sampler from Ramboll Environ who travelled from the Ramboll Environ office in Shanghai to undertake the sampling;
- Representative samples were obtained by subsampling tailings material collected periodically over 10 days;
- An appropriate sampling methodology was employed in the field (as detailed above in Section 1);
- Sufficient volumes of material were collected in consultation with the receiving laboratory for the required suite of analytes;
- Intra-laboratory duplicate samples of tailings material were collected at a rate of 1 in 10 primary samples;
- Inter-laboratory duplicate samples of tailings material were collected at a rate of 1 in 20 primary samples; and
- Samples were preserved and transported under Chain of Custody (COC) protocol.

All analytes presented a relative percentage difference (RPD) of <30% with the exception of:

- Primary sample LT105 / intra-laboratory sample QA101 – leachable boron (163%) exceeded RPD limits;
- Primary sample LT119 / intra-laboratory sample QA102 – leachable lithium (48%), leachable aluminium (75%) and leachable boron (156%) exceeded RPD limits; and
- Primary sample LT105 / inter-laboratory sample QC101 – total lead (40%), total lithium (59%), leachable lithium (37%), leachable fluoride (120%), and leachable boron (143%) exceeded RPD limits.

Where one result was found to be below the PQL, a value of 0.5*PQL was assigned for the purpose of calculating the percentage RPD. This was applied for the leachable fluoride, leachable boron, and leachable aluminium results referenced above leading to exceedances in the RPD.

These exceedances are an artefact of the near PQL concentrations and are not considered to affect the usability of the data.

The following QA/QC measures were undertaken in the primary and secondary laboratory as part of the analysis of the tailings material:

- ALS Melbourne were used as the primary laboratory and Envirolab Services were used as the secondary laboratory. ALS and Envirolab laboratory certificates are both NATA stamped and both laboratories are accredited for the analyses performed in this assessment;
- All critical samples analysed and all analytes analysed according to Standard Operating Procedures (SOPs);
- Practical Quantitation Limits (PQLs) were appropriate;
- Laboratory duplicate samples were analysed at an appropriate rate;
- Relative percentage difference (RPDs) for laboratory duplicate samples of 30 to 50%; and
- Analysis of the following at appropriate rates:
 - Method blanks (results non-detect);
 - Matrix spikes (results in the range of 70 to 130% recovery);
 - Surrogate spikes (results in the range of 70 to 130% recovery, with the exception of OCP surrogate for LT111 and LT112);
 - Laboratory control samples (with the exception of some total metals analysis by ICP-MS (suite X), where no laboratory control duplicates were analysed in the primary laboratory);
 - Reagent blanks; and
 - Reference material.

Due to the time spent in transit from the Sichuan Province, P.R. China to the laboratories in Australia, the holding times for several analytes were breached. This is not expected to have an impact on the validity of the result, with all these analytes reporting below the laboratory detection limits.

Overall, it is considered that the data obtained is of suitable quality to meet the waste classification objectives for this WMS.

1.8 References

- ANZECC (2000). National Water Management Strategy, *Australian Guidelines for Water Quality Monitoring and Reporting*, Australian and New Zealand Environment and Conservation Council, October 2000
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