CONSULTING EARTH SCIENTISTS

22 September 2020

CES Document Reference:
CES070607-KLF-22092020

Breen Resources Pty Ltd
Level 9, 92 Pitt Street
Sydney NSW 2000

For the attention of Mr. Benjamin Warner

RE: Breen Resource Recovery Facility – Current Operational and Post-Capping Stages Leachate Generation Assessment

Dear Sirs,

1) INTRODUCTION

Consulting Earth Scientists Pty Ltd (CES) has been requested by Breen Resources Pty Ltd (Breen) to undertake an assessment and comparison between anticipated leachate generation for the current operational state and following construction of the permanent capping of the landfilled areas of the Breen Resource Recovery Facility, located at Captain Cook Drive in Kurnell, New South Wales. For the purpose of this report, the landfilled areas shall be referred to as the site.

2) LEACHATE GENERATION MODELLING METHODOLOGY

For the purpose of the leachate generation modelling, we have employed the use of The Hydrologic Evaluation of Landfill Performance software program produced by the United States Environmental Protection Agency and as modified by Dr Klaus Berger of the University of Hamburg (HELP 3.95D).

To model the anticipated leachate generation at the site, the following assumptions have been applied.

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3) LEACHATE GENERATION MODELLING ASSUMPTIONS

3.1 CLIMATE DATA

The evapotranspiration, rainfall, temperature and solar radiation data utilising the weather data for Sydney Airport AMO (Station ID 066037) obtained from the Bureau of Meteorology (BOM). The station is located approximately 9km from the site. The climate data used in this modelling exercise is for the period 1967 to 2018 (50 years).

3.2 ASSUMED AREAS & GEOTECHNICAL MODEL

The site has been divided into Areas A1 to E that are broadly consistent with the areas shown in Cardno Drawing reference: 89913035-SK-108 dated 10 July 2017.

Areas C2 and C3 (Stages 1B and 3 Sports Fields) will be backfilled with clean fill (VENM/ recovered fines) and thus not included in this assessment.

3.2.1 Current Operational Stage

For the purpose of modelling the current operational state, it is assumed that the site generally has an existing 500mm intermediate cover based on the cover thickness encountered within the six leachate observation well boreholes installed in 2016. This has been modelled as sandy loam with poor stand of grass assumed to predominant at the site.

The intermediate cover is assumed to overlie general solid waste of varying thickness as shown in Appendix 1. A 300mm clay leachate barrier has been modelled for Areas A1 and A2. Future cells (Cell B11 Stages B, C and D) are modelled with a 300mm leachate drainage layer and a leachate barrier comprising geosynthetic clay liner (GCL) with a saturated hydraulic conductivity of 5×10^{-11} m/sec and HDPE Geomembrane with geotextile overlay.

3.2.2 Post-capping Stage

The final capping designs assigned to the sub-areas are as prescribed in the updated Progressive Capping Plan (CES Document CES070607-KLF-31 Revision F). In general, the assumed geotechnical model from top to bottom is as follows:

- Revegetation Layer (minimum 1 m thick), modelled as slightly compacted sandy clay loam with fair stand of grass for Areas A1, A2, B, D1 and D2 whereas good stand of grass for Area C1. For rehabilitation landscape areas, a subgrade material

(minimum 800 mm thick) is included in this Revegetation Layer, which is modelled as slightly compacted sandy clay loam.

- General Fill Layer of variable thickness modelled as stated in Appendix 1. It is assumed that the General Fill Layer will comprise Recovered Fines that conforms with the NSW 'The Continuous Fines Order 2014 - General Resource Recovery Exemption made under clauses 91 and 92 of the Protection of the Environment Operations (Waste) Regulation 2014'. This layer has been modelled as a moderately compacted sandy clay.

- Compacted Clay Cap is modelled to comprise a sealing layer (compacted clay layer minimum 600 mm thick), modelled as a barrier soil with a saturated hydraulic conductivity of 1 x 10^{-9} m/sec with a sloping gradient of 5.24% (i.e. 3 degrees) to drainage points.

- Seal Bearing Layer (minimum 300 mm thick), modelled as moderately compacted sandy clay.

- Waste - General Solid Waste of variable thicknesses as shown in Appendix 1 modelled as municipal waste with a porosity of 0.55 (based on published literature) and a saturated hydraulic conductivity of 2.38 x 10^{-5} m/sec (based on lower quartile value from six falling head permeability test results for the waste layers conducted within the leachate observation wells installed in 2016).

- Compacted Clay Barrier, modelled as a barrier with a saturated hydraulic conductivity of 1 x 10^{-9} m/sec. In Area D2, a leachate drainage layer, a GCL and HDPE membrane have been modelled as leachate barrier as described under Section 3.2.1.

Additional scenarios have been modelled for new Landfill Cell B11 (Stages B, C and D):

- Scenario 1: The landfill cells are filled to proposed final waste level and 300mm of intermediate cover placed over the waste.
- Scenario 2: The proposed permanent capping has been constructed.

In addition to the above, a sensitivity assessment has been undertaken to compare the effect of varying thicknesses (5m, 9m, and 14m) of General Fill Layer (Recovered Fines) on estimated annual volumes of water at the base of the General Fill Layer.

A summary of the modelling assumptions including areas, slope length, slope gradient, capping design and geotechnical model corresponding to the sub-area is shown in Appendix 1.

4) LEACHATE GENERATION MODELLING RESULTS

The results of the leachate generation modelling are shown in Appendix 1.

5) ASSESSMENT

Based on the results of the leachate generation modelling, the following is assessed:

- The estimated total annual volume of leachate generation permeating the base of the leachate barrier for the assessed areas is modelled to reduce from approximately 531,668m^3 (current operational stage) to approximately 43,936m^3 (post-capping stage), this is a reduction of approximately 92%.

- The estimated total annual volume of leachate permeating through the compacted clay cap sealing layer is estimated to be less than 5% of the annual rain falling on the site following the construction of the permanent capping and final landform.

- The annual volume of water infiltration at the base of the General Fill Layer (Recovered Fines) (above the cap sealing layer) is estimated to be 134,485m^3, 122,634m^3 and 117,389m^3 for 5m, 9m and 14m thick layers of General Fill respectively. This indicates that the variation in the thickness of the General Fill Layer has relatively minor effect on the volume of water at the base of the General Fill (Recovered Fines) layer.

6) REFERENCES

1) Bureau of Meteorology (BOM), 2020, Average annual and seasonal evaporation, Australian Government, (accessed September 2020) websitehttp://www.bom.gov.au/climate/data/
2) Cardno Pty Ltd, July 2017, landform design drawings (Drawing No. 89913035-SK-108 Sheet 1 to Sheet 5, Revision No.2, dated 10 July 2017)
3) Consulting Earth Scientists Pty Ltd (CES), 2020, Progressive Capping Plan, CES070607-KLF-31 Revision F dated 18 September 2020.
4) New South Wales Environment Protection Authority (NSW EPA), 2016, Environmental Guidelines: Solid Waste Landfills, Second Edition.

5) University of Hamburg, 2017, The Hydrologic Evaluation of Landfill Performance (HELP) Model (HELP3.95D).

7) CLOSURE

Should further clarification be required regarding this report, please do not hesitate to contact the undersigned.

For and on behalf of Consulting Earth Scientists Pty Ltd

Ivan Wong
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Attachments:

Appendix 1: Table Summary of Modelling Assumptions & Results

Appendix 1: Summary Table of Modelling Assumptions and Results

No.	Final Capping Design Category	Post-closure Land Use	Sub-Area (Cardno, 2017)	Designated Lot Number / Landfill Cell	Area (hectares)	Estimated Slope Length[1] (m)	Estimated Slope Gradient[1] (%)	Estimated Elevation (m AHD)			Post-Capping Condition									Current Operational Condition				
											[3]Assumed Geotechnical Model with Layer Type & Thickness (m)							Results[4]		[3]Assumed Geotechnical Model with Layer Type & Thickness (m)				Results[4]
								Top of Compacted Base Liner[2]	Current Landform[1]	Future Landform[1]	RVL	GFL[6]	CCC	SBL	WFL	DRL	CCB	Infiltration Below CCC	Leachate Below CCB	Cover	WFL	DRL	CCB	Leachate Below CCB
1	Open Space 1	Open Space	Area A1	Lot 1122	12.7	300	8%	1.5	30	40	1.0	4.2	1.2	0.3	31.8	-	0.3	21,350 / 4.9%	20,635 / 4.7%	0.5	28.0	-	0.3	233,065/ 52.9%
2	Open Space 2	Open Space	Area A2	West and middle of Lot 1123	12.2	380	12%	1.5	24	26	1.0	1.8	0.7	0.3	20.7	-	0.3	19,199/ 4.5%	18,638/ 4.4%	0.5	22.0	-	0.3	225,091/ 53.3%
3	Open Space 3	Open Space	Area B	Lot 6/ South of Cell B10	2.2	80	18%	1.8	22	28	1.0	-	0.6	0.3	24.3	-	0.5	1,817 / 2.4%	1,699 / 2.2%	0.5	19.7	-	0.5	27,516/ 36.4%
4	Playing Fields 9 & 10	Playing Fields 9 & 10 and associated Landscape Rehabilitation Area	Area C1	Lot 6/ West of Cell B10	3.8	100	5%	2.7	22	28	1.0	-	0.6	0.5	23.2	0.3	0.5	3,174/ 2.4%	2,964/ 2.2%	0.5	18.8	-	0.5	45,996/ 35.0%
5	Open Space 3	Commercial/ Industrial but Breen proposed to be Open Space and associated Landscape Rehabilitation Area	Area D1	North and middle of Lot 5/ Leachate Ponds	5.2	65	23%	1.8	22	28	This area will be backfilled with VENM/recovered fines to allow construction of the final cap over the new landfill cells in Area D2.									0.5	19.7	0.3	0.5 (with GCL)	Nil
			Area D2	East of Cell B10, [5] Cell B11	12.0	120	20%	1.8	22	28	1.0	-	0.6	0.3	23.2	0.3	0.5 (with GCL)	4,326/ 2.4%	Nil	0.5	19.7	0.3	0.5 (with GCL)	Nil
6	Commercial/ Industrial	Commercial/ Industrial, proposed for Breen's new resource recovery facility	Area E	East of Lot 5	9.0	120	3%	-	3	5 to 10	Structural Fill/ Treated Ground over Pond Fill									Pond Fill and Stockpiles				
Estimated Total Average Annual Volume of Leachate Generation Through the Base of Leachate Barrier											**43,936m^3**									**531,668m^3**				

Note:

[1] Slope lengths and slope gradients are estimated from Cardno's Final Landform Design Drawings (Drawing reference: 89913035-SK-108 dated 10 July 2017).

[2] Top of base liner assumed from Leachate Investigation Report (CES070607-KLF-121 dated 19 June 2017)

[3] Layer type RVL – Revegetation Layer (modelled as sandy loam), GFL – General Fill Layer (assumed to be 'recovered fines' modelled as clayey sand material), CCC – Compacted Clay Cap (modelled with saturated hydraulic conductivity of 1 x 10^{-9} m/sec, SBL – Seal Bearing Layer (modelled as moderately compacted sandy clay), WFL – Waste Fill Layer (modelled as municipal waste with porosity of 0.55 (Yuen & Styles, 2000) and saturated hydraulic conductivity of 2.38 x 10-5 m/sec (based on lower quartile value from six falling head permeability test results for the waste layers conducted within the leachate observation wells installed in 2016) from Leachate Investigation Report (CES070607-KLF-121 dated 19 June 2017) , DRL – Drainage Layer (modelled as lateral drainage layer comprising gravel), CCB – Compacted Clay Base Liner, Geosynthetic Clay Liner (GCL) – (modelled with hydraulic conductivity of 5 x 10^{-11} m/sec with a 2mm HDPE membrane). The thicknesses have been largely interpreted based on Cardno's Final Landform Design Drawings (Drawing reference: 89913035-SK-108 dated 10 July 2017). It should be noted that the thickness of GFL indicated on drawings are highly variable across the site and thus representative average thickness has been considered in the assessment.

[4] Results are in Annual Estimated Volume of Infiltration or Leachate in terms of cubic metres (m^3) / percentage (%) of Annual Rainfall

[5] Additional scenarios were modelled for Cell B11 Stages B,C and D. Scenario 1 models the cells to be filled to proposed final waste level with 300mm of intermediate cover, which resulted in annual volume infiltration below the cover of approximately 25,642m^3 or 6.2% of annual rainfall. Scenario 2 models the permanent capping of 1m RVL and 0.6m CCC above the intermediate cover, which resulted in annual volume infiltration below the cover of approximately 9,965m^3 or 2.4% of annual rainfall.

[6] Additional modelling were completed for varying thicknesses of GFL to assess the effects of increasing thickness parameter against leachate generation for Area A1. The results are tabulated below.

Scenario	**Thickness (m)**	**Estimated Annual Volume of Leachate at the base of GFL**
GFL underlies 1m of RVL and overlies 1.2m CCC and WFL varying from 23m to 31m in thicknesses	5	134,485 (30.5%)
	9	122,634 (27.9%)
	14	117,389 (26.7%)