5 August 2019

Attention: Stephen O'Donoghue
Team Leader – Resource and Energy Assessments
Department of Planning & Environment
Email: stephen.odonoghue@planning.nsw.gov.au

Dear Stephen,

RE: Eraring Ash Dam Augmentation Modification (MOD1) – Clarification of Ash Dam Stability

As part of its assessment of MOD1, the Department of Planning & Environment (**DPE**) is considering the potential impact of MOD1 on the required Eraring Ash Dam (**ERAD**) stability works and the impact of an ERAD wall break on the Myuna Bay Sports & Recreation Centre (**MBRC**).

This letter addresses the DPE's request for further information in relation to the abovementioned issues as they relate to MOD1. Specifically, the DPE has asked Origin;

1. The reasons for the requirement to undertake the proposed stability works to the ERAD;
2. Whether MOD1 has a material impact on the ERAD wall stability; and
3. Whether MOD1 would increase the impact of an ERAD wall break.

To substantiate the responses to questions #2 and #3, Origin engaged its Engineer of Record (**EoR**) Stantec Inc. (**Stantec**) to provide an opinion as set out in Appendix 1.

Project Background and Need

Origin Energy (**Origin**) owns and operates the Eraring Power Station (**EPS**) and associated ERAD located at Eraring in the Lake Macquarie Local Government Area (**LGA**). EPS has operated since 1982 and is Australia's largest power station with a generation capacity of 2,920 megawatts.

As a result of recent power station closures and changes in the electricity market, EPS has operated at increased generation capacity factors to meet NSW and National electricity market demand. In 2017, EPS produced ~19% of NSW energy which has increased to ~25% in 2019 year to date. Eraring is also crucial in providing sufficient capacity in the NSW electricity market and in turn system security - over the last 3 years, the highest daily demand recorded in NSW was 13,986MW. On this day there was unutilised available generation of approximately 463MW (including interconnector flows); EPS provided 2,378MW of generation, 17% of total demand.

The increased generation levels of the EPS has resulted in increased ash disposal and in turn, a reduction to the capacity of the ERAD in a shorter timeframe than originally planned. Consequently, alternative ash placement strategies are required shortly to extend the storage capacity of the ERAD for the short to mid-term.

Reaching capacity of the ERAD would lead to cessation of EPS generation due to the inability to deposit ash without significant risks to safety and the environment. Therefore, it is essential that the currently anticipated storage life of the ERAD be increased as soon as possible to ensure the continued operation of EPS and the security of the NSW and National Electricity Market.

Origin is proposing to augment the ERAD using an alternate placement strategy and landform design (the **Project**) to maintain operational flexibility and extend the storage life of the ERAD in the short to mid-term whilst continuing to support long term ash placement strategies towards 2032.

The preferred option for ash dam augmentation would retain operational flexibility whilst providing an estimated additional 5 million cubic metres of storage capacity, extending the operational life of the Eraring Ash Dam to approximately 2025. A key feature of the augmented ash dam deposition strategy is that deposition is limited to the existing operational footprint of the ERAD, limiting environmental impacts when compared to other mid-term alternatives.

1. Requirement to undertake proposed ERAD stability works

As set out below, the requirement to undertake stability works resulted from an increase in the ERADs consequence category under the Dam Safety Committee (**DSC**) Guidelines, not as a result of a change in the EPS or ERAD operations.

As part of Origin's continuous risk and assurance processes, Origin engaged its EoR to undertake a detailed assessment of the impact of a dam break. The dam break assessment concluded that as there was an increase in the assessed population at risk (**PAR**), compared with previous assessments, and as such the ERADs consequence category under the DSC Guidelines should be increased.

Origin subsequently engaged its EoR to undertake a stability assessment to determine whether the ERAD still met the DSC safety requirements based on the criteria of the increased consequence category. The assessment concluded that the ERAD no longer met the required factor of safety due to the increased seismic requirements associated with the increase in dam consequence category.

As a result, the EoR recommended that stability works be undertaken to meet the required factor of safety under the DSC Guidelines - Origin is currently developing these works.

2. Impact of MOD1 on the ERAD dam wall stability

As set out in Appendix 1, the EoR concludes that:

> *"the scope of work proposed for the Ash Dam Augmentation Project (MOD 1) <u>does not have</u> any bearing on the assessment of stability or likelihood of failure of ERAD".*

The rational provided by the EoR as to why the proposed augmentation of the ash dam will not have an adverse impact on the on the stability of the Southern Embankment can be summarised as:

a. The southern embankment is located 575 m from the closest extent of the fly ash deposition footprint. The additionally placed fly ash is not anticipated to be displaced in the direction of the Southern Embankment in a way that would make it become unstable and fail, as it will be deposited using a spigot and beaching method, resulting in a deposited slope of 1- 2%. This slope meets the minimum post seismic factor of safety requirement recommended by ANCOLD Guidelines; and

b. The Southern Embankment is assessed to remain stable even where the Decant Pond is maintained at the maximum operational high rainfall level (RL 127.6 m EPSD), noting that typically operational Decant Pond levels is able to be maintained below the dry weather operational level (RL 125.5 m EPSD). The Decant pond operating levels will not change as a result of the Augmentation Project.

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3. Impact of MOD1 on a dam break

Stantec have undertaken additional dam break modelling of the worst-case dam break scenario to assess the impact of additional ash storage associated with MOD1. The worst-case scenario is a 'sunny-day liquefaction breach' as identified in the initial March 2019 modelling which assesses a November 2018 base case.

The analysis indicates a slightly increased inundation footprint on Wangi Rd and the MBRC resulting in a ~4% increase in the assessed Population at Risk (**PAR**) from 286 for the November 2018 base case to 297 for the re-assessed case including MOD 1. This is manageable in the overall context of the ERAD and MOD1 given:

- The EoR has concluded that in operational terms and under normal circumstances, the ERADs southern embankment is assessed as being likely to perform satisfactorily and in accordance with its designed functionality;
- There is no change to the consequence category of the dam as a result of the MOD1;
- The PAR (by definition) does not take into account emergency procedures which when in place, would likely lead to a reduction in the impact on MBRC inhabitants when compared with the assessed PAR impact; and
- Stability works are in progress for the southern embankment foundations that will reduce the risk of a dam break from an earthquake event such that the OBE and MDE criteria for a 'High A' dam are achieved.

If you would like to discuss the information contained within, please do not hesitate to contact Lauren Barnaby on 0472 879 898 or at lauren.barnaby@originenergy.com.au,.

Your Sincerely,

Greg Jarvis
Executive General Manager, Energy Supply and Operations
Origin Energy

Appendix 1 – Stantec Letter of Advice

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Memo

To:	Fernanda Maluly Kemeid (OEE) Eraring Power Station, NSW	From:	Charlie Strick / Theo Gerritsen Brisbane, QLD
File:	Eraring Ash Dam, NSW	Date:	August 7, 2019

Reference: Impact of Ash Dam Augmentation Project on Southern Embankment Stability, ERAD, NSW

Introduction

Stantec Australia Pty Ltd (Stantec) has been engaged to provide an opinion on the impact of the 'stability' of the current configuration of the Eraring Ash Dam (ERAD) Southern Embankment as a result of the execution of the scope of works contemplated in the Ash Dam Augmentation Project Environmental Assessment prepared by AECOM in 2018 (AECOM, 2018a). This has been prepared in response to a request from the NSW Department of Planning and Environment (DPE) as part of its assessment of the Ash Dam Augmentation Project.

a. We have interpreted the 'stability' of the Southern Embankment to refer to its physical stability under imposed loading (encompassing its self-weight, the weight of the saturated and unsaturated ash retained behind it, as well as loading due to design earthquake events, design traffic loading and supernatant water).

b. The stability of the Southern Embankment in its current state has already been assessed by Stantec (Stantec 2018). The query seeks to determine whether any additional stability considerations are anticipated to arise as a result of the scope of works contemplated in the Ash Dam Augmentation Project Environmental Assessment (AECOM 2018a).

These two items are addressed in Stantec's Position Statement below.

Stantec has also been requested to provide commentary on the consequences of failure of the Southern Embankment (i.e. a dam-break scenario) as a result of the execution of the Ash Dam Augmentation Project works. The outcomes of the dam-break reassessment in this scenario are reported in a standalone technical memorandum (Appendix A).

Stantec's Position Statement

Based on our detailed knowledge of the project, it is Stantec's view that the scope of work proposed for the Ash Dam Augmentation Project does not have any bearing on the assessment of stability or likelihood of failure of the Southern Embankment. This conclusion is supported by the following arguments:

1. The scope of works for the Ash Dam Augmentation Project, as articulated by AECOM in the 2018 Environmental Assessment (EA) and Response to Submissions (RtS), which includes mine void remediation of the Awaba mine workings and construction of the Western Embankment does not entail works being undertaken on the Southern Embankment dam (for which the foundation stability works are proposed).

2. We draw on the conclusions reported following earlier analyses set out in the Ash Terrace Feasibility Assessment (Stability Assessment) for Eraring Ash Dam, AECOM (2018b), which demonstrate that an ANCOLD / DSC compliant short-term, long-term and post-seismic[1] factor of safety can be achieved for an ash embankment with a batter / terrace slope of 1V:30H (3% gradient) similar to that contemplated in AECOM, 2018a). We note that the deposition landform proposed in AECOM (2018a) Figure 2 has a slope of less than 3%, which by inference is assessed as being stable. It is important to mention that

[1] Of these three types of analysis, post-seismic slope stability analysis governs the outcome.

since the publication of AECOM (2018a) and AECOM (2018b) the operational strategy for deposition of tailings has changed; being currently one of spigot deposition from agreed locations on the periphery of the Ash Dam resulting in gradually sloping beached tailings formation down to a Decant Pond. Beach slopes of 1 – 2% are typically achieved, which is flatter than the 3% outlined in AECOM (2018b). This relatively flat deposition landform supports our statement that the scope of work proposed for the Ash Dam Augmentation Project does not have any bearing on the assessment of stability or likelihood of failure of the Southern Embankment. For reference, the current deposition technique is the same as that described in Section 4.1 of AECOM (2018a) as 'hydraulic ash placement'.

3. Given that the Southern Embankment is located 1.5 km south-east of the Awaba mine workings, and 575 m from the closest extent of the fly ash deposition footprint delineated in AECOM (2018a) – Figure 2, and on the assumption that the 5 million m^3 of fly ash placed for the Ash Dam Augmentation Project is stable (Position Statement 2), only an increase in the current operational water level of the Decant Pond would lead to a reduction in stability of the Southern Embankment.

4. OEE has provided assurances to Stantec that there is no intention to operate the Decant Pond at higher water levels as a result of the Augmentation Project. The current normal dry weather operational level of the ash dam is RL 125.5 m EPSD and this would remain unchanged as a result of the Augmentation Project. Operational procedures supporting this include the presence of a real-time level gauge providing OEE operational personnel with information on the water level in the Decant Pond. This information is relayed to the control room and an alarm is triggered when the water level reaches RL 125.5 m EPSD. The water level is controlled by opening and shutting valves at the intake siphon. These valves are operated automatically in response to the trigger alarm, however in the event of rain being forecast they are able to be manually overridden to increase storage and/or flow, providing an additional control on Decant Pond level. In high rainfall events the decant pond level may increase above RL 125.5 m EPSD. Stantec's assessment of dam wall stability (Stantec, 2018) assesses the stability of the Southern Embankment up to RL 127.6 m EPSD (spillway level) and RL 129.6 m EPSD and confirms the embankment remains stable under normal operating conditions. The operational strategy during high rainfall events is to maintain dam levels below RL 127.6 m EPSD, and this would not change as a result of the Augmentation Project. We note remedial works are proposed to mitigate stability impacts in the event of an earthquake. The latter is identified by Stantec, 2018 as having the potential to impact the stability of the Southern Embankment.

5. In summary, Stantec's assessment is that placement of the proposed 5 million m^3 of fly ash contemplated as part of the Ash Dam Augmentation Project is not assessed to have an adverse impact on the stability of the Southern Embankment for two main reasons:

    a. The factor of safety against post-seismic instability under both current and the initially proposed (AECOM 2018a) storage configurations for the 5 million m^3 meets the minimum requirement recommended by ANCOLD and DSC Guidelines (i.e. the additionally placed fly ash is not anticipated to be displaced in the direction of the Southern Embankment in a way that would make it become unstable and fail); in summary, the scope of works for the Ash Dam Augmentation Project is a long distance from the Southern Embankment and the relatively flat deposition landform (1 – 2% slope) means the placed ash is assessed to remain stable.

    b. The Southern Embankment is assessed to remain stable even where the Decant Pond is maintained at the maximum operational high rainfall level (RL 127.6 m EPSD), noting that typically operational Decant Pond levels is able to be maintained below the dry weather operational level (RL 125.5 m EPSD).

We trust that this information is sufficient for your current requirements. However, should you require further information, please do not hesitate to contact us.

Charlie Strick van Linschoten
MEng MSc RPEQ
Principal Geotechnical Engineer
Stantec Australia Pty Ltd

Theo Gerritsen
MEng, CEng, MICE, RPEQ
Tailings Discipline Lead
Engineer of Record Eraring Ash Dam
Stantec Australia Pty Ltd

Cc. Paul Hill (OEE), Taylor Welch (OEE), Lauren Barnaby (OEE), Matt Davies (OEE), Gemma Dobson (OEE)

Attachments:

Appendix A: Dam Break Re-Assessment, Southern Embankment (Rev 0), dated 21 June 2019.

References:

AECOM (2018a). *Ash Dam Augmentation Project – Environmental Assessment*, 15 August 2018.

AECOM (2018b). Eraring Ash Dam. Ash Terrace Feasibility Assessment – Stability Assessment.

Stantec (2018). *Geotechnical Stability Assessment, Southern Embankment, ERAD*, Rev 2, 8 March 2019.

Appendix A: Dam Break Re-Assessment, Southern Embankment

Stantec

Memo

To:	Lauren Barnaby Origin Energy Eraring	From:	Charlie Strick van Linschoten Stantec (Brisbane)
File:	M_20190621_EPS_1077_Dam Break Re-Assessment_TLG_0	Date:	June 21, 2019

Reference: Dam Break Re-Assessment – Southern Embankment, Additional Stacked Ash (5 million m^3)

Origin Energy Eraring Pty Ltd (OEE) requested that Stantec Australia Pty Ltd (Stantec) perform a dam break assessment and consequences assessment to simulate up to an additional 5 million cubic metres of ash placed within the Eraring Ash Dam (ERAD) footprint in accordance with scope of work contemplated by the Ash Dam Augmentation Project (also known as the 'Area 6/7 Project') Environmental Assessment (AECOM 2018). This memorandum summarises the additional modelling and results. We have specifically addressed OEE's request to assess whether the consequences of a dam break event would increase as a result of the AECOM scope of work (compared to the previous dam break assessment conducted by Stantec for the Southern Embankment).

The figure from AECOM's 2018 Environmental Assessment for the Ash Dam Augmentation Project illustrating the location of the additional stacking is shown below (AECOM, 2018) as Figure 1.

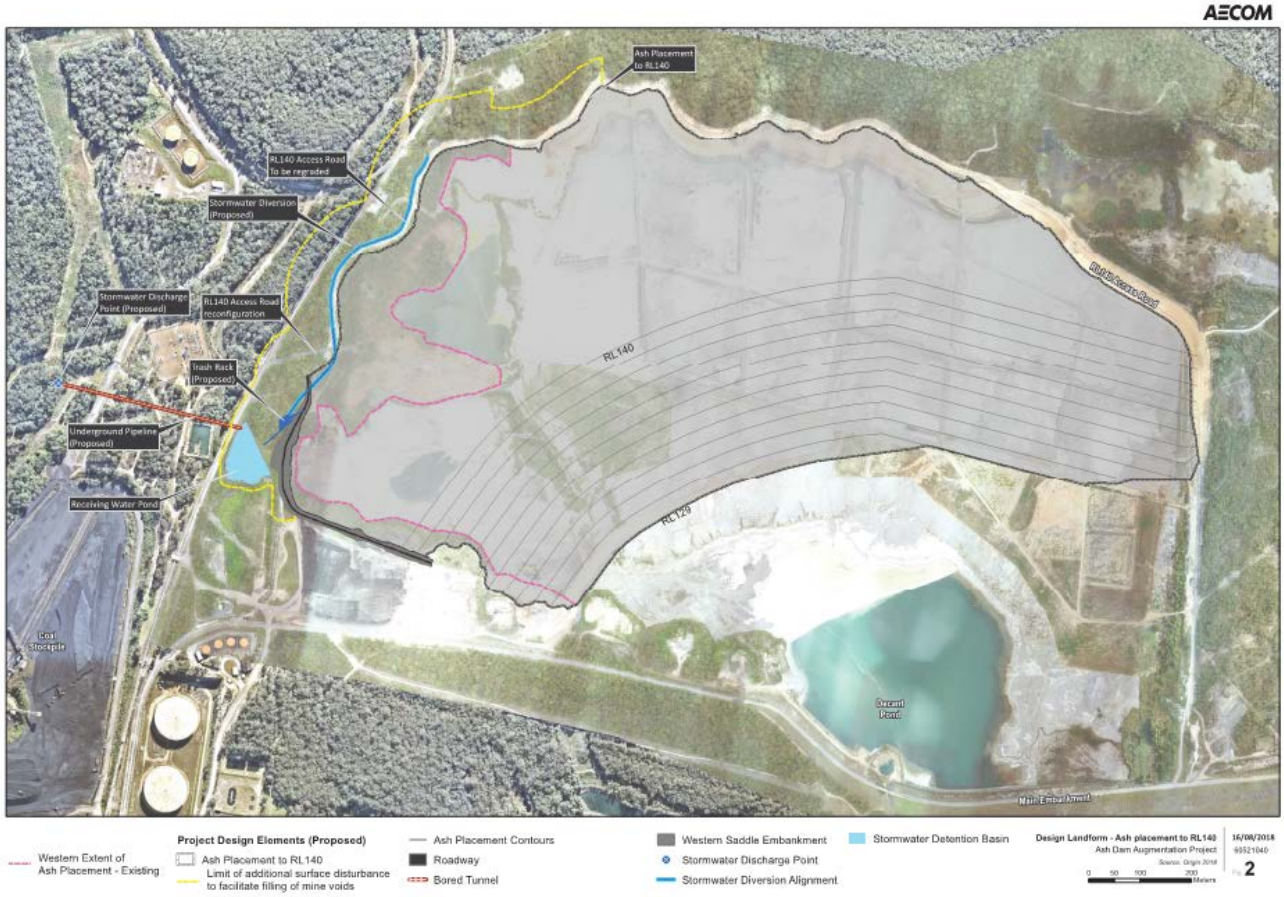

Figure 1. AECOM 2018 Environmental Assessment for the Ash Dam Augmentation Project

Dam Break Analysis

The previous dam break assessment for Eraring Ash Dam (Southern Embankment) was performed by Stantec in 2018 and evaluated five breach scenarios (Stantec, 2018):

- Location 1: "sunny-day" breach
- Location 1: PMP breach
- Location 2: "sunny-day" breach
- Location 2: PMP breach
- Location 3: "sunny-day" liquefaction breach

A figure showing the breach locations is included below.

Figure 2. Breach Locations

The results of these analyses are summarised in "Dam Break Assessment – Eraring Ash Dam" prepared by Stantec and dated November 30, 2018. The breach scenario with the largest downstream consequences was the Location 3: "sunny-day" liquefaction breach. For this reassessment the results consider the change in Population at Risk (PAR) that may result from remodeling the additional 5.0 million cubic metres associated with the Ash Dam Augmentation Project. PAR includes all people who would be directly exposed to flood waters assuming they took no action to evacuate and is a key determinant in assessing a dam's consequence category. The base of the breach elevation was assumed to be 104 metres, the crest of dike was assumed to be 130.5 metres, and the water surface elevation was assumed be at the crest of the dike (130.5 metres). These assumptions are the same assumptions made in the previous assessment (Stantec, 2018).

To prepare the updated modelling, stage-storage information for the Ash Dam Augmentation project was developed based on contours provided by OEE corresponding to Figure 2 in AECOM's 2018 Environmental Assessment for the Ash Dam Augmentation Project (included in this memo for completeness as Figure 1 above). These contours were used to generate a surface in Autocad Civil3D limited to 5.0 million cubic metres of additional ash storage. The surface was compared to the June 2018 topographic data used in the previous assessment in order to compute a revised stage-storage associated with the additional stacked ash. This stage-storage information was used to supplement the stage-storage calculations from the previous assessment. This information is summarised in Attachment A.

Consistent with the previous assessment, 35% of the ERAD ash volume (including the additional 5.0 million cubic metres of fly ash in the total volume) was assumed to mobilise. This volume was used to update the breach width and time to failure computations, which are based on guidelines in the Queensland Government document "Guidelines for Failure Impact Assessment of Water Dams." A more detailed discussion of how these parameters are computed is presented in the previous assessment report (Stantec, 2018). A summary of the breach parameters for the re- assessment is shown below in Table 1. For comparison, the breach parameters from the previous assessment are also shown.

Table 1. Breach Parameter Summary

Scenario	Breach Volume (V_w) Water --- Ash (mega-litres)	Height differe-ntial (h) (metres)	Breach Formation Factor (BFF) (mega-litres-metres)	Volume of Material Removed (V_m) (mega-litres)	Bottom Breach Width (b) (metres)	Develo p-ment Time (T) (hours)	Check (B/b betwe en 1.06-1.74?)	Check (B/d betwee n 0.84-10.93?)
Location 3: "sunny-day" liquefacti on breach (previous assessme nt)	3390.6 --- 10256.8	26.5	$3.62x10^5$	$1.36x10^5$	47.9	2.3	1.55, Yes	2.81, Yes
Location 3: "sunny-day" liquefacti on breach (re-assessme nt)	3390.6 --- 12006.8	26.5	$4.08x10^5$	$1.53x10^5$	54.7	2.4	1.48, Yes	3.06, Yes

The U.S. Army Corps of Engineers Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) model used in the previous assessment was updated with the revised breach width, time to failure, and stage-storage information. The revised outflow hydrograph is shown in Figure 3. For comparison purposes, the flow hydrograph from the previous assessment for the "sunny-day" liquefaction breach is also shown.

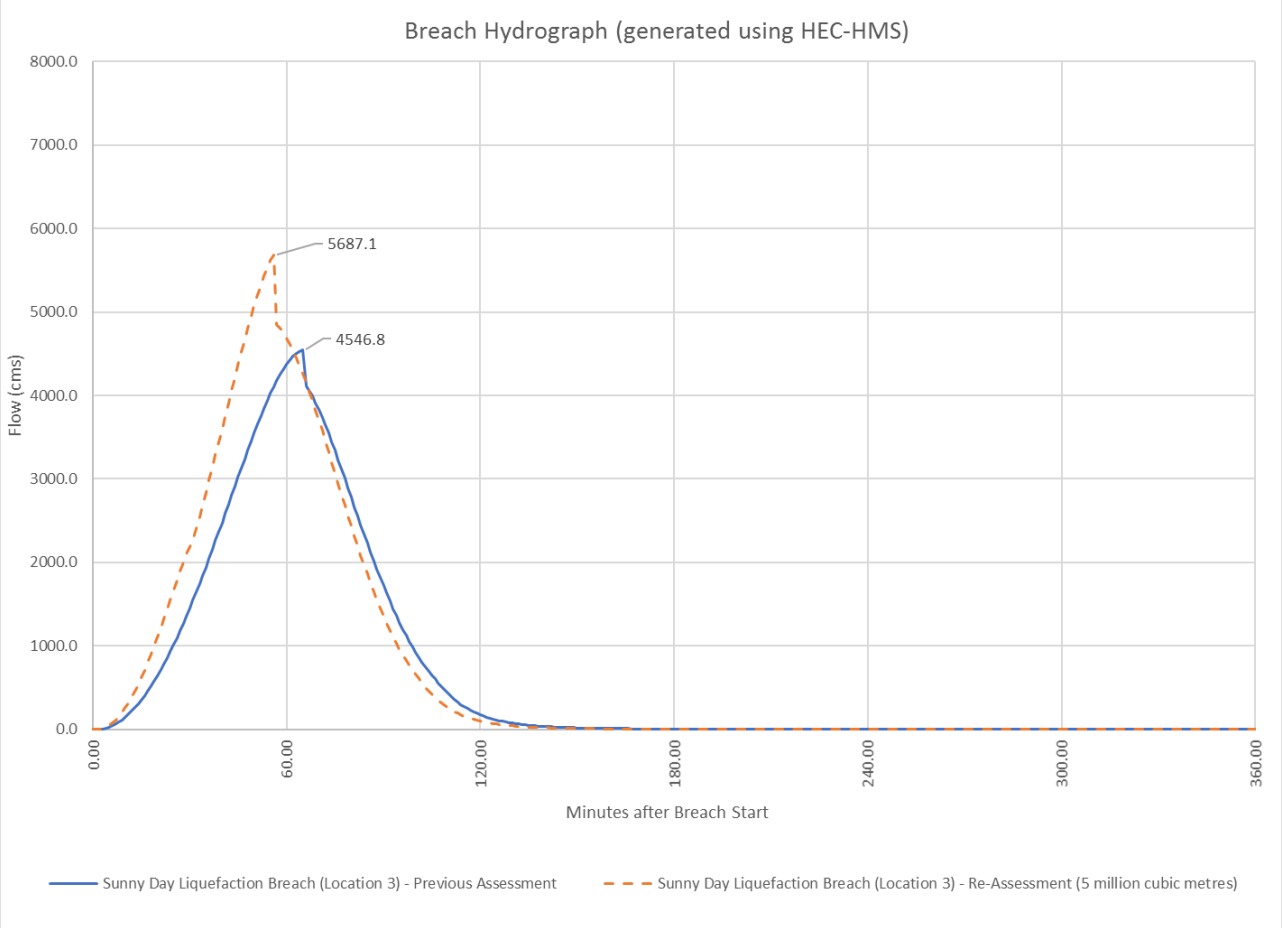

Figure 3. Breach Outflow Hydrographs

The outflow hydrograph was multiplied by one minus the average sediment fraction (as described in the previous assessment report, Stantec, 2018) to compute the water outflow, and the sediment volume at each timestep was computed. The same void ratio assumed in the previous assessment (0.83) was assumed for the re-assessment. These values were used as input into the hydraulic model.

Hydraulic Analysis

The FLO-2D (version 18.09.19) Flood Routing Model developed for the previous assessment was re-run with the modified inflow hydrograph. Other parameters were not modified and are as described in the previous assessment report (Stantec, 2018).

Results and Downstream Consequences

Downstream consequences related to population at risk (PAR) were evaluated. PAR was re-calculated using the same methods noted in the previous assessment report (Stantec, 2018). Different levels of occupancy rates of the Myuna Bay Sport and Recreation Centre (since November 2018) were not considered in order to obtain a direct comparison between the results of the previous assessment and current assessment, as directed by OEE.

A summary of the PAR for the re-assessment and the previous assessment are included in Table 2. Additional structures contributing to the PAR for the re-assessment include two maintenance buildings contributing 2 PAR each to the day PAR (structure ID's 9 and10), one residence contributing 4 PAR to the night PAR (structure ID 12), and the administration block contributing 4 PAR to the day PAR (structure ID 15). The entire footprint of the Maroubra Lodge Parking Lot (structure ID 28) is inundated as well, however, parking lots were assumed to

contribute zero to the PAR. This was done so as to avoid double-counting any of the PAR, noting people would not be in the parking lots and buildings at the same time.

Table 2. PAR Summary

Scenario	Length of Wangi Road Inundated (km)	Time for vehicle to pass (minutes)[1]	PAR associated with Wangi Road[2]	PAR associated with Myuna Bay (day)	PAR associated with Myuna Bay (night)	Total PAR[3]
Location 3: "sunny-day" liquefaction breach (previous assessment)	1.51[4]	1.01	21	265	254	286
Location 3: "sunny-day" liquefaction breach (re-assessment)	1.70	1.13	24	273	258	297

[1] Length of road inundated was divided by the speed limit (90 km/hr) and converted to minutes.

[2] Time for vehicle to pass was multiplied by persons per minute travelling across Wangi Road (21.2 persons per minute).

[3] Represents the maximum of the day and night PAR for Myuna Bay added to the PAR associated with Wangi Road.

[4] During the re-assessment it was noted that the previous assessment summary table (Stantec, 2018) underrepresented the road inundation by 0.25 km. The previous assessment PAR summary table results have been updated, herein, to account for an inundation length of 1.51 km.

The PAR still falls within the 100-1000 persons range, which is consistent with a consequence category of High A based on Table 2 from the June 2012 Dam Safety Committee for New South Wales "Tailings Dams" document (Dam Safety Committee for New South Wales, 2012).

Stantec appreciates the opportunity to provide these engineering services. Please do not hesitate to contact us should you have any questions.

Charlie Strick van Linschoten
MEng, MSc, DIC, RPEQ
Principal Geotechnical Engineer
Stantec Australia Pty Ltd

Theo Gerritsen
MEng, CEng, MICE, RPEQ
Tailings Discipline Lead
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REFERENCES

AECOM (2018). Ash Dam Augmentation Project Environmental Assessment. August 15, 2018.

Australian National Committee on Large Dams (ANCOLD) (2012). "Guidelines on the Consequence Categories for Dams." October 2012.

Dam Safety Committee for New South Wales (2012) "Tailings Dams (DSC3F)." June 2012.

Stantec (2018). "Dam Break Assessment – Eraring Ash Dam" November 30, 2018.

Attachment A: Stage Storage Data – Sunny Day Breach – Location 3 (Updated)

Stage-Storage information for sunny-day breach, Location 3 - updated to account for Ash Dam Augmentation Project

Elevation (metres)	Ash Volume (cubic metres)[1]	Additional Stacked Volume (Ash Dam Augmentation Project) metres	Water Volume (cubic metres)[2]	Total Volume (cubic metres)[3]	Ash Volume above elevation 104 metres[4]	35% Ash Volume (cubic metres)	Water Volume above elevation 104 metres[5]	Breach Volume (cubic metres)[6]	Sediment Fraction at Elevation	
102	0.0			0.0	0.0	0.0	0.0	0.0		
103	124115.4			124115.4	0.0	0.0	0.0	0.0		
104	297584.2			297584.2	0.0	0.0	0.0	0.0		<< Bottom
105	525199.7			525199.7	227615.6	79665.4	0.0	79665.4	0.55	
106	811887.0			811887.0	514302.8	180006.0	0.0	180006.0	0.55	
107	1162592.1			1162592.1	865007.9	302752.8	0.0	302752.8	0.55	
108	1587450.4			1587450.4	1289866.2	451453.2	0.0	451453.2	0.55	
109	2165805.5			2165805.5	1868221.3	653877.5	0.0	653877.5	0.55	
110	2806606.8			2806606.8	2509022.6	878157.9	0.0	878157.9	0.55	
111	3512428.4			3512428.4	3214844.2	1125195.5	0.0	1125195.5	0.55	
112	4289400.7			4289400.7	3991816.5	1397135.8	0.0	1397135.8	0.55	
113	5176665.4			5176665.4	4879081.3	1707678.4	0.0	1707678.4	0.55	
114	6138790.2			6138790.2	5841206.1	2044422.1	0.0	2044422.1	0.55	
115	7188172.4			7188172.4	6890588.2	2411705.9	0.0	2411705.9	0.55	
116	8312024.6		0.0	8312024.6	8014440.4	2805054.1	0.0	2805054.1	0.55	
117	9520152.2		613.9	9520766.1	9222568.1	3227898.8	613.9	3228512.7	0.55	
118	10797595.3		9392.9	10806988.2	10500011.2	3675003.9	9392.9	3684396.8	0.54	
119	12152987.7		30961.4	12183949.1	11855403.5	4149391.2	30961.4	4180352.6	0.52	
120	13565561.2		66970.3	13632531.5	13267977.0	4643792.0	66970.3	4710762.3	0.51	
121	15026550.7		125785.3	15152336.1	14728966.6	5155138.3	125785.3	5280923.6	0.49	
122	16534779.8		207695.7	16742475.5	16237195.6	5683018.5	207695.7	5890714.2	0.47	
123	18108858.3		311307.2	18420165.5	17811274.1	6233945.9	311307.2	6545253.2	0.46	
124	19734043.9		435265.7	20169309.6	19436459.7	6802760.9	435265.7	7238026.6	0.45	
125	21415527.8		579690.3	21995218.1	21117943.6	7391280.3	579690.3	7970970.6	0.44	
126	23128987.6		761803.1	23890790.8	22831403.4	7990991.2	761803.1	8752794.3	0.42	
127	24835697.6		1048797.0	25884494.6	24538113.5	8588339.7	1048797.0	9637136.7	0.37	
128	26411040.8		1520550.5	27931591.3	26113456.6	9139709.8	1520550.5	10660260.3	0.29	
129	27928749.9	222653.875	2148886.8	30300290.6	27853819.6	9748836.9	2148886.8	11897723.7	0.27	
130	29153577.2	439965.8487	2936417.1	32529960.1	29295958.8	10253585.6	2936417.1	13190002.7	0.21	
130.5	29602633.4	569486.1346	3390630.6	33562750.1	29874535.3	10456087.4	3390630.6	13846717.9	0.17	
131		699006.4206		33692270.4	30004055.6	10501419.5	3390630.6	13892050.0	0.55	
132		986124.8718		33979388.8	30291174.1	10601910.9	3390630.6	13992541.5	0.55	
133		1350986.851		34344250.8	30656036.0	10729612.6	3390630.6	14120243.2	0.55	
134		1781183.071		34774447.0	31086232.3	10880181.3	3390630.6	14270811.9	0.55	
135		2238918.148		35232182.1	31543967.3	11040388.6	3390630.6	14431019.1	0.55	
136		2763532.315		35756796.3	32068581.5	11224003.5	3390630.6	14614634.1	0.55	
137		3317284.258		36310548.2	32622333.5	11417816.7	3390630.6	14808447.3	0.55	
138		3890183.138		36883447.1	33195232.3	11618331.3	3390630.6	15008961.9	0.55	
139		4465193.987		37458457.9	33770243.2	11819585.1	3390630.6	15210215.7	0.55	
140		5000000		37993263.9	34305049.2	12006767.2	3390630.6	15397397.8	0.55	<< Top

water volume	3390.6	mega-litres
ash volume	12006.8	mega-litres
average void ratio	0.83	
assumed % solids by Volume of Ash	55%	
Between Elevation	104.0	metres
and Elevation	140	metres
Average Sediment Fraction	0.43	

[1] Ash volume computed for the full pond area. Ash above 130.5 metres for the existing condition is assumed not to mobilize.

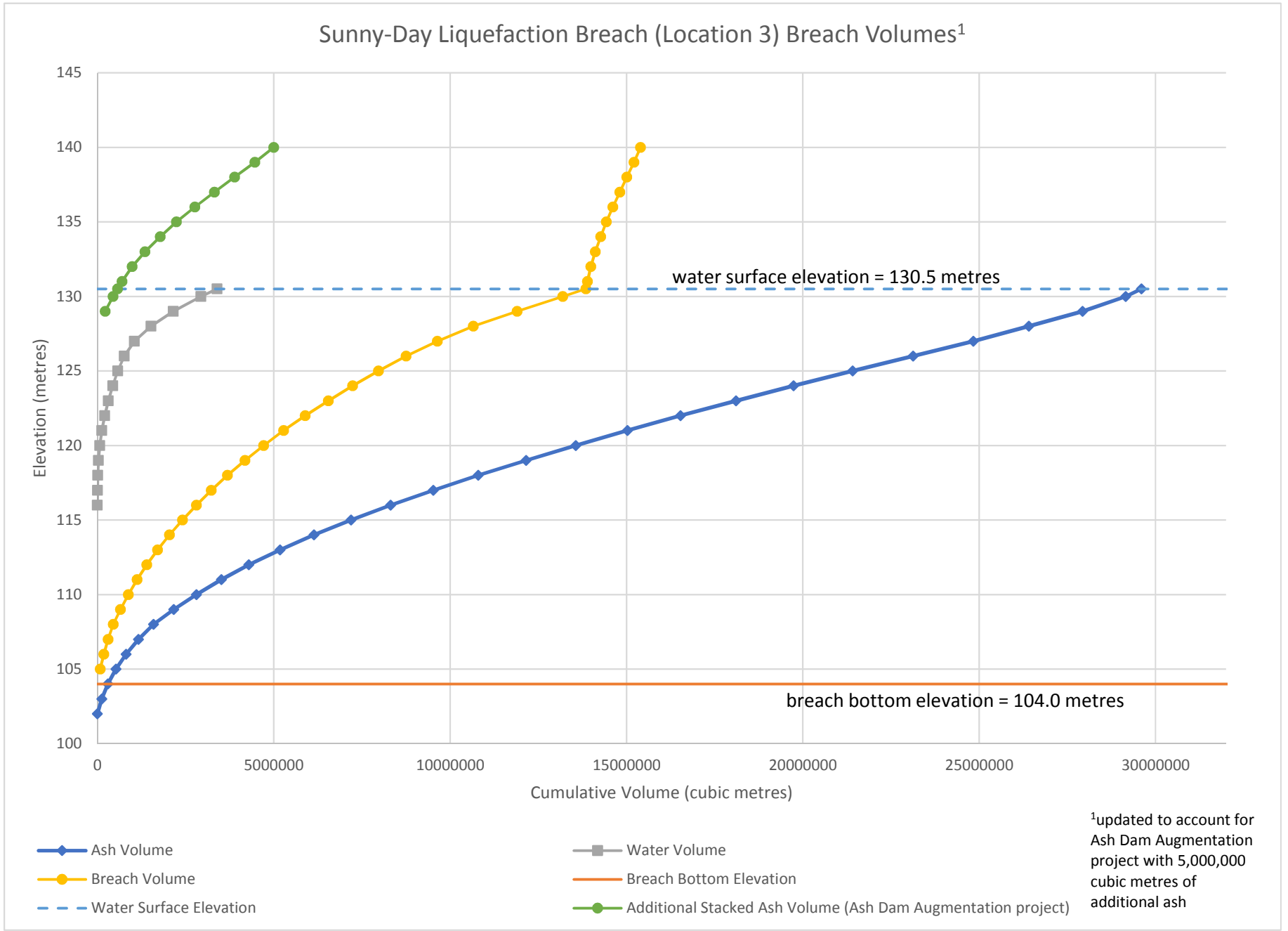
[2] Water volume from the stage-storage information used in the PMP hydrologic analysis.

[3] Total volume = ash volume + water volume + additional stacked volume.

[4] Considers ash volume above the breach bottom elevation of 104 metres.

[5] Considers water volume above the breach bottom elevation of 104 metres.

[6] Breach volume = 0.35*ash volume + water volume - assumes 35% of the ash material leaves the pond during the breach. Volumes taken above breach bottom elevation of 104.


Sunny-Day Liquefaction Breach (Location 3) Breach Volumes[1]
145
140
135
130
125
120
115
110
105
100
Elevation (metres)
water surface elevation = 130.5 metres
breach bottom elevation = 104.0 metres
0
5000000
10000000
15000000
20000000
25000000
30000000
Cumulative Volume (cubic metres)
Ash Volume
Water Volume
Breach Volume
Breach Bottom Elevation
Water Surface Elevation
Additional Stacked Ash Volume (Ash Dam Augmentation project)
[1]updated to account for Ash Dam Augmentation project with 5,000,000 cubic metres of additional ash