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Alcoa
Wagerup ROWS Pond Project WG 0159

ROWS Pond Capacity

Problem Definition

PROJECT NO.: **H336562**

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Executive Summary

During the RSA 9 Project (WG 0159) FEL2.2 it was identified that with expansion of the residue area current ROWS Pond capacity will not meet the required design criteria when RSA 9 is constructed, which is forecast to be in mid 2013, or for RSAs beyond this date. The ROWS Pond Project, a result of identifying this problem, is currently in problem definition phase and will culminate in agreement of the Design Criteria to be progressed into Solution Analysis.

Alcoa has a water balance for the contaminated water streams on-site. Hatch has modified the balance to calculate monthly operating storage volumes so the wet season ROWS Pondrun-off volume peaks can be identified. In addition, a Monte Carlo analysis of rainfallsimulation has been incorporated to forecast rainfall when simulating future storage volume requirementsprovide a probabilistic estimate of the accumulated water across a number of years.

This model has allowed for the analysis of various scenarios with four scenarios selected for analysis;

1. Overflowed volume if awith an annual rainfall having a 1% probability of exceedence (1% wet year occurs)
2. Overflowed volume if a 1% wet year occurs, followed by an average year
3. Overflowed volume if a 1% wet year occurs, followed by one year ofrainfall modelled via a Monte Carlo forecast rainfall datasimulation
4. Overflowed volume projected from by a Monte Carlo forecast rainfall datasimulation only across a 10 year period from 2011 until 2022.

All scenarios analysed indicate that current ROWS Pond capacity is sufficient for the current catchment area, but following the construction of RSA9, it's volume is insufficient for future requirements, with the size of the capacity deficitexcess dependent on the level of acceptable riskreturn period adopted in the analysis and period length analysedover which the analysis is run. The deficit excess in run-off increases with time due to the expected residue area expansion, which results in a greater amount of run-off collected per unit of rainfall (mm).

Traditionally Alcoa has used an annual rainfall having a 1% probability of exceedence the 1%wet year as the basis for ROWS Pond capacity designestimating the excess run-off water which needs to be managed. , whichThis results in an excess to the current ROWS Pond capacity deficit ranging from 400 ML in 2014 (following the construction of RSA9) to 1,000 ML in 2020 (following the construction of RSAs 10 and 11), with the deficit increasing due to the anticipated growth of the residue area.

Modelling indicates that there will be an accumulation of volumea "carry-over" of water in the ROWS Pond following an average rainfall year (860mm/yr) unless activities outside normal operations occur to remove the volume stored in the ROWS Pond. To avoid carry-over from one wet year to the next, additional strategies are required which will reduce the volume of excess water in the system. This is reflected in the Scenario two results, whereby the ROWS Pond continues to overflow in the year following a 1% wet year if an average rainfall year is experienced, and operations are unable to remove ROWS water outside of the modelled activities.

Applying a Monte Carlo simulation to estimate a probability of excess water following a 1% wet year (Scenario three) also indicates continued ROWS Pond overflows in the yearexcess water following a

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1% wet year~~ using rainfall forecast by the Monte Carlo simulation~~, with the ~~level of acceptable risk influencing the magnitude of overflowed volume.~~

Scenarios 1 to 3 estimate the probability of continued excess water following a 1% wet year. Scenario 4 removes the initial 1% wet year, and simply looks at the probability of having an excess of water across a nominate time period. ~~four doesn't force a 1% wet year, forecasting rainfall for the entire period instead and produces the most conservative short term overflow result~~. ~~If a 1% level of risk is assumed, then the deficit in ROWS capacity until July~~For the period 2011 to 2016, the volume of excess with a probability of exceedence of 1% ~~–~~is 287 ML. ~~The deficit in ROWS capacity increases rapidly however to~~If the period is extended to 2020, this volume of excess increases to almost 3,000ML~~ in July 2020~~. This increase is the result of accumulated volume a number of successive wet years in the Monte Carlo simulation.

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1 Background

The Wagerup ROWS Pond is designed to store low TA run-off water collected from the residue area. The water collected in the ROWS pond supplies the high TA water circuit during the dry season when evaporation exceeds rainfall resulting in the high TA water circuit balance becoming net negative.

During the RSA 9 Project (WG 0159) FEL2.2 it was identified that with expansion of the residue area to include RSA 7N and 8, the current ROWS pond has insufficient capacity to store a 1% wet year. Cthe current ROWS Pond capacity will not meet the required design criteria when RSA 9 is constructed, which is forecast to be in mid 2013, or for RSAs beyond this date. The ROWS Pond Project, a result of identifying this problem, is currently in problem definition phase and will culminate in agreement of the Design Criteria to be progressed into Solution Analysis.

2 Introduction

Alcoa has a water balance for the contaminated water streams on-site. The current refinery operating practice is to transfer from the ROWS pond to the Super Thickener (which overflows to the cooling Pond) or to the Cooling Pond directly in summer. This is intended to maintain the Cooling Pond at a constant level. In the balance, the steady state discrepancy between water inputs and outputs is calculated and the annual discrepancy stored as either volume accumulation or consumption in the ROWS Pond. The operating practice to is reduce the ROWS pond to minimum level by May each year (400 ML), and the volume then increases over winter ans rainfall run-off volume exceeds the refineries need for water. however tThe calculated annual stored volumes using the accumulation/consumption method correlates well with historical data on a month-by-month and an annual basis.

Hatch has modified the balance to calculate monthly operating storage volumes so the wet season ROWS Pond volume peaks can be identifiedacross a number of successive years. In addition, a Monte Carlo analysis simulation of rainfall has been incorporated to forecast rainfall when simulating future storage volume requirementsprovide a probabilistic estimate of excess run-off water and hence a probability of exceeding current storage volumes. The Monte Carlo model forecasts futuresimulation takes its rainfall from rainfall data, using a Gamma distribution probability density function derived from historical rainfall data and stores the outputs for Monte Carlo analysis.

The modelling has been done allowing for future residue expansion milestonesbased on forecast residue area expansions, and the projection of future storage volume allows allowing Alcoa stakeholders to specify the Design Criteria for the Project in full knowledge of the constraints under which the design is valid.

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3 Basis for Projecting Future Volumes

3.1 Operating Basis

Current ROWS capacity is 4,000 ML whilst the minimum operating volume allowable is 400 ML. Hence the current ROWS pond provides up to 3,600 ML of surge capacity.

No change was made to the existing basis used in the water balance model, and so discrepancies between the water inputs and outputs were stored as either volume accumulation or consumption in the ROWS pond.

A ROWS pond starting operating volume of 400 ML for the start of May 2011 was used.. The model contains historical rainfall data up to mid 2010, and when reviewed in line with the current dry year, achieving the minimum level prior to winter 2011 is reasonable.

3.2 ~~Forecasting Basis~~Assumptions for the Modelling

All modelling has been performed allowing for:

- An alumina production rate creep of 50tpd stepped annually, with a base production of 7,000tpd in 2010.
- Condensate evaporative losses in the cooling towers at a rate of 0.22kL/tonne of alumina production.
- Annual pump-up from the detention ponds to the upper/lower dam of 300 ML total across August and September if rainfall for the previous 12 months is < 900mm.
- RSA 9 is modelled to be online in July 2013.
- RSA 10 is modelled to be 43ha and online in July 2016.
- RSA 11 is modelled to be 43ha and online in July 2019.
- Additional RSA construction beyond 2019 has not been considered.

3.3 Weather Basis

~~Provide sufficient water storage for a~~A wet year with a 1 % probability of exceedence (~~-~~1% wet year) is assumed to be ~~(~~1400mm of cumulated rainfall within twelve consecutive months~~)~~.

~~Contain the run-off collected from an average rainfall year in the year following a 1% wet year.~~ An average rainfall year has a rainfall of ~~is equivalent to~~ 860mm/year.

Extenuating factors such as a 1% 72hr storm event contributing to the 1% wet year have not been considered.

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4 Capacity Projections

4.1 Scenarios Modelled

Alcoa has historically determined run-off storage capacity requirements by applyingrequired to cater for a 1% wet year. The model uses differing run-off co-efficients between active storage areas, remediated areas and water bodies. No change was made to any parameters relating to these factors when modelling.

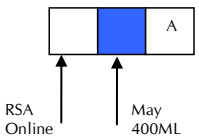
Modelling results for the capacity required at the conclusion of each incremental expansions of the residue area between 2010 and 2022 are shown in Table 4-1. Four capacity scenarios have been modelled:

Scenario 1

Current ROWS Pond level at 400ML for the start of May in the year following the construction of a new RSA, whereby a 1% wet year is endured. This scenario indicates the minimum overflow volume / additionalexcess run-off to the current ROWS capacity required in order to containresulting from a 1% wet year.

Scenario 2

Current ROWS Pond level at 400ML for the start of May in the year following the construction of a new RSA, whereby a 1% wet year is endured, followed by an average rainfall year. This scenario indicates the ROWS Pond excess run-off volume the year after a 1% wet year has occurred, with modelled operations indicating whether additional volume has been accumulated or magnitude of ROWS capacity reclaimed following a the 1% wet year.



A = Average Year
M = Probable rRainfall (determined by Monte Carlo)
= Wet vear

Scenario 3

Current ROWS Pond level at 400 ML for the start of May in the year following the construction of a new RSA, whereby a 1%wet year is endured, followed by rainfall forecast by themodelled via a Monte Carlo analysissimulation. Similar to Scenario two, except the rainfall year following a 1% wet year is independently forecast, based on historical data and probabilitydetermined via the Monte Carlo simulation providing a probabilistic output.

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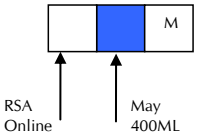

A – Average Year
M – ~~Probable r~~Rainfall ~~(~~determined by Monte Carlo)
– Wet year

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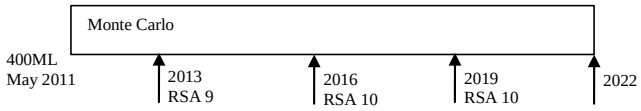
Scenario 4

~~Current~~ ROWS pond level at 400ML in May 2011. Storage capacity is on based on operating basis, forecast criteria and projected rainfall in each year ~~from~~ via a Monte Carlo ~~analysis~~ simulation until 2022. This ~~scenario indicates the required ROWS~~provides a probabilistic estimate of the excess run-off across the ~~capacity using forecast rainfall for the entire~~ analysis period.



4.2 Modelling Results

Where the Monte Carlo has been applied, both the 95th and 99th percentile ~~overflow~~ for excess water ~~results~~ are provided so the magnitude of the change with probability can be assessed.

Table 4-1: Scenario modelling results

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	Scenario 1	Scenario 2	Scenario 3			
	~~ROWS Pond Overflows~~Excess Run-off Volume	Excess Run-off Volume~~ROWS Pond Overflows~~	95th Percentile ~~overflows~~Excess	99th Percentile Excess~~Overflows~~	95th Percentile Excess~~overflows~~	99t Percer Overfl
July 2013 - June 2016 (RSA 9 online)	420 ML	887 ML	1,329 ML	1,885 ML	No overflows	287
July 2016 - June 2019 (RSA 10 online)	740 ML	1,462 ML	1,902 ML	2,539 ML	658 ML	1,601
July 2019 - June 2022 (RSA 11 online)	1,061 ML	2,044 ML	2,305 ML	2,985 ML	1,733 ML	2,933

(Is the 2019 – 2022 across just these years or is it across 2013 – 2022??)

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The modelling results indicate that current ROWS Pond capacity will be insufficient to meet future needs, with the deficit of ROWS Pond capacity dependent on the required design life of the ROWS Pond and the method of analysis.

Traditionally Alcoa has used the 1% wet year as the basis for ROWS Pond capacity design, which results in a capacity deficit ranging from 400 ML in 2014 to 1,000 ML in 2020, with the deficit increasing due to the anticipated growth of the residue area which increases the run-off collected for storage.

Modelling indicates that there will be an accumulation of volume in the ROWS Pond following an average rainfall year (860mm/yr) unless activities outside normal operations occur to remove the volume stored in the ROWS Pond. This is reflected in the Scenario two results, whereby there is an excess volume ~~ROWS Pond continues to overflow~~ in the year following a 1% wet year if an average rainfall year is experienced, and operations are unable to remove ROWS water outside of the modelled activities.

Scenario three also indicates continued ~~ROWS Pond overflows~~excess run-off in the year following a 1% wet year using rainfall forecast by the Monte Carlo simulation, with the ~~level of acceptable risk influencing the magnitude of overflowed volume.~~level of excess increasing as the probability of exceedence is reduced.

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Scenario four doesn't force a 1% wet year, forecasting rainfall for the entire period instead, and produces the most conservative short-term ~~overflow~~ result in terms of potential excess run-off. ~~In line with the 1% wet year basis, if~~If a 1% ~~level of risk~~probability of exceedence is assumed, then the ~~deficit in ROWS capacity~~excess volume until July 2016 is 287 ML. The ~~deficit in ROWS capacity~~excess volume increases rapidly however to almost 3,000 ML by July 2022, peaking in September 2021 due to the potential for ongoing accumulation of run-off ~~,~~as a result of successive wet years in the Monte Carlo simulations.