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Appendix F
Use of spill basin to further reduce final effluent variability - report

Pőyry (November 2008)
Use of the emergency basin to further reduce the variability of final effluent quality. Report prepared for Gunns Limited.

TECHNICAL REPORT

GUNNS LTD.
BELL BAY PULP MILL

November 2008

USE OF THE EMERGENCY BASIN TO FURTHER REDUCE THE VARIABILITY OF FINAL EFFLUENT QUALITY

Contents

1 INTRODUCTION

The Independent Expert Group (IEG) have requested further information demonstrating that the use of the emergency basin (EB) at the effluent treatment plant (also called Spill Basin) to control the peaks of monthly maximum concentrations will not contravene the requirements of the Tasmanian Government Permit.

According to the permit Gunns have to operate the EB such that the minimum available capacity of the basin is 90000 kl 95 % of the time when calculated on an annual average. The total volume of the EB is 100000 kl.

This requirement implies that the EB can be used to store off-limit effluent up to an average volume of 10000 kl during 346.75 days/a, and beyond the 10000 kl volume 18.25 days/a.

This report discusses the possible operation modes of the EB and the resulting compliance situation with the State Government Permit.

2 PURPOSE AND OPERATION PRINCIPLES OF THE EMERGENCY BASIN

The purpose of an EB together with an equalization basin (EqB) is to protect the downstream activated sludge process against possible sudden surges of excessively high or hazardous effluent loads. They may kill or otherwise inactivate the microbial biomass in the plant resulting in a severe violation of the permitted effluent loads.

The EB and EqB have been integral parts of the pulp mill effluent treatment plants (ETP) for more than 20 years. In older plants the basins are only smaller than in the modern plants. The AMT design principle is that the volumes of the EB and EqB should correspond to 24 and 12 hours' design effluent flow, respectively.

During the normal operation of the ETP, the emergency basin is kept empty. Only in case the raw effluent load and/or quality entering the ETP exceed the design values of the ETP, the EB is used.

The raw effluent can be diverted to the EB from various parts of the ETP, including the primary clarifier inlet and outlet, equalisation basin outlet, and possibly the secondary clarifier outlet. The stored effluent is normally returned from the EB to the primary clarifier inlet. In case there is no excessive TSS in the effluent, it can also be returned to the primary clarifier outlet (= to EqB).

The EB is normally not provided with any fixed aerators or mixers.

Figure 2/1 presents an aerial photo of a modern pulp mill ETP showing a typical emergency basin arrangement. The EB is empty, except for a small amount of rain water trapped inside.

Figure 2/1. An Extended Aeration Activated Sludge Plant at a Pulp Mill in Finland

The main task of the EB is to protect the activated sludge process against upsets due to external factors, ie. high variability of the raw effluent load from the pulp mill. The problems normally include high BOD and COD-loads due to black liquor spills, high TSS-loads due to fiber spills, high effluent temperature, abnormal effluent pH, and hazardous process chemical spills.

As discussed in the EIMP, the EB can also be used to level down peak loads due to abnormal operation of the activated sludge process. The root cause of disturbances may be the off-limit raw effluent quality, but the unavoidable variability of the activated sludge process itself can also cause problems.

The key activated sludge process factors, F/M-ratio, effluent temperature, pH, DO in aeration, and BOD:N:P-ratio, cannot be kept at a constant, optimum level simultaneously all the time. Therefore variations in the microbial composition of mixed liquor solids take place.

The ETP of the Bell Bay mill will feature the latest design to control the quality of the mixed liquor solids and the sludge volume index (SVI). Despite this, the risk of excessive amounts of filamentous bacteria in mixed liquor and even sludge bulking cannot be ruled out.

They will cause occasional high TSS concentrations in the final effluent. Since this TSS comprises biomass, not fibres or other biologically neutral substances, it will also increase the final effluent BOD and nutrient concentrations.

Therefore, Gunns have proposed that the EB could also be used as an additional back-up to help to control the unavoidable, occasional peak concentrations of TSS, BOD, and nutrients in the final effluent.

3 CONTROL OF EFFLUENT VARIABILITY DUE TO SPILLS AND OTHER UPSETS IN THE PULP MILL

The most important hazard to control is the risk of black liquor spills from the unbleached fiberline, the evaporation plant, and the recovery boiler area.

As described elsewhere, the Bell Bay mill will be provided with the state-of-the-art spill prevention, monitoring, retrieval, and recovery systems, which are working in real time and are integrated with the mill wide DCS (Distributed Control System).

These in-plant spill containment system will almost invariably contain any spills, allowing them to be fed to the effluent treatment plant at a rate that will not compromise the plant’s stringent performance variability requirements. However, it is conceivable that these in-plant containment systems could themselves fail, in which case the EB would need to be relied upon.

Based on statistics from modern mills, the **frequency** of the spills is quite low, because they are proactively prevented with the built-in safeguards in the DCS. Therefore, the spills are normally associated only with the start-ups and shut-downs of the mills once or twice a year. This implies that modern mills may typically have 1-2 critical periods in a year when the probability of a spill is higher than normal.

The **duration** of such periods in existing mills can be up to about one week for start-ups and a couple of days for shut-downs. As an average, the total time in a year when spills are likely to occur is estimated at about 10-15 days. 15 days a year correspond to about 4.1 % of time, which is in compliance with the State Permit.

When the in-plant spill control systems are proven and operational, any spill, which may occur, is automatically contained inside the mill. However, there could be incidents due to equipment failure or human error, when a spill gets into the process effluent drain for a short period of time.

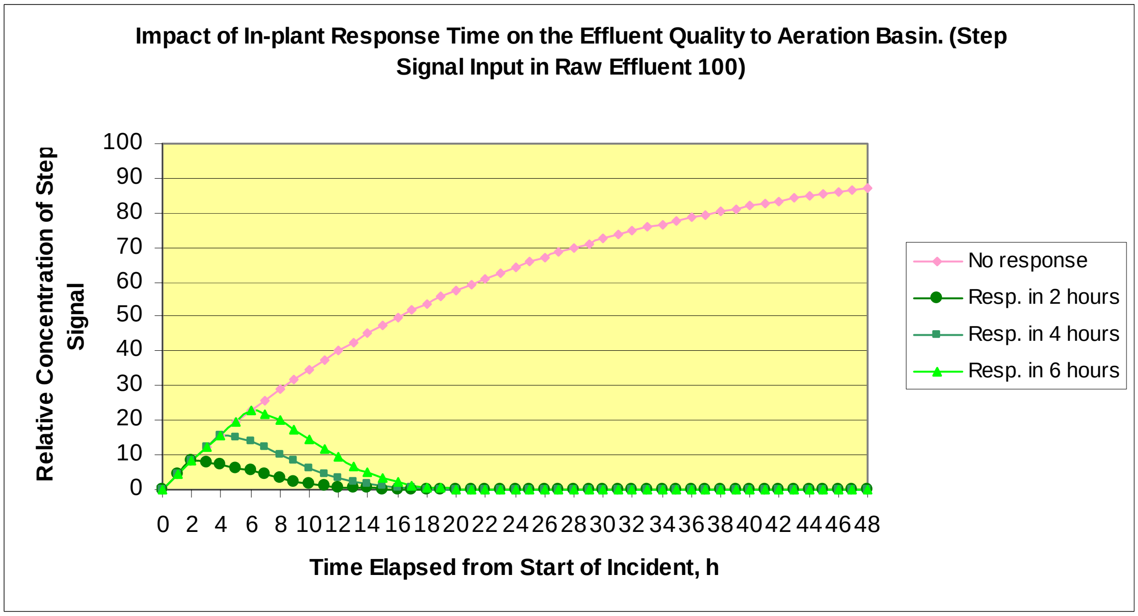
The statistics from older Swedish mills showed that the average duration of a spill was about 4 hours.

In modern mills the duration is much shorter, since the automatic interlockings and back-up systems are more efficient and the human errors are mitigated with better education and training in environmental matters. Therefore, the lead time to actuate the in-plant spill control systems is practically zero counted from the DCS alarms.

In the unlikely case that the automatic actuation will not take place, the EqB and the EB provide effective buffers to protect the activated sludge process.

Figure 3/1 depicts a simple simulation of the effect of a spill on the raw effluent quality through the primary clarifier and the equalisation basin to the activated sludge section of the ETP.

Figure 3/1. Increase of Effluent Concentration to Aeration Due to a Spill as Function of the Response Time in Spill Control at the Pulp Mill



According to Fig. 3/1 2-6 hour delays in the in-plant response can result in 10-23 % increase in effluent load to aeration when the original step signal input due to a spill is 100 %. The total time to get the situation back to normal is correspondingly about 10 to 18 hours from the elimination of the spill in the mill.

A 10 % increase could still be absorbed by the activated sludge process without any major risks, but larger variations should be avoided. This can be achieved by diverting the off-limit effluent to the EB.

In the event of a failure of the in-plant spill containment systems response action would be expected to reinstate them within no more than 4-6 hours from the start of an incident. Since the amount of effluent is normally not increased by a spill to any noticeable extent, the effluent amount of the Bell Bay mill to be diverted to the EB is estimated at about 3000 kl/h. Hence, the maximum amount of effluent to be diverted to the EB during a 4 hours' delay is about 12000 kl/incident and during a 6 hours' delay about 18000 kl/incident.

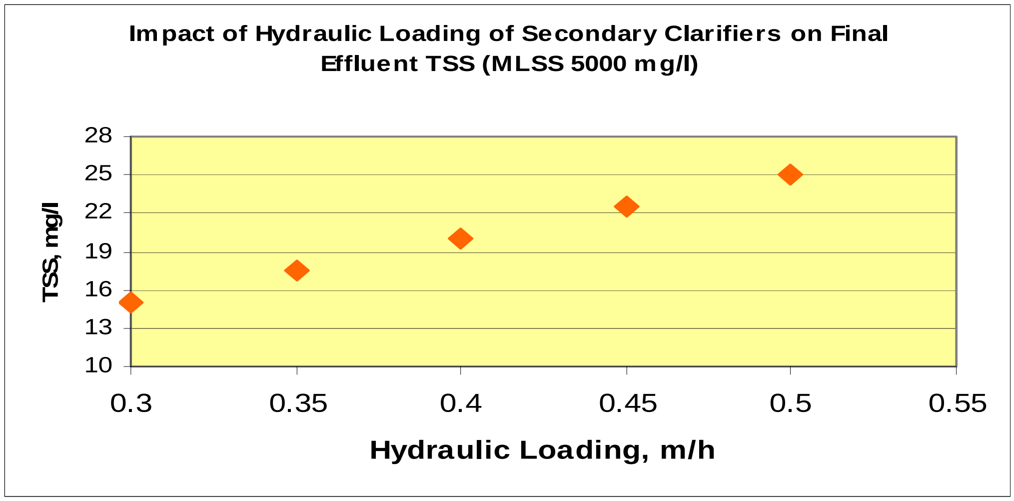
4 CONTROL OF FINAL EFFLUENT VARIABILITY DUE TO PROCESS UPSETS IN THE EFFLUENT TREATMENT PLANT

The root cause to the internal process upsets in the ETP is the dynamic behaviour of activated sludge in variable growth conditions. This was discussed in Chapter 2.

The proposed strategy to mitigate the periodic surge of TSS in the final effluent is as follows:

- The quality of mixed liquor suspended solids (MLSS) is inspected on a daily basis in the environmental lab to assess the trends in the abundance of filaments, floc forming bacteria, and protozoa.
- The SVI of MLSS is measured during each shift
- Once a trend indicating a steadily increasing SVI and/or the share of filaments in the mixed liquor population is established, the process conditions in the plant must be checked and adjusted in accordance with the supplier's operating instructions,
- If the final effluent TSS still continues to increase, dosing of polyelectrolyte to the secondary clarifier influent will be commenced. The dose would be about 3 mg PE/l,
- In case sufficient improvement is not achieved, for instance in one day, the hydraulic loading of the secondary clarifiers should be reduced from the normal 0.4 m/h to 0.3-0.35 m/h. This can be achieved by diverting part of the EqB effluent to the EB.
- Experience based on a large number of data points from secondary clarifiers suggest that a reduction of hydraulic loading by 0.1 m/h could reduce the FE TSS by about 5 mg/l at normal MLSS level of about 5 g/l and SVI <50 ml/g. The results of a best fit regression equation based on an analysis of about 100 data points featuring a rather wide statistical distribution are presented in Figure 4/1.
- It is estimated that with the combination of PE dosing and reduction of the hydraulic loading, the FE TSS could be reduced by about 10 mg/l.
- The TSS reduction will reduce the FE BOD and nutrients, as well. The correlations between the FE TSS and BOD_5, nitrogen, and phosphorus are approximately as follows:
    - 1 mg TSS causes 0.2-0.3 mg BOD_5 in final effluent
    - 1 mg TSS causes 0.08-0.12 mg N in final effluent
    - 1 mg TSS causes 0.01-0.015 mg P in final effluent.

Figure 4/1. Approximate Correlation between the Hydraulic Loading of Secondary Clarifiers and the Final Effluent TSS at MLSS Concentration of 5 g/l and SVI < 50 ml/g.



Monitoring data from the modern extended aeration ETP's suggest that the typical **frequency** of the increased TSS-periods is once in 1-2 weeks. The **duration** of such periods is typically 1-4 days. The average frequency of an incident may be once in 10 days with an average duration of 2 days.

The total surface area of the 2 secondary clarifiers of the Bell Bay mill ETP is 6633 m². Hence, the reduction of the hydraulic loading by 0.05 m/h and 0.1 m/h reduces the effluent flows by 332 kl/h and 664 kl/h, respectively.

The corresponding daily amounts of effluent diverted into the EB are 7968 kl/d and 15936 kl/d in these two cases. The total amounts of the effluent during the average duration of 2 days would then be 15940 kl and 31870 kl, respectively.

After the incident is under control, the effluent from the EB will be pumped back to the EqB. As an average this can take place during a period of about 8 days. The return flow would increase the hydraulic loading of the secondary clarifiers only marginally, or by about 0.0125-0.025 m/h.

Over the average 10 day period of a TSS surge event, the return of the 15940 kl to 31870 kl from the EB to the EqB corresponds to an average occupancy of the EB volume of about 1594-3187 kl/d, which is well below the permitted 10000 kl/d during 95 % of the year.

In the situation of a pulp mill spill or process upset (Chapter 3) coinciding with an effluent treatment plant upset, the combined maximum diversion requirements would be approximately 21,000 kL per day (18,000 from the pulp mill plus 3000 from the effluent treatment plant). The maximum number of such coincidences would be 15 (from Chapter 3). Again, this is within the restrictions set by the State permit.

In the situation of a pulp mill spill or process upset coinciding with an effluent treatment plant process upset, the combined diversion requirements would be up to approximately 21,000 kL per day on 15 days of the year. This is still within the restrictions set by the State permit.

5 STORAGE OF FINAL EFFLUENT IN THE SURGE BASIN AND/OR EMERGENCY BASIN

Gunns plan to build a recycling pipeline from the final effluent surge basin (Volume 15000 kl) to the emergency basin. Providing that the free volume in the surge basin is not sufficient for temporary storage, the EB can also be used. The measure would reduce the TSS, BOD_5, and nutrient loads to the ocean outfall but does not have any impact of the final effluent concentrations. Therefore, the only beneficial impact achievable is an increased dilution factor in the initial mixing zone, because of a smaller amount of effluent dispersed with the sea water through a diffuser designed for larger effluent flow.

This measure can primarily be used to mitigate the inefficient mixing during the tidal slack water over a period of about 2 hours per day. This would imply that the total amount effluent to be stored in the surge basin or in the EB would be around 6000 kl/d. This effluent could be pumped away from the basins even during the same day.

The required number of days in a year should be defined in the planned hydrodynamic modelling to asses the impact of this measure on the annual storage capacity utilisation of the EB. It is, however, probable that since the surge basin has, in principle, enough capacity for a 2 hours' temporary storage, the impacts on the EB are minimal.

6 CONCLUSION

The action plans and balance calculations presented in this report demonstrate that it is possible to operate the emergency basin within the stipulations of the State Permit even in case the EB is used as a temporary storage of the final effluent during the periods of the occasional high concentrations of the parameters controlled in the EPBC permit.

The prerequisite to this conclusion is that the pulp mill, the in-plant spill control system, and the effluent treatment plant are built and operated in strict compliance with the AMT principles of the modern bleached kraft pulp industry.