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Nelson Regional Sewage Business Unit

Bell Island Wastewater Treatment Plant
Odour Management Assessment

Project Name:	NRSBU Odour Assessment
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Client Name:	Nelson Regional Sewage Business
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Executive Summary

A spate of odour complaints from Best Island residents over the period December 2017 to March 2018 has led to questioning of the reliability of odour control at the WWTP.

A site visit to Bell Island WWTP was conducted by Dr Chris Hearn, Senior Process Engineer of BPO Ltd. on 13 and 14 September 2018. During the site visit discussions with members of the operations team (Nelmac) and NRSBU were conducted over the various parts of the plant, recent odour events and their concerns.

The main purpose of the assessment was to review:

- the odour management history at the plant,
- the key odour risks in the wastewater treatment process at Bell Island,
- comment on the current odour management systems, and
- outline options that could be taken to reduce the odour generation risks for Bell Island in the future.

The conclusion from this review is that the Bell Island facility had low levels of odour management complaints in the period 2006 – 2017 but that issues were experienced at the end of 2017 and early 2018. Since this time operations and maintenance activities have been undertaken that have returned the facility to the level of odour management that was in place when there was a low number of odour complaints.

Work undertaken by BPO shows that while the system has been returned to the former level of odour containment and treatment, that there are still a number of areas where the odour risk can be improved. Options for improvements have been suggested.

BPO believe that the largest single risk area within the mechanical treatment plant is now effective containment and treatment of the ATAD system off gases, and that undertaking this work will result in a significant reduction in the risk of odour from the mechanical unit operations on the Bell Island facility.

The ponds are inherently a less controllable plant asset but there are a number of mechanisms in place to allow sufficient control of the ponds in most circumstances. A number of recommended actions have been provided to enhance control. However, this pond control requires selective operator intervention to be effective and so relies on experienced operators with the time available to focus on this aspect of their overall duties.

1 Introduction

A spate of odour complaints from Best Island residents over the period December 2017 to March 2018 has led to questioning of the reliability of odour control at the WWTP.

A site visit to Bell Island WWTP was conducted by Dr Chris Hearn, Senior Process Engineer on 13 and 14 September 2018. Dr Hearn has a degree in Biotechnology and a PhD in Process and Environmental Technology. He has 35 years experience in wastewater treatment involving wastewater treatment plant design including odour control, Waste to Energy systems and gas management design, process design and commissioning for odour management systems and odour assessments. Chris was involved in Bell Island Wastewater Treatment Plant upgrades and operations in the 2000 -2011 period and so is familiar with the plant but has not been to site since that time. During the site visit discussions with members of the operations team (Nelmac) and NRSBU were conducted over the various parts of the plant, recent odour events and their concerns.

1.1 Purpose

- To review the odour performance at Bell Island Wastewater Treatment plant over the last 15 years, including complaint records, and to consider current odour performance, and odour control systems.
- To review the key odour risks in the wastewater treatment process at Bell Island excluding the ponds, and comment on the current odour management systems, and outline options that could be taken to reduce the odour generation risks for Bell Island in the future.
- To produce a report on the findings of the review.
- When a component is found to be not functioning adequately identify options that can be considered for reducing odour risks.

1.2 Ponds

Review of the odour risks of the ponds was added after the initial version of the report was completed.

2 Odour Sources

The following parts of the plant have been indicated as potential odour sources:

- Screening chamber
- Screening chamber biofilter
- Grit removal
- Primary clarifier
- Primary clarifier sludge/scum sumps

- The old remnant aeration basin, currently used as a sludge dump
- C2, the splitter chamber to ponds and new aeration basin
- Aeration basin
- Secondary clarifier
- Secondary clarifier sludge/scum sumps
- C3 splitter chamber for the three Facultative ponds
- Facultative and Maturation ponds
- Gravity Belt Thickener and associated odour treatment
- Dissolved Air Flotation
- Sludge Storage Tank
- ATADs
- ATAD biofilter
- Biosolids Storage Tank.

Each area of the plant were inspected checked for odour by nose and personal safety sensor that measures hydrogen sulphide (H2S, highly odorous), carbon monoxide (CO, no odour but indicative of restricted oxidation, lower explosive limit (LEL, for methane, indicative of anaerobic conditions that would probably develop odour). The history of odour was discussed with the operators for each part of the plant and the odour potential based on the nature and condition of each part was considered.

2.1 Screening chamber and biofilter

The operators have reported relatively high hydrogen sulphide concentrations within the screening chamber averaging 200 ppm with peaks to 500 ppm. The measurements were reported to be made with personal gas safety sensors, which are not designed for such measurements. Continuous or repeated exposure to H_2S above STEL, even over a relatively short time period, typically overloads the specific H_2S sensor and gives level readings until run in clean air for an extended period and then turned off and reset.

This does not suggest that all the high H_2S readings are false. Measurements during the site visit did show that there is a relatively high H_2S concentrations inside the screening chamber. The measurements were not taken inside the chamber (due to overload concerns) but were taken at gaps in the screen covers.

H_2S levels measured were variable in the range of 5 to 30 ppm. This does suggest higher concentrations inside the screens chamber. These readings fell to zero when the meter was moved to 50 to 100 mm from the gaps. Lower or zero readings for H_2S were found in other gaps in the chamber covers further away from the screens. The winds at the time were light and variable with open area velocities of 0-3 m/s.

These conditions may explain the variable readings as gusts of winds may either dilute the H_2S or push puffs of the internal air with higher H_2S concentration out of the chamber periodically.

Below the rotary drum screens the wastewater is falling through the chamber creating a high surface area. This high surface area will increase H_2S release compared to water flowing in a channel or sitting in a sump. Reported significant degradation of the internal concrete does suggest that elevated sulphide levels are present.

It was noted that no sulphide readings above 0 ppm were found at distances greater than about 200 mm from the covers. H_2S is detectable by nose at much lower levels than the minimum reading of 1 ppm of the gas safety sensors. In various visits to the screening chamber over two days no H_2S was detected by the author at distance of 0.5 to 1 m from the chamber and screen covers. This suggests that most of the time the typical wind conditions of Bell Island make the screening chamber a low odour risk even in its present somewhat poor odour containment condition.

It is understood that winds are typically very light in summer and tend to be katabatic with offshore wind in the morning but onshore winds in the afternoon. These onshore winds tend to carry any odour towards the Best Island residences but when very light do not provide as much dilution so give higher H_2S concentrations. On the other hand, the Best Island residences are 1230 m to 1560 m from the closest part of the screen chamber providing a high degree of attenuation even by diffusion in very light winds.

It is BPOs opinion that the odour risk posed by the screening chamber is low to medium low.

The biofilter fan is reported to deliver a flow of 3,798 m^3/hr. Measurements taken on site gave a velocity in the fan discharge of 7.5 m/s in a 300 mm PVC pipe. This gives a flow of about 1,900 m^3/hr. That flow gives an Empty Bed Residence Time (EBRT) of 121 seconds for the biofilter which is at the higher end of the typical range (30-120 seconds) used for biofilter design. The measurement point available is not ideal and so there is a reasonable degree of uncertainty about the accuracy of the air flow velocity.

The measured pressure at the discharge of the fan was 6 mm H_2O which is quite low for a biofilter. This may in part be due to the very recent renewal of the biofilter distribution pipework, gravel and media. However, the suction line from the screening chamber to the biofilter fan has an underground loop and there is uncertainty regarding the drainage of this pipe loop, and therefore there is a possibility that it may be collecting water and creating a headloss on the suction side of the fan, resulting in the lower flows.

It is understood that concern has been expressed about ability of the existing biofilter to treat air with 200-500 ppm H_2S, NRSBU indicated that they have been informed that most biofilters treat lower concentrations. Measurement of H_2S at the sample point just after the fan was 3-6 ppm. This is expected to be because much of the air extracted from the screen chamber is short-circuiting. It is expected that the high H_2S measured by the operators is predominantly because the air flow in that area of the chamber is low, and is therefore allowing higher accumulation of H_2S.

The dissolved sulphide levels in the wastewater where reported by NRSBU to be typically about 10 mg/l. At equilibrium this would give H_2S concentrations in the air of 3,.000 to 3,500 ppm depending on the Wastewater pH. This suggests that the H_2S concentrations in the air in the chamber are below equilibrium concentrations.

Improving the airflow in the screen area will result in a lower concentration. It is expected that the mass flow of H_2S will not change significantly because the current concentration is only about a tenth of the equilibrium concentration, and that the increase in the concentration difference (which is the driving force for mass transfer) will be minor.

It is expected that improved air flow though the chamber will result in a much lower H_2S concentration and therefore treatment in a Biofilter would be considered appropriate.

NRSBU indicated that others have suggested that higher H_2S concentrations will “saturate” a biofilter and so a wet scrubber or activated carbon filter will be required. BPO’s experience is that the concern over “saturation” is with ammonia. Ammonia at higher concentrations preferentially adsorbs within the biofilter and allows hydrogen sulphide to break through.

Observation of the chamber and screen covers and the take-off points for the biofilter flows shows that the arrangement is not ideal. Nathan Clarke of NRSBU and Alan Jones of Nelmac have indicated that improvements in the arrangement are in progress. **BPO recommends a number of actions to improve the performance of the inlet containment and odour management, these actions are outlined in Appendix A**, most of which are understood to already be planned for implementation.

2.2 Grit Removal

The grit removal system currently is predominantly covered but not connected to an odour treatment system. No H_2S was detected outside or just below the cover of the grit system at the time of the site visit. The newer parts of the grit system are covered by gratings. The flow channels are of relatively low turbulence and so the risk of odour from this system is very low. Works for this area are considered as low priority.

BPO suggest that this system is periodically monitored by the operators to determine if full covering is justified. Note that increased coverage may result in a large increase in concentration of H_2S which may increase deterioration of the concrete.

2.3 Primary Clarifier

Measurements during the site visit showed that H_2S was present in the outlet overflow weir box area. H_2S was detected at 5-28 ppm close to the water level below the weir, decreasing with elevation. H_2S was detected at 0-11 ppm on top of the chamber wall but was not detectable 50 mm out from the wall. The turbulence of the weir enhances release of hydrogen sulphide but it appears that this release is slow and is dissipated rapidly even in light winds. H_2S was detected in the main weir channel at 0-3 ppm downwind for a few meters but was not detectable on top of the wall of the weir channel.

It is not considered necessary or beneficial to cover the main weir area of the primary clarifier given this would make cleaning problematic and would lead to increased corrosion. Rust on the handrails around the primary clarifier suggest this area is a higher than normal corrosion zone, which suggests that H2S could occur within the area, but such corrosion will occur at very low H_2S levels and maybe due to the marine environment and is not an indication that odour containment is required.

The primary clarifier is considered a low odour risk. Only the outlet weir was observed to release odour and at a low rate only. This is a small area to cover but covers alone would not significantly reduce potential odour release and so would require extraction of air and treatment. **Monitoring of the situation only is recommended.**

2.4 Primary Clarifier Scum Tanks

The scum tanks are covered. A small volume of air will be periodically pushed out as the tank fills but the rate will be low and so even though these tanks/sumps are sometimes a bit smelly when opened the risk of odour complaints from these tanks is very low.

No works are considered necessary for odour issues.

2.5 The Old Aeration Basin (abandoned)

This area was quite smelly to walk past during the site visit. This area is used as a sludge dump at times. There is no practical way of containing or collecting and treating the odour from these activities if they continue to be undertaken.

BPO recommend stopping the storage of waste sludge or other materials within the old aeration basin. Alternative disposal of these sludges should be instigated.

2.6 C2

This sump is not covered but the wastewater is of low turbulence, the surface area is small and the water surface 2-3 m below the top of the walls. No H_2S was detected an arm's length inside the chamber.

This structure is not considered as an odour risk at this time.

2.7 Aeration basin

This area does exhibit some rust in the weld areas of the hand rails. It is likely that this is due to the maritime environment of the island. The basin is aerobic and oxidation of hydrogen sulphide is rapid and complete in such an environment. This structure is considered as very low odour risk.

No odour control works are suggested.

2.8 Secondary Clarifier

No odour was detected in this area. The aerobic condition of the aeration basin means that the clarifier is likely to be aerobic or slightly anoxic and so not develop the fully anaerobic conditions required to generate odorous compounds.

No odour control works are suggested, however care needs to be taken that sludge bed age does not get sufficiently long that anaerobic conditions become possible.

2.9 Secondary Clarifier Scum Sumps

See primary scum sump discussion.

No odour control works are suggested.

2.10 C3

Odour was detected immediately (1-3 m) around C3 at the time of the site visit in the morning but not later in the afternoon which had higher winds. The odour in the morning may be due to the degree of bypassing of wastewater around the aeration basin at the time. The flow control weirs do give quite a bit of turbulence which allows for odour release. C3 is 866 m from the nearest Best Island building and so significant attenuation of odour is expected. C3 is covered with an open grating and there is no odour removal or treatment systems installed. Full coverage would reduce odour release but because influent is sent directly to this chamber, the potential for H_2S release is present. Increased containment also increases risk of sulphide attack on the internal concrete of C3 and so air removal and treatment will probably be required if covers are added to C3.

Works recommended for Chamber C3 are outlined in Appendix A

2.11 Facultative and Maturation Lagoons

The Bell Island lagoons have a surface area of 50 hectares and this large surface area has the potential for substantial release of malodour if conditions in the ponds develop malodorous compounds and bring then to the surface. The sludge layers in the pond will be anaerobic and most malodorous compounds require anaerobic conditions to be generated. However, where the ponds are operating acceptably the aerobic layer on the top of the pond oxidises the malodorous compounds to non-malodorous compounds at a rate such that malodour is not detectable at any reasonable distance. Therefore, the risk of odour release from the ponds is essentially related to mechanisms that bring the malodorous compounds to the surface at sufficient rates that the odour is detectable at distance (the closest dwelling is just over 400 m from the edge of Lagoon F3). Another general issue is that the odour release needs to occur over a reasonable length of time to have the potential to generate an odour complaint. Unfortunately, sensitization will occur where lengthy odour releases have occurred in the past. This was the case for Bell Island WWTP prior to the 2004 - 2005 upgrade. The good plant performance in the years subsequent to the upgrade generally desensitized the Best Island population to short term odour releases, however, the odour events of late 2017 to early 2018 have probably re-sensitised the population so that a relatively short odour release, of say 5 minutes or less, might now result in an odour complaint whereas a year ago it would have taken a much longer period to result in odour complaints. It is understood that proactive work by the NRSBU team has already reestablished a good relationship with most Best Island residents. However, as a result of the previous events the risk of odour complaints is now higher than it was and it is likely to take a number of years of good performance to return the Best Island population to the fully desensitized state.

2.11.1 Sludge Accumulation

A common cause of odour release from WWTP ponds is the build-up of sludge so the depth of water above the sludge layer is small and so less able to oxidise the reduced anaerobic compounds. This can take a long time where the solids are deposited uniformly across the pond(s). In most ponds solids deposition is not uniform but rather tends to form banks where the flow velocity from the inlet flow, wind induced flows or flows from added aerators or mixers dissipates enough to allow sedimentation.

Odour release from sludge banks can be seasonal with spring time releases characteristic of this odour release mechanism. In the winter the anaerobic activity in the settled sludge layer slows or stops and so sludge accumulates more rapidly and to a large extent and the degradation of the digestible fraction of the solids is low. As the pond warms up in the spring the anaerobic activity increases and it is working on much more than normal stored degradable material accumulated over the winter. The release of low molecular weight soluble compounds such as volatile fatty acids and hydrogen sulphide is rapid and enough may be produced that they reach the surface before they are all oxidized. More commonly the increased activity results in a high rate of gas production which lifts the odorous compounds to the surface for release. Equally, high wind events increase mixing and so bring the compounds to the surface through the increased mixing. A sludge survey conducted in 2014 showed average distance to the sludge layer as being 990 mm, 1080 mm and 1110 mm in ponds F1, F2 and F3 respectively. However, there were banks of sludge giving a minimum depth to the sludge of 410 mm in F1, 430 mm in F2 and 490 mm in F3. The depth to the sludge layer is subject to the water depth prevailing in the ponds at the time. The maturation ponds rise and fall twice a day due to the tidal discharge. The extent will depend on the flows into the maturation ponds. The facultative ponds levels change less frequently as their level is a function of the inflow over the last month versus the discharge flows over that period as the ponds are used as flow buffers due to the peak permitted discharge flow being considerably lower than the possible stormwater driven inflows. A sludge survey conducted in 2017 shows that while the average sludge levels have risen in F2 and fallen in F1 and F3, to a small extent, between the two surveys the changes are probably more related to uncertainty in the measurements. What is apparent from the two surveys is that since 2014 the sludge has been redistributed to some extent and the areas of high sludge levels have been minimised. It is not clear why the redistribution occurred although it is noted that the aerators in each pond were re-positioned in 2013 and that, long term, this action may have improved mixing and so reduced the sludge bank formation.

Works recommended to address the sludge bank odour risk are outlined in Appendix A

2.11.2 Stratification and Inversion

Stratification is the separation of a pond water into vertical layers predominantly through temperature effects during periods of low winds and/or lack of mixing in the pond. Of itself it is not necessarily an odour issue but stratification introduces the risk of inversion. Inversion is normally temperature driven but can be density driven if, for example high salt waters are introduced to the top of the pond although this is rare. Inversion is most commonly driven by rapid cooling of the surface layer in a pond increasing its density so that the cold water sinks and displaces the lower warmer less dense water to the top of the pond. The rise of the warmer water brings the anaerobic sludge layers to the surface and so causes a high release rate of odour release.

Even light winds usually provide enough mixing to prevent significant stratification and so inversion. The risk is present only when extended periods of calm weather and associated changes in air temperature occur or clear skys at night give high heat radiation losses cooling the top layer. The risk can be ameliorated by mechanical mixing to avoid still conditions in the pond. Currently F1 and F3 have 5 aerator/mixers of about 1-5 kW each giving mixing energies of about 0.1 to 0.25 W/m^3. This range is very much in the low mixing energy range for facultative ponds. F2 has 9 nine wind powered mixers. It is not clear if these units have the 0.55kW back-up motor. Assuming they are present F2 may still have a vulnerability to stratification in extended periods of calm weather because the mixing energy is low at 0.0495 W/m^3.

It is recommended that additional mixing be installed or be available to be installed to combat stratification.

2.11.3 Algal Blooms

Extended calm clear weather combined with lower loadings and higher nutrient concentrations encourages the growth of blue-green algae. The growth itself is not necessarily a problem but when conditions change the blue-green algae die and the floating mats of dead algae become a major malodour source. While blue-green algae are the main cause of this issue other algae can also cause this issue as can sludge from the pond bottom floated by entrapped gases. There is the potential to lessen the impact of low loading by adding a higher flow and load to each facultative pond in turn so that the low load is not continuous but it does mean that the other ponds do get an even lower load. It is hard to quantify how well this works. Essentially the conditions that cause the floating of algal mats of lift sludge cannot be controlled effectively and so the focus must be on providing the ability to dissipate these floating mats or to capture and remove the material in the mats. Floating mats will be driven by the wind and so the areas requiring dissipation will be dependent on the wind direction at the time. The existing aerator/mixers in F1 and F3 are generally placed near the pond edges and so do focus on mixing around the pond edges so this is a good start. However, they are from 150 to 250 m apart and so various edge areas are not served well.

Works recommended to address the floating algal mats and scum odour risk are outlined in Appendix A.

2.11.4 Insufficient Algae

Algae are the main source of oxygen input to the ponds and so are critical to good operations. Problems occur when the algae number and/or the activity of the algae is reduced meaning there may no longer be enough algae to meet the prevailing oxygen requirements. There are a number of causes of insufficient algal numbers:

- Seasonal species change - where the next species favoured by the new conditions are low in numbers or conditions swing back and forth causing die off of both groups and so there is a lag before enough of the news species are present.
- Organic overloading – this increases the oxygen demand and may depress the Dissolved Oxygen (DO) concentration which strongly reduces the activity and growth rates of at least most algae.
- Suspended solids overloading – this causes shading and reduces light penetration and so reduces algal activity and growth.
- High wind events – such events can uplift solids from the sludge layer and reduce settling of the wastewater TSS reducing light penetration which in turn reduces algal activity.
- Fungal infections – this causes die-off of certain algal species dropping the active algal mass. Infection also can impact on algal succession in that the numbers of the next algae in the seasonal sequence are low. The oxygen input to the ponds reduces lowering the DO. Most algae do not grow well in low DO conditions so there can be a lag period before enough of the new algal species are present.
- Sustained bad weather – will reduce the amount of sunlight and so reduce the algal activity.

The lack of algae numbers is an issue for the ponds because no matter what the cause the result is a reduction in the amount of oxygen put into the water compared to the amount required. This gives low or no DO and so the required oxidation of malodorous compounds is compromised and the risk of malodour release greatly increases.

There is limited or no ability to directly control the various causes of insufficient algae. Essentially the operators can try to:

- Control the organic load to the ponds via the pre-treatment system.
- Control the suspended solids to the pond via the pre-treatment system.
- Increase the mass of algae present by reseeding from the maturation ponds or another facultative pond if there are still good algae numbers in that pond.
- Add oxygen mechanically via aerators.
- Add oxygen by enhancing oxygen input via the pond surface through mixing.
- Add oxygen through chemical addition.

Chemical addition is expensive and so typically is a last resort and only practiced for a short period of time.

The other mechanisms are available to Bell Island WWTP. The aeration basin and clarifiers allow the operators to control the organic and suspended solids load to the ponds. Without very large capital expenditure little can be done to improve this system apart from ensuring that the equipment is in good condition and the well settling culture is maintained. This requires that the operators have the time and the necessary training and experience to manage the pre-treatment system effectively.

Historically the ponds have each behaved differently and with two maturation ponds in series some of the issues that will reduce algal numbers will often not extend to all of the ponds and this allows for reseeding of the algal culture from a healthy pond. There is an existing provision for this but it is quite limited in that the transferred algal suspension is added to the facultative ponds somewhat near the outlets rather than the inlets (or Chamber C3) which would be a better solution. The facultative ponds have some aerators and mixers but the oxygen capacity of these units is limited and there is little facility to focus on the ponds that are failing.

Works recommended to address the insufficient algae odour risk are outlined in Appendix A.

2.11.5 Inlet By-pass

Currently if there are problems in the inlet works the available bypass directs all inflow to pond F1. This bypass results in high overloading of F1 and severe underloading of F2 and F3. There are planned works, briefly discussed above, that will require the inlets works be isolated and bypassed. Therefore, there is a high priority to provide a bypassing system that will allow each unit operation to be bypassed individually without bypassing other units that are still in working order and should be used.

Works recommended to address the bypass odour risk are outlined in Appendix A.

2.12 Gravity Belt Thickener

The thickener is not currently used, at least partially due to it releasing odour/hydrogen sulphide into the workshop underneath. The building is connected to an activated carbon filter. There is no evidence that the carbon has been replaced. If the carbon has not been replaced then even though its usage has been low, it is expected that replacement will be required if the GBT is to be reinstated.

The recommendations made to allow for odour reduction works should the GBT be reinstated are outlined in Appendix A

2.13 DAF

The DAF is an aerobic process and is not considered as an odour release risk outside of the building.

No further odour control works is suggested.

2.14 Sludge Storage Tank

The current sludge storage tank is covered but has no offtake of air. This means that the tank "breathes" as it is filled and emptied. The quantity and rate of air displacement is low. Discussions and observations on site indicate the existing tank is in poor condition and there is an intention to build a replacement tank next to the existing one and, once complete, to replace the existing tank and build a second sludge storage to increase capacity and redundancy.

It is suggested that both tanks should be connected to the ATAD biofilter suction manifold.

The recommended actions for the sludge storage tank are outlined in Appendix A

2.15 ATADs

The ATADs are considered to be the major odour complaint risk for the mechanical parts of the Bell Island WWTP. There are a number of potential odour release points at the top of each ATAD tank and release of steam was observed from at least one of these points during the visit.

ATAD trains B & C have Frings 1200 TA mixer/aerators in each tank. The engineering handbook for these aerators shows that at 3.8 m submergence each aerator will bring 410 m^3/hr of air into each ATAD tank. The estimated air temperature inside the pipework at the measurement point is 40 °C. Correcting from the 0 °C of the definition of "normal" gives 470 m^3/hr flow to the biofilter from each of 4 aerators. A total flow of 1,880 m^3/hr from these two ATAD trains is driven by these aerators.

ATAD train A has blower driven aeration system, which most of the time runs one blower at minimum speed. These operating conditions should deliver an air flow of about 700 m^3/hr at the assumed air temperature at the velocity measuring point. This suggests that under most conditions the aeration in the ATADS has a flow of about 2580 m^3/hr of air.

The air velocity measured downstream of the fan was 20 m/s, giving a flowrate of 4,780 m3/hr.

If there are no unexpected resistances to flow in the pipework it follows therefore that the fan is drawing an extra 2,200 m^3/hr of through the ATADs.

There is some air being drawn into the fan pipework around the penetration out of the concrete manhole immediately upstream of the fan. This will reduce the excess air drawn through the ATAD system. However, BPO were unable to measure or calculate the flow rate of this leak.

A flow of 7,600 m^3/hr for the ATAD fan has been indicated by NRSBU based on information provided by the supplier and the name plate on the Fan. The flow of a fan will be very dependent on the differential pressure across the fan, the temperature of the gas being pumped, and the suction losses leading to the fan, and therefore the flowrate would be expected to be lower than the nameplate reading, which is in line with the measured flow of 4,780 m3/hr

Comments from the operators suggest that this fan is operated by a manually controlled VFD. The measured air flow should be adequate if most of the current openings in the tank tops are closed, the flows from the tanks are balanced and the flows into the two biofilter beds are corrected to be the same.

Air (condensing water vapour) was observed coming out of ATAD Tank B2. This observed vapour was intermittent but this may be a function of the somewhat variable wind at the time. The arrangement of the ATAD walkways and a safety isolation due to the removal of the C2 foam breaker leaving a large opening on the top of that tank, made it somewhat difficult to determine if there was a flow of air out of the other tanks.

It is likely that the opening in Tank C2 resulting from the foam breaker being out for maintenance may have led to additional air ingress at tank C2, reducing the suction at tank B2, which would have contributed to gas release from tank B2.

Similar vapour was not observed from the other tanks, however, the lower temperature of the primary tanks and the conditions of the day make it unlikely that air discharging from these three tanks would be visible.

The outflow of air from one or more tanks suggests that either there are a number of leaks in the fan suction pipework or tanks close to the fan, such that the net inflow of air from the aeration outweighs the flow removed from the ATAD tanks.

It is understood from NRSBU that they are considering adding damper valves for the 7 existing offtakes (6 ATAD tanks and the Biosolids tank) to allow for flow balancing.

The original design intent was to allow the aeration to set the flow from each tank.

This could work for the ATADs if all other potential air inflow points are sealed and the biosolids tank air inlet was restricted to balance the flow from this tank. The nominal fan flow is much higher than the design airflows of the ATAD aerators and therefore this approach could be appropriate if other air ingress to the system can be reduced.

However improved monitoring of the pressure in the headspace of each of the ATAD tanks would assist with improved control. If it were possible to monitor the pressure under the ATAD covers, it would be possible to identify when insufficient airflow was occurring.

Placing dampers on the air outlet of each tank could work but it is understood that the blower speed, and so airflow, on ATAD train A does vary, and similarly it is sometimes necessary to turn the B and C train aerators off to limit temperature rise. These changes would probably require adjustment of dampers to rebalance the air flows. This would be undesirable if the airflows vary frequently.

Similarly, adding a control loop to the fan to control the fan speed to achieve a target pressure below atmospheric in the manifold would also be beneficial.

The manifold currently runs along the side to the walkway above the three primary ATAD tanks (A1, B1, and C1). This means that the offtake pipes from the secondary tank are much longer than those from the primary tanks. The offtake pipes are 150 mm SS pipes and so, assuming a uniform flow from all 6 ATAD tanks, the flow velocity would be 12 m/s or higher when allowing for the lower density of the hotter air from the secondary ATAD tanks. The velocity in the main manifold is about 20-23 m/s. These velocities will give significant friction headlosses and make balancing the airflow between tanks more problematic. **It is recommended that a second manifold be installed to cover the secondary ATADs tanks (A2, B2, and C2) and the biosolids storage tank leaving the existing manifolds to cover the primary tanks and the future two sludge storage tanks.**

In addition to adding the second manifold we recommend the addition of a second biofilter fan to provide redundancy.

A cross connection between the two manifolds will allow for this redundancy and provide a suitable location for a pressure sensor for control of the fans speeds.

The ATAD biofilter, at the measured air flow of 4,780 m^3/hr, assuming a bed depth of 1 m, gives an Estimated Bed Retention Time (EBRT) of 105 seconds. If the bed was 1.5m deep as is allowed by the biofilter walls the EBRT would be 158 seconds. These EBRTs are at the high end of most Biofilter designs ranges.

The ATAD biofilter consists of two units with a common wall to allow to replacement of media on one bed while the other bed takes the ATAD air flow. The current airflow through the biofilter is not balanced, with a significantly higher flow through one bed compared to the other.

Measurements of the flow to each biofilter shows the near side has a flow velocity of 10-13 m/s and a pressure of 12 mm H_2O, while the far side has a velocity of 3-5 m/s and a pressure of 6 mm H_2O. The far side of the biofilter is on a 90 degree side arm of a TEE fitting and has an extra 90 degree elbow plus 11 m of pipe compared to the near side where the flow is straight across the Tee.

The recent replacement of the media has resulted in low headlosses through the biofilter beds and it is believed that the losses in the pipework are now likely to be the factor dominating the flow split and therefore the cause of the uneven flow split between the biofilter beds.

The media in the biofilters is uneven and well below (0.5 – 0.9 m) the top of the wall. The low bed depth and particularly the uneven depth may be encouraging short circuiting.

This uneven flow should be remedied, by adjusting the dampers on the fan discharge and the bed should be have additional media added to raise the bark to about 100 mm below the top of the Walls. The bark surface should be levelled.

Ammonia odours were detected from the biofilters at some distance. It is possible that increasing bed depth and leveling the beds and balancing the air flow between the two beds will reduce or eliminate that odour.

Testing of the air flow to the ATAD biofilters showed no detectable H_2S at the time. This does not mean that H_2S will not be present at some time. That ammonia is breaking through the biofilter presently does suggest that if H_2S is present it will also breakthrough the biofilter bed. While it is possible the biofilter can be remediated to eliminate odour release it is likely that further works will be required. The likely mass load of ammonia means that activated carbon filters are likely to be very expensive to operate. A scrubber upstream of the biofilter is suggested targeting ammonia. This scrubber could be acid or water based, and would also act as a gas cooler.

An acid scrubber will capture the ammonia in the form of ammonium sulphate (with sulphuric acid use) or ammonium phosphate (with phosphoric acid use). The resulting ammonium liquid then requires disposal or sale as a liquid fertilizer. The marketability of such a liquid fertilizer is uncertain especially as the quantity is likely to be relatively small in the general fertilizer market. If not marketable disposal of this liquid would be problematic. Acid based scrubbers have a significant operating cost due to purchase of the acid and the resulting HSE issues arising from its handling and use.

A water based scrubber using water cycled to and from the ponds would have a lower cost than an acid scrubber and would provide cooling of the air stream, which BPO believe would extend the media life in the biofilter.

The disadvantage is that the ammonia captured in the water is added to the ponds increasing the nitrogen load to the ponds.

Design documentation suggests an ammonia concentration of 100 ppm in the air from the ATADs. This estimate is a rough estimate only.

This concentration would deliver an ammonia load of 8.72 kg NH_3/day and a nitrogen load of 7.18 kg N/d to the scrubber and slightly less than this to the ponds. This load is small compared to the allowable nitrogen discharge from the Bell Island plant and so is unlikely to jeopardize compliance with the discharge consent.

It is recommended that the ammonia concentration of the air to the biofilter be measured for ammonia to confirm the likely load that would be sent to the ponds if a water based scrubber was used.

The suggested works for the ATAD and biofilter system are outlined in Appendix A

2.16 Biosolids Storage Tank

As biosolids are sent to the storage tank a release of ammonia to the headspace is expected. The biosolids storage tank cover is old and the seal to the tank wall is not very good, this may allow fugitive odour release due to excessive air inlet area. The tank headspace is connected to the ATAD biofilter suction pipework but poor current balancing is increasing the risk of odour emission from this tank. As for the current sludge storage cover, the biosolids cover is a flexible membrane increasing the risk that wind will move or “flap” the cover potentially pushing odorous air out of the tank. **The actions recommended for the Biosolids Storage tank are outlined in Appendix A:**

3 Conclusion

The Bell Island WWTP experienced a significant increase in the number of odour complaints in late 2017 to early 2018. BPO was engaged to review the odour control system and identify odour risks, and odour management improvements that could be made that would reduce the odour risks.

BPOs Dr Chris Hearn spent 2 days on site, observing the facility, discussing issues with the site operators, and measuring and monitoring the odour within the facility.

The conclusion from this review is that the Bell Island facility had low levels of odour management complaints in the period 2006 – 2017 but that issues were experienced at the end of 2017 and early 2018. Since this time operations and maintenance activities have been undertaken that have returned the facility to the level of odour management that was in place when there was a low number of odour complaints.

Work undertaken by BPO shows that while the system has been returned to the former good level of odour containment and treatment, that there are still a number of areas where the odour risk can be improved. Options for improvements have been suggested.

BPO believe that the largest single risk area within the mechanical treatment plant is now containment and treatment of the ATAD system off gases, and that undertaking this work will result in a significant reduction in the risk of odour from the mechanical unit operations on the Bell Island facility.

The ponds are inherently a less controllable plant asset but there are a number of mechanisms in place to allow sufficient control of the ponds in most circumstances. A number of recommended actions have been provided to enhance control. However, this pond control requires selective operator intervention to be effective and so relies on experienced operators with the time available to focus on this aspect of their overall duties.

BPO ENVIRONMENTAL SUCCESS

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APPENDIX A – RECOMMENDED ACTIONS TO REDUCE ODOUR RISKS ASSOCIATED WITH THE BELL ISLAND WASTEWATER TREATMENT PLANT

The following is an outline list of actions that BPO recommend are implemented to reduce the odour risk associated with the Bell Island WWTP.

1. Inlet area improvements

There are a number of Improvements that can be made to the inlet system that will assist to reduce the risk of odours from the site, the improvements recommended are:

- Move or add additional air offtakes directly to the screen covers.
- Seal leaks in the covers. (NRSBUs proposed replacement with much larger covers is an appropriate option)
- Separate the internals of the screen chamber into two sections each of which can be isolated to allow maintenance of that part of the chamber and associated screen whilst the other screen and chamber are in duty.
- Provide appropriately sized air inlet ports in the covers placed to maximise the swept volume of the chamber.
- Fit a drain point to the underground loop of the air pipework if one is not already installed. It may be simpler to replace this with an above ground pipe.
- Operate the system for a period and measure the performance and the gas concentrations to confirm resulting chamber H_2S concentration after the above works.
- Review the system performance and if necessary, add an additional Biofilter and fan to increase the dilution of H2S being received by the Biofilter.
- The current biofilter has an alkalinity layer at the base to neutralize acid formation, but also has sources of alkalinity within the bark mix. Monitoring of the biofilter should be undertaken to monitor the Performance and if the biofilters is found to be unable to effectively remove hydrogen sulphide an addition or alternative odour treatment may be need to be considered.

2. Primary Clarifier Improvements

- The primary clarifier is considered a low odour risk.
- Monitoring of the situation only is recommended.

3. Old Aeration basin

- BPO recommend stopping the storage of waste sludge or other materials within the old aeration basin. Alternative disposal of these sludges should be instigated.

4. Chamber C3

The recommended actions for Chamber C3 are as follows, and while the risk of odour complaints as a result of C3 is considered to be medium to low. It is suggested that:

- the operators monitor the situation to see if odour is detectable at a greater distance towards Best Island under low wind conditions.
- If the assessment confirms the need, cover C3 and try to maximize odour containment
- Add sulphide attack protection to the internal concrete surfaces of C3.
- Provide a small biofilter and associated pipework and fan to control odour, or
- Provide an activated carbon filter odour control facility.

5. Facultative and Maturation Ponds

Sludge bank accumulation:

- Monitoring the sludge accumulation in the ponds on a regular basis (2 to 4 year intervals). This is the current practice.
- Add and/or reposition aerator/mixers to dissipate sludge banks. Appears to have happened at least once in 2013.
- Selective desludging of ponds where accumulation occurs. It is understood that desludging of the edges of F1 and F3 is planned in the near term to reduce the remaining sludge. F2 is not included in this action in order to not interfere with the trial of the wind powered mixers in F2..
- Full desludging of ponds where total accumulation of sludge reaches a point where the sludge occupies too much of the pond volume. This would typically be at 15 to 25 year intervals.

Stratification and pond inversion:

- It is recommended that additional mixing be installed or be available to be installed to combat stratification.

Floating algae and scum:

- Investigate suitable portable mixing, to re-entrain the solids back into the water column, that can be placed where the problem occurs and redeployed if wind changes move the mats.
- Investigate a floating boom or similar that can be used to “corral” the floating mats and a way of effectively removing the material. This may be some form of skimming device owned by NRSBU or maybe the hire of a vacuum tanker.

Insufficient algae:

- Ensure the operators have the time and experience to operate the pretreatment systems effectively.

- Purchase new or refurbish existing unused aerators to increase the oxygenation capacity if required.
- Install a reseeding network that directs seeding streams to the optimal inlet areas of the ponds and in such a way that the seeding stream can be directed to the required pond or ponds easily.
- Consider installation of addition electrical distribution network capability for re-seeding pumps and/or to allow extra aerators to be moved to a failing pond or investigate whether purchase or hire of portable gensets would be a more cost effective way of meeting these temporary demands.

Inlet bypass to F1

- Remove the inlet overflow and bypass directly to F1.
- Add an overflow/bypass system that allows each unit to be bypassed individually.

6. Gravity Belt Thickener

The following recommendations are made to allow for reinstatement of the GBT:

- Seal up the penetrations between the top and bottom floors
- Extract the air from the GBT area via the GBT. Add low level extraction ducts to the GBT room to pick up the relatively dense H_2S.
- Seal up the sump in the work shop area and increase the extraction rate inside of the sump to the odour treatment unit.
- Add a fan at one end of the workshop area to flush any fugitive odours out of the building. A relatively high flow is suggested but the low odour load in this area of the building once flushed should mean that this air stream would not need to be treated.
- Consideration on improved monitoring procedure for the performance of the Carbon filter would also be appropriate

7. Sludge Storage tank and new sludge storage tank.

The recommended actions are:

- Construct the tanks from suitable materials for the expected concentrations of possible corrosive compounds.
- Cover the sludge storage tanks with a good quality cover such as the FRP cover used on the ATADs.
- Provide a small air inlet pipes and elbow with mesh to exclude rain and birds respectively. A pipe provides a pathway length to minimize the risk of fugitive odours being drawn from the tanks by pressure fluctuation resulting from wind gusts.
- Connect each tank to the ATAD biofilter suction manifold with a damper to control air flow from each tank.

8. ATAD system improvements

The suggested works for the ATAD and biofilter system are as follows, in order:

- Seal off the various penetrations in the top of the ATAD tanks. Some can simply be sealed with some form of cover or flange. The annulus around each foam breaker mounting plate needs a flexible seal around its perimeter to allow for the independent movement of the plate and the top of the tanks (from vibration, walkway movement and thermal expansion).
- Add a second odour manifold and second fan to cover the secondary tanks and the biosolids storage tank. This provides for redundancy and reduces the friction head losses allowing better control of flow balancing.
- Connect the proposed new sludge storage tanks to the ATAD biofilter suction pipework.
- Provide automation of fans speed to control pressure in the air suction system. This will provide for better flow balancing and reduce energy consumption. Connect the Odour Management system to the SCADA so that the pressure, speed and other aspects can be easily seen, and can be recorded.
- If necessary, add control dampers to the pipework (to allow isolation of tanks taken from service) and consider automated dampers with pressure feedback.
- Confirm that the underground section of the suction pipework is adequately drained to prevent accumulation of condensate.
- Add dampers to each biofilter bed to facilitate flow balancing. There are butterfly valves present that could be used for this purpose but each time a bed was isolated rebalancing would be required. Dampers could be permanently set and the butterflies used for isolation only, if isolation was relatively frequent.
- Adjust the connection pipe to the far biofilter bed to fully drain condensate back to the condensate sump and repair the small hole currently draining condensate to ground.
- Level the biofilter beds and top up to the design depth.
- Measure the ammonia concentration before and after the biofilters to confirm the need for an ammonia scrubber and the potential additional nitrogen load to the ponds.
- If the ammonia concentrations indicate the need, add a water based scrubber using recycled pond water to scrub ammonia prior to the biofilter. The scrubber will also cool the air and extend the life of the biofilter media.
- If the additional nitrogen load to the ponds from a water based scrubber are considered to be too high, fit an acid based scrubber. Ensure that a cost effective method for sale or disposal of the ammonia salt solution is available and reliable.

9. Biosolids Storage tank improvements

The suggested works for the Biosolids storage tank system are as follows, in order:

- In the short term add a damper valve to the air extraction pipework to facilitate good flow balancing. This will require other works as discussed above in the ATAD and biofilter system to allow this to be effective.
- Consider replacing the current flexible cover with a FRP cover to minimize fugitive odour risk.
- Provide an air inlet with a good path length and provision to exclude rain and birds.