SUCCESSFUL R&D IMPLEMENTATION OF ‘ODOZONE’ ODOUR MITIGATION TECHNOLOGY AT GVW

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ABSTRACT

In 2020, after receiving odour complaints and discovering corrosion at a pump station in Shepparton, Goulburn Valley Water (GVW) trialled ozone dosing to mitigate these complaints and improve the asset. Aquatec was asked to deploy its OdoZone Mobile Diagnostic Unit (MDU), utilising on-site ozone generation designed to meet the foul air demand of the pump station.

Pump station SHPS21 is situated along a public roadside near an industrial building. Wet well corrosion was primarily due to the presence of organic-laden foul air in the incoming effluent from upstream industrial waste processes.

Aquatec’s OdoZone is an innovative alternative to traditional chemical dosing, in the form of oxygen/ozone dosing technology generated on-site, on-demand to mitigate odours. Ozone has a very high redox potential, and in breaking down odorous compounds, the by-products are predominantly oxygen and water. This system has a smaller footprint, less public disruption, and simplified WHS requirements compared with chemical dosing.

GVW initially commissioned a two-week trial in the peak of summer. In its first week, the MDU baselined H_2S levels for later comparison, and in the second week, different dosing set points were trialled to gauge H_2S removal effectiveness. The MDU’s effect on H_2S levels was noticeable immediately.

GVW expanded the trial’s parameters for removal of other contaminants, and to assess the effect on downstream odour prevention. For a subsequent two weeks, the unit was tested against non-H_2S odours, and its effect on the rising main which discharged six kilometres away was assessed.

Week one’s baseline data, compared to week two’s dosing, showed a 99.0% reduction of H_2S levels (Figure 3). The unit was then turned off at midday each day, demonstrating odour would return to pre-dosing levels, and to prove that observed levels were not due to changes in sewer constancy.

Multiple gas grab samples were taken both during times of dosing and non-dosing. Figure 4 shows average odour units while not dosing of 110,000 OU, comprising of predominately non-H_2S contaminants.

During dosing, the odour level was reduced by 94.7% down 5,800 OU on average, proving ozone’s ability to reduce and oxidise both sulphides as well as other odorous compounds.

Lastly, as DO (Dissolved Oxygen) within the wastewater increased, the downstream effect of dosing at SHPS21 was measured at the downstream pump station (refer Figure 6 - average hourly H_2S level at SHPS5). For the 36 hours prior to dosing the H_2S levels were 53.6ppm (average) and 597.0ppm (peak). Once dosing recommenced, the H_2S levels dropped to 4.5ppm (average) and 47.0ppm (peak); a 91.6% reduction.

OdoZone MDU Key Outcomes:

1. Eliminated public complaints
2. Effectively removed odour at SHPS21
3. Improved corrosion protection extending the asset's expected life
4. Effective removal of odour and improved corrosion protection at receival point
5. Operational cost reduction compared to traditional chemical dosing

A collaborative approach to building a holistic odour profile enabled the most efficient and cost-effective mitigation strategy to be selected. In this case, this was an OdoZone system, which Aquatec have since installed at SHPS21 as a permanent unit.

KEYWORDS

Ozone

Oxygen

Pump Station

Odour Control

PRESENTER PROFILE

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With over 25 years of experience in information technology, software development, analytics and R&D, Andrew leads Aquatec's innovation and product development teams. Andrew works collaboratively with clients and the wider wastewater industry towards mutually beneficial outcomes and is regularly involved in facilitating trials of new and emerging technology globally. His current major focus is on odour control systems and their efficiency gains through improved modelling and control philosophies.

INTRODUCTION

H_2S AND CORROSION

Bacteria (i.e. biofilm) in wastewater collection systems will use (in order of preference) dissolved oxygen, nitrate, and sulphate as oxygen sources for respiration. Dissolved oxygen is usually present in fresh wastewater but is rapidly depleted by biological activity within the first couple of hours (based on BOD/COD). There is typically very little nitrate present in the wastewater, while sulphate is typically abundant. Since little or no nitrate is available, the bacteria begin utilising sulphate when the dissolved oxygen is depleted. The by-product of the sulphate uptake process is dissolved sulphide. The dissolved sulphide combines with hydrogen ions to then form odorous Hydrogen sulphide (H_2S). In combination with creating odours, hydrogen sulphide can also be oxidised to create sulphuric acid, causing corrosion problems in downstream assets.

GOULBURN VALLEY WATER

Goulburn Valley Water is an urban water corporation operating in the Hume Region of Victoria, Australia. Goulburn Valley Water's catchment area extends across 20,000 square kilometres, from the outskirts of Melbourne in the south to the Murray River in the north. It supplies water to 54 towns from 37 supply systems and provides reticulated sewerage to 30 regional towns via 26 wastewater management facilities. It provides drinking water, sewerage collection and treatment, recycled water, and trade waste services to a population of over 125,000 residents and 6,000 businesses.

The Goulburn Valley region is known as 'the food bowl of Australia'. The Corporation services major companies operating food processing plants in the region that require large volumes of high-quality water, and their wastewater streams create unique environmental challenges.

These challenges are further compounded by Goulburn Valley Water's higher than normal proportion of pump stations and long rising mains due to the relatively flat terrain.

Figure 1: Goulburn Valley Water service area

ODOUR ISSUES AT SHEPPARTON PUMP STATION 21

Shepparton Pump Station 21 (SHPS21) is a new pump station, which began suffering corrosion attack very early in its operating life (Photograph 1). It is on the side of a roadway with full public access, only metres from a commercial premises car park and delivery receival area (Photograph 2). The existing vent stack is limited in height due to proximity to overhead mains power cables, limiting passive odour dispersion. (Photograph 3).

Photograph 1: Visible corrosion at SHPS21

The influent (BOD: 600 mg/L) is predominantly industrial waste from a dairy producer upstream , generating the majority of the 110,000 Odour Units (OU). Only 41.1% of the total odour is made up of H_2S (Avg 14.65ppm; Peak 200ppm).

SHPS21 discharges into a six-kilometre rising main, with an average Hydraulic retention time (HRT) of 2-3 hours to SHPS5. There are air valves along this rising main, which have been a source of additional odour complaints. The sulphide production dramatically increases within this main with the H_2S measured at SHPS5 at an average of 53.6ppm, peaking at 597ppm.

ASSESSING SOLUTIONS TO CONTROL ODOUR AND CORRISION

When assessing solutions, understanding the application is key to success, as there is no ‘one size fits all’ when it comes to odour control. Contributing factors at this site included:

- Sources of odour
  - Odour both in the influent as well as being generated downstream
  - Complex cocktail of H_2S and other organic odours from industrial waste
- Turbulence releasing odour within the well
- Accelerated corrosion due to high levels of odour
- Temperature
- Downstream HRT
- Public accessibility
- Proximity to businesses and major roadway
- Onsite footprint limitations
- High voltage overhead mains power

Photograph 2: SHPS21 location.

Photo courtesy of Google

Photograph 3: SHPS21, highlighting proximity to major roadway, power lines, and commercial premises car parking.

IDENTIFIED OPTIONS

The following technologies were considered in the mitigation of the odours at SHPS21, as well as to help reduce further corrosion:

- Active headspace extraction
    - Biological and/or Activated carbon treatment
- Chemical dosing
- Oxygen and Ozone infusion

ACTIVE HEADSPACE EXTRACTION

SHPS21 is passively ventilated via a short vent stack. The option of actively ventilating the well with an extraction fan, treating this odourous air, and then venting the treated air was considered.

This was deemed non-viable due to:

- Height requirements of Biological and Activated carbon vessels and their proximity to high voltage overhead mains power lines
- Operator media replacement activities both close to major roadway as well as high voltage overhead mains power lines
- Exceeding the limited available footprint onsite
- Public accessibility of the site
- Visual impact

CHEMICAL DOSING

Chemical dosing options such as the two pictured on the following page (picture 4 & 5) were considered but deemed non-viable as:

- GV Water does not use chemical dosing elsewhere within their network, and therefore was reluctant to use chemical dosing at this site.
- Exceeding the limited available footprint onsite
    - Onsite Storage
    - Bunded truck parking for chemical delivery
- Public accessibility to the site
- Most of the identified odour not being H_2S.
    - Chemical dosing at best would reduce only the H_2S proportion of total odours. i.e. 41%
- Visual impact

Photograph 4:   Example of typical MHL dosing unit

Photograph 5:   Example of typical Ferric Chloride dosing unit

OXYGEN AND OZONE INFUSION

Neither Oxygen nor Ozone are new to the wastewater industry, with both being used in the treatment of wastewater and its corresponding odours. However, historically Oxygen infusion technologies have suffered from the same issues as Chemical dosing regarding:

- Onsite Storage
- Chemical delivery and truck parking
- WHS and chemical handling
- Footprint size
- Unsightly or intrusive equipment

However, with the miniaturization and increased reliability of Oxygen generators, O_2 can now be generated onsite, on demand, with the only consumable being mains power and ambient air. This simplifies WHS considerations, reduces footprint and improves the aesthetics of the installation.

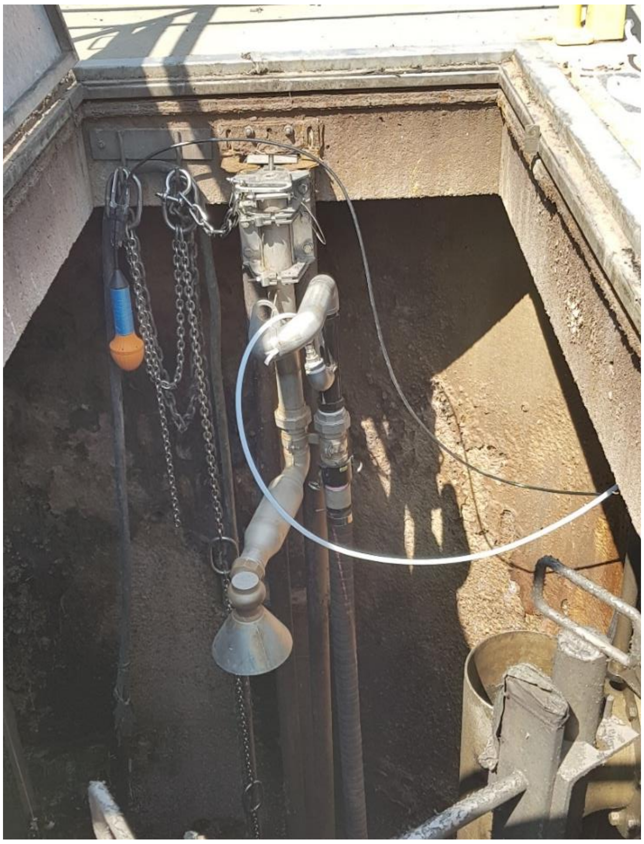
This therefore led to Oxygen and Ozone infusion being the recommended solution for the odour and corrosion issues at SHPS21.

TRIALLING OXYGEN AND OZONE DOSING AT SHPS21

H_2S EFFECTIVENESS

As part of assessing the recommend odour control solution, GVW commissioned a two-week trial of Oxygen and Ozone dosing in the peak of summer (as pictured in photograph 6). In its first week, the baselined H_2S levels were captured for later comparison, and in the second week, different dosing set points were trialled to gauge H_2S removal effectiveness. The effect of dosing Oxygen and Ozone on H_2S levels was noticeable immediately.

Week one's baseline data (blue) was compared to week two's dosing (orange) and showed a 99.0% reduction of H_2S levels (Figure 2). The unit was turned off at midday each day, demonstrating odour would return to pre-dosing levels, and to prove that observed levels were not due to changes in sewer constancy.



Photograph 6: Trial equipment installed

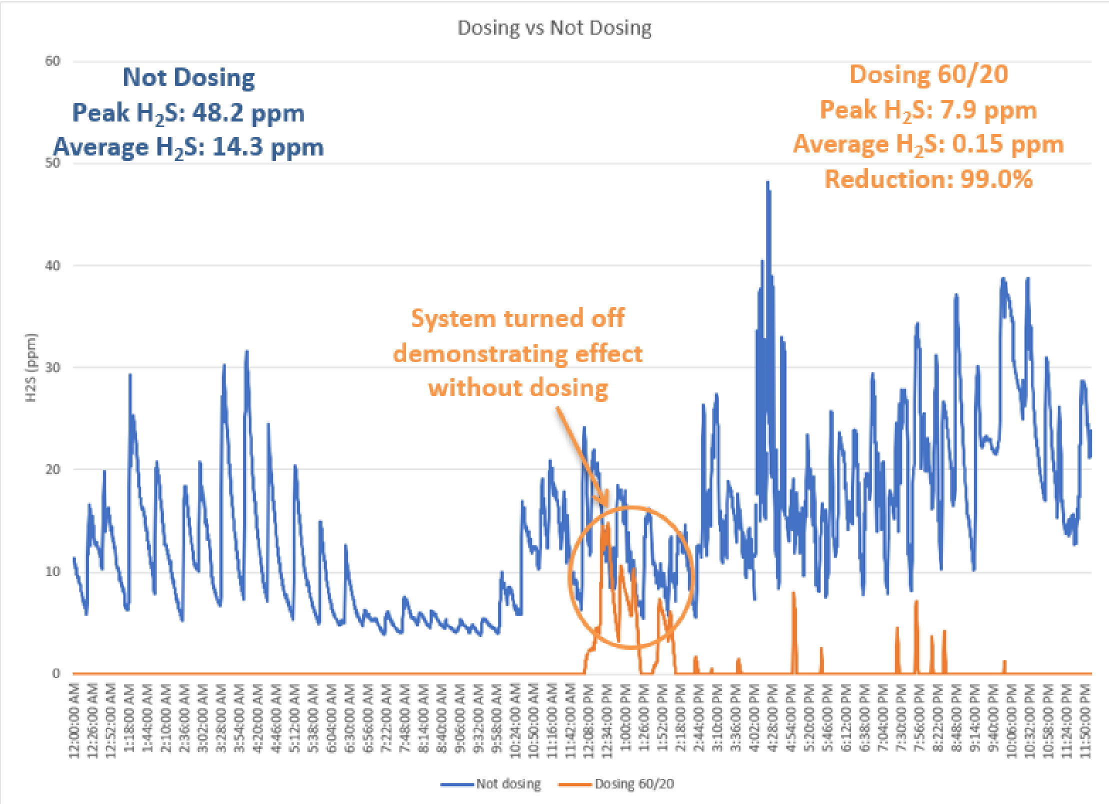


Figure 2: Comparative H_2S level for dosing verses not dosing

NON-H_2S EFFECTIVENESS

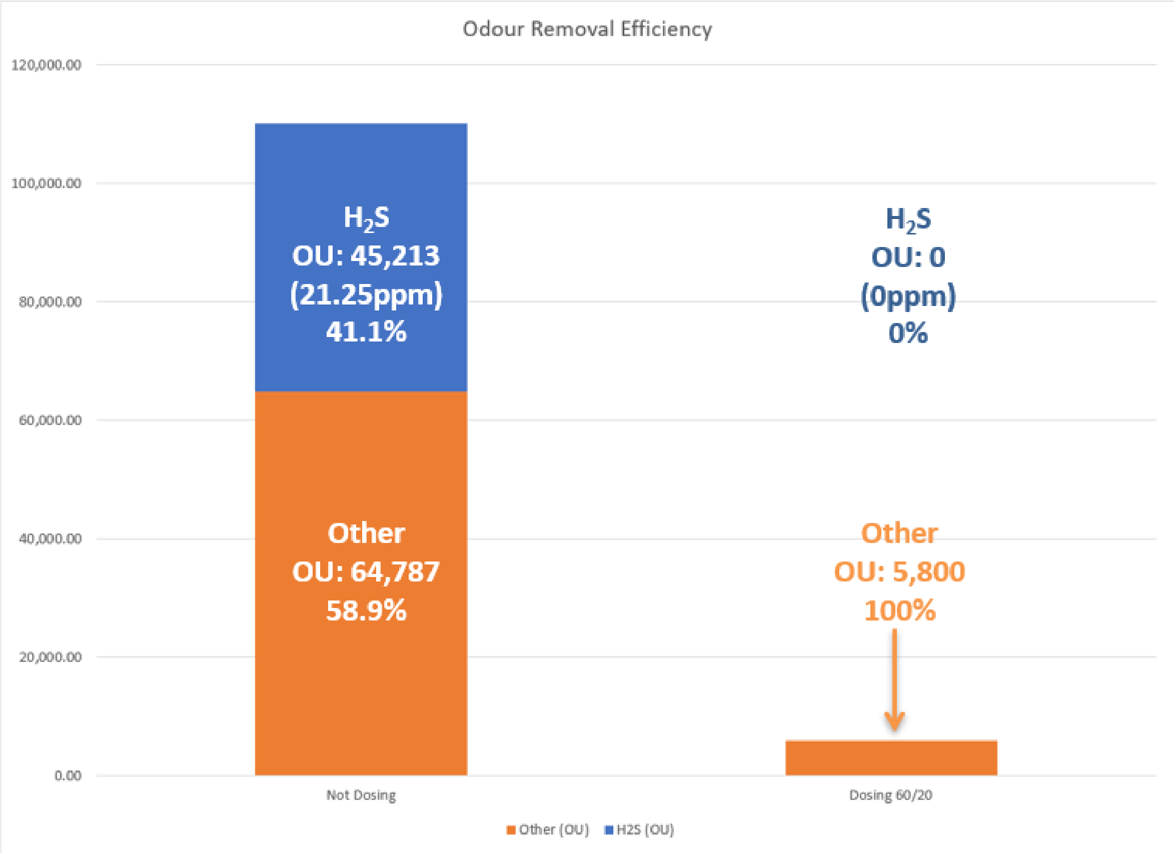


Figure 3: Total Odour removal efficiency

GVW expanded the trial's parameters for removal of other contaminants, and to assess the effect on downstream odour prevention. For the subsequent two weeks, the unit was tested against non-H_2S odours, and its effect on the rising main which discharged six kilometres away at SHPS5 was assessed.

Multiple gas grab samples were taken both during times of dosing and non-dosing (as pictured in photograph 7). Figure 3 (above) shows average odour units while not dosing of 110,000 OU, comprising of predominately non-H_2S contaminants.

During dosing, the total odour level was reduced by 94.7% down to 5,800 OU on average, proving ozone's ability to reduce and oxidise both sulphides as well as other odorous compounds.

Photograph 7: Gas grab samples being taken

DOWNSTREAM EFFECT

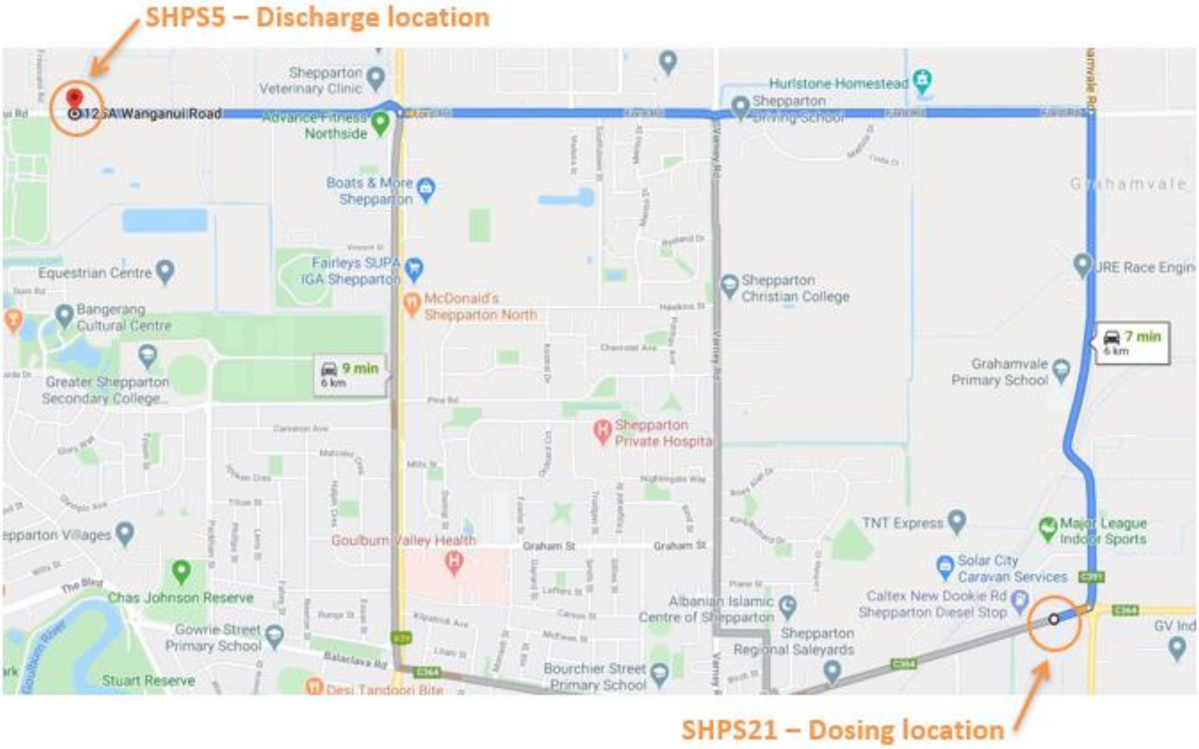


Figure 4: Approximate rising main siting

Map courtesy of Google

As discussed in prior sections, the by-product of Sulphide reduction and oxidation is Water and Oxygen. The Oxygen increases the DO (Dissolved Oxygen) within the effluent promoting the outer layer of the biofilm to aerobic. In the case of SHPS21's BOD/COD level, this would minimise Sulphide production for a couple of hours downstream.

SHPS21 discharges into a six-kilometre rising main (as pictured in Figure 4), with an average HRT of 2-3 hours to SHPS5. There are air valves along this rising main, which have been a source of additional odour complaints as the rising main passes by two schools, some industrial premises and residential areas.

To baseline the H_2S levels at SHPS5, the Oxygen and Ozone dosing was ceased at SHPS21 for several days, to allow the natural equilibrium to alter back to anaerobic. The H_2S levels where then captured at SHPS5, and found to be averaging at 53.6ppm, and peaking at 597ppm.

Dosing at SHPS21 was then recommenced, and once the treated effluent reached SHPS5 3 hours later, the H_2S levels dropped to 4.5ppm (average) and 47ppm (peak). This equated to a 91.6% reduction, as shown in Figure 5. It should also be noted, that SHPS5 receives influent from other pump stations, thus some of the residual H_2S could have been coming from these other sources.

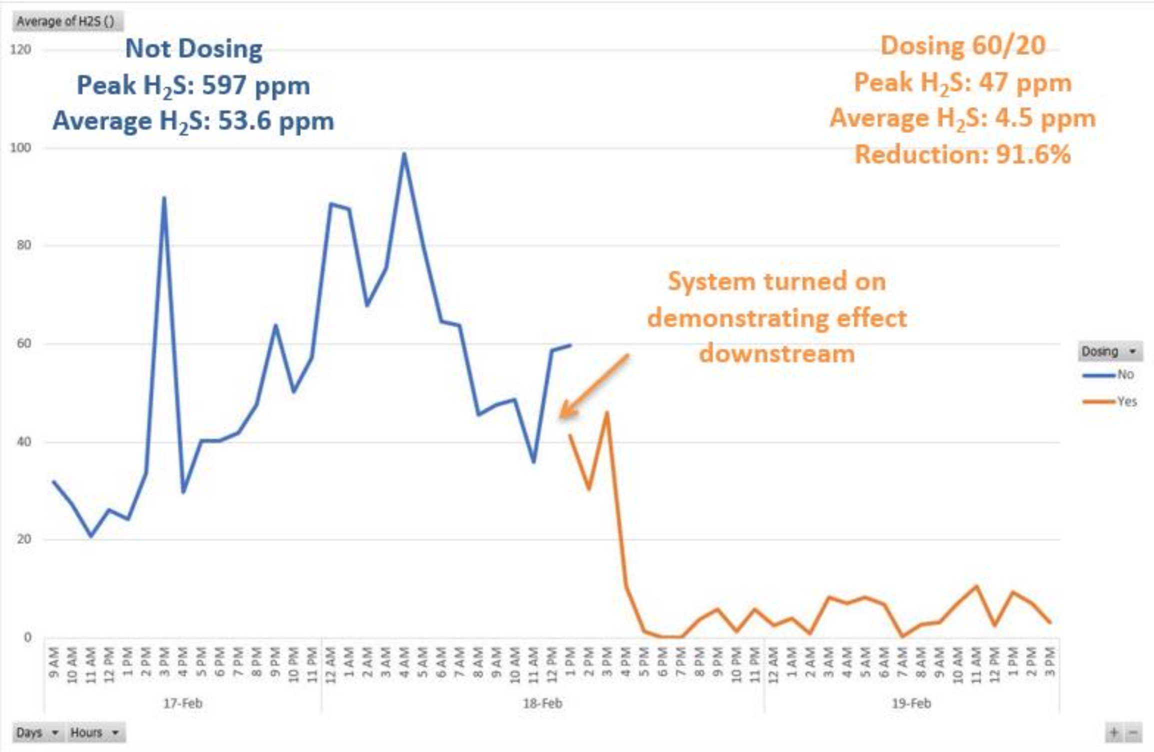


Figure 5: Downstream Effect of Dosing

EXPECTED PAYBACK AND RETURN ON INVESTMENT

Whilst chemical dosing was determined to be a non-viable solution, a TOTEX comparison between it and ozone dosing for the first 60 months was calculated. It showed an ROI (return on investment) of 13 months when compared to chemical dosing.

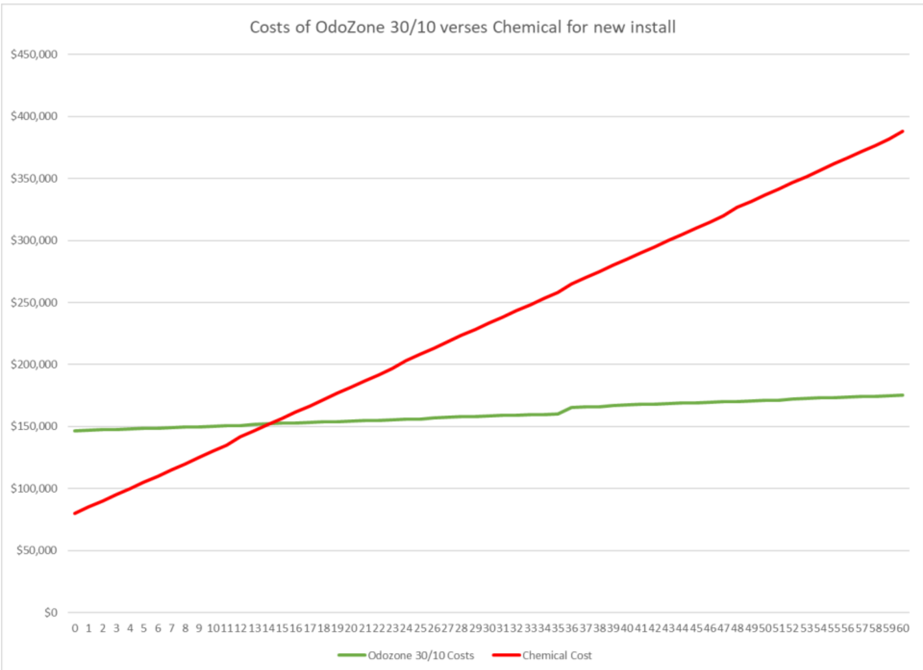


Figure 6: OdoZone verses chemical dosing over 60 months

HOW IT WORKS

ABOUT OXYGEN

When Oxygen is dosed to sewer, it is utilized for both sulfide and BOD/COD oxidation. Oxygen is effective in controlling sulphide production while there is more than 1mg/L of oxygen present, as it promotes the outer layer of the biofilm to aerobic. The inner layer remains anaerobic, however sulphides generated are oxidised as they diffuse through the aerobic layer, preventing build up within the liquid phase. Thus, in addition to preventing sulfide formation, any sulfide present would be oxidized.

The oxygen transfer to sewage is limited due to low solubility of oxygen. As a result, it difficult to keep the entire sewer pipe aerobic, especially in the case of long pipes, as the available oxygen is quickly consumed in sewer and during long HRT periods.

Oxygen addition has no long-lasting inhibitory effect, as biological activity will move to nitrate, and sulphate as alternative oxygen sources for respiration, once there is no-longer any available oxygen.

ABOUT OZONE

Ozone has a very High redox (reduction/ oxidation) potential making it very fast reacting, with a half-life of seconds to minutes in wastewater.

Ozone also has a very wide range of reactions:

- Sulphides: $H_2S + 3O_3 \rightarrow H_2O + 2O_2 + SO_4$ (shown in figure 7)
- sulfur compounds
- Ammonia: $2NH_3 + 3O_3 \rightarrow N_2 + 3H_2O + 3O_2$
- Organic compounds including solids & VOCs
- Pharmaceuticals, Petroleum byproducts, & Colour/Dye removal

It is 13 times more soluble than oxygen, and degrades to Oxygen (O_2) and water upon reaction with sulphides.

When injected into wastewater, it reduces buildup of fats, oils and grease (FOG), odour & subsequent corrosion within the wet well and downstream assets.

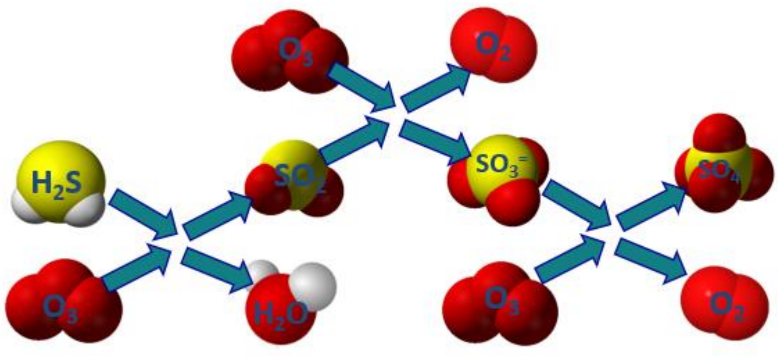


Figure 7: Reduction and oxidation of H_2S to Sulphate, Oxygen and Water

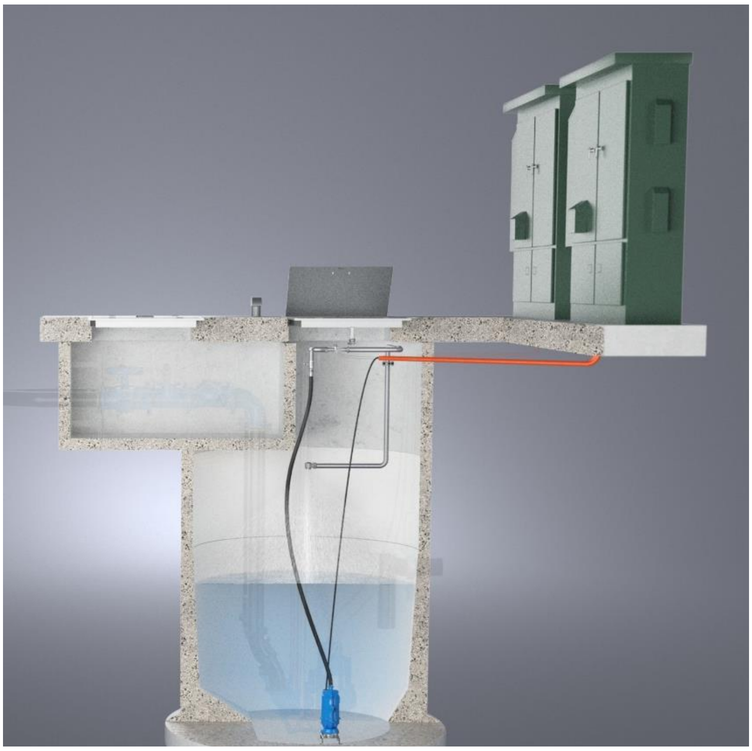
ODOZONE

OdoZone (Oxygen and Ozone infusion) is designed for FOG, odour & corrosion control within the wet well, by drawing in ambient air from the environment to generate an Oxygen and Ozone mixture on demand via inbuilt corresponding Oxygen and Ozone generators.

This mitigates the need for truck parking, chemical deliveries, and storage. Thus, the typical footprint is a cabinet roughly 2 metres wide by 0.4 metres deep.

The system is very quiet, typically emitting less noise than background neighborhood levels.

Photograph 8: Major internal components



Photograph 9: Render of major external components

A grinder pump recirculates wastewater inside the wet well through a venturi to infuse the Oxygen and Ozone. This treated wastewater then showers back throughout the wet well.

While the treated wastewater recirculates in the wet well, it continually mixes with and treats new wastewater.

The dissolved ozone instantaneously begins to reduce and oxidise any H_2S into non-odorous sulphate, while targeting other non-H_2S odours as well.

Photograph 10: Example of infuser and spray inside well

As demonstrated with SHPS21, the increase in dissolved oxygen generates Aerobic activity over Anaerobic Bacteria, reducing H_2S downstream and eliminating the potential for Sulphuric acid generation and associated corrosion issues.

CONCLUSIONS

Oxygen and Ozone injection into the wastewater at SHPS21 was successfully trialed to determine its effectiveness in reducing the odours both at the pump station, along with the downstream rising main and receiving pump station.

The outcome of this trial was:

1. Reduction in odour onsite at SHPS21, and expected complaint levels
2. Minimising ongoing corrosion at SHPS21
3. Reduction of expected complaint levels at air valves along rising main.
4. Reduction in odour and corrosion levels at receival point (SHPS5)
5. Reduced operational expenditure in comparison to traditional chemical dosing (as shown in figure 6)

POST TRIAL OUTCOME

As the trial not only exceeded H_2S reduction expectations at SHPS21, but also solved subsequent issues at SHPS5 and adjoining rising main, GVW has since installed a permanent OdoZone system as shown in the image below.

Photograph 11: Permanent OdoZone (oxygen and ozone dosing) unit installed at SHPS21.

ACRONYMS

ACRONYMS	DEFINITION
AEROBIC	Aerobic means 'with air' and refers to the biology producing energy with the use of oxygen.
ANAEROBIC	Anaerobic means 'without air' and refers to the biology producing energy without oxygen.
BOD	Biochemical oxygen demand (BOD) is the amount of dissolved oxygen (DO) needed (i.e. demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period.
COD	Chemical oxygen demand (COD) is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution
DO	Dissolved Oxygen. The Amount of Oxygen Dissolved within the wastewater. Typically measured in either mg/L or ppm.
FOG	Fat, Oil & Grease
GVW	Goulburn Valley Water
GV WATER	Goulburn Valley Water
H_2O	Water
H_2S	Hydrogen sulphide is a colorless gas known for its pungent "rotten egg" odour at low concentrations.
H_2SO_4	Sulphuric acid
HRT	Hydraulic retention time (HRT) is defined as the average time interval over which the effluent stays in a rising main or wet well.
MDU	Mobile Diagnostic Unit (MDU), is a portable OdoZone unit that can be used to trial varying dosing rates of Oxygen and Ozone, and used as a proof of concept.
N_2	Nitrogen
NH_3	Ammonia a colourless gas with a characteristic pungent smell, which dissolves in water to give a strongly alkaline solution.
O_2	Oxygen (O_2) is a chemical element found in the air as a colorless odorless tasteless gas that is necessary for life.

O_3	Ozone (O_3) is a highly reactive gas composed of three oxygen atoms.
ODOZONE	Short for Odour Ozone. It is used for FOG, odour & corrosion control within the wastewater pump stations.
OU	Odour units. An odour unit is a number where a panel is presented odours in decreasing dilution (increasing concentration) until detection. This is termed the detection threshold (DT) and is 1 Odour Unit.
PPM	Parts per million
REDOX	Reduce and oxidise. A chemical reaction that takes place between an oxidizing substance and a reducing substance.
ROI	Return On investment
SHPS5	Shepparton Pump Station 5
SHPS21	Shepparton Pump Station 5
SO_4	Sulfate
TOTEX	The TOTEX (Capital Expenditure + Operational Expenditure) approach looks at the total cost of expenditure, over a term of operating life.
VOC	Volatile organic compounds
WHS	Work, Health and Safety

Table 1: Acronyms and definitions master list