INTEGRATED ODOUR MANAGEMENT

Graeme Salmon and Nick Walmsley
GHD Ltd, New Zealand

ABSTRACT

Offensive odours from wastewater networks can have a serious impact on ratepayers and cause a vexing problem for Network Owners and Operators to resolve. This paper outlines an integrated approach to dealing with wastewater odour issues from existing systems, using the Hibiscus Coast Trunk Wastewater System experiences as an example.

Technical methodologies are outlined as a tool to integrated odour management, along with process methodology and fundamental philosophies to integrated odour management. Airflow auditing, network operational strategy, construction detailing and venting requirements are also considered. The paper includes the importance of reliable asset information and thorough communication strategies with affected parties. The value of community interaction and engagement in parallel to the technical competencies is demonstrated. Innovative methods for point source odour control are also outlined, together with system operational philosophies and analytical methodology.

KEYWORDS

Wastewater, Odour, Sewerage, Bio-Filter, Wastewater Systems, Odour Control, Carbon Filter, Odour Bed

1 INTRODUCTION

The first a Local Authority normally knows of an odour issue with a wastewater network is often by receiving a complaint from a member of the community. Receiving a complaint can be seen by some as an unwanted annoyance, or troublesome issue to be dealt with as quickly as possible. The complaint of foul smells emanating from a wastewater network is more often than not a symptom of deeper underlying issues. It is important to understand these underlying issues and not just deal with the symptom.

Integrated Odour Management considers the benefits of effective engagement of stakeholders including affected members of the community, network operators, designers and asset managers, combined with a systematic technical analysis to provide effective, sustainable and least cost solutions to wastewater odour issues.

2 TRADITIONAL ODOUR TREATMENT

2.1 FIRST RESPONSE

A common first response to an odour complaint is to seal or close off the offending source. Often this is by sealing manholes with DENSO tape, placing small carbon filters on house vent stacks or other rudimentary methods of isolating the odour. This can often initially be effective in addressing the immediate concern. Members of the community feel assured when immediate action is being taken. There is often a good chance the extent of the problem for the initial complainant will be reduced.

This approach however does not address the root cause of the issue and almost always moves the problem elsewhere; typically the next manhole or connection just up or down the line. More often than not the Local Authority will later receive either a repeat complaint or an additional complaint from the same general area. Repeating efforts to seal the source of odour can result in the problem moving again and an ever increasingly reactive cycle; resulting in multiple complaints and a vexed Local Authority.

2.2 POINT SOURCE CONTROL

There are a large number of options available for point source control of odours. Some are attractive as they are quick and easy to implement, such as sealing a manhole with DENSO. Treatment options such as bio-filters and carbon filters are more expensive and require longer to implement. Bio-filters and carbon filters both have attributes making them most suitable to a particular application, including available space, loading rates, ongoing maintenance requirements and cost.

An innovative solution was deployed in Rodney District over the Christmas holiday period of 2009/10. An influx of holiday visitors to Rodney District's beaches and towns, combined with warm weather and residents remaining at home during the day with friends and family often results in an increase in sewer odour complaints.

A 'rapidly deployable' carbon filter was designed (refer Photo 1). This was based on readily available materials and designed to be deployable by one network operator with a ute. The prototype model consisted of a 200l PE food barrel, several bags of activated carbon and a diffuser stage consisting of a PVC tee piece, scoria and a layer of filter cloth such as bidim or similar to form a plenum. Manhole lids were pre-cut with a 150mm Dia hole. On receipt of an odour complaint, a controlled ventilation point could be easily installed by swapping the manhole lids over, ducting air from the manhole to the 'carbon filter' with 150mm non perforated Nova-coil, and filling the barrel with activated carbon.

Photograph 1: 'Rapidly Deployable' Carbon Filter on Pump Station Vent Stack at Martins Bay Campground

Martins Bay Campground, at the Eastern end of the Mahurangi Peninsula, overlooking Kawau Island, enjoys a significant influx of campers over the summer holiday period. While the existing pump station is planned for replacement, the sharp spike in summer flows cause odour issues. An existing small carbon filter was not adequately dealing with wet-well air flows. A 'rapidly deployable' carbon filter was cut into the wet-well vent stack increasing the residence time of wet-well air flow and effectively dealing with the odour issues.

While these 'rapidly deployable' carbon filters are obviously only a temporary measure, they have given the Local Authority a valuable tool to address odour issues. Other than being a legitimate technical solution by providing a controlled sewer air venting point, residents were often reassured by the 'visible' action from the Council. The units proved very useful on a number of occasions, however the control of condensation is key to reliable operation as both activated carbon and expanded alumina products available for use in odour control are ineffective at high relative humidity or moisture content.

2.2.1 SYMPTOM OR CAUSE

Without appropriate investigation, implementation of point source control measures will only address the symptom of the issue and not the root cause and is likely to lead to an ineffective solution and ongoing complaints. The temptation for Local Authorities to respond quickly to an issue is real and timeliness of a solution is a significant factor.

To provide an effective and sustainable long term solution, an understanding of the underlying root cause is required. Wastewater odours are a symptom of a system that is not operating effectively.

2.3 SOURCES OF ODOUR ORIGINS AS DESCRIBED BY COMPLAINANTS

2.3.1 PERCEPTION AND SUBJECTIVITY

It is common for complainants to offer information to assist in the resolution of the issue. Effective engagement of the complainant has several benefits. Of primary concern is keeping complainants engaged and informed of progress.

The complainant's perception of the odour source should be understood. It is very common for complainants to site the most visual option available as the odour source. This is often not correct and without careful investigation will result in a point source control being installed at an incorrect location. An example of this was a sewer vent pipe, being a 200mm diameter green pole clearly visible to the public. This vent stack had been previously disconnected. Members of the public complained that the vent stack was the source of odour, whereas the source was from surcharging manholes.

3 TWO FLUIDS / AIR FLOW PATH

It is important to remember wastewater networks carry two fluids, wastewater and air. Focus is often dominated by conveyance of the wastewater portion, particularly for Peak Wet Weather Flows. What happens to the air flow gets overlooked. Significant efforts are expended on the operation of wastewater networks to avoid sewage overflows in wet, typically winter high flow periods. The dry, low flow summer periods, when most odour can be generated, are all but forgotten.

Due attention to the management of the air flows in sewers is essential to effective odour control.

3.1 AIR FLOW AUDIT

The first step in a technical investigation is to confirm available air flow paths. Air must be able to travel along the sewer with the wastewater flow. Air will be able to enter the sewer at a number of locations from gulley traps, house vent stacks, manhole lids and other leakage paths. Conversely, air will be able to exit the sewer from all of the aforementioned leakage paths. Therefore designed air exit points, or controlled vent points, are required. Understanding the air flow path into, along and out of the sewer is fundamental to controlling sewer odours.

There can be a number of impediments to steady air flow along a sewer. Air flow will take the path of least resistance and very small changes in pressure will cause airflow to change paths.

3.1.1 TOOLS FOR AIR FLOW AUDIT

The logical starting point for an air flow audit is as-built records. In an ideal situation air inflow and vent points will have been designed, constructed and documented as such. A simple hands-on investigation of designed vent points can be highly valuable to confirm their presence and correct operation. It is likely that if an odour problem is occurring, sewer air is flowing where it should not. This indicates reality differs from as-built information or other asset knowledge. A hands-on investigation can often identify the cause of an issue, i.e. broken connecting pipe, blocked odour bed drainage or past modifications not captured by as-built records. It is acknowledged that the presence of reliable as-built information and system Operating & Maintenance Manuals greatly aids investigation and resolution of odour and other wastewater network issues.

The degree of investigation should be proportional to the scale of problem at hand and confidence of existing asset information. A number of tools are available to assist with air flow audits and wider system behavior. The following have been used to good effect:

- CCTV for confirmation of connectivity of pipework and air ducting, especially at pump stations.
- Hotwire anemometer for measuring air flow speeds and flow-rates at fixed points in the network (handheld).
- Digital recording Manometer – to record very small changes in air pressure. The use of digital manometers is discussed further below.
- Smoke testing, to demonstrate asset condition and the presence of leakage paths.

3.2 FLUID FLOW – HYDRAULICS

Adequately understanding the fluid flows and their hydraulic effects in the network is central to understanding airflows in the sewers. In a constant grade pipe with a steady fluid flow the air will usually be swept along with the sewage down the sewer. This provides good natural ventilation along the sewer provided there are no impediments to air flow.

Any points of hydraulic restriction will impede air flow. This includes any point where the pipe runs full or surcharges, or where hydraulic jumps occur e.g. a rapid change in Froude number. These are most common around changes of grade but hydraulic blocks can also occur at manholes with poor benching detail causing a hydraulic curtain effect, or due to blockages (fats, roots etc) and structural failures. In these instances odour complaints can be the trigger for network maintenance prior to a more serious wastewater spill.

If a hydraulic model exists for the Wastewater Network a hydraulic analysis at various flow rates can be very quick and efficient. Otherwise simple desktop calculations can suffice for a practical starting point. It is important to verify desktop predictions with field observations. Discrepancies between the two are common and will often lead to the cause of the odour complaint, being an aspect of the network or its operation that is not as it should be.

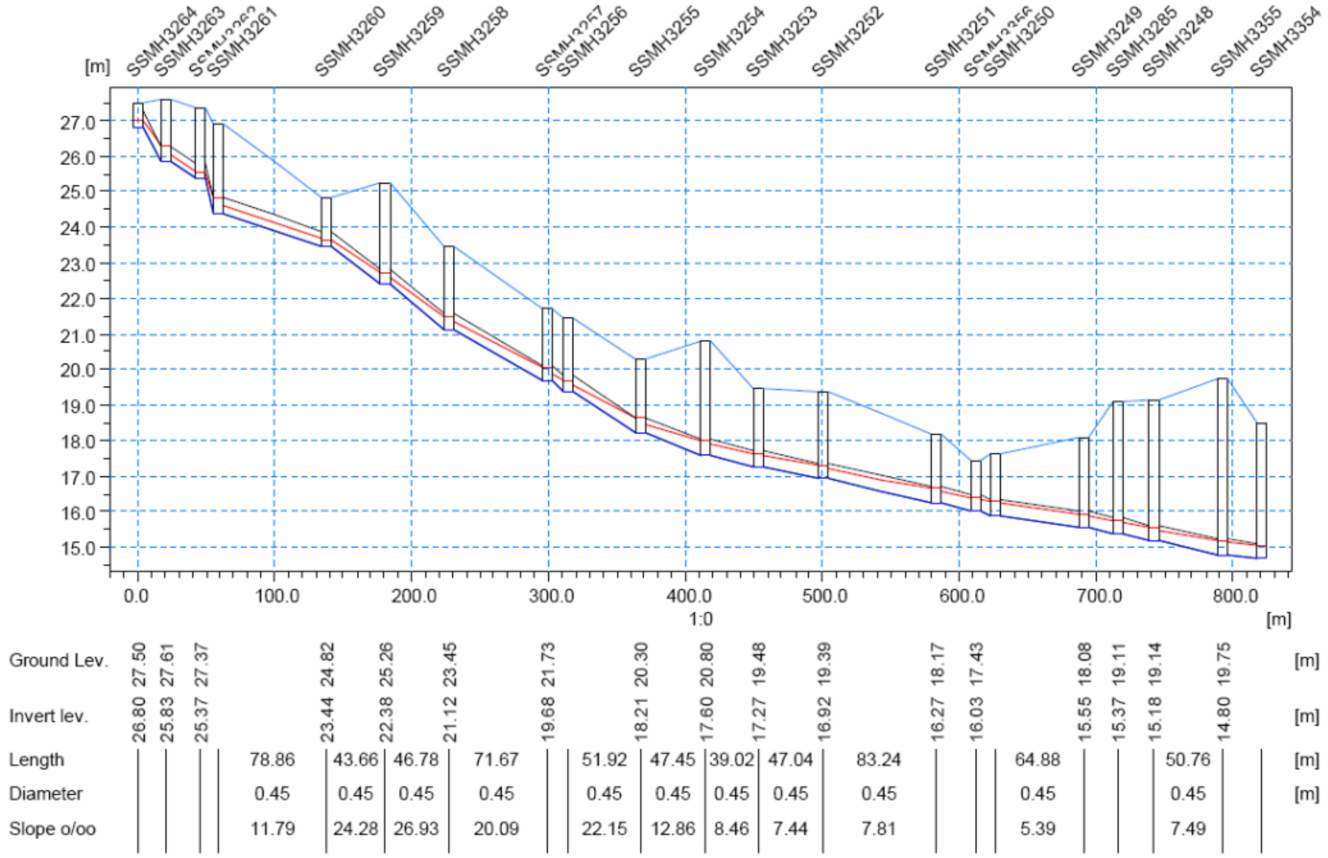
An example of hydraulics causing odour complaints is as below in Figure 1. The ‘Shaddon Place to D’Oyly Drive’ line is a section of the Whangaparaoa trunk transfer network. Long rising mains discharge close to Shaddon Place, where a 450mm diameter gravity line transfers flows down to D’Oyly Drive. The line has significant fall with relatively steep grades flattening out towards the D’Oyly Drive end.

Ongoing and serious odour complaints were being received from properties surrounding the middle section of this line.

Hydraulic analysis showed that various pipes were surcharging where the grade changed to flatter sections, i.e. at manholes SSMH 3255 & 3254 of Figure 1. With steeper grades at the start of the line airflow was being readily sucked along with the fluid flow. Upon reaching a surcharged manhole the airflow was blocked and would seek escape paths from the sewer, releasing fugitive odours and initiating odour complaints. Further, as flows in the line increased, the sections of line would surcharge further upstream, displacing more air out of the line.

A factor in the severity of complaints was the very high levels of hydrogen sulfide (H_2S) in the sewer air generated in part from the approximately 3,000m of rising main discharging into this gravity section. Due to the high levels of H_2S the suitability of point source odour control devices was variable, there was a risk odour control devices would not control the odour, or in the case of carbon filters, would run out quickly causing a repeat complaint. Additionally, all manholes are on private property and several in close or very close proximity to dwellings.

Figure 1: Shaddon Place to D'Oyly Drive Long Section and Hydraulic Grade Line



Attempts had been made to seal the manholes. This included using 'DENSO' to seal lids and re-grouting manhole risers and lids. Cyclic pressurisation of sewer air in the manholes due to surcharging meant that this was ineffective. The manholes would become a de facto pressure vessel resulting in the escape of sewer air via cracks in the concrete risers and lids.

Due to the regular surcharging of the line and very close proximity of dwellings to manholes, it was decided to seal the four manholes including and upstream of SSMH3254 with CIPP liners. This section of line had been previously rehabilitated with 'rib-loc' liner. The CIPP liners ran straight through each manhole making the line a pressure-gravity line rather than a traditional gravity line. By piping straight through the manholes there was no longer a void available for air to be entrapped in and pressurise.

To prevent transferring the problem further up the line two manholes were selected as vent points. These were SSMH 3259 and 3260. Both are on private property and a reasonable distance from any dwellings. A 'rapid deployment' carbon filter was installed initially and later replaced by a permanent unit. The 'rapid deployment' unit served two purposes, firstly in that it could be installed immediately (just prior to Christmas), secondly to confirm effectiveness of the solution including air flow rates, sizing of the unit and associated residences times.

This solution proved to be effective. While ongoing maintenance of the carbon filter is required, only one carbon filter was required to be installed. In a chance meeting with a resident several months after installation, the resident stated she had "completely forgotten about the odour issue".

3.3 PUMP OPERATION

Pump station operation is central to hydraulic performance and effective air flow through the wastewater trunk main system. Pump stations and rising mains are often designed to cater for PWWF rates with little consideration given to the impact of operations during low flow periods.

Confirmation of pump flow rates is important to add confidence to the hydraulic analysis. Ideally a flow meter will be available on the rising main to confirm flow rates. In many situations, particularly on smaller systems, flow meters are not available. In these cases flow rates can be derived from pump and system curves. Of most benefit in these situations are pressure gauges on outlet manifolds. Problems can be encountered confirming the reliability of estimated flows with multiple pumps running, or determining different flows from duty and standby pumps due to wear, age and other factors.

Pump operation often dictates the behaviour for the wastewater system. At pump start up the lines fill with fluid that displaces air out of the sewer. If this air is being purged from the line at pump start up it is the likely cause of odour complaints. Pump stations with low stop start levels result in short pump cycles and proportionally more pump starts per day. Consideration of pump operation can reduce the number of pump starts and reduce the number of times air is purged from the lines downstream. This can serve to reduce the severity of odour problems and reduce the loading rates on odour treatment devices.

Hydraulic analyses focus on the steady state behaviour of the system and hydraulic blockages to air flow at expected pump flow rates. This information can lead to the design and placement of vent points and odour control devices just upstream of the hydraulic constriction.

However, odour treatment devices and steady state analysis will fail to resolve the issues if dynamic system behaviour is dominant.

3.4 DYNAMIC STATE SYSTEMS

The most perplexing issue can arise when following the steps above e.g. an air flow path has been confirmed, hydraulic blockages have been understood and an odour control device installed at a designed vent point, only for complaints to continue! Rechecking of calculations and revisiting of design assumptions can confirm the problem should be resolved. What next?

Following confirmation that all existing detail is correct and odour control devices are well maintained and otherwise operating effectively, it can be concluded that dynamic state conditions are dominant in the system. Dynamic state behaviour can be difficult to identify due to its transient and short lived nature. A basic understanding of the wastewater pipe filling and emptying may not provide sufficient information to identify the cause of the issue.

Effective engagement with affected property owners and network operators at this point can provide useful information. Moving or rocking toilet bowl water is clear evidence of surging airflows in lines and an indication of dynamic state behaviour. Other information about the time, place and extent of odours can also provide useful information.

Good engagement of property owners can serve several purposes, firstly in keeping property owners informed of progress and instilling some confidence the issue is being taken seriously and being progressed. Secondly, in making the property owners feel comfortable in coming forth with information they may see as embarrassing or, in their view, of little relevance.

Of immense value in identifying and resolving dynamic state situations is the digital manometer. These are available as hand held units recording small air pressure changes down to fractions of a Pascal (Pa). This is illustrated for the Ellenbury odour bed example below (refer Figure 2). Changes in air pressure indicate air flow, but most importantly, it is the difference in air pressure which drives air out of leakage paths and causes fugitive odours.

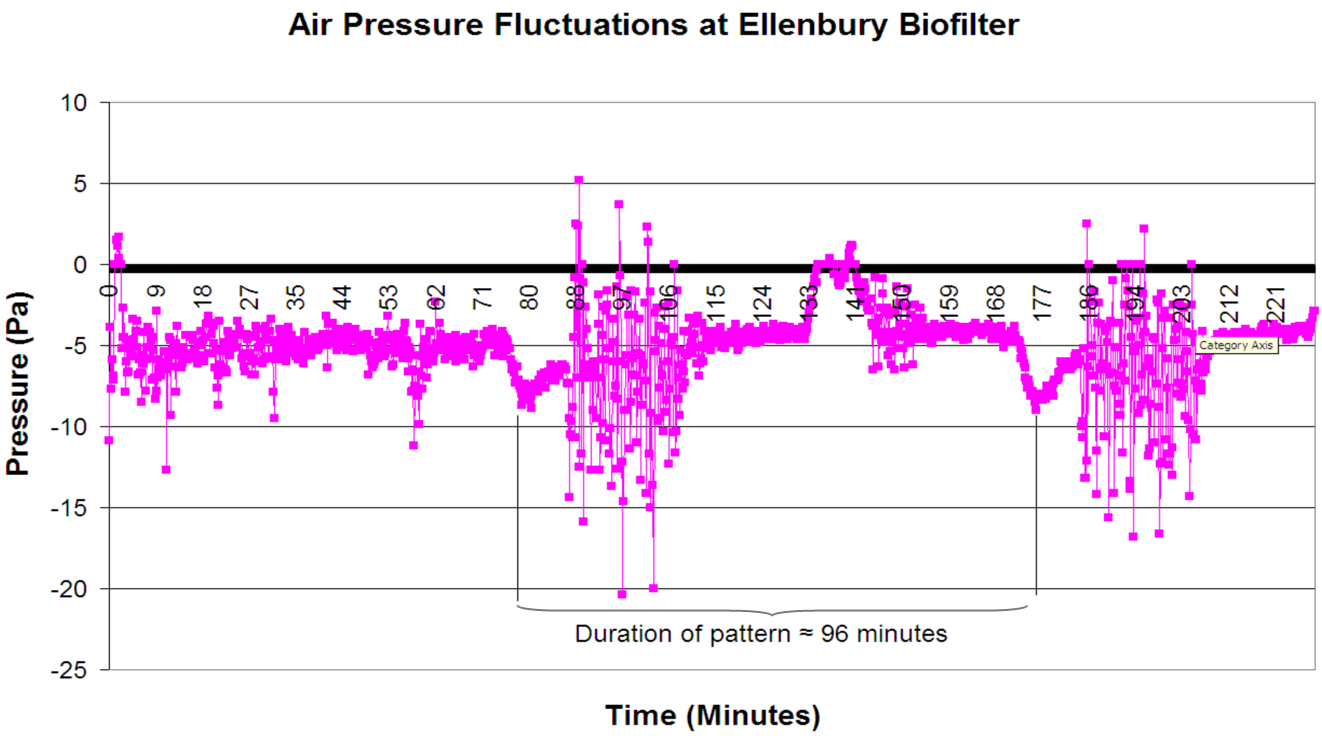
Understanding of dynamic state conditions was required to resolve ongoing issues around Ellenbury Place on the 'Shaddon Place to D'Oyly Drive' line.

A bio-filter was installed in Council Reserve on the 450mm trunk line behind Ellenbury Place, Whangaparaoa at manhole SSMH 3354. The purpose of the bio-filter was to ventilate a relatively flat section of line between two known hydraulic constrictions being the surcharging 'middle section' of the line, and the line running away from D'Oyly Drive, which is approx 2,500m of 630 OD PE pipe of a very flat grade. The bio-filter was commissioned with a multi-stage fan on variable speed drive (VSD). Air flow rates were set to adequately ventilate the sewer section and maintain adequate retention time in the bio-filter.

Residents continued to complain of sewer odours.

A digital manometer was installed on the receiving manhole and air pressure recorded in the sewer every ten seconds for several hours. Figure 2 shows that during steady state operation the fan and bio-filter maintain a slight but consistent negative pressure in the sewer of approximately –5 Pa. A periodic cycle is evident of the air pressure dropping lower consistently, then jumping about rapidly between negative and positive pressures. The positive pressure caused air to bypass the bio-filter via leakage paths and led to odour complaints.

Figure 2: Air Pressure Fluctuations at Ellenbury Biofilter



The duration and frequency pattern of pressure surges matches the pump cycles at the upstream pump station closely. Downstream flow hydraulics were also identified that should not have affected this section of line, but did. Large surging sewage flows in the very flat sections of 630OD PE leading away from D'Oyly Drive caused surging airflows back up the line that would escape the system around the bio-filter at Ellenbury via leakage paths intended to be controlled by maintaining a negative airflow into the line.

Control of the surging flows was required in order for the existing odour control devices to function effectively.

3.5 PROPORTIONAL FLOW CONTROL

In order to control Dynamic State dominance in the wastewater network, step changes in flow should be avoided and rates of flow rate change should be minimised. This becomes increasingly important for larger pump stations and higher flow rate pumps.

Take for example Stanmore Bay PS, set up to handle PWWF in the order of 500 l/s. The flow rate with one pump operating is 220 l/s with a stop / start operation. With every pump start the downstream line fills at 220 l/s, displacing air at the same flow rate and requiring it to be expelled from the system, either by leakage paths, controlled vent points, or into the next pump station.

Existing pump start levels meant that Stanmore PS had an average pump cycle of 5 min, with average time between cycles of 12 min and an average time between pump starts of 17 min. This led to the regular purging of air from the line at the high flow rate of 220 l/s every 17 minutes or so, causing a number of issues relating to sewer odours.

The principle of Proportional Flow Control (PFC) is for each pump station to 'follow the flow' and pump out at the same flow rate as that coming in. As flows increase, pumping rates correspondingly increase by use of VSD's. This minimises the rate of change of flow rates and subsequent air flow rates in the system and avoids surging flows. PFC also minimises wastewater retention time within the system, reducing sulphide generation and issues associated with odour and corrosion.

Optimum PFC will result in pumps running for long periods at lower flow rates. This reduces the cumulative number of pump starts and results in more consistent air flow rates in the system. This dramatically reduces the likelihood of fugitive odours escaping due to rapid flow rate changes and surging pressures. While pump run time will increase, overall energy costs will be reduced as the system will be operating at lower dynamic heads.

4 HEALTHY SYSTEM OPERATION

Wastewater odours are often a symptom of a system that is not operating effectively. Conversely a system that is operated effectively would not have odour issues and will minimise degradation of assets via sulphide corrosion.

Sulphide corrosion occurs due to bio-chemical reactions within the slime layers grown on pipe walls and resultant acid attack. Sulphide production is increased with increased slime layers.

Standard system operations should ensure self cleansing velocities are obtained daily, to minimise build up and anaerobic decomposition of settled solids.

Additionally slime shear velocities should be achieved, preferably on a weekly basis, to reduce the slime layers grown on the pipe walls and minimise sulphide generation. The analogy of a goldfish bowl can be made, where if the goldfish bowl has not been cleaned for some time it will go green and slimy, and smell somewhat unpleasant. Eventually the goldfish will die. Regular slime shearing will have a similar cleansing effect. It will also serve to reduce energy costs by reducing friction losses along the pipe wall.

Self cleansing and slime sheering regimes should be programmed as a fundamental aspect of normal network operation. Benefits particularly of achieving slime shearing on a regular basis will result not only in reduced odour issues but can serve to extend the asset life by the avoidance of corrosion by sulphide degradation.

Network operators can influence the performance of a wastewater network as much as system design and maintenance. Effective engagement of network operators is essential to a healthy wastewater network. A wastewater network cannot be operated in isolation, or designed in isolation. It must be designed for the operations and operated to the design. While reliable as-built information and complete Operating & Maintenance manuals form a platform for this, it is the effective engagement of network operators, asset owners and the community that results in the success of Integrated Odour Management.

5 CONCLUSIONS

Integrated Odour Management is extremely important to maintain the health of the sewer network and to provide the ‘invisible’ service the community expects. Integrated Odour Management combines the benefits of:

- Positive engagement with stakeholders; public complainants, network operators and asset owners.
- Technical evaluation of both network fluids; sewage and airflows.
- Review and management of dynamic state conditions.

Having good as-builts and asset knowledge is obviously important but it only tells part of the story. It is also necessary to understand how the system performs; both the operations and its impact on the community. In order to maintain long term benefits the network should be designed for the operations and operated to the design. This needs to be understood by all parties and documented through operational manuals.

ACKNOWLEDGEMENTS

Rodney District Council staff assistance, co-operation and support in getting to the root cause of odour and corrosion complaints and providing long term solutions.

REFERENCES

GHD Ltd (2010), Rodney District Council ‘Sewerage Odour Control’.

Melbourne & Metropolitan Board of Works (1989), Hydrogen Sulphide Control Manual, Technical Standing Committee on Hydrogen Sulphide Corrosion in Sewerage Works.