

ODOUR CONTROL FOR PUMP STATIONS

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ABSTRACT

In any wastewater pump station, as the water level rises before the pumping cycle starts, odourous air is displaced. This odour can cause a nuisance for neighbours. The main odourous compound is H₂S (hydrogen sulphide), present at concentrations up to 100 ppm, and occasionally higher. Odour control technologies, such as carbon beds, biological scrubbers, and soil bed filters, are required to mitigate the odour nuisance.

H₂S concentrations were logged at two pump stations to obtain data for LCC (life cycle cost) analysis. At the 'larger' Otumanga pump station, a biological scrubber, and later a carbon bed adsorber were installed and monitored. At the 'smaller' Mangawhai Village pump station, a passive (no fan) carbon bed adsorber was installed and monitored.

The carbon bed adsorber removed greater than 99.9% of the H₂S, and eliminated the odour nuisance. The biological scrubber successfully eliminated the odour nuisance when coupled with a final carbon bed polishing unit.

A carbon bed adsorber has the lowest LCC for a pump station with a PDWF (peak dry weather flow) of 100 l/s or less, and an average H₂S concentration of less than 10 ppm.

KEYWORDS

Odour control, pump stations, hydrogen sulphide, biological scrubbers, carbon adsorption beds

1 INTRODUCTION

LCC (life cycle cost) analysis was used to identify the most cost effective odour control technology for two pump stations. This requires a detailed knowledge of H₂S concentrations in the air to be treated. Published data detailing conditions, both inside pump stations, and in air extracted from pump stations, is scarce. Further, the data available is often spot or peak measurements, rather than 24 hour averaged data required for LCC analysis. A significant portion of this investigation involved logging H₂S concentrations.

Historically, it has been uncommon to install odour control systems, even though the technology has been available. Public tolerance of nuisance sewer odour is now much lower. To meet public and Council expectations, odour control systems need, not only to control odours, but also be visually unobtrusive, have minimum moving parts to service, and be compact, as they are often sited in residential situations with minimal space available.

2 BACKGROUND

Wastewater pump stations are an integral component of sewage systems. As wastewater flows into a pump station before a pumping cycle begins, the water level rises and physically displaces air. The displaced air carries with it odourous compounds that may include sulphides, amines, fatty acids, aldehydes, ketones and other VOCs (volatile organic compounds). When these compounds are present at concentrations higher than their odour threshold concentration, this can result in an odour nuisance.

H₂S (hydrogen sulphide) is by far the most dominant odour-causing compound, and can be present at concentrations up to 100 ppm and occasionally higher. As H₂S has an odour threshold concentration of 0.0005

ppm (Wikipedia), any air displaced from a pump station with H₂S concentrations, of say 20 ppm, must be reduced/diluted by 40,000 times before it reaches the neighbours' boundary in order to eliminate an odour nuisance. This is equivalent to a concentration reduction of more than 99.99%. A large degree of reduction/dilution happens naturally with wind and distance, but when a neighbouring boundary is less than 10 metres away, this degree of odour reduction/dilution is not possible without the use of odour control technology.

For odour control of larger pump stations in New Zealand, soil bed filters, with packed beds filled with organic media, are successfully used. They require a fan, an irrigation network, a relatively large area, and can have operating stability problems, including: drying out, acidification, salt deposition and compaction. There is a small residual odour in air leaving the bed. Generally, soil bed filters are suitable for air streams with H₂S concentrations less than about 50ppm.

However, in Europe and USA, biological scrubbers, rather than traditional compost-based biofilters, is the technology of choice (Dirske, 2009). This technology is also being used in Australia, but is yet to be widely adopted in New Zealand. The first two biological scrubbers in New Zealand were installed at fertilizer plants to remove high concentrations of H₂S from air streams from sulphur melters (Holyoake et al, 2007). Biological scrubbers feature an inorganic high surface area support material, populated with microorganisms that consume the H₂S. This takes place in an enclosed vessel, and is not affected by weather and ground conditions. Nutrients are usually dosed to maintain the health of the microorganisms. They have a footprint less than 10% of that of a soil bed filter.

Carbon adsorption beds have been successfully used worldwide for many years to control odour from sewage vents. Activated carbon is a crude form of graphite, with a highly porous structure. Pores vary from visible cracks and crevices to those of molecular size. Intermolecular attractions in these smallest pores result in adsorption forces, causing condensation and capture of volatile gases. Water vapour molecules interfere with the adsorption processes (Keener and Zhou, 1990), so it is common practice to use heaters to control the maximum relative humidity of the air to less than 80%. Activated carbon impregnated with hydroxide improves H₂S removal (Boppart, 2009) from moist air, as moisture is required for the chemical reactions involved. Carbon adsorption beds have a footprint less than 10% of that of a soil bed filter.

3 DETAILS OF PUMP STATIONS INVESTIGATED

A biological scrubber and a carbon bed adsorber were installed and monitored at the 'larger' Otumanga pump station. A passive (no fan) carbon adsorption bed was installed and monitored at the 'smaller' Mangawhai Village pump station. Details of the two different sized pump stations are given in Table 1.

Table 1: Two Pump Stations Investigated

	'Larger' Otumanga Pump Station, Welcome Bay, Tauranga	'Smaller' Mangawhai Village Pump Station, Northland
PDWF (Peak dry weather flow), l/s	75	10
Volume Pumped, m ³ /day	2000	100
Max Pump Rate, l/s	140	22
Dimensions to water level, m	4m x 4m x 4m deep	2.25 diam x 2.1 deep
Air Volume, m ³	64	9

4 H₂S MEASUREMENTS

H₂S concentrations were logged with OdaLog Gas Data Loggers (Photo 1). Three different units were used with ranges: 0 to 20, 0 to 100 and 0 to 1000. The manufacturer, App-Tek International Pty Ltd, states the OdaLogs are purpose designed to log H₂S within sewerage pumping stations and receiving manholes up to 90% relative humidity and non-condensing. It was found during this investigation that the air streams were often 100% relative humidity and condensing, hence the OdaLogs regularly became fouled with both dirt and water, resulting in a number of gaps in the data. The OdaLogs measured total sulphides. The accuracy of the H₂S concentration data is estimated at plus/minus 10%, or plus/minus 0.2 ppm. The New Zealand suppliers, APS Ltd, provided the calibration service.

Air Matters Ltd sampled the inlets and outlets of the Otumanga carbon bed onto ATD tubes in accordance with USEPA method TO-17, and were analysed for VOCs. Sulphides were sampled into a zinc acetate/sodium hydroxide solution and analysed in accordance with APHA Method 4500.

Photo 1: OdaLog Gas Data Logger on Carbon Bed Outlet



5 OTUMANGA PUMP STATION INVESTIGATION

5.1 OTUMANGA PUMP STATION BACKGROUND

Otumanga pump station in Welcome Bay, Tauranga, has a PDWF of 75 l/s (see Table 1). The pump station is constructed of concrete, with lids of non-sealing galvanized steel.

The major inflow into the Otumanga pump station is a 300 mm diameter by 1.4 km long rising main from the Waitaha pump station, the last portion of which slopes towards Otumanga. The theoretical residence time in the rising main is 21 minutes, based on a pumping rate of 60 l/s. However, as a typical pumping event is 2 minutes duration, the actual residence time is always longer - up to 2 to 4 hours; long enough for the sewage to go anaerobic and H₂S to form. All other flows into the Otumanga pump station are from local domestic sewers.

The Otumanga pump station is in a low-lying area, adjacent to the harbour in a fenced enclosure, with its own service building (Photo 2). The water level in the pump station is below the high tide mark. The boundary of the nearest neighbour is 9 metres to the west. Odour nuisance from this pump station has been an ongoing problem, for neighbouring properties and pedestrians. The Tauranga City Council undertook to install an odour treatment system such as, a soil bed filter, and wanted to investigate alternative technologies that took less space and potentially lower running costs.

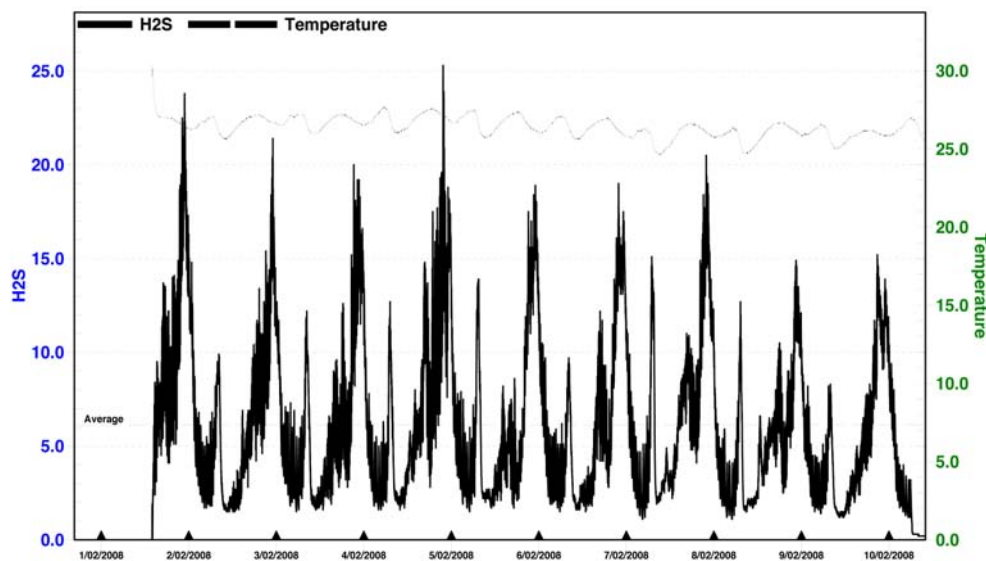
Photo 2: Otumanga Pump Station, Welcome Bay, Tauranga



5.2 OTUMANGA PRELIMINARY H₂S CONCENTRATIONS

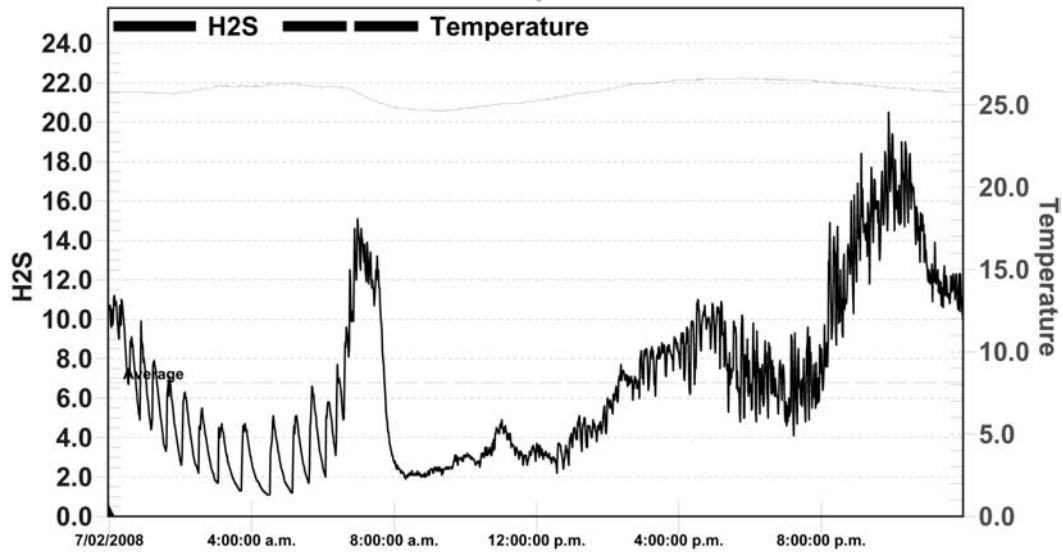
Preliminary H₂S concentrations inside the Otumanga pump station were measured over a period of 9 days with an Odalog, (Figs 1, 2), before any odour control technology was installed.

Fig 1: Otumanga Pump Station. H₂S Concentrations. Period 9 days: 1-10 February 2008
No ventilation. Average H₂S Conc.: 6.1 ppm. Peak H₂S Conc.: 25.3 ppm



H₂S concentrations (Fig 1) follow a repeating diurnal cycle, peaking at approximately 20 ppm at 10pm each evening and 15 ppm at 7am each morning. The expanded data (Fig 2) shows H₂S concentration peaks more clearly. The jagged nature of the curve between 12 midnight and 7am is the result of the intermittent discharges from the Waitahi pump station.

Fig 2: Otumanga Pump Station. H₂S Concentrations. Period 1 day: 6-7 February 2008
No ventilation. Average H₂S Conc.: 6.8 ppm. Peak H₂S Conc.: 20.5 ppm



5.3 BIOLOGICAL SCRUBBER AT OTUMANGA

A biological scrubber was set up at the Otumanga pump station during April and May, 2009 (Photo 3).

Photo 3: Biological Scrubber Trial at Otumanga Pump Station, Tauranga



Air was extracted from the top of the pump station at a rate that varied between 35 l/s and 55 l/s (the capacity of the equipment used). H₂S concentrations in the inlet to the biological scrubber were monitored with Odalogs (Figs 3, 4). The Odalog on the biological scrubber outlet failed to log, and the results given in Table 2 are manual readings noted from the Odalog.

Fig 3: Otumanga Pump Station. Biological Scrubber Inlet H₂S Concs. Period 7 days: 29 April/7 May 2009
Ventilation 35-55 l/s. Average H₂S Conc.: 1.6 ppm. Peak H₂S Conc.: 11.4 ppm

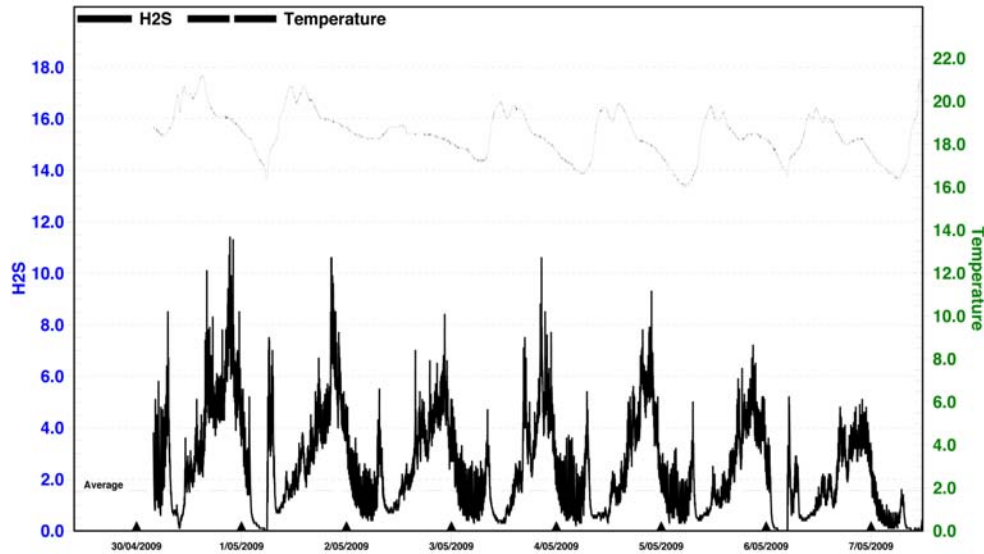


Fig 4: Otumanga Pump Station. Biological Scrubber Inlet H₂S Concs. Period 1 day, 4 May 2009
Ventilation 35-55 l/s. Average H₂S Conc.: 2.4 ppm. Peak H₂S Conc.: 9.3 ppm

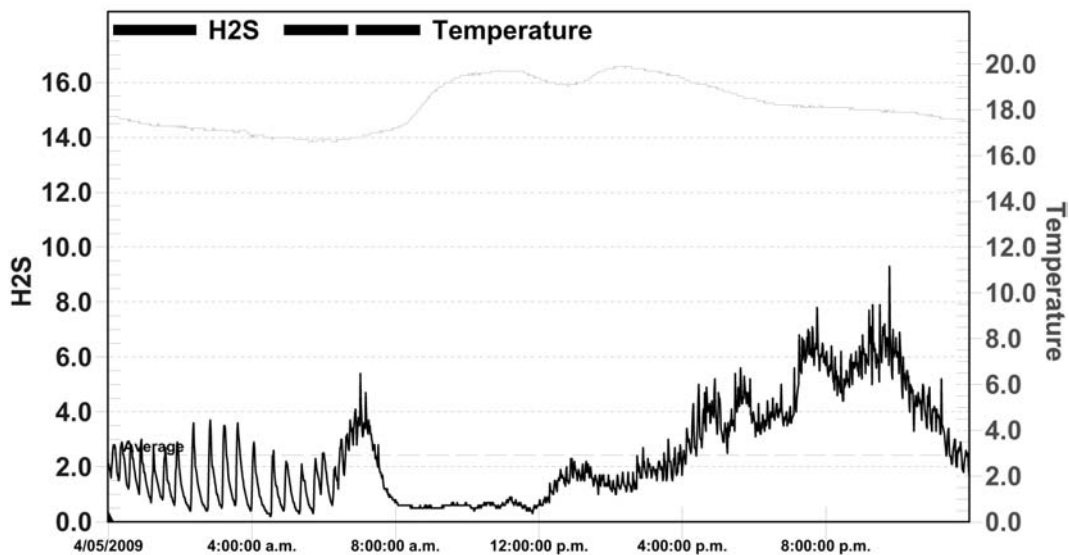


Table 2: Otumanga Pump Station: Biological Scrubber H₂S Removal

Date, 2009	H ₂ S at Inlet, ppm	H ₂ S at Outlet, ppm	H ₂ S Removal, %
21 st April	3.6	0.3	92
21 st April	2.8	0.2	93
27 th April	3.8	0.2	95
27 th April	5.2	0.3	94
7 th May	2.5	0.1	96

H₂S concentrations (Figs 3, 4) follow the same diurnal patterns as previously (Figs 1, 2). Average H₂S and peak H₂S concentrations are less than half of when air was not being extracted from the pump station. The temperature dropped from 26°C in February 2008, to 18°C in April 2009.

H₂S removal efficiency achieved by the biological scrubber was about 94 to 96%, consistent with results at other biological scrubber installations (Holyoake et al., 2007; Dirske, 2009). The air from the biological scrubber,

containing 0.1 to 0.3 ppm H₂S, was discharged at ground level five metres from the neighbouring boundary. The neighbour reported that the smell was ‘very horrible’, especially when the wind was blowing from the east towards the property.

A stack, 8 metres in height was installed to improve dispersion; resulting in an immediate improvement. The neighbour advised the H₂S odour could now only be detected when there was a light wind blowing towards the property.

An activated carbon adsorption bed polishing unit was installed after the biological scrubber for the final investigation, instead of a stack. The H₂S concentration in the air exiting the carbon polishing bed measured 0.0 ppm on the Odalog. The neighbour advised that the H₂S odour could ‘just be detected’, but again, only when there was a light wind blowing towards the property.

The likely explanation for faint odours, when there was a stack or a carbon bed polishing unit after the biological scrubber, is that the odours were fugitive emissions from the pump station; i.e. the ventilation rate of 35 to 55 l/s was insufficient to totally capture the odours. The maximum filling rate for the Otumanga pump station is estimated to be 100 l/s, 60 l/s of which comes from the Waitahi pump station. Therefore, the ventilation rate used for the biological scrubber of up to 55 l/s was insufficient to capture all of the air displaced from the pump station. Also, the air was extracted from the top of the pump station, not ideal for odour capture.

5.4 CARBON ADSORPTION BED AT OTUMANGA

In October 2009, the biological scrubber was removed and a carbon adsorption bed installed, complete with an inlet filter, and fan with an acoustic attenuation housing (Photo 4). The maximum airflow rate of the carbon bed system was 360 l/s. The estimated life of the carbon, based on an air flow rate of 150 l/s, is four years for an average H₂S concentration of 2.4 ppm, and two years for an average H₂S concentration of 5 ppm.

Photo 4: Otumanga Pump Station: Carbon adsorption bed with inlet filter, fan & acoustic housing



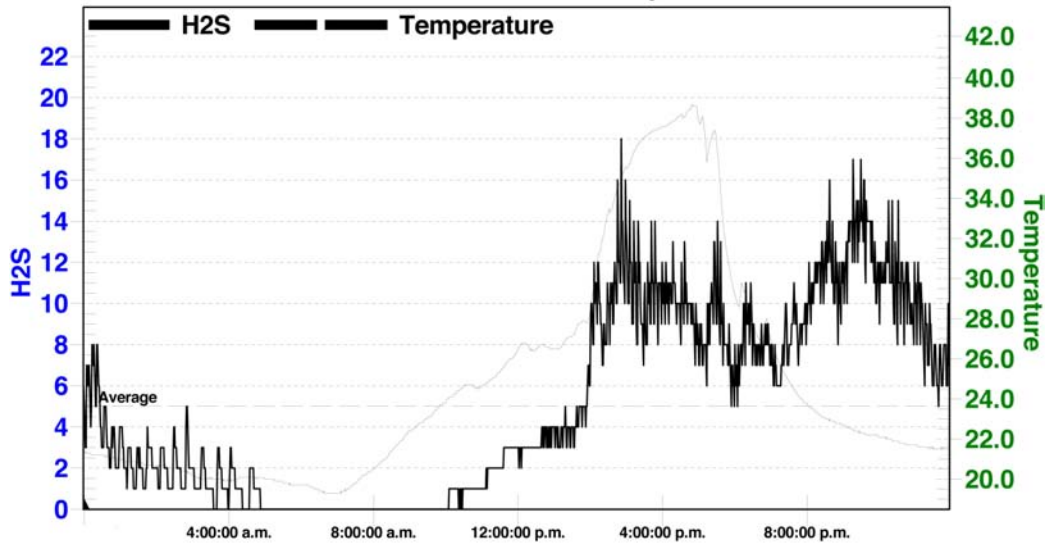
The carbon bed was initially installed without a heater to control the relative humidity of the air. This was done to investigate whether the carbon bed could remove the H₂S, and other odourous VOC compounds from the high humidity air stream, without the ongoing energy cost of a heater.

Air was extracted from a depth of three metres below the top of the pump station, or about one metre above the water level. The actual air flow rate through the carbon bed, after the system was installed, ranged from 180 l/s down to less than 100 l/s as the inlet filter progressively blocked. Initially, the inlet filter was manually cleaned at irregular intervals. In March 2010, an air inlet filter with automated daily cleaning was installed, and this kept the airflow steadier at 200 to 220 l/s.

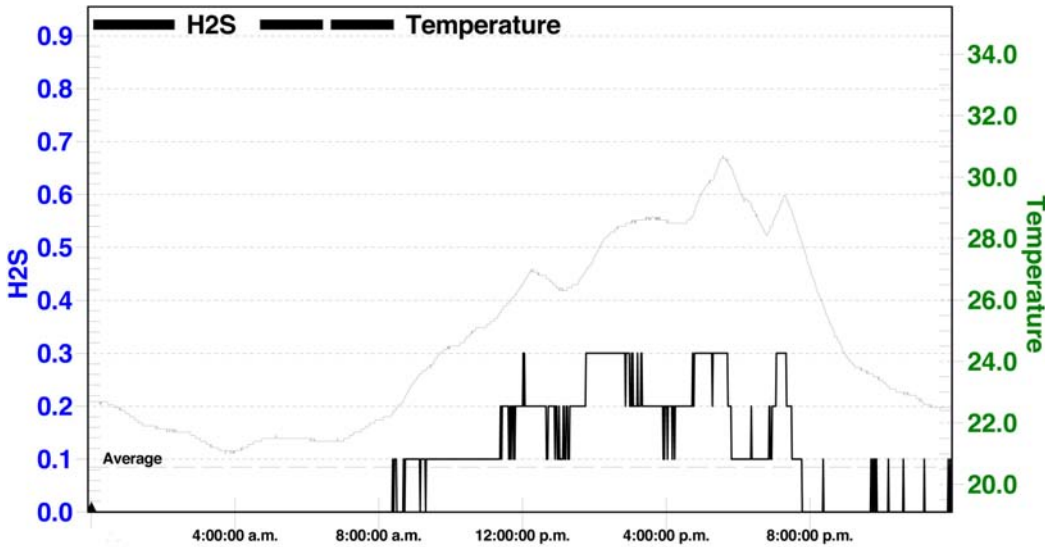
This airflow rate achieved a negative pressure of less than 20mm in the pump station, and there was no discernible air velocity through gaps around cable entries. Therefore, the source of the air must have been from the sewers feeding the pump station. This highlights the difficulty of containing the odorous air inside pump stations.

H₂S concentrations on the inlet and outlet of the carbon bed were monitored with Odalogs (Figs 5, 6), after the carbon bed had been operating for four months.

*Fig 5: Otumanga Pump Station. Carbon Bed Inlet H₂S Concs. Period 1 day: 27 January 2010
Ventilation 180 l/s est. from 3-metre depth. Average H₂S Conc.: 5.0 ppm. Peak H₂S Conc.: 18 ppm*



*Fig 6: Otumanga Pump Station. Carbon Bed H₂S Outlet Concs. Period 1 day: 27 January 2010
Ventilation: 180 l/s est. Average H₂S Conc.: 0.1 ppm. Peak H₂S Conc.: 0.3 ppm*



Based on the average Odalog H₂S concentrations, the carbon bed achieved H₂S reductions of 98%. The carbon bed outlet H₂S concentrations of up to 0.3 ppm (Fig 6) should have resulted in a strong odour being detectable in the carbon bed outlet, but it was not. According to the neighbour, the carbon bed immediately eliminated all odour nuisance. The accuracy of the Odalog is low; the H₂S concentrations are at the bottom end of the range, and there is moisture interference.

The average H₂S concentration in January 2010 (Fig 5) with a ventilation rate of 180 l/s was 5.0 ppm, more than 3 times that measured in April/May 2009 (Fig 3) when the ventilation rate was 35-55 l/s. The higher H₂S concentration could be because the air was extracted from lower in the pump station. Another factor is seasonal, with higher concentrations being in the month of January, when the average temperature was about 25°C (Fig 5),

compared to the 19°C average temperature in the month of April/May (Fig 3). The H₂S concentration diurnal peak at 7am recorded earlier (Figs 1 to 4), was not evident this time (Fig 5).

In April 2010, after six month's operation, an odour nuisance returned. This time the neighbour described the odour as a "sweet sickly smell", not the typical 'rotten egg' H₂S smell that had characterized the odour previously. The air was sampled onto ATD tubes, then analysed by automated thermal desorption – gas chromatography – mass spectrometry. The sulphides were sampled into a solution of zinc acetate/sodium hydroxide. Concentrations of the compounds close to or above their odour threshold concentration are tabled below (Table 3). After the air had been sampled, the carbon was removed and a new fresh charge of carbon was installed. Immediately the neighbour stated the 'sewer' odour had gone.

*Table 3: Otumanga Pump Station with Carbon Bed Adsorber.
Concentrations of Compounds Close to or Above Their Odour Threshold.
Airflow 180 l/s. Extracted from 2 metres depth. No heater on inlet air stream.*

Compound	Formula	Odour Thresholds (Wikipedia)	Carbon Bed Inlet Concentration	Carbon Bed Outlet Concentration
Hydrogen sulphide	H ₂ S MW = 34	0.5 ppb or 0.0006 mg/m ³	2.60 mg/m ³	< 0.001 mg/m ³
Total sulphides	NA	NA	2.63 mg/m ³	< 0.001 mg/m ³
Methyl mercaptan	CH ₃ SH MW = 48	2 ppb or 3 mg/m ³	0.0	0.0
Dimethyl sulphide	(CH ₃) ₂ S MW = 62	20 ppb or 0.04 mg/m ³	0.0	0.014 mg/m ³
Dimethyl disulphide	(CH ₃) ₂ S ₂ MW = 94	8 ppb or 0.03 mg/m ³	0.0	0.008 mg/m ³
Dimethyl trisulphide	(CH ₃) ₂ S ₃ MW = 126	0.01 ppb or 0.00004 mg/m ³	0.0	0.008 mg/m ³

H₂S removal efficiency from Table 2 is greater than 99.96%. These measurements have a far greater accuracy than the Odalog, confirming that activated carbon can remove H₂S from high humidity air streams. This also verifies that the Odalog data for low H₂S concentrations (Table 2, Fig 6) is low in accuracy.

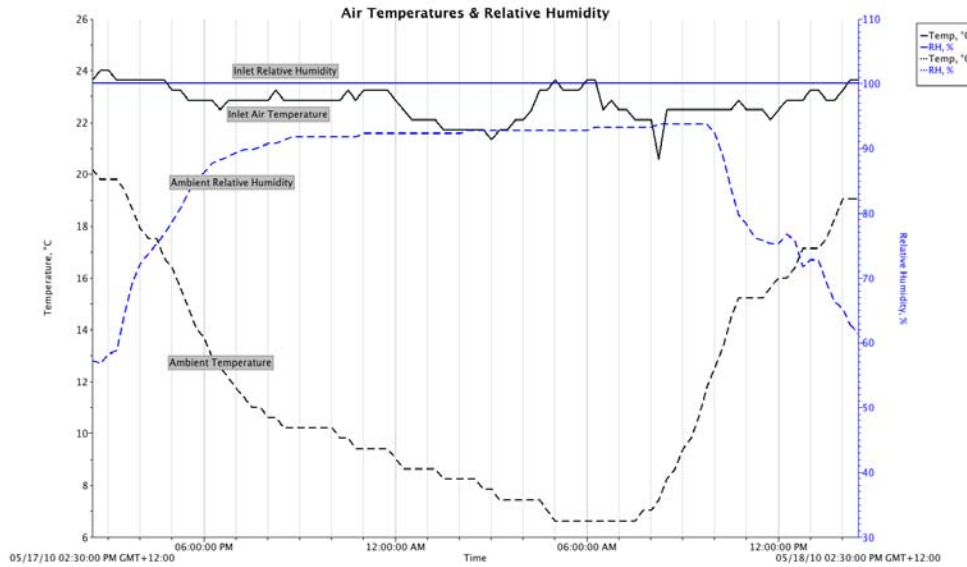
The presence of other sulphide compounds was an unexpected development. The concentrations of dimethyl sulphide, and dimethyl trisulphide were both above their respective odour threshold concentrations. In particular, the dimethyl trisulphide concentration was 200 times its odour threshold concentration, and the most probable source of the odour. Trimethyl sulphide, like most of the organic sulphide compounds, has a 'rotten cabbage' or 'brassica' odour. This odour description does not match with that described by the neighbour, which was a 'sweet sickly smell'. There is no obvious explanation. Dimethyl sulphide and trimethyl disulphide were not found in the inlet air stream, only the outlet air stream; meaning, these compounds must be forming in the carbon bed itself. A possible method for their formation, is as byproducts of microbiological activity in the carbon bed.

Blowflies were observed on the outside of the carbon bed. Dimethyl trisulphide is described as an attractant to blowflies (Wikipedia).

5.5 AIR RELATIVE HUMIDITY AND MOISTURE CONDENSATION

A considerable quantity of water condensation was found during both the biological scrubber and carbon bed trials. At one stage, condensation completely blocked a 150mm diameter duct in a matter of days. When the carbon was changed out in April 2010, water vapour was found to be condensing on the inside of the carbon bed shell, and this water was permeating through the carbon bed. The temperature and relative humidity of the carbon bed inlet air stream and the ambient air were logged over a 24-hour period to confirm this (Fig 7).

Fig 7: Otumanga Pump Station. Carbon Bed Air Temperatures & Relative Humidity. Period 1 day: 17/18 May 2010. Ventilation 180 l/s est.



The inlet air to the carbon bed had a relative humidity of 100% at all times (Fig 7). As the ambient air temperature was always below the air temperature in the carbon bed, the carbon bed shell was always colder than the air inside. Under these conditions, condensation continuously formed on the inside wall of the carbon bed shell, subsequently spreading through the carbon bed.

The traditional method of overcoming this problem is to heat the inlet air and reduce the relative humidity to less than 80%, so that the dew point of the air is higher than the surface temperature of the carbon bed shell. Insulating the carbon bed shell would minimise heat loss and the quantity of condensation formed.

5.6 OTUMANGA LCC ANALYSIS OF ALTERNATIVE ODOUR CONTROL SYSTEMS

On the basis of the data obtained, LCC analyses were done for alternative odour control technology options for the Otumanga Pump Station, at a ventilation rate of 100 l/s, and for inlet H₂S average concentrations of 5 ppm and 30 ppm (Figs 8, 9). The estimated capital cost was spread uniformly over 15 years. No account was taken for the cost of the land area needed; the soil bed filter requires 10 times the area of both a biological scrubber and a carbon bed adsorber.

Fig 8: Otumanga Pump Station: LCC Analysis of Odour Control Options. Airflow 100 l/s. Average Inlet H₂S Concentration 5 ppm

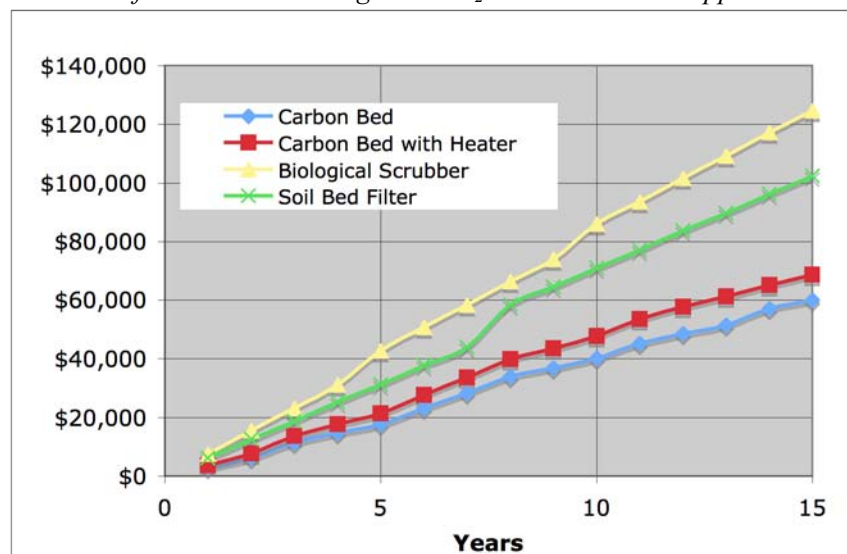
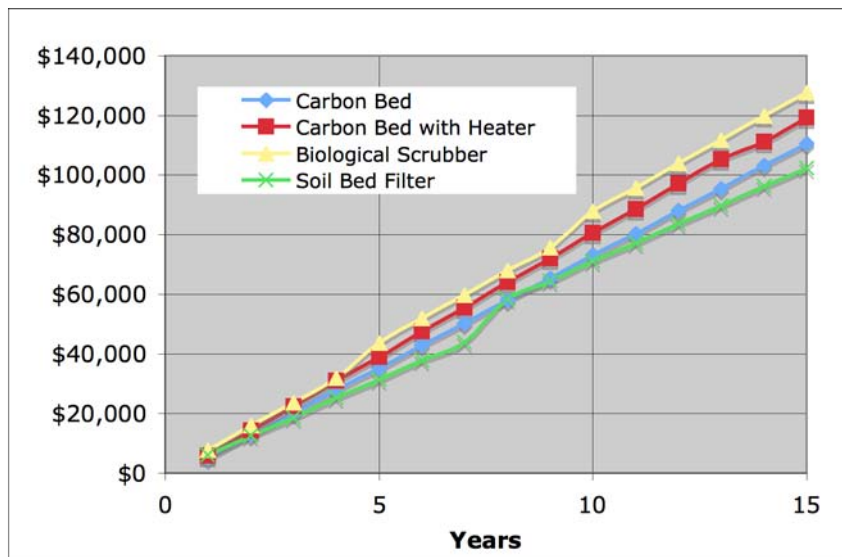


Fig 9: Otumanga Pump Station: LCC Analysis of Odour Control Options
Airflow 100 l/s. Average Inlet H₂S Concentration 30 ppm



For an average H₂S concentration of 5 ppm, a carbon bed adsorber has the lowest LCC (Fig 8). The biological scrubber has the highest LCC. For an average H₂S concentration of 30 ppm, the soil bed filter has the lowest LCC (Fig 9).

6 MANGAWHAI VILLAGE PUMP STATION

6.1 MANGAWHAI VILLAGE PUMP STATION DESCRIPTION

The Mangawhai Village pump station is located on Molesworth Drive, 100 metres to the north of Mangawhai Village. Details of the pump station are given in Table 1. It is constructed of concrete, with close fitting lids of galvanized steel and rubber strips (not totally sealed). The inflows are from both gravity sewers and pressure sewers. The station pumps directly to the main Mangawhai wastewater pump station, near the Mangawhai wastewater treatment plant.

Sewer odours were apparent when the pump station was first commissioned. The boundary of the nearest neighbour, a gift store, is 10 metres to the southwest of the pump station.

6.2 PASSIVE CARBON BED ODOUR FILTER INSTALLED

Water Infrastructure Group constructed the Mangawhai wastewater system, and recognized the need to install odour control systems on two of the Mangawhai pump stations, including this one. They wanted them to be suitable for relatively small pump stations, with minimum maintenance, low operating costs, and low visual impact. Therefore, they selected 'Green Dome' passive (no fan) carbon bed odour filters from Arimatec Environmental Ltd.

The passive carbon bed is connected directly to the pump station with a duct, and treats the air as it is physically displaced from the pump station when the water level rises. All parts are designed to have a very low pressure drop, ensuring as much air as possible exits the pump station via the carbon bed. It is installed partly underground, with the ducting from the pump station totally underground, minimising visual impact. A domed lid covering the top of the carbon bed is all that is visible. The system can be located away from the pump station to suit the site, e.g. adjacent to the pump station control cabinet (Photo 5).

Photo 5: Mangawhai Village Pump Station with 'Green Dome' Passive Carbon Bed Odour Filter



There was no data available for H₂S concentrations for the Mangawhai Village pump station. However, based on the work done at the Otumanga Pump Station in Tauranga, it was estimated that if the average H₂S concentration was 5 ppm, the life of the carbon could be two to five years.

6.3 MANGAWHAI VILLAGE ODOUR FILTER H₂S REMOVAL PERFORMANCE

The sewer odour nuisance ceased as soon as the passive carbon bed odour filter was installed in February 2010. Performance testing was done with Odalogs in June 2010 (Fig 10), and July 2010 (Fig 11). An Odalog was hung in the pump station, and another was placed above the carbon bed in the 'Green Dome' odour filter, to measure the H₂S concentration after the air had passed through the carbon bed.

Fig 10: Mangawhai Village Pump Station & Carbon Bed H₂S Concentrations. Period 2 days: 2/4 June 2010
Ventilation: None – passive only. Average H₂S Conc.: 14.3 ppm. Peak H₂S Conc.: 121.5 ppm

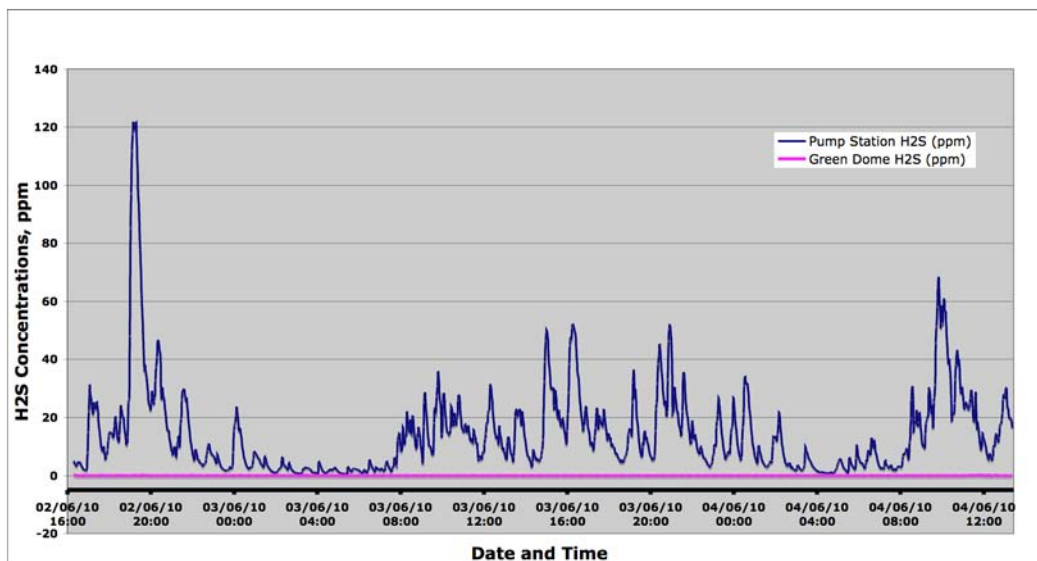
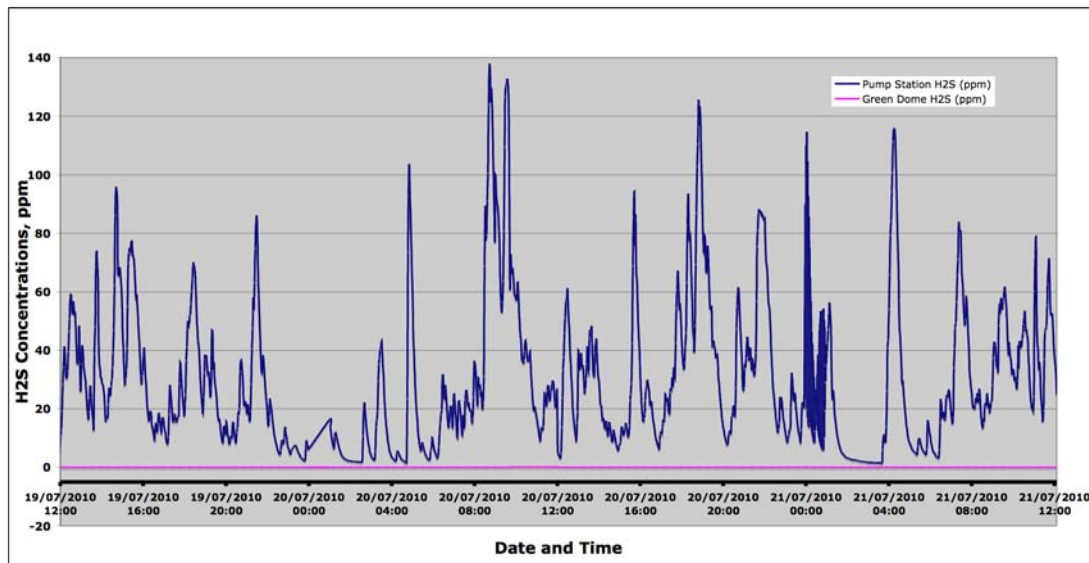


Fig 11: Mangawhai Village Pump Station & Carbon Bed H₂S Concentrations. Period 2 days: 19/21 July 2010
 Ventilation: None – passive only. Average H₂S Conc.: 30.3 ppm. Peak H₂S Conc.: 137.5 ppm



The average H₂S concentration in the pump station was 14.3 ppm and 30.3 ppm, two to four times that measured in the unvented Otumanga pump station (Figs 1, 2). The only two pump stations in Mangawhai that have odour problems are two with inlet flows from pressure sewers. Mangawhai is mainly a holiday destination, with population increasing dramatically in summer months. This work was carried out in the months of June and July, when wastewater flows were at a minimum, resulting in longer residence times and higher H₂S concentrations, even though ambient temperatures were lower. Storm water infiltration into the sewers, after a period of heavy rain, had increased volumetric flows prior to the June monitoring (Fig 10).

The average H₂S concentration in the outlet side of the ‘Green Dome’ passive carbon bed odour filter was 0.004 ppm. This was calculated from a total of 1352 measurements logged at two-minute intervals; 1297 of which were 0.0 ppm and 50 were 0.1 ppm (the lowest resolution of the instrument). This highlights the difficulties of using the Odalogs at the bottom of their range.

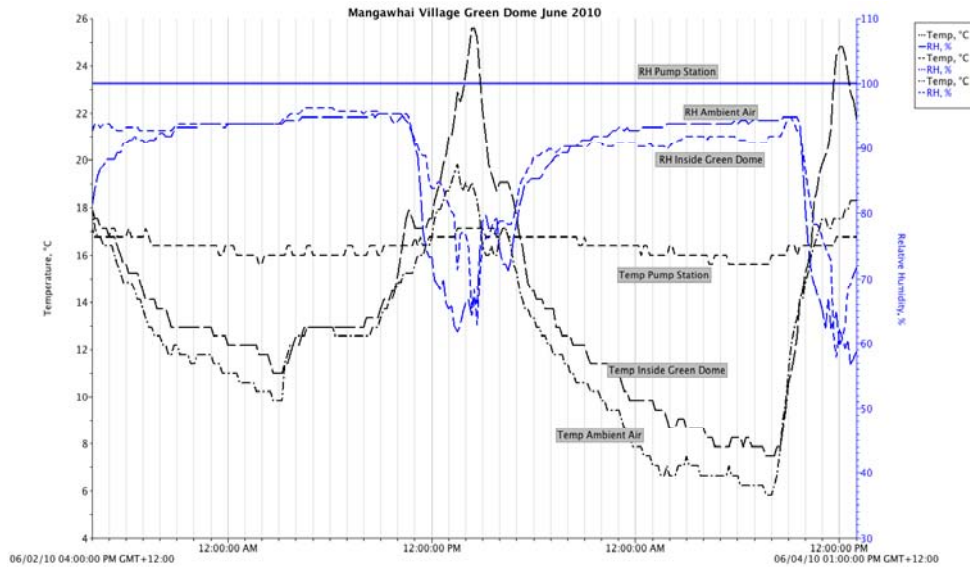
Attendants in the neighbouring gift store stated emphatically, that no sewer odours had been detected in the store since the carbon bed odour filter had been installed.

To check whether this carbon bed would have the same difficulties with moisture as the carbon bed at Otumanga, air temperatures and relative humidity were logged (Fig 12). The relative humidity in the pump station was 100%, the same as recorded at Otumanga. The relative humidity at the top of the carbon bed closely matched ambient conditions. This is probably because the carbon bed breathes both out (increasing pump station water level) and in (pumping down), and the airflow rate is low.

A small amount of condensation was found on the inside the dome over the carbon bed odour filter at 7am when the ambient air temperature was at a minimum, but the carbon itself was dry throughout the bed.

The ‘Green Dome Odour Filter’ is buried. Earth insulates and minimises heat transfer that drives the amount of condensation formed. The inlet duct is also totally buried, and acts to cool the air and condense part of the moisture.

Fig 12: Mangawhai Village Pump Station and Carbon Bed Air Temperatures & Relative Humidity. Period 2 days: 2/4 June 2010. Ventilation: None – Passive Only.



7 CONCLUSIONS

7.1 H₂S CONCENTRATIONS IN PUMP STATIONS

- With no ventilation, average H₂S concentrations varied from 6.1 ppm to 30.3 ppm, and peak H₂S concentrations varied from 20.5 ppm to 121.5 ppm.
- With forced ventilation, using a fan, average H₂S concentrations varied from 1.6 ppm to 5 ppm, and peak H₂S concentrations varied from 11.4 ppm to 18 ppm.
- Ventilation of a pump station lowers H₂S concentrations by a factor of 2 to 6 times.
- Ratio of peak to average H₂S concentration varied from 3 to 8 times.
- H₂S concentrations in the air extracted from a pump station increased when the air was taken from lower in the pump station.
- H₂S concentrations are higher with pump stations handling wastewater from pressure sewer systems.

7.2 AIR TEMPERATURES AND RELATIVE HUMIDITY IN PUMP STATIONS

- Air temperatures inside the pump stations averaged between 16°C and 25°C.
- Relative humidity was 100% at all times.
- Condensation occurred in both ducting and odour control equipment, especially during the cooler periods at night.
- High humidity conditions are ideal for a biological scrubber, but not for a carbon bed adsorber.

7.3 AIR EXTRACTION RATES FOR PUMP STATIONS

- The recommended minimum air extraction rate, to contain sewage odours within a pump station, is the PDWF, typically half the flow rate of the pump station pump.

- It is not always possible to achieve a large negative pressure inside a pump station, due to air being able to enter via sewer pipes.

7.4 USE OF ODALOGS FOR H₂S MEASUREMENT

- Odalogs are easy to use for H₂S measurement, and provide suitable data for LCC analysis.
- Accuracy is limited at low H₂S concentrations, especially below 1 ppm.
- 100% relative humidity and dirty air in pump stations can foul the Odalogs.

7.5 BIOLOGICAL SCRUBBERS FOR ODOUR CONTROL

- A single stage biological scrubber removed more than 95% of H₂S.
- The only chemical required was a minimal amount of nutrient.
- Air discharged from the single stage biological scrubber was still an odour nuisance.
- The odour nuisance from the biological scrubber ceased when a carbon bed polishing unit was added to treat the air discharged.
- A short stack attached to the biological scrubber dispersed the residual odour.

7.6 CARBON BED ADSORBERS FOR ODOUR CONTROL

- A carbon bed adsorber removed more than 99.99% of the H₂S, and achieved an odour free discharge.
- The 100% relative humidity of the air from the pump station resulted in moisture condensing on the inside of the carbon bed shell, and spreading through the carbon bed.
- H₂S removal in excess of 99.99% was still achieved with the carbon wet.
- Not all other odourous VOCs were removed when the carbon was wet. In particular, dimethyl sulphide and dimethyl trisulphide formed in the carbon bed, possibly by biological action.
- A passive (no fan) carbon bed adsorber successfully controlled odours on a smaller pump station.
- No condensation occurred in the passive carbon bed, when it was buried.

7.7 LIFE CYCLE COSTS

- For a pump station with a PDWF (peak dry weather flow) of 100 l/s or less, and an average H₂S concentration of less than 10 ppm, a carbon bed adsorber has the lowest LCC.
- For a pump station with an average H₂S concentration of 30 ppm, a soil bed filter has the lowest LCC, but requires 10 times the physical area of a carbon bed adsorber and a biological scrubber.
- A biological scrubber with carbon polishing bed has the lowest LCC for large airflows and high H₂S concentrations.

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