Performance Testing of a Biotrickling Filter/Chemical Scrubber Odor Control System at Western Australia's Largest WTTP

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ABSTRACT

In 2006 the Water Corporation of Western Australia formed the W2W Alliance (W2WA) to deliver a five-year $352 million program of upgrades to the State's three largest metropolitan wastewater treatment plants (WWTPs). At the Woodman Point WWTP, W2WA was tasked with installing best practice odor control to achieve a 50 percent reduction in odor emmissions. The Stage 1 odor control improvements involve new covers of the grit tanks, sealing existing covers at the primary treatment area, and new covers and extraction systems for sludge treatment areas and SBR anoxic zones. Biotrickling filters followed by chemical scrubbers offered the best solution for treating the extracted air. The Stage 1 commissioning in 2009 was very successful with no odor incidents during startup of the facilities. The biotrickling filters acclimated faster than expected and reduced inlet hydrogen sulfide (H_2S) as high as 80 parts per million (ppm) to less than 0.5ppm. Biotrickling filter performance testing showed outlet odor ranging from 1,020 to 3,160 Odor Units (OU), which met the requirment of 5,000 OU. The odor reduction goal of greater than 95 percent was also achieved. Chemical scrubber performance testing showed inlet H_2S as high as 37ppm reduced to less than 0.05ppm, which met the 0.1ppm requirement. Odor removal was relatively good, but some stack outlet samples were above the 1,000OU goal. When the combined system is tested, it is expected that the outlet odor goal can be met when the chemical scrubber is receiving lower inlet loads.

KEYWORDS: Odor control, biotrickling filter, wet scrubber, hydrogen sulfide

INTRODUCTION

The Water Corporation's Woodman Point Wastewater Treatment Plant (WWTP) is the largest wastewater treatment plant in Western Australia, serving a population of 600,000 people living south of the Swan River. The plant currently treats 120 megaliters per day (ML/d) of wastewater and has a rated hydraulic capacity of 160 ML/d. The population is expected to grow at a rapid rate with plant capacity reached in 2015. The population is projected to double by 2045 to 1.2 million, which will require a plant expansion to handle 240 ML/d. An ultimate capacity of 320 ML/d is projected at full development.

The Woodman Point WWTP was developed in 1966 as a primary treatment facility. At that time, residential areas were distant from the plant and the surrounding land uses were rural, public reserves, and industrial. As development continued, the plant was upgraded and expanded several times. In 2000-2002, the plant was upgraded to provide full secondary treatment. The upgrade also included covering the screens, grit tanks and primary treatment tanks, with the odorous air extracted from beneath the covers and treated in two odor scrubbers. Two large egg-shaped digesters were constructed to achieve better stabilisation of biosolids and reduce odor emissions while the sludge drying beds were replaced by centrifuges.

In 2003, comprehensive odor modelling indicated that elevated odor levels were predicted to occur beyond the existing buffer, although few odor complaints had been received. A subsequent telephone survey of residents closest to the plant found that the majority were annoyed by the odor. The environmental regulator directed that significant additional odor control be achieved by the end of 2008.

The Water Corporation formed the W2W Alliance (W2WA) with the local and international engineering and construction firms of Black & Veatch, Thiess, and SKM, to deliver a program of upgrades to the State's three metropolitan WWTPs at Beenyup, Subiaco and Woodman Point. The first task in the upgrade program involved odor control improvements at the Woodman Point WWTP.

ODOR CONTROL PROGRAM

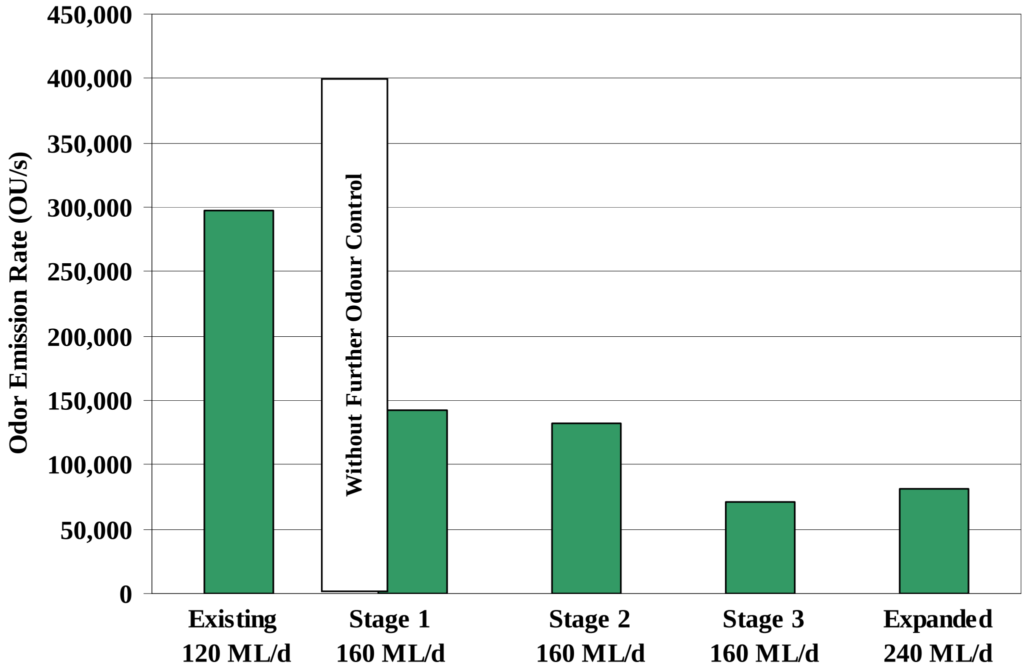
To achieve acceptable odor control and ensure the continued operation of essential treatment infrastructure, W2WA is engaged in a program of work to upgrade the Woodman Point WWTP and install Australian best practice odor control in up to three stages.

The Stage 1 odor control improvements include covering the anoxic zones of the Sequencing Batch Reactor (SBR), upgrading odor containment and increasing extraction rates throughout the treatment plant, decommissioning the existing scrubbers, and constructing a new odor control system. The new odor control system treats foul air from the preliminary and primary treatment works, SBR anoxic zones, and sludge treatment areas. The odor control system includes a 50 meter (m) stack to discharge the scrubbed gases well above any local inversion levels. The Stage 1 odor controls are designed to reduce ground level odor emissions from the plant by a further 50 percent. Stage 1 improvements also incorporate a sludge amplification component which includes a new ferric chloride dosing system and new high-temperature waste gas flares to reduce odor emissions. Stage 1 odor control improvements cost about $52.5 million and were commissioned in 2009.

The planned Stage 2 works would improve the effectiveness of odor control at the plant inlet and primary works by increasing the air extraction rates under the covers. These works are scheduled to be completed around 2012. Stage 3 would further reduce odor emissions by covering the aerated sections of the secondary treatment (SBR), if required. Stage 3 also provides additional secondary treatment capacity needed to treat wastewater while these covers are being installed. Stage 3 is anticipated to be completed by 2015.

As shown in Figure 1, each of the odor control stages will reduce total odor emissions. Stage 1 will provide over 50 percent reduction from current odor emissions at 120 ML/d. The reduction is even greater compared to the emissions projected at 160 ML/d without further odor control. Stages 2 and 3 will provide further odor reductions. Emissions increase slightly when plant throughput is increased to 240ML/d, but the overall emissions are 73 percent less than current emissions.

Figure 1 - Odor Reduction of Staged Improvements



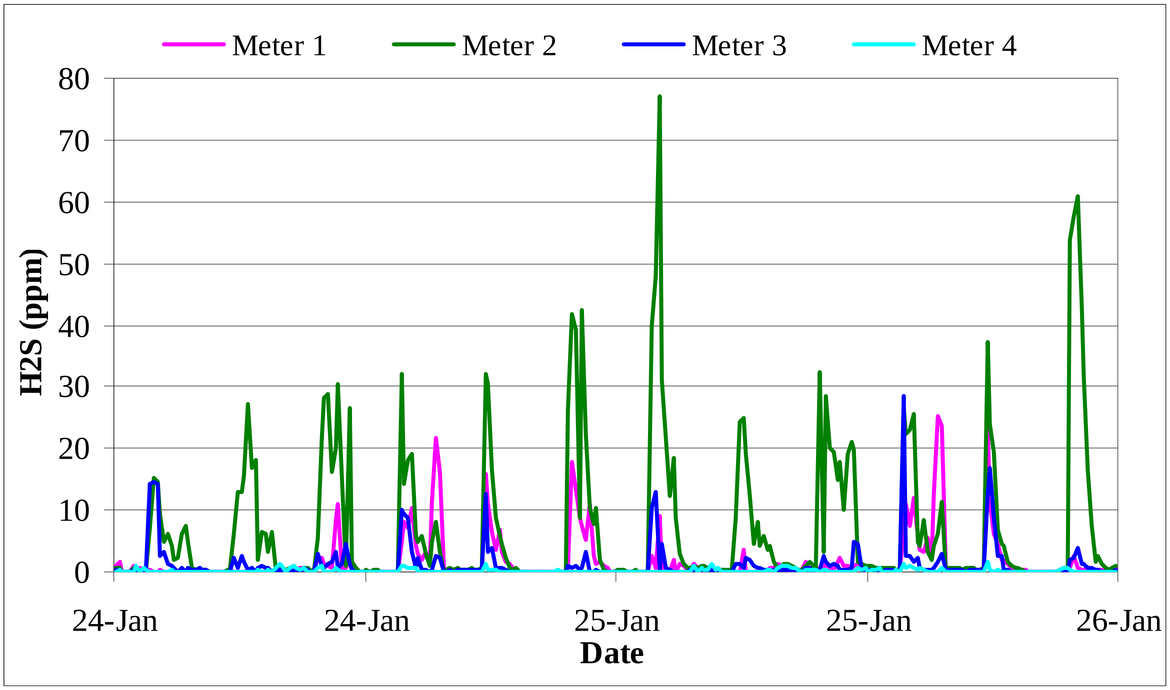
ODOR CONTROL SYSTEM CONCEPTUAL DESIGN

In previous applications at the Woodman Point WWTP and the other major treatment plants at Beenyup and Subiaco, chemical scrubbers were Water Corporation's preferred technology for odor control. They provide effective and reliable treatment and operations staff are familiar with the service and maintenance requirements. However, with high H_2S loads, chemical scrubbers consume a large amount of chemicals and become very expensive to operate. Biotrickling filters afford a much more economical means of treating high H_2S. They have been shown to provide consistent and reliable treatment and are relatively easy to operate and maintain. Although biofilters provide excellent H_2S reduction, other odorous compounds are not completely removed.

Based on comprehensive odor modeling, a tall stack with a low discharge odor of 1,000 OU was recommended at the Woodman Point WWTP. To achieve these strict stack discharge goals, chemical scrubbers were incorporated in the design as a final polishing step. The chemical scrubbers provide the required additional treatment at a very low operating cost because the H_2S load is significantly reduced by the biotrickling filters.

Air flows and contaminant loadings were developed by examining existing source data and performing supplemental sampling to estimate H_2S and other contaminants. Preliminary grab samples from the SBR bioselectors showed high H_2S and the SBR air flow was initially routed through the biotrickling filters. However, the samples were taken at the inlet weirs where high turbulence strips sulphide from the primary influent, so they were not representative of overall emissions from the areas to be covered. Figure 2 shows additional data collected at four locations along the bioselector channels of SBR 2 using OdaLog continuous recording meters.

Figure 2 - SBR Bioselector H_2S Data



Meters 1 and 2 were located before and after the inlet weirs, while meters 3 and 4 were downstream along the channels. Sampling occurred in January 2007 with several days of temperatures above 40ºC. As shown by the green line in Figure 2, meter 2 located after the weirs had the highest peaks, but the readings were much lower at the other locations. The H_2S peaks coincide with filling and mixing cycles in the bioselector. Based on the detailed data, H_2S concentrations of 25ppm average and 50ppm peak were applied for the bioselector air flow. At these moderate H_2S concentrations, it was recognized that the SBR bioselector air could be routed directly to the chemical scrubbers and significantly reduce the number of biotrickling filters required.

The chemical scrubber plant was sized to handle the future Stage 2 air flow and contaminant loading. Two stages of chemical scrubbers were used so that one scrubber could be removed from operation for maintenance with treatment maintained by the remaining unit. The system was set up for potential conversion to single stage operation in the future to double the air flow capacity, if long-term performance confirms that single stage treatment is acceptable.

Supplemental sampling was performed at various locations to determine the concentrations of other compounds including reduced sulphur compounds (R-SH), volatile organic compounds (VOC), ammonia (NH_3), and dimethyl sulphide (DMS). Table 1 summarizes the Stage 1 design air flows and compound concentrations for major process areas.

Table 1 - Design Air Flows and Contaminant Concentrations

Contaminants (ppm)	Location and Air Flow						
	Sludge Area 22,381 m^3/hr	Inlet Works 14,500 m^3/hr	Primary Area 23,130 m^3/hr	BTF Inlet 60,611 m^3/hr	BTF Outlet 60,611 m^3/hr	SBR Bioselector 65,891 m^3/hr	CS Inlet 125,902 m^3/hr
H_2S							
Avg	35	286	161	144	0.7	25	13
Peak	70	450	248	230	1.2	50	27
R-SH							
Avg	5.9	0.76	0.3	2.5	0.5	3.9	2.3
Peak	9.9	1.37	1.6	4.6	0.5	10.2	5.6
NH_3							
Avg	3.2	0.26	0.1	1.3	0.1	0.1	0.1
Peak	7.8	1.58	1.1	3.7	0.1	1.0	0.6
VOC							
Avg	8.7	27	15	16	3.9	3.6	3.7
Peak	14	102	41	49	11	13	12
DMS							
Avg	9.3	32	7.4	14	1.4	2.7	2.1
Peak	24	67	18	32	3.2	11	7.3

The design criteria were provided to selected equipment vendors for preparation of submittals for consideration. After evaluation of the submittals, Bioway was selected as the biotrickling filter supplier for the Stage 1 project. Bioway has an extensive background of previous installations with a good track record of reliability and performance. Bioway has an office in Australia and had recently installed a biotrickling filter system of similar size and complexity at the Werribee Odor Control Plant in Melbourne, Victoria.

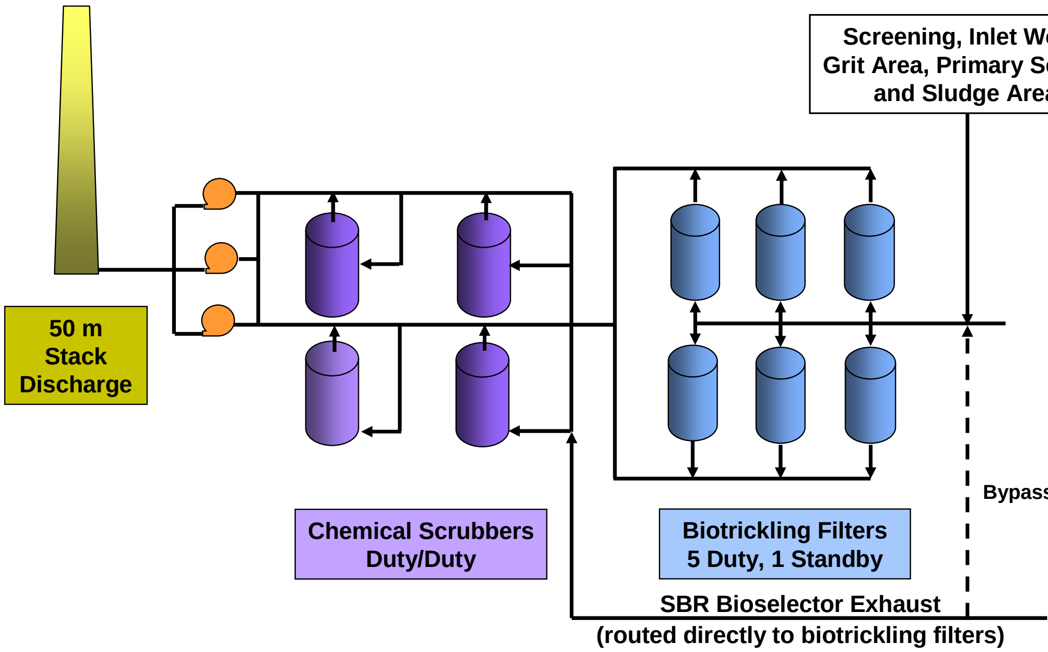
ODOR CONTROL SYSTEM DESCRIPTION

The target reliability and availability of the odor treatment system is 99.9 percent, which equates to a down time of just 8 hours and 45 minutes per year. In order to achieve this strict requirement, the design incorporated numerous elements to ensure that all treatment systems and fans operate on a continuous basis. Careful consideration was given to the critical service requirements for electricity and water. Standby systems are generally available for all mechanical and electrical equipment. Control system failure modes are also designed to allow the treatment system to continue operation.

Biotrickling Filters

The biotrickling filter plant consists of six Bioway vessels (5 duty, 1 standby) operating in parallel, as shown in Figure 3. Connecting ductwork with isolation dampers allows individual units to be taken off-line for maintenance while maintaining air flow to the rest of the plant. A bypass duct was installed to allow for the majority of the SBR bioselector air flow to be treated through the biotrickling filters during emergency operations, although removal rates of odorous compounds will be reduced if this is done.

Figure 3 - Schematic of Biotrickling Filter and Chemical Scrubber Odor Control System



Foul gas enters at the base of a biotrickling filter tower and flows upwards through sections of media where contaminants in the gas phase are transported to the liquid phase and degraded by microbes on the media surface. The bottom section of the tower removes H_2S and operates around pH 2, while the top section operates at a neutral pH allowing other odorous contaminants to be removed. Water is introduced at the top of the biotrickling filter intermittently to wet the microbes and assist in the removal of sulphuric acid. The water supply system is fully redundant, with reclaimed effluent supplied during normal operating conditions and potable water with artificial nutrients supplied when reclaimed effluent is unavailable.

The Bioway media provides a low pressure loss through the biotrickling filters, high contact area between microbes and gas streams, and tolerance to a low pH environment. A minimum gas residence time of 14 seconds is provided in the duty scrubbers to achieve high levels of odor removal. The biotrickling filters are designed to achieve a minimum of 99.5 percent H_2S removal and 95 percent odor unit removal through the treatment process. On-line instrumentation is installed to monitor key operating parameters including: inlet air flow, water flow, inlet and outlet H_2S, and differential pressure between the inlet and outlet of each unit and the plant.

The biotrickling filter plant is located in a concrete containment area due to the low pH of the waste liquid. The biotrickling filter vessels are located on elevated bases for protection from low pH liquid, if any spills occur. The nutrient dosing system is in a separate containment area drained to the biotrickling filter sump. Multi-level access platforms are provided in the center of the biotrickling filter installation, and are designed to accommodate future units and ducting.

Chemical Scrubbers

The Environmental Group Limited (EGL) was chosen as the chemical scrubber supplier. EGL is an Australian firm with a long history in chemical scrubbing including installations throughout Australia. More importantly, they had previously installed chemical scrubbers at Beenyup, Subiaco, and Woodman Point and Water Corporation was satisfied with the overall quality and performance of their equipment.

As shown in Figure 3, the EGL chemical scrubber plant consists of four scrubbers operated as two trains of two scrubbers in series. Foul air from the SBR bioselectors combines with the treated exhaust from the biotrickling filter plant and enters the base of the primary chemical scrubber and flows upwards though a media bed where it comes into contact with recirculated scrubber liquid. The partially treated air exits the primary scrubber and enters the base of the secondary scrubber for final purification before discharge through a 50 m tall stack.

The scrubber liquid consists of sodium hypochlorite (NaOCl) and/or sodium hydroxide (NaOH) carried by softened potable water. The scrubber liquid is introduced at the top of each scrubber through a spray system that evenly distributes the liquid. The scrubber liquid is provided by a duty/standby recirculation system for each chemical scrubber. The pH and ORP of the recirculating scrubber liquid is measured and controls the NaOH and NaOCl dosing pumps. A portion of the scrubber liquid is constantly wasted to prevent the build-up of contaminants within the scrubber liquid. Softened potable water is introduced into the sump which displaces scrubber liquid to an overflow drain for wasting. A master/slave water softener and brine tank are located within the chemical storage area. The chemical scrubbers and dosing systems are designed with independent mechanical systems to reduce the risk of a common mode failure.

The primary scrubber is intended to operate with NaOH alone at a pH of 11 to 12 to achieve 70 percent H_2S removal and 50 percent removal of mercaptans. The secondary scrubber uses both NaOH and NaOCl to treat the remaining H_2S and mercaptans, and remove DMS and other odorous contaminants. The secondary scrubber is intended to operate at a pH of 9 to 9.5 and an oxidation reduction potential (ORP) of 650 to 700mv.

This type of two-stage treatment has proven effective at Beenyup and Subiaco. In normal operation, most of the contaminant load is removed using less costly NaOH, while only the residual load undergoes refined treatment with both NaOH and NaOCl. All the chemical scrubbers have the capability to use both NaOH and NaOCl to allow either unit to operate as a single stage when one unit is taken offline.

For the greatest overall economy of construction, the chemical scrubbers were sized to treat an air flow of 195,900 m^3/hr. The scrubber internal diameter is 4100mm, which results in a face velocity of 2.1m/s at the Stage 2 design air flow. The media depth is 4000mm, which equates to a media volume of $53m^3$. Demisters at the top of the scrubbers above the distribution spray nozzles remove liquid droplets to minimize the visibility of the plume at the discharge stack. The chemical scrubbers are designed to achieve less than 100ppb H_2S and less than 1,000OU.

The inlet header and fan inlet and outlet headers are sized for the 240MLD design, so future scrubbers and extraction fans can easily be added with flanged connections to existing ductwork.

The ductwork is designed to provide a bypass to the secondary scrubber or directly to the extraction fans using a series of isolation dampers. The isolation dampers are located for optimal flexibility, such that the influent air flow can be treated by the primary scrubber, secondary scrubber or primary and secondary scrubber. Additional blanked flanges are provided for future ductwork to allow operation as four single stage scrubbers. A photo of the odor control system is shown in Figure 4.

Figure 4 - Biotrickling Filter and Chemical Scrubber Odor Control System with 50m Stack

On-line instrumentation is installed to monitor key operating parameters for the chemical scrubber plant including: inlet and outlet H_2S, softened water flow rates, bleed flow rates, pH and ORP of recirculated flows, sump levels, inlet pressure and differential pressure across each scrubber, and inlet, per train and outlet air flows. The chemical scrubber plant is located within a containment area with vessels and recirculation pumps located on elevated bases. The containment has separate pipework and drainage channels covered with fiberglass grating. Multi-level access platforms are provided in the center of the chemical scrubber installation.

Chemical storage consists of storage tanks and dosing pumps within separate containment areas for NaOH and NaOCl. A concrete-paved loading bay with an area drain for spillage collection is provided for truck parking during chemical delivery. The storage tanks are designed to maintain a minimum of 4 days storage during peak load conditions and 10 days storage during average load conditions. The NaOH and NaOCl dosing systems have duty/standby dosing pumps to each chemical scrubber with pipework double contained from the storage tank outlet to the dosing points. The NaOH pipework is heat-traced from the storage tank outlet to the containment wall.

COMMISSIONING AND PERFORMANCE TESTING

Commissioning

The main priority during commissioning of the odor control system was to limit the exposure of odors to the surrounding community. This was enabled through the development of a Construction Odor Management Plan and a detailed Commissioning Plan. One of the risks highlighted in these plans was the time required to develop the microbes in the biotrickling filter. It typically takes several weeks to develop a sufficient population of microbes for the required treatment capacity.

Foul air flow sources were connected to the Odor Control System over a 19 week period. The length of this period was influenced by construction timelines (availability of odor sources) and ensuring the microbe population was sufficient to handle any new loads. The load to the biotrickling filters needed to introduced over time to the system, so that the system was not initially overloaded due to inadequate microbe population.

The two-stage chemical scrubbers are intended as polishing treatment, but they are conservatively designed, so it was recognized that they could readily handle higher loadings during startup of the biotrickling filters. The first step in the Commissioning Plan was commencing the chemical scrubbers. Foul air was sourced from the anoxic zone of the SBR, which is the only air flow that can be diverted to either the biological or chemical scrubbing facility. In the final operating scheme, it is intended that this low strength air flow will be sent directly to the chemical scrubbers, but initially this air flow was routed through the biotrickling filters then through to the chemical scrubbers, so microbial growth could begin.

Each biotrickling filter was seeded with approximately 100L of mixed liquor sourced from the SBR, which was introduced through the recirculation tanks. The recirculation to “fresh” liquid ratio was initially 1:1 with fresh liquid being either reclaimed effluent or potable water. The objective of the high recirculation ratio is to maintain a pH around 2 to encourage microbial growth. Over the 19 weeks, the ratio was decreased until only fresh liquid was being used. The preferred water source was filtered reclaimed effluent, however if this was unavailable due to construction activities, then potable water with nutrient dosing was provided.

Once the chemical scrubbers were operating with confidence, sequential loads were added to the biotrickling filters. The anoxic zone of the SBR was diverted directly to the chemical scrubbers. As part of the Commissioning Plan, a detailed source loading sequence was developed for the biotrickling filters. The initial sources were selected to have a high H_2S concentration but low volume, as this provides the microbes a longer reaction time to consume the H_2S.

The preliminary treatment area was the first source transferred to the biotrickling filter. The main aim was the growth of biology in the lower level of the biotrickling filter media, which contains the bulk of the H_2S converting microbes. When acclimation was evident and effective treatment was obtained then the sequential loading continued with primary treatment air flow transferred from the existing chemical scrubbers to the biotrickling filters.

The upper layer biology was developed during the addition of the sludge loads to the biotrickling filter. While H_2S is the major odor causing constituent in the air flow, other odorous compounds such as mercaptans and DMS are also present. The main function of the microbes in the upper layer is to remove the other odorous compounds. To aid in the development of the microbes in the upper layer, Bioway supplies a special blend of innoculant microbes, which was added to the biotrickling filter recirculation system along with 100L of mixed liquor

The Commissioning Plan included several contingencies to safeguard against odor problems during startup of the Odor Control System. Actions to be implemented included:

- Increasing the pH setpoint in the caustic only chemical scrubber to improve removal in the first stage
- Adding chlorine at the Primary Sedimentation Tanks, while air flow is transferred from the existing to new odor control system
- Keeping the existing scrubber in operation as backup in the event of odor excursions

The duration of the commissioning was significantly extended due to a leakage problem with many of the air flow isolation dampers, which required removal and replacement. However, the advance planning and conscientious execution resulted in a highly successful commissioning with no major odor excursions. During the entire commissioning period there were only a few occasions of short duration (less than 3 hours) where the H_2S concentration exiting the stack was above 1.5ppm (maximum detection limit of the stack outlet H_2S instrument). These brief episodes were due to mechanical problems or planned shutdowns.

Performance Testing

The contractual 10-day performance testing for the chemical scrubbers was conducted from May 12 through May 22, 2009. Preliminary performance data were collected at the biotrickling filters commencing at startup in March, 2009. The biotrickling filters were performance tested over four weeks from July 14 to August 11, 2009 with air sampling conducted during the 10-day period from July 15 through July 25.

Test Methods. The Water Corporation is required to report H_2S concentration and odor units to the environmental regulators, so those were the main performance criteria. The online H_2S analysers located at the biotrickling filter inlet and outlet and chemical scrubber inlet sample points are Polytron 700 with Drager H_2S LC-6809 610 for Low Concentration. The analysers are setup with a moisture trap and flame arrestor. The H_2S analyser is currently set to a measurement range of 0 – 200ppm. It has an accuracy of ±4ppm and a sensitivity of ±3% of the measured value. The extraction of the sample occurs via a 400mm tube inserted into the duct. The chemical scrubber outlet H_2S analyser is a Honeywell SPM EP Chemcassette with a 50 to 1500ppb Chemkey. Again the sample is extracted via a 400mm tube inserted into the duct and passes through moisture trap before entering the analyser. Air flows are obtained from Endress & Hauser thermal dispersion units.

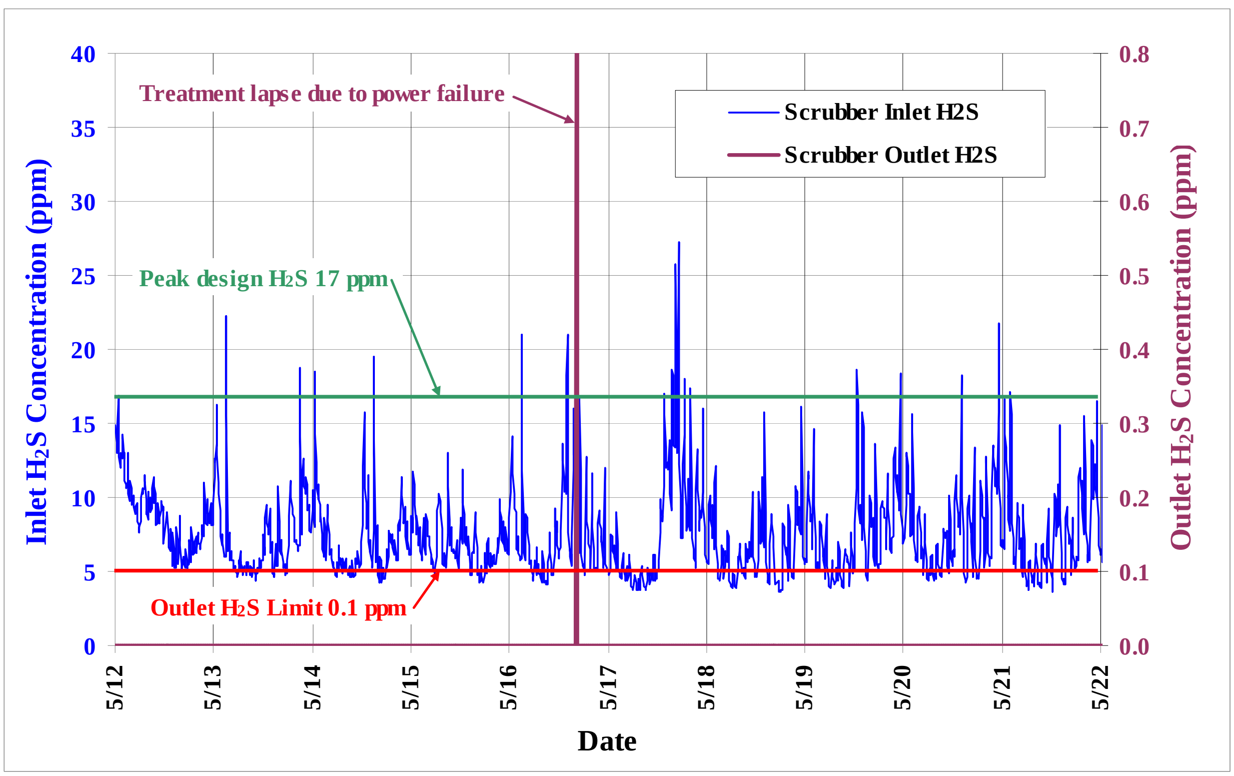
Odor was collected in Mylar bags using the conventional ‘pump and drum’ sampling method. The sample bags were transported to The Odour Unit of Sydney for olfactometry analysis within 30 hours, following Australian Standard ‘The Determination of Odour Concentration by Dynamic Olfactometry (AS/NZS 4323.3:2001).

Additional sample bags were collected and transported to the Chemistry Centre of Western Australia and underwent analysis for determining concentration of individual species including H_2S, DMS and total mercaptans using gas chromatography to separate the individual gas components which were then analysed by sulphur chemiluminescence. Additionally ammonia and a range of VOC were analysed using various methods.

Chemical Scrubber Performance Testing. It was desired that the chemical scrubbers be tested at the Stage 2 capacity of 195,900 m^3/h or 97,500 m^3/h per train, but at the time of the performance testing, all of the sources were not yet connected. To approach the desired air flow rate and H_2S concentrations it was necessary to route a higher portion of air through one train at a time. The 10-day test protocol was revised to five days per train. The air flow to Train 1 averaged 72,800 m^3/h during the first five days of testing and the air flow to Train 2 averaged 63,800 m^3/h for the final five days.

As shown in Figure 5, the chemical scrubber consistently achieved its design target of less than 0.1ppm, except during planned shutdowns for commissioning activities or mechanical interruptions. The final outlet H_2S was measured with a continuous readout Chemcassette recorder. The majority of the time, the outlet H_2S concentration was less than 0.05ppm (the minimum detection limit on the H_2S analyser). The design peak for the chemical scrubbers is 17ppm. During commissioning, peaks of up to 37ppm were recorded on the inlet H_2S analyser and the outlet remained under 0.05ppm.

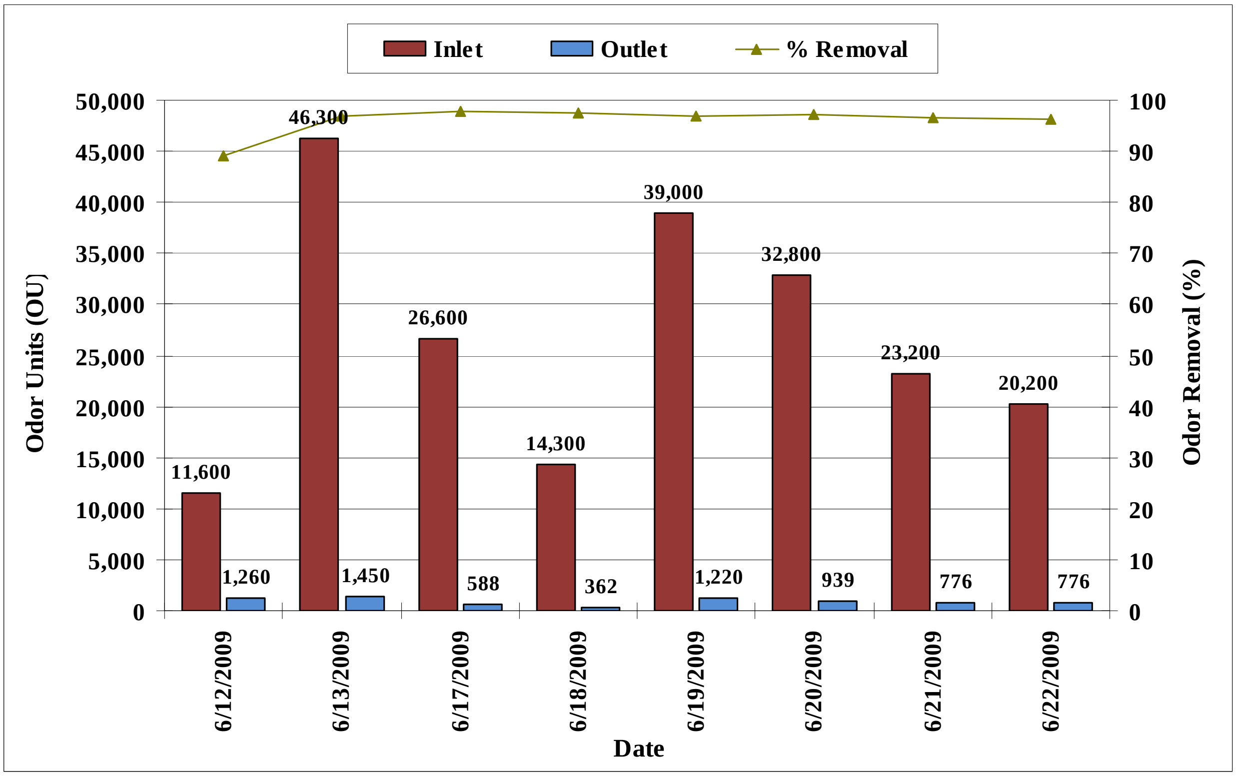
Figure 5 - H_2S Results for Chemical Scrubbers



The chemical scrubber performance test odor samples, presented in Figure 6, show relatively good odor reduction with an average of 96 percent removal. Three of the eight odor samples exceeded the stack odor goal of less than 1,000OU. During the performance test, the chemical scrubbers were operated with caustic only in the first stage and caustic and hypochlorite in the second stage.

Some of the outlet odor samples were noted to have chlorine odor and some were noted to have a sewage smell. Residual chlorine odor could be minimized by operating with caustic and hypochlorite in the first stage and caustic only in the second stage. If the residual odor is due to incomplete treatment, then stack outlet odor could be improved using caustic and hypochlorite in both stages.

Figure 6 - Odor Results for Chemical Scrubbers



During the chemical scrubber performance testing, DMS, mercaptans, and ammonia were measured by collecting bags samples at the system inlet, primary scrubber outlet, and secondary scrubber outlet. The expected concentrations were previously shown in Table 1. The measured concentrations presented in Table 2 are significantly lower than projected with all values in the low ppb range.

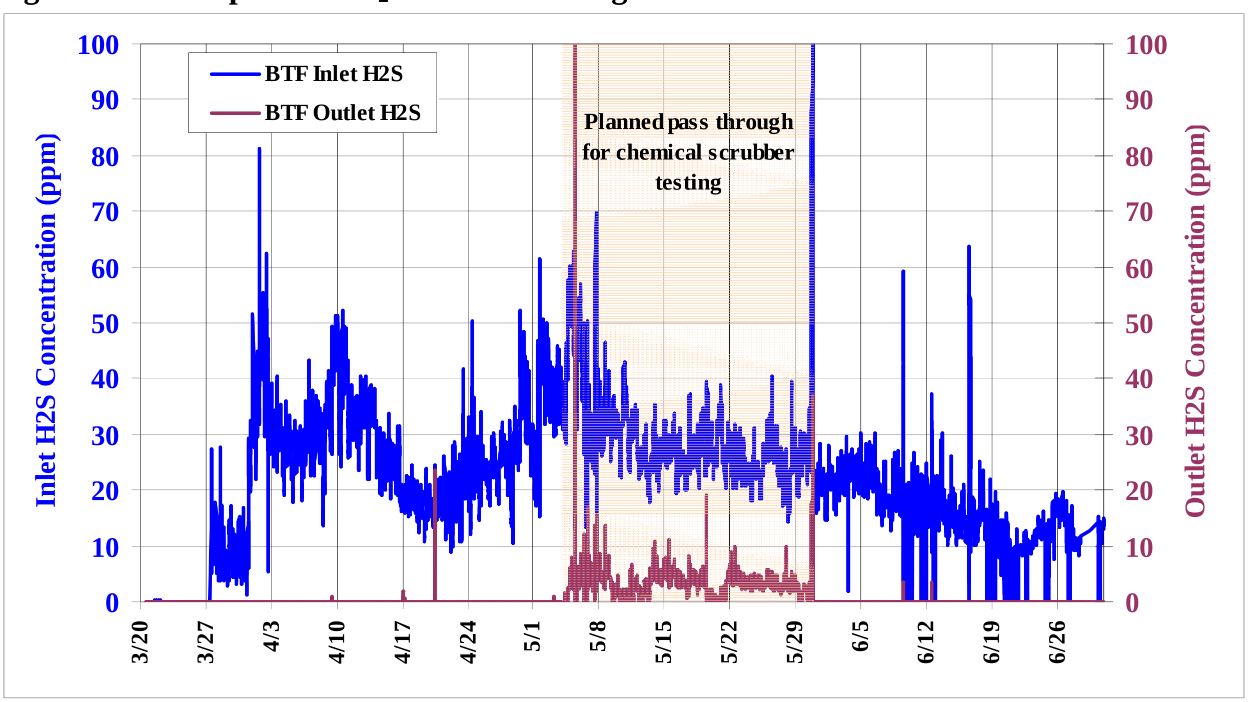
Additional analyses were performed for a long list of VOC compounds with most non-detectable and only a few such as dimethyl disulfide, and carbon disulfide present in the low parts per billion (ppb) range.

Table 2 - Results of GCMS Analysis of Bag Samples

GCMS Bag Sample Location	Scrubber Train 1				Scrubber Train 2			
	May 12		May 17		May 19		May 21	
	4pm	12am	4pm	12am	4pm	12am	4pm	12am
DMS (ppb)								
Inlet	4.4	< 3.1	< 3.1	< 3.1	3.3	3.5	< 3.1	< 3.1
Primary Outlet	< 3.1	< 3.1	< 3.1	< 3.1	4.5	3.7	3.2	< 3.1
Secondary Outlet	< 3.1	< 3.1	< 3.1	< 3.1	< 3.1	< 3.1	< 3.1	< 3.1
Mercaptan (ppb)								
Inlet	150	230	130	96	110	130	100	< 4.8
Primary Outlet	7.2	< 4.8	48	47	62	91	53	< 4.8
Secondary Outlet	< 4.8	< 4.8	< 4.8	< 4.8	< 4.8	< 4.8	< 4.8	< 4.8
Ammonia (ppb)								
Inlet	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Primary Outlet	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Secondary Outlet	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Biotrickling Filter Performance Testing. Throughout the startup period the biotrickling filters consistently achieved the design outlet H_2S concentration target of less than 0.5ppm, as shown in Figure 7. The biotrickling filters handled surge loadings better than anticipated and outlet H_2S remained below 0.5ppm, even during the initial ramping up period in March when loadings were rapidly increased from less than 30ppm to over 80ppm. The period in May when the biotrickling filter outlet H_2S exceeds 0.5ppm was intentional to provide a higher loading to the chemical scrubbers for performance testing. The higher loads were obtained by allowing the microbes in selected units to die, so a portion of the air flow was not treated.

Figure 7 – Startup Period H_2S for Biotrickling Filters



The biotrickling filter performance test results for H_2S and odor are shown in Figures 8 and 9.

Figure 8 – Performance Test H_2S Results for Biotrickling Filters

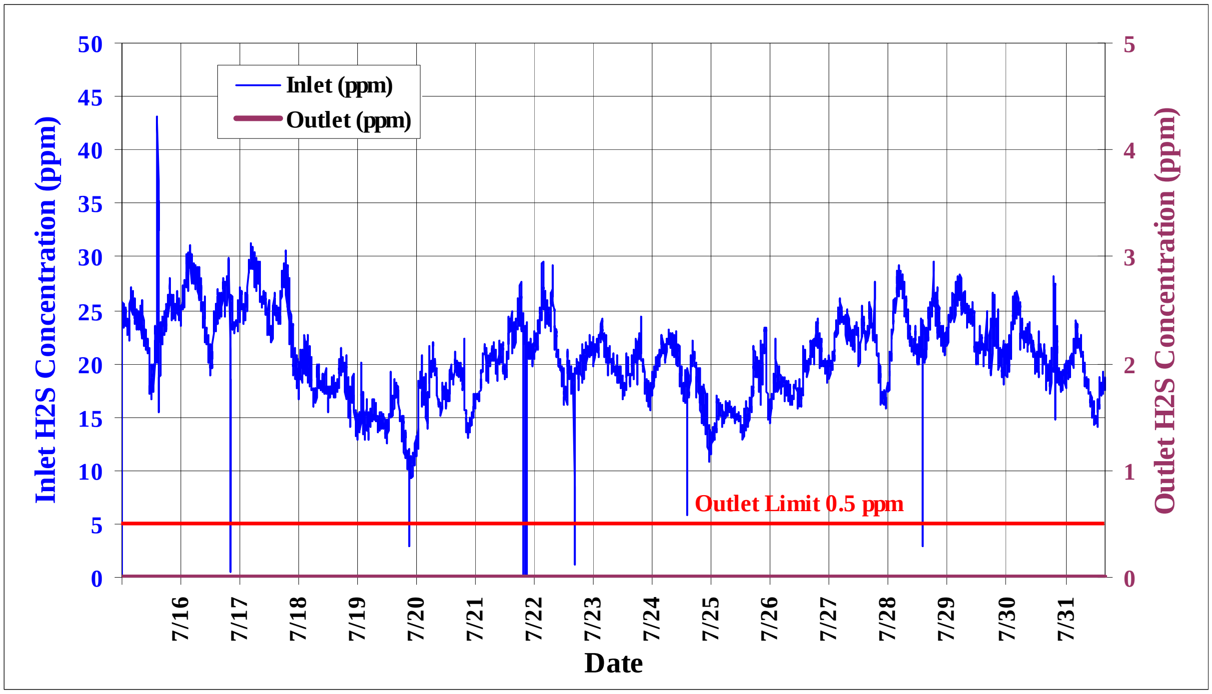
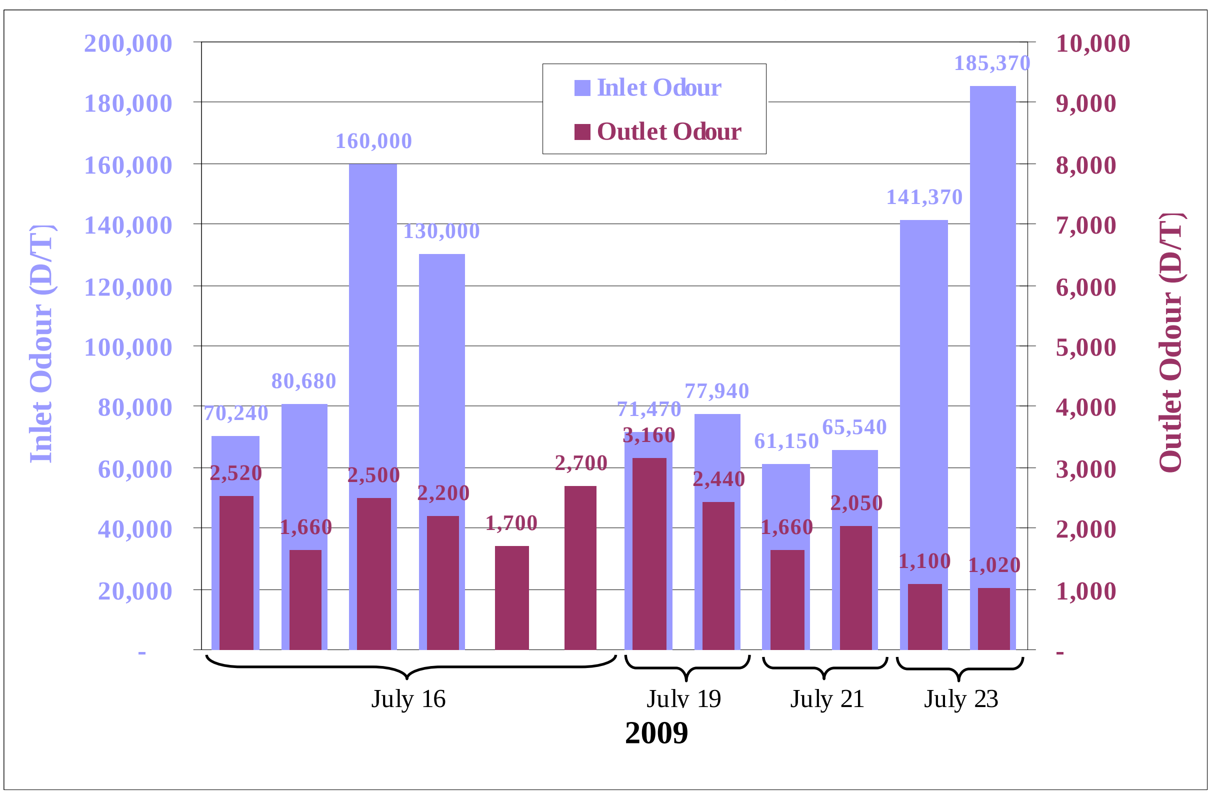


Figure 9 – Performance Test Odor Results for Biotrickling Filters



As shown in Figure 8, the downward trend in inlet H_2S concentration, evident in Figure 7, continued as outdoor temperatures cooled. During the performance test period, inlet H_2S concentrations peaked at 44ppm and averaged about 20ppm. The outlet H_2S remained below the required 0.5ppm limit throughout the test period. The 99.5 percent removal criteria was also achieved even at the low inlet levels, which required outlet H_2S concentrations below 0.1ppm.

The outlet odor requirement was achieved with all the outlet odor values less than 5,000 OU as shown in Figure 9. The highest outlet odor measured was 3,160 OU. The percent odor removal was also greater than 95 percent in all cases. At the highest inlet odor of 185,370 OU the outlet odor was lowest at 1,020 OU, which is over 99 percent removal.

The combined outlet odor from the biotrickling filters and chemical scrubbers has not yet been measured. However, if the biotrickling filters continue to provide the same low outlet odor as measured during the performance testing, the chemical scrubbers may be able to achieve stack outlet odor below the 1,000 OU goal without adjusting the chemistry from the current low-cost operating mode.

CONCLUSIONS

Chemical scrubbers have been the technology of choice for the Water Corporation, but with high H_2S loads, chemical scrubbers are costly to operate. For Stage 1 improvements at the Woodman Point WWTP, the W2W Alliance partners found that biotrickling filters offered the most economical means of treating high H_2S. In order to achieve the stringent odor control requirements mandated at the Woodman Point WWTP, chemical scrubbers were used as a final polishing step. The chemical scrubbers operate at a low cost because the H_2S load is significantly reduced by the biotrickling filters.

The low strength SBR air was rerouted directly to the chemical scrubbers, which reduced biotrickling filter capital costs without undue increase in chemical use. The odor control works incorporates six biotrickling filters (five duty, one standby) to treat air from preliminary, primary, and sludge treatment areas. Two stages of chemical scrubbers were installed to treat the foul air from the SBRs and the treated exhaust from the biotrickling filters. The chemical scrubber plant was sized to treat the future Stage 2 air flow.

A detailed Comissioning Plan was developed to gradually increase air flows and loadings to the biotrickling filters to ensure that no odor incidents occurred during startup. The completion of commissioning in 2009 was very successful with no odor incidents during startup of the facilities. The biotrickling filters acclimated faster than expected and reduced inlet H_2S as high as 80ppm to less than 0.5ppm. Performance test data showed that odor removal across the biotrickling filters was better than anticipated with outlet odor ranging from 1,020 to 3,160 OU and over 95 percent removal maintained.

Extensive data collected during the 10-day performance test of the chemical scrubbers showed inlet H_2S as high as 37ppm reduced to less than 0.05ppm. Odor removal was relatively good, but some stack outlet samples exceeded the 1,000OU goal. It was noted that the economical operating mode used performance testing was not optimal for odor removal. The combined odor removal across the biotrickling filters and chemical scrubbers has not yet been measured, but if the biotrickling filters provide the same low outlet odor as measured in the performance testing, the chemical scrubbers may be able to meet the 1,000 OU goal without adjusting the chemistry from the current low-cost operating mode.

The odor control works at the Woodman Point WWTP represents international best practice odor control, which will ensure that local residents are not unduly impacted by odor. Based on odor modelling, the final exhaust of 1,000OU discharged through a 50-m tall stack yields over 50 percent reduction in off-site odor. After the Stage 1 odor control system is commissioned and performance testing is completed, a detailed emissions measurement, odor modelling, and ground-truthing program will be undertaken. The program will include sampling of all odor sources, assessment of fugitive odor releases, assessment of odor releases during normal operation, community odor surveys, ambient odor surveys, and modelling.