Comox Valley REGIONAL DISTRICT

Staff report

DATE: January 12, 2017

FILE: 5340-20/CVWPCC

TO: Chair and members
Comox Valley sewage commission

FROM: Debra Oakman, CPA, CMA
Chief Administrative Officer

RE: Odour control systems dispersion modelling results and upgrade options - Comox Valley water pollution control center

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Purpose

To present the results of the Comox Valley water pollution control center (CVWPCC) odour control system dispersion modelling study and to provide options and a recommendation to improve the CVWPCC odour control system.

Policy analysis

Policy 5340-00 being the "Expenditure of funds for odour control – Comox Valley Water Pollution Control Centre" policy (2006)", establishes how the Comox Valley Regional District (CVRD) will consider the expenditure of additional funds to control odours at the CVWPCC or the biosolids composing site.

On November 26, 2013 the board approved the following recommendations:

> *THAT the Comox Valley Regional District complete an evaluation of the existing odour control equipment and practices at the CVWPCC including performance testing of the odour control system, an odour audit of operational and maintenance practices, a review of odour control technologies or enhancements to current technology and the development of a monitoring system to ensure odour control performance;*
>
> *AND FURTHER THAT a complaint tracking system be designed and implemented that addresses odour complaints in a consistent manner and provides statistical information related odour complaint frequency.*
>
> *AND FINALLY THAT funding for the above evaluation, in the amount of $50,000 be included in the 2014-2018 Comox Valley sewerage service financial plan.*

The 2016-2020 financial plan included $60,000 for the completion of dispersion modelling and scrubber performance testing.

Executive summary

In 1997 the regional district installed a wet chemical scrubber odour control system at the CVWPCC. This system draws odourous air from the pre-treatment area and the solids management process, chemically treats the air within a wet chemical scrubber and then discharges the treated air through a vent stack to the atmosphere. When originally commissioned, the system was found to be 99.3 per cent efficient at removing hydrogen sulphide compounds from the treated air. Since commissioning of the system in 1997, CVRD staff preform regular and routine maintenance on the system to ensure effective odour control.

The system has now been operational for 19 years and in November 2013 the board passed a motion directing CVRD staff to complete an evaluation of the existing odour control equipment and practices at the CVWPCC including performance testing, a review of operational and maintenance practices, a review of odour control technologies and the development of a complaint tracking system.

Following the board motion from 2013, an odour complaint tracking program was implemented in 2014. Since implementation of the odour complaint tracking system, 111 complaints have been received from 16 addresses.

In 2015, RWDI Air Inc. was retained to review and evaluate the existing odour control equipment and practices at the CVWPCC, report attached as appendix A for background. The 2015 report concluded that the CVWPCC is operated well in terms of odour control measures and that the design of the stack and scrubber seem to provide good dispersion of odours. However the report recommended that dispersion modelling of the CVWPCC be conducted in order to conclude if the odour collection system is operating sufficiently and controlling odours that are emitting to the surrounding community.

From the recommendations made in the 2015 report, RWDI was retained again in 2016 to complete dispersion modelling of the plant and to undertake a performance test of the scrubber system (reports attached as appendix B and C). The purpose of this work was to determine if further controls or expansion to the odour collection system are necessary and to evaluate the CVWPCC against odour standards from other jurisdictions until such time that British Columbia adopts their own odour standards.

To complete the dispersion modelling, emission rates from the plant were determined and odour concentrations, measured in odour units, were recorded at 12 sensitive receptors located in the area surrounding the CVWPCC. These concentrations were then compared to the Ontario odour standard and were determined to exceed the standard at all 12 sensitive receptors. Exceedance under the Ontario odour standard occurs if the odour concentration at a sensitive receptor is determined to be greater than one odour unit for more than 0.5 per cent or 44 hours per year. At the 12 sensitive receptors the average maximum recorded odour concentration was 7.67 odour units and the average frequency of exceedance of the Ontario odour standard was 11.6 per cent. Based on this modelling, RDWI determined that reducing odour emissions from the scrubber stack and the primary clarifiers would yield the greatest reduction in odours.

Upon completion of the odour dispersion modelling, ISL Engineering and Land Services was retained to provide capital cost estimates for various options to improve odour emissions (appendix D). ISL's recommended option includes covering of the primary clarifiers, venting the new equalization tank through the primary clarifiers, retrofitting the existing scrubber to increase its efficiency to 99 per cent and adding a dual bed activated carbon polisher. Covering of the primary clarifiers and retrofitting the existing scrubber stack will help to remove 99 per cent of the hydrogen sulfide and 90 per cent organic odour. Addition of new technology in the form of an activated carbon polisher, will help to remove the small amount of odourous air that is not being treated within the scrubber stack. The estimated capital cost for this option is $2.18 million.

The installation of the odour control system was to primarily treat hydrogen sulfur compounds, including hydrogen sulfide, with less of an emphasis on organic compounds. With the development of new odour control technologies, such as activated carbon polishers, upgrades to the CVWPCC system are recommended to further improve all odour emissions to ensure the CVRD continues to be proactive in odour management and to minimize impacts to surrounding residents.

The recommended option as proposed by ISL will utilize new technologies to minimize sources of odour and help the CVWPCC better achieve any future guidelines that may come into effect in BC in regards to odours. Additionally CVRD staff will be undertaking bench-scale testing for the addition of Bioxide within the sludge dewatering process to determine if a further reduction in sludge odour emissions is feasible. A public open-house will also be held to inform the public of the study results and next steps.

Recommendation from the chief administrative officer:
THAT odour control measures per recommended option 1 as described within the December 2016 "CVWPCC-Odour Control Options" report completed by ISL Engineering and Land Services be added to the scope of work for the Comox Valley water pollution control center phase one upgrades to be initiated in spring 2017.

Respectfully:

D. Oakman

Debra Oakman, CPA, CMA
Chief Administrative Officer

Background/current situation
The most offensive odour causing compounds that are generated as part of the wastewater treatment process include organic and inorganic forms of sulfur, including hydrogen sulfide, mercaptans, ammonia, amines and organic fatty acids. These odours produce smells that are commonly identified as fishy, pungent or similar to rotten eggs and vegetables. Typically these odour develop during the pre-treatment, primary treatment and solids management processes.

In 1997 the regional district installed a wet chemical scrubber odour control system at the CVWPCC to combat these odours. This system draws odourous air from the pre-treatment area and the solids management process, chemically treats the air within a wet chemical scrubber and then discharges the treated air through a vent stack to the atmosphere. When originally commissioned, the system was found to be 99.3 per cent efficient at removing hydrogen sulphide compounds from the treated air.

The system has now been operational for 19 years and in November 2013 the board passed a motion directing the CVRD complete an evaluation of the existing odour control equipment and practices at the CVWPCC including performance testing, a review of operational and maintenance practices, a review of odour control technologies and the development of a complaint tracking system.

Odour Complaint Tracking
In 2014 the odour complaint tracking system was developed and implemented. The system consists of a centralized database which records names, addresses, dates of complaints, nature of the issue and duration of the issue. Since inception of the system in 2014, a total of 111 complaints from 16 addresses have been recorded. The majority of the recorded complaints occur within the summer months during the evening.

Odour Control System Evaluation Report
In 2015, RWDI was retained to review the wet-chemical scrubber's performance, audit the facilities operational practices, review new odour control technologies and provide preliminary cost estimates for any recommended improvements.

RWDI concluded that the odour collection system was in good working condition and all components were under sufficient negative pressure to ensure adequate collection. RWDI also completed scrubber testing under normal operating conditions and concluded that the scrubber was 60 per cent efficient in removing sulfur and 42 per cent efficient at removing odours.

However RWDI further recommended that in order to determine whether the stack and scrubber were providing sufficient odour control in the surrounding community or if expansions to the odour control system to include additional sources is required, dispersion modelling of the exhaust stack and other odour sources should be completed.

Wet Scrubber Efficiency Testing
From these recommendations, the CVRD proceeded to retain RWDI in 2016 to complete dispersion modelling of the CVWPCC and evaluate scrubber performance. The purpose of the wet scrubber efficiency testing was to determine if the scrubber could still work as efficiently as when installed. The testing concluded that the scrubber is still capable operating at its design removal efficiency and is operating reasonably well under normal operating concentrations.

Odour Dispersion Modelling
In 2016 RWDI also completes dispersion modelling of the CVWPCC. It is important to note that while numerical modelling is a conservative approach, it represents the worst case scenario and is the preferred protocol in Ontario and other jurisdictions.

Site specific emission rates were determined for the primary clarifiers, aeration basins and the scrubber. Using this data maximum 10-minute averages were determined and were entered into the model. Odour concentrations, measured as odour units, were recorded at 12 sensitive receptors located in the area surrounding the CVWPCC and compared to Ontario odour standards. See figure one below for the location of the 12 sensitive receptors. Currently there are no odour standards within BC but to ensure that the CVWPCC is effectively mitigating odours results were compared to the Ontario odour standards. The odour standard was exceeded at all 12 sensitive receptors and the CVWPCC was predicted to generate odour above the standard as far as two kilometers away. The acceptable frequency of exceeding the Ontario odour standard is 0.5 per cent or 44 hours per year, that the odour concentration exceeds one odour unit. Table no. 1 below provides the maximum predicted concentrations at each of the 12 sensitive receptors.

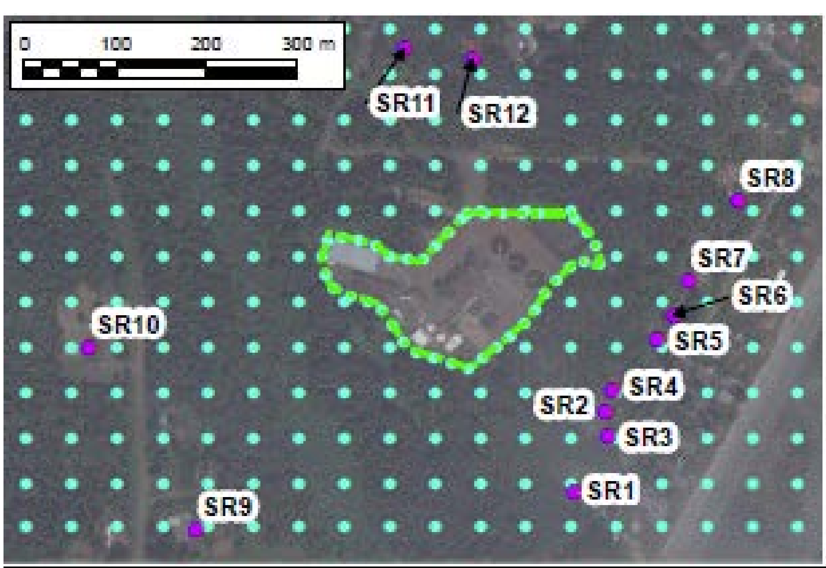

Figure 1: Sensitive receptor locations

Table No. 1: Maximum predicted odour concentrations at sensitive receptors

Sensitive Receptor	Odour Concentration (OU)	Frequency of Exceedance (%)
SR1	5.45	4.1
SR2	6.8	13.7
SR3	5.9	10.8
SR4	8.5	16.3
SR5	11.1	18.4
SR6	10.6	17.3
SR7	10.0	15.9
SR8	9.7	11.7
SR9	4.57	0.8
SR10	5.22	3.6
SR11	6.54	11.4
SR12	7.7	15.6

The areas where the frequency of exceedance was the greatest was located nearest to the scrubber stack and primary clarifiers. RWDI noted that reducing odour emissions from the primary clarifiers and improving the scrubber stack control efficiency to above 90 per cent would yield the greatest reduction in odour.

Odour Control Options
From this work ISL engineering developed capital cost estimates and recommend option to reduce odours from the CVWPCC. ISL evaluated different technologies and developed three options to reduce odour emissions from the treatment plant. All three options include covering of the primary clarifiers but exclude covering of the bioreactors due to costs. Covering of the bioreactors would require the installation of an additional dedicated scrubber system at a cost of approximately $3 million. In order to ensure sufficient odour control occurs without covering the bioreactors all three options include introduction of a new technology/second stage of odour control. Table no. 2 compares the capital costs, operating costs and net present value (NPV) for all three options.

Table No. 2: Capital costs, operating costs and NPV for all three options.

	Option 1	Option 2	Option 3
Description*	Retrofit existing chemical scrubber and a dual-bed carbon polisher	Bio-trickling scrubber and dual-bed carbon polisher	Dual bed absorber with activated carbon
Capital Cost	$2,180,000	$4,017,000	$2,078,000
Annual Operating Costs	$175,854	$134,844	$224,436
NPV	$5,055,000	$6,222,000	$5,748,000

*All options include covering of the primary clarifiers

The analysis indicated that option one provides the lowest NPV. This option incudes covering the primary clarifiers, retrofitting the existing chemical scrubber system and installing a new dual-bed activated carbon polisher to the process to further reduce residual odour compounds. Retrofitting the scrubber is expected to achieve 99 per cent hydrogen sulfide reduction and 90 per cent organic odour removal. However even with improved removal efficiency of the scrubber stack, some detectable odours will still be leaving the stack. By adding the dual-bed activated carbon polisher to the system a second stage of odour control is provided that will catch detectable odours that are exiting the scrubber stack along with providing protection within the system against odour spikes.

In addition to improvements to the odour control system, CVRD staff will be performing bench-scale testing for the addition of a Bioxide solution within the sludge dewatering area of the CVWPCC.

Options

The board has the following options:

1. Include odour control upgrades within the phase one upgrades at the CVWPCC as per ISL's recommended option 1.
2. Include odour control upgrades within the phase one upgrades at the CVWPCC as per ISL's recommended option 3.
3. To not proceed with odour control upgrades.

Through the work completed by RWDI it was predicted that odours generated from the CVWPCC are well above the Ontario odour standard. Although BC does not currently have odour standards, compliance with the Ontario odour standard is recommended to minimize odour impacts on the general public and help the CVWPCC better achieve any future guidelines that may come into effect in BC in regards to odours. ISL's option one provides the lowest cost option for compliance and as such only option no. 1 above is recommended.

Financial factors

Capital costs for the odour control system upgrades are estimated at $2.18 million and can be completed in two phases. Phase one can occur immediately and phase two can be implemented based on the timing of the phase on upgrades that are scheduled to occur at the CVWPCC.

The recommended odour control upgrades can be accommodated without impact to the municipal requisition included in the proposed financial plan.

Legal factors

BC currently does not have their own odour standards however in comparing results from the CVWPCC to odour standards from Ontario's Ministry of Environment and Climate Change, the CVWPCC was predicted to generate odours above the standards as far as two kilometers away. Reducing these emission values will help the CVWPCC be proactive in mitigating odours and should help the CVWPCC better achieve any future guidelines that may come into effect in BC in regards to odours.

Regional growth strategy implications

Improvements to the odour control system will help to mitigate odours generated from the CVWPCC, ultimately reducing the amount of odour complaints generated and supporting a high quality of life that enhances community well-being.

Intergovernmental factors

The Comox Valley sewerage service is governed by the sewage commission whose membership includes representation from the Town of Comox, the City of Courtenay and the Department of National Defence.

Interdepartmental involvement

The engineering service branch is leading this work.

Citizen/public relations

In order to inform the public of the recently completed study work and the next steps for the odour control system, a public information session will be held in the coming months. The public event will build on past events and will serve to provide an opportunity for the public to ask questions in regards to the odour control system.

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Attachments: Appendix A - "Odour Control System Evaluation, RWDI, dated October 2015"
Appendix B - "Odour Dispersion Modelling Report, RWDI, dated November 2016"
Appendix C - "Wet Scrubber Efficiency Memo, RWDI, dated September 2016"
Appendix D - "Odour Control Options Report, ISL Engineering, dated December 2016"

APPENDIX A

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Comox Valley Water Pollution Control Centre

FINAL REPORT

Revision 1

Odour Control System Evaluation

RWDI # 1500239
October 30, 2015

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INTRODUCTION

The Comox Valley water pollution control centre (CVWPCC) is a secondary level wastewater treatment plant that provides improved wastewater treatment to the City of Courtenay and the Town of Comox. The plant is located east of the Town of Comox in a rural area adjacent to the Strait of Georgia (Figure 1 Site Map).

Soon after start-up in 1984 the Comox Valley Regional District (CVRD) began to receive odour complaints related to plant operation. These complaints tended to be from residents along Curtis Road where odours are more frequent, especially on evenings in the late summer or early fall when certain weather conditions (off-shore wind) prevail.

Current situation

RWDI AIR Inc. (RWDI) has completed a review and evaluation of the ongoing performance of the wet chemical scrubber system installed at the CVWPCC. The overall odour control practices at the plant were also reviewed.

Figure 1: Site Map (CVRD RFQ September 2014)

RWDI presents this document to provide a report consisting of the following:

1. Review of the existing wet-chemical scrubber odour control system performance that establishes the current performance relative to initial start-up performance.
2. An odour audit of operational and maintenance practices.
3. Develop a monitoring system to ensure odour control performance.
4. Review the current state of the art with respect to wastewater treatment plant odour control and if warranted, make recommendations on alternate technologies for CVWPCC odour control.
5. Provide cost estimates for any recommended improvements.

METHODOLOGY

Phase 1 - Pre-Study

Prior to beginning the site work RWDI reviewed the CVRDs background information related to the original selection and installation of the wet chemical scrubber system. This involved a review of design flow rates, concentrations and removal efficiencies on which the design was based, plant flow at time of design, etc.

A cursory review of the scrubber operation was made at this time and included flow measurements within the system, chemical usage rates, scrubber solution renewal rates, water make-up and overall physical condition.

RWDI met with CVRD staff to determine the best way to interact with area residents near the CVWPCC to better understand their concerns with respect to existing odour issues.

RWDI audited the operational and maintenance odour potential of the existing plant. This included process rates, standard maintenance practices and general physical condition of the plant equipment.

Phase 2 – Evaluation of wet chemical scrubber system

In order to evaluate the control efficiency of the scrubber unit RWDI tested the scrubber under normal working conditions. Originally it was proposed that artificially induced concentrations of hydrogen sulfide be examined. Based on the availability of pure hydrogen sulfide gas, difficulties with transporting the gas and safety concerns around using the pure gas, it was decided that it was more appropriate to test the scrubber under the actual working conditions. The other scenarios are not truly relevant to the normal control efficiency of the scrubber.

It is very important to evaluate scrubber efficiency at normal load since removal efficiency for wet scrubbers is often lower with low inlet concentrations.

Velocity, Temperature and Volumetric Flow Rate Determination

Source velocity and flow rates were determined by U.S. EPA Methods 1 and 2. Velocity measurements were taken with a pre-calibrated S-type Pitot tube in conjunction with an incline manometer. Temperature measurements were made simultaneously with the velocity measurements, using a chromel-alumel type “k” thermocouple in conjunction with a digital temperature indicator. The volumetric flow rate was determined by following the equal area method as outlined in Method 2.

With reference to stack gas composition, the dry molecular weight (Md) was determined by following calculations outlined in Method 3. Stack gas composition was determined through the employment of a Nova Combustion Analyser. The analyser measures the CO_2 concentration of the stack gas by means of a non-dispersive infrared (NDIR) detector. The O_2 concentration is measured by the analyser through the use of an electrochemical cell. Moisture determination was conducted by following Method 4.

Hydrogen Sulfide Sampling

Sampling for H_2S was performed in accordance with U.S. EPA Methods CEMS 5 using a continuous emission monitor (CEM). The method provides real-time measurement for total reduced sulfur. The exhaust gas sample was withdrawn from a point at the center of the duct using a stainless steel probe. The sample proceeded to a heated filter, where particulate matter was removed, and then transferred via a heated Teflon® line to a sample conditioner. The Teflon® line was heated above the condensation temperature of the exhaust gas stream. The sample conditioner eliminated any condensation in the exhaust. The sample was then routed to the CEM for measurement. Reference method measurements were taken at both the inlet of the scrubber and at the outlet of the scrubber. Measurements were alternated between the two locations.

The scrubber removal efficiency was calculated by comparing inlet and outlet concentrations. The chemical efficiency was calculated from the mass of H_2S removed in the scrubber. The theoretical chemical usage can be calculated from the chemical equations for H_2S removal. This value was compared to the chemical feed rate into the scrubber.

Odour Sampling

In addition to the H_2S sampling, it was felt that it would be prudent to collect odour samples in Tedlar bags and have them submitted for odour panel analysis. Hydrogen sulfide is a major component of the odour from waste water treatment plants but is not the only component. It is possible that local odour issues are not related solely to H_2S impacts. This allowed RWDI to evaluate the scrubber efficiency in terms of odour removal as well as H_2S removal.

The field dilution odour sampling system operates by delivering nitrogen gas to an eductor at a constant rate to provide the necessary suction to draw sample gas into the Tedlar gas sample bag. The odourless nitrogen gas also acts to dilute the sample gas as it is extracted from the source. The sample gas is drawn through a calibrated capillary tube from the sample probe. The low sample flow rate is measured by a Magnehelic differential pressure gauge which measures the pressure drop across the capillary tube. Sample bags are purged with diluted stack gas prior to being filled. This sampling method complies with OSTC ON-6 (Ontario Source Testing Code). The purpose of performing the field dilutions is to eliminate condensation in the sample bags.

Once the samples have been collected in Tedlar bags, they are covered to avoid exposing the sample to light and to minimize potential photochemical reactions.

The samples were then submitted for subsequent analysis by an odour panel. The panel was tested prior to odour analysis and the members are considered to be in the normal odour sensitivity range as determined through an accepted odour panelist screening process. The samples were transferred by airfreight to the Pinchin odour lab in Mississauga, Ontario for analysis within 24-hours of sampling.

The odour evaluation uses an olfactometer with a multi-port system to deliver the odour samples to the panel members. The sample bag is pressurized and an electronic mass flow controller meters the sample flow rate. A three way valve is operated to permit the sample to flow into either one of the two ports. The analysis begins with a high dilution sample, diluted at a controlled flow rate with odourless air. The test is then repeated at decreasing levels of dilution until the odour panelists can detect the odour. For each dilution of the sample, the panelist identifies from which port the odour is detected. A data acquisition system records the panelists' responses and performs a regression analysis to calculate the odour threshold value. The odour threshold value, also called the ED50 (effective dilution to 50% response), is a statistical measure which identifies the dilution at which 50% of the panel can just detect the odour.

The odour samples were shipped to a lab and analysed within 24-hours of sampling.

Vacuum Checks

RWDI completed vacuum measurements throughout the odour collection ductwork in all accessible locations. The measurements were taken using a calibrated digital manometer. RWDI has itemized leak points in the system. At most points there were also flow rate measurements taken using a hotwire anemometer. The flows and pressures were compared to the initial air balance done during commissioning of the system.

Review of Scrubber Operations

RWDI examined the ongoing maintenance and operational procedures of the scrubber. This included but was not limited to: examining the service schedule and records, the measurement and feedback system for adjusting chemicals and water levels in the scrubber.

Additional Equipment

RWDI also completed a complete survey of the site including those areas and pieces of equipment that are not currently captured by the scrubbing system. These pieces of equipment and areas were examined using a Jerome 621 hand held H_2S detector. Hydrogen sulfide concentrations near to these pieces were measured and where the values were significant, the pieces of equipment or specific areas were considered for inclusion in the scrubber gas collection.

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OBSERVATIONS

Phase 1 - Observations

RWDI staff was at the plant from January 19 to January 22, 2015. The site visit involved touring of the facility and the neighboring community, collecting information from plant staff and making various measurements and observations related to the operation of the plant generally and the odour collection system specifically.

Overall Operation of the CVWPCC

The overall impression of the facility at the time of the visit was that it was well operated and that the staff had taken several innovative steps to reduce odour from the facility. These steps include:

- selective damming at the drop of the primary clarifiers to reduce the drop height of the water and the amount of odour released at that point;
- the installation of flow diverters at the end of the secondary tank to eliminate dead flow zones and stagnation in the collection trough and;
- the installation of spray bars on the secondary tanks to break up the formation of bacterial foam which occurs occasionally in the Summer.

The plant was commissioned in 1984 but seems to be in good shape based on cursory observations. All major components of the plant were operating properly at the time of the visit and the general level of “housekeeping” was excellent for this type of facility.

Review of Initial Odour Control Design

The original complaints at the facility stemmed from the operation of a bio-solids composting facility on the site which was moved at about the same time the odour control system was installed in 1996/97. Generally the compound of greatest concern with regard to odours from waste water treatment plants is hydrogen sulfide (H_2S). The selection of a packed column wet scrubber with a caustic/hypochlorite feed is a traditional and effective way to control H_2S emissions from this type of source.

The collection system has focused on the most odorous components of the treatment plant and has for the most part sealed those components and put them under negative pressure. The original design of the system indicated that the overall flow was to be approximately 27,000 cubic feet per minute (cfm). The review of the mechanical specifications showed a 40 horsepower centrifugal fan which seemed to indicate a maximum flow rate of approximately 20,000 cfm. In either case, the design of the system was adequate to supply sufficient flow and vacuum to keep the odourous components of the system under negative pressure.

The stack design from the scrubber is also sufficiently tall to be removed from building wake effects and will supply dilution without experiencing a building downwash effect during poor dispersion meteorology.

Review of Scrubber Operation

The packed column scrubber is a standard design with a counter flow system using a caustic/hypochlorite scrubbing solution. The solution is monitored with pH and chlorine sensors and fresh chemicals are added as required based on the input from the sensors. The source testing program showed an inlet loading of between 14.5 and 4.4 mg/s. These cases were with the aerator operating/not operating. As an estimate of typical loading we would assume a value of about 7.3 mg/s. This translates to roughly 230 kg of total reduced sulfur compounds (as H_2S) per year or 6.7 kMol. Based on discussions with staff, there were three 550 litre totes of 25% sodium hydroxide used in 2014 and 36,000 litres of 12% sodium hypochlorite used. This translates to 413 kg of sodium hydroxide or 10.3 kMol and 4320 kg of sodium hypochlorite or 58 kMol. The hydrogen sulfide and the solution react as per the formulas below:

$$H_2S + 4NaClO \rightarrow Na2SO_4 + 4NaCl$$
$$H_2S + 2NaOH \rightarrow Na2S + 2H_2O$$

Based on the above, if only hypochlorite was used to neutralize the reduced sulfur compounds 13.4 kMol would be required. Similarly, 13.4 kMol of sodium hydroxide would be required if only sodium hydroxide was used. The hypochlorite also will neutralize many other compounds, it will also act as a disinfectant to neutralize biological agents and it serves to act as a masking agent for the stack odour.

The feed rate of chemicals is adequate to neutralize the reduced sulfur compounds. There is some excess of hypochlorite but this does perform the functions discussed above. The chemical feed system appears to be dosing at an appropriate rate based on the observations made.

There was initially a hydrogen sulfide sensor installed in the duct after the scrubber. This sensor has been inoperable for some time and we do not recommend that it be replaced. These types of sensors will not provide meaningful measurements in the required range.

Community Observations

On the morning of January 20, 2015, the weather conditions were overcast, with light fog, winds were light and variable blowing generally from the plant towards the sea. These conditions should have provided near worst-case dispersion for experiencing odours in the community. There are a series of observations listed below

- 10:30 - Walter Road – some areas where very faint mercaptan odours were detected – very faint
- 10:35 - Andrew Road – very faint mercaptan odour, intermittent – more like pulp and paper
- 10:40 - 396 Curtis Road – downwind of stack – very faint intermittent odour – would probably not be noticed if not trying to smell the plant
- 10:45 to 10:50 - 413 to 453 Curtis Road faint to mild odour but intermittent

The observations were made during worst case atmospheric conditions and odours were intermittent and barely perceptible.

Flows and Loading

The odour system was designed and built in 1996/97 and since that time the population in the area has increased a comparison was made between earlier years of operation and 2014. Table 1 below shows the flows in 1997 and 2014. The table also shows influent Biological Oxygen Demand (BOD) loading for 2014 and also average BOD loading for 2004.

Table 1: 1997 and 2014 Flows and BOD Loading

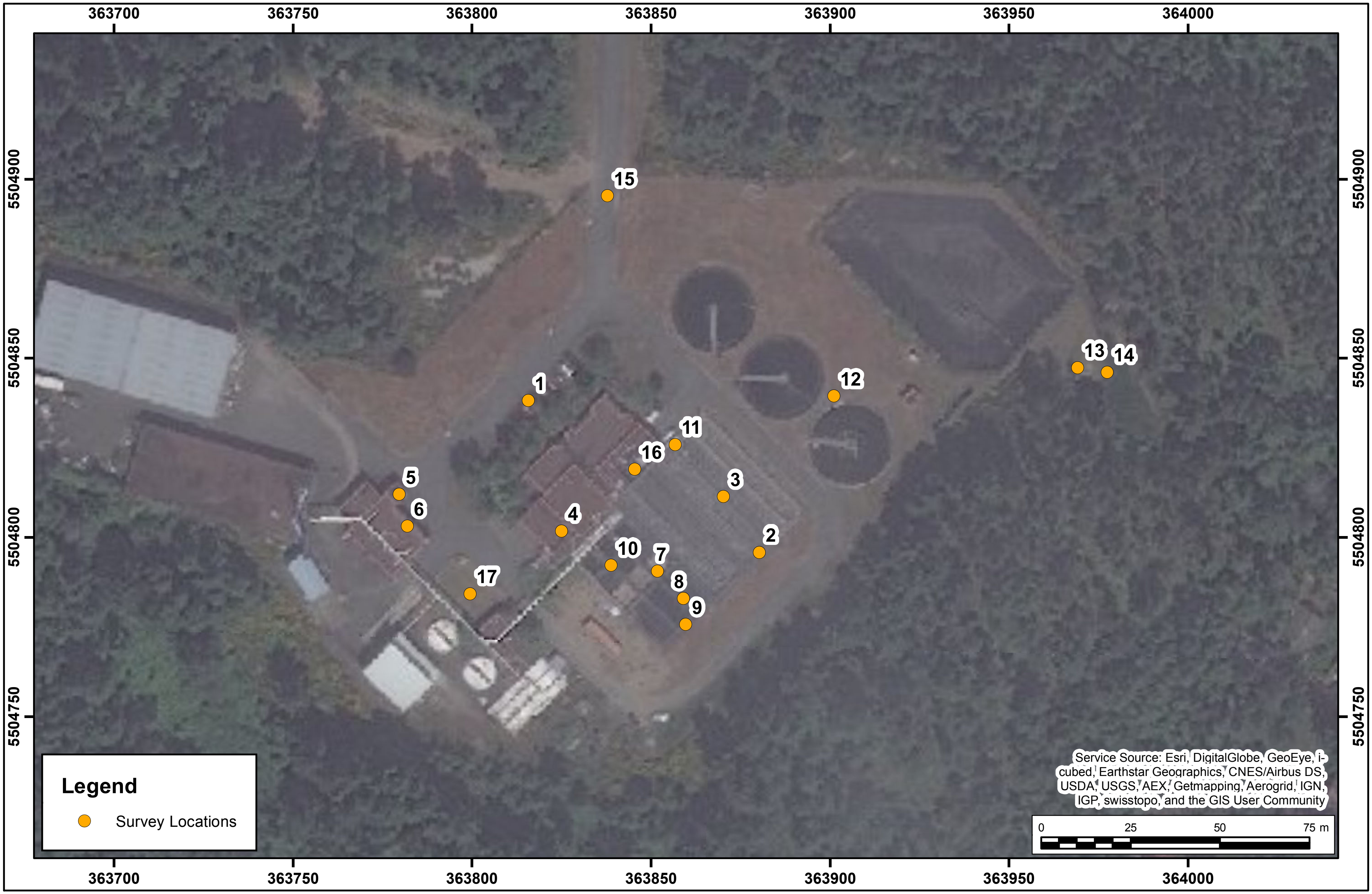
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	1997	TOTAL BOD
MAX (m^3)	26329	50336	64298	38823	41801	41459		38540	40143	39453	22927	24743	64298	(tonnes)
MIN (m^3)	11948	11372	11086	10550	12758	12277		12733	12216	12779	11626	12906	10550	
AVG (m^3)	15509	21146	22878	16957	18928	18704		14782	16896	17585	15173	15569	17648	
BOD* (g/m^3)													239	1540
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	2014	TOTAL BOD
MAX (m^3)	22623	24911	21137	14850	15581	12916	13459	13656	13874	28977	19974	38462	38462	(tonnes)
MIN (m^3)	11899	11123	13083	12366	11682	10982	11400	11241	10965	11570	12306	12931	10965	
AVG (m^3)	13574	15523	15993	13244	13047	11954	12258	12255	12335	15918	15154	19338	14216	
BOD (g/m^3)	351	244	212	232	317	429	355	280	315	188	234		287	1489

Notes: ** Please note that BOD numbers for 1997 were not easily available so values for 2004 were used since those values were the earliest available in electronic format.*

Despite the growth in population, the overall flows have dropped slightly since 1997. This is due to low-flow initiatives that the region has implemented. There is no control for differences in precipitation in these statistics. While flows have decreased, the total amount of BOD loading has increased leaving the overall BOD loading very similar. Anecdotally, the staff have related that BODs have been steadily increasing over the years. This increase in BOD concentrations may cause an increase in odours at some times but the overall statistics would indicate that loading is similar to earlier years. This indicates that the design parameters for the odour control system are still valid.

Hydrogen Sulfide Survey

A handheld Jerome 621 Gold Film analyzer for hydrogen sulfide was used at various locations around the facility. The locations of these measurements are shown in Figure 2. The results are shown in Table 2



Comox Valley Water Pollution Control Centre Hydrogen Sulfide Survey

January 21, 2015

Map Projection: NAD 1983 UTM Zone 10N.

True North

Drawn by:	NBN	Figure:	2
Approx. Scale:	1:1,500		
Date Revised:	Mar. 18, 2015		

RWDI

Comox Valley Water Pollution Control Centre - Comox Valley, BC

Project #1500239

Table 2: H_2S Sampling Results

Sample Point	H_2S (ppb)	Sample Location
1	0	parking lot in front of main door to control bldg
2	0	back end of bioreactors
3	0	6 feet above bioreactor in the middle
4	0	bar screen room
5	66	solids loading bay
6	19	centrifuge room
7	2	2 feet above primary surface
8	5	2 feet above primary tank adjacent to bubbling gas
9	5	above water drop at end of primary
10	0	2 feet above primary tank at top end
11	0	beneath walkway at the end of the bioreactors
12	0	edge of clarifier
13	1	on edge of pressure chamber
14	0	about 18" below goose neck vent from discharge well chamber
15	0	front gate
16	1	blower room
17	2	DAF building

Notes: Survey was taken on January 21 between 1:30 and 3:00.
The measurements were taken with a Jerome 621 H_2S handheld. analyzer
The winds were light and variable during testing but samples were all taken at the point with the greatest odour near the source.

Phase 2 - Observations

Review of Odour Collection System

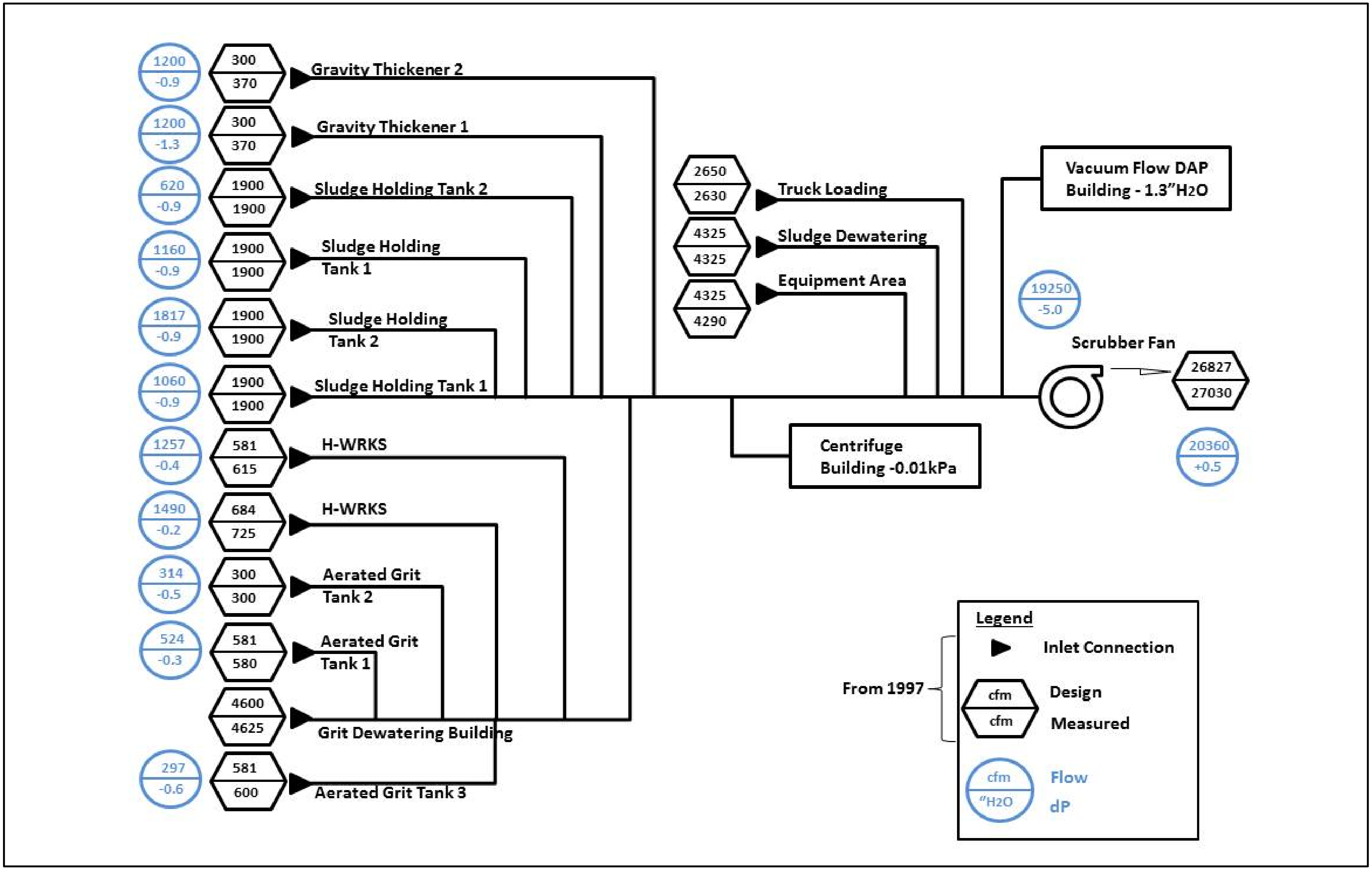
The odour collection system was examined during the site visits and it was determined that the system is in good working order and all components were under sufficient negative pressure to ensure adequate collection. Figure 3 shows a schematic of the odour collection system and the flows and pressures measured during the site visit. It was not possible to measure flows from all components but pressure measurements were made at all locations. The figure also shows the original design flows as well as the initial flow measurements of the system.

The system does have several large leak points which should be sealed or at least reduced. The openings on top of the sludge thickeners are much larger than they need to be. These openings could be reduced in sized and the remaining area could be covered with neoprene flaps. This would still leave ample access for maintenance and decrease the amount of vacuum leakage. Similarly, the opening above the headworks inlet chamber could be partially closed off with the same technique. There is also an opening in the back wall of the centrifuge building where the conveyer enters the building that represents a large vacuum leak.

There is an additional fan in the centrifuge building that previously was operated with an automated switch. This has been recently overridden and is on at all times now; we would recommend that this continues.

One of the odour sources on-site occurs from the unloading of vacuum trucks. Anecdotally, two drivers had mentioned that the unloading process would be accelerated if there was some additional head pressure in the hose that drains the trucks. This would seemingly decrease the amount of time for unloading and therefore the odour impact. Material transfers of this type are not RWDI’s expertise but it would seem to be fairly easily accomplished by raising the ramp/pad for the vacuum trucks another half to quarter metre. We would suggest that the matter be examined to see if it is a feasible improvement.

There are likely other smaller leaks around sealed cover plates and other small sources. We would recommend that an ongoing check of vacuum at various points in the system to identify areas where leaks have developed. As stated earlier, the system is operating effectively but the system could probably be expanded to include more sources without additional fan power if the leaks were addressed.



Flow Balance Diagram Comox Valley Water Pollution Control Centre

True North

Drawn by: NBN | Figure: 3

Approx. Scale: N/A

Date Revised: Mar. 18, 2015

Comox Valley Water Pollution Control Centre - Comox Valley, BC

Project #1500239

Stack/Scrubber Testing

The testing program was completed on January 21 and 22, 2015 using the techniques described in the methodology section. The flow and TRS measurements were taken on January 21.

The TRS testing was initially done on the scrubber inlet during normal conditions. After an hour an aerator was turned on to increase loading on the system. The scrubber inlet was monitored for a period while the aerator was on. The exhaust stack was then monitored for approximately one hour while the aerator was on. The scrubber inlet was then monitored again to see if there was a decrease in TRS levels. Tables of all the testing results are included in Appendix A and the summary Table 3 below.

Table 3: Summary of TRS Sampling

			Avg TRS	Avg TRS	Emission Rate*
	Start Time	**End Time**	**(ppm)**	**(µg/m^3)**	**(mg/s)**
Inlet to scrubber	12:30	13:30	0.3	439.2	4.4
Inlet to scrubber (aerator on)	13:45	14:00	1.0	1464	14.5
Exhaust Stack	14:35	15:35	0.4	585.6	5.8
Inlet to scrubber	15:50	16:10	0.5	732	7.3
Dry reference flow rate (m^3/s)	9.92				

The odour sampling was completed on January 22, 2015 and samples were shipped to the odour lab for analysis on January 23, 2015. The odour lab results are shown in Appendix B and are also summarized in Table 4 below.

Table 4: Laboratory Analysis Sample Results

Location	Odour	Sample	Net Odour	Odour Emission Rate
	Threshold	**Dilution**	**(OU/m^3)**	**(OU/s)**
Inlet 1	1114	5.2:1	5792.8	57465
Inlet 2	1020	5.2:1	5304	52616
Inlet 3	1324	5.2:1	6884.8	68297
Inlet Average				**59459**
Exhaust 1	721	4.5:1	3244.5	32185
Exhaust 2	663	4.5:1	2983.5	29596
Exhaust 3	935	4.5:1	4207.5	41738
Exhaust Avg				**34507**
Dry reference flow rate (m^3/s)				9.92

Notes: *Odour units (OU) are based on the required dilution for 50 % of the population to be able perceive an odour. This does assume that the population all have a normal range of sensitivity to odour.

Scrubber Efficiency

The inlet concentration of reduced sulfur is very low and did not get much over 1 part per million during the testing. The nature of scrubber solutions is that there will always be some gas coming out of solution as well as being absorbed into the solution. Even with perfectly fresh solution the exhaust concentration would probably be a few hundred parts per billion. The scrubber would probably show a much higher efficiency if the inlet concentration was higher but it is not relevant to the plant's operation parameters. The best case removal efficiency for reduced sulfur was 60%. The removal efficiency for odour was 42%.

Community Consultation

As part of the community consultation process the Comox Valley Regional District conducted a mail survey regarding odours from the Comox Valley Water Pollution Control Centre. The purpose of the survey was twofold. Firstly it was an assessment of odour impacts from the facility in terms of frequency, seasonality, intensity etc. Secondly it was to gauge the level of concern in the area surrounding the plant.

There were a total of 85 surveys mailed out to residents who live near the plant. A total of 27 surveys were filled out and returned. The detailed results are included Appendix D of this report.

The results of the survey indicated that roughly half the respondents experienced the plant odours frequently. Only about a quarter of the people that experienced odours deemed them strong and objectionable. The survey responses indicated that the Region should allocate some resources to informing the public of the new complaint process. Based on public response, there was a perception that odour impacts were more frequent in the Summer but this is a small enough bias that it is probably more related to increased resident time outdoors rather than any operational change. Similarly, there was a perception that there were more odour impacts in the evening than other times of day. This may have been related to meteorology or again, the increased likelihood of residents being outside.

There was a wide range of responses in the written comments but the most common note was a desire to know what was going on with regard to odours from the plant.

DISCUSSION

Based on our observations we would make the following conclusions:

- The plant is operated well with regard to odour control activities.
- The interaction with the public will be achieved by means of a mail out survey which has been supplied to the Region for comment at this point.
- The odour impact in the community was very faint and intermittent in a limited area during the RWDI visit.
- Ambient measurements of hydrogen sulfide were zero at all points on the perimeter of the facility and in almost all outdoor locations on the property.

- The odour collection system is operating well but several leak points should be addressed particularly if the collection system is expanded.
- The height of the ramp/pad for the vacuum trucks should be reviewed. However based on discussions with the Region this may not be productive.
- The scrubber is not working very efficiently but the overall emission rate from the stack is not that high in terms of reduced sulfur compounds – including hydrogen sulfide.
- The scrubber is removing 42% of the odour emission in the exhaust.
- The stack is a good design and is providing good dispersion of the exhaust odours.
- There are some odours in the community but the impacts seem to be restricted to the area fairly near the plant and are similar to what we have observed elsewhere at similar facilities in other jurisdictions. Including jurisdictions with odour regulations.
- The Region may want to include some information update process linked to the website so residents can be aware of upgrades, upsets, plans or construction at the plant.

Phase 3 – Evaluation of alternate technologies

Upgrades to the vacuum collection system to include more sources

Upon review of the collection system it was determined that there was probably some excess capacity in the system that could allow for some expansion. Based on the survey, the two most odourous sources that are not currently captured by the vacuum collection system are the primary tanks and the secondary bioreactors. It is likely that the primary tanks are the more dominant source of odour and it could be enclosed in a cover building that would be vented to the vacuum system/scrubber.

The budget cost for an enclosure to cover the primary bioreactors would be approximately $600,000 based on current rough building cost guidelines for BC for warehouse type buildings. This is probably a conservative estimate since the structure will not have a floor or foundation. A mechanical balance will have to be completed to determine if the structure can be ventilated properly with only the existing vacuum system. The safest rate of ventilation would be 12 air changes per hour but as little as 4 air changes could be used. If the building was ventilated separately from the current vacuum system we would estimate the required fan and ducting would have a budget price of $40,000.

The construction materials should either be coated with thick polymer or be constructed from plastic or FRP type materials. As an alternative, the possibility of only enclosing the only effluent weirs could be examined

If both the secondary bioreactors and primary tanks were enclosed we would estimate that the enclosure cost would be roughly $1,000,000 but again, this is probably a conservative estimate. There would be a requirement for additional fan power if both the primaries and bioreactors were enclosed and we would estimate a budget price of $60,000 for fan and ducting

To determine whether enclosing either the primary tanks or bioreactors would be beneficial, we would recommend that an odour emission rate estimate be completed from measurements of similar sources. We would further recommend that these odour emissions be modelled using a numerical dispersion model such as CALPUFF or AERMOD to determine what the odour impact of these emissions is on surrounding residences.

Optimization of the current wet scrubbing system

As part of our investigations we evaluated the current scrubber efficiency and capacity. The removal efficiency of the scrubber for odour in general and for reduced sulfur compounds in particular is not as high as manufacturer's claims but this is due to the relatively low inlet concentration. Basically the chemical balance indicates that an appropriate amount of chemicals are being used. There could be some gains made by increasing the amount of makeup water but this will require the use of additional chemicals. It is unlikely that the gains would be significant in terms of overall impacts.

Expanding the wet scrubbing system

At present there would seem to be little point in expanding the wet scrubbing system. The air through the scrubber has sufficient residence time and the loading on the scrubber is very light. If it were determined that enclosing the primary and/or secondary bioreactors would be beneficial, it may be necessary to expand the scrubber system but that would need to be determined after any additions were made.

Adding a Bio-filter system

Bio-filtration is a traditional control for these types of sources since many of the components in the exhaust stream are effectively treated by bio-filters. A combination of a wet scrubber and a bio-filter will usually achieve 80% or better odour removal efficiency. Typically the operating costs are fairly low with these types of systems but it can vary based on several factors. The downfall of this type of treatment is that it does require a fairly large footprint. The other downfall is that bio-filters rarely achieve better than 90% odour removal.

The capital cost for these types of systems (U.S. EPA) is between $3 and $21 per cfm of exhaust. In the current configuration, this would give a budgetary price of roughly $600,000 dollars of capital cost. If the collection system was expanded the price would increase if the flow increased.

There is no way to tell if the addition of a bio-filter would provide a significant benefit at present. We would recommend that the odour emissions from the current stack be modelled using a numerical dispersion model such as CALPUFF or AERMOD to determine what the odour impact of these emissions is on surrounding residences. The source could then be remodeled to determine the benefit from the addition of a biofilter

Adding a Thermal Destruction System

Thermal destruction has a very high efficiency in terms of odour removal, generally greater than 95%, but there are several disadvantages for this type of system.

First it is very costly, with a capital cost in the $140 per cfm (U.S. EPA) range which would translate to a budgetary price of roughly $3,000,000 for capital costs. The operating costs would be in the range of $300,000 per year.

Secondly, there is an increase in emissions of oxides of nitrogen, carbon monoxide, sulfur dioxide and greenhouse gases. It is possible that there may be a compliance issue with one of these emissions.

Finally, most thermal destruction units have a relatively short lifespan and need to be replaced after ten to twenty years.

We would not recommend a thermal destruction unit unless further analysis showed that an odour destruction efficiency of greater than 95% was required.

Adding Other Control Technologies

There are several other technologies that would possible be beneficial. One of these technologies is non-thermal plasma destruction. This technology does not have a long, proven track record but it does have some advantages that may be worth examining. The odour removal efficiency is quoted at 90% which is very good and we would estimate the budgetary capital cost at about $300,000. The operating costs would include additional electricity use which would be less than $10,000 per year. The systems are modular and can be expanded fairly easily if required. We have been in contact with a British Columbia supplier that could also supply a pilot unit to examine the control efficiency on the facility’s exhaust.

However, this is a control technology that does not have widespread acceptance and the one similar unit that RWDI has any working knowledge of, is not currently working.

We would not recommend any further examinations of this technology until it is determined if additional control is required on the exhaust stack.

SUMMARY RECOMMENDATIONS

It is not possible to say at this point whether the stack and scrubber are providing sufficient odour control in the surrounding community. We would recommend that dispersion modeling of the exhaust stack as well the other sources of odour at the plant. Modeling would determine if further controls on the exhaust stack would make a significant difference or whether it would be better to expand the odour collection system to include other sources such as the primary tanks. Modelling would also allow the site to be evaluated against odour standards from other jurisdictions until such time as BC gets their own odour standard. If the plant achieves the standard it would go a long way in limiting any possible civil liability.

A community odour monitoring plan has been developed in consultation with the Region and is included in the attached Appendix C. We would recommend that these surveys begin as soon as possible so that there can be a baseline established to determine community odour impacts. This will be important in establishing whether any improvements made at the facility have a significant effect.

The results of the public odour consultation should be evaluated to see the degree of the perceived odour problem in the area. This will allow the Region to gauge the urgency of any improvements to odour control at the site.

APPENDIX A
TEST RESULT TABLES

TRS SAMPLING DATA

year	day	time	TRS (ppm)
2015	21	1231	0.014525
2015	21	1232	-0.0111
2015	21	1233	-0.03813
2015	21	1234	-0.03235
2015	21	1235	-0.06918
2015	21	1236	-0.0878
2015	21	1237	-0.02263
2015	21	1238	-0.03265
2015	21	1239	0.002725
2015	21	1240	0.1359
2015	21	1241	0.174275
2015	21	1242	0.09345
2015	21	1243	0.075025
2015	21	1244	0.0438
2015	21	1245	0.009775
2015	21	1246	0.01535
2015	21	1247	0.062125
2015	21	1248	0.1431
2015	21	1249	0.191275
2015	21	1250	0.18285
2015	21	1251	0.219825
2015	21	1252	0.288
2015	21	1253	0.195775
2015	21	1254	0.20715
2015	21	1255	0.232525
2015	21	1256	0.2395
2015	21	1257	0.174275
2015	21	1258	0.22105
2015	21	1259	0.201225
2015	21	1300	0.2126
2015	21	1301	0.158775
2015	21	1302	0.18415
2015	21	1303	0.230925
2015	21	1304	0.2847
2015	21	1305	0.294675
2015	21	1306	0.31585
2015	21	1307	0.307425
2015	21	1308	0.2804
2015	21	1309	0.249175
2015	21	1310	0.23775
2015	21	1311	0.230725
2015	21	1312	0.2747
2015	21	1313	0.298875

year	day	time	TRS (ppm)	
2015	21	1314	0.29325	
2015	21	1315	0.304625	
2015	21	1316	0.3542	
2015	21	1317	0.378175	
2015	21	1318	0.37535	
2015	21	1319	0.396525	
2015	21	1320	0.3355	
2015	21	1321	0.345475	
2015	21	1322	0.29585	
2015	21	1323	0.307025	
2015	21	1324	0.2702	
2015	21	1325	0.342575	
2015	21	1326	0.32835	
2015	21	1327	0.359525	
2015	21	1328	0.3795	
2015	21	1329	0.363875	
2015	21	1330		
2015	21	1331	0.299691	30 min avg
2015	21	1332		
2015	21	1333		
2015	21	1334		
2015	21	1335		
2015	21	1336		
2015	21	1337		
2015	21	1338		
2015	21	1339		
2015	21	1340		
2015	21	1341		
2015	21	1342		
2015	21	1343	0.0896	
2015	21	1344	0.1928	
2015	21	1345	0.2518	
2015	21	1346	0.405	
2015	21	1347	0.5852	
2015	21	1348	0.6604	
2015	21	1349	0.6746	
2015	21	1350	0.771	
2015	21	1351	0.8518	
2015	21	1352	0.9312	
2015	21	1353	0.9596	
2015	21	1354	1.0192	
2015	21	1355	1.008	
2015	21	1356	1.0094	
2015	21	1357	1.0264	
2015	21	1358	1.0888	
2015	21	1359	1.0576	

year	day	time	TRS (ppm)	
2015	21	1400		
2015	21	1401	1.0349	inlet sampling with ae
2015	21	1402		5 min avg after ramp u
2015	21	1403		
2015	21	1404		
2015	21	1405		
2015	21	1406		
2015	21	1407		
2015	21	1408		
2015	21	1409		
2015	21	1410		
2015	21	1411		
2015	21	1412		
2015	21	1413		
2015	21	1414		
2015	21	1415		
2015	21	1416		
2015	21	1417		
2015	21	1418		
2015	21	1419		
2015	21	1420		
2015	21	1421		
2015	21	1422		
2015	21	1423		
2015	21	1424		
2015	21	1425		
2015	21	1426		
2015	21	1427		
2015	21	1428		
2015	21	1429		
2015	21	1430		
2015	21	1431		
2015	21	1432		
2015	21	1433		
2015	21	1434		
2015	21	1435		
2015	21	1436	0.385333	
2015	21	1437	0.424867	
2015	21	1438	0.3564	
2015	21	1439	0.327733	
2015	21	1440	0.331667	
2015	21	1441	0.3	
2015	21	1442	0.257133	
2015	21	1443	0.283667	
2015	21	1444	0.2862	
2015	21	1445	0.302933	

year	day	time	TRS (ppm)
2015	21	1446	0.355267
2015	21	1447	0.3506
2015	21	1448	0.336133
2015	21	1449	0.325867
2015	21	1450	0.2914
2015	21	1451	0.251333
2015	21	1452	0.270867
2015	21	1453	0.265
2015	21	1454	0.291533
2015	21	1455	0.340867
2015	21	1456	0.3986
2015	21	1457	0.408333
2015	21	1458	0.399467
2015	21	1459	0.3766
2015	21	1500	0.370733
2015	21	1501	0.318067
2015	21	1502	0.3064
2015	21	1503	0.338733
2015	21	1504	0.291467
2015	21	1505	0.2528
2015	21	1506	0.242533
2015	21	1507	0.303067
2015	21	1508	0.3012
2015	21	1509	0.387533
2015	21	1510	0.411267
2015	21	1511	0.506
2015	21	1512	0.497333
2015	21	1513	0.492867
2015	21	1514	0.4712
2015	21	1515	0.476533
2015	21	1516	0.429267
2015	21	1517	0.4104
2015	21	1518	0.428533
2015	21	1519	0.415467
2015	21	1520	0.3954
2015	21	1521	0.375333
2015	21	1522	0.358067
2015	21	1523	0.3322
2015	21	1524	0.375933
2015	21	1525	0.447867
2015	21	1526	0.4816
2015	21	1527	0.499733
2015	21	1528	0.544867
2015	21	1529	0.5488
2015	21	1530	0.474733
2015	21	1531	0.491467

year	day	time	TRS (ppm)	
2015	21	1532	0.5166	
2015	21	1533	0.416933	
2015	21	1534	0.284667	
2015	21	1535		
2015	21	1536		
2015	21	1537		
2015	21	1538	0.374803	scrubber exhaust
2015	21	1539		1hour avg
2015	21	1540		
2015	21	1541		
2015	21	1542		
2015	21	1543		
2015	21	1544		
2015	21	1545		
2015	21	1546		
2015	21	1547		
2015	21	1548		
2015	21	1549		
2015	21	1550	0.35	
2015	21	1551	0.45	
2015	21	1552	0.439	
2015	21	1553	0.55	
2015	21	1554	0.5438	
2015	21	1555	0.558	
2015	21	1556	0.5154	
2015	21	1557	0.4642	
2015	21	1558	0.4996	
2015	21	1559	0.4854	
2015	21	1600	0.4996	
2015	21	1601	0.5264	
2015	21	1602	0.569	
2015	21	1603	0.5406	
2015	21	1604	0.5292	
2015	21	1605	0.5136	
2015	21	1606	0.4994	
2015	21	1607	0.5264	
2015	21	1608	0.515	
2015	21	1609	0.542	
2015	21	1610	0.5662	
2015	21	1611		
2015	21	1612	0.508705	inlet sampling
2015	21	1613		20 min avg

Stack Gas Velocity and Volumetric Flow Rate

Client:	Comox WWTP		
Project #:		**Pitot Coefficient, Cp:**	0.79
Locations:	Main Stack	**Molar Weight Stack Gas:**	29.06
Date:	21-Jan-15	**Moisture, Bws (%):**	1.3%
Time:		**Static Pressure, Pg (" H2O):**	0.5
stack diameter (inches):	30		
Stack Area, (ft2):	4.9		
Barometric Press, Pb (" Hg):	29.80		
Stack Pressure, Ps (" Hg):	29.84		

		Traverse 1				**Traverse 2**			
Point	**Position** (in)	**delta P** (" H_2O)	**Temp (Ts)** (^oF)	**Velocity** (ft/s)	**Cyclonic** Angle	**delta P** (" H_2O)	**Temp (Ts)** (^oF)	**Velocity** (ft/s)	**Cyclonic** Angle
1	2	1.90	52	71.4	0	1.78	52	69.1	0
2	4	1.90	52	71.4	0				
3	6	1.90	52	71.4	0				
4	8	2.00	52	73.3	0				
5	10	1.90	52	71.4	0				
6	12	2.00	52	73.3	0				
7	14	1.80	52	69.5	0				
8	16	1.80	52	69.5	0				
9	18	1.80	52	69.5	0				
10	20	1.90	52	71.4	0				
	22	1.80	52	69.5	0				
	24	1.60	52	65.5	0				
	26	1.5	52	63.5	0				
	28	1.2	52	56.8	0				
Average		**1.79**	**52**	**69.1**		**1.78**	**52**	**69.1**	

Average velocity	(ft/s)	69.1
	(m/s)	21.1
Flow Rate, Qs (actual)	(cfm)	20,357
	(m3/min)	576.4
	(m3/sec)	9.61
Flow Rate, Qs (ref,dry)	(cf/sec)	350
	(m3/sec)	**9.92**

Dry Ref Flow - Actual O2	25oC	9.9	(8.5%O2)
Dry Ref Flow - 11% O2	25oC	-0.9	
	20oC	-0.9	
	0oC	-0.8	

Dry Molecular Weight

O_2	21.8	%
CO_2	1.4	%
CO	0	ppm
N_2	75.9	%
Ar	0.9	%
Md	**29.20**	

Stack Gas Moisture Content

Impinger	Final	Initial	Gain
1			23.6
2			9.9
3			4.1
4			8.5
Total	(g)		**46.1**

Volume of gas sampled

Dry Gas Meter Reading	1,000.00	ft^3
Dry gas meter temp	49	^oF
Orifice Pressure	0.5	" H_2O
Dry gas meter pressure	29.84	
Dgm correction	0.9593	
Total Volume(dry.ref)	**1,009.38**	ft^3

BWS

Volume water vapour	2.2128	ft^3
Moisture (B_{ws})	**0.013**	<assumes 100%RH at 49F

Stack Gas Velocity and Volumetric Flow Rate

Client:	Comox WWTP
Project #:	
Locations:	Blower Inlet
Date:	21-Jan-15
Time:	
stack diameter (inches):	30
Stack Area, (ft2):	4.9
Barometric Press, Pb (" Hg):	29.80
Stack Pressure, Ps (" Hg):	29.43

Pitot Coefficient, Cp:	0.79
Molar Weight Stack Gas:	29.07
Moisture, Bws (%):	1.2%
Static Pressure, Pg (" H2O):	-5

		Traverse 1				Traverse 2			
Point	**Position** (in)	**delta P** (" H_2O)	**Temp (Ts)** (^oF)	**Velocity** (ft/s)	**Cyclonic** Angle	**delta P** (" H_2O)	**Temp (Ts)** (^oF)	**Velocity** (ft/s)	**Cyclonic** Angle
1	2	1.50	49	63.7	0	2.00	49	73.5	0
2	4	1.70	49	67.8	0	2.00	49	73.5	0
3	6	1.70	49	67.8	0	1.80	49	69.8	0
4	8	1.60	49	65.8	0	1.80	49	69.8	0
5	10	1.50	49	63.7	0	1.80	49	69.8	0
6	12	1.50	49	63.7	0	1.70	49	67.8	0
7	14	1.50	49	63.7	0	1.70	49	67.8	0
8	16	1.60	49	65.8	0	1.70	49	67.8	0
9	18	1.60	49	65.8	0	1.70	49	67.8	0
10	20	1.40	49	61.5	0	1.70	49	67.8	0
	22	1.20	49	57.0	0	1.70	49	67.8	0
	24	1.10	49	54.5	0	1.70	49	67.8	0
	26	1	49	52.0	0	1.7	49	67.8	0
	28	1.1	49	54.5	0	1.5	49	63.7	0
Average		**1.43**	**49**	**62.0**		**1.75**	**49**	**68.8**	

Average velocity	(ft/s)	65.4
	(m/s)	19.9
Flow Rate, Qs (actual)	(cfm)	19,248
	(m3/min)	545.1
	(m3/sec)	9.08
Flow Rate, Qs (ref,dry)	(cf/sec)	329
	(m3/sec)	**9.32**

Dry Molecular Weight

O_2	21.8	%
CO_2	1.4	%
CO	0	ppm
N_2	75.9	%
Ar	0.9	%
Md	**29.20**	

Stack Gas Moisture Content

Impinger	Final	Initial	Gain
1			23.6
2			9.9
3			4.1
4			8.5
Total	(g)		**46.1**

Volume of gas sampled

Dry Gas Meter Reading	1,000.00	ft^3
Dry gas meter temp	49	^oF
Orifice Pressure	0.5	" H_2O
Dry gas meter pressure	29.84	
Dgm correction	0.9593	
Total Volume(dry.ref)	**1,009.38**	ft^3

BWS

Volume water vapour	2.2128	ft^3
Moisture (B_{ws})	**0.012**	<assumes 100%RH at 49F

APPENDIX B

ODOUR EVALUATION REPORT

FINAL

Odour Evaluation Report

2470 Milltower Court
Mississauga, ON
L5N 7W5

Prepared for:

John DeYoe

RWDI
830-999 West Broadway Road
Vancouver, BC, V5Z 1K5

February 3, 2015

Pinchin File: 23026-012315

MEMBER OF
THE PINCHIN GROUP

Issued to: RWDI
Contact: John DeYoe

Issued on: February 3, 2015
Pinchin file: 23026-012315
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APPENDICES

MEMBER OF THE PINCHIN GROUP

1.0 EVALUATION SAMPLE & TIMING SUMMARY

Pinchin Ltd. (Pinchin) was contracted to determine the detection threshold (DT), recognition threshold (RT), hedonic tone (HT) and character of air samples submitted to Pinchin's Odour Laboratory located in Mississauga, Ontario. The particulars of the odour panel were as follows:

Client Name:	RWDI
No. of Samples Delivered:	6
Date Samples Received:	January 23, 2015
Condition of the Sample Bags on Arrival:	No leaks or condensation detected.
No. of Samples Analyzed:	6
Date of Odour Panel Analysis:	January 23, 2015
Time of Odour Panel Analysis:	9:37 – 11:44 AM

2.0 METHODOLOGY

2.1 Laboratory Methodology

All samples were evaluated in accordance with the Ministry of the Environment "Ontario Source Testing Code" (OSTC), Version #3, June 2010 (Part G, Method ON-6), using an AC'SCENT International triangular forced-choice, ascending concentration, dynamic dilution Olfactometer. A listing of Standard Practices to which the evaluations conform is provided in Appendix IV.

The AC'SCENT Olfactometer was calibrated according to the manufacturer's guidelines on the day of sample evaluation. The CHEMFLUOR® PTFE tubing through which the odour sample is presented to the panellists was replaced prior to the assessment session. All sample delivery lines were purged continuously with odour free air between sample presentations.

A panel of eight trained assessors was employed in the evaluation of the odour samples. Each panel is screened for accuracy and repeatability following the procedures outlined in British Standard, BS EN 13725:2003, "Air quality – Determination of odour concentration by dynamic olfactometry", utilizing 50 ppm n-butanol calibration gas prior to sample evaluation. The geometric mean of the individual threshold estimates for 50 ppm n-butanol was determined to be between 20 and 80 ppb/v.

The odour samples were presented to the panellists using the "triangular forced-choice" method, described by ASTM E679-04, "Standard Practice for Determination of Odour and Taste Thresholds By a Forced-Choice Ascending Concentration Series Method of Limits". Each panellist evaluated the odour by "sniffing" the diluted odour samples presented by the Olfactometer. At each dilution level, the panellist "sniffed" three sample presentations, two of which were blank, odour free samples and one that contained the odorous air. The panellist was then asked to identify which of the three presentations was different from the other two by recording a "guess", "detect" or "recognize" response as defined by ASTM E679-04.

A "guess" response was recorded when the assessor could not distinguish between any of the presentations. A "detect" response was recorded when the assessor could differentiate the odorous sample from the two blanks, and "recognize" was recorded when the assessor could identify and describe the odorous sample.

As per BS EN 13725:2003, each sample assessment began with the Olfactometer diluting the odorous sample to sub-detection levels. The odour sample and two blanks were then presented to one panellist, who "sniffed" the three presentations and recorded their response. The concentration of odorous gas was then doubled and re-presented to the same assessor with two blanks. Again, the assessor "sniffed" the three presentations and recorded their response. The process continued with the concentration of odorous gas increasing until the panellist had correctly detected the odour in at least two consecutive presentations as described by BS EN 13725:2003. The process was repeated for each panellist until all samples were evaluated.

Sample analysis was conducted "blind"; neither the panellist nor the test administrator knew which port would deliver the odour sample. Panellist's results were recorded and analyzed using AC'SCENT DataSense Olfactometry software integrated with the Olfactometer. The software incorporates an Access database program designed specifically for olfactometry laboratories and is compatible with international olfactometry standards including BS EN 13725:2003 and ASTM E679-04.

As part of laboratory Quality Assurance and Quality Control (QAQC), test results were retrospectively screened in accordance with BS EN 13725:2003. As the standard requires, each assessor's individual threshold estimate (Z_{ITE}) was compared to the panel's average threshold, with the ratio between the individual threshold estimate and the panel average threshold represented as ΔZ. Assessors having a ΔZ greater than 5.0 or lower than -5.0, were eliminated from the results. The purpose was to exclude panel members that showed deviant responses due to health factors or specific hyperosmia or anosmia for the odour of the analyzed sample. Where screening was required, both the screened and unscreened results were provided.

2.2 Odour Evaluation Parameters

2.2.1 Odour Threshold Values – Detection Threshold (DT)

The detection threshold (DT) is the dilution ratio at which 50% of the panellists correctly detected the odour. DT, as defined by ASTM E679-04, is synonymous with the MOE definition of an odour threshold value (ED_{50}) and the BS EN 13725:2003 definition of odour concentration (C_{OD}). That is, the DT represents the amount of dilution required for the odour to be just detectable. Since DT values are dimensionless, pseudo-dimensions of odour units per unit volume (i.e. odour units per cubic metre (ou/m^3)) are often used for reporting purposes.

In accordance with BS EN 13725:2003, individual threshold estimates (Z_{ITE}) were calculated as the geometric mean of the lowest dilution ratio where the odour could not be detected and the dilution ratio at which the panellist correctly detected the odour. Where a detection response could not be established at the Olfactometer's dilution limit, it was assumed that the panellist would have detected the odour at a dilution ratio half that of the limit, and the Z_{ITE} was calculated. The sample odour concentration (C_{OD}) was then calculated as the geometric mean of the Z_{ITE} values.

2.2.2 Odour Threshold Values – Recognition Threshold (RT)

The recognition threshold (RT), as defined by ASTM E679-04 is the dilution ratio at which the assessor first detects the odour's character (i.e. the odour "smells like...") or the dilution level at which 50% of the panellists correctly recognized the odour.

RT was evaluated following the same procedure as outlined for DT except once the assessor correctly detected the odour, the process continued with the concentration of odorous gas increasing until the panellist had correctly recognized the odour in at least two consecutive presentations. The process was repeated for each panellist until all samples were evaluated.

Calculations for RT were based on the BS EN 13725:2003 procedures for the determination of odour concentration (C_{OD}) where the individual recognition threshold estimates were calculated as the geometric mean of the lowest dilution ratio where the odour could not be recognized and the dilution ratio at which the panellist correctly recognized the odour. Where a recognition response could not be established at the Olfactometer's dilution limit, it was assumed that the panellist would have recognized the odour at a dilution ratio half that of the limit, and the individual recognition threshold estimate was calculated. The sample RT was then calculated as the geometric mean of the individual recognition threshold estimates.

2.2.3 Hedonic Tone (HT)

Hedonic tone (HT) is a measure of the pleasantness or unpleasantness of an odour sample and is independent of its character. Odours are commonly ranked by hedonic tone using the following 21 point scale:

+10	Most Pleasant
0	Neutral
-10	Least Pleasant

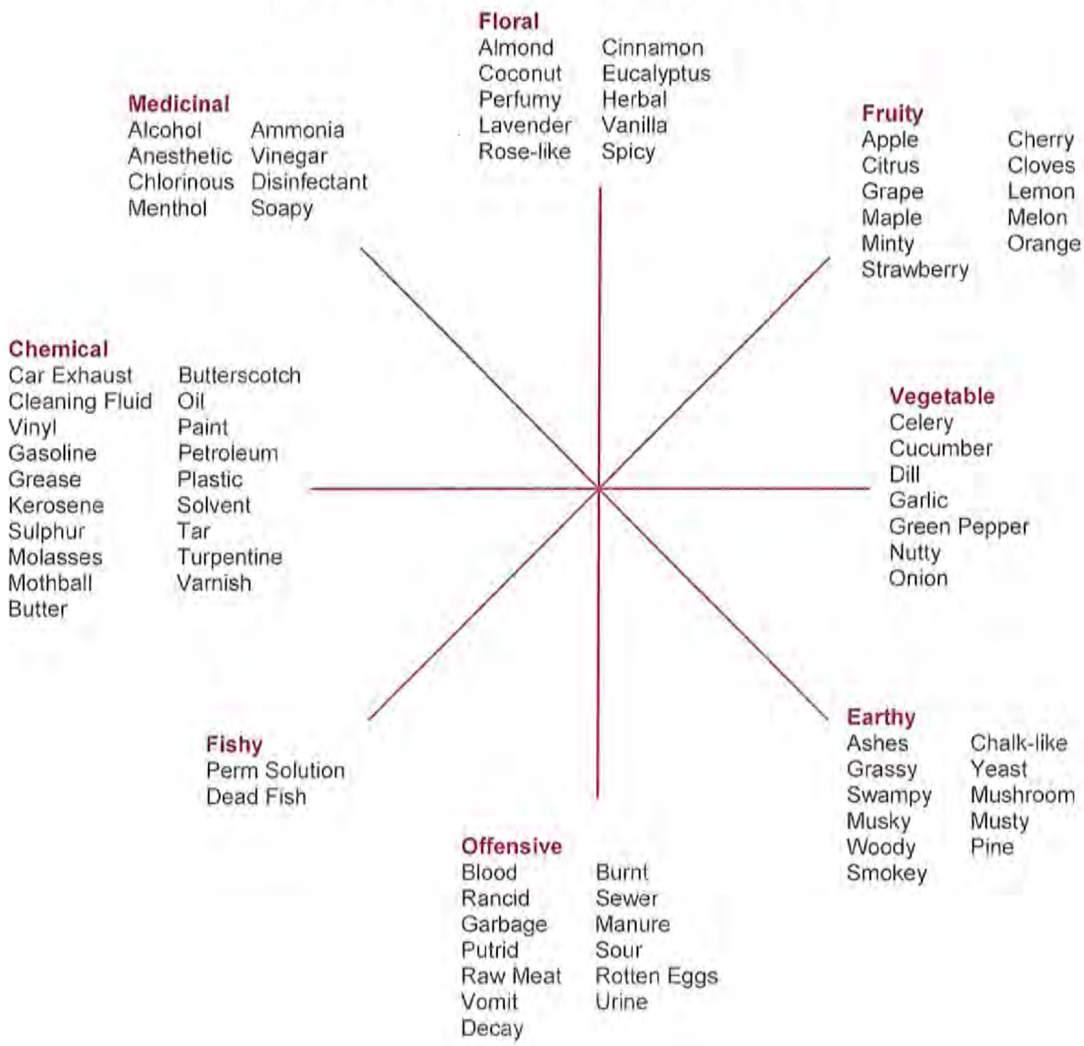
Prior to evaluating a sample for HT, each panellist was provided with a copy of an odour descriptor data collection form. For each sample requiring HT, the recognition threshold (RT) was determined by following the procedures outlined above. Once the panellist had correctly recognized the odour in two consecutive responses, the panellist was asked to mark the box corresponding to the point on the 21 point scale which best described the "pleasantness" of the odour. HT evaluation is done independently by each panellist without the consultation of the other panel members or the test administrator.

The average of the individual HT values was reported as the HT for the sample. If the panellist was unable to recognize the odour at the Olfactometer's dilution limit, that panellist was eliminated from the calculation of the sample HT.

2.2.4 Odour Character

There are numerous odour wheels available for use as a referencing vocabulary when describing an odour's character. The eight recognized odour categories include "Vegetable", "Fruity", "Floral", "Medicinal", "Chemical", "Fishy", "Offensive" and "Earthy". Each of the eight odour categories includes a list of specific descriptors to be used for further odour character analysis. The odour wheel currently used as Pinchin is shown in the figure below (Figure 1).

Figure 1: Odour Character Reference Vocabulary Wheel



Prior to evaluating a sample for odour character, each panellist was provided with a copy of an odour descriptor data collection form. For each sample requiring characterization, the recognition threshold (RT) was determined by following the procedures outlined above. If a panellist was unable to recognize the odour at the Olfactometer's dilution limit, that panellist was eliminated from odour character evaluations. Once the panellist had correctly recognized the odour in two consecutive responses, the panellist was asked to indicate which of the eight general odour categories best described the odour. In addition, the assessor was asked to mark the box corresponding to the strength of the odour within that general category. The odour strength is referred to as the relative odour intensity.

The relative odour intensity was determined using a 5 point scale. The number "1" corresponds to a mild odour and "5" corresponds to a strong odour. Assessors were given the option to choose as many general categories as required to describe the odour. The eight general odour categories were presented on a spider graph with each extension representing a scale of 0 to 5, referencing relative intensity (mild to strong). The intensity is the average of the individual intensity scores reported for that category. General odour categories showing a "0" were not used by the panellists in the odour's general character description.

Once the general odour character section was complete, the assessors were asked to indicate specific odour descriptors. Assessors were given the option to choose as many specific descriptors as required to describe the odour and to add their own descriptions as required. A histogram was used to present the percentage of assessors that assigned specific descriptors to the odour sample.

All odour character evaluation is done independently by each panellist without the consultation of the remainder of the panel or the test administrator.

3.0 RESULTS

3.1 Odour Threshold Values – Detection Threshold (DT) & Recognition Threshold (RT)

The odour threshold value results for detection threshold (DT) and recognition threshold (RT) are presented in Table 1. Where appropriate, the DT and RT values have been adjusted for field pre-dilution reported by the client. The adjusted DT and RT values are recorded as DT_{NET} and RT_{NET}, respectively. Datasheets are provided in Appendix I.

Table 1 – Odour Threshold Value Results

Odour Evaluation Results

Client: RWDI

Pinchin Project No.: 23026

Client Project No.:

Test Reference No.: 23026-012315

Evaluation Date: 23-Jan-15

Lab No.	Field Number/ Description	Dilution Factor	Evaluation Time	Detection		Recognition		Comments
				DT	DT_{NET}	RT	RT_{NET}	
PO15-23026-J1395	OUT1	4.5 :1	9:37 - 9:57 AM	721	3245	279	1256	
PO15-23026-J1396	OUT2	4.5 :1	9:58 - 10:18 AM	663	2984	332	1494	
PO15-23026-J1397	OUT3	4.5 :1	10:19 - 10:34 AM	935	4208	430	1935	
PO15-23026-J1398	IN1	5.2 :1	10:36 - 10:58 AM	1114	5793	511	2657	
PO15-23026-J1399	IN2	5.2 :1	11:01 - 11:21 AM	1020	5304	468	2434	
PO15-23026-J1400	IN3	5.2 :1	11:24 - 11:44 AM	1324	6885	468	2434	

DT_{NET} - Results have been adjusted for field dilution
RT_{NET} - Results have been adjusted for field dilution
Presentation Flow Rate = 20 litres per minute

Odour Evaluation Report Nomenclature

DT Detection Threshold

RT Recognition Threshold

DT_{NET} Detection Threshold adjusted for field dilution

RT_{NET} Recognition Threshold adjusted for field dilution

3.2 Hedonic Tone (HT) & Odour Character

The hedonic tone (HT) values are presented in Table 2. The relative odour intensities and corresponding general odour character for each sample are represented in the spider graphs attached as Appendix II.

Specific descriptors were the second part of the odour character evaluation. The histograms found in Appendix III present the percentage of assessors that assigned specific descriptors to the odour sample. The results summary is provided in Table 2.

Table 2 – Hedonic Tone & Odour Character Results

Odour Characterization Results

Client:	**RWDI**	**Test Reference No.:**	**23026-012315**
Pinchin Project No.:	**23026**	**Evaluation Date:**	**23-Jan-15**
Client Project No.:		**Evaluation Time:**	**9:37 - 11:44 AM**

Lab No.	**Field No. Description**	**Average HT**	**Range HT**	**Primary Descriptor**	**Specific Descriptors[1]**
PO15-23026-J1395	OUT1	-2	-8 to 3	Offensive	Car exhaust, earthy, **garbage**, kerosene, **offensive**, putrid, sewer, smoky, swampy.
PO15-23026-J1396	OUT2	-3	-7 to 2	Offensive	Burnt, earthy, **garbage**, offensive, rancid, sewer, swampy.
PO15-23026-J1397	OUT3	-3	-10 to 3	Offensive	Earthy, garbage, **offensive**, rancid, raw meat, sewer, swampy, vomit.
PO15-23026-J1398	IN1	-3	-10 to 4	Offensive	Earthy, **garbage**, offensive, onion, rancid, **sewer**, smoky, sour, swampy, vomit.
PO15-23026-J1399	IN2	-2	-8 to 3	Offensive	Apple, earthy, fruity, **garbage**, musky, musty, offensive, onion, rancid, sewer, swampy, vegetable.
PO15-23026-J1400	IN3	-2	-6 to 4	Offensive	Earthy, fruity, **garbage**, manure, melon, mushroom, musty, offensive, rancid, **sewer**, sour.

Odour Evaluation Report Nomenclature

HT Hedonic Tone

Note 1 – The most commonly selected specific descriptor(s) for a sample are presented in **Bold**.

23026-012315 RWDI Odour Lab Report

Template: 14852 – Report Template for Recognition Threshold & Characterization - September 19, 2014

APPENDIX I

Odour Evaluation Data Sheets

Pinchin File: 23026-012315

(6 Pages)

Olfactometer Evaluation Results
AC'SCENT International Olfactometer

Test Name : RWDI **Test No. :** 23026-012315 **Test Date :** 1/23/2015

Test Administrator : Jessie Elder **Test Method :** Triangular Forced Choice

Flow Rate (lpm) : 20 **Sniff Time (sec) :** 3

Sample Information

Lab No. : PO15-23026-J1395 **Field No. :** OUT1

Description : 4.5:1

Sampling Date : 1/22/2015

Sampling Time :

Sample Collector : RWDI

Sample Source : Unknown

Dilution Level	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Sample Volume	0.31	0.58	1.24	2.50	4.94	9.9	19.8	39.7	78.05	157	314	627	1257.8	2534.2
Total Volume	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150
Dilution Ratio	65,000	34,741	16,250	8,060	4,079	2,046	1,020	507	258	128	64.2	32.1	16.0	8.0
Geometric Mean	91,924	47,520	23,760	11,444	5,734	2,889	1,444	719	362	182	91	45.4	22.7	11.3
Log (Geo. Mean)	4.96	4.68	4.38	4.06	3.76	3.46	3.16	2.86	2.56	2.26	1.96	1.66	1.36	1.05

Calibration Date : 1/23/2015

THRESHOLDS

G = Guess

D = Detection

R = Recognition

Assessor/Round		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Log G	Log D	Log R
14853-665	1						2	1	1	1	6	8	8			2.26	2.26	1.96
00001	1						1	1	6	6	8	8				2.86	2.86	2.26
14853-668	1						1	1	6	8	8					2.86	2.86	2.56
14853-917	1						2	1	6	6	8	8				2.86	2.86	2.26
14853-671	1						1	6	8	8						3.16	3.16	2.86
14853-719	1						1	6	8	8						3.16	3.16	2.86
000100	1						1	2	6	8	8					3.16	2.86	2.56
14853-787	1						2	1	6	6	8	8				2.86	2.86	2.26

Sample Comments :

Specific Chemical Concentration Data

Chemical : n/a

Concentration (ppm) :

Response Key:

1 = Incorrect Guess
2 = Correct Guess
5 = Incorrect Detection
6 = Correct Detection
7 = Incorrect Recognition
8 = Correct Recognition

Final Results

	G	D	R
Avg. Log Value	2.90	2.86	2.45
Std. Dev.	0.30	0.28	0.32
Threshold	787	721	279

Olfactometer Evaluation Results
AC'SCENT International Olfactometer

Test Name : RWDI **Test No. :** 23026-012315 **Test Date :** 1/23/2015

Test Administrator : Jessie Elder **Test Method :** Triangular Forced Choice

Flow Rate (lpm) : 20 **Sniff Time (sec) :** 3

Sample Information

Lab No. : PO15-23026-J1396 **Field No. :** OUT2 **Sampling Date :** 1/22/2015

Sampling Time :

Description : 4.5:1

Sample Collector : RWDI

Sample Source : unknown

Dilution Level	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Sample Volume	0.31	0.58	1.24	2.50	4.94	9.9	19.8	39.7	78.05	157	314	627	1257.8	2534.2
Total Volume	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150
Dilution Ratio	65,000	34,741	16,250	8,060	4,079	2,046	1,020	507	258	128	64.2	32.1	16.0	8.0
Geometric Mean	91,924	47,520	23,760	11,444	5,734	2,889	1,444	719	362	182	91	45.4	22.7	11.3
Log (Geo. Mean)	4.96	4.68	4.38	4.06	3.76	3.46	3.16	2.86	2.56	2.26	1.96	1.66	1.36	1.05

Calibration Date : 1/23/2015

THRESHOLDS
G = Guess
D = Detection
R = Recognition

Assessor/Round		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Log G	Log D	Log R
14853-665	1						2	5	5	5	6	8	8			2.26	2.26	1.96
00001	1						2	6	8	8						3.46	3.16	2.86
14853-668	1						1	8	8							3.16	3.16	3.16
14853-917	1						2	2	6	8	8					3.46	2.86	2.56
14853-671	1						2	5	6	8	8					2.86	2.86	2.56
14853-719	1						2	1	6	8	8					2.86	2.86	2.56
000100	1						1	2	1	1	6	8	8			2.26	2.26	1.96
14853-787	1						1	6	6	8	8					3.16	3.16	2.56

Sample Comments :

Specific Chemical Concentration Data

Chemical : n./a

Concentration (ppm) :

Response Key:
1 = Incorrect Guess
2 = Correct Guess
5 = Incorrect Detection
6 = Correct Detection
7 = Incorrect Recognition
8 = Correct Recognition

Final Results

	G	D	R
Avg. Log Value	2.93	2.82	2.52
Std. Dev.	0.47	0.37	0.41
Threshold	860	663	332

Olfactometer Evaluation Results
AC'SCENT International Olfactometer

Test Name : RWDI **Test No. :** 23026-012315 **Test Date :** 1/23/2015

Test Administrator : Jessie Elder **Test Method :** Triangular Forced Choice

Flow Rate (lpm) : 20 **Sniff Time (sec) :** 3

Sample Information

Lab No. : PO15-23026-J1397 **Field No. :** OUT3

Description : 4.5:1

Sampling Date : 1/22/2015

Sampling Time :

Sample Collector : RWDI

Sample Source : unknown

Dilution Level	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Sample Volume	0.31	0.58	1.24	2.50	4.94	9.9	19.8	39.7	78.05	157	314	627	1257.8	2534.2
Total Volume	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150
Dilution Ratio	65,000	34,741	16,250	8,060	4,079	2,046	1,020	507	258	128	64.2	32.1	16.0	8.0
Geometric Mean	91,924	47,520	23,760	11,444	5,734	2,889	1,444	719	362	182	91	45.4	22.7	11.3
Log (Geo. Mean)	4.96	4.68	4.38	4.06	3.76	3.46	3.16	2.86	2.56	2.26	1.96	1.66	1.36	1.05

Calibration Date : 1/23/2015

THRESHOLDS
G = Guess
D = Detection
R = Recognition

Assessor/Round		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Log G	Log D	Log R
14853-665	1						2	2	6	8	8					3.46	2.86	2.56
00001	1						1	6	8	8						3.16	3.16	2.86
14853-668	1						1	6	8	8						3.16	3.16	2.86
14853-917	1						1	2	6	8	8					3.16	2.86	2.56
14853-671	1						1	6	8	8						3.16	3.16	2.86
14853-719	1						1	2	6	8	8					3.16	2.86	2.56
000100	1						1	1	1	6	8	8				2.56	2.56	2.26
14853-787	1						2	6	6	8	8					3.46	3.16	2.56

Sample Comments :

Specific Chemical Concentration Data

Chemical : n./a

Concentration (ppm) :

Response Key:
1 = Incorrect Guess
2 = Correct Guess
5 = Incorrect Detection
6 = Correct Detection
7 = Incorrect Recognition
8 = Correct Recognition

Final Results

	G	D	R
Avg. Log Value	3.16	2.97	2.63
Std. Dev.	0.28	0.22	0.21
Threshold	1,445	935	430

Olfactometer Evaluation Results
AC'SCENT International Olfactometer

Test Name : RWDI **Test No. :** 23026-012315 **Test Date :** 1/23/2015

Test Administrator : Jessie Elder **Test Method :** Triangular Forced Choice

Flow Rate (lpm) : 20 **Sniff Time (sec) :** 3

Sample Information

Lab No. : PO15-23026-J1398 **Field No. :** IN1

Description : 5.2:1

Sampling Date : 1/22/2015

Sampling Time :

Sample Collector : RWDI

Sample Source : unknown

Dilution Level	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Sample Volume	0.31	0.58	1.24	2.50	4.94	9.9	19.8	39.7	78.05	157	314	627	1257.8	2534.2
Total Volume	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150
Dilution Ratio	65,000	34,741	16,250	8,060	4,079	2,046	1,020	507	258	128	64.2	32.1	16.0	8.0
Geometric Mean	91,924	47,520	23,760	11,444	5,734	2,889	1,444	719	362	182	91	45.4	22.7	11.3
Log (Geo. Mean)	4.96	4.68	4.38	4.06	3.76	3.46	3.16	2.86	2.56	2.26	1.96	1.66	1.36	1.05

Calibration Date : 1/23/2015

THRESHOLDS
G = Guess
D = Detection
R = Recognition

Assessor/Round		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Log G	Log D	Log R
14853-665	1					2	1	6	8	8						3.16	3.16	2.86
00001	1					2	2	1	6	8	8					2.86	2.86	2.56
14853-668	1					1	6	8	8							3.46	3.46	3.16
14853-917	1					2	2	6	8	8						3.76	3.16	2.86
14853-671	1					2	6	8	8							3.76	3.46	3.16
14853-719	1					2	6	5	1	8	8					2.56	2.56	2.56
000100	1					1	1	2	2	6	6	8	8			3.16	2.56	1.96
14853-787	1					1	2	6	6	8	8					3.46	3.16	2.56

Sample Comments :

Specific Chemical Concentration Data

Chemical : n./a

Concentration (ppm) :

Response Key:
1 = Incorrect Guess
2 = Correct Guess
5 = Incorrect Detection
6 = Correct Detection
7 = Incorrect Recognition
8 = Correct Recognition

Final Results

	G	D	R
Avg. Log Value	3.27	3.05	2.71
Std. Dev.	0.42	0.36	0.39
Threshold	1,869	1,114	511

Olfactometer Evaluation Results
AC'SCENT International Olfactometer

Test Name : RWDI **Test No. :** 23026-012315 **Test Date :** 1/23/2015

Test Administrator : Jessie Elder **Test Method :** Triangular Forced Choice

Flow Rate (lpm) : 20 **Sniff Time (sec) :** 3

Sample Information

Lab No. : PO15-23026-J1399 **Field No. :** IN2 **Sampling Date :** 1/22/2015

Sampling Time :

Description : 5.2:1 **Sample Collector :** RWDI

Sample Source : unknown

Dilution Level	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Calibration Date : 1/23/2015		
Sample Volume	0.31	0.58	1.24	2.50	4.94	9.9	19.8	39.7	78.05	157	314	627	1257.8	2534.2			
Total Volume	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	THRESHOLDS		
Dilution Ratio	65,000	34,741	16,250	8,060	4,079	2,046	1,020	507	258	128	64.2	32.1	16.0	8.0	G = Guess		
Geometric Mean	91,924	47,520	23,760	11,444	5,734	2,889	1,444	719	362	182	91	45.4	22.7	11.3	D = Detection		
Log (Geo. Mean)	4.96	4.68	4.38	4.06	3.76	3.46	3.16	2.86	2.56	2.26	1.96	1.66	1.36	1.05	R = Recognition		
Assessor/Round															**Log G**	**Log D**	**Log R**
14853-665 1					1	1	2	6	8	8					3.16	2.86	2.56
00001 1					1	1	6	8	8						3.16	3.16	2.86
14853-668 1					1	1	6	8	8						3.16	3.16	2.86
14853-917 1					1	2	6	8	8						3.46	3.16	2.86
14853-671 1					1	6	5	8	8						2.86	2.86	2.86
14853-719 1					1	2	6	8	8						3.46	3.16	2.86
000100 1					1	2	2	2	6	8	8				3.46	2.56	2.26
14853-787 1					1	2	6	6	6	8	8				3.46	3.16	2.26

Sample Comments :

Specific Chemical Concentration Data

Chemical : n./a

Concentration (ppm) :

Response Key:

1 = Incorrect Guess
2 = Correct Guess
5 = Incorrect Detection
6 = Correct Detection
7 = Incorrect Recognition
8 = Correct Recognition

Final Results

	G	D	R
Avg. Log Value	3.27	3.01	2.67
Std. Dev.	0.22	0.23	0.27
Threshold	1,872	1,020	468

Olfactometer Evaluation Results
AC'SCENT International Olfactometer

Test Name : RWDI **Test No. :** 23026-012315 **Test Date :** 1/23/2015

Test Administrator : Jessie Elder **Test Method :** Triangular Forced Choice

Flow Rate (lpm) : 20 **Sniff Time (sec) :** 3

Sample Information

Lab No. : PO15-23026-J1400 **Field No. :** IN3

Description : 5.2:1

Sampling Date : 1/22/2015

Sampling Time :

Sample Collector : RWDI

Sample Source : unknown

Dilution Level	1	2	3	4	5	6	7	8	9	10	11	12	13	14			
Sample Volume	0.31	0.58	1.24	2.50	4.94	9.9	19.8	39.7	78.05	157	314	627	1257.8	2534.2	Calibration Date : 1/23/2015		
Total Volume	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	20,150	THRESHOLDS		
Dilution Ratio	65,000	34,741	16,250	8,060	4,079	2,046	1,020	507	258	128	64.2	32.1	16.0	8.0	G = Guess		
Geometric Mean	91,924	47,520	23,760	11,444	5,734	2,889	1,444	719	362	182	91	45.4	22.7	11.3	D = Detection		
Log (Geo. Mean)	4.96	4.68	4.38	4.06	3.76	3.46	3.16	2.86	2.56	2.26	1.96	1.66	1.36	1.05	R = Recognition		
Assessor/Round															**Log G**	**Log D**	**Log R**
14853-665 1					2	1	2	6	8	8					3.16	2.86	2.56
00001 1					1	6	6	8	8						3.46	3.46	2.86
14853-668 1					1	1	6	8	8						3.16	3.16	2.86
14853-917 1					2	1	6	8	8						3.16	3.16	2.86
14853-671 1					1	6	6	8	8						3.46	3.46	2.86
14853-719 1					2	1	6	8	8						3.16	3.16	2.86
000100 1					2	1	1	1	6	6	8	8			2.56	2.56	1.96
14853-787 1					1	2	6	6	8	8					3.46	3.16	2.56

Sample Comments :

Specific Chemical Concentration Data

Chemical : n./a

Concentration (ppm) :

Response Key:

1 = Incorrect Guess
2 = Correct Guess
5 = Incorrect Detection
6 = Correct Detection
7 = Incorrect Recognition
8 = Correct Recognition

Final Results

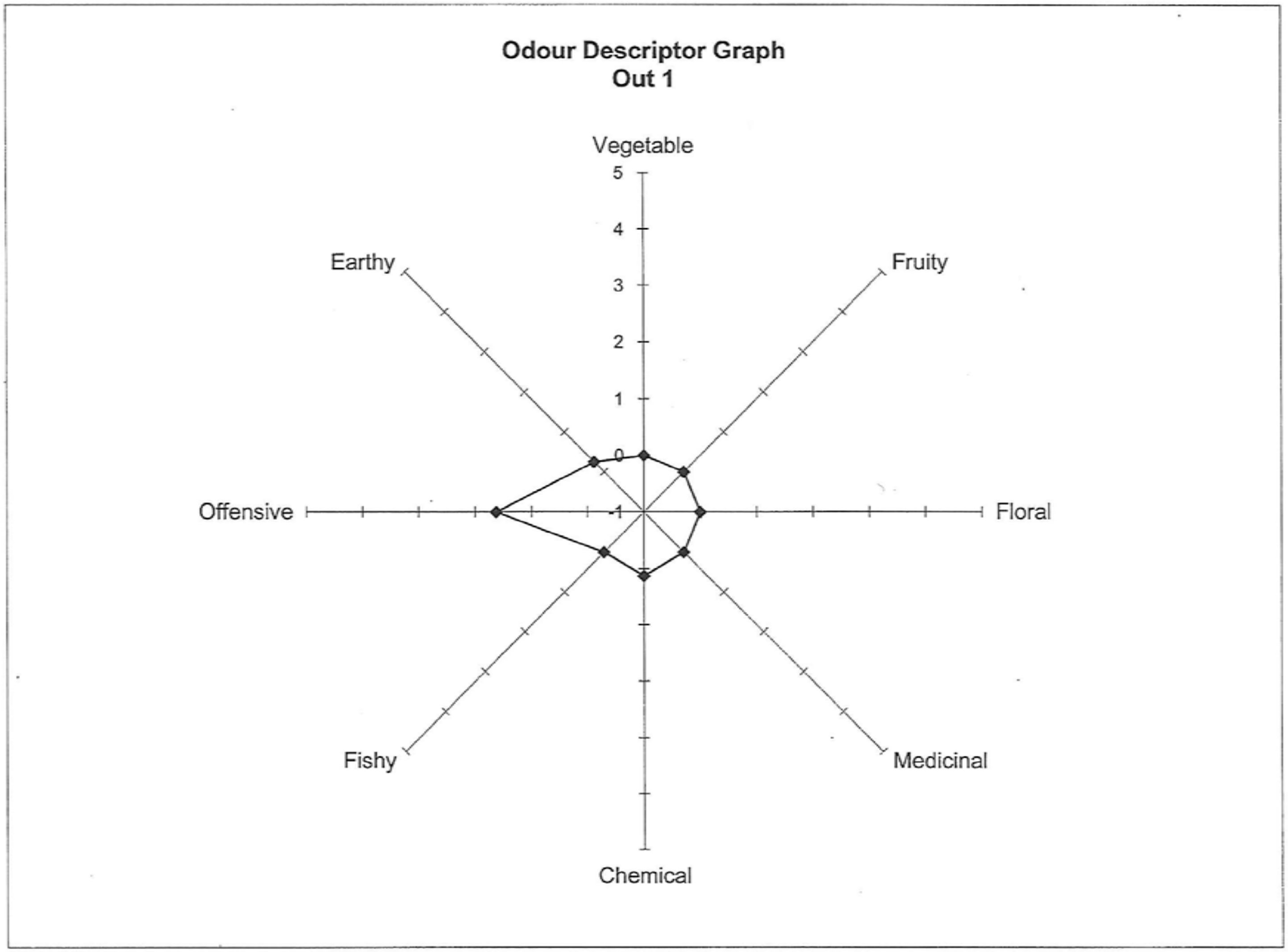
	G	D	R
Avg. Log Value	3.20	3.12	2.67
Std. Dev.	0.30	0.30	0.32
Threshold	1,575	1,324	468

APPENDIX II

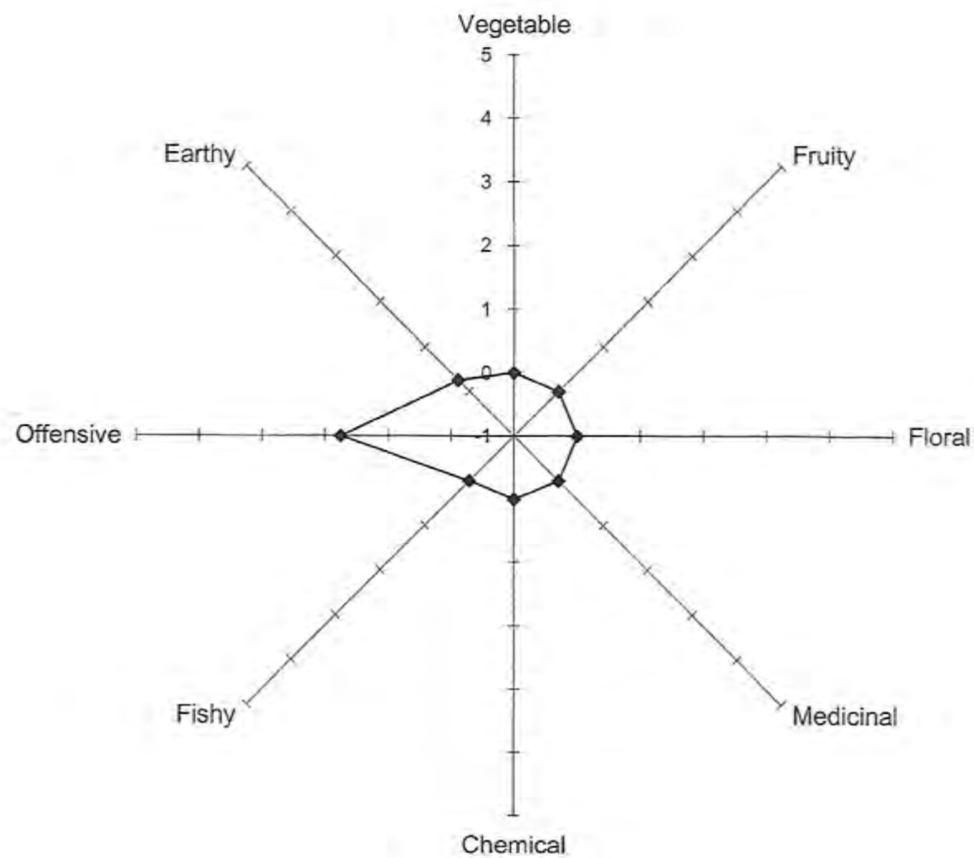
Relative Odour Intensity Spider Graphs

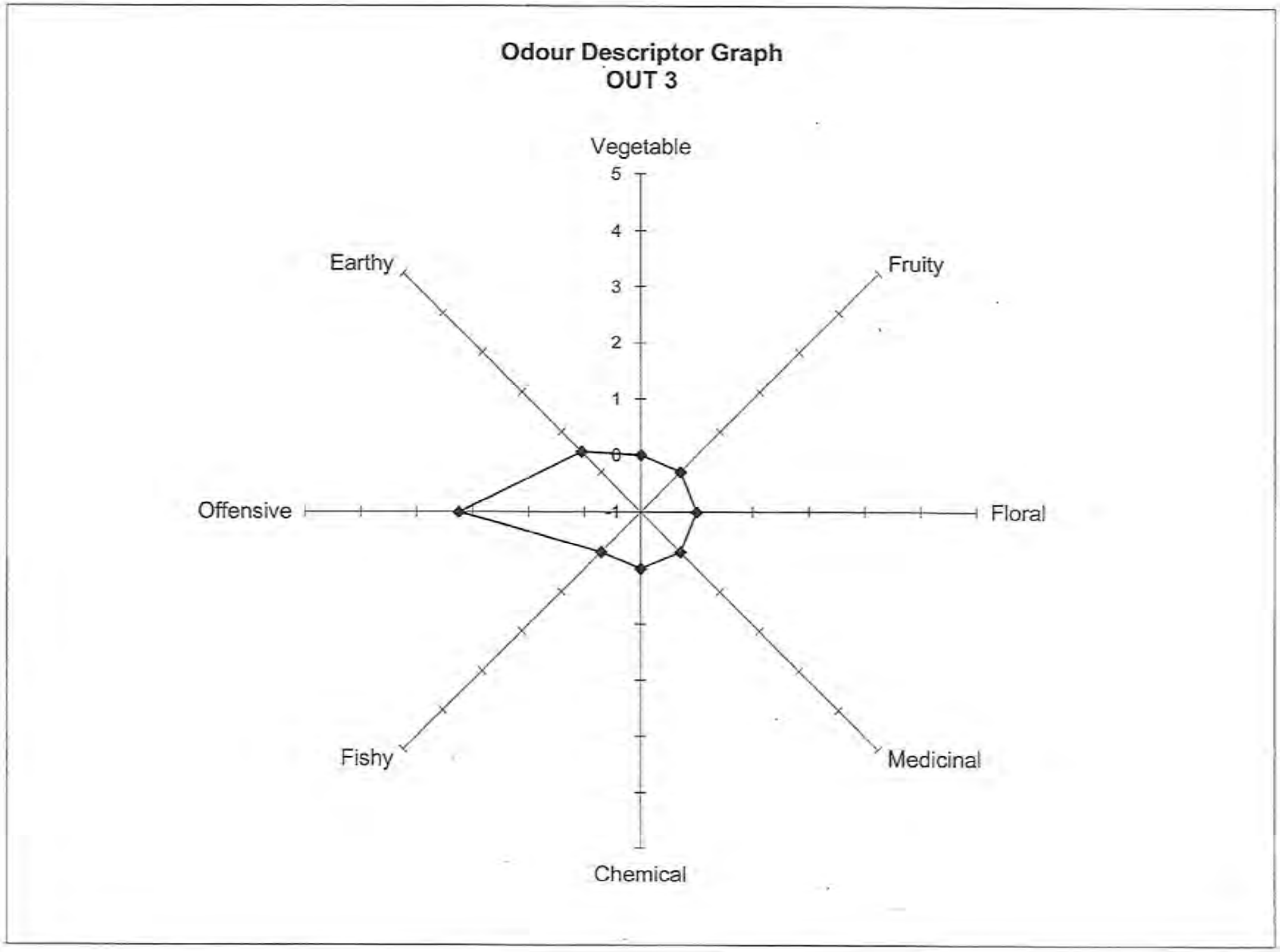
Pinchin File: 23026-012315

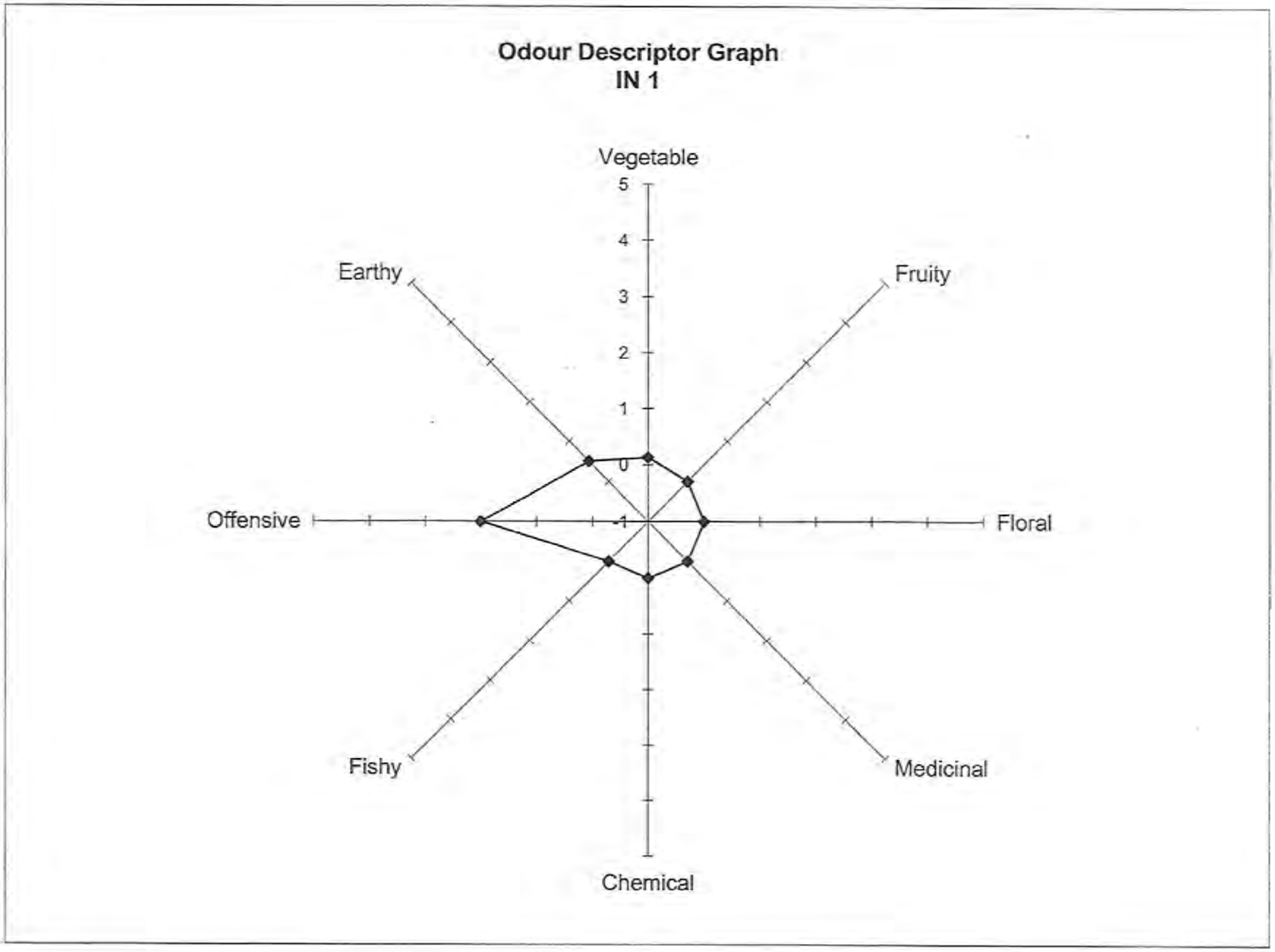
(6 Pages)

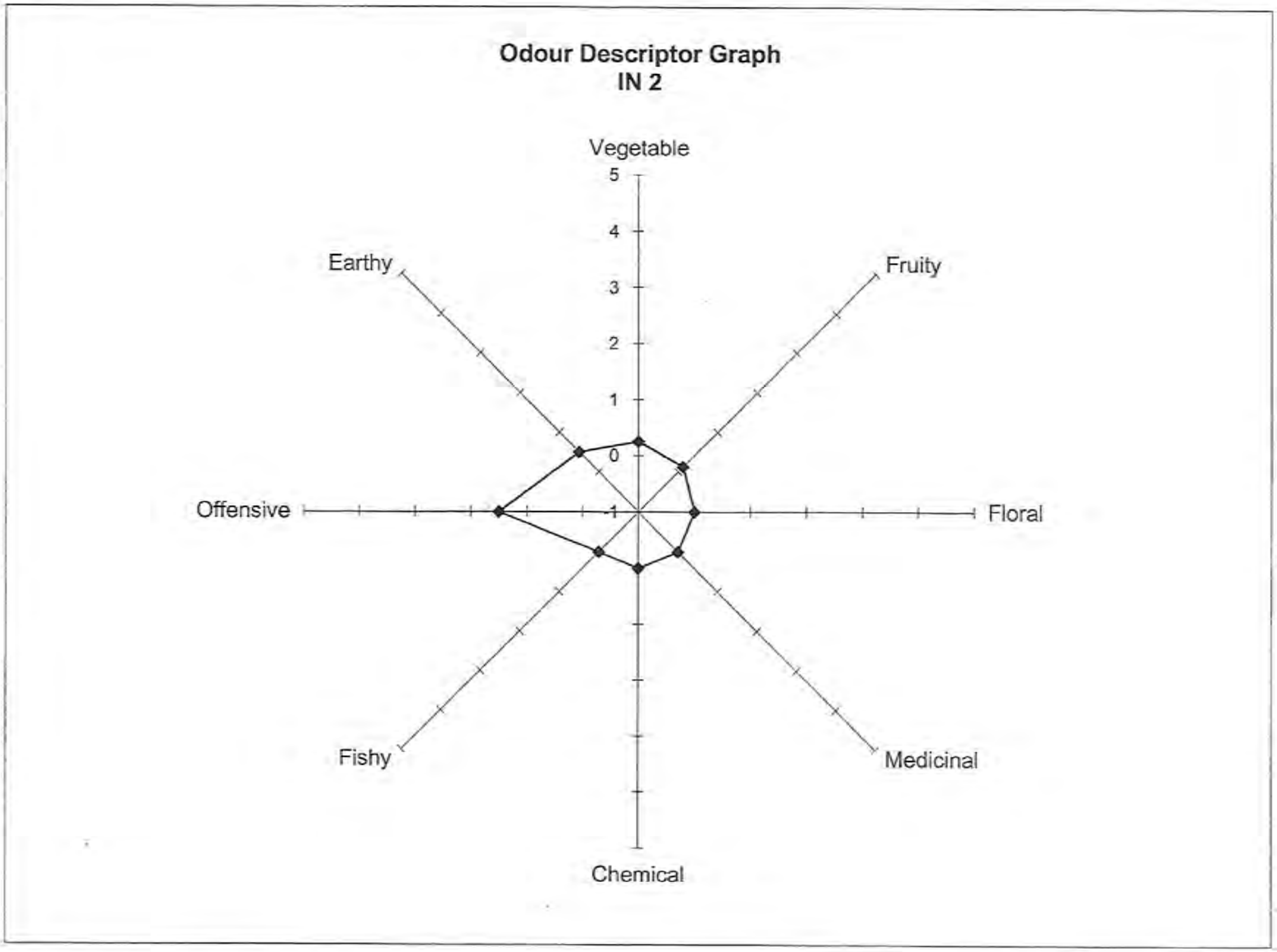

Odour Descriptor Graph
Out 1
Vegetable
5
4
3
2
1
0
-1
Fruity
Floral
Medicinal
Chemical
Fishy
Offensive
Earthy

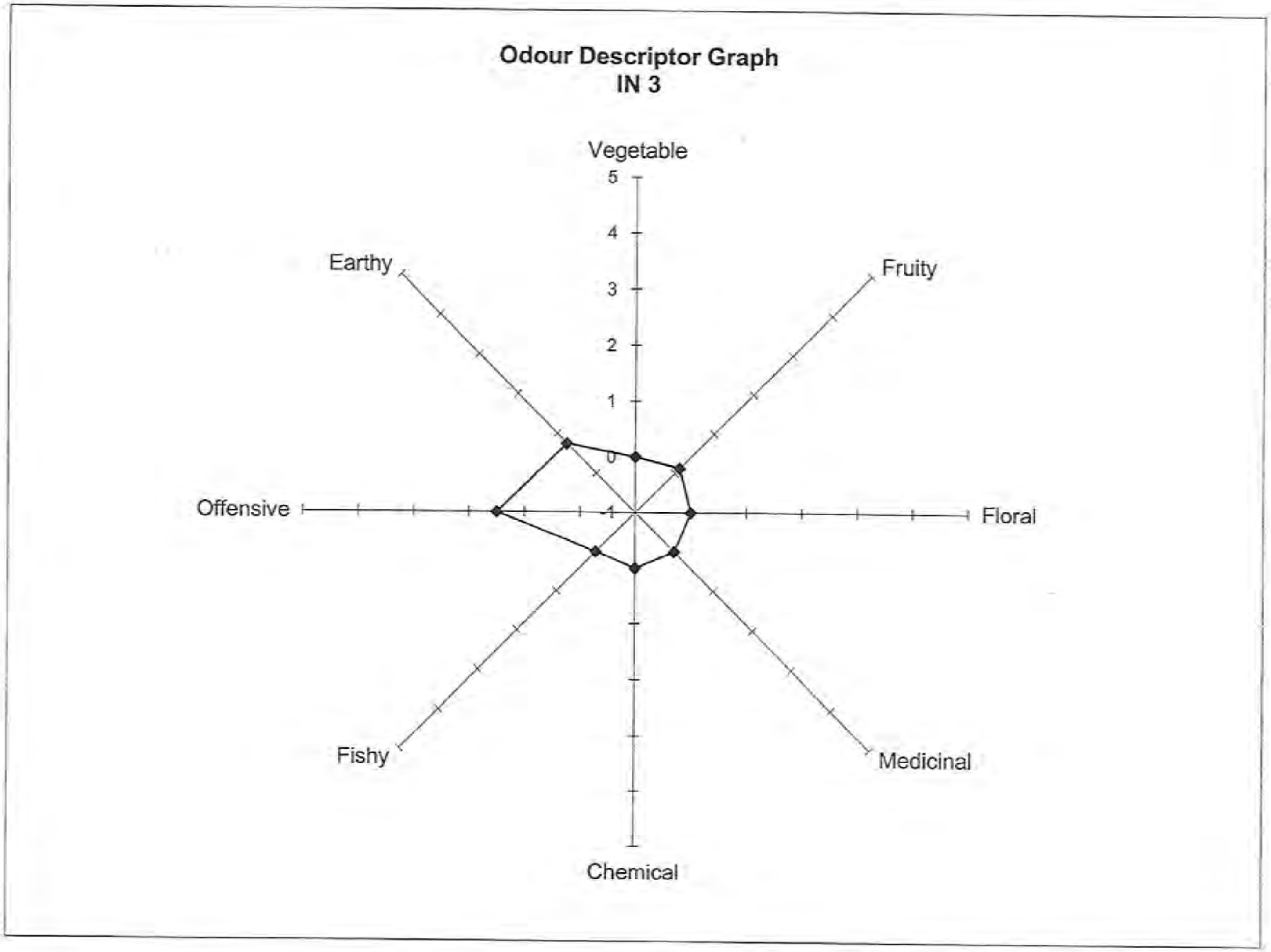
Odour Descriptor Graph
OUT 2




Odour Descriptor Graph
OUT 3
Vegetable
5
4
3
2
1
0
-1
Earthy
Fruity
Offensive
Floral
Fishy
Medicinal
Chemical


Odour Descriptor Graph
IN 1
Vegetable
5
4
3
2
1
0
-1
Fruity
Floral
Medicinal
Chemical
Fishy
Offensive
Earthy


Odour Descriptor Graph
IN 2
Vegetable
5
4
3
2
1
0
-1
Fruity
Floral
Medicinal
Chemical
Fishy
Offensive
Earthy


Odour Descriptor Graph
IN 3
Vegetable
Fruity
Floral
Medicinal
Chemical
Fishy
Offensive
Earthy
5
4
3
2
1
0
-1

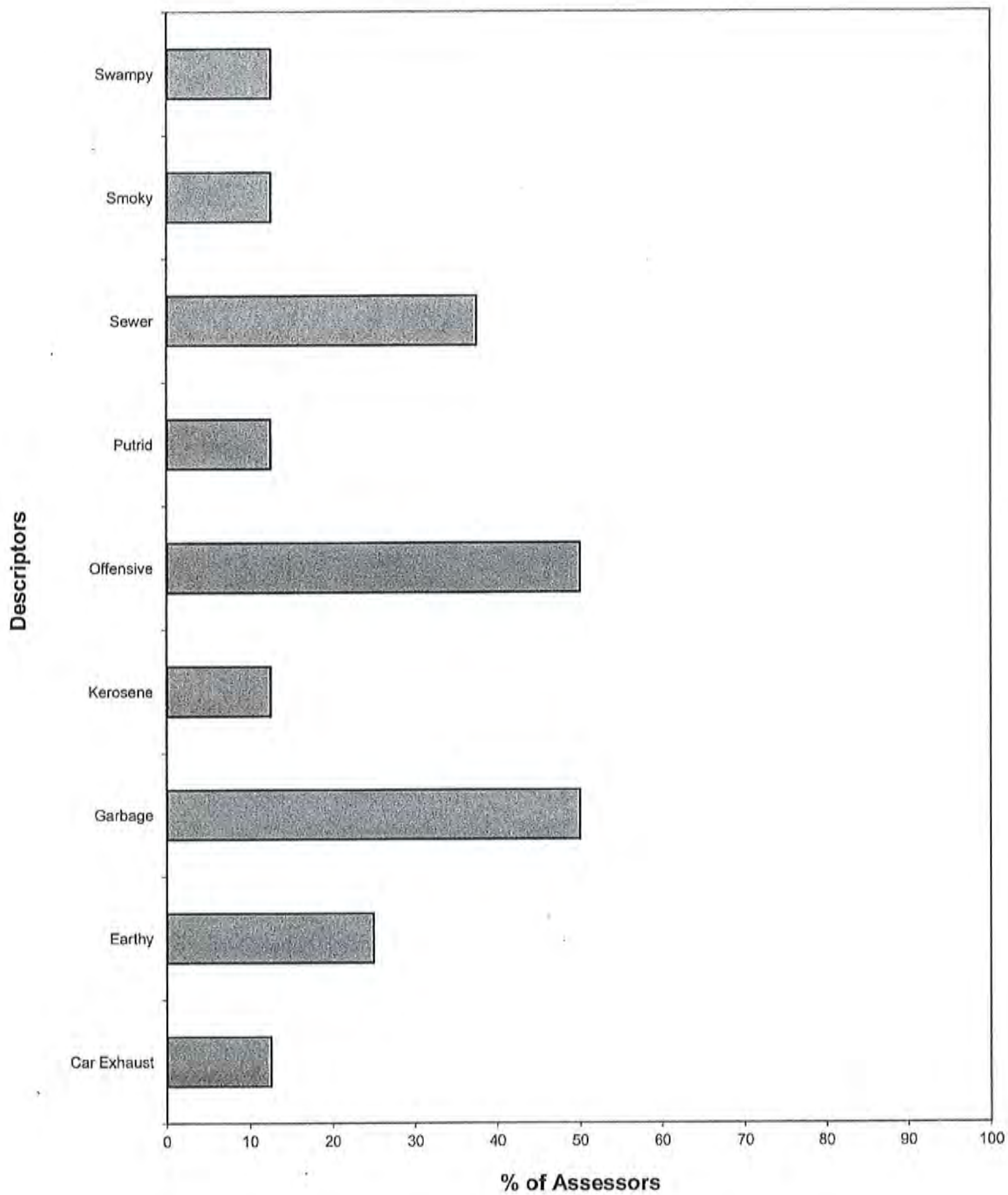
APPENDIX III

Specific Descriptor Histograms

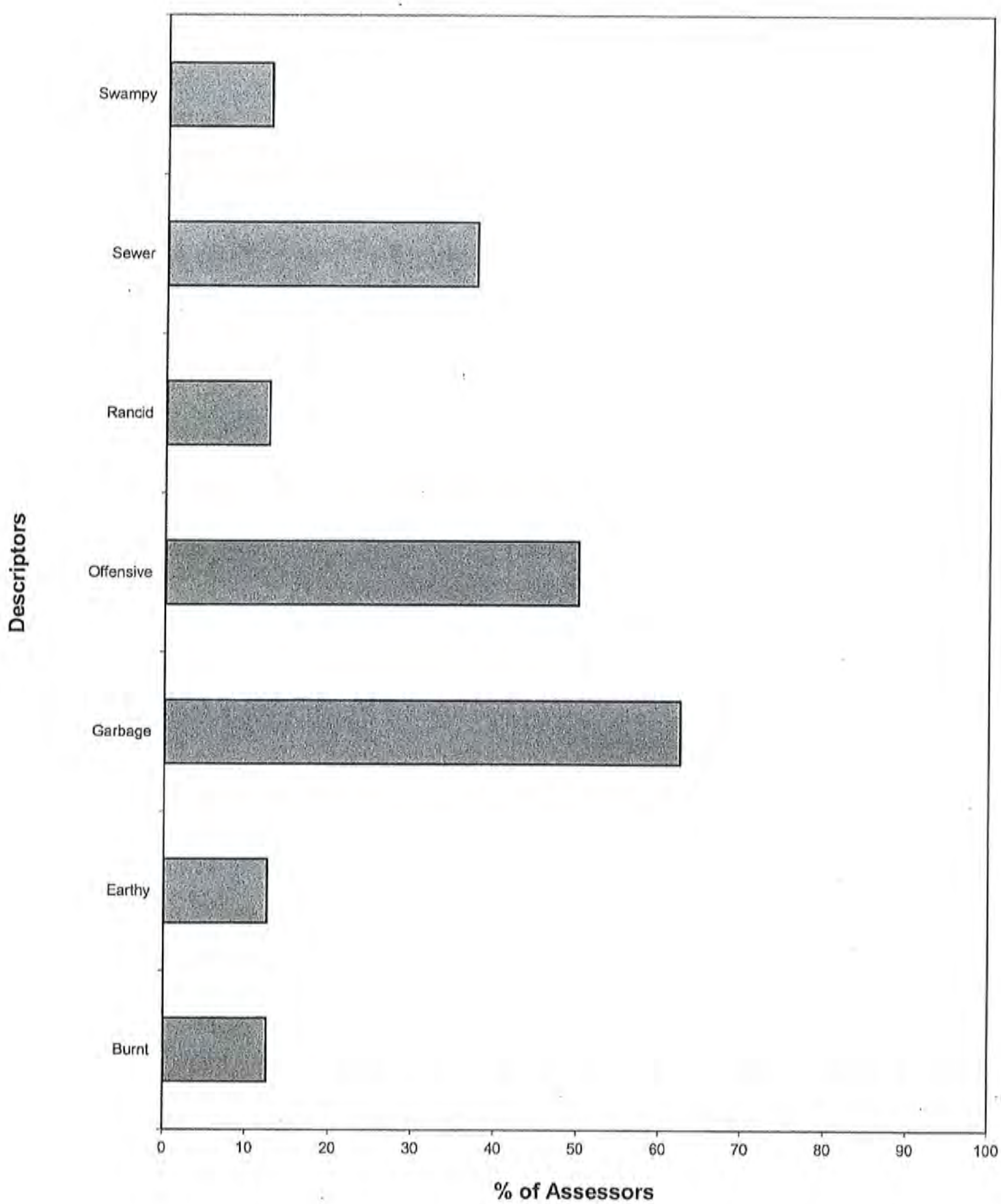
Pinchin File: 23026-012315

(6 Pages)

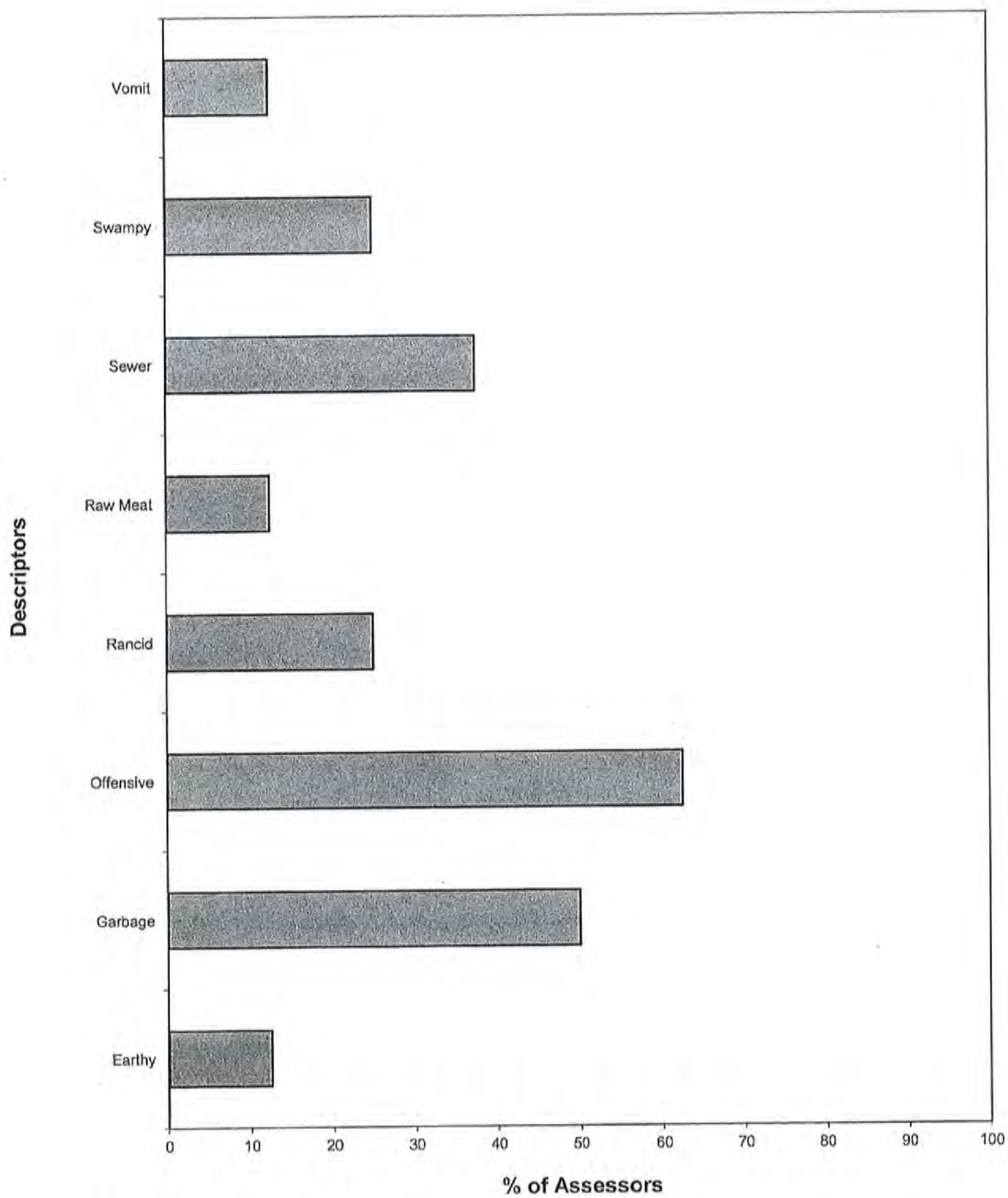
Odour Descriptors Histogram
Out 1



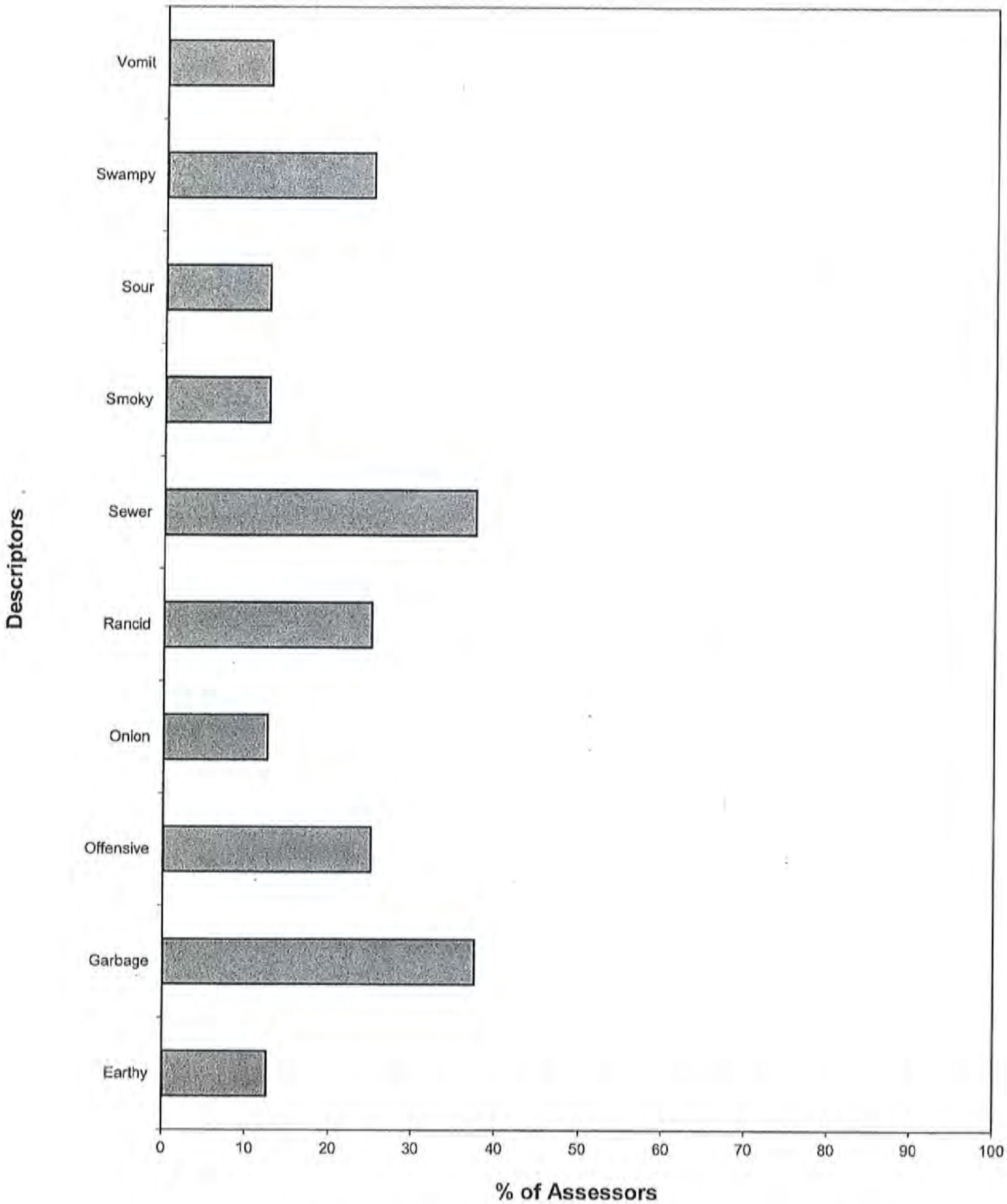
Odour Descriptors Histogram
OUT 2



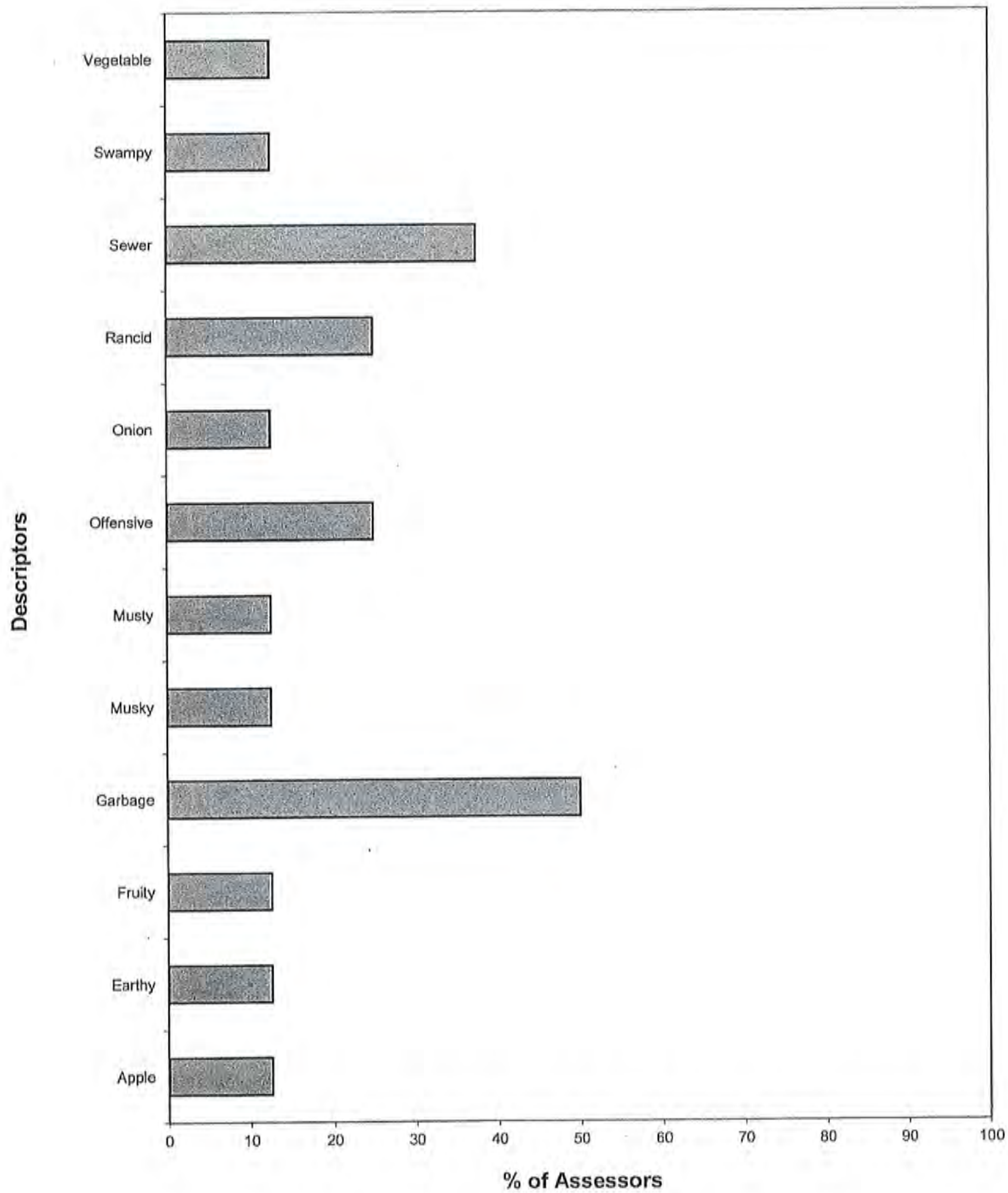
Odour Descriptors Histogram
OUT 3

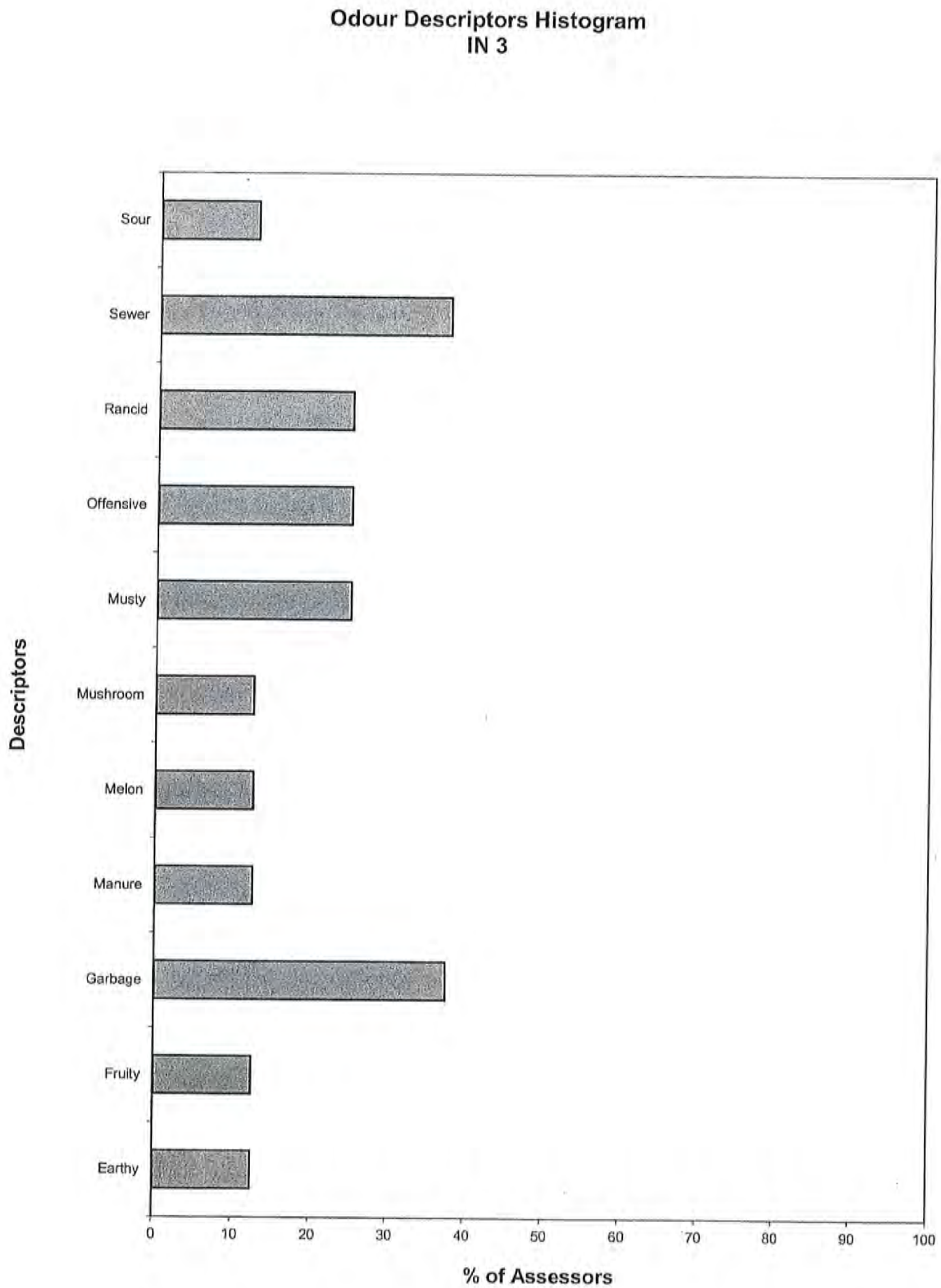


Odour Descriptors Histogram
IN 1



Odour Descriptors Histogram
IN 2





Odour Descriptors Histogram
IN 3
Descriptors
Sour
Sewer
Rancid
Offensive
Musty
Mushroom
Melon
Manure
Garbage
Fruity
Earthy
0
10
20
30
40
50
60
70
80
90
100
% of Assessors

APPENDIX IV

Odour Evaluation Quality Assurance

Pinchin File: 23026-012315

(1 Page)

ODOUR EVALUATION QUALITY ASSURANCE

- Odour evaluations conducted at the Pinchin Odour Laboratory conform to the procedures outlined in the Ministry of the Environment "Ontario Source Testing Code" (OSTC), Version #3, June 2010 (Part G, Method ON-6) and are in accordance with ASTM (American Society for Testing and Materials) Standard Practice E679-04, Determination of Odour and Taste Thresholds by a Forced-Choice Ascending Concentration Series of Limits.
- The AC'SCENT® Dynamic Dilution Forced-Choice Triangle Olfactometer complies with all aspects of the ASTM E679-04 standard as well as the operational requirements of the British Standard, BS EN 13725:2003, "Air quality – Determination of odour concentration by dynamic olfactometry".
- The detection threshold values are reported as defined by ASTM E679-04 and BS EN 13725:2003.
- Assessors are selected and trained in accordance with BS EN 13725:2003.
- The Pinchin Odour Laboratory is managed based on the requirements of the International Organization for Standardization (ISO) International Standard ISO 17025:2005, "General requirements for the competence of testing and calibration laboratories".
- Samples are consumed during the evaluation and all sample bags are destroyed 48 hours after transmittal of the Preliminary Odour Evaluation Results, unless otherwise specified.

APPENDIX C
ODOUR MONITORING PROTOCOL

ODOUR MONITORING PROTOCOL

Based on discussions with the Comox Valley Regional District (The Region), RWDI has developed a community odour monitoring protocol for the Comox Valley Water Pollution Control Centre (the facility). As part of the on-going odour improvement, an on-going method to evaluate odour impacts in the community is required.

In the interest of developing an impartial and transparent evaluation method, it is suggested that a pool of observers be compiled from members of the community liaison committee (CLC) and from Region's staff – though not individuals that actually work at the facility. Each survey will be completed by one community member and one member of the Region staff. The two observers will travel together and make observations in the same place at the same time. It is suggested that four observers from each group be selected so that there is a reasonable chance that an observer from the CLC and the Region will always be available.

Each of the proposed observers will undergo odour detection threshold testing in accordance with ASTM E679-91 using n-butanol as the odour standard. Each individual will be tested to determine the range they can detect the n-butanol sample to determine whether or not the individuals are with the acceptable normal range (detection at concentrations between 1.3 to 5.0 ppm). If the observers are not in this range then alternate observers will be selected. The certification is valid for a 1 year period.

The observations will be made once per calendar month and will be completed either between 9:00 am and 10:00 am or between 6:00 pm and 7:00 pm. The observations should be made during periods of fairly light winds, i.e. less than 10 km/h. The survey cannot be completed during heavy rain, though periods of light mist are acceptable. It is suggested that the monthly survey be scheduled for the second Monday of the month with several alternate times during that week in case of inclement weather or observer unavailability.

In addition to the regularly scheduled times, a series of three surveys should be completed when there are more complaints than usual are received in the course of a week, unless the complaints can be explained as a plant upset that has been remedied.

Observations should be made at points contained within the attached map figure. The individual surveys do not need to include every point. Only those points generally downwind from the facility on the survey day should be included. The survey should begin with the downwind points furthest away and travel towards the points closest to the facility. Each observer should take a new map for every survey and the time date and approximate wind angle on the observation day. If the wind shifts during sampling, it is acceptable to show more than one arrow.

The observations should be recorded on a copy of the attached table. Each observer should each have a fresh copy of the table whenever they complete a survey. The survey should be turned into the CVRD staff to compile the results. It may be advisable to scan and email the individual results to the CLC when the sheets are turned over.

The observers should make a note of the wind direction recorded by Environment Canada at the Comox airport just prior to the survey http://weather.gc.ca/city/pages/bc-61_metric_e.html They should begin at the point that is farthest downwind and record their observations. They should then proceed to points either side of the downwind line and record their observations and generally work their way towards the facility.

The observers should record their name, the date and general weather observations at the top of the form. At each of the observation points they should record the point number, the time of day, any relevant notes and the odour ranking number.

The odour ranking number is a scale to describe the intensity of odour, based on an odour intensity scale. This scale is described below:

0 - no odour

1 - odour just detectable

2 - distinct and definite odour

3 - strong and objectionable enough to cause a person to attempt to avoid it after a period of exposure

4 - so powerful to be offensive and repulsive and bordering on being intolerable

5 - overpowering, nauseating, intolerable odour.

Once the data is collected the CVRD personnel assembling the data should compile the data on an annual basis. In addition, the sheets should be reviewed when they come in. If unusual results are seen on any particular survey it may be prudent to investigate whether there were any upset conditions at the facility or whether it would be prudent to repeat the survey.

Appendix C Table

COMOX WPCC ODOUR SURVEY LOG

Date:___________________ **Name:**___________________________

Wind Speed and direction:______________ **Weather:**_________________________
(i.e., Cloudy, sunny, mist, fog etc.)

Location Number	Time	Odour Intensity #	Notes:

Notes:

Odour Intensity Numbers

0 - no odour

1 - odour just detectable

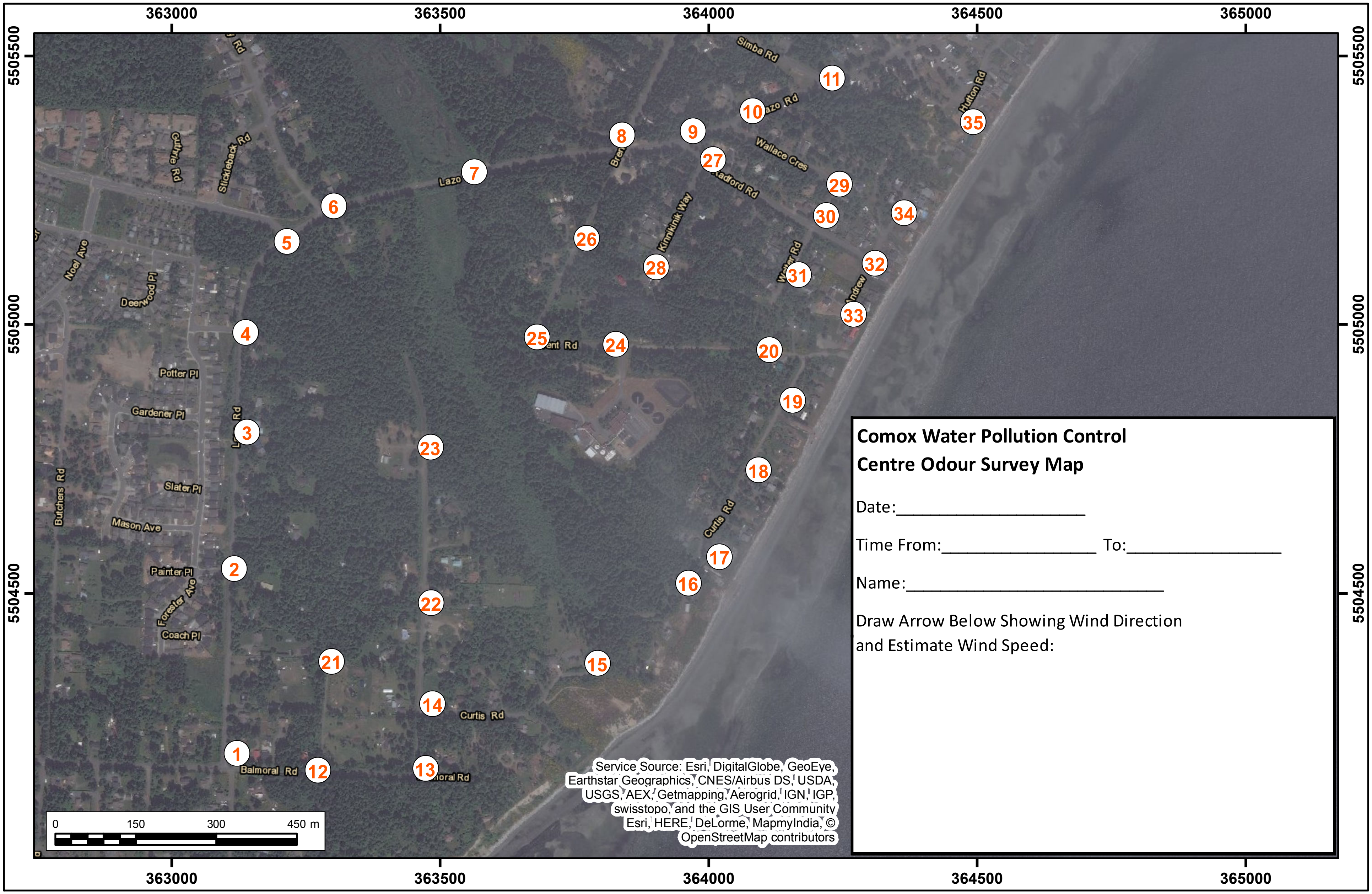
2 - distinct and definite odour

3 - strong and objectionable enough to cause a person to attempt to avoid it after a period of exposure

4 - so powerful to be offensive and repulsive and bordering on being intolerable

5 - overpowering, nauseating, intolerable odour.

Appendix C Figure



Comox Water Pollution Control Centre Odour Survey Map

Date:____________________

Time From:________________ To:________________

Name:___________________________

Draw Arrow Below Showing Wind Direction and Estimate Wind Speed:

Odour Survey Map for Observers

Map Projection: NAD 1983 UTM Zone 10N

True North

Drawn by: NBN	Figure: C-1
Approx. Scale:	1:10,000
Date Revised:	June 2, 2015

RWDI

Comox Valley Water Pollution Control Centre - Comox Valley, BC

Project #1500239

APPENDIX D
ODOUR SURVEY RESULTS SUMMARY

Tel: 604.730.5688
Fax: 604.730.2915

RWDI AIR Inc.
830 – 999 West Broadway
Vancouver, BC, Canada
V5Z 1K5
Email: solutions@rwdi.com

CONSULTING ENGINEERS & SCIENTISTS

CANADA'S BEST MANAGED COMPANIES Platinum member

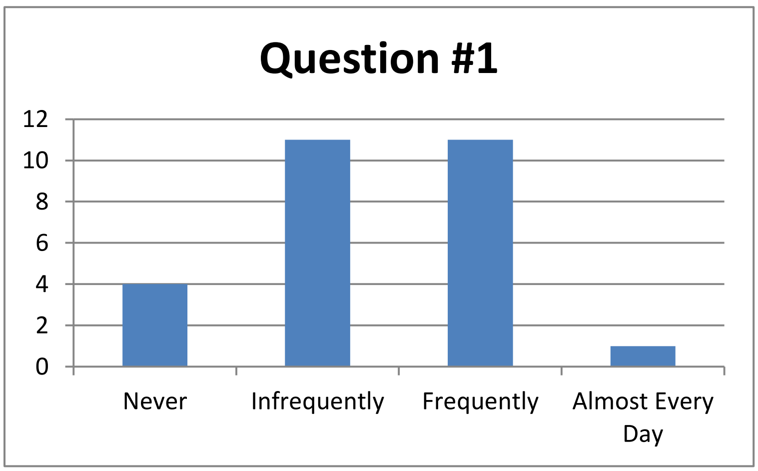
ODOUR SURVEY ATTACHMENT

As part of the community consultation process the Comox Valley Regional District conducted a mail survey regarding odours from the Comox Valley Water Pollution Control Centre. The purpose of the survey was twofold. Firstly it was an assessment of odour impacts from the facility in terms of frequency, seasonality, intensity etc. Secondly it was to gauge the level of concern in the area surrounding the plant.

There were a total of 85 surveys mailed out to residents who live near the plant. A total of 27 surveys were filled out and returned. The results are included in this attachment. Where individuals gave multiple responses to the same question the responses were weighted proportionally. Where individuals did not respond

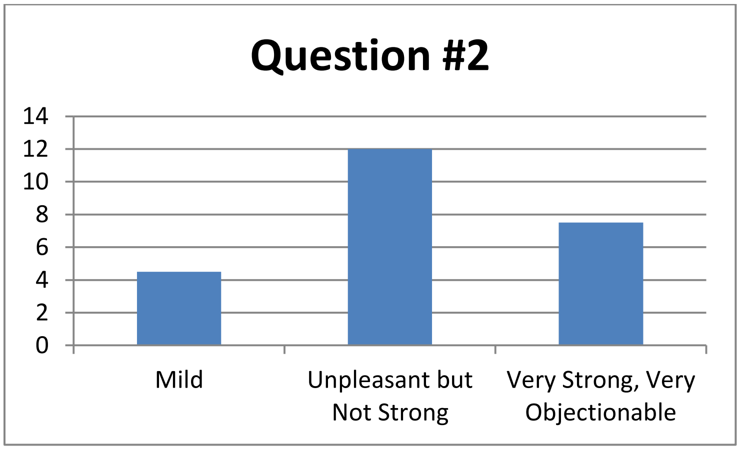
SURVEY RESULTS

1) How often do you detect odours from the plant?



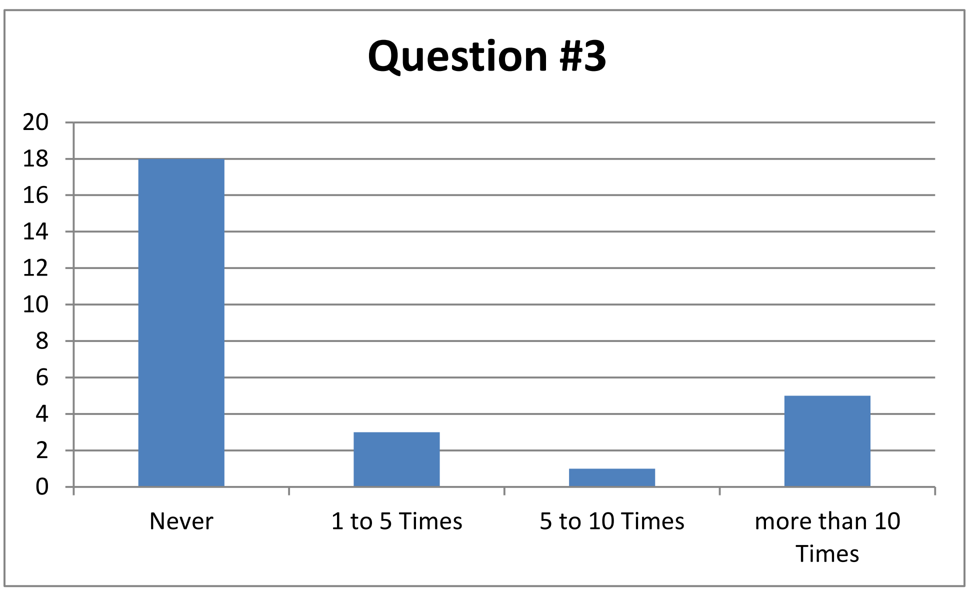
Roughly half the respondents experience odours from the facility frequently.

2) When you detect odours from the plant, how would you rate the odour?



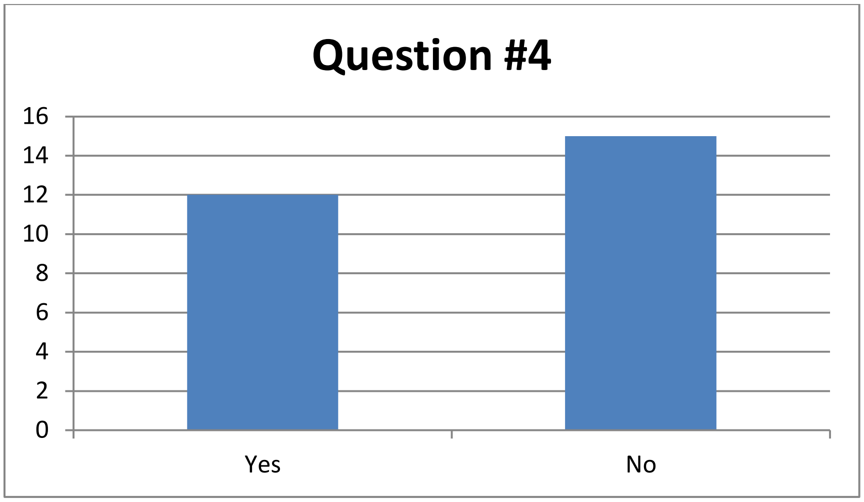
Roughly 25% of the people who detected odours found it to be strong and objectionable.

3) How often have you complained to the Regional District about the odour in the past two years?



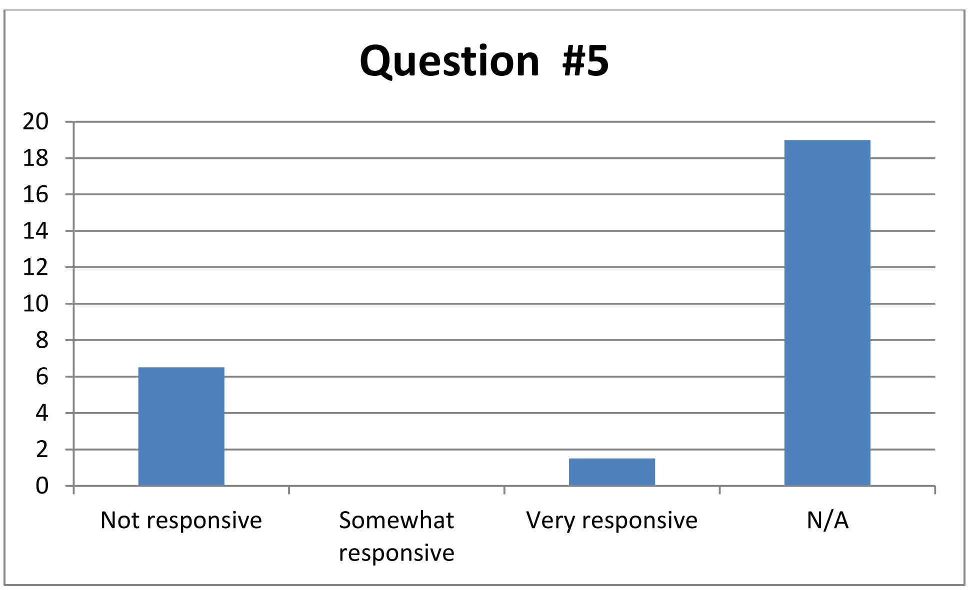
Of the 27 respondents, only nine had ever complained with regard to the odour from the facility. This certainly does not mean that only nine people ever experienced any but it does place the odour issues in the community in perspective.

4) Are you aware of the Regional District's new process for recording complaints from the plant?



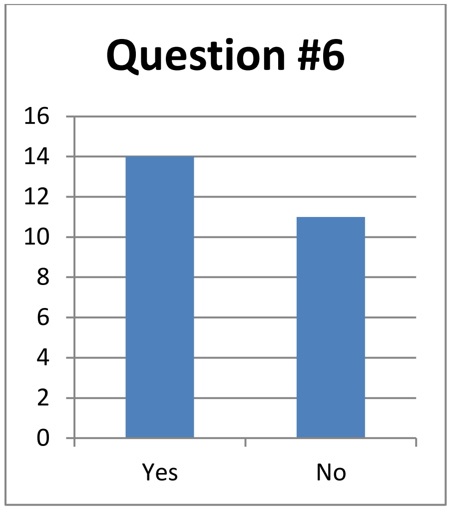
The Region should devote some resources to informing the public of the complaint process.

5) If you have used the Regional District's complaint process, did you feel that they responded to your concerns appropriately, how would you rate the from the Region's level of responsiveness to your complaint?



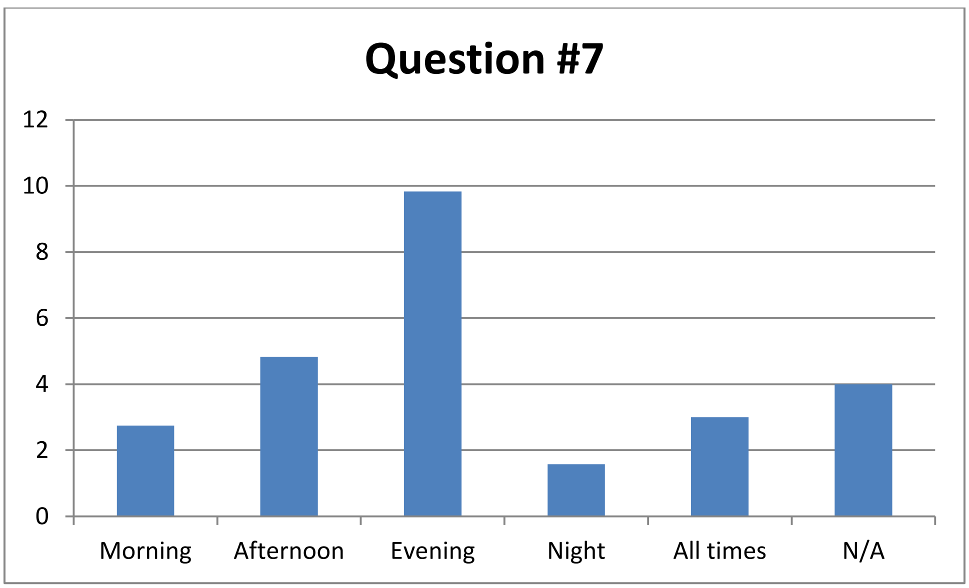
Of the people that have used the complaint system the modal response was that the Region was not very responsive to complaints but based on some notations this does seem to be improving. It is the nature of the process that meaningful responses may often take a significant amount of time.

6) Would you like to receive more information with regard to the formal complaint process?



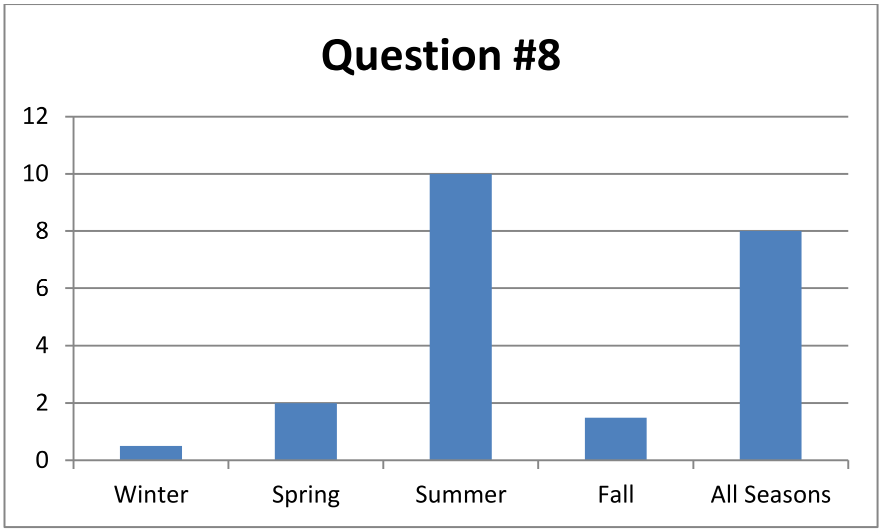
The Region should devote some resources to informing the public of the complaint process.

7) If you detect odours from the plant, what time of day do you tend to notice it?



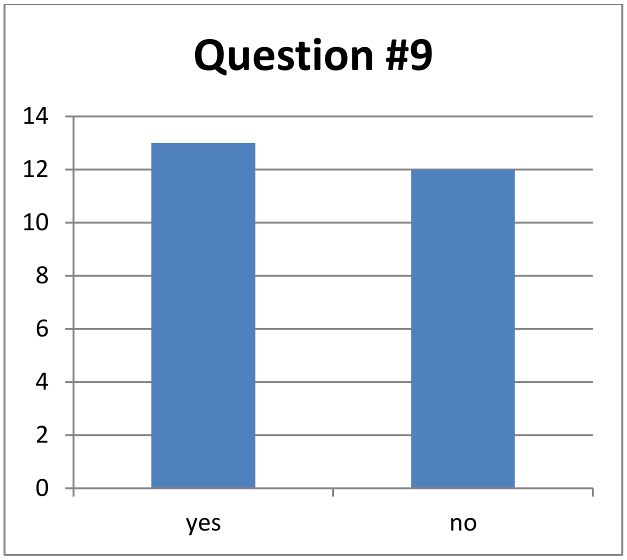
Based on these responses, there does seem to be some increase in odour perception in the evening which is typical for these types of facility but the response is not overwhelming and is likely due to increased outdoor activities of the respondents.

8) If you detect odours from the plant, what time of year do you tend to notice it most?



The modal response to this question was summer but clearly there are enough indications that it is all seasons. The increase in the summer response may well be related to individuals being outside more and not related to any operational differences in the Summer.

9) Would you be interested in touring the facility?



There does seem to be a reasonable number of people who would like to tour the facility. Perhaps the Region could do a tour a month for a few months so that all those interested can have a chance to tour.

10) Is there anything you would like to see as part of the complaint process or as part of the overall sharing of information with residents?

Of the 27 response forms, eighteen had provided comments on this question. Of the eighteen responses, six would be classified as negative to angry, seven would be classified as neutral to negative and five would be classified as neutral. One of the recurring themes in the comments is a desire to be better informed of what is going on in terms of operations and plans to improve the odour issues.

Comox Valley Water Pollution Control Centre Odour Survey Data

Questions										
Respondent	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	b	b	a	b	d	a	c	e	a	y
2	c	b	a	b	d	a	b/c	c	a	y
3	d	c	d	a	a	a	c/d	e	b	y
4	a	a	a	a	d					
5	b	a	a	b	d	b	a/c	b/d	a	y
6	b/c	c	a	b	d	a	c	e	b	y
7	b	b	a	b	d	b	b	e	b	y
8	b	b	a	b	d	b	a	e	a	y
9	c	c	d	b	a	a	c	c	a	y
10	c	b/c	b	a	a	a	e	b/c/d	a	y
11	b/c	c	a	b	d	a	b	c	a	y
12	c	b	b	a	a	a	e	e		y
13	c	c	d	b	a	a	b/c/d	b/c/d	b	y
14	b	b	a	b	d	b	c/e	c	b	y
15	c	a	a	a	d		a/c	b/c/d	b	n
16	b	b	c	a	a/c	b	a/c	e	a	y
17	a		a	a	d	b	f	f	b	n
18	b	b	a	b	d	a	b	e	b	n
19	a		a	a	d	b	f	f	b	n
20	a		a	b	d	b	f	f	a	n
21	c	b	b	a	d	a	c	c	a	y
22	b	a/b	a	b	d	a	b	c	b	y
23	c	c	d	a	c	b	c/d	c	a	n
24	c	b	a	b	d	a	c/e	b/c	b	n
25	b	a	a	b	d	b	f	f	a	y
26	c	c	d	a	a	a	a/2\c\d/2	a/c	a	y
27	b	b	a	a	d	b	c	c	b	n
Totals										
a	4	4.5	18	12	6.5	14	2.75	0.5	13	
b	11	12	3	15	0	11	4.83	1.99	12	
c	11	7.5	1		1.5		9.83	9.99		
d	1		5		19		1.58	1.49		
e							3	8		
f							4	4		

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Comox Valley Water Pollution Control Centre

REPORT

Odour Dispersion Modelling

RWDI # 1500239
November 8, 2016

SUBMITTED TO

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1 INTRODUCTION

The Comox Valley water pollution control centre (CVWPCC) is a secondary level wastewater treatment plant that provides improved wastewater treatment to the City of Courtenay, the Town of Comox, the Department of National Defence and the K'omoks First Nation. The plant is located east of the Town of Comox in a rural area adjacent to the Strait of Georgia (Figure 1 Site Map).

Soon after start-up in 1984 the Comox Valley Regional District (CVRD) began to receive odour complaints related to plant operation. These complaints tended to be from residents along Curtis Road where odours are more frequent, especially on evenings in the late summer or early fall when certain weather conditions (off-shore wind) prevail. RWDI was contracted to conduct odour sampling on the primary clarifier and secondary bioreactor, and a dispersion modeling study to estimate the effect of the CVWPCC on neighbouring areas.

Figure 1: Site Map (CVRD RFQ September 2014)

In the *Comox Valley Water Pollution Control Centre – Odour Control System Evaluation* report (RWDI 2015), it was not possible to conclude whether the scrubber was providing sufficient odour control. RWDI has recommended dispersion modelling be conducted for the exhaust stack and other sources of odour at the facility.

2 METHODOLOGY

It is understood that numerical modelling is a conservative approach. The emission factors modelled are conservative with results representing the worst case meteorological scenario.

A dispersion model study was conducted to determine the off-site areas that may have been influenced by odour from the CVWPCC during times when odour complaints were recorded. Three additional mitigation scenarios with the scrubber stack at 90% efficiency and various sources directed to it were also modelled. The model study was conducted using the CALPUFF regulatory dispersion model. CALPUFF is a recommended model under the *British Columbia Air Quality Dispersion Modelling Guideline* (BC MOE 2015).

The CALPUFF model is linear with respect to emission rates. As such, provided the other source characteristics remain unchanged, model results for a given emission rate may be multiplied by a factor corresponding to any other emission rate. For example, if the emission rate for each source doubles but everything else remains the same, then the model results will also double.

As there is currently no odour standard in British Columbia, odour standards from Ontario's Ministry of Environment and Climate Change have been referenced. The Ontario standard is similar to methodology proposed by Metro Vancouver in their previous draft guideline.

The calendar year 2014 was selected for the model year as it represents the most recent year for which the BC MOE meteorological data required for use in the model study were available from the nearest monitoring station.

2.1 Meteorological data

Meteorological information for CALPUFF was provided using a single station ISC-type meteorological data file. This was developed from measurements for the model period of 2014 from the Courtenay station that is part of the BC MOE network of stations. As per the British Columbia Air Quality Dispersion Modelling Guideline, the mixing heights were derived using the 'plume+1' approximation and surface meteorological data.

2.2 Dispersion Modelling

The ISC-type meteorological data file (a year of hourly single point meteorology) was used as input to the CALPUFF (version 7.2.1) dispersion model to predict the maximum expected odour units resulting from estimated emissions. To understand the contribution of various sources, emissions sources were modelled separately. The total contribution from all sources was also modelled.

2.3 Model Domain

The CALPUFF model domain (Table 1) within which odour was predicted is the 20 km by 20 km study area shown in Figure 2. Model predictions are reported at discrete receptor locations within the dispersion modelling study area.

Table 1: UTM Coordinates of CALPUFF Model Domain

Domain Vertex	UTM Easting (km)	UTM Northing (km)
Southwest	353.846	5494.812
Northwest	353.846	5514.812
Southeast	373.846	5494.812
Northeast	373.846	5514.812

2.4 Receptor locations

Receptors locations were chosen in accordance with British Columbia Air Quality Dispersion Modelling Guideline. Local elevation data were used to determine receptor elevations so that topography in the area of the facility is properly represented. Receptor spacing for the Cartesian grid is as follows:

- 20-m spacing along the terminal fenceline;
- 50-m spacing within 500 m of the terminal;
- 250-m spacing within 2 km of the terminal;
- 500-m spacing within 5 km of the terminal; and
- 1,000-m spacing for the remainder of the study area.

Twelve special receptors were identified as the nearest residences in various directions from the CVWPCC property boundary.

Terrain elevations for all receptors included as input to the CALPUFF model were extracted from 1:50,000 scale Canadian Digital Elevation Data obtained from GeoGratis.

2.5 Odour source parameters

Odour sources (Figure 3) were input to the model as follows:

- One point source to represent the scrubber;
- Five area sources to represent the primary clarifier, and secondary bioreactor and Secondary Clarifiers

**Please note that because the Secondary Clarifiers are fairly well separated from each other physically, they were modelled as three individual area sources.*

The scrubber stack was estimated to be 17 metres from the ground, with an inner diameter of 0.762 metres, exit velocity of 21.8 m/s and exit temperature of 11^{o}C. Clarifiers and bioreactors were modelled as area sources; the surface was estimated to be one metre from the ground, with areas estimated from the exposed surface of each bioreactor.

Emission rates are expressed in Odour Units per second (OU/s). An odour unit is defined as the amount of odourant that when dispersed in a cubic metre of clean air would be detectible to 50% of the population. Emission rates are provided in Table 2.

The scrubber emission rate is based on odour sampling completed on January 22, 2015 (RWDI 2015) and detailed in our Odour Control System Evaluation report dated October 30, 2015.

Emission rates of the primary clarifier and secondary bioreactor are based on the average of odour measured onsite by RWDI and analyzed by Environmental Odour Consulting Corporation on August 17, 2016. Details of the testing and analysis are contained in Appendix A & B.

The secondary clarifiers are not a major source of odour and were not tested specifically at this site. As a very conservative approach to the modelling, odour source emission for the secondary clarifiers from the Orangeville Water Pollution Control Plant in Ontario.

Table 2: Emission Rates

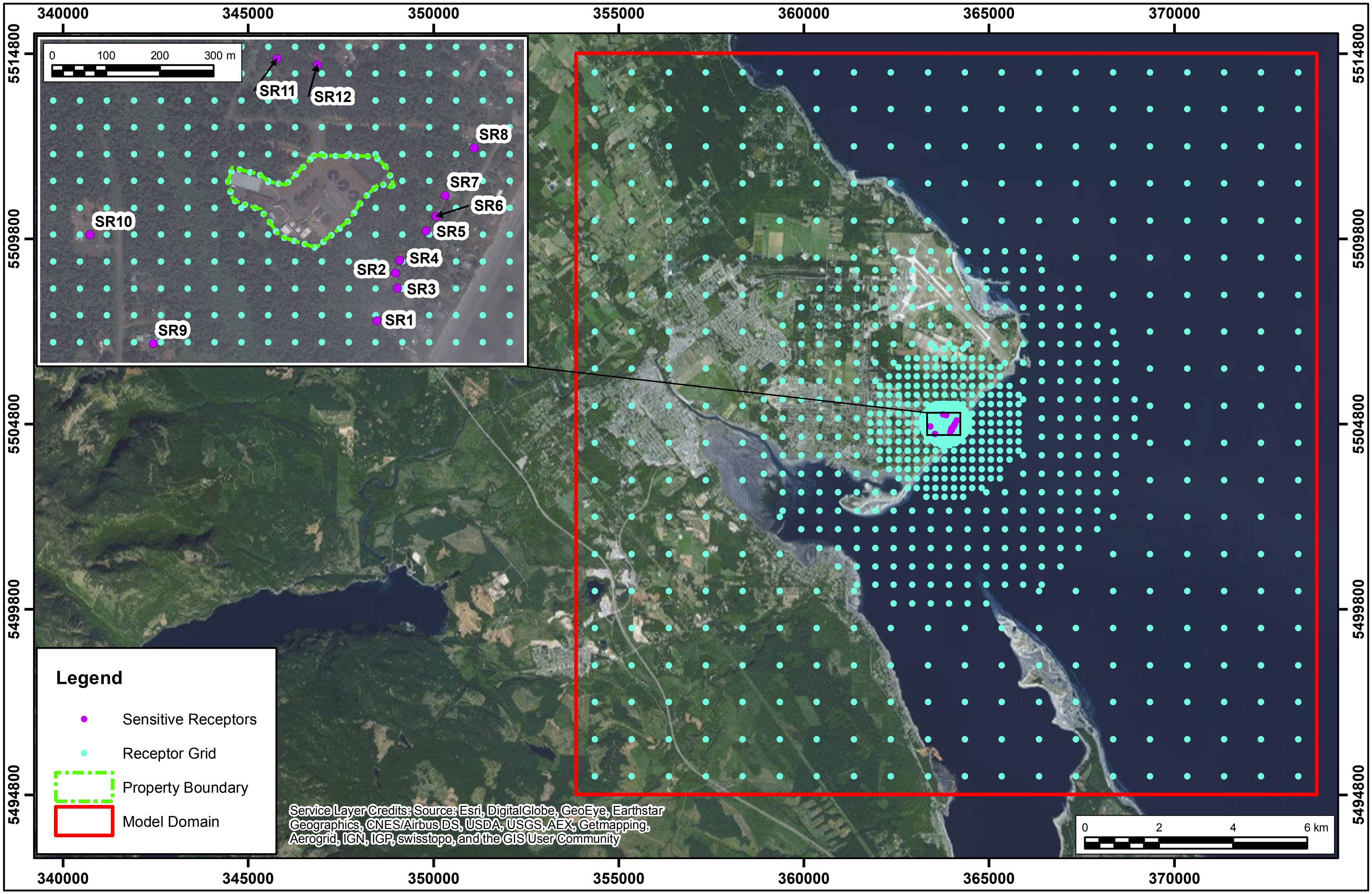
Emission Source	Source Type	Emission Flux Rate	Emission Rate
Scrubber	Point	-	34,507 (OU/s)
Primary Clarifiers	Area	1.537 (OU/s/m^2)	966.7 (OU/s)
Secondary Bioreactors	Area	0.5565 (OU/s/m^2)	734.5 (OU/s)
Secondary Clarifier 1	Area	0.0888 (OU/s/m^2)	32.5 (OU/s)
Secondary Clarifier 2	Area	0.0888 (OU/s/m^2)	32.5 (OU/s)
Secondary Clarifier 3	Area	0.0888 (OU/s/m^2)	32.5 (OU/s)
All Sources	Point and Area	2.360 (OU/s/m2)	36,306 (OU/s/m^2)

In an effort to reduce odour impact at the surrounding residences, additional mitigation scenarios were evaluated. The following three scenarios were modelled:

- Mitigation Scenario 1: All sources (as previously modelled) but with the scrubber stack at 90% control efficiency
- Mitigation Scenario 2: The primary clarifiers directed to the scrubber stack with 90% control efficiency
- Mitigation Scenario 3: The primary clarifiers and bioreactors directed to the scrubber stack with 90% control efficiency

2.6 Post Process of Model Results

Post-processing of hourly model results was conducted to determine required results for comparison with ambient air quality objectives over various averaging periods. Model results are expressed as odour units (OU) and represent worst-case values over the 1 year of meteorological data. The modelled concentrations were converted from 1-hour based averages to a 10-minute averaging time (typical for odour assessments) using a 1.65 conversion factor as per the Ministry of Environment and Climate Change (formerly Ontario Ministry of Environment) guidance document *Methodology for Modelling Assessments of Contaminants with 10-Minute Average Standards and Guidelines* (MOECC 2008).



Dispersion Modelling Receptor Grid and Sensitive Receptors

Map Projection: NAD 1983 UTM Zone 17N

Comox Valley Water Pollution Control Centre - Comox, British Columbia

True North

Project #1500239

Drawn by: DJH	Fig: 2
Approx. Scale:	1:145,000
Date Revised:	Jun. 8, 2016

RWDI

Odour Emission Sources	True North	Drawn by: DJH	Fig: 3
Map Projection: NAD 1983 UTM Zone 17N		Approx. Scale: 1:1,395	
Comox Valley Water Pollution Control Centre - Comox, British Columbia	Project #1500239	Date Revised: Sept 23, 2016	

3 MODEL RESULTS

While numerical modelling is a conservative approach, it represents the worst case scenario and is the preferred protocol in Ontario and other jurisdictions. Isopleths showing the maximum predicted 10-minute average odour concentrations and the frequency of exceeding the Ontario odour standard are presented in Figure 4 and Figure 5 respectively. The maximum predicted odour concentration was predicted at the property as expected. The area where maximum odour concentration was predicted to be greater than 1 OU extends over two kilometres north from the CVWPCC to Knight Road, and west to Pritchard Road. The acceptable frequency of exceeding the Ontario odour standard is 0.5%, which was predicted to encompass residential areas in all directions from the CVWPCC up to 1.5 kilometres.

Maximum predicted 10-minute average odour concentrations and the frequency of exceeding the Ontario odour standard at sensitive receptors are presented in Table 3. The Ontario odour standard was exceeded at all sensitive receptors, as the frequencies of exceedance were greater than the acceptable percentage of 0.5% or 44 hours per year. The sensitive receptors with the greatest odour concentration predicted are above 15% at SR4, SR5, SR6, and SR7 located approximately 300 metres east of the scrubber stack and within 200 metres of the clarifiers and bioreactors.

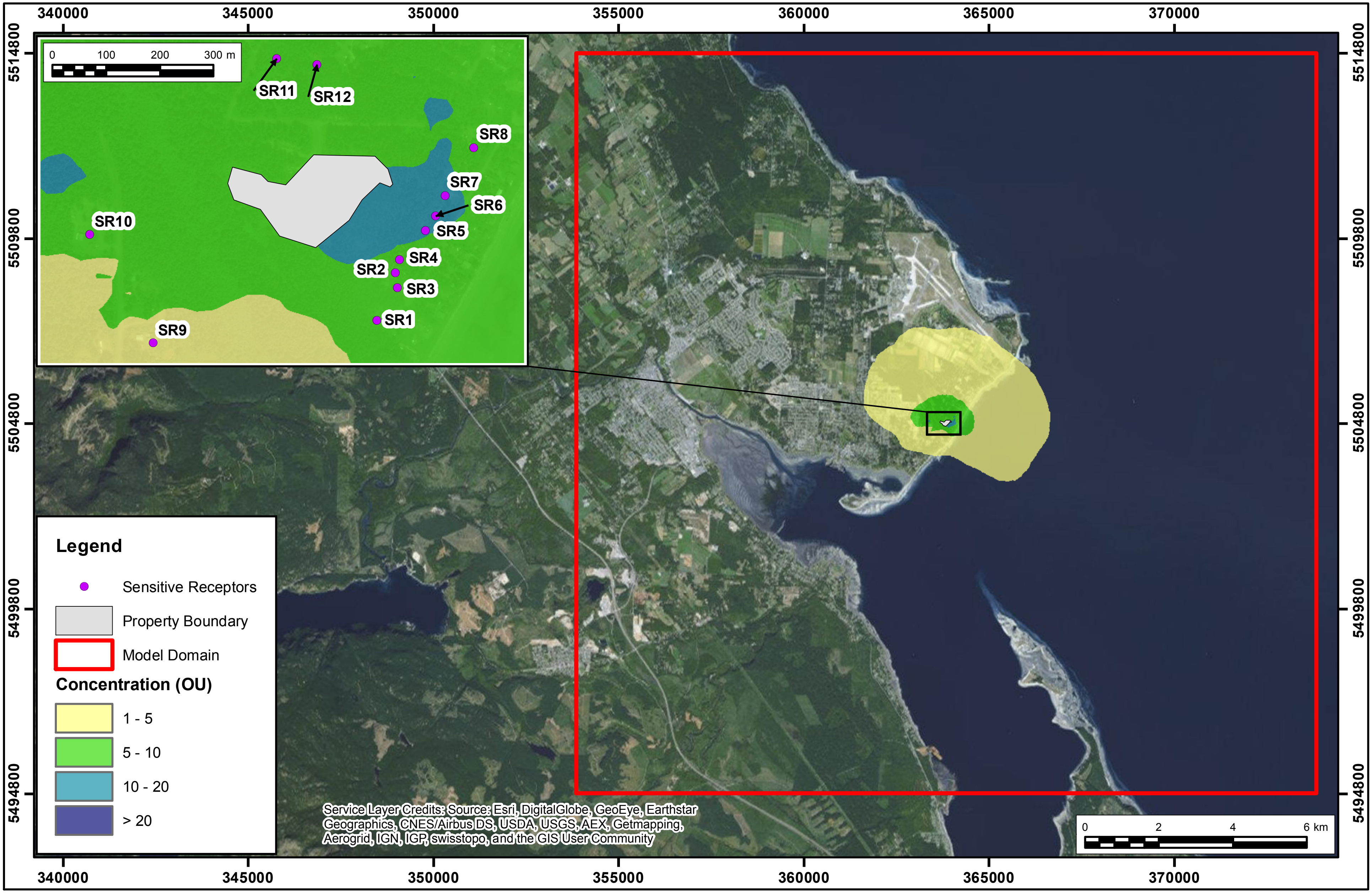
Table 3: Maximum Predicted Concentrations at Sensitive Receptors

Sensitive Receptor	Odour Concentration (OU)	Frequency of Exceedance (%)
SR1	5.45	4.1
SR2	6.8	13.7
SR3	5.9	10.8
SR4	8.5	16.3
SR5	11.1	18.4
SR6	10.6	17.3
SR7	10.0	15.9
SR8	9.7	11.7
SR9	4.57	0.8
SR10	5.22	2.6
SR11	6.54	11.4
SR12	7.7	15.6

Emission source contributions at sensitive receptors are presented in Table 4. Emission source contributions were calculated based on the maximum predicted 10-minute average odour concentrations for each source, and may not correspond to the same time when the maximum predicted 10-minute average odour concentration where all sources are combined, as presented in previous tables. In general, the scrubber stack is the largest contributor to odour at sensitive receptors considered in this study. At the sensitive receptors where the greatest odour concentrations were predicted (as shown in Table 3), the primary clarifier is also a significant contributor to odour at SR4, SR5 and SR6 locations as the bioreactors are located 100 metres closer than the scrubber stack. The secondary bioreactor is the third largest contributor to overall odour at all sensitive receptors. Secondary Clarifiers were predicted to contribute very little to the overall odour concentrations at sensitive receptors. Controlling odour emissions from the scrubber stack and the primary clarifier would be most beneficial in reducing the area of effect, maximum odour concentrations and frequency of exceedance of the Ontario odour standard.

Table 4: Source Contribution at Sensitive Receptors

Sensitive Receptor	Scrubber		Primary Clarifier		Secondary Bioreactor		Secondary Clarifiers	
	OU	%	OU	%	OU	%	OU	%
SR1	3.2	78.6%	0.5	12.0%	0.3	8.4%	0.04	1.0%
SR2	3.4	49.3%	2.2	30.9%	1.3	18.9%	0.07	0.9%
SR3	3.4	55.7%	1.6	27.0%	1.0	16.5%	0.05	0.8%
SR4	3.4	46.2%	2.2	29.9%	1.6	21.8%	0.2	2.1%
SR5	4.2	56.3%	1.7	23.3%	1.3	17.6%	0.2	2.8%
SR6	4.1	59.6%	1.5	21.2%	1.1	16.6%	0.2	2.6%
SR7	3.9	62.2%	1.3	19.9%	1.0	15.5%	0.1	2.4%
SR8	4.8	76.0%	0.8	11.9%	0.7	10.7%	0.09	1.5%
SR9	2.6	55.0%	1.2	25.0%	0.9	17.8%	0.1	2.1%
SR10	2.8	56.1%	1.3	25.2%	0.8	16.6%	0.1	2.1%
SR11	4.0	71.3%	0.8	15.1%	0.7	11.7%	0.1	1.9%
SR12	4.6	54.5%	2.0	24.1%	1.6	18.8%	0.2	2.6%



Maximum Predicted 10-Minute Odour Concentrations

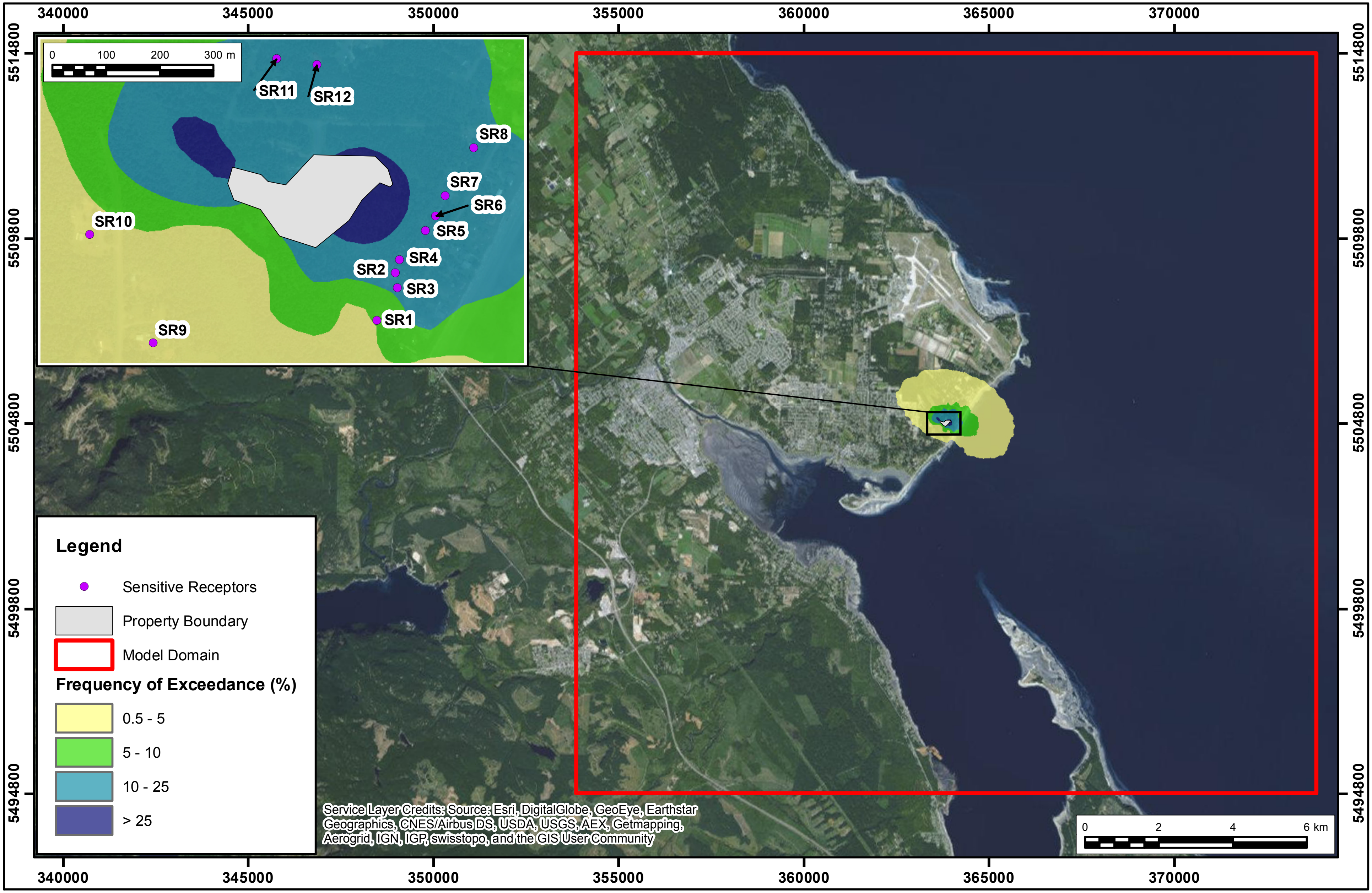
Map Projection: NAD 1983 UTM Zone 17N

Comox Valley Water Pollution Control Centre - Comox, British Columbia

True North

Project #1500239

Drawn by:	CAM	Fig:	4
Approx. Scale:	1:145,000		
Date Revised:	Sept. 7, 2016		



Frequency of Exceedance of the Ontario 10-Minute Odour Standard

Map Projection: NAD 1983 UTM Zone 17N

Comox Valley Water Pollution Control Centre - Comox, British Columbia

True North

Project #1500239

Drawn by:	CAM	Fig:	5
Approx. Scale:	1:145,000		
Date Revised:	Sept. 7, 2016		

4 MITIGATION SCENARIOS

The Ontario odour standard was exceeded at all sensitive receptors for the current scenario. Thus, to review the effectiveness of applying control technologies in odour emissions, three additional mitigation scenarios (as described in Section 2.5) were modelled. Emission rates for the mitigation scenarios are provided in Table 5.

Table 5: Emission Rates for Mitigation Scenarios

Emission Source	Source Type	Emission Rate (OU/s) and Emission Flux Rate (OU/s/m2)				
		Current Scenario		Mitigation Scenario 1	Mitigation Scenario 2	Mitigation Scenario 3
Scrubber	Point	34,507 (OU/s)	-	3,451 (OU/s)	3,547 (OU/s)	3,621 (OU/s)
Primary Clarifiers	Area	966.7 (OU/s)	1.537 (OU/s/m^2)	1.537 (OU/s/m2)	-	-
Secondary Bioreactors	Area	734.5 (OU/s)	0.5565 (OU/s/m^2)	0.5565 (OU/s/m2)	0.5565 (OU/s/m2)	-
Secondary Clarifier 1	Area	32.5 (OU/s)	0.0888 (OU/s/m^2)	0.0888 (OU/s/m2)	0.0888 (OU/s/m2)	0.0888 (OU/s/m2)
Secondary Clarifier 2	Area	32.5 (OU/s)	0.0888 (OU/s/m^2)	0.0888 (OU/s/m2)	0.0888 (OU/s/m2)	0.0888 (OU/s/m2)
Secondary Clarifier 3	Area	32.5 (OU/s)	0.0888 (OU/s/m^2)	0.0888 (OU/s/m2)	0.0888 (OU/s/m2)	0.0888 (OU/s/m2)
All Sources	Point and Area	36,306 (OU/s)		5,249 (OU/s)	4,379 (OU/s)	3,718 (OU/s)

Maximum predicted 10-minute average odour concentrations and the frequency of exceeding the Ontario odour standard at sensitive receptors for the mitigation scenarios are presented in Table 6. For Mitigation Scenario 1, the Ontario odour standard was exceeded at all sensitive receptors except SR1, as the frequencies of exceedance were greater than the acceptable percentage of 0.5% or 44 hours per year. For Mitigation Scenario 2, the Ontario odour standard was exceeded at SR4, SR5, SR6, SR7, SR8 and SR12. For Mitigation Scenario 3, there were no exceedances of the Ontario odour standard at the sensitive receptors. Therefore, Mitigation Scenario 3 was the only scenario that met the Ontario odour standard of 1 OU at all sensitive receptors.

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Table 6: Maximum Predicted Concentrations at Sensitive Receptors for Mitigation Scenarios

Sensitive Receptor	Mitigation Scenario 1		Mitigation Scenario 2		Mitigation Scenario 3	
	OU	%	OU	%	OU	%
SR1	1.4	0.2%	0.6	0.0%	0.6	0.0%
SR2	5.0	**3.4%**	2.3	0.0%	0.6	0.0%
SR3	3.7	**1.3%**	1.7	0.1%	0.6	0.0%
SR4	5.1	**6.5%**	2.7	**1.3%**	0.6	0.0%
SR5	5.1	**8.7%**	2.6	**4.3%**	0.7	0.0%
SR6	4.5	**7.8%**	2.6	**4.1%**	0.8	0.0%
SR7	4.2	**6.6%**	2.4	**3.5%**	0.9	0.0%
SR8	2.9	**3.2%**	1.8	**0.6%**	0.99	0.0%
SR9	3.5	**0.5%**	1.6	0.1%	0.5	0.0%
SR10	3.6	**0.5%**	1.6	0.2%	0.5	0.0%
SR11	2.3	**2.7%**	1.2	0.1%	0.7	0.0%
SR12	6.3	**6.4%**	3.0	3.9%	0.8	0.0%

NOTES: Values in **bold** indicate frequency of exceedances greater than 0.5%

5 CONCLUSIONS & RECOMMENDATIONS

Numerical modelling is a conservative approach that is consistent with regulatory protocols in Ontario and other jurisdictions.

Maximum 10-minute averages were estimated from the modelled maximum 1-hour averages. These showed greater areas potentially being influenced by the odours from the CVWPCC. The CVWPCC was predicted to generate odour above the Ontario odour standard over two kilometres from the facility. The frequency of exceedance was predicted to be in excess of 20% at four sensitive receptor locations east of the facility.

Dispersion modelling results show the strongest odour emissions were from the scrubber stack, followed by the primary clarifier which is located near sensitive receptors within 200 metres from an emission source. Reducing odour emissions from these sources would yield the most reduction of odour.

In general, the scrubber stack is the largest contributor to odour at sensitive receptors considered in this study. At the sensitive receptors where the greatest odour concentrations were predicted (as shown in Table 3), the primary clarifier is also a significant contributor to odour at SR4, SR5 and SR6 locations as the bioreactors are located 100 metres closer than the scrubber stack. The secondary bioreactor is the third largest contributor to overall odour at all sensitive receptors. Secondary Clarifiers were predicted to contribute very little to the overall odour concentrations at sensitive receptors.

There were predicted exceedances at all sensitive receptors except SR1 when the scrubber stack was modelled with a 90% control efficiency (Mitigation Scenario 1). There were predicted exceedances at SR4, SR5, SR6, SR7, SR8 and SR12 when the scrubber stack was modelled with a 90% control efficiency and emissions from the primary clarifiers were directed to the scrubber stack (Mitigation Scenario 2). However, there were no exceedances predicted at sensitive receptors when odour emissions from the primary clarifiers and bioreactors were directed to the scrubber stack with an emissions control efficiency of 90% (Mitigation Scenario 3).

The greatest single impact to improving the odour impacts from the facility would be achieved by putting an additional control on the scrubber stack. This would likely be best achieved with a bio-filter type system. However, even with additional control on the stack, the site would still have significant odour impacts associated with the primary clarifiers and the bioreactors. We would recommend that those tanks be covered and also be vented through the scrubber stack with an improved control efficiency.

6 REFERENCES

British Columbia Ministry of Environment (BC MOE), 2015. *Environment British Columbia Air Quality Dispersion Modelling Guideline*, Environmental Protection Division, Environmental Standards Branch, Clean Air Section. Victoria, British Columbia. November 2015.

Ministry of the Environment and Climate Change (MOECC). 2008. *Technical Bulleting: Methodology for Modelling Assessments of Contaminants with 10-Minute Average Standards and Guidelines.* (https://dr6j45jk9xcmk.cloudfront.net/documents/1468/3-7-33-10-minute-standards-en.pdf) Accessed: June 1, 2016

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APPENDIX A

ODOUR SAMPLING METHODOLOGY

INTRODUCTION

Summary of Test Program

RWDI AIR Inc. (RWDI) was retained by the Comox Valley Regional District (CVRD) to conduct odour emission sampling at their Comox Valley water pollution control centre (CVWPCC) Site located in the Town of Comox in a rural area adjacent to the Strait of Georgia.

Schedule

RWDI completed the testing during the morning of August 16th, 2016.

SOURCE DESCRIPTION

Source Description

The sources being tested were the primary clarifiers and the bioreactors. These are the two major sources of odour at the facility that have not yet been quantified with site specific measurements. The influent to the plant is screened and then enters to primary clarifiers. There are three primary clarifiers and each one is comprised of a single open air tank. Once the waste water has passed through the primary clarifiers it passes to the bioreactors. The bioreactors are each comprised of two aerated, open air tanks. The waste water passes through both tanks and then flows to the secondary clarifiers.

Sample Locations

The program consisted of a number of odour samples being collected at various points on the primary clarifiers and the bioreactors.

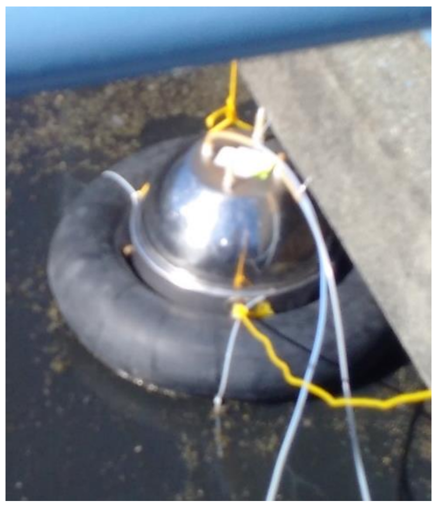
One sample was collected near the entrance of two primary clarifiers. One sample was collected at the midpoint of two primary clarifiers. One sample was collected near the exit of two primary clarifiers for a total of six samples from the primary clarifiers.

Two samples were collected from the same location at the entrance to one bioreactor. Two samples were collected at the same location from the mid-point of the bioreactor. Two samples were collected at the same location from near the exit of the bioreactor. The reason that two samples were collected at the same location was that a slightly different methodology was used between the two samples. The alternative method was used as a contingency in case there were problems caused by the aeration of the bioreactor.

TESTING METHODOLOGY

Flux Chamber Sampling

Odour emissions from the waste water surface were measured using a floating flux chamber. The flux chamber is 40.6 cm in diameter; and approximately 35 cm high, and constructed of 14 gauge stainless steel, as per the designer’s specifications outlined in Ontario Stack Testing Code Method ON-6. All interior and exterior fittings are constructed from odour neutral material being stainless steel and all lines were made from Teflon tubing with some variance at connections. The flux chamber is equipped with ports: one for sweep gas line and one for sample line. The chamber is fitted with a floatation device to hold it on top of the surface.



Before taking measurements, the flux chamber was lowered on the surface of the waste water using ropes such that the inlet of the chamber would be slightly below the surface of the waste water. Ultra high purity nitrogen gas was used as the sweep gas, which was metered into the chamber at a constant rate of 5 litres per minute. The sweep gas was allowed to run through the chamber for 30 minutes prior to sample collection.

The exception to this were the duplicate samples taken on the bioreactors which were taken as a contingency in case odour levels in the sample bags were below detection limits.

The odour samples were collected through a sample port on the flux chamber into a Tedlar bag using a lung sampler. The sample bag was filled at a rate of less 5 L/min and should not significantly affect the equilibrium of the chamber.

Two flux chambers were used for the sampling procedure.

Odour Sample Analysis

Once collected, the samples were air shipped to Environmental Odour Consultants (EOC) for subsequent analysis by an eight-member odour panel within 30-hours of testing. The panel is tested prior to the odour analysis and the members are screened to have normal odour sensitivity. Details with regard to the odour panel methodology are contained in the attached analytical report from EOC.

Once the odour concentration of the samples has been determined, the odour flux rate is calculated. The sweep gas rate is used to calculate the odour flux rate based on the total air movement into the chamber. The formula that was used to calculate the odour flux rate is as follows:

$$OdourFlux\ Rate\left(\frac{ou}{s\cdot m^2}\right) = \frac{Odour\ Concentration\ \left(\frac{ou}{m^3}\right)\cdot Sweep\ Rate\ \left(\frac{m^3}{s}\right)}{Area\ of\ flux\ chamber\ (m^2)}$$

The odour flux rates from the primary clarifiers were simply averaged and the flux rate was applied to the total surface area of the primary clarifiers. Only the bioreactor samples with the suffix "A" were used in calculating the emission rate. Additionally, there is a noticeable difference in the entrance area to the bioreactors which we estimated extend over less than a ¼ of the first bioreactor tank – one eighth of the bioreactor surface area.

RESULTS

The table below shows the sample results for the odour samples collected:

Sample Label	Location	Collection Time	Odour Strength (OU)	Odour Flux ($OU/m^2/s$)
PRIM1A	Back end of Primary 1	7:50	2451	1.575
PRIM1B	Back end of Primary 2	8:45	1975	1.269
PRIM2A	Mid-point of Primary 1	9:47	3221	2.070
PRIM3B	Mid-point of Primary 2	10:45	2120	1.363
PRIM3A	Entrance of Primary 1	11:28	1877	1.206
PRIM3B	Entrance of Primary 2	12:07	2702	1.737
SEC1A	Entrance to Bioreactor 3	8:05	3566	2.292
SEC1B	Entrance to Bioreactor 3 (no sweep gas)	8:20	5770	not used
SEC2A	Mid-point of Bioreactor 3	9:15	386	0.248
SEC2B	Mid-point of Bioreactor 3 (no sweep gas)	9:40	310	not used
SEC2A	Exit of Bioreactor 3	10:20	574	0.369
SEC2B	Exit of Bioreactor 3 (no sweep gas)	10:30	358	not used

NOTES:

40.6	Chamber Diameter (cm)
1297	Surface area covered (cm^2)
0.130	Surface area covered (m^2)
5.0	sweep gas flow rate (lpm)
8.33E-05	sweep gas flow rate(m^3/s)

The table below shows the emission rates of odour emission sources:

Emission Source	Source Type	Surface Area	Emission Flux Rate	Emission Rate
Scrubber	Point	-	-	34,507 (OU/s)
Primary Clarifiers	Area	629.0 m^2	1.537 (OU/s/m^2)	966.7 (OU/s)
Secondary Bioreactors	Area	1320.0 m^2	0.5565 (OU/s/m^2)	734.5 (OU/s)
Secondary Clarifier 1	Area	368.5 m^2	0.0888 (OU/s/m^2)	32.5 (OU/s)
Secondary Clarifier 2	Area	366.0 m^2	0.0888 (OU/s/m^2)	32.5 (OU/s)
Secondary Clarifier 3	Area	382.0 m^2	0.0888 (OU/s/m^2)	32.5 (OU/s)
All Sources	Point and Area	3065.5 m^2	2.360 (OU/s/m2)	36,306 (OU/s/m2)

APPENDIX B

EOC ODOUR PANEL EVALUATION

Report

Odour Panel Evaluation

Report to:

RWDI Air Inc.
650 Woodlawn Road West
Guelph, Ontario
N1K 1B8

Mr. John DeYoe, B.A., d.E.T
Air Quality Specialist/Principal
E-mail: john.deyoe@rwdi.com
Phone: 519 823 1311 Ext. 2258

Prepared by:

EOC Environmental Odour Consulting Corporation

Anna H. Bokowa, M.Sc.
President
Tel: (647) 988-5814
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Date of the Report
August 21, 2016
7 pages, 1 Appendix

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1. INTRODUCTION

EOC Environmental Odour Consulting Corporation (EOC) was contracted by RWDI Air Inc. (RWDI) to perform an odour evaluation on samples shipped to EOC.

On August 17, 2016 twelve samples were shipped via Air Canada Cargo. EOC retrieved the samples from the Air Canada Cargo terminal in Mississauga, Ontario for same-day evaluations.

All samples were in good condition upon delivery.

2. METHODOLOGY

2.1 Odour Panel Evaluation

The evaluations were based on the European Standard EN 13725:2003 with the exception that each sample was introduced once to the panel members; eight panel members were used for all evaluations. Odour evaluations were also completed in accordance to the Ontario Ministry of the Environment's Method ON-6 "Determination of Odour Emission from Stationary Sources." The EOC olfactometer is capable of performing evaluations using either the Triangular Forced Choice Method, or the Binary Forced Choice Method. For the Forced Choice Method, the panelist is presented with two or three ports (Triangular, Binary), of which one presents diluted sample and the other(s) neutral gas. The sample is presented randomly over the two or three ports. The panelist is asked to indicate the port with the sample. The panelist is also asked if his/her choice was a guess, inkling or certain. By combining the chosen results and the indicated level of certainty, the response is classified as false or true. The odour evaluation procedure requires the first sample to be presented to the panelist at the dilution that will be below the detection threshold. Therefore, the several initial presentations to the panelists require the panelist to select one port by guessing. Each panelist observes an odour sample in the ascending concentration series (increasing concentration). For this program a Binary Forced Choice Mode was chosen for odour evaluations. Each sample bag was evaluated by eight panelists with the option that for each dilution each of the 8 panelists were asked to indicate their responses. Therefore, each panelist was introduced to the same dilution steps.

The panelists' responses were recorded by computer software and were processed to determine the odour detection threshold value (ODTV) for each sample. The ODTV is a dilution factor and therefore has no units. For convenience however, the ODTV may be expressed in odour units (ou).

A screened odour panel was used for all evaluations. Appendix 1 shows the screening data for the panelists. They were tested for odour sensitivity using n- butanol as a reference gas and are considered to be within the normal range according to the European Standard EN 13725:2003(20-80ppb n - butanol).

Prior to an evaluation session, the panelists are instructed to ensure that they do not have a residual odour from eating, drinking beverages (other than water), body odours or perfumes etc. Each panelist must closely follow instructions for evaluating a sample. Panelists who are ill or are taking medication which may affect their olfactory response are not allowed to participate in an evaluation session.

3. QUALITY CONTROL MEASURES AND CALIBRATION DATA

EOC provided extensive quality control measures for the evaluations. These included, but were not limited to:

- Keeping constant dilution steps between analysis of the samples from the same source.
- Each sample bag was evaluated by eight panelists with the option that for each dilution each of the 8 panelists were asked to indicate their responses (each panelist was exposed to the same dilution).
- The EOC olfactometer is calibrated by the manufacturer against carbon monoxide at all used ports. The calibrations are within the limits of EN13725 standard.
- The EOC olfactometer is checked before each use for consistent volumetric flow rates at each "sniff port."
- EOC panelists are screened using European Method EN; 13725 with n-butanol and they are within the range of that standard- all screening data are provided in the report.
- EOC panelists are trained to avoid any odorous products such as perfumes and scented lotions.
- EOC panelists are advised and trained to avoid coffee or spicy food one hour before a session.
- EOC makes sure that the sessions for the odour panel evaluations are not too long.
- EOC provides frequent breaks to avoid any panelist's fatigue.
- All panelists' data are computer recorded.

4. RESULTS

Table 1 shows the results for odour detection threshold values for samples evaluated on August 17, 2016.

Samples marked as SEC 1A and SEC 1B had very strong rotten eggs smell. Sample marked as PRIM 1A was described as a mixture of sewage and bleach. Sample marked as PRIM 3B was described as oily.

Prepared by:

H. Bokowa

Anna H. Bokowa, M.Sc.
President, Environmental Odour Consulting

Table 1: Odour Detection Threshold Values- August 17, 2016

Client Description	EOC Sample Identification	ODTV OU
SEC 1A	B17081676	3566*
SEC 1B	B17081677	5770*
SEC 2A	B17081678	386
SEC 2B	B17081679	310
SEC 3A	B17081680	574
SEC 3B	B17081681	358
PRIM 1A	B17081682	2451**
PRIM 1B	B17081683	1975
PRIM 2A	B17081684	3221
PRIM 2B	B17081685	2120
PRIM 3A	B17081686	1877
PRIM 3B	B17081687	2702**

*- rotten eggs
**- mixture of sewage smell and bleach
***-oily

APPENDIX 1

Panelist's Screening Data

(1 page)

Panelists Screening Data 2016

Panelist No	Panelist ID	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10	Test 11	Test 12	Average
								n- butanol ppb						
1508-3	1	42	36	40	32	48	40	41	40	38	42	40	40	40
1508-6	2	32	32	29	29	32	29	32	29	32	32	40	29	31
1508-7	3	46	42	43	44	46	51	49	44	46	58	43	46	47
1508-9	4	29	27	29	29	32	32	29	29	27	29	32	29	29
1508-2	5	54	52	52	52	54	60	58	52	54	52	52	52	54
1508-1	6	32	32	40	40	32	29	36	36	40	29	32	32	34
1508-11	7	29	32	32	32	40	38	39	38	38	39	32	34	36
1508-15	8	42	40	40	42	42	40	52	54	42	40	42	40	43
	Average:													39

Panelist Screening Data: August 17, 2016

Panelist No	Panelist ID	Test
1508-3	1	40
1508-6	2	29
1508-7	3	46
1508-9	4	29
1508-2	5	52
1508-1	6	32
1508-11	7	34
1508-15	8	40
Average:		**38**

CONSULTING ENGINEERS & SCIENTISTS

CANADA'S BEST MANAGED COMPANIES Platinum member

Memorandum

Tel: 604.730.5688
RWDI AIR Inc.
830 – 999 West Broadway
Vancouver, B.C., Canada V5Z 1K5
Email: solutions@rwdi.com

Date: **21 September, 2016** **RWDI Reference #:** 1500239

To:	Mike Imrie Comox Valley Regional District	**E-Mail:**	mimrie@comoxvalleyrd.ca
cc:	Kris La Rose Comox Valley Regional District	**E-Mail:**	klarose@comoxvalleyrd.ca
From:	John DeYoe, B.A., d.E.T.	**E-Mail:**	john.deyoe@rwdi.com

Re: **CVWPCC Wet Scrubber Efficiency Testing- Preliminary Draft**
CVRD Comox Valley Odour Control
Comox, BC

Dear Mike,

RWDI was retained to complete efficiency testing on the wet scrubber located at the Comox Valley Water Pollution Control Centre (CVWPCC). The scrubber testing was done previously under normal working conditions. The scrubber needed to be challenged with higher concentrations of Hydrogen Sulfide (H_2S) in order to see if the scrubber was still working as efficiently as when it was installed. An experimental process was designed where pure H_2S was metered into the inlet of the scrubber just upstream of the blower while H_2S concentrations at the stack were being monitored.

Velocity, Temperature and Volumetric Flow Rate Determination

Source velocity and flow rates were determined by U.S. EPA Methods 1 and 2. Velocity measurements were taken with a Standard type Pitot tube in conjunction with a digital manometer. Temperature measurements were made simultaneously with the velocity measurements, using a chromel-alumel type “k” thermocouple in conjunction with a digital temperature indicator. The volumetric flow rate was determined by following the equal area method as outlined in Method 2.

With reference to stack gas composition, the dry molecular weight (Md) was determined by following calculations outlined in Method 3. Stack gas composition was assumed to be similar to previous measurements which were determined through the employment of a Nova Combustion Analyser. The analyser measures the CO_2 concentration of the stack gas by means of a non-dispersive infrared (NDIR) detector. The O_2 concentration is measured by the analyser through the use of an electrochemical cell. Moisture determination was conducted by following Method 4.

Hydrogen Sulfide Sampling

Sampling for H_2S was performed in accordance with U.S. EPA Methods CEMS 5 using a continuous emission monitor (CEM). The method provides real-time measurement for total reduced sulfur. The exhaust gas sample was withdrawn from a point at the center of the duct using a stainless steel probe. The sample proceeded to a heated filter, where particulate matter was removed, and then transferred via a heated Teflon® line to a sample conditioner. The Teflon® line was heated above the condensation temperature of the exhaust gas stream. The sample conditioner eliminated any condensation in the exhaust. The sample was then routed to the CEM for measurement. Reference method measurements were taken at the outlet of the scrubber and in one case at the inlet of the scrubber. The inlet concentration was calculated based on the precisely measured flow of H_2S entering the system diluted by the measured flow of air through the system. A background inlet concentration of two parts per million was also added to the inlet concentration.

The test time for the experiment was limited somewhat due to the amount of pure hydrogen sulfide that was available for testing. It was felt that only one cylinder of H_2S should be used because of safety and environmental odour concerns.

The scrubber removal efficiency was calculated by comparing inlet and outlet concentrations. The chemical efficiency was calculated from the mass of H_2S removed in the scrubber. The theoretical chemical usage can be calculated from the chemical equations for H_2S removal. This value was compared to the chemical feed rate into the scrubber.

Results and Discussion

The results of the efficiency testing are shown in Table 1 and Table 2. The flow measurements are shown in Table 3. The results of the efficiency testing are also shown graphically in Figures 1 and 2, attached.

Test 1 shows that the initial low concentration testing showed fairly low efficiency, which was to be expected, since the inlet concentrations were close to the off-gassing equilibrium of the scrubber solution found in the outlet. As the inlet concentration was increased the scrubber efficiency went to above 95%. However, as time went by the efficiency of the scrubber decreased. It was discovered that the pH of the scrubber solution and the hypochlorite level were below the set point and could not recover quickly enough to accommodate the increased H_2S loading.

CVWPCC staff made adjustments and the hypochlorite and PH levels in the scrubber solution were raised back to working levels and the scrubber was challenged again with a high level concentration of H_2S. The scrubber performed at greater than 95% removal efficiency. However, as the scrubber fluid was challenged the pH and hypochlorite levels became reduced, the removal efficiency dropped off.

Please note, the instrument used to measure outlet concentration was required to be set at a 0 to 500 ppm range. As such, it is reasonable to expect an output accuracy of ± 2 ppm. We will therefore prefer to state that the removal efficiency is greater than 95% than to quote the strict numeric value shown in the tables.

Conclusion

The scrubber is still quite capable of operating at its design removal efficiency. However, the automated system for maintaining the scrubber solution is not currently adapted for dealing with prolonged high levels of H_2S. The system is operating reasonably well under normal operating conditions and is quite capable of dealing with any spikes in H_2S concentrations that may occur. If H_2S levels in the inlet stream were anticipated to increase it may be advisable to increase the set points for pH and hypochlorite levels. It may be advisable to increase these levels as a precaution under current operations if the CVRD staff felt it was reasonably achievable.

Kind regards,

John DeYoe, B.A., d.E.T.
Project Director / Air Quality Specialist / Principal

CONSULTING ENGINEERS & SCIENTISTS

Table 1 - Comox Valley Water Pollution Control Centre. Scrubber Efficiency Test #1

	Inlet	Outlet	Control
	H_2S	H_2S	Efficiency
Date/Time	(ppm)	(ppm)	(%)
8/17/2016 13:37	3.0	2.2	25.2
8/17/2016 13:38	3.0	2.3	23.9
8/17/2016 13:39	3.0	2.3	21.4
8/17/2016 13:40	3.0	2.4	20.0
8/17/2016 13:41	3.0	2.5	16.6
8/17/2016 13:42	3.0	2.5	16.9
8/17/2016 13:43	3.0	2.4	20.0
8/17/2016 13:44	3.0	2.1	28.4
8/17/2016 13:45	3.0	2.2	27.3
8/17/2016 13:46	3.0	2.3	23.8
8/17/2016 13:47	3.0	2.2	26.8
8/17/2016 13:48	3.0	2.1	29.8
8/17/2016 13:49	3.0	2.2	27.8
8/17/2016 13:50	3.0	2.2	27.2
8/17/2016 13:51	4.3	2.3	47.4
8/17/2016 13:52	4.3	2.3	46.1
8/17/2016 13:53	4.3	2.4	45.0
8/17/2016 13:54	4.3	2.3	46.3
8/17/2016 13:55	4.3	2.3	45.8
8/17/2016 13:56	4.3	2.4	45.3
8/17/2016 13:57	4.3	2.4	44.8
8/17/2016 13:58	4.3	2.5	42.9
8/17/2016 13:59	4.3	2.5	42.9
8/17/2016 14:00	4.3	2.5	43.1
8/17/2016 14:01	4.3	2.4	44.2
8/17/2016 14:02	4.3	2.5	42.1
8/17/2016 14:03	4.3	2.6	39.8
8/17/2016 14:04	4.3	2.7	37.1
8/17/2016 14:05	4.3	2.8	36.4
8/17/2016 14:06	4.3	2.8	36.3
8/17/2016 14:07	4.3	2.8	35.3

	Inlet H_2S	Outlet H_2S	Control Efficiency
8/17/2016 14:08	4.3	2.9	32.5
8/17/2016 14:09	4.3	2.8	35.0
8/17/2016 14:10	4.3	2.7	36.8
8/17/2016 14:11	4.3	2.7	37.3
8/17/2016 14:12	4.3	2.7	37.8
8/17/2016 14:13	4.3	2.6	40.5
8/17/2016 14:14	4.3	2.5	41.1
8/17/2016 14:15	4.3	2.4	45.1
8/17/2016 14:16	4.3	2.3	47.5
8/17/2016 14:17	4.3	2.2	49.0
8/17/2016 14:18	4.3	2.2	49.4
8/17/2016 14:19	4.3	2.1	51.2
8/17/2016 14:20	4.3	1.9	55.0
8/17/2016 14:21	5.4	2.0	63.9
8/17/2016 14:22	5.4	1.9	64.8
8/17/2016 14:23	5.4	1.8	67.6
8/17/2016 14:24	5.4	1.6	70.0
8/17/2016 14:25	5.4	1.5	72.6
8/17/2016 14:26	5.4	1.6	70.9
8/17/2016 14:27	5.4	1.6	71.0
8/17/2016 14:28	5.4	1.5	72.8
8/17/2016 14:29	5.4	1.5	72.9
8/17/2016 14:30	5.4	1.4	75.0
8/17/2016 14:31	5.4	1.3	75.5
8/17/2016 14:32	5.4	1.2	77.0
8/17/2016 14:33	5.4	1.2	78.4
8/17/2016 14:34	5.4	1.2	78.4
8/17/2016 14:35	5.4	1.2	78.5
8/17/2016 14:36	5.4	1.1	80.4
8/17/2016 14:37	5.4	1.0	82.2
8/17/2016 14:38	15.6	1.0	93.9
8/17/2016 14:39	15.6	1.0	93.8
8/17/2016 14:40	15.6	0.9	94.3

	Inlet	Outlet	Control
	H_2S	H_2S	Efficiency
8/17/2016 14:41	15.6	1.0	93.8
8/17/2016 14:42	15.6	0.8	94.6
8/17/2016 14:43	15.6	0.8	94.8
8/17/2016 14:44	15.6	0.8	94.7
8/17/2016 14:45	15.6	0.8	94.6
8/17/2016 14:46	15.6	0.7	95.6
8/17/2016 14:47	15.6	0.7	95.8
8/17/2016 14:48	15.6	0.7	95.2
8/17/2016 14:49	15.6	0.7	95.4
8/17/2016 14:50	15.6	0.7	95.6
8/17/2016 14:51	15.6	0.7	95.7
8/17/2016 14:52	15.6	0.7	95.4
8/17/2016 14:53	15.6	0.6	96.4
8/17/2016 14:54	15.6	0.6	96.3
8/17/2016 14:55	15.6	0.7	95.4
8/17/2016 14:56	15.6	0.6	95.9
8/17/2016 14:57	15.6	0.6	96.2
8/17/2016 14:58	15.6	0.5	97.0
8/17/2016 14:59	15.6	0.2	99.0
8/17/2016 15:00	15.6	0.2	98.9
8/17/2016 15:01	15.6	0.1	99.5
8/17/2016 15:02	15.6	0.2	98.5
8/17/2016 15:03	24.5	0.1	99.7
8/17/2016 15:04	24.5	0.1	99.7
8/17/2016 15:05	24.5	0.2	99.2
8/17/2016 15:06	24.5	0.1	99.6
8/17/2016 15:07	24.5	0.1	99.6
8/17/2016 15:08	24.5	0.1	99.5
8/17/2016 15:09	24.5	0.1	99.5
8/17/2016 15:10	24.5	0.2	99.1
8/17/2016 15:11	24.5	0.3	98.9
8/17/2016 15:12	24.5	0.3	98.9
8/17/2016 15:13	24.5	0.3	99.0

	Inlet	Outlet	Control
	H_2S	H_2S	Efficiency
8/17/2016 15:14	24.5	0.4	98.6
8/17/2016 15:15	24.5	0.5	97.9
8/17/2016 15:16	24.5	0.7	97.0
8/17/2016 15:17	24.5	0.8	96.7
8/17/2016 15:18	24.5	1.0	95.8
8/17/2016 15:19	24.5	1.2	95.2
8/17/2016 15:20	24.5	1.5	93.9
8/17/2016 15:21	24.5	1.6	93.4
8/17/2016 15:22	24.5	1.8	92.6
8/17/2016 15:23	24.5	2.1	91.5
8/17/2016 15:24	24.5	2.3	90.5
8/17/2016 15:25	24.5	2.5	90.0
8/17/2016 15:26	24.5	2.6	89.4
8/17/2016 15:27	47.4	2.8	94.2
8/17/2016 15:28	47.4	2.1	95.5
8/17/2016 15:29	47.4	1.7	96.4
8/17/2016 15:30	47.4	2.6	94.6
8/17/2016 15:31	47.4	3.7	92.2
8/17/2016 15:32	47.4	4.8	89.9
8/17/2016 15:33	47.4	6.1	87.2
8/17/2016 15:34	47.4	7.3	84.5
8/17/2016 15:35	47.4	9.5	80.1
8/17/2016 15:36	47.4	9.2	80.7
8/17/2016 15:37	47.4	8.7	81.7
8/17/2016 15:38	47.4	8.5	82.1
8/17/2016 15:39	47.4	8.1	82.9
8/17/2016 15:40	47.4	8.9	81.1
8/17/2016 15:41	47.4	10.0	78.9
8/17/2016 15:42	47.4	10.5	77.8
8/17/2016 15:43	47.4	11.0	76.7
8/17/2016 15:44	47.4	11.4	76.0
8/17/2016 15:45	47.4	11.5	75.7
8/17/2016 15:46	47.4	11.7	75.4

	Inlet	Outlet	Control
	H_2S	H_2S	Efficiency
8/17/2016 15:47	47.4	11.9	74.9
8/17/2016 15:48	47.4	12.1	74.6
8/17/2016 15:49	47.4	12.4	73.9
8/17/2016 15:50	47.4	12.4	73.9
8/17/2016 15:51	47.4	12.6	73.4
8/17/2016 15:52	47.4	12.9	72.8
8/17/2016 15:53	89.5	13.1	85.3
8/17/2016 15:54	89.5	13.4	85.0
8/17/2016 15:55	89.5	17.0	81.0
8/17/2016 15:56	89.5	22.9	74.4
8/17/2016 15:57	89.5	28.0	68.7
8/17/2016 15:58	89.5	32.1	64.1
8/17/2016 15:59	89.5	34.2	61.8
8/17/2016 16:00	89.5	31.2	65.2
8/17/2016 16:01	89.5	29.6	66.9
8/17/2016 16:02	89.5	29.8	66.8
8/17/2016 16:03	89.5	30.8	65.6
8/17/2016 16:04	89.5	30.2	66.3
8/17/2016 16:05	89.5	30.1	66.3
8/17/2016 16:06	89.5	32.7	63.5
8/17/2016 16:07	89.5	36.6	59.1
8/17/2016 16:08	47.4	35.3	25.5
8/17/2016 16:09	47.4	31.7	33.2
8/17/2016 16:10	47.4	28.0	40.9
8/17/2016 16:11	47.4	24.5	48.4
8/17/2016 16:12	47.4	21.4	54.9
8/17/2016 16:13	47.4	17.8	62.4
8/17/2016 16:14	47.4	15.8	66.6
8/17/2016 16:15	47.4	15.0	68.4
8/17/2016 16:16	47.4	13.8	70.8
8/17/2016 16:17	47.4	13.1	72.4
8/17/2016 16:18	47.4	12.4	73.8
8/17/2016 16:19	47.4	11.9	74.9

	Inlet H_2S	Outlet H_2S	Control Efficiency
8/17/2016 16:20	47.4	12.7	73.3
8/17/2016 16:21	47.4	13.7	71.2

Table 2 - Comox Valley Water Pollution Control Centre. Scrubber Efficiency Test #2

	Inlet H_2S	Outlet H_2S	Control Efficiency
Date/Time	**(ppm)**	**(ppm)**	**(%)**
8/17/2016 18:26	89.5	0.0	99.9
8/17/2016 18:27	89.5	0.0	99.9
8/17/2016 18:28	89.5	0.0	99.9
8/17/2016 18:29	89.5	0.0	99.9
8/17/2016 18:30	89.5	0.0	99.9
8/17/2016 18:31	89.5	0.0	99.9
8/17/2016 18:32	89.5	0.0	99.9
8/17/2016 18:33	89.5	0.0	99.9
8/17/2016 18:34	89.5	0.0	99.9
8/17/2016 18:35	89.5	0.0	99.9
8/17/2016 18:36	89.5	0.2	99.8
8/17/2016 18:37	89.5	0.9	99.0
8/17/2016 18:38	89.5	1.2	98.7
8/17/2016 18:39	89.5	1.3	98.6
8/17/2016 18:40	89.5	1.6	98.2
8/17/2016 18:41	89.5	3.5	96.1
8/17/2016 18:42	89.5	6.2	93.1
8/17/2016 18:43	89.5	8.2	90.8
8/17/2016 18:44	89.5	10.0	88.9
8/17/2016 18:45	89.5	11.8	86.9
8/17/2016 18:46	89.5	13.3	85.2

RWDI
CONSULTING ENGINEERS & SCIENTISTS

TABLE 3
Stack Gas Velocity and Volumetric Flow Rate

Client:	Comox WWTP
Project #:	
Locations:	Main Stack
Date:	17-Aug-16
Time:	
stack diameter (inches):	30
Stack Area, (ft2):	4.9
Barometric Press, Pb (" Hg):	29.92
Stack Pressure, Ps (" Hg):	29.73

Pitot Coefficient, Cp:	1
Molar Weight Stack Gas:	29.06
Moisture, Bws (%):	1.3%
Static Pressure, Pg (" H2O):	-2.55

Point	Position (in)	Traverse 1 delta P (" H_2O)	Traverse 1 Temp (Ts) (°F)	Traverse 1 Velocity (ft/s)	Traverse 1 Cyclonic Angle	Traverse 2 delta P (" H_2O)	Traverse 2 Temp (Ts) (°F)	Traverse 2 Velocity (ft/s)	Traverse 2 Cyclonic Angle
1	3	0.67	72	54.8	0	0.38	72	41.3	0
2	6	0.62	72	52.7	0	0.46	72	45.4	0
3	9	0.61	72	52.3	0	0.60	72	51.9	0
4	12	0.62	72	52.7	0	0.62	72	52.7	0
5	15	0.62	72	52.7	0	0.65	72	54.0	0
6	18	0.64	72	53.6	0	0.66	72	54.4	0
7	21	0.65	72	54.0	0	0.65	72	54.0	0
8	24	0.68	72	55.2	0	0.67	72	54.8	0
9	27	0.68	72	55.2	0	0.69	72	55.6	0
Average		**0.64**	**72**	**53.7**		**0.60**	**72**	**51.6**	

Average velocity	(ft/s)	52.6
	(m/s)	16.0
Flow Rate, Qs (actual)	(cfm)	15,504
	(m3/min)	439.0
	(m3/sec)	7.32
Flow Rate, Qs (ref,dry)	(cf/sec)	256
	(m3/sec)	**7.25**

Dry Molecular Weight		
O_2	21.8	%
CO_2	1.4	%
CO	0	ppm
N_2	75.9	%
Ar	0.9	%
Md	**29.20**	

Stack Gas Moisture Content			
Impinger	Final	Initial	Gain
1			23.6
2			9.9
3			4.1
4			8.5
Total	(g)		**46.1**

Volume of gas sampled		
Dry Gas Meter Reading	1,000.00	ft^3
Dry gas meter temp	49	°F
Orifice Pressure	0.5	" H_2O
Dry gas meter pressure	29.96	
Dgm correction	0.9593	
Total Volume(dry.ref)	**1,013.44**	ft^3

BWS		
Volume water vapour	2.2128	ft^3
Moisture (B_{ws})	**0.013**	

Figure 1 - CVWPCC Scrubber Control Efficiency Test #1

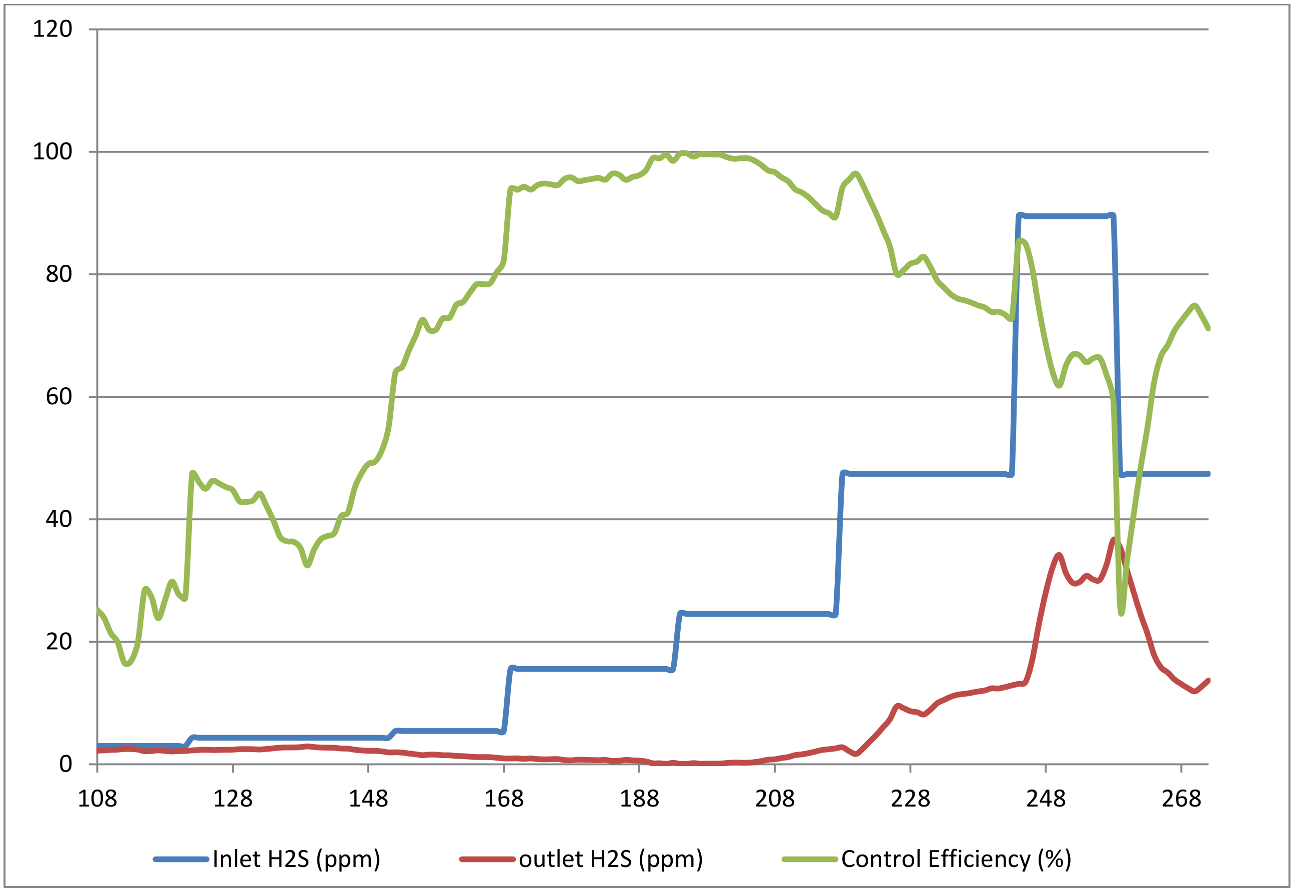
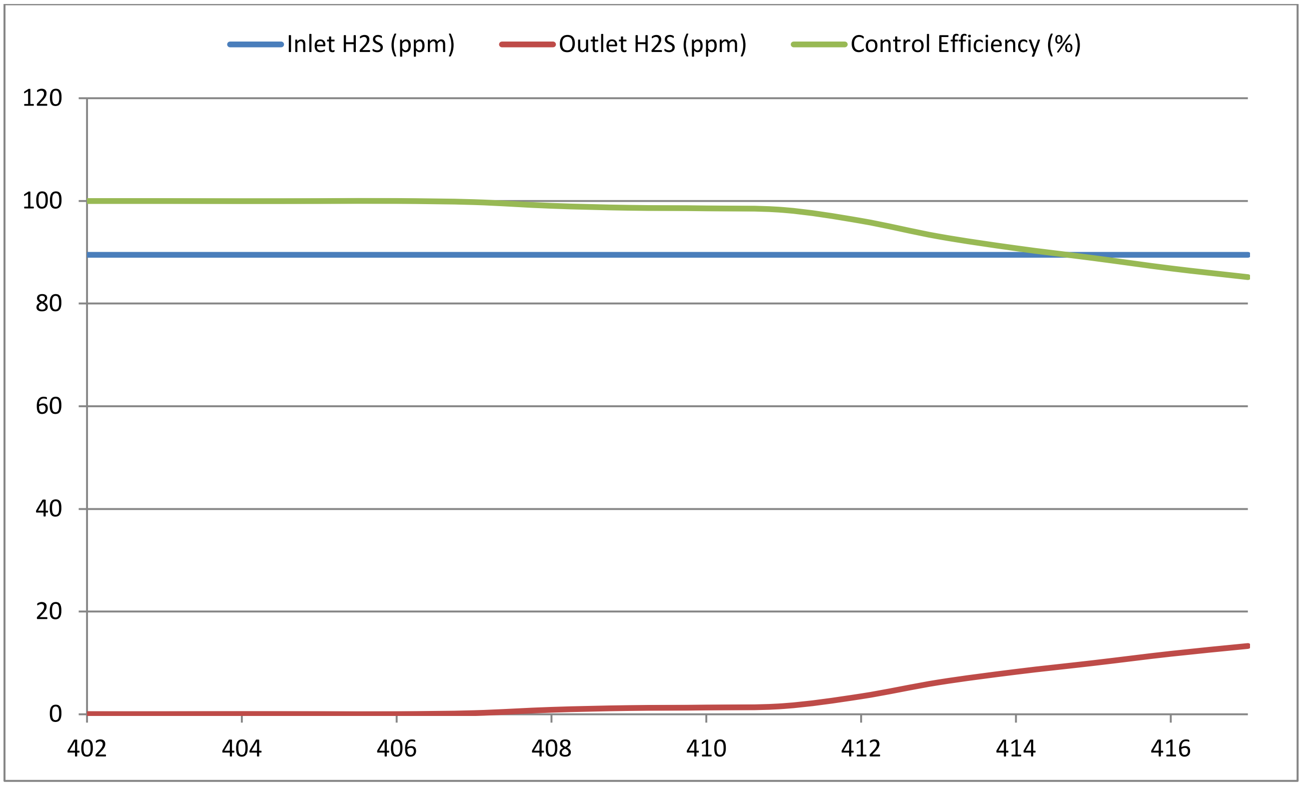


Figure 2 - CVWPCC Scrubber Control Efficiency Test #2



APPENDIX D

ISL Engineering and Land Services

Inspiring sustainable thinking

Comox Valley Regional District

Draft Report

CVWPCC - Odour Control Options

December, 2016

ISL Engineering and Land Services

ISL Engineering and Land Services Ltd. is an award-winning full-service consulting firm dedicated to working with all levels of government and the private sector to deliver planning and design solutions for transportation, water, and land projects.

Table of Contents

1.0 Introduction

1.1 Background

ISL Engineering and Land Services Ltd. (ISL) was retained by the Comox Valley Regional District (CVRD) to provide engineering consulting services for the Comox Valley Water Pollution Control Centre (CVWPCC), Odour Control Options. The project consists of identifying the total air volume that needs to be treated from the existing facilities and the new infrastructure that will be added in the near future. The project also includes addressing the existing wet scrubber system, evaluating available odour control technologies, preparing capital and operating cost of each technology, and identifying any required work for implementation.

The CVWPCC is a secondary level wastewater treatment plant and classified as a Level IV facility. The plant serves the city of Courtenay, the town of Comox, K'omoks First Nation and CFB Comox. The facility is comprised of five main components:

- Preliminary Treatment
- Primary Treatment
- Biological and Secondary Treatment
- Sludge Processing and Disposal
- Odour Control with Chemical Wet Scrubber

Although the facility was constructed in 1984, its major odour treatment system was added during the plant upgrade in 1997. Due to frequent odour complaints from sounding residents, the composting facilities were relocated out of the treatment plant in a way to minimize odour impacts. However, there are still some odour complaints received, especially on evenings in the late summer or early fall when certain weather conditions (off-shore wind) prevail.

1.2 Generation of Odour

Domestic wastewater contains biosolids, which are an abundant source of food for microorganisms including proteins, amino acids and carbohydrates. These microorganisms degrade these energy sources and odorous compounds are formed. Organic and inorganic forms of sulphur, mercaptans, ammonia, amines, and organic fatty acids are identified as the most offensive odour causing compounds associated with wastewater treatment plants. These compounds typically are released from the biosolids by heat, aeration and digestion. The odours vary by the type of solids processed and the method of processing. In general, most odours develop during pre-treatment, primary treatment and solid management processes.

The most common odours, description and thresholds are described in Table 1.1.

Table 1.1 – Sewage Odour Characteristics

Malodour	Odour Description	Odour Threshold
Hydrogen Sulphide (H_2S)	Rotten eggs	3 ppb
Mercaptans	Skunk, rotten cabbage	20 to 300 ppt
Carbon Disulphide	Rotten vegetables	200 to 800 ppb
Dimethyl Sulphide	Decayed vegetables	1 ppb
Indole, Skatole	Fecal, nauseating	100 ppt
Amine	Putrid, fishy	400 ppt to 100 ppb
Ammonia	Pungent, irritating	17 to 50 ppm

ppm = parts per million; ppb = parts per billion; ppt = parts per trillion

1.3 Summary of Previous Studies

RWDI AIR Inc. (RWDI) has completed the studies below at the CVWPCC; findings are summarized in this section. Appendix A includes previous reports.

1.3.1 Odour Control System Evaluation Report

- In October 30, 2015, RWDI completed a study “Odour Control System Evaluation”. This study involved a review of design flow rates, concentrations and removal efficiencies, set up odour samplings and models, and audited the operational and maintenance odour potential of the existing plant.
- In this report, the existing scrubber efficiency was found to be 60% sulphur removal and 42% removal efficiency of odour. The test was completed under normal working conditions where the inlet concentration of reduced sulphur was very low and did not exceed 1 part per million (ppm) during testing.
- The current odour control system does have several large leak points which should be sealed or at least reduced to minimize any odour escaping from the collection duct works. There are likely other smaller leaks around sealed cover plates and other small sources. A recommendation was made to check on vacuum at various points in the system to identify areas where leaks developed. These openings could be reduced in size and the remaining area could be covered with neoprene flaps. This would still leave ample access for maintenance and decrease the amount of vacuum leakage.
- The air sampling resulted in various levels of H_2S at the plant, ranging from zero to 66 parts per billion (ppb). Table 1.2 shows sampling results and Figure 1.1 indicates sampling locations with red circles being classified as high, blue as medium and green as low. Note that the detection threshold limit of H_2S is 3.0 ppb, so all circled areas represent the treatment infrastructures that need odour collection and control. The non-circled areas were measured at zero ppb.

Table 1.2 – H_2S Sampling Results

Sample Points	H_2S (ppb)	Sample Locations
1	0	parking lot in front of main door to control building
2	0	back end of bioreactors
3	0	6 feet above bioreactor in the middle
4	0	bar screen room
5	66	solids loading bay
6	19	centrifuge room
7	2	foot above primary surface
8	5	foot above primary tank adjacent to bubbling gas
9	5	above water drop at end of primary
10	0	foot above primary tank at top end
11	0	beneath walkway at the end of the bioreactors
12	0	edge of clarifier
13	1	on edge of pressure chamber
14	0	approximately 18" below goose neck vent from discharge well chamber
15	0	front gate
16	1	blower room
17	2	DAF building

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CVWPCC - ODOUR CONTROL OPTIONS

HYDROGEN SULFIDE SAMPLING LOCATIONS
IMAGE ADAPTED FROM RWDI (2015)

Figure 1.1

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- RWDI measured the Total Reduced Sulphur (TRS) at the scrubber inlet and exhaust stack. Table 1.3 summarizes TRS measurements that were taken on January 2015

Table 1.3 – Summary of TRS sampling (based on RWDI Report (2015)).

Location	Average TRS (ppm)	Emission Rate (mg/s)
Inlet to Scrubber (aerator off)	0.3	4.4
Inlet to Scrubber (aerator on)	1.0	14.5
Exhaust Stack	0.4	5.8

1.3.1 Odour Dispersion Modelling Report

- In September 21, 2016, RWDI completed a study "Odour Dispersion Modelling". This study conducted odour sampling on the primary clarifier and secondary bioreactor, and a dispersion modeling study to estimate the effect of the CVWPCC on neighbouring areas. The dispersion modeling was used to determine if the existing scrubber and the exhaust stack provide sufficient odour control. The modeling also studied other sources of odour at the facility.
- In this report, the CVWPCC was predicted to generate odour above the Ontario odour standard over two kilometres from the facility. The strongest odour emissions were from the scrubber stack, followed by the primary clarifiers. The secondary bioreactor is the third contributor to overall odour at all sensitive receptors. Secondary clarifiers were predicted to contribute very little to the overall odour concentrations at sensitive receptors. The greatest single impact to improving the odour impacts from the facility would be achieved by putting an additional control on the scrubber stack. The study concluded that even with additional control on the stack, the site would still have significant odour impacts associated with the primary clarifiers and the bioreactors. The study recommended that those tanks be covered and vented through the scrubber stack.

1.3.2 CVWPCC Wet Scrubber Efficiency Testing Memorandum

In September 21, 2016, RWDI completed efficiency testing of the existing chemical scrubber. The test was done under challenging conditions by injecting H_2S in the scrubber inlet. The scrubber achieved greater than 95% removal efficiency of H_2S at inlet concentrations higher than 15.0 ppm. For H_2S concentrations of 3 to 5 ppm, the scrubber efficiency ranged from 25% to 80%.

2.0 Design Criteria

Current and anticipated foul air flow rates are summarized in this section. These flow rates are used as the design criteria to determine and compare various odour control treatment technologies and their capital and long-term lifecycle costs

2.1 Existing Air Flow Rates

The record drawings by Reid Crowther (1997) and Earth Tech (2002) were used as a base to determine the air flows from various treatment processes buildings. Table 2.1 provides the designed flow rate from each unit process.

Table 2.1 – Existing Air Flows from Various Processes

#	Treatment Process	Design Air Flow m^3/hr	Duct Size mm
1	Gravity Thickener #2	300	250
2	Gravity Thickener #1	300	250
3	Sludge TS Holding Tank[1]	1,900	350
4	Sludge TWAS Holding Tank[1]		350
5	Sludge TS Holding Tank[1]	1,900	350
6	Sludge TWAS Holding Tank[1]		350
7	Pre-aeration #2	581	200
8	Pre-aeration #1	581	200
9	Grit Dewatering Building	4,600	450
10	Pre-aeration #3	581	200
11	Influent Channel	581	300
12	DAF Building[2]	2,496	400
13	Truck Loading	2,650	400
14	Sludge Dewatering	4,325	450
15	Equipment Area	4,325	450
	Total	**28,920**	

Notes:
[1] ISL assumed a total of 3800 m^3/hr from the existing sludge tanks as per record drawings (1997 and 2002) which provides approximately 6 air changes per hour when the tanks are empty. The duct works of the sludge tanks are sized based on (4 x 1900 m^3/hr = 7600 m^3/hr).
[2] All flow rates are based on 1997 record drawings with exception of the DAF building which is added 2002, DAF building flow rate is based on Earth Tech 2002 record drawings.

2.2 Future Air Flow Rates

The RWDI 2016 study concluded that even with additional control on the stack, the site would still have significant odour impacts associated with the primary clarifiers and the bioreactors. The study identified the scrubber stack as the largest odour contributor followed by the primary clarifiers. The secondary bioreactor was considered the third largest contributor to overall odour.

The study concluded that the primary clarifiers and bioreactors need to be covered and vented through the scrubber stack. Table 2.2 provides the estimated future air flows from the anticipated future structures (up to 2037).

Table 2.2 – Future Air Flows from Various Processes

No.	Future Facilities (up to 2037)	Planned Construction Year	No. of Units	Dimensions, each (m)					Max. Void/ Air Volume (m^3)	No. Air Changes/ Hour	Aerated Air Flow (m^3/hr)	Max. Air Flow (m^3/hr)
				Dia-meter	Length	Width	Full Height	Min. Water Depth				
16	Cover existing primary tanks	2017	3		32.65	6.10	3.60	2.91	323	12	0.0	3,872
17	New grit chamber and channels	2017	1	5.00			5.20	4.79	5	12	0.0	62
18	Grit removal channels		1		30.00	1.15	1.30	0.88	9	12	0.0	112
19	Offline equalization tank	2017	1		40.00	30.00	6.25	0.10	7,080	0	0.0	0
20	Two primary clarifiers	2033	2		32.65	6.10	3.60	2.91	215	12	0.0	2,581
											Total (Future up to 2037)	**6,627**
					Optional							
21	Cover existing bioreactors (existing)	2017	3		76.20	5.23	4.11	3.49	921	4.0	13,200	16,882
22	One new bioreactor (new)	2024	1		76.20	5.23	4.11	3.49	307	4.0	4,400	5,627
											Total (Optional)	**22,510**

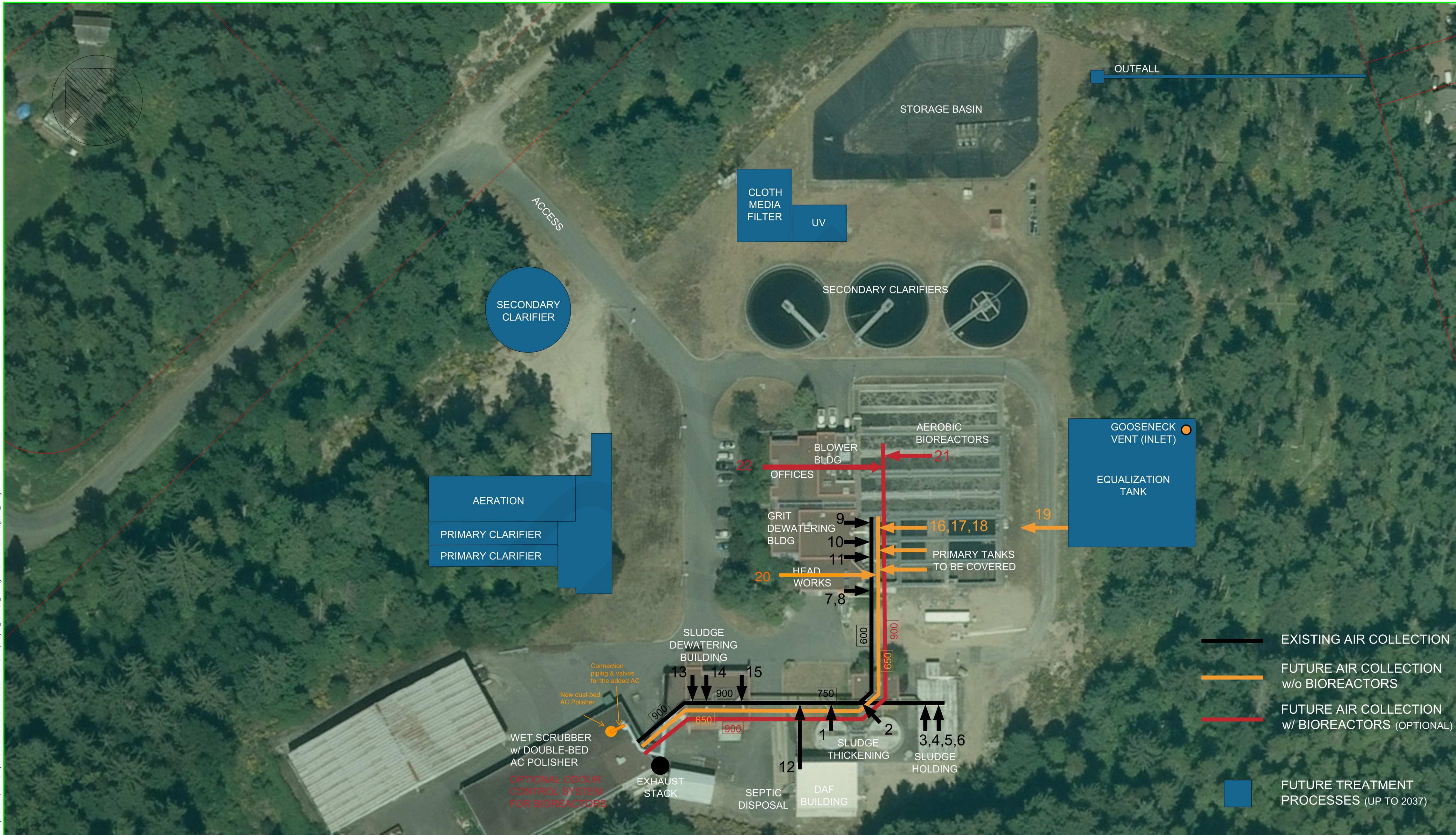
In developing the anticipated future air volumes, these assumptions were used:

- For bioreactors, in addition to the required air changes per hour, the bioreactors are aerated using fine bubble diffusers; therefore, higher ventilation rates are needed to account for the diffused air through the liquid and released at the surface. The required total air flow from the four bioreactors (3 for year 2017 and 1 for 2024) is 22,510 m^3/hr, which represents a substantial new air load to the system. The current capacity of the chemical scrubber is 27,000 m^3/hr which covers all existing structures. So, in order to cover the bioreactors and treat the air from them, an additional dedicated scrubber system will be required for the bioreactors.
- The measured H_2S at the location of the bioreactors is 0 ppm (6 feet above bioreactors in the middle) as per the sampling results in Table 1.2, this sample result represents a one-time measurement and the readings may be higher at any other times. In order to provide a system with a reasonable cost, the required air flow from the bioreactors was separated and treated as an optional item that can be included in the immediate construction stage or delayed for future construction.
- Primary clarifiers will be covered with FRP flat covers (50 mm thickness).
- Mechanical mixing will be used for mixing of the equalization tank.
- Twelve air changes are used for primary clarifiers and new grit removal (vortex type).
- Four air changes are used for bioreactors.
- Due to the large size of the offline equalization tank and its intermediate operation (during emergencies only), and the variability of the water surface during operation, the equalization tank will be ventilated through the primary clarifiers. The primary clarifiers and equalization tank fresh air inlet will be located on the top of the equalization tank, and both clarifiers and equalization tanks will be maintained under air vacuum at all times. The equalization tank is considered a confined space, and all safe entry procedures shall be implemented by the plant staff which includes forced air ventilation by portable blower during emergency access.

Figure 2.1 is a schematic of the required air pipes to accommodate the anticipated air volumes. This schematic is developed for cost estimating purposes. In the preliminary design, the existing main air duct can be replaced with a bigger diameter duct or a new separate duct system can be implemented. Table 2.3 summarizes the total air requirements.

Table 2.3 – Total Air Requirements

	Future Facilities (up to 2042)	Existing + Future without Bioreactors	Bioreactor
		m^3/hr	m^3/hr
1	Existing system	25,120	
2	Existing pre-aeration system (to be removed)	-1,743	
3	Future air requirements without bioreactors up to year 2037	7,887	
4	Bioreactors (optional)		22,510
	Total	**31,264 Rounded to 32,000**	**22,510 Rounded to 23,000**



Peter Rupar / Nov. 9, 16 / T:\Projects\31000\31548 CVRD Wastewater Treatment Capacity\02_CADD\20_Drafting\CVRD Odour Control Figure 1_2.dwg

ISL Engineering and Land Services

CVWPCC - ODOUR CONTROL OPTIONS

KEY TREATMENT ASSETS AND ODOUR COLLECTION PATHS
PLAN VIEW

Figure 2.1

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3.0 Odour Control

There are various technologies available to limit or control odours. The technologies considered for CVWPCC include:

- Chemical scrubber (existing odour control system)
- Activated carbon;
- Biological filters; and
- Ultraviolet (UV) radiation.

Each of these technologies has advantages and disadvantages depending on the application. All options were evaluated based on the following:

Total Air Flow Rate	32,000 m^3/hr (18,800 cfm)
Average Inlet H_2S and Organic Odour Concentration	2 ppm and 2 ppm
Peak Inlet H_2S Concentration	10 ppm
Minimum H_2S and Odour Removals	99.0% or 0.02 ppm out, whichever is greater

The following sections provide a brief summary on each odour control technology.

3.1 Existing Chemical Wet Scrubber

From the RWDI report (2015), the existing packed column scrubber is a standard design with a counter flow system using a caustic soda and sodium hypochlorite scrubbing solutions. The chemical wet scrubber is a proven technology which can remove up to 99% of H_2S.

There are sensors to monitor pH and Oxidation Reduction Potential (ORP) levels. A pH probe and controller maintain the proper pH by regulating the rate of sodium hydroxide added to the solution. An ORP probe and controller maintain the proper chlorine residual by regulating the rate of sodium hypochlorite added to the solution.

As the plant has very limited ammonia and other nitrogen compounds, the existing single stage scrubber system is suitable. In terms of the current scrubber operation, the caustic dosing pump turns on or off based on the set level of pH 10.1 while the on and off setting of the hypochlorite dosing pump is driven by the set level of ORP 650 mV. The set levels of pH and ORP are within the typical scrubber operational values.

The first chemical is Caustic Soda (Sodium Hydroxide -NaOH) to target H_2S removal. The second chemical used is Sodium Hypochlorite (NaOCl) to oxidize the remaining H_2S and organic odours. The hypochlorite also neutralizes many other compounds and acts as a disinfectant, and serves as a masking agent for the stack odour. The mechanisms of the system are based on the two formulas below:

$$H_2S + 2NaOH \rightarrow Na_2S + 2H_2O$$
$$H_2S + 4NaClO \rightarrow Na_2SO_4 + 4NaCl$$

The RWDI testing program showed that the existing scrubber efficiency was found to be 60% sulphur removal and 42% removal efficiency of odour. The test was carried under normal working conditions where the inlet concentration of reduced sulphur was very low and did not exceed 1 ppm during testing. The study showed that the actual chemical consumption of the existing scrubber is high compared with the theoretical chemical consumption according to the above chemical reactions. This can be attributed to the following:

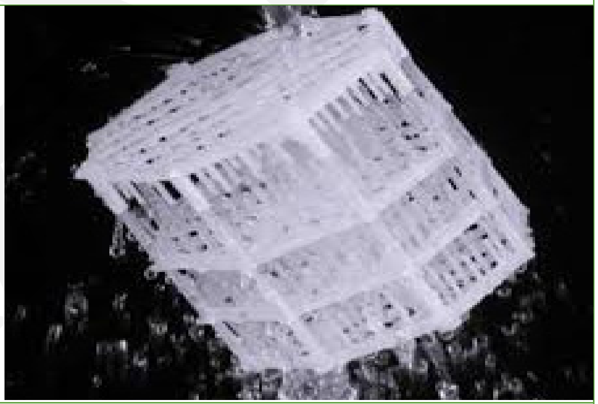
- The existing scrubber system cannot effectively and efficiently treat the odour compounds present at the plant other than H_2S. However, an interview with the plant's operation staffs revealed that the chemical dosing pumps might have air plug issues when the testing program was conducted.
- Due to the large air quantity and the low concentration of H_2S, the chemical consumptions may be driven by the quantity of CO_2 not by the concentration of the odour compounds. An estimated of 35% to 40% of the foul air contains CO_2. The chemical reaction is:

$$CO_2 + 2NaOH \rightarrow Na_2CO_3 + H_2O$$

Existing Scrubber Media: Jaeger Tripack with solid deposits.

Existing Scrubber Media: Jaeger Tripack with solid deposits at central section of the scrubber vessel.

Internal wall of the existing FRP scrubber vessel (below scrubber media section).



New Scrubber Media: Lanpac XL (courtesy of Evoqua Water Technologiies).

After the review of the existing scrubber system by the equipment manufacturer on November 18, 2016, replacing of the existing scrubber media with more efficient scrubber media appears to be feasible (see images above). Typically, the lifespan of scrubber media is 20 years per the manufacturer's recommendation as sulfate, sulfur and acids end up as slurry solids depositing in the scrubber and clogging air and chemical solution passages (see images above). The conditions of the existing FRP scrubber vessel, piping and supporting platforms appears to be in good shape and only is cleaning needed when the media and nozzles are replaced. The existing FRP vessel will accommodate the future increased total air flow of 32,000 m^3/hour (18,800 cfm).

3.2 Activated Carbon

Activated carbon (AC) media removes odour through the process of adsorption. Activated carbon is an extremely porous media with very large surface area. As air passes through the carbon media the odourous contaminants are trapped in the microscopic pores. This removal mechanism is called adsorption. Odourous air is collected and passed through the adsorber. The activated carbon catalytically oxidizes the hydrogen sulphide to produce elemental sulphur and water by the following reaction:

$$2H_2S(g) + O_2(g) \longrightarrow 1/4S_8(s) + 2H_2O(g)$$

The sulphur produced is adsorbed on the internal surface of the activated carbon while the water is mainly lost to the flowing air gas stream. The flowing air stream dissipates the heat. The adsorption process continues until the activated carbon pores are filled. In practice, it is estimated that about 25% of unused carbon will remain in the system when odours begin to breakthrough (breakthrough is the term used when detectable odours begin to be emitted from the system). The life expectancy of activated carbon is a function of the type and concentration of contaminants in the air stream. Some activated carbon has an H_2S capacity on the order of 0.30 grams H_2S per cubic centimetre of carbon. Once the carbon is saturated, it must be replaced with clean media.

Normally, the activated carbon system consists of the following major components to achieve 99.0% of H_2S and the sum of odour gases:

- Air exhaust fan
- Mist eliminator
- Vessel inlet volume control damper
- Fan outlet/adsorber inlet transition
- Carbon adsorber vessel
- Activated carbon media
- Control panel

3.3 Biofilters (Bio Trickling Filter)

Odour control systems using biofilters include moving odourous gases through a packing filter in which two processes occur: sorption (adsorption/absorption) and bioconversion. Odourous gases are absorbed onto the surfaces where microorganisms oxidize the compounds to remove odour from the air. The indigenous bacteria and other microorganisms of the media acclimate to the compounds present and are sufficient to provide the "scrubbing" action; no bacterial innoculation or chemical addition is required.

A biofilter odour control system typically consists of the following major components to achieve 99.0% of H_2S and the sum of odour gases:

- Premium corrosion-resistant material tank with multi-stage odour control module; A typical material is FRP
- Expanded clay media for treatment of inorganic odors (H_2S)
- Coal-based virgin media for treatment of inorganic and organic odours
- Irrigation system
- Air distribution system
- Nutrient addition system including the nutrient pump
- Air exhaust fan
- Control panel

3.4 Ultraviolet (UV)

The ultraviolet (UV) technology is found to be effective and offers chemical-free for odour treatment. A few full scale operations such as the Dockside Green plant in Kelowna, BC, and some lift stations in Vernon, BC, adapt the system to reduce foul air. The wavelength frequency of the UV system's lamps is particularly tuned to affect the gas molecules of a wide range of compounds, including those of petrochemical origin and those containing sulphur, such as H_2S and mercaptans. The UV light acts as a catalyst, breaking down the ambient oxygen and water vapour molecules into O- and OH-(hydroxyl) radicals. These free radicals oxidize the odorous contaminants in the air. This reaction results in a sequential and instantaneous gas breakdown of the contaminants with by-products of elemental sulphur, CO_2, water vapour, molecular oxygen and trace ozone.

3.5 Advantages and Disadvantages

The advantages and disadvantages of each technology are summarized in Table 3.2.

Table 3.2 – Odour Control Technologies - Advantages and Disadvantages

Technology	Advantages	Disadvantages	Target Application
Chemical Scrubber (Existing System)	High efficiency for H_2S and organics	Chemical cost is proportional to odour concentration; however, at low odour concentrations, chemical consumption is mainly driven by the ambient CO_2 concentration more than by odour gases concentrations	High flow rates
	High air flow capacity per unit footprint	Complex chemical controls	Limited space areas
	Lower capital cost	Cost of maintenance	Moderate foul air concentration <50 ppm
	Effective with odour spikes		High concentration of organic odours
			High removal efficiency
Activated Carbon	Low capital cost	Limited H_2S and organic odour capacities	Low foul air levels (1 to 20 ppm)
	Treat H_2S and some organic odours	High operating cost because of the AC media replacement, especially if it is used as the only standalone treatment	Polishing stage after chemical scrubber or biofilter
	Moderate air flow capacity	Limited capacity for some organic odours	
	Good response to odour spikes		
Biofilter	High efficiency for H_2S removal	Requires long contact time (footage) compared with other technologies	High H_2S concentrations >50 ppm
	Moderate air flow capacity	High capital cost	Pre-treatment of H_2S prior to chemical scrubber or biofilter
	Low operating cost	Less responsive to sudden odour spikes	More effective in hot climates
		Treatment efficiency is reduced in cold months	

Technology	Advantages	Disadvantages	Target Application
		Requires large footprint compared with other technologies	
		Efficiency depends on the health of microorganisms	
		The need to keep the biofilter moist at all times (100% humidity is typical). Cost of operation is increased.	
		10 years of media life as compared to 20 years on chemical scrubber.	
UV System	Smaller footprint	Proprietary technology, literature and publications appears to be limited	Mainly target small air flows, small systems (pump stations)
	Low capital cost	Limited installations for high capacity applications compared with other technologies	Area where Internal air circulation is possible
		Pilot testing is highly recommended if chosen	

Based on the advantages and disadvantages, all technologies will be considered with the exception of UV systems due to the limited installations of similar size systems within North America.

4.0
Odour Control – Technology Options

This section will aim to provide a description and conceptual sizing of odour control equipment options that will minimize the odour within the treatment plant and surrounding areas. Sizing was carried out for planning and cost estimating purposes.

From the above descriptions of the available technologies and the preliminary information received from system suppliers. It is practical to combine two treatment technologies to target various odour compounds to achieve higher than two logs of odour reductions (i.e., 99%).

The existing chemical scrubber may be retrofitted with a vessel cleaning and replacements of the packing media and spray nozzles to achieve 99% H_2S reduction and 90% organic odour removal. Those levels of reductions are predicted by Evoqua; however, they cannot guarantee the performance due to the facts that the scrubber was not built by them and there are many other factors outside our control such as the chemical feed and controls, and the air and liquid distribution. The existing scrubber and chemical system, once being tuned and functional, should have no problem responding to the fluctuations in the inlet odour concentrations. At an inlet H_2S concentration of 2 ppm, 99% removal will result in an exit concentration of 0.02 ppm or 20 ppb. The odour threshold for H_2S is on the order of 1 ppb. Note that the retrofitted scrubber will remove 99% of the H2S, which means that 1% will exit the scrubber. If the inlet concentration spikes to 100 ppm, then a 1 ppm (1,000 ppb) spike will exit the scrubber. The primary organic odour likely presented at the plant is methyl mercaptan (MM) which level is expected to be around 0.5 ppm or 500 ppb entering the scrubber. With an expected MM reduction of 90% in the scrubber, an order of 50 ppb of MM may be exiting the scrubber. The odour threshold for MM is less than 1 ppb. This 10% exist from the scrubber, again, is based on the inlet concentration. Other organic compounds such as Carbon disulphides are not expected to be substantial to be considered at the plant. As a result, even with the scrubber functioning properly there will be some detectable odour leaving the stack. The stack exhausts at a fairly high level, and this small amount of odour may be dispersed and diluted by a factor of 10x or more before it reaches the nearest neighbours. But even so, there could still be some small amount of odour reaching the neighbours. And of course the wind is not always reliable.

The purpose of adding a second stage odour control with an activated carbon polisher is to catch the small amount of odour leaving the scrubber. The levels may be 20 ppb of H_2S, 50 ppb of MM and other volatile organic compounds, or much higher if the inlet odour concentration is higher than 2 ppm. This second stage of an activated carbon polishing also protects against such odour spikes.

There are three options proposed, their capital and annual operating costs and net present values are presented in Section 5.0.

Option 1:

Use of the existing chemical scrubber, replace the scrubber media, replace the chemical spray nozzles and add a dual-bed AC polisher. The new scrubber media and spray nozzles will enable more exposure of hydroxide and hypochlorite solution to foul air in the scrubber. The dual-bed activated carbon (AC) polisher will be added to further reduce residual odour compounds out of the existing scrubber system.

Based on the existing scrubber efficiency (60% reduction of H_2S and 40% of organic odour compounds), the polisher's AC media is expected to be saturated after 7.4 months of operation. The AC media life will be extended to 5.64 years of operation when the replacement of the existing scrubber media and nozzles are made. The volume of polisher's AC media is estimated at 27 m^3. The plant has a plan to use the exhausted AC media in their composting facility to replenish carbon in biodegradation.

Option 2:
Install bio-trickling scrubber plus a dual-bed AC polisher. This option completely replaces the existing chemical scrubber with a biofilter odour control system and a dual-bed AC polisher. The AC media is expected to be saturated after 1.44 years of operation. The volume of AC media is estimated at 27 m^3.

Option 3:
Install dual-bed adsorber with AC media. This option replaces the existing chemical scrubber with a dual-bed adsorber that acts as the only odour control system. It is anticipated that the AC media would be saturated within 0.32 months. The volume of AC media is estimated at 27 m^3.

Table 4.1 summarizes the design air flowrate, sizing of odour system, odour quantities and chemical usages of the four proposed options.

4.1 Dewatering Odour Control

As the existing dewatering process is one of the major sources of odour, its odour reduction and prevention should be considered. During our discussions with the proposed technology vendors, it appears that utilizing a Bioxide solution which is a nitrate rich proprietary product manufactured by Evoqua Water Technologies (EWT). Bioxide may effectively eliminate and prevent the formation of hydrogen Sulphate and other odour causing substances commonly found in most wastewater collection/treatment systems. The solution is a non-hazardous chemical product to be stored and handled. The application of the Bioxide solution can be dosed into either the upstream of the sludge thickening or the upstream of the dewatering process. Dosing of the solution is specific for each wastewater dewatering. In order to confirm the effectiveness and feasibility of the product and the required dosage, a ben-scale trial is required. The objectives of the trail, as identified by EWT, are as follows:

1. Utilize dewatered sludge produced onsite at the CVWPCC to run bench-scale testing to reduce hydrogen sulphide levels formed in the solids holding/storage area to an acceptable level.
2. Establish application methodology and dosage rates to the samples to accomplish acceptable levels of treatment for the required time period.

Upon completing the demonstration, the manufacturer will:

1. Provide a follow-up report on the pilot trial with monitoring results, dosage rates and suggestions for permanent application
2. Quotation for the site specific system equipment as well as ongoing Bioxide supply cost.

If the bench-scale testing is successful, the CVWPCC can benefit from the reduction of odour at the sludge processing area and during the sludge transportation to the region's composting facility.

We recommend the Operations staff to consider the said bench-scale trial to determine if the Bioxide would work at the plant to maximize reduction of odour. Details of the trial procedures can be found in Appendix C. Cost of the trial for three days onsite is quoted at $4,775 plus applicable taxes.

Table 4.1 – Odour Control Options Sizing

Description	Units	OPTION 1		OPTION 2		OPTION 3
		Ex. Single-Stage Chemical Scrubber	Dual-Bed Carbon Polisher	Bio-trickling Scrubber	Dual-Bed Carbon Polisher	Dual-Bed Adsorber with Activated Carbon
Total System Design Air Flow Rate	m^3/hr	32,000		32,000		32,000
Average Inlet H_2S Concentration, ppm	ppm	2	0.02	2	0.05	2
Average Organic Odours	ppm	2	0.2	2	0.4	2
Assumed Inlet CO_2 Concentration	ppm	400	n/a	n/a	n/a	n/a
Total CO_2 Loading	kg/hr	22.0	n/a	0	n/a	n/a
Number of Scrubbers (in duty)	#	1	1	1	1	1
H_2S Removal Efficiency	-	99%	99%	95%	99%	99%
Total H_2S Outlet Concentration	ppm	0.02	0.0002	0.1	0.001	0.02
Total H_2S and Organic Inlet Mass Loading	kg/hr	0.17	0.01	0.16	0.04	0.16
Organic Removal Efficiency	-	90%	90%	60%	90%	90%
Outlet Organic Odours	ppm	0.2	0.02	0.8	0.08	0.2
Packed Bed Width or Diameter	m	2.4	4.0	4.3	4.0	4.0
Packed Bed Length (rectangular units only)	m	n/a	n/a	n/a	n/a	n/a
Number of Parallel Media Beds	#	1	2	1	2	2
Media Height	m	3.0	0.9	5.9	0.9	0.9
Face Velocity	m/min	109	21	36	21	21
Gas-Media Contact Time (per scrubber)	sec	1.7	2.7	10.0	2.7	2.7
Vessel Height	m	7.6	4.0	9.6	4.0	4.0

[1] Items are based on post to the scrubber retrofit with the replacement of the scrubber media and spray nozzles.

5.0 Financial Analysis

In order to fully evaluate Options 1, 2 and 3, both capital and operational cost estimates were produced and are summarized in Table 5.1, 5.2 and 5.3.

A further detailed breakdown is provided in Appendix B of this report.

5.1 Capital Costs

The estimated capital costs in Table 5.1 are considered to be at a conceptual level (Class D). A contingency of 40% is included in the cost estimates for engineering and construction. The cost estimates do not include applicable taxes.

Table 5.1 – Capital Costs

Description	OPTION 1		OPTION 2		OPTION 3
	Existing Chemical Scrubber	Dual-Bed Carbon Polisher	Bio-trickling Scrubber	Dual-Bed Carbon Polisher	Dual-Bed Adsorber with Activated Carbon
General Requirements (30%)	$18,027	$345,405	$316,680	$345,405	$342,405
Unit Capital Cost Per System	$21,610	$410,000	$729,000	$410,000	$410,000
Installation Cost (Mechanical and Electrical only)	$38,480	$164,000	$291,600	$164,000	$164,000
FRP Covers		$352,350	$ -	$352,350	$352,350
Duct Works		$200,000		$200,000	$190,000
Equipment Pad		$25,000	$35,000	$25,000	$25,000
Capital Cost (rounded)	**$60,000**	**$1,497,000**	**$1,372,000**	**$1,497,000**	**$1,484,000**
Engineering and Contingency (40 %)	**$623,000**		**$1,148,000**		**$594,000**
Total Capital Cost (rounded)	**$2,180,000**		**$4,017,000**		**$2,078,000**
Capital Ranking	**2**		**3**		**1**

5.2 Operating Costs

Operating costs were developed for all the options. The assumptions used for calculating the operating costs are as follows:

- Total air flow of 32,000 m^3/hour (18,800 cfm) for 24/7 treatment; including the existing and the future added air flows.
- Average inlet level of 2 ppm of H_2S and 2 ppm of organic compounds for odour treatment.
- Average total odour reduction rate of 99% or 2 logs.
- Existing scrubber's odour removal efficiency is 60% on H_2S, 42% on organic compounds.
- Caustic soda cost = 0.25 $/lit
- Sodium hypochlorite cost = 0.25 $/lit
- Water (potable) = $1/$m^3$
- Wastewater (effluent) = $0.1/$m^3$ (pumping cost)
- Electricity = $0.1/kWh
- Labour cost = $40/hour
- Equipment life cycle = 20 years
- Carbon media = 3053 $/$m^3$
- Chemical scrubber media = 960 $/$m^3$
- Bio-trickling filter media = 1193 $/$m^3$
- Nutrient cost = 6 $/kg

Table 5.2 provide the yearly operating costs.

Table 5.2 – Yearly Operating Costs

Description	Unit	OPTION 1		OPTION 2		OPTION 3
		Ex. Single-Stage Chemical Scrubber	Dual-Bed Carbon Polisher	Bio-trickling Scrubber	Dual-Bed Carbon Polisher	Dual-Bed Adsorber with Activated Carbon
Total System Operating Power	bhp	47	34	47	34	34
Total Power Cost		$30,714	$22,219	$30,714	$22,219	$22,219
25% Sodium Hydroxide Usage	lit/30 days	22,927				
Annual Sodium Hydroxide Cost		$68,781				
12.5 Sodium Hypochlorite Usage	lit/30 days	7,442				
Annual 12.5% Sodium Hypochlorite Cost		$22,326				
Media Life	yr	20	5.64	10.0	1.44	0.32
Media Volume	m^3	14	23	85	23	23
Average Annualized Media Cost		$683	$12,199	$10,131	$47,895	$221,963
Annual Water Usage	m^3	475		6,660		
Annual Water Cost		$475		$666		
Annual Nutrient Cost				$ 254		
Maintenance Manhours/Week	hrs	7	1	7	1	2
Annual Maintenance Cost (materials + labour)		$15,874	$3,515	$17,112	$3,515	$5,595
Annual Operating Costs (rounded)		**$176,000**		**$135,000**		**$225,000**

5.3 Net Present Value Analysis (NPV)

To provide a complete financial analysis, ISL undertook a 20-year Net Present Value analysis using the following basis:

- A discount rate of 4%; and
- An inflation rate on the annual operating costs of 2% per year.

Table 5.3 – Net Present Value Analysis

Description	OPTION 1		OPTION 2		OPTION 3
	Ex. Single-Stage Chemical Scrubber	Dual-Bed Carbon Polisher	Bio-trickling Scrubber	Dual-Bed Carbon Polisher	Dual-Bed Adsorber with Activated Carbon
Net Present Value (Rounded)	$5,055,000		$6,222,000		$5,748,000
NPV Ranking	1		3		2

5.1 Financial Analysis Evaluation

Table 5.4 summarizes the capital costs, operating costs and the net present value analysis over 20 years for all options. Total capital costs include 40% engineering and construction contingencies. All costs are represented in 2016 dollars.

Table 5.4 – Capital Costs, Operating Costs and NPV

Description	OPTION 1		OPTION 2		OPTION 3
	Ex. Single-Stage Chemical Scrubber	Dual-Bed Carbon Polisher	Bio-trickling Scrubber	Dual-Bed Carbon Polisher	Dual-Bed Adsorber with Activated Carbon
Capital Cost (rounded)	$2,180,000		$4,017,000		$2,078,000
Annual Operating Cost (rounded)	$175,854		$134,844		$224,436
Net Present Value (NPV, rounded)	$5,055,000		$6,222,000		$5,748,000

It is estimated that adding a separate chemical scrubber and an AC filter to deal with the air flows from the bioreactors will cost approximately an extra $3.0 million. This cost estimate includes FRP covering of the bioreactors and expansion of the existing chemical scrubber building to accommodate two scrubbers. The cost also includes 40% engineering and contingencies.

6.0 Findings and Recommendations

6.1 Findings

- From RWDI reports:
  - The existing scrubber efficiency was found to be 60% sulphur removal efficiency and 42% removal efficiency of odour. The test was completed under normal working conditions when the inlet concentration of total reduced sulphur was very low and did not exceed 1 ppm during the testing.
  - The air sampling indicated various levels of H_2S at the plant, ranging from zero to 66 ppb, with the highest H_2S concentration measured at the location of the dewatered sludge loading bay.
  - The CVWPCC was predicted to generate odour above the Ontario odour standard over two kilometres from the facility. The strongest odour emissions were from the scrubber stack, followed by the primary clarifiers. The secondary bioreactor is the third contributor to overall odour at all sensitive receptors. Secondary clarifiers were predicted to contribute very little to the overall odour concentrations at sensitive receptors. The greatest single impact to improving the odour impacts from the facility would be achieved by putting an additional control on the scrubber stack. The study concluded that even with additional control on the stack, the site would still have significant odour impacts associated with the primary clarifiers and the bioreactors. The study recommended that those tanks be covered and vented through the scrubber stack.
- CVWPCC is in the process of expanding the treatment plant by adding different process structures. The anticipated added/removed structures within the next 20 years that of concern to the odour control system are:
  - Adding an equalization tank (2017);
  - Replacing the existing grit removal tanks (pre-aeration tanks) with grit removal with vortex style (2017); and
  - Adding bioreactor (2024).
- The current system design flow rate according to 1997 and 2002 record drawings is 28,920 m^3/hr (17,034 cfm) while the fan's capacity was stated at 27,000 m3/hr (15,903 cfm) in 1997. Note that the actual performance of the scrubber fan is unknown, but can be measured when the scrubber is cleaned and the media and nozzles are replaced. This verification allows the proper sizing of either a new booster fan installed at the carbon polisher or a new upsized scrubber fan to deliver the desired air flow.
- The anticipated air flow from the existing and future structures is 32,000 m^3/hr (18,800 cfm) excluding the current and future bioreactors.
- Covering the current and future bioreactors will increase the odour control system substantially and will require a separate odour system with an anticipated capacity of 23,000 m^3/hr (13,600 cfm). In order to provide an odour control with a reasonable cost, the required air flow from the bioreactors was separated as an optional system which can be included in the immediate construction stage or delayed for future construction. The timing of this optional odour control system may depend on the available project funding and the CRVD's choice. It is estimated that this optional covering of the bioreactors and adding a separate chemical scrubber and an AC polisher will cost approximately an additional $3.0 millions without applicable taxes.
- Various odour treatment technologies were evaluated and options were proposed to reduce an overall reductions of odours from the wastewater treatment plant. The following options were considered:
  - Option 1: use of the existing chemical scrubber with the replacements of the scrubber nozzles and media, and add a new dual-bed AC polisher to further reduce residual odour compounds
  - Option 2: install a biofilter scrubber plus a dual-bed AC polisher; this option replaces the existing chemical scrubber with a biofilter odour control system and a dual-bed AC polisher
  - Option 3: install a dual-bed adsorber with AC media; this option replaces the existing chemical scrubber with dual-bed adsorber that acts as the only odour control system

6.2 Recommendations

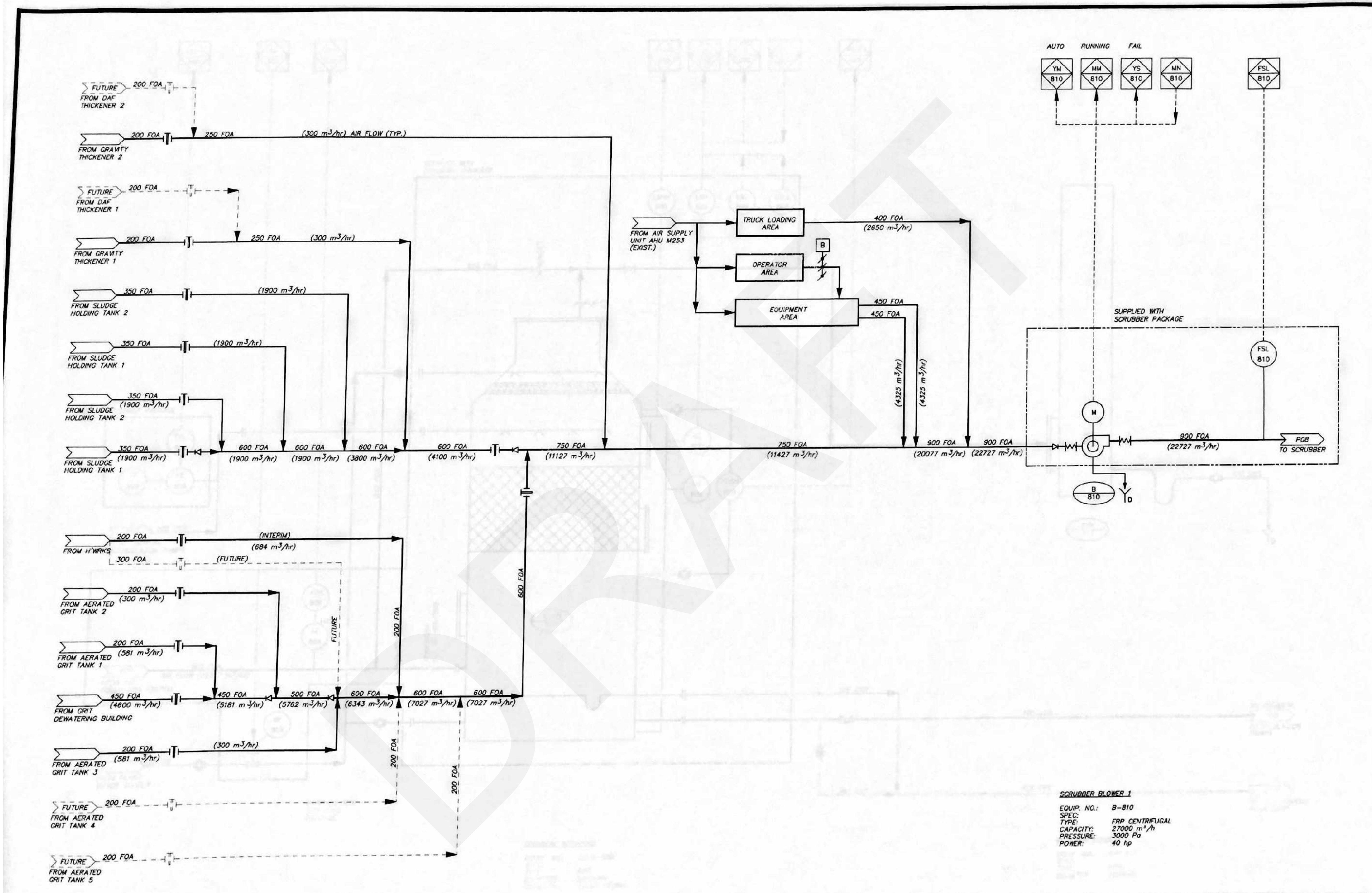
- The replacement of the existing scrubber nozzles and media is recommended to increase the scrubber's odour removal efficiency and thus extends the media life of activated carbon in the proposed dual-bed polisher.
- Capital cost of the media and nozzle replacement is approximately $60 K (rounded) excluding applicable taxes. The media and nozzle replacement, vessel cleaning and scrubber commissioning will take 8 hours a day for one week. The quoted cost can be reduced to $46 K (rounded) if the CVWPCC can assign an technician full time to assist Evoqua (one person) for one week.
- Option 1 and Option 3 represent the lowest capital cost of $2.40 M and $2.30 M respectively.
- Option 3 has a highest annual operating cost, which is due to more frequent replacement of the activated carbon media compared with other options. Option 3 is not recommended.
- Option 2 has the highest capital cost, and this option is more suitable for high H_2S concentrations with minor fluctuation. Its removal efficiency will suffer considerably based on the flocculate outside air temperature and the inlet foul air concentration. Option 2 is not recommended.
- Option 1 represents the best value option (the lowest NPV) and is recommended.
- Option 1 can be implemented in two phases. In the first phase, the scrubber media and nozzles to be replaced to increase the odour removal efficiency. An additional dual-bed AC polisher can be added, along with associated components such as fan and duct work, in the second phase when the future foul air is collected for odour treatment.
- In addition to the recommended Option 1 – first phase. ISL recommends the bench-scale trial for three days to determine if the Bioxide solution would work at the plant. Details of the trial and cost can be found in Appendix C. If the trial is successful, the CVWPCC can benefit by reducing the source odour right at the sludge dewatering area; further more, much less odour will be released during sludge transportation to the region's composting facility.

7.0 References

- Regional Sewage System CFB Comox Gravity Sewer and Forcemain. Design by Associated Engineering Services Ltd., 1982.
- Stage 1 Odour Control Design Drawings for the CVWPCC. Designed by Reid Crowther, October 1997.
- Record drawings, Associated Engineering Services Ltd., 1982.
- Odour Dispersion Modelling Report for CVWPCC. Report by RWDI AIR Inc., September 21, 2015.
- Odour Control System Evaluation Report for Comox Valley Water Pollution Control Centre. Final Report by RWDI Air Inc., October 30, 2015
- CVWPCC Wet Scrubber Efficiency Testing Memorandum for Comox Valley Water Pollution Control Centre. Preliminary Draft by RWDI AIR Inc., September 21, 2016.
- CVRD Odour Control Options. Proposal by ISL Engineering and Services, October 11, 2016.

Appendix A

Odour Collection Flows – Record Drawings



3	07/08/97	RECORD DRAWING	TJ	MKF
2	04/12/96	ISSUED FOR CONSTRUCTION	TJ	MKF
1	22/10/96	ISSUED FOR TENDER	TJ	MKF

detail symbol

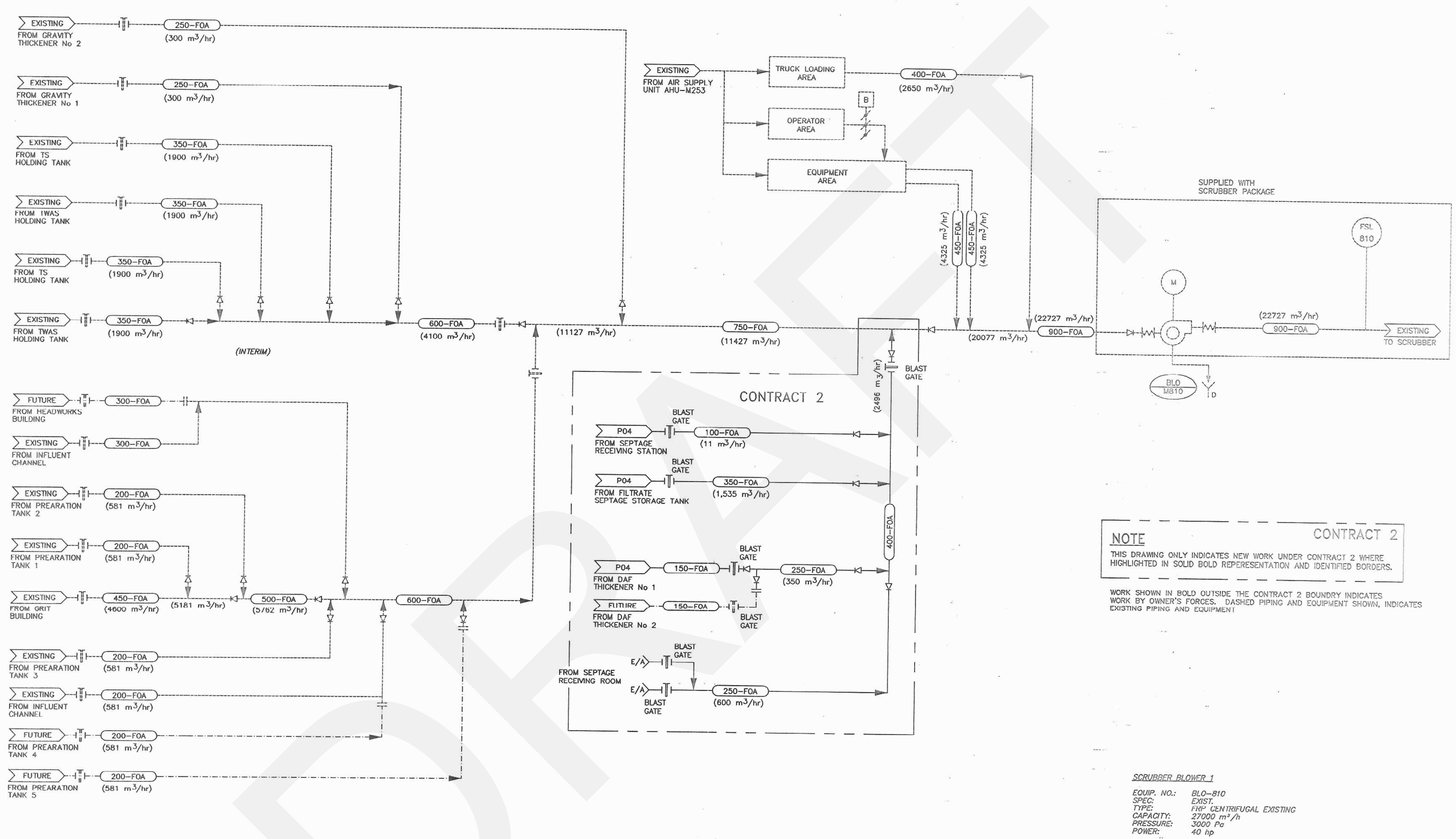
Reid Crowther

Reid Crowther & Partners Ltd.
Consulting Engineers

project: Comox Valley Water Pollution Control Centre
Stage 1 Odour Control

Foul Air Collection System
Process & Instrumentation Diagram

designed TJ	scale NTS	date SEPT '96
drawn CJC	project no. 33228	
checked TJ	drawing no. P07	rev. 3
approved MKF		



CONTRACT 2

NOTE

THIS DRAWING ONLY INDICATES NEW WORK UNDER CONTRACT 2 WHERE HIGHLIGHTED IN SOLID BOLD REPERESENTATION AND IDENTIFIED BORDERS.

WORK SHOWN IN BOLD OUTSIDE THE CONTRACT 2 BOUNDRY INDICATES WORK BY OWNER'S FORCES. DASHED PIPING AND EQUIPMENT SHOWN, INDICATES EXISTING PIPING AND EQUIPMENT

SCRUBBER BLOWER 1

EQUIP. NO.:	BLO-810
SPEC:	EXIST.
TYPE:	FRP CENTRIFUGAL EXISTING
CAPACITY:	27000 m³/h
PRESSURE:	3000 Pa
POWER:	40 hp

PROJECT RECORD COPY

no.	rev.	y/m/d	issued for	by	app.
1		2002.06.06	ISSUED FOR CONSTRUCTION	PJY	TJ
0		2002.06.12	ISSUE FOR TENDER	PAL	TJ

ISSUED FOR CONSTRUCTION

no.	y/m/d	revision	by	app.

seal

EARTH TECH
EARTH TECH (CANADA) INC.

Robinson CONTRACTING LTD.

project
COMOX VALLEY WATER POLLUTION CONTROL CENTRE
SOLIDS THICKENING UPGRADES

AREA 8 – ODOUR CONTROL
FOUL AIR COLLECTION SYSTEM
PIPING AND INSTRUMENTATION DIAGRAM

designed TJ	scale NONE	y/m/d FEB. 2002
drawn PAL	project no. 53470	contract 2
checked LN	drawing no. P08	rev. 0
approved TJ		

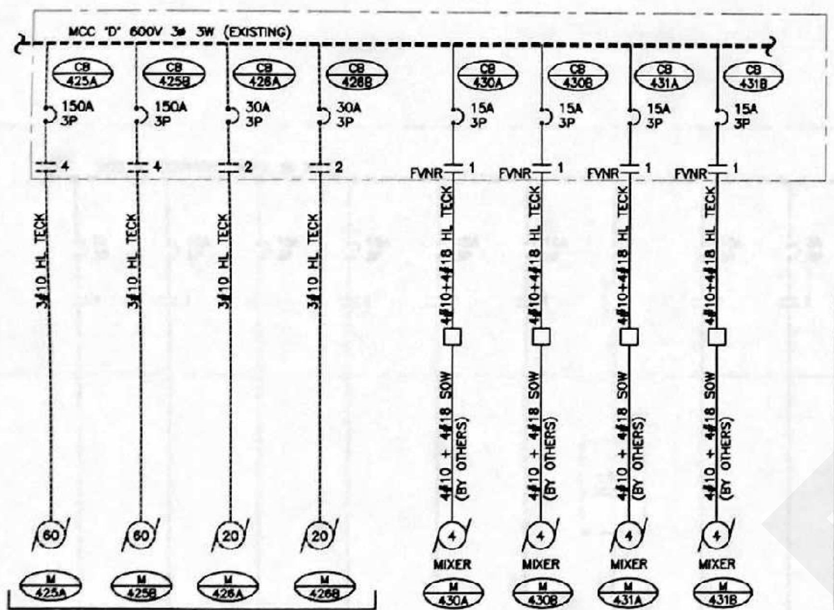
PROCESS EQUIPMENT SCHEDULE

ELEC. NO.	MECH. NO.	FUNCTION	LOCATION	HP/kW/ FLA/MCA	VOLT	PH	EMERG (Y/N)	STARTER TYPE	STARTER SUPPLY	STARTER INSTALL	STARTER WIRING	STARTER CTRL	STARTER SIZE	BKR SIZE	SUPPLY SOURCE	FEEDER	REMARKS
M	M-430A	SLUDGE MIXER	HOLDING TANK	4 HP	600V	3	N	MG	DIV 16	DIV 16	DIV 16	HOA	1	15A/3P	MCC 'D'	4#10 + 4#18 HL TECK	WIRE TEMP SENSOR TO STARTER O/L
M	M-430B	SLUDGE MIXER	HOLDING TANK	4 HP	600V	3	N	MG	DIV 16	DIV 16	DIV 16	HOA	1	15A/3P	MCC 'D'	4#10 + 4#18 HL TECK	WIRE TEMP SENSOR TO STARTER O/L
M	M-431A	SLUDGE MIXER	HOLDING TANK	4 HP	600V	3	N	MG	DIV 16	DIV 16	DIV 16	HOA	1	15A/3P	MCC 'D'	4#10 + 4#18 HL TECK	WIRE TEMP SENSOR TO STARTER O/L
M	M-431B	SLUDGE MIXER	HOLDING TANK	4 HP	600V	3	N	MG	DIV 16	DIV 16	DIV 16	HOA	1	15A/3P	MCC 'D'	4#10 + 4#18 HL TECK	WIRE TEMP SENSOR TO STARTER O/L

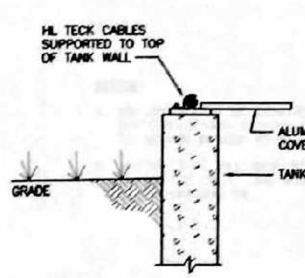
STARTER TYPE:
MN – MANUAL
MP – MANUAL W/ PILOT LGT
MG – MAGNETIC
CM – COMBINATION
SS – SOFT START

STARTER CONTROL:
HOA – HAND/OFF/AUTO SWITCH
S/S – START/STOP PUSHBUTTONS
O/F – ON/OFF SWITCH
O/A – OFF/AUTO

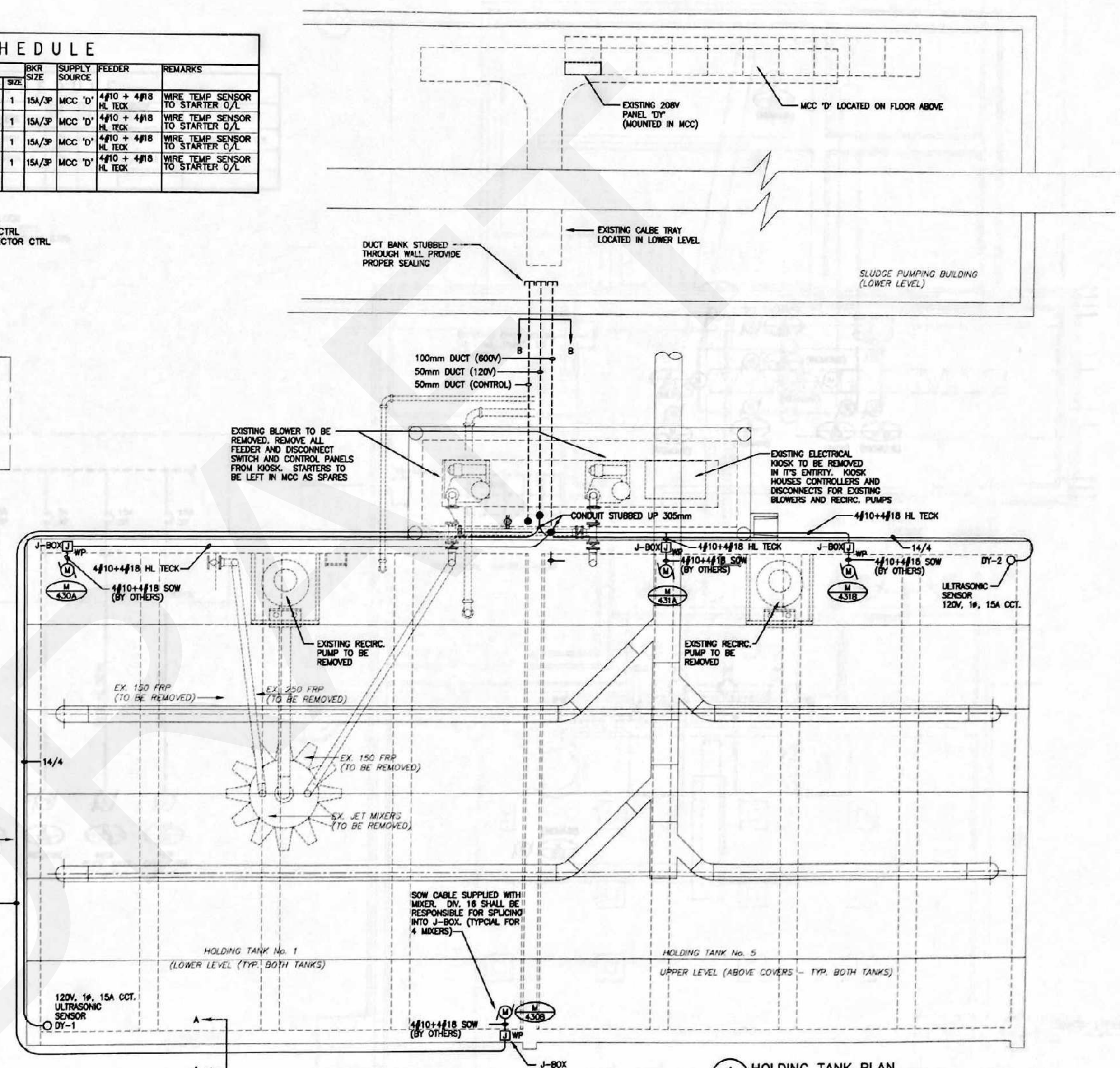
NOTES (MISCELLANEOUS):
P – PRESSURE SW CTRL
F – FLOAT SW CTRL
C – TIME CLOCK CTRL
T – THERMOSTATIC CTRL
I – INTERLOCK
M – MANUAL CTRL
CO – CO DETECTOR CTRL



1 / E4 MCC 'D' PARTIAL RISER
N.T.S.



2 / E4 SECTION 'A-A'
N.T.S.



4 / E4 HOLDING TANK PLAN
1:50

no.	date	revision	by	app.
4	MAY 12/97	AS BUILTS	AY	
3	DEC. 4/98	ISSUED FOR CONSTRUCTION	MJM	
2	OCT. 22/98	ISSUED FOR TENDER	MJM	
1	OCT. 11/98	ISSUED FOR REVIEW		

detail symbol
A. detail number
B. drawing where detail shown.
C. cross reference to drawing where detail taken or shown.

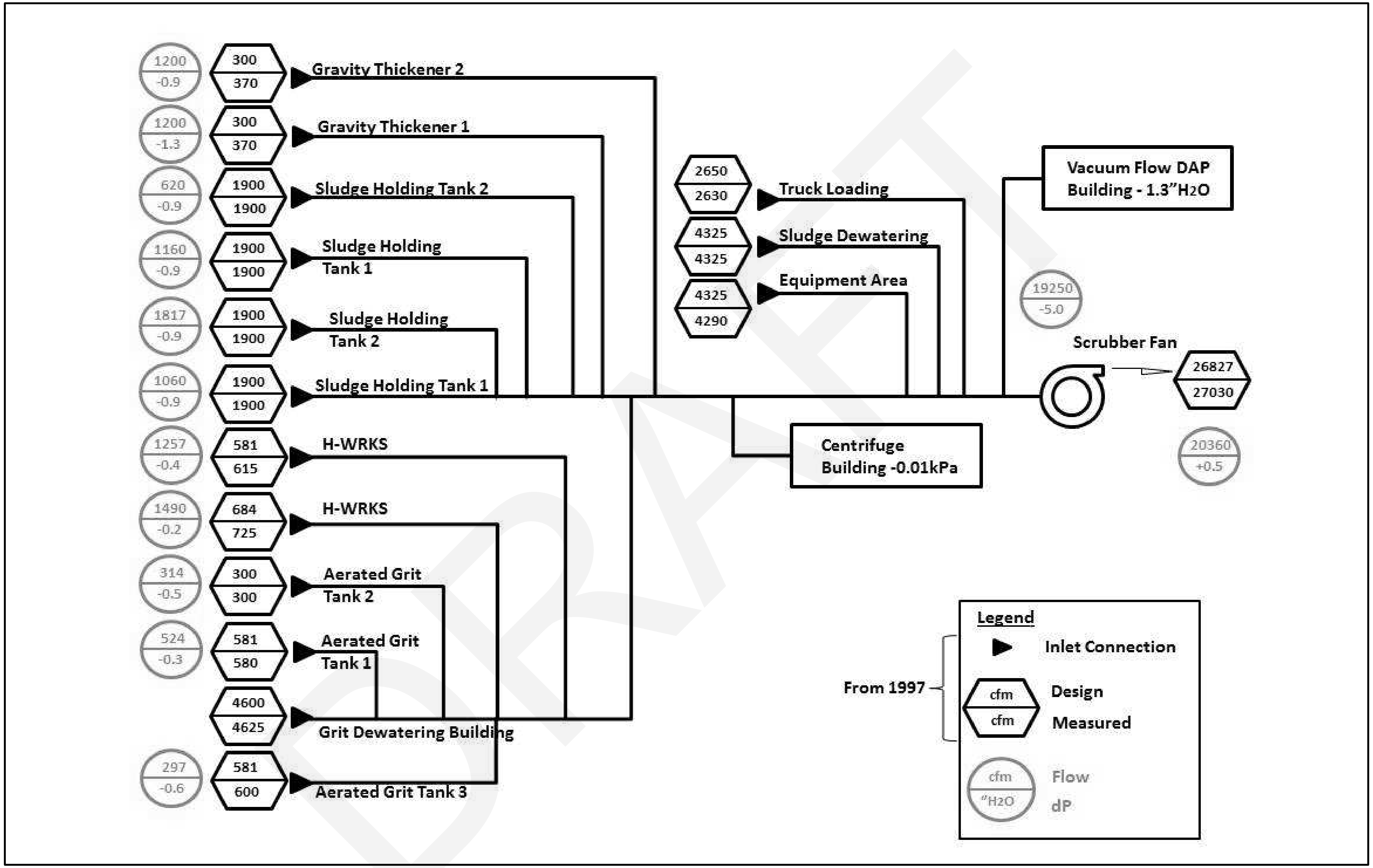
consultants

Reid Crowther
Reid Crowther & Partners Ltd.
Consulting Engineers

project: COMOX VALLEY WATER POLLUTION CONTROL CENTRE STAGE 1 ODOUR CONTROL

drawing: AERATED SLUDGE HOLDING TANKS ELECTRICAL PLAN AND SECTIONS

designed MJM	scale AS SHOWN	date DEC. 1996
drawn RC	project no. 33228	contract
checked MJM	drawing no. E04	rev. 4
approved MKF		



Flow Balance Diagram Comox Valley Water Pollution Control Centre

True North

Drawn by: NBN	Figure: 3
Approx. Scale: N/A	
Date Revised: Mar. 18, 2015	

RWDI

Comox Valley Water Pollution Control Centre - Comox Valley, BC

Project #1500239

Appendix B

Manufacturer Literatures

EVOQUA
WATER TECHNOLOGIES

CHEMICAL SCRUBBER & ACTIVATED CARBON ODOR CONTROL SYSTEM

FOR

COMOX WWTP

COMOX, BC, CANADA

Quotation #M17-004

30-November-2016

SALES CONTACT:

Michael Greig
Mequipco Ltd.

Mobile: 1-604-644-5051
Tel: 1-604-273-0553, Ext. 142
mgreig@mequipco.com

November 30, 2016

Ashraf Rayyan
Kevin Liu
ISL Engineering

Ref: Odor Control System for Comox Valley

Dear Ashraf and Kevin,

Attached please find our technical proposal and scope of work revised to include the scrubber upgrades, and the new carbon adsorber system sized for 18,800 cfm.

If you would like us alter our scope of work please let me know.

Sincerely,

Rick Parker
Manager, Odor Control Systems

PROPOSAL AND QUOTATION

Evoqua Water Technologies is pleased to offer this proposal and budgetary quotation to supply a single stage chemical odor control system for the Comox Valley project. The performance requirements and our recommended system design are presented below.

DESIGN AND PERFORMANCE REQUIREMENTS

Customer	ISL Engineering
Plant & Location	Comox WWTP, Comox, BC, Canada
Air Flow Rate	18,800 cfm
Average H2S concentration	2 ppm
Outlet H2S concentration	< 0.02 ppm
H2S Removal Efficiency	99%

DESIGN ASSUMPTIONS

Hazard Zone Rating	Non-hazardous
Power Supply Available	380V, 3 phase, 50 Hz
Ambient Temperature	50 deg C

REFURBISHMENT OF EXISTING CHEMICAL SCRUBBER

Design Basis	Single-stage chemical scrubber with activated carbon polishing stage
Chemical Scrubber Model	Refurbish existing 8-ft dia scrubber
Scrubber Chemistry	NaOH and NaOCl
Blower Type and material	Use existing blower
Scrubber Recirculation Pumps	Use existing recirculation pumps
Recommended chemical tank sizing	Use existing chemical tanks
Scrubber Packing Media	Lanpac XL, polypropylene replacement packing media
Scrubber Nozzles	Replace with new BETE nozzles
Scrubber Demister	Acid wash existing demister
Scrubber Tower	Acid wash existing tower and internals
Commissioning	Re-commission scrubber system and perform inlet & outlet H2S testing

SUPPLY OF NEW ACTIVATED CARBON ODOR CONTROL SYSTEM

Activated Carbon Model	RJC-1300D
Number of parallel carbon beds	2
Activated carbon type	VC36C coconut shell based virgin activated carbon
Carbon quantity	12,858 kg (26,230 lbs)
Blower type	FRP centrifugal blower sized for 18,800 cfm at 8” WC static pressure
Estimated carbon life	5.9 years
Controls & Instrumentation	Relay based local control panel, with starter motors, disconnect, Hach pH probe & controllers, alarms and interlocks, panel A/C

evoqua
WATER TECHNOLOGIES

PROCESS DESCRIPTION

The existing Odor Control System is a single-stage chemical scrubber, installed in 1996. During the site visit on November 18, 2016 it was observed that the internal packing media was badly plugged (see photos below).

Evoqua proposes to replace the packing media, and to clean the demister and FRP tower with acid to remove the scale buildup. Scrubber nozzles will be inspected and cleaned or replaced as needed. The scrubber system will then be re-commissioned using the existing blower, recirculation pumps, chemical pumps, controls and instrumentation.

Evoqua also proposes the additional of an activated carbon system downstream from the chemical scrubber to remove any remaining hydrogen sulfide (H_2S) and organic odors from the process air stream.

Odor Control Process

The packed tower chemical scrubber uses a solution of 25% w/w sodium hydroxide (NaOH) and 12.5% sodium hypochlorite (NaOCl) to remove the hydrogen sulfide. Makeup water is provided to the scrubber, and the blowdown waste streams from the chemical scrubber may be returned to the waste treatment process.

Chemicals are stored in chemical storage tanks adjacent to the scrubbers. Chemicals are dosed to the scrubbers automatically as required to maintain the pH and ORP set-points in the scrubber sump solutions by means of pH and ORP controllers and variable speed chemical dosing pumps. Chemical dosing pumps are located on the scrubber pump deck. Chemical tanks are not included in Evoqua's scope of work.

The activated carbon system is a vertical flow, horizontal dual bed system with air entering between the two beds and exiting through separate exhaust stacks. Coconut shell based virgin activated carbon (VC36C) is used because of its extremely fine pore structure and superior ability to remove organic compounds such as methyl mercaptan, dimethyl sulfide, and dimethyl disulfide. Each carbon bed is fitted with three sample ports for testing carbon at 25%, 50% and 75% of the bed height. Carbon media is loaded and removed through an access hatch on the top of the vessel.

The exhaust fan is located upstream from the chemical scrubber. A Teflon shaft seal is provided to prevent any leakage of odor from the exhaust fan. The fan runs at a constant speed, and is sized to overcome the static pressure through the scrubber and carbon bed.

SCOPE OF WORK

The following Scope of Work is included with the refurbishment of the chemical scrubber.

ITEM #1 SCRUBBER PACKING & MATERIALS	QUANTITY
Replacement of Scrubber Packing and Materials	
· Scrubber Packing Media, Lanpac XL by Lantec Products, polypropylene, approximately 500 cubic feet · Spray nozzles · New EPDM gaskets and hardware for packing and nozzle flanges	1 lot
Freight, FOB job site (excluding customs fees and taxes)	Included
Cost for Replacement packing media and materials, excluding taxes	**$21,610 CAD**

ITEM #2 LABOR AND MATERIALS	QUANTITY
Clean and recommission old scrubber	

· Labor, 2 man team, 40 hours on site, for
    · Acid wash of scrubber tower
    · Acid wash Demister
    · Remove old packing media (disposal by others)
    · Inspect and clean chemical injection fittings and piping
    · Inspect and clean chemical pressure relief valves and check valves
· Travel expenses
· Rental of scissors type manlift
· Muriatic acid for scrubber cleaning
	1 lot

Cost for labor, travel and consumables, excluding taxes	**$38,480 CAD**

Note the labor cost for Item #2 is based on a two man team on site for one week. If the Comox PCC assigns one technician to assist Evoqua full time for that week, we can reduce Evoqua scope to a one man team, and reduce the cost to $24,100 CAD.

ITEM #3 ACTIVATED CARBON ADSORBER SYSTEM	QUANTITY
Air Exhaust Blowers	
FRP centrifugal blower, backward inclined, 18,800 cfm at 8” WC SP, sized for chemical scrubber & carbon adsorber	1
RJC-1300D Dual Bed Activated Carbon Adsorber · FRP vessel with two media beds and two exhaust stacks · Carbon media, VC36C coconut shell virgin activated carbon · FRP support grating and polypropylene screen · Carbon sample ports · Differential pressure gauge · Drain valve	1
Interconnecting Ductwork · Inlet transition duct from fan outlet to scrubber inlet · Ductwork from scrubber outlet to carbon adsorber inlet	1 set
Electrical Control Panel Upgrade	
· Motor starter for larger fan (installation in existing control panel by others)	1
Neoprene Cushioning Pad for carbon adsorber	1
Anchor Bolts	Included
Engineering Services	
Engineering Design and O&M Manuals (English only)	Included
Inspection, Commissioning and Startup of Odor Control System and Operator Training	Included
Equipment Warranty for One Year	Included
Shipping	
FOB job site in Comox, BC	
PRICE FOR ABOVE SCOPE OF WORK	**$410,000 CAD**

The following items are assumed to be provided by purchaser.

LIST OF EXCLUSIONS
Odour Control System
All odorous air ductwork and dampers from process to odour control system fan inlet
Ductwork supports between the scrubber exhaust and carbon system inlet.
All air balancing of upstream odorous air ductwork and dampers
All scrubber chemicals
Utilities including electrical power, water and drainage.
Chemical storage tanks
Disposal of old packing media, and spent chemicals from acid washing and cleaning of scrubber
Shipping
Equipment Handling at Border Entry into Canada, including any Customs Duties/Fees, Port Charges, and all Federal/Provincial/Local Taxes
Installation
Equipment Unloading and Storage
All Civil Works including concrete, buildings, shelters, containment berms, weather covers and duct supports.
Power Connection
All Fill and Drain Piping
Mechanical and Electrical Installation of Odor Control System including All Field Piping Design, Materials and Installation, All Field Wiring Design, Materials, and Installation

SPECIFICATION CLARIFICATIONS AND DEVIATIONS

No project specifications were provided. The Evoqua odor control system is based on Evoqua's standard design

FIELD SERVICES

Scrubber refurbishment includes a 2 man team for one week on site. Installation inspection and commissioning of carbon adsorber is based on 1 man-week on site.

SCHEDULE

On any ensuing contract, we shall mutually agree upon a production schedule. Our normal lead time for this type of equipment is as stated below. However, due to fluctuations in backlog, an actual schedule cannot be established until after receipt and acceptance of a complete written purchase agreement.

Design Submittals, if required:	6 Weeks after Receipt of Fully Executed Purchase Order
Equipment Shipment:	16 Weeks after Seller's Written Receipt of Submittal Approval and Release for Fabrication
Estimated Delivery	4-6 Weeks after Shipment

Special Note: Our price does not include any costs for storage of equipment between the time it is ready to ship and when the equipment is actually installed. The costs to protect, insure, and store the equipment at the job site, or at any off site location, is the responsibility of the Buyer.

PROPOSAL VALIDITY

This proposal is valid for 90 days from the proposal date.

TAXES

Our budgetary price does not include federal, provincial and other taxes, customs duties, import fees, storage and handling changes, or other such charges. All applicable taxes shall be paid by the purchaser.

WARRANTY

Our standard warranty for equipment is 12 months from beneficial occupancy or 18 months from shipment, whichever occurs first. Longer term warranty is available at additional cost.

EVOQUA WATER TECHNOLOGIES LLC

Standard Terms of Sale

1. **Applicable Terms.** These terms govern the purchase and sale of equipment, products, related services, leased products, and media goods if any (collectively herein "Work"), referred to in Seller's proposal ("Seller's Documentation"). Whether these terms are included in an offer or an acceptance by Seller, such offer or acceptance is expressly conditioned on Buyer's assent to these terms. Seller rejects all additional or different terms in any of Buyer's forms or documents.

2. **Payment.** Buyer shall pay Seller the full purchase price as set forth in Seller's Documentation. Unless Seller's Documentation specifically provides otherwise, freight, storage, insurance and all taxes, levies, duties, tariffs, permits or license fees or other governmental charges relating to the Work or any incremental increases thereto shall be paid by Buyer. If Seller is required to pay any such charges, Buyer shall immediately reimburse Seller. If Buyer claims a tax or other exemption or direct payment permit, it shall provide Seller with a valid exemption certificate or permit and indemnify, defend and hold Seller harmless from any taxes, costs and penalties arising out of same. All payments are due within 30 days after receipt of invoice. Buyer shall be charged the lower of 1 ½% interest per month or the maximum legal rate on all amounts not received by the due date and shall pay all of Seller's reasonable costs (including attorneys' fees) of collecting amounts due but unpaid. All orders are subject to credit approval by Seller. Back charges without Seller's prior written approval shall not be accepted.

3. Delivery. Delivery of the Work shall be in material compliance with the schedule in Seller's Documentation. Unless Seller's Documentation provides otherwise, delivery terms are ExWorks Seller's factory (Incoterms 2010). Title to all Work shall pass upon receipt of payment for the Work under the respective invoice. Unless otherwise agreed to in writing by Seller, shipping dates are approximate only and Seller shall not be liable for any loss or expense (consequential or otherwise) incurred by Buyer or Buyer's customer if Seller fails to meet the specified delivery schedule.

4. Ownership of Materials and Licenses. All devices, designs (including drawings, plans and specifications), estimates, prices, notes, electronic data, software and other documents or information prepared or disclosed by Seller, and all related intellectual property rights, shall remain Seller's property. Seller grants Buyer a non-exclusive, non-transferable license to use any such material solely for Buyer's use of the Work. Buyer shall not disclose any such material to third parties without Seller's prior written consent. Buyer grants Seller a non-exclusive, non-transferable license to use Buyer's name and logo for marketing purposes, including but not limited to, press releases, marketing and promotional materials, and web site content.

5. **Changes.** Neither party shall implement any changes in the scope of Work described in Seller's Documentation without a mutually agreed upon change order. Any change to the scope of the Work, delivery schedule for the Work, any Force Majeure Event, any law, rule, regulation, order, code, standard or requirement which requires any change hereunder shall entitle Seller to an equitable adjustment in the price and time of performance.

6. **Force Majeure Event.** Neither Buyer nor Seller shall have any liability for any breach or delay (except for breach of payment obligations) caused by a Force Majeure Event. If a Force Majeure Event exceeds six (6) months in duration, the Seller shall have the right to terminate the Agreement without liability, upon fifteen (15) days written notice to Buyer, and shall be entitled to payment for work performed prior to the date of termination. "Force Majeure Event" shall mean events or circumstances that are beyond the affected party's control and could not reasonably have been easily avoided or overcome by the affected party and are not substantially attributable to the other party. Force Majeure Event may include, but is not limited to, the following circumstances or events: war, act of foreign enemies, terrorism, riot, strike, or lockout by persons other than by Seller or its sub-suppliers, natural catastrophes or (with respect to on-site work), unusual weather conditions.

7. **Warranty.** Subject to the following sentence, Seller warrants to Buyer that the (i) Work shall materially conform to the description in Seller's Documentation and shall be free from defects in material and workmanship and (ii) the Services shall be performed in a timely and workmanlike manner. Determination of suitability of treated water for any use by Buyer shall be the sole and exclusive responsibility of Buyer. The foregoing warranty shall not apply to any Work that is specified or otherwise demanded by Buyer and is not manufactured or selected by Seller, as to which (i) Seller hereby assigns to Buyer, to the extent assignable, any warranties made to Seller and (ii) Seller shall have no other liability to Buyer under warranty, tort or any other legal theory. The Seller warrants the Work, or any components thereof, through the earlier of (i) eighteen (18) months from delivery of the Work or (ii) twelve (12) months from initial operation of the Work or ninety (90) days from the performance of services (the "Warranty Period"). If Buyer gives Seller prompt written notice of breach of this warranty within the Warranty Period, Seller shall, at its sole option and as Buyer's sole and exclusive remedy, repair or replace the subject parts, re-perform the Service or refund the purchase price. Unless otherwise agreed to in writing by Seller, (i) Buyer shall be responsible for any labor required to gain access to the Work so that Seller can assess the available remedies and (ii) Buyer shall be responsible for all costs of installation of repaired or replaced Work. If Seller determines that any claimed breach is not, in fact, covered by this warranty, Buyer shall pay Seller its then customary charges for any repair or replacement made by Seller. Seller's warranty is conditioned on Buyer's (a) operating and maintaining the Work in accordance with Seller's instructions, (b) not making any unauthorized repairs or alterations, and (c) not being in default of any payment obligation to Seller. Seller's warranty does not cover (i) damage caused by chemical action or abrasive material,

misuse or improper installation (unless installed by Seller) and (ii) media goods (such as, but not limited to, resin, membranes, or granular activated carbon media) once media goods are installed. THE WARRANTIES SET FORTH IN THIS SECTION 7 ARE THE SELLER'S SOLE AND EXCLUSIVE WARRANTIES AND ARE SUBJECT TO THE LIMITATION OF LIABILITY PROVISION BELOW. SELLER MAKES NO OTHER WARRANTIES OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR PURPOSE.

8. **Indemnity.** Seller shall indemnify, defend and hold Buyer harmless from any claim, cause of action or liability incurred by Buyer as a result of third party claims for personal injury, death or damage to tangible property, to the extent caused by Seller's negligence. Seller shall have the sole authority to direct the defense of and settle any indemnified claim. Seller's indemnification is conditioned on Buyer (a) promptly, within the Warranty Period, notifying Seller of any claim, and (b) providing reasonable cooperation in the defense of any claim.

9. **Assignment.** Neither party may assign this Agreement, in whole or in part, nor any rights or obligations hereunder without the prior written consent of the other party; provided, however, the Seller may assign its rights and obligations under these terms to its affiliates or in connection with the sale or transfer of the Seller's business and Seller may grant a security interest in the Agreement and/or assign proceeds of the agreement without Buyer's consent.

10. **Termination.** Either party may terminate this agreement, upon issuance of a written notice of breach and a thirty (30) day cure period, for a material breach (including but not limited to, filing of bankruptcy, or failure to fulfill the material obligations of this agreement). If Buyer suspends an order without a change order for ninety (90) or more days, Seller may thereafter terminate this Agreement without liability, upon fifteen (15) days written notice to Buyer, and shall be entitled to payment for work performed, whether delivered or undelivered, prior to the date of termination.

11. **Dispute Resolution.** Seller and Buyer shall negotiate in good faith to resolve any dispute relating hereto. If, despite good faith efforts, the parties are unable to resolve a dispute or claim arising out of or relating to this Agreement or its breach, termination, enforcement, interpretation or validity, the parties will first seek to agree on a forum for mediation to be held in a mutually agreeable site. If the parties are unable to resolve the dispute through mediation, then *any dispute, claim or controversy arising out of or relating to this Agreement or the breach, termination, enforcement, interpretation or validity thereof, including the determination of the scope or applicability of this agreement to arbitrate, shall be determined by arbitration in Pittsburgh, Pennsylvania before three arbitrators* who are lawyers experienced in the discipline that is the subject of the dispute and shall be jointly selected by Seller and Buyer. *The arbitration shall be administered by JAMS pursuant to its Comprehensive Arbitration Rules and Procedures. The Arbitrators shall issue a reasoned decision* of a majority of the arbitrators, which shall be the decision of the panel. Judgment may be entered upon the arbitrators' decision in any court of competent jurisdiction. The substantially prevailing party as determined by the arbitrators shall be reimbursed by the other party for all costs, expenses and charges, including without limitation reasonable attorneys' fees, incurred by the prevailing party in connection with the arbitration. For any order shipped outside of the United States, any dispute shall be referred to and finally determined by the International Center for Dispute Resolution in accordance with the provisions of its International Arbitration Rules, enforceable under the New York Convention (Convention on the Recognition and Enforcement of Foreign Arbitral Awards) and the governing language shall be English.

12. **Export Compliance.** Buyer acknowledges that Seller is required to comply with applicable export laws and regulations relating to the sale, exportation, transfer, assignment, disposal and usage of the Work provided under this Agreement, including any export license requirements. Buyer agrees that such Work shall not at any time directly or indirectly be used, exported, sold, transferred, assigned or otherwise disposed of in a manner which will result in non-compliance with such applicable export laws and regulations. It shall be a condition of the continuing performance by Seller of its obligations hereunder that compliance with such export laws and regulations be maintained at all times. BUYER AGREES TO INDEMNIFY AND HOLD SELLER HARMLESS FROM ANY AND ALL COSTS, LIABILITIES, PENALTIES, SANCTIONS AND FINES RELATED TO NON-COMPLIANCE WITH APPLICABLE EXPORT LAWS AND REGULATIONS.

13. **LIMITATION OF LIABILITY.** NOTWITHSTANDING ANYTHING ELSE TO THE CONTRARY, SELLER SHALL NOT BE LIABLE FOR ANY CONSEQUENTIAL, INCIDENTAL, SPECIAL, PUNITIVE OR OTHER INDIRECT DAMAGES, AND SELLER'S TOTAL LIABILITY ARISING AT ANY TIME FROM THE SALE OR USE OF THE WORK, INCLUDING WITHOUT LIMITATION ANY LIABILITY FOR ALL WARRANTY CLAIMS OR FOR ANY BREACH OR FAILURE TO PERFORM ANY OBLIGATION UNDER THE CONTRACT, SHALL NOT EXCEED THE PURCHASE PRICE PAID FOR THE WORK. THESE LIMITATIONS APPLY WHETHER THE LIABILITY IS BASED ON CONTRACT, TORT, STRICT LIABILITY OR ANY OTHER THEORY.

14. **Rental Equipment / Services.** Any leased or rented equipment ("Leased Equipment") provided by Seller shall at all times be the property of Seller with the exception of certain miscellaneous installation materials purchased by the Buyer, and no right or property interest is transferred to the Buyer, except the right to use any such Leased Equipment as provided herein. Buyer agrees that it shall not pledge, lend, or create a security interest in, part with possession of, or relocate the Leased Equipment. Buyer shall be responsible to maintain the Leased Equipment in good and efficient working order. At the end of the initial term specified in the order, the terms shall automatically renew for the identical period unless canceled in writing by Buyer or Seller not sooner than three (3) months nor later than one (1) month from

termination of the initial order or any renewal terms. Upon any renewal, Seller shall have the right to issue notice of increased pricing which shall be effective for any renewed terms unless Buyer objects in writing within fifteen (15) days of issuance of said notice. If Buyer timely cancels service in writing prior to the end of the initial or any renewal term this shall not relieve Buyer of its obligations under the order for the monthly rental service charge which shall continue to be due and owing. Upon the expiration or termination of this Agreement, Buyer shall promptly make any Leased Equipment available to Seller for removal. Buyer hereby agrees that it shall grant Seller access to the Leased Equipment location and shall permit Seller to take possession of and remove the Leased Equipment without resort to legal process and hereby releases Seller from any claim or right of action for trespass or damages caused by reason of such entry and removal.

15. **Miscellaneous.** These terms, together with any Contract Documents issued or signed by the Seller, comprise the complete and exclusive statement of the agreement between the parties (the "Agreement") and supersede any terms contained in Buyer's documents, unless separately signed by Seller. No part of the Agreement may be changed or cancelled except by a written document signed by Seller and Buyer. No course of dealing or performance, usage of trade or failure to enforce any term shall be used to modify the Agreement. To the extent the Agreement is considered a subcontract under Buyer's prime contract with an agency of the United States government, in case of Federal Acquisition Regulations (FARs) flow down terms, Seller will be in compliance with Section 44.403 of the FAR relating to commercial items and those additional clauses as specifically listed in 52.244-6, Subcontracts for Commercial Items (OCT 2014). If any of these terms is unenforceable, such term shall be limited only to the extent necessary to make it enforceable, and all other terms shall remain in full force and effect. The Agreement shall be governed by the laws of the Commonwealth of Pennsylvania without regard to its conflict of laws provisions. Both Buyer and Seller reject the applicability of the United Nations Convention on Contracts for the international sales of goods to the relationship between the parties and to all transactions arising from said relationship.

EVOQUA WATER TECHNOLOGIES

ATTACHMENTS

Generic Drawings

Qualifications

Product Brochures

NOTE: WE STRONGLY RECOMMEND THAT WATER HARDNESS IS LESS THAN 100 PPM $CaCO_3$ FOR MAKEUP WATER TO REDUCE MAINTENANCE.

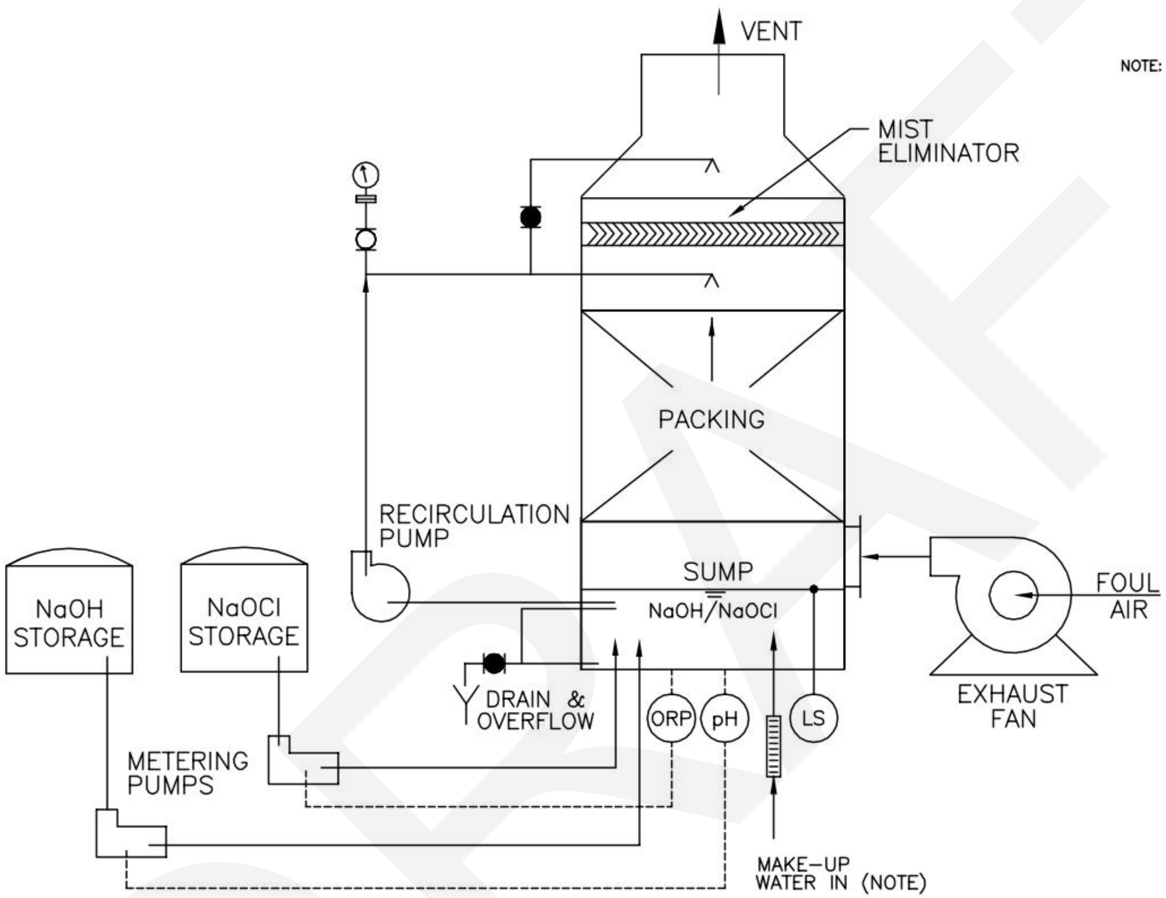


FIGURE 2 : SINGLE STAGE PACKED TOWER PROCESS DIAGRAM

REV	DESCRIPTION	DATE	DWN	CHKD	APVD	ECN

DESIGNER	DATE
CHECKER	DATE
ENGINEER	DATE
MANAGER	DATE
FILE:	
SCALE: NTS	

TITLE PACKED TOWER PROCESS FLOW DIAGRAM

CLIENT

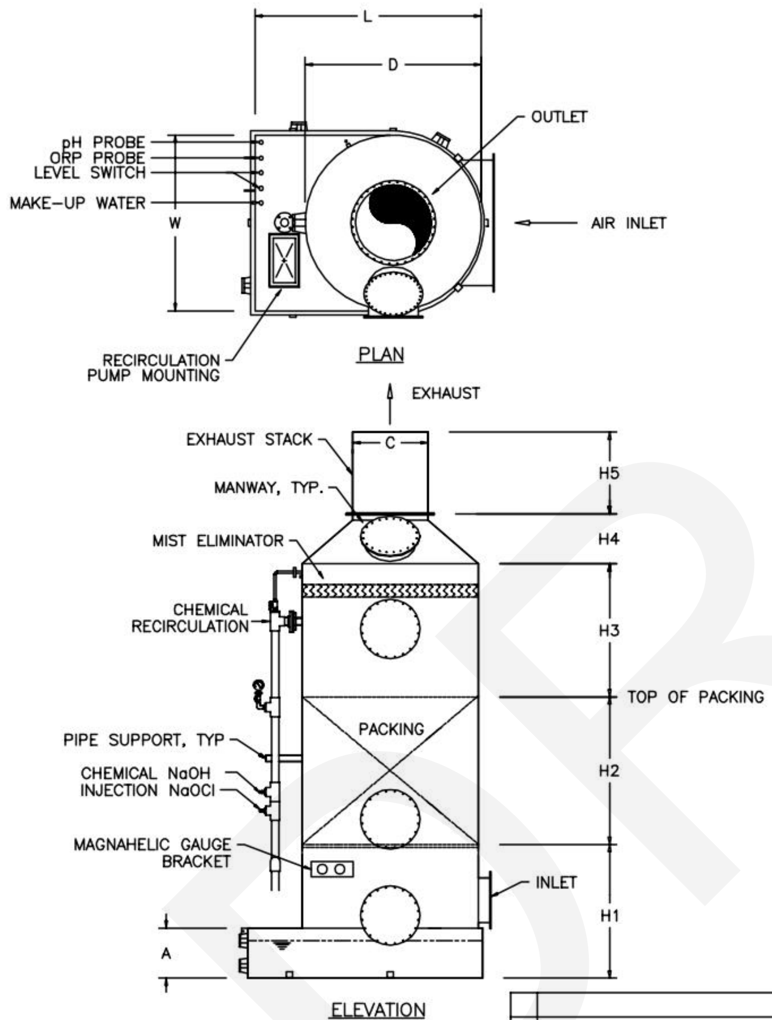
EVOQUA Water Technologies
SAN DIEGO, CA
858-487-2200

PROJECT	CODE	DRAWING	SHEET	REV
			OF	

BAR = 1" AT PLOT SCALE

INTL REF:

STD: BORDER-0307-11X17B



AIR FLOW RATE, cfm	18,000
SCRUBBER DIAMETER, ft (D)	8.0
SCRUBBER HEIGHT, ft (H1 TO H5)	25.0
DIMENSION, ft (H1)	6.0
DIMENSION, ft (H2)	10.0
DIMENSION, ft (H3)	4.0
DIMENSION, ft (H4)	2.0
STACK DIAMETER, ft (C)	3.5
STACK HEIGHT, ft (H5)	3.0
SUMP LENGTH, ft (L)	11.5
SUMP WIDTH, ft (W)	2.5
SUMP HEIGHT, ft (A)	8.0
LIQUID LEVEL, ft	2.0
GAS INLET, RECTANGULAR, ft X ft	1.5 x 6.0

NOTES:

1. RESIN: HETRON 922 FRP
   LINER: 2 PLY 1.5 oz. CHOPPED STRAND GLASS (E GRADE)
   SURFACING VEIL: "C" VEIL
   TOTAL MINIMUM LINER THICKNESS: 100 MIL.
2. TOTAL WALL THICKNESS: PER STRUCTURAL CALCULATIONS.
3. FABRICATION SHALL BE IN ACCORDANCE WITH ASTM D3299, C581 & PS15–69.
4. QUALITY ASSURANCE SHALL BE IN ACCORDANCE WITH ASTM D2563
5. ALL NOZZLES SHALL BE PLATE GUSSETED PER DWG.
6. TRUE ORIENTATION IS IN PLAN VIEW ONLY.
7. TANK EXTERIOR TO BE GELCOATED WITH UV–A ULTRAVIOLET LIGHT INHIBITOR. COLOR TO BE CHOSEN BY OWNER.
8. ALL INLET DUCTING IS TO BE COORDINATED AND PROVIDED BY OTHERS.
9. INSULATION, IF REQUIRED, TO BE 2" THK. LAYER OF POLYURETHANE INSULATION MATERIAL OVERLAYED WITH SAME FRP AS VESSEL, 0.125" THK.

FIGURE 1 : SINGLE STAGE PACKED TOWER GENERAL ARRANGMENT

REV	DESCRIPTION	DATE	DWN	CHKD	APVD	ECN

DESIGNER: ED	DATE: 1-8-01
CHECKER	DATE
ENGINEER	DATE
MANAGER	DATE
FILE:	
SCALE:	

TITLE: PACKED TOWER
ODOR CONTROL SYSTEM
GENERAL ARRANGEMENT

CLIENT: SALES STANDARDS
SINGLE STAGE

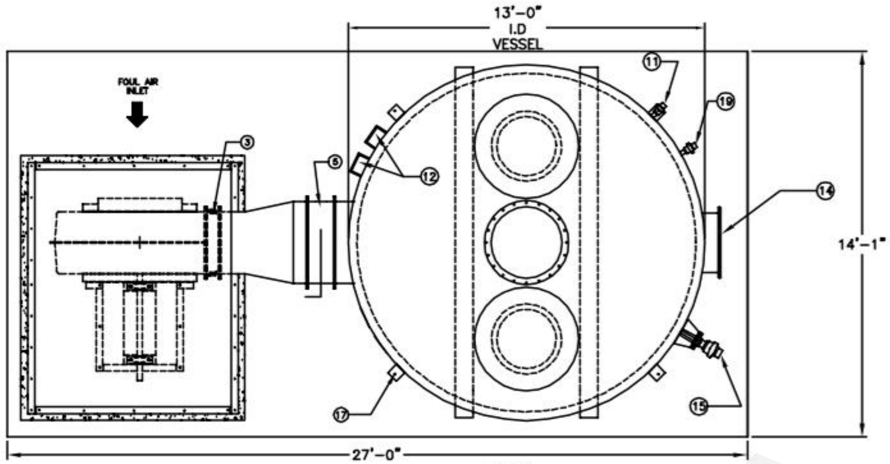
EVOQUA

PROJECT	CODE	DRAWING	SHEET	REV
		PT–SSCM_F01	OF	

BAR = 1" AT PLOT SCALE

INTL REF:

STD: 1-0600-11X17B



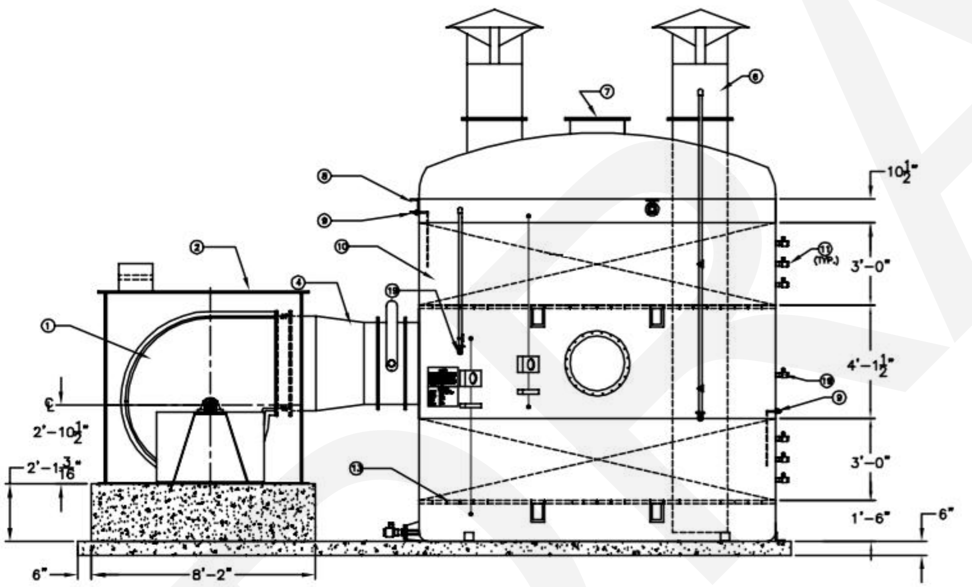
PLAN

SYSTEM #	1
AIR FLOW RATE, cfm	16,700
CARBON MEDIA BED HEIGHT/PER BED, ft	3.0
OPERATING WEIGHT, lbs	34,000

LEGENDS

1 FAN
2 FRP SOUND ENCLOSURE (FIELD-ASSEMBLED BY OTHERS)
3 FAN OUTLET FLEXIBLE CONNECTOR
4 FRP FAN OUTLET TRANSITION PIECE
5 36" I.D. MANUAL CONTROL DAMPER
6 24" I.D ADSORBER OUTLET (TYP.)
7 24" I.D TOP MANWAY ACCESS
8 LIFTING LUGS (TYP.)
9 GROUNDING ROD
10 ACTIVATED CARBON (3 FT BED)
11 CARBON SAMPLE VALVE (TYP.)
12 DIFFERENTIAL PRESSURE GAUGE (TYP.)
13 CARBON SUPPORT GRATING AND SCREEN
14 24" I.D SIDE ACCESS MANWAY
15 2" DRAIN VALVE
16 –
17 ANCHOR LUGS (TYP.)
18 –
19 1" AIR SAMPLE VALVE (TYP.)

NOTE: TRUE ORIENTATION IN PLAN VIEW ONLY



ELEVATION

REV	DESCRIPTION	DATE	DWN	CHKD	APVD	ECN

DESIGNER	DATE
CHECKER	DATE
ENGINEER	DATE
MANAGER	DATE
FILE:	
SCALE: NTS	

TITLE CARBON ADSORBER ODOR CONTROL
GENERAL ARRANGEMENT
13-FT DIAMETER DUAL-BED SYSTEM

CLIENT

EVOQUA

PROJECT	CODE	DRAWING	SHEET	REV
M03-323		M03-323	OF	

evoqua

WATER TECHNOLOGIES

LO/PRO® PACKAGED ODOR CONTROL SYSTEM

Evoqua Water Technologies offers a full range of chemical scrubber odor control systems for municipal and industrial odor control.

LO/PRO Multi-Stage Scrubber

The patented LO/PRO® multi-stage scrubber system is the most efficient and versatile chemical odor control system available. By promoting different chemical reactions in each stage, the LO/PRO system can target a range of compounds in a single scrubber system.

The LO/PRO system an treat up to 24,500 cfm of odorous air in a single scrubber with very compact footprint. Higher airflows may be accommodated with special designs. Because of the low profile it may easily be installed indoors or outdoors and results in 99.5% removal of H_2S.

Standard Configuration

In the standard configuration, the first stage uses NaOH to remove 70% of the H_2S. The second and third stages use NaOH and NaOCl to remove the remaining H_2S and organic odors. This multi-chemistry system reduces chemical costs to less than half that required by conventional packed tower scrubbers.

Special Configurations

The LO/PRO system may also be configured to remove ammonia and amines in the first stage using H_2SO_4, and then remove H_2S and organic odors in the second and third stages using NaOH and NaOCl. This configuration is well suited to dewatering and solids handling operations, where lime stabilization causes ammonia and amine odors.

When operating at high ORP levels the LO/PRO system is very efficient at oxidizing mercaptans and organic sulfides. In such systems a final NaOH stage may be used to prevent any residual chlorine odors.

Standard Features

- Patented Multi-stage Odor Control Process
- Removes H_2S, Mercaptans, Organic Sulfides, Ammonia and Amines in One System
- Low Profile enables indoor installations
- Factory Assembled for near "Plug & Play" Installation
- Premium vinylester FRP construction
- Evoqua Service and Support

EVOQUA
WATER TECHNOLOGIES

BULK ACTIVATED CARBON ADSORBER ODOR CONTROL SYSTEMS

Evoqua Water Technologies offers a full range of activated carbon systems for municipal and industrial odor control.

Single Bed Systems

Single bed systems are offered to treat up to 8,000 cfm (13,600 m^3/h) of odorous air. Air flow may be vertically upwards or vertically downwards. Systems may be designed to operate under vacuum or forced draft.

Dual Bed Systems

Dual bed systems are designed to provide double the treatment capacity in the same footprint as in the single bed systems. Air enters at the center of the vessel. Half the air passes vertically upward through the upper bed and half down through the lower bed. Exhaust stacks may be internal or external.

High Flow V-Bank Systems

The V-bank uses horizontal flow through two vertical beds and are ideally suited for projects where height constraint, or high air flows are required. The systems have been built to treat up to 60,000 cfm (100,000 m^3/h) in a single vessel.

Bulk activated carbon odor control systems are manufactured from premium vinyl ester FRP for optimum strength and corrosion resistance.

Optional Features

An acoustic enclosure is offered as an option to reduce noise levels in residential locations. The Evoqua RJMC Series

Adsorbers are offered in premium vinyl ester FRP for optimum corrosion resistance. Systems are designed to hold a wide range of activated carbon media. Systems are normally sized to provide a minimum of one year media life.

A grease filter/mist eliminator is recommended upstream of the fan to reduce the maintenance and extend the carbon life.

Standard Features

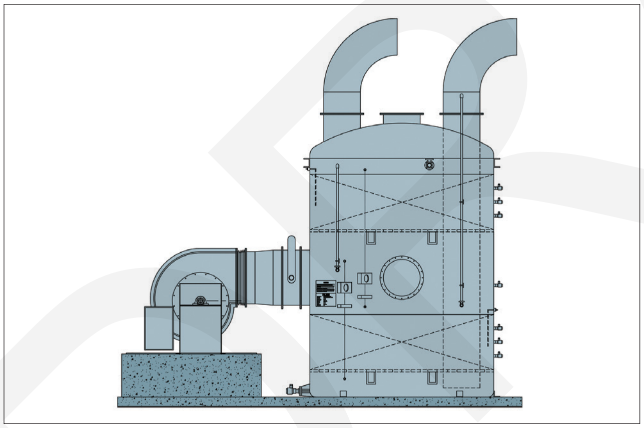
- Air flow rates up to 20,000 cfm in a single unit
- Single or dual-bed systems
- High performance carbon media
- High Volume V-bank designs available

Carbon Adsorbers used as polishing units following a Biotrickling filter.

RJC DESIGN INFORMATION

Model	Airflow Rate	Type	Diameter	Footprint Dimensions L x W x H*	Inlet Connection O.D.	Carbon Wt**	Operating Wt	Fan Motor	Power Supply
Unit	cfm	No. of carbon beds	ft	ft	inches	lbs	lbs	HP	FLA at 460V/3Ph/60Hz
	m^3/hr		*mm*	*mm*	*mm*	*kgs*	*kgs*	*kW*	
RJC-0600	2000	Single	6.0	11 x 7.0 x 7.75	16 3/8	2,500	4,800	5.0	7.5
	3400		*1829*	*3352 x 2134 x 2362*	*416*	*1,136*	*2,182*	*3.7*	
RJC-0800	3500	Single	8.0	14 x 9.0 x 8.5	16 3/8	4,500	8,400	7.5	10.1
	5950		*2438*	*4277 x 2743 x 2565*	*416*	*2,045*	*3,818*	*5.5*	
RJC-1000	5500	Single	10.0	16.5 x 11 x 9.5	19 3/8	7,000	13,000	10	13.5
	9350		*3048*	*5030 x 3353 x 2870*	*492*	*3,182*	*5,909*	*7.5*	
RJC-1200	8000	Single	12.0	18.75 x 13 x 10.25	23 3/4	10,200	19,000	15.0	19.1
	13600		*3658*	*5715 x 3962 x 3124*	*603*	*4,636*	*8,636*	*11*	
RJC-1000D	11000	Double	10.0	17.75 x 11 x 16	25 3/4	14,100	23,000	20	25.2
	18700		*3048*	*5410 x 3353 x 4852*	*654*	*6,409*	*10,455*	*15*	
RJC-1100D	13000	Double	11.0	19.5 x 12 x 16.75	28 5/8	17,100	28,000	25.0	31.1
	22100		*3353*	*5944 x 3658 x 5105*	*721*	*7,773*	*12,727*	*18.5*	
RJC-1200D	16000	Double	12.0	20.5 x 13 x 17	31 1/16	20,300	33,000	25.0	31.1
	27200		*3658*	*6250 x 3962 x 5182*	*789*	*9,227*	*15,000*	*18.5*	
RJC-1400D	20000	Double	14.0	23.25 x 15 x 18.3	34 1/16	27,600	45,000	40.0	49.8
	34000		*4267*	*7087 x 4572 x 5589*	*865*	*12,545*	*20,455*	*30.0*	

* Height to vessel top, excluding stack | ** Dependent upon media type, values are +/- 7%



Media

Evoqua carbon odor control systems are designed to work with a wide range of media.

Midas® OCM

For H_2S odor removal we recommend Midas® Odor Control Media. Midas OCM has the highest odor removal capacity of any media on the market (0.30 g H_2S/cc carbon) and will reduce the frequency of media changeout.

Other Media offered:

- VoCarb® UOCH-KP Caustic impregnated odor control media
- VoCarb® P60 pelletized, coal-based, virgin activated VOC carbon
- VoCarb® 48C, 36C granular, coconut shell activated carbon
- 48C granular, coconut shell activated carbon

Email odorcontrol@evoqua.com or visit www.evoqua.com/bulk to connect with an expert.

EVOQUA WATER TECHNOLOGIES

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BTF BIOSCRUBBER ODOR CONTROL SYSTEM

BTF BIOSCRUBBER

The patented BTF Bioscrubber is a bio-trickling scrubber system which uses sulfur-oxidizing bacteria to remove H_2S and organic odors from odorous air.

Bioscrubbers are characterized by their very low operating cost, and ability to handle very high H_2S concentrations up to and exceeding 1000 ppm. They are especially well suited for treating raw sewage odors as found in pump stations, headworks operations, and primary sedimentation.

PROCESS DESCRIPTION

The BTF bioscrubber uses random packed polyurethane foam (PUF) cubes as the support media for biomass growth. The media bed is irrigated with water and nutrients either continuously or intermittently. Maekup water is added to maintain the pH in a safe range, typically between pH=1 and 2. This provides an optimum environment for the preferential growth of acidophilic, sulfur-oxidizing bacteria.

The PUF media has a very high H_2S elimination capacity, in the range of 80 to 100 gm/m^3/hr. Better than 99% H_2S removal can be achieved at an empty bed residence time (EBRT) from 8 to 10 sec. Better than 90% odor removal is usually achived with BRT between 15 to 20 sec.

BTF DESIGN PARAMETERS

Each BTF is custom sized to optimize the performance for each application, based on the air flow rate, H_2S and organic odor concentrations, and % removal required. BTF systems can be designed to treat from 1,000 cfm to 15,000 cfm in a single 6-ft to 12-ft.

All BTF systems are fabricated from premium vinyl ester FRP with resin rich interior corrosion liner and exterior UV resistant gel coat. A factory-assembled Nucirc skid is available for improved reliability and ease of installation.

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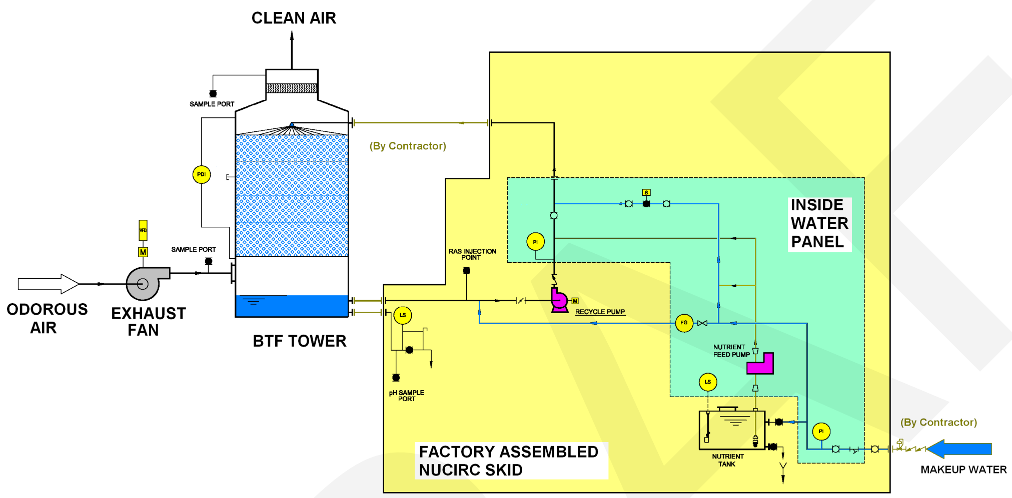
SINGLE STAGE AND 2-STAGE DESIGNS

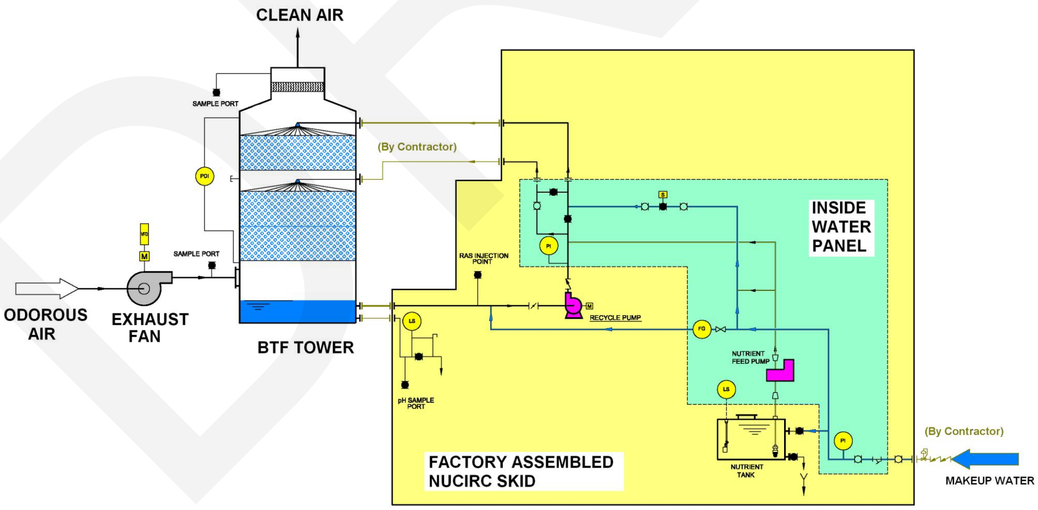
The BTF may be configured as either a single stage or 2-stage bioscrubber. In the single stage BTF the irrigation water is recirculated continuously over the entire media bed. This is the normal mode of operation for system acclimation, and the preferred mode for very high H2S concentrations. After acclimation the single stage BTF may also be operated with intermittent fresh water irrigation.

In the 2-stage BTF the first stage uses continuous recirculation and the second stage uses intermittent irrigation of fresh water. The 2-stage BTF process provides superior control of organic odors.

PROCESS FLOW DIAGRAM: Single Stage



PROCESS FLOW DIAGRAM: Two-Stage



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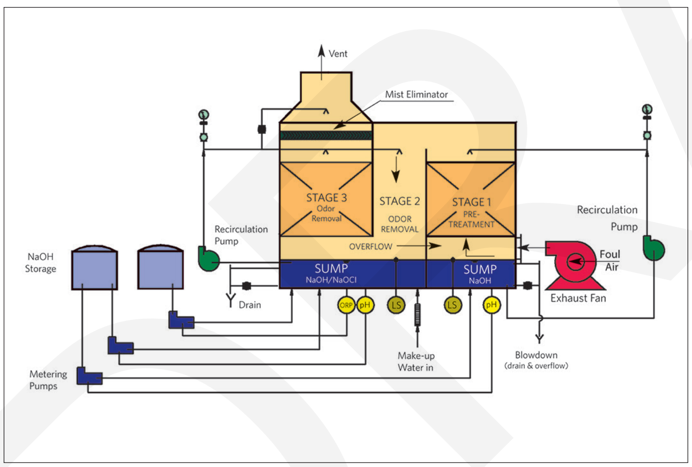
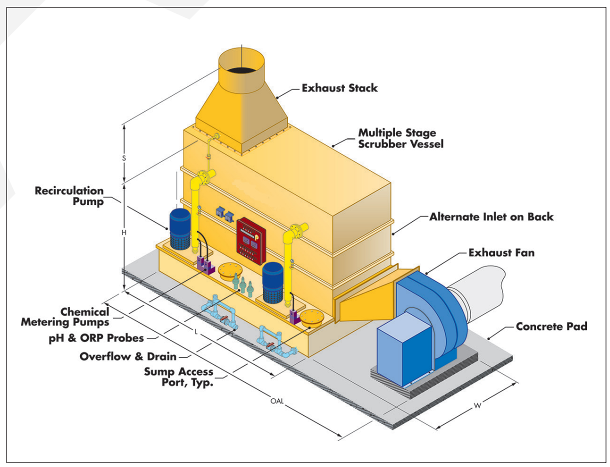
THE LO/PRO SYSTEM DESIGN INFORMATION

Model Unit	Airflow Rate* cfm	Dimensions LxWxH ft	Overall Length (OAL) ft	Shipping Wt lbs	Operating Wt lbs	Estimated System Power HP
LP-2000	1,700	6.00 x 4.50 x 9.25	11.0	2,200	6,000	13
LP-2250	2,200	6.75 x 4.75 x 9.25	12.5	2,500	7,000	17
LP-2500	2,700	7.50 x 5.00 x 9.50	13.0	1,100	8,000	18
LP-2750	3,300	8.25 x 5.25 x 9.50	15.0	3,700	9,500	20
LP-3000	4,000	9.00 x 5.50 x 10.50	15.5	4,400	11,000	25
LP-3500	5,500	8.75 x 6.00 x 11.00	16.0	5,000	12,000	30
LP-4000	7,100	10.00 x 6.50 x 11.00	17.5	5,600	14,500	35
LP-4500	9,100	11.25 x 7.00 x 11.25	19.5	6,200	17,000	45
LP-5000	11,200	12.50 x 7.50 x 11.50	20.5	6,800	19,500	50
LP-5500	13,600	13.75 x 8.00 x 11.75	22.0	7,500	22,000	50
LP-6000	16,200	15.00 x 8.50 x 12.00	24.0	8,300	22,500	60
LP-6500	20,000	16.25 x 9.00 x 12.25	26.0	9,100	28,500	70
LP-7000	24,500	17.50 x 9.50 x 12.50	27.0	10,000	32,000	90

* Standard Exhaust Stack "S" is six feet



Process Flow Diagram



Isometric Drawing

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LO/PRO is a trademark of Evoqua, its subsidiaries or affiliates, in some countries. Features of the LO/PRO system are covered by U.S. Patent Nos. 5,876,662 & 6,174,498).

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 Subject to change without notice OC-LOPRO-DS-1014 enduro

WATER & WASTEWATER PRODUCTS

Proposal No.	**16-044-C**	**Rev.**	**0**	**Date:**	**11/01/16**

To:

Project: **Comox-Strathcona**
Bid Date: **N/A**
Location: **Comox, Vancouver**
Spec Section: **N/A**
Drawing #: **N/A**
Addenda: **N/A**

Rep Firm:
Enduro Sales Mgr: **Francisco Alvidrez**

This proposal is based upon:

Scope of Work:

- Supply only of materials for FRP Tank Cover System including:
  - FRP Deck Panels
  - FRP Beams
  - Shelf Angles
  - Fasteners, Anchors, Gaskets, and Sealant
  - Hatches, Vent Nozzles, and other materials as included herein
- Freight prepaid by Enduro to jobsite. FOB point is the Enduro factory.
- Submittal/Installation Drawings (11" x 17" sheets).
- Tank Cover dimensions:
  - 3 Covers at 5.2 m Wide x 12 m Long
  - 3 Covers at 5.2 m Wide x 13.2 m Long
  - 3 Covers at 4.1 m Wide x 5.4 m Long

1. **Proposal Includes: Enduro Fiberglass (FRP) Tank Cover with these components:**
   a. SureGrip Tank Cover Panels (non-skid surface) – FRP
      - Resin: Polyester
      - Color: Gray
      - Height: 2 1/8"
   b. FRP Raised Hatches w/Gaskets
      - 5 @ 22" x 48" / per tank
      - Optional: 316 SS Hold-Open Device
   c. 12F12 Primary Structural Beam - FRP
      - Resin: Vinyl Ester
      - Color: Gray
   d. Stub-Up HVAC Connections / Flanged Nozzles
      - Material: FRP, PVC or 304 Stainless
      - 2 @ 6" diameter / tank
      - Flange Pattern: ANSI 150#
   e. Pipe Penetration Retrofit Flashings

- 4 @ 2" – 7 1/4" diameter / tank

f. FRP Flat Strip
g. FRP Perimeter Flashing
h. Gasket & Sealant
i. 316 Stainless Steel hardware

2. <u>Proposal is based on these assumptions:</u>

- Dead + Live or Snow Load = 105 psf
  Concentrated Load = 250 lbs. (within 30" x 30" area)
  - Deflection Limit = L/180   Factor of Safety = 2.5
  - Minimum L/D = 180   Minimum Factor of Safety = 2.5
- Tank Cover panels shall be installed inside of tank walls.
- Tank Cover Beams shall be placed on top of tank walls and supported by 316 SS structural supports.
- Tank cover shall be flat with no slope and not completely airtight.
- Shelf angle beam supports shall be provided by Enduro.
- Existing walls, floors or any adjacent surfaces for attachment of FRP components shall be smooth, level, and straight.
- Existing tank walls, floors or other adjacent structures shall support the dead and live loads of tank cover.
- Existing walkway shall support dead and live loads transferred to it by tank cover system.
- Connections to walls and adjacent structures shall be allowed as necessary to secure Tank Cover Panels, trusses, and beams.
- Concrete strength is a minimum of 3000 psi.
- Buyer shall approve Enduro Submittal Drawings and Data in writing.
- Buyer shall dismantle, relocate, or modify any interference points or existing equipment obstructions interfering with or penetrating tank cover system layout.
- Buyer shall arrange relocate, modify, or install any penetrations into cover as 90-degree penetrations (perpendicular to cover tank surface) to maximize sealing.
- Buyer shall field cut all penetrations for truss hangers, bracing, nozzles, hatches, or any other miscellaneous penetrations. Bevel or edge cutting also may be necessary around perimeter.
- Buyer shall do field cutting for penetrations for items not listed herein with Enduro's written authorization.
- Warranty against material defects and workmanship shall be in effect for 12 months following date of shipment.

3. <u>Clarifications/Exceptions:</u>

- No exceptions.

4. <u>Proposal does not include:</u>

a. Fabrication for openings less than 6" square or 6" diameter; perimeter block-outs; or pipe chases.
b. Bevel cutting of FRP Beams: Components will be supplied longer than necessary to insure proper lengths unless approved otherwise in writing by Buyer.
c. PE certified review/design of submittal packages, unless specifically noted in scope of supply above.
d. Staging, storage, unloading, installation or field labor of any kind.

e. Field dimensioning, site visits, or field advisor unless it is listed as included in the Scope Section or Inclusion Section in this proposal.
f. Any handrail, grating, ventilation, duct, equipment, or other component not listed as included in the Scope Section or Inclusion Section in this proposal.
g. Taxes, permits, duties, brokerage fees, or bonds
h. O&M Manuals
i. Any material to modify concrete or other adjoining material surfaces.
j. Certificate test data and structural calculations stamped by P.E. verifying system meets specification criteria (unless stated otherwise in this proposal).
k. Compliance with Specifications, Drawings, or Addenda not listed in this proposal.

5. Terms:

a. FOB Factory (Houston, TX). Pricing includes freight to jobsite.
b. Pricing valid for 90 days.
c. Payment terms:
    i. 95% @ delivery of equipment
    ii. 5% @ 45 days after receipt of equipment
d. All payments Net 30 days.
e. Proposal per Enduro Composites' standard terms & conditions

6. Estimated Lead Time for Submittal Package:

a) 4-6 weeks after execution of contract.
   – Each PE review/certification will add an additional 1-2 weeks.

7. Estimated Lead Time for Start of Shipping:

a. 9-11 weeks after written approval of submittal package.

8. Price (USD): $242,497.00

We look forward to working with you and hope this proposal meets with your satisfaction.

Francisco Alvidrez
Regional Sales Manager – Water & Wastewater Products
Email: falvidrez@endurocomposites.com

Individual Pricing For Items if Added to Scope Above

Adders to base price for items not listed above as included:

a. Access Hatches (each):
   1. 12” x 12”…………………..$485.00 (Observation Hatch)
   2. 22” x 22”…………………..$549.00 (Raised Hatch)
   3. 22” x 30”…………………..$582.00 (Raised Hatch)
   4. 22” x 36”…………………..$611.00 (Raised Hatch)
   5. 22” x 48” …………………..$675.00 (Raised Hatch)
   6. Optional 316SS hold-open devices for above - $75.00 each

b. Penetration Support Framing / Perimeter Block-Outs:
   i. $450 each.

c. Flanged Stub-Up HVAC Connections / Nozzles (each):
   1. 4 inch = $198 12 inch = $528

2. 6 inch = $396 14 inch = $572
3. 8 inch = $418 16 inch = $628
4. 10 inch = $462 18inch = $660

ii. Above pricing not applicable to gooseneck vent connections. Contact Enduro for pricing.

d. P.E. Certification of final design package:
   i. $2,300.00.
   ii. Add $1,000 for each preliminary design package to be reviewed & re-certified

e. Enduro Field Advisor:
   i. One (1) trip, one (1) day on-site: Add $2,350 per trip.
      1. Add $850/day for each additional day required.
   ii. These prices apply to projects located in the USA, Mexico, or Canada.

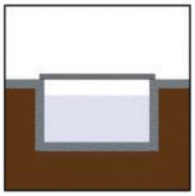
SureGrip Tank Cover System

System Overview

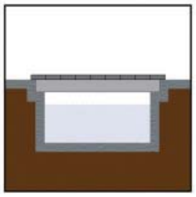
Enduro SureGrip tank cover systems are ideal for channels, odd-shaped basins, or covers with numerous penetrations.

SureGrip system components include SureGrip FRP deck panels, FRP beams, access hatches and stainless steel hardware.

Configurations available for the SureGrip tank cover:



Flat, Clear Span



Flat, Beam-Supported

SureGrip beam-supported cover system over 70' diameter steel tank Aeration & Equalization Basin

Key SureGrip Features & Benefits

Viewports are lower cost and provide quick viewing.

- **Good Odor Control**

  SureGrip design includes EPDM gaskets at outer edges and tight panel joints that produce a relatively air-tight cover system.

- **Medium Span Capability**

  The SureGrip panels can clear span across channels with 10 ft. or less width. Supported by Enduro FRP beams, the SureGrip Cover System is suitable for larger basins as well.

Perimeter flashing with integral lift handles and penetration flashing is available for slidegates and piping.

- **Accessibility**

  With gritted, non-skid surface, high-strength SureGrip deck panels are designed for safe, operator foot traffic. Access Hatches are available in sizes from 1' square view ports up to 4' square sizes.

- **Easy, Low-cost Installation**

  The 12" wide SureGrip panels snap together and are bolted to FRP support beams that are typically spaced 6' to 10' apart.

- Corrosion Resistant
- **High Strength**
- **Lightweight**
- UV Protection
- Turn Key Solutions
- Customized System
- Non-skid Surface
- **Low Profile**

SureGrip Tank Cover System

Applications

- Headworks & Grit Covers
- **Clarifiers**
- **Aeration & Equalization**
- Sedimentation
- **Sludge & Gravity Thickeners**
- **Chlorine Contact Basins**
- **Filtrate Storage Tanks**
- **Chemical Process Tanks**

SureGrip beam-supported tank cover system
Sedimentation Basin

SureGrip sloped tank cover system
Screw Pump Structure

SureGrip beam-supported splash cover
Racetrack Aeration Basin

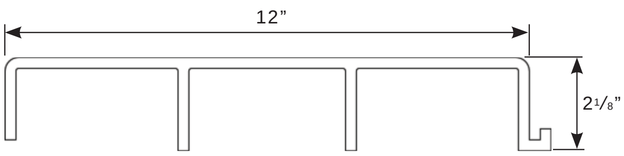
SureGrip beam-supported cover - 31′ diameter
Grit Basin

SureGrip beam-supported tank cover system and access hatches
Sedimentation Basin

SureGrip beam-supported cover with Tuff Span removable enclosure. See pg. 13 for more about Tuff Span enclosures. Aeration Basin

SureGrip Tank Cover System

Profile

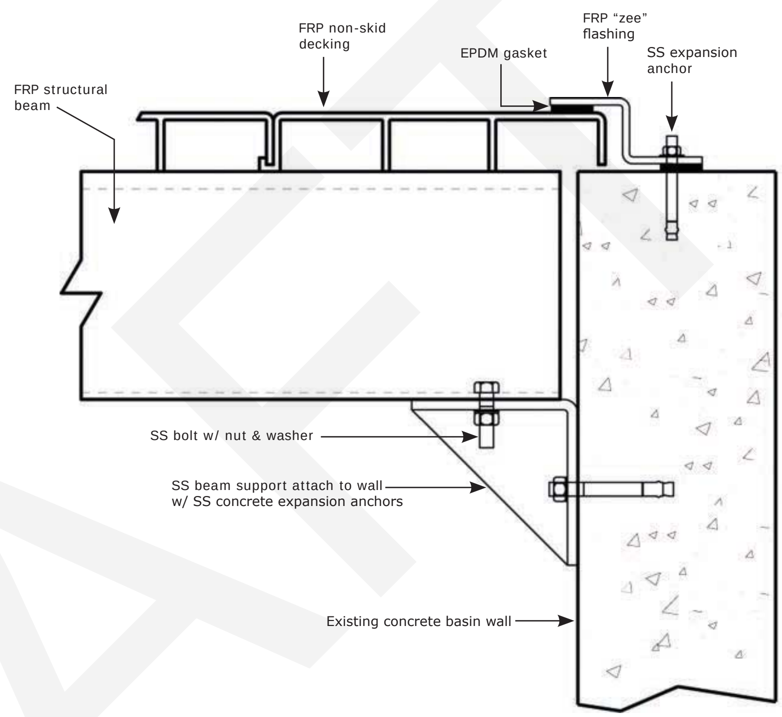


Load Span Table

Maximum Allowable Load - Safety Factor = 2.5

Span	Uniform Live or Snow	
	L/D = 120	L/D = 180
10 ft.	29 psf	-
9 ft.	40 psf	27 psf
8 ft.	58 psf	38 psf
7 ft.	86 psf	57 psf
6 ft.	136 psf	90 psf

Typical Detail



Specification: SureGrip Tank Cover System

Part 1 – General
1.01 Description of Work
Scope of work shall include materials for fiberglass reinforced plastic (FRP) flat tank covers including: Cover deck panels; Structural supports; Flashing and trim; Fasteners and anchors; Gaskets and sealant.

1.02 Design Criteria

A. Design Loads
1. Live or Snow ______ psf
2. Wind Uplift ______ psf
3. Dead Load ______ psf

B. Design Limits
1. Dead + Live or Snow Load: Limit: L/120 (min); Factor of Safety = 2.5
2. Wind Uplift less Dead Load: Deflection Limit - L/60; Factor of Safety = 1.88
3. Personnel Load: Cover panels shall support 250 lb. concentrated load over a 2.5 SF area located at mid-span.

C. Hatches: Hatch covers accessible to foot traffic shall support a 300 lb. load spread over top of hatch.

D. Tank cover shall be designed as relatively airtight.

Part 2 – Products
2.01 Materials
A. SureGrip Tank Cover Deck Panels
1. FRP deck panels shall have top surface thickness of 3/16" (min). Deck leg supports shall be ¼" thick.
2. Resin type for FRP cover decking shall be UV stabilized, isophthalic polyester.
3. Glass fiber reinforcements shall be a minimum of 50% of the material weight.
4. Materials shall be fire retardant and have a flame spread rating of 25 or less per ASTM E84.
5. Materials shall exhibit these Physical Properties (at a minimum):

Tensile Strength	30,000 psi	ASTM D 638
Compressive Strength	30,000 psi	ASTM D 695
Flexural Strength	30,000 psi	ASTM D 790

6. The top of the tank cover decking shall be flat and non-profiled with a factory applied, non-skid, UV resistant surface. Color shall be gray.

B. Hatches (if indicated on drawings)
1. Hatches shall be sized as indicated on drawings.
2. Hatches shall have a stainless steel hold-open device and hand-operable latch.
3. Lid shall have a factory-applied non-skid, UV resistant surface and plastic or stainless steel lift handle.

C. FRP Structural Framing: Materials shall be same as A. 2.– 4.

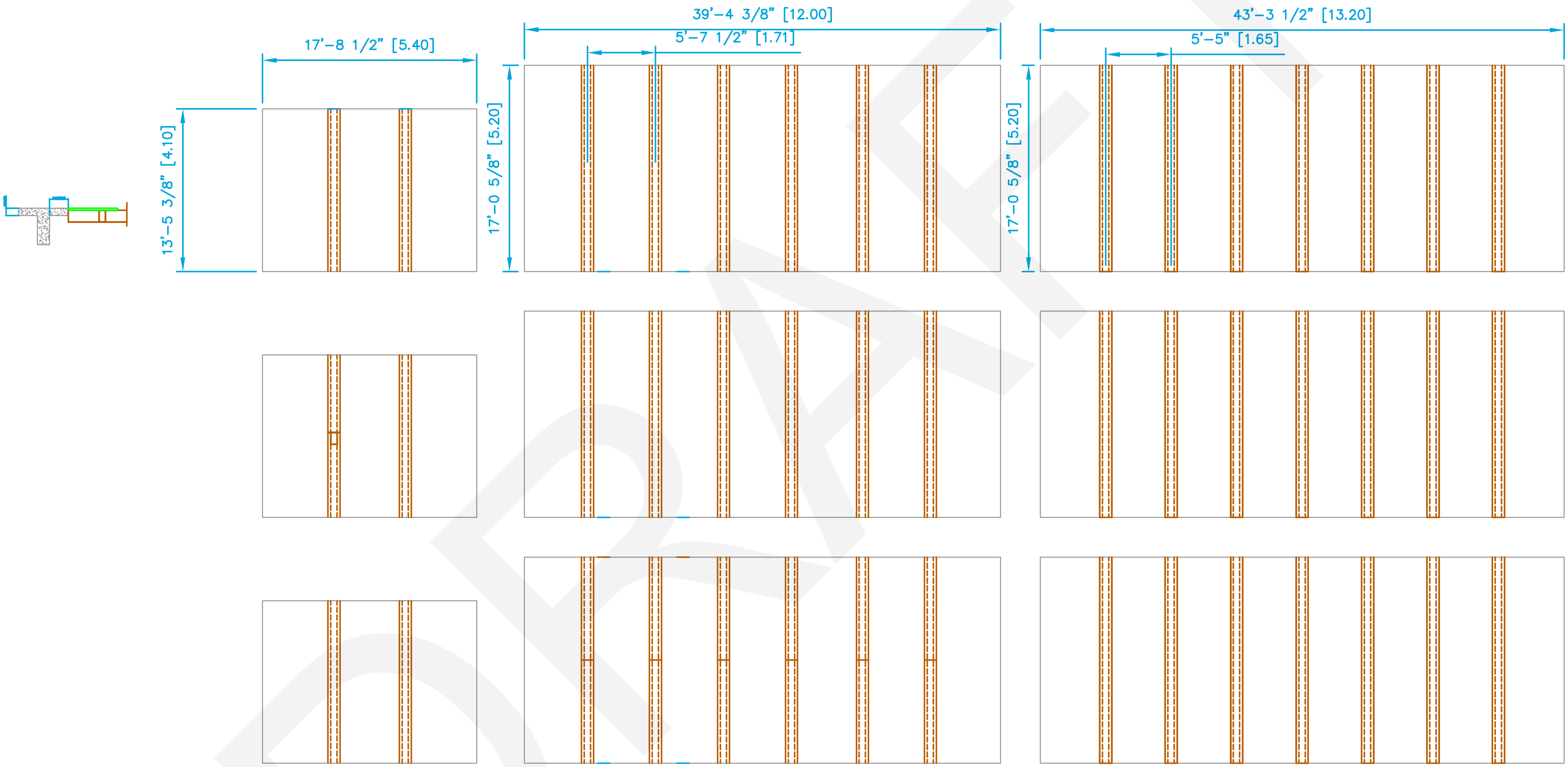
D. Flashing shall be FRP or 304 Stainless Steel.

E. Fasteners, anchors, and hinges, and other accessories shall be 316 Stainless Steel.

F. EPDM or neoprene gaskets shall be installed at end joints of deck panels and under flashing.

G. Sikaflex®-1A sealant shall be applied by contractor at vari ous locations.

For expanded specification, please contact us.


17'-8 1/2" [5.40]
13'-5 3/8" [4.10]
39'-4 3/8" [12.00]
5'-7 1/2" [1.71]
17'-0 5/8" [5.20]
43'-3 1/2" [13.20]
5'-5" [1.65]
17'-0 5/8" [5.20]

Appendix C

Dewatering Odour Trial

To:	Ashraf Rayyan & Kevin Liu	From:	Bryan Haan
Company:	ISL Engineering	Title:	Account Manager – Odour Control Solutions
CC:	Mike Greig – Mequipco	Company:	Evoqua Water Technologies Ltd.
Tel:	604-629-2696	Address:	2045 Drew Road Mississauga, ON L5S 1S4
Email:			
Total Pages:	5	Tel:	(416) 200-4536
Date:	November 2016	Email:	bryan.haan@evoqua.com
Subject:	**Comox WWTP** **Odour Control Pilot Proposal**	Internet	www.evoqua.com

Re: Proposal to Demonstrate Full Service Odour Control at the Comox WWTP.

Evoqua Water Technologies Ltd., (hereafter EWT) are pleased to submit the following proposal to demonstrate our Full Service Odour Control utilizing the Bioxide™ treatment process. To confirm required dosage rates to control odours on the dewatered sludge material bench top testing is suggested as a primary step. The information gained from the pilot trial will confirm treatment efficiency as well as provide required sizing information for possible full scale system.

Bioxide is a proprietary product manufactured by EWT which effectively eliminates and prevents the formation of hydrogen sulphide and other odour causing substances commonly found in most wastewater collection / treatment systems. Bioxide is very safe to store and handle and is the only leading chemical method of hydrogen sulphide control that is not on EPA's CERCLA list of hazardous chemicals. Please see brochure attached.

Demonstration Objectives

1. To utilize dewatered sludge produced onsite at the Comox WWTP to run bench top testing to reduce hydrogen sulphide levels formed in the solids holding/storage area to an acceptable level.

2. To establish application methodology and dosage rates to the samples to accomplish acceptable levels of treatment for the required time period.

3. To provide a follow up report on the pilot trial with monitoring results, dosage rates and suggestions for permanent application

4. Quotation for site specific system equipment as well as ongoing Bioxide supply.

Demonstration Description

EWT will provide the following:

- On site personnel for pilot trial (1 site visit for 3 days)
- Equipment for bench top testing
- Monitoring equipment for pilot trial as well as atmospheric testing of loading bay

Customer to provide the following:

- Access to site and working area for testing
- Access to dewatered sludge for samples
- Personnel to assist in collection and testing protocol to be worked out
- Onsite space for sample storage
- Any analytical costs that you wish to perform past our onsite testing

The purpose of the trial will be to determine the dosage rates required with the Bioxide product to reduce the level of odours (measured as hydrogen sulphide) to reasonable and acceptable levels. This will be done using 5 Gal buckets with roughly 10 lbs samples (half full) of dewatered sludge. The buckets will be sealed to capture headspace gas generation.

Untreated samples will be used to baseline the odour generation. A range of treated samples will be used to determine treatment efficiency and length of treatment. The target would be to carry treatment for roughly 2 days (considered to be the max holding time of dewatered sludge). To complement the bench top testing, monitoring can be done on the process using atmospheric testing units with datalogging ability (odalogs). This will allow for potential trending of generation in the dewatering and transfer process.

EWT in co-operation with customer personnel will monitor the solids characteristics to ensure no adverse effects are seen.

If Comox would like to proceed please suggest some potential weeks available.

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Demonstration Cost

EWT will provide field services, required Bioxide and the testing equipment specified. The cost for the pilot trial would be $4,775 CDN.

If you have any questions please feel free to contact our office.

Thank you for your consideration of EWT's full service odour control services and we look forward to working with you on this or any other applications you may have.

Sincerely,

Bryan Haan

Account Manager – Odour Control Solutions
Evoqua Water Technologies Ltd.

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BIOXIDE® BIOCHEMICAL SOLUTION – THE NATURAL CHOICE FOR ODOR AND CORROSION CONTROL

BIOXIDE® solution is a unique, proven product because it achieves sewage odor control naturally, rather than chemically. This process eliminates the odor, prevents corrosion and overcomes safety concerns associated with atmospheric hydrogen sulfide.

BIOXIDE solution controls hydrogen sulfide odors and corrosion biologically. Introduction of nitrate oxygen via addition of BIOXIDE solution into a waste stream creates an environment in which certain naturally occurring bacteria thrive. These bacteria utilize the dissolved hydrogen sulfide which is present as a part of their metabolism, thereby cost effectively removing any dissolved hydrogen sulfide from the wastewater. As a result, BIOXIDE solution both removes dissolved hydrogen sulfide and prevents its formation.

In addition to hydrogen sulfide, BIOXIDE also combats most other odors commonly found in wastewater treatment systems. BIOXIDE solution has proven effective treatment in many types of wastewater facilities, in widely varying flows, and in any kind of weather.

TYPICAL PHYSICAL PROPERTIES

Nitrate Oxygen Content	3.5 lb/gal
Appearance	Clear liquid
Odor	Odorless
Solubility in Water	Complete
Specific Gravity	1.458 at 20°C
Density	12.16 lb/gal at 20°C
Freezing Point	< -20°C
pH	5 - 7

Typical properties are listed for information only, and are not to be considered as specification requirements. These items are not analyzed on a routine basis.

Typical Applications

- Force mains/Pressure mains
- Gravity interceptors
- Lift Stations
- Biosolids processing
- Ponds and lagoons

Proper dosage (as determined by Evoqua Water Technologies) of BIOXIDE treatment solution to a sludge or a wastewater stream, provides for a population of beneficial bacteria which oxidize dissolved hydrogen sulfide and other reduced sulfur compounds as part of their metabolism. By treating the hydrogen sulfide both in flow and solids of the wastewater stream, the process prevents release of hydrogen sulfide into the air, reducing odors and corrosion.

Typical Feed Requirements

Treatment is typically applied in a collection system upstream of the odorous control point. From a carefully selected point(s), the benefits will spread throughout the collection system to the influent of the treatment plant. The process has been documented to reduce dissolved hydrogen sulfide from over 50 mg/l to < 0.1 mg/l in numerous wastewater collection force mains, wet wells and gravity interceptors. Similar results have been achieved with BIOXIDE treatment in sludge lagoons and storage tanks. Due to the biochemical nature of this process, complete sulfide removal is extremely cost effective in applications where extended detention times produce septic conditions.

For additional treatment information, including dosage specific to your application, please contact your Evoqua Water Technologies representative.

Storage and Handling

BIOXIDE solution is environmentally safe. It contains no hazardous substances as defined by the CERCLA list of reportable quantities and the OSHA Hazard Communication Standard (29 CFR 1910.1200). The active ingredient is nitrate oxygen which is a stable, safe compound found in nature. This compound is selected as the active ingredient for BIOXIDE solution because it specifically interacts with naturally occurring bacteria to remove and prevent dissolved sulfide, resulting in an effective, safe and cost efficient product.

Can be stored outdoors in ambient conditions. Follow all local, state and federal regulations for storage. Do not dump on the ground or release into any body of water. All disposal methods must be in compliance with all Federal, State, Local and Provincial laws, and regulations. Regulations may vary in different locations.

See Material Safety Data Sheet for additional safety and handling information before storing or handling BIOXIDE solution.

Packaging

BIOXIDE solution is normally shipped in 3,800 gallon bulk tanker loads. Mini bulk deliveries (<2,000 gallons) are available in many parts of the country. For further information, please contact your Evoqua Water Technologies representative. For reorders and customer service, call 1.800.345.3982.

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