LAQS

AIR QUALITY
IMPACT ASSESSMENT

Prepared for

AFRO FISHING (PTY) LTD

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AIR QUALITY IMPACT ASSESSMENT

1 INTRODUCTION

Messrs Afro Fishing (Pty) Ltd (Afro Fishing) operates a pilchard cannery in the harbour precinct of Mossel Bay in the Western Cape Province. The pilchards are harvested off South African shores, but due to dwindling availability in local waters, most of the pilchards used are imported.

Waste materials from fresh fish processing prior to canning is removed from site and serves as input materials in a fishmeal processing plant in Mossdustria outside Mossel Bay.

To supplement their operations in Mossel Bay, Afro Fishing is considering the possibility of harvesting industrial fish, e.g. anchovy, red-eye, etc., from local waters for the sole purpose of producing fishmeal. It is planned to locate the new plant on premises previously that served a fish processing factory. These premises are located immediately adjacent to Afro Fishing's current operations.

Afro Fishing is thoroughly aware of the fact that they are located very close to the centre of the town of Mossel Bay and some of its residential areas, albeit in the precinct of a commercial harbour. Although it is well known that fish meal processing can easily lead to odorous emissions, Afro Fishing believes that modern fishmeal production technology, together with the correct air pollution abatement technology, will prevent any odorous emissions from escaping from the plant.

Afro Fishing appointed Cape Environmental Assessment Practitioners (Cape EAPrac) to lead the process of obtaining environmental authorisation for the planned fishmeal production process. Fishmeal production is included in the *List of Activities That Result in Atmospheric Emissions* published by the Department of Environmental Affairs and an atmospheric emission license (AEL) is required to operate the process.

An application for an AEL of this nature must be accompanied by a specialist air quality impact assessment and, on recommendation by Cape EAPrac, Afro Fishing appointed Lethabo Air Quality Specialists (Pty) Ltd (LAQS) for this purpose.

This report discusses the steps taken by LAQS in assessing the potential impact that emissions from Afro Fishing's site may have on the area surrounding their site. Particular attention was paid to estimated ground-level concentrations in the residential areas most likely to be affected by emissions.

2 RELEVANT GOVERNMENT REGULATIONS

The following Government Regulations apply to this air quality impact assessment and are referred to in the report where applicable.

1 "*National Ambient Air Quality Standards*" as published in Government Notice 1210 of 24 December 2009 (GN1210)

2 "*Declaration of Small Boilers as Controlled Emitters and Establishment of Emission Standards*" as published in Government Notice 831 of 1 November 2018 (GN831)

3 "*List of Activities That Result in Atmospheric Emissions*" as published in Government Notice 893 of 22 November 2018 (GN893)

4 "*Regulations Regarding Air Dispersion Modelling*" as published in Government Notice GN R.533 of 11 July 2014 (GN R.533)

3 PROPOSED FISHMEAL PLANT

3.1 PROCESS DESCRIPTION

A conceptual design of the plant has been done to obtain orders of magnitude so that a mass balance of the process could be done. Prior to a complete design, Afro Fishing wants an indication of the potential air quality impact to point out those areas that need refining.

Nevertheless, the reduction process will include the following unit operations:

-- Cooking
-- Pressing
-- Liquid-solid separation
-- Steam drying
-- Waste heat evaporation
-- Oil-liquid separation
-- Cooling / grinding / bagging
-- Boilers for steam generation.

Cooking:

The fish is transported via screw conveyors from the fish storage pits into the cooker feed hopper. Fish will be mashed prior to this if required and metal will be removed using electromagnets. The minimum cooking capacity will be 900 tons per day. Cooker heating will be by inner rotor and outer jacket steam application. Cookers will be designed for 6 bar steam and able to cook fish to a maximum temperature of 90-95 °C. The cooking time depends on the steam pressure, the speed of rotation and the level that the cooker is filled. The average cooking time to achieve a temperature of 80 °C is about 20 minutes. During the cooking of the fish the oil is liberated together with water soluble protein. The cooked fish exits the cooker into a dewatering conveyor. The dewatering screens in this conveyor will remove the free liquid from the solids. This liquid is tanked and pumped to the decanters.

Pressing:

The wet solids are conveyed into the press. The press consist of two rotary screws that compress the feed thereby removing the liquid. The press cake that exits the press has an average of 50% water content. The liquid is pumped into the decanter feed tank.

Solid – Liquid Separation:

The liquid from the press and the dewatering screen are put through a decanter to separate the suspended solids from the liquid phase. These solids (grax) are added to the solids from the press. The liquid along with oil is pumped to the tanks feeding the centrifugal separators. The liquid is centrifuged in a liquid-liquid centrifuge. The water with 10% solids content is removed from the oil and stored in a stick water tank. The oil is polished in another liquid-liquid centrifuge and pumped into oil storage tanks. The water is pumped to water processing plants.

Water Processing:

The blood-water from the fish storage pits is pumped from the drainage sumps to a steel tank and cooked. This blood-water is normally combined with the cooker feed and worked as expeditiously as possible. The stick-water resulting from the separation processes therefore consists of valuable water soluble proteins. This will be concentrated in falling film waste heat evaporators. The stick-water will be concentrated from a 10% solids content to approximately 38% and the resultant concentrate added back to the press cake prior to drying. A triple effect falling film evaporator will be installed which will use the waste heat from the steam dryers to evaporate the water at low temperatures and under vacuum.

Steam Drying:

The grax from the decanters and the press cake are conveyed via screw conveyors to the steam dryers. The concentrated process water from the evaporation plant is mixed in with the press cake. This mixture is dried to a moisture content below 10% in the indirect steam driers. The dryers will apply outer jacket heating plus internal heating discs and designed for steam pressures of 6 bar.

Cooling / grinding/bagging:

Fishmeal coolers will be used to cool down the fishmeal to room temperature using air. Grinders equipped with electromagnets will be used to produce a fine fish meal free of metal. Rolling sieves will remove any coarse material and the final product bagged by means of automatic packing. Bulk bags with 50 kg bagging capability will be catered for. Anti-oxidant dosing of the fishmeal will be included to stabilize the finished product.

Steam generation:

An LSO fired boiler will be used to generate the steam required for fishmeal processing. The existing boiler will be used with an additional boiler to achieve the quantity of steam needed. Condensate will be recovered from the cookers and dryers in order to reduce water and fuel consumptions and increase boiler efficiencies.

PLC Control:

A SCADA system is proposed to enable full remote control of the plant.

Oil and meal Storage:

Fish oil is stored in oil storage tanks. The fish oil is loaded in bulk tankers and bulk containers. The fish oil is pumped from the storage tanks through a loading pipe directly into the tankers or containers. Antioxidant is added to certain loads of oil to stabilize the product. Fishmeal will be stored in polypropylene bags in the main warehouse. Pest control and the normal quality management practices will be maintained in the stores.

Boilers:

Low sulphur oil (LSO) with a sulphur content of 1.5% will be used to fire two boilers to generate steam for the process as and when needed. Excess capacity will be provided so that the boilers never run on full capacity.

3.2 PROPOSED ODOUR REDUCTION MEASURES

Afro Fishing plans to use the following odour control measures:

Fish Handling:

It is Afro Fishing's plan to process industrial fish within 24 hours of harvesting to minimise the formation of compounds that lead to odorous emissions. This implies that fish are caught at sea, transported to quayside, off-loaded and processed within a period of 24 hours.

In the article, "Volatile amines as criteria for chemical quality assessment" presented to SeaFoodPlus in 2005, the author, Monique Etienne of Ifremer, Nantes, France, shows that very little TMA formation occurs within the first few days after harvest if the fish is kept on ice. She concludes that "*TMA-N is an excellent indicator for the spoilage of fish, it is useful as a rapid means of objectively measuring the quality of many fish specially on the medium-later phases of spoilage but it cannot be used as an freshness indicator (constant level during the first days of iced storage)*."

The best approach is, therefore, to process fish as soon as possible and Afro Fishing's plan to do so within 24 hours is a prudent approach.

Odour management:

Ducting will be used to draw odours from the various unit operations, cooling conveyors and the cooler. These gases will be passed through a condenser to help remove offensive odours.

A wet scrubber will be used to capture odorous compounds prior to emission to atmosphere. In their Compilation of Air Pollutant Emission Factors, generally referred to as AP-42, the United States of America's Environmental Protection Agency (USEPA) USEPA states that chlorinator scrubbers have been found to be 95 to 99 percent effective in controlling odours from cookers and driers.

Should it prove necessary, a regenerative thermal oxidation (RTO) unit will be installed to remove remaining offensive odorous gases. According to AP-42, such units achieve virtually 100 percent odour control.

From these steps it can be seen that all emission will be via a stack serving the scrubber / RTO unit and that no uncontrolled fugitive emission will escape from the plant.

4 ODOUR DETECTION LIMIT LITERATURE SEARCH

LAQS conducted a literature search for information of odour detection limits of the odorous compounds associated with fish processing as minimisation of emission of odours is regarded as a critical part of the planned operation. According to the United States of America's Environmental Protection Agency, the main contributors to odours associated with fishmeal processing are hydrogen sulphide (H2S) and trimethylamine (TMA).

The following sources and relevant information were studied:

1 *Odor thresholds and irritation levels of several chemical substances: A review. Ruth JH. 1986. Am Ind Hyg Assoc J 47:142-151.*

2 *Occupational exposure to hydrogen sulfide in the sour gas industry: Some unresolved issues. Guidotti TL. 1994. Int Arch Occup Environ Health 66:153-160.*

3 *Odour Complaints Checklist*; *Health Protection Agency, UK; 2011.*

4 *Odor Threshold Determinations of 53 Odorant Chemicals; Gregory Leonardos, et al. Journal of the Air Pollution Control Association, 19:2, 91-95*

5 *Odor perception and physiological response. Iowa State University, University Extension, PM 1963a, May 2004.*

6 *Odor & Flavor Detection Thresholds in Water, Leffingwell & Associates. http://www.leffingwell.com/odorthre.htm*

Odour detection thresholds contained in these references showed substantial variation.

-- The reported odour detection limits for H_2S are all below 1 μg/m^3, but the reported odour recognition thresholds varied between 6.7 and 42.6 μg/m^3. For the sake of this study LAQS assumed an odour detection limit of 0.7 μg/m^3.

-- The reported odour detection limits for TMA varied from 0.8 to 2.6 μg/m^3. For the sake of this study LAQS assumed an odour detection limit of 0.8 μg/m^3.

This study focuses on the emissions from Afro Fishing's proposed fishmeal production plant as there are no other major sources of odorous emissions located in the harbour and surrounding area.

5 DISPERSION MODELLING STUDY

The dispersion modelling study was carried out with EnviMan, a GIS-based emissions management software suite produced by Opsis AB in Sweden. The dispersion modelling component of the suite consists of the following four modules:

Mapper: A map manipulation tool
Emissioner: An extensive, relational emissions data base
Envimet: A meteorological data management program
Planner: The actual dispersion model

5.1 MAPPER

Mapper is a digital map compiler. It is used to define GIS data sets and map sets to be used by all EnviMan GIS modules. It can import a variety of digital maps and structure the data in suitable forms, e.g. sheets, objects, etc.

It is the basis of the EnviMan GIS suite as it defines all co-ordinates for subsequent use by the various EnviMan modules.

5.2 EMISSIONER

Emissioner is a comprehensive, relational emissions data base that locates emission sources at fixed co-ordinates on the map compiled with Mapper. Sources are placed on the map by the user and the co-ordinates are automatically generated by Mapper.

Emissioner can handle particulate and gaseous emissions from the following sources:

-- Point sources, e.g. industrial stacks
-- Area sources, e.g. landfill sites
-- Grid sources, e.g. complete informal settlement areas
-- Line sources, e.g. motor vehicle emissions

Of these, point sources are applicable to this study.

5.3 ENVIMET

Envimet uses meteorological data collected at ground level to calculate boundary scaling data sets used in dispersion modelling studies. Of primary importance are those parameters that define scaling of the boundary air layer. These minimum requirements are:

- Wind speed
- Wind direction
- Temperature
- Solar radiation

These parameters are used by Envimet to calculate all of the parameters, e.g. stability of the air boundary layer, mixing heights, climate sets, etc., which are required by Planner in calculating the dispersion of pollutants from a source.

5.4 PLANNER

Planner is the dispersion module of the EnviMan suite and links with Mapper, Emissioner and Envimet to carry out dispersion modelling activities. It is designed to run simulations of air quality based on emission data created in Emissioner for the following scenarios:

- Hypothetical weather definitions, i.e. user-supplied information about temperature, wind speed, wind direction, cloud cover, etc.

- True weather period, i.e. using recorded data from a weather monitoring station to simulate plume dispersion hour-by-hour over a defined period

- Statistical weather period, i.e. using a pre-calculated sample of various weather conditions that typically occur during a year. This allows the creation of annual air quality maps for comparison against national guidelines and limit values.

Of these scenarios, the statistical period is applicable to the study of plume dispersion from the proposed fishmeal plant.

Planner makes use of three different dispersion models, two of which are aimed at motor vehicle emissions. The third is the Aermod dispersion model and is used for calculating the dispersion of emissions from point, area and grid sources. Aermod is an USEPA-approved Gaussian plume dispersion model and is capable of simulating dispersion of pollutants over a distance up to approximately 50 km from the source. Aermod is also accepted as a suitable model for the purpose of this project by the South African Department of Environmental Affairs, as discussed in "*Regulations Regarding Air Dispersion Modelling*", published in Government Notice R.533 of 11 July 2014 (GN R.533).

6 INPUT DATA

6.1 MAPPER

A digital map of the area was imported into Mapper and it covers an area of approximately 6 km x 4 km with Afro Fishing's operation set at the approximate centre of the map. The maps are shown in Figure 1 below.

The emissions data base (Emissioner) links with the map and places emission sources on specific locations, as defined by the user.

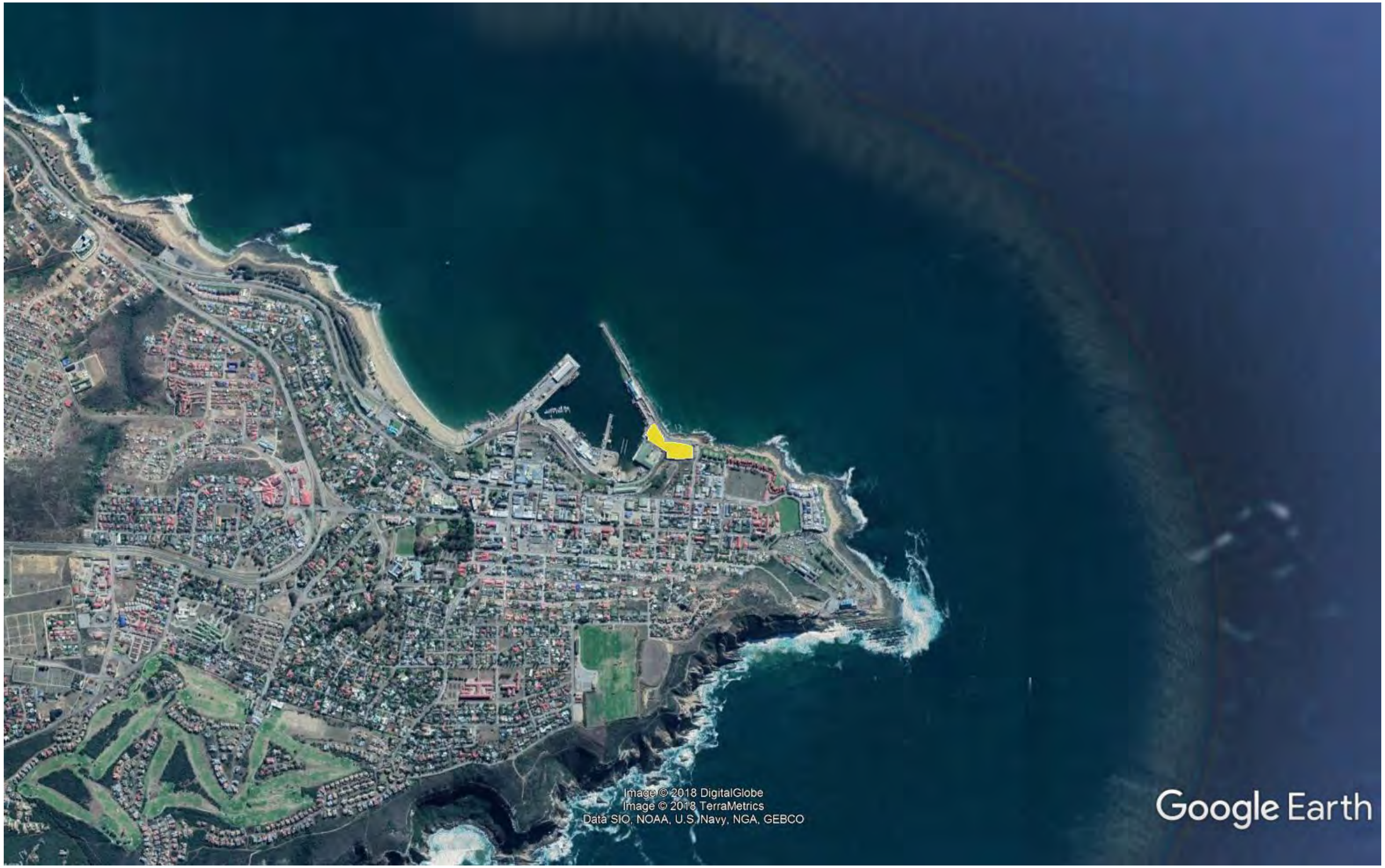

Figure 1: Map of 6 km x 4 km indicating the location of Afro Fishing's planned developments

6.2 EMISSIONER

In calculating emissions from point sources, GN R.533 stipulates that maximum emission rates, as defined in atmospheric emission licences, should be used. Emission factors may be used in cases where no emissions limits have been specified, e.g. as published in AP-42. Alternatively, design data may be used, and measured data can be used as a last resort.

As stated above, point and area sources are applicable to emissions from the sources of odorous emission identified for this project.

Compulsory information required for point source emissions are:

-- Stack height

-- Stack diameter

-- Flue gas velocity

-- Flue gas temperature

-- Dimensions (height, width) of structures immediately adjacent to each stack

-- Definition of pollutants

-- Annual mass emission rates of pollutants

6.2.1 Boiler Stacks

As stated in Section 3.1, two boilers will be used in Afro Fishing's expanded operations. The boilers will use light fuel oil (LFO) with a low sulphur content of 1.5% by mass.

The expected firing rate of LSO is 1.21 tons per hour in total, i.e. 0.6 tons per boiler. Based on a lower heating value of 39.5 MJ/kg, the net input energy per boiler is calculated to be 6.6 MW which is below the threshold for a boiler to be regarded as a controlled emitter in terms of GN831. The rounded off quantity if LSO that will be burned per year is estimated to be 9 600 tons, based on 24 hours per day and 330 days' operation per year.

LAQS made use of emission factors published by the USEPA in their Compilation of Air Pollutant Emission Factors, generally referred to as AP-42, to estimate expected emissions from the two boilers, using the expected combustion rate and composition of the LSO. Furthermore, AP-42 states that 86% of the TPM emissions will consist of PM10 particulate matter and this factor was used to estimate the PM10 emissions from the boiler stacks.

The relevant emission factors are:

--	TPM:	1.2 kg/kl
--	PM10:	1.03 kg/kl
--	SO_2:	157 x %S kg/kl

-- NOx: 3.1 kg/kl

-- CO: 0.6 kg/kl

As the NOx emission essentially consist of NO, and NO is oxidised to NO_2 in ambient air by the presence of ozone, LAQS converted the NOx emissions to NO_2 equivalent values by multiplying the NOx value by 0.8, as is stipulated in GN R.533

As the plant has not yet been designed in detail, Afro Fishing provided estimated details of the boiler stacks and LAQS assumed a stack height of 15 metres. The stack parameters were thus obtained:

-- Stack height: 15 m

-- Stack diameter: 1.1 m

-- Flue gas temperature: 180 ºC

-- Flue gas velocity: 10 m/s

LAQS subsequently calculated the expected flue gas volumes and, together with the emissions limits listed above, calculated the following annual mass emissions per boiler stack:

-- PM10: 11.5 tons per annum

-- SO_2: 210 tons per annum

-- NO_2: 18.4 tons per annum

-- CO: 4.5 tons per annum

These emissions will occur essentially uncontrolled, as it is not normal for such small boilers to be fitted with sophisticated air pollution abatement equipment. However, should emission limits for small, liquid fuel-fired boilers be imposed on Afro Fishing's two boilers due to its location, the estimated SO_2 emissions will reduce. The SO_2 emission limit imposed on new plant is 500 mg/Nm^3, corrected to 3% O_2, implying that the total emissions will reduce to approximately 81.6 tons per annum per boiler.

6.2.2 Drier Stack

The mass balance of the proposed process shows that 8 tons per hour of flue gas will be emitted from the scrubber stack.

Stack parameters:

Based on the moisture content removed by the drying process, as described in Section 3, LAQS calculated that the volume of the flue gas will be 1.825 m^3/s at NTP (0° C and 101.3 kPa). If it is assumed that the flue gas temperature will be 180 ° C, the volumetric flow rate of the flue gas will be 2.828 m^3/s at stack conditions.

Assuming a typical flue gas velocity of 10 m/s, LAQS calculated that the required stack diameter will be 0.5 metres. To prevent any impact of the wind flow profile by adjacent buildings, LAQS further assumed that the height of the stack will be 15 metres.

Emissions:

Emission factors for fishmeal production from both fresh fish and stale fish have been published in AP-42. Following the description of Afro Fishing's plans, the following emission factors for fresh fish processing were obtained (per ton of raw fish processed):

Total particulate matter (TPM): 2.5 kg/ton

Trimethylamine: 0.15 kg/ton

Hydrogen sulphide: 0.005 kg/ton

No TPM reduction rates were provided, but LAQS assumed that 80% of TPM will be removed by a wet scrubber. LAQS made use of the odorous gas reduction possibilities given by the USEPA (section 3.2) the estimate emission under two different odour control scenarios. These are:

-- Chlorinated scrubber: AP-42 states that such systems are 95 - 99% effective and LAQS assumed the lower value of 95%.

-- Thermal treatment: AP-42 states that such units achieve virtually 100 percent odour control and LAQS assumed this to imply 99.9% effectiveness.

Based on Afro Fishing's planned production rate of 25 tons per hour, LAQS calculated the following emission from the process:

Pollutant	Uncontrolled	Chlorinated scrubber	Thermal treatment
TPM	742.5	74.25	74.25
TMA	44.55	2.23	0.223
H_2S	1.485	0.074	0.007

Table 1: Drier stack emissions, tons per annum

As no particle size distribution data is available, LAQS assumed that all of the particulate emissions meet PM10 requirements. This is an over-estimation of emissions as PM-10 particulates form a sub-set of TPM.

6.3 WEATHER DATA

The minimum data required by Envimet is given in Section 5.3 above.

GN R.533 states that locally measured meteorological data is the preferred source of data for dispersion modelling purposes. Should such data not be available, alternative sources of data can be used, provided that some criteria are met.

The Garden Route District Municipality (GRDM) operates a weather station located in Mossdustria. This station records data for, inter alia, wind speed, wind direction, wind direction standard deviation, temperature and solar radiation and GRDM kindly made this data available for this study.

Data for the period from 17 August 2016 to 18 November 2018 was provided to meet the data period requirements of GN R.533 (minimum 1 year).

6.4 PLANNER

Planner does not require any user input as it extracts data from Mapper, Emissioner and Envimet.

7 RESULTS

The approach to the project was to estimate the following ground-level concentrations of all of the pollutants discussed above:

- Annual average concentrations
- 99-percentile concentrations (the level below which concentrations can be expected to occur for 90% of the time) for PM10, SO_2, NO_2 and CO
- 99 and 95-percentile concentrations (the level below which concentrations can be expected to occur for 95% of the time) for odorous compounds (H_2S and TMA)
- Annual average, 99 and 95 percentile concentrations of TMA and H_2S under both odour control scenarios discussed in this report.

All simulations were carried out for a receptor height of 2 metres above ground level and a plume dispersion period of 60 minutes. This simulation period ensured that very low winds, e.g. below 1 m/s, would carry pollutants some distance from the plant.

Graphic presentation of the dispersion of pollutants is shown in Figures 2 to 15 below.

7.1 UNCONTROLLED EMISSIONS

Figures 2 and 3 show the estimated annual average and 99-percentile PM10 concentrations as a result of uncontrolled drier emissions.

Figures 4 and 5 show the estimated annual average and 99-percentile SO_2 concentrations.

Figures 6 and 7 show the estimated annual average and 99-percentile NO_2 concentrations.

Figures 8 and 9 show the estimated annual average and 99-percentile CO concentrations.

Figures 10 and 11 show the estimated annual average and 99-percentile H_2S concentrations as a result of uncontrolled drier emissions.

Figures 12, 13 and 14 show the estimated annual average, 90-percentile and 99-percentile TMA concentrations as a result of uncontrolled drier emissions.

Figure 2: Annual Average PM10 Concentrations, uncontrolled drier emissions; micrograms per cubic metre
Scale range from 10 μg/m^3 (blue) to 100 μg/m^3 (burgundy).

Figure 3: 99-percentile daily average PM10 Concentrations, uncontrolled drier emissions; micrograms per cubic metre
Scale range from 100 µg/m^3 (AQ standard) (blue) to 1000 µg/m^3 (burgundy).

Figure 4: Annual Average SO_2 Concentrations
Scale range from 3 μg/m^3 (blue) to 30 μg/m^3 (burgundy).

Figure 5: 99-percentile hourly SO_2 Concentrations
Scale range from 60 µg/m^3 (blue) to 400 µg/m^3 (burgundy).

Figure 6: Annual Average NO_2 Concentrations
Scale range from 2 μg/m^3 (blue) to 10 μg/m^3 (burgundy).

Figure 7: 99-percentile NO_2 Concentrations
Scale range from 20 µg/m^3 (blue) to 200 µg/m^3 (burgundy).

Figure 8: 8-hour Average CO Concentrations
Scale range from 0.3 μg/m^3 (blue) to 3 μg/m^3 (burgundy).

Figure 9: 99-percentile CO Concentrations
Scale range from 5 $\mu g/m^3$ (blue) to 40 $\mu g/m^3$ (burgundy).

Figure 10: Annual Average H_2S Concentrations, uncontrolled drier emissions; micrograms per cubic metre
Scale range from 0.02 µg/m^3 (blue) to 2 µg/m^3 (burgundy).

Figure 11: 99-percentile H_2S Concentrations, uncontrolled drier emissions; micrograms per cubic metre
Scale range from 0.7 µg/m^3 (blue) to 20 µg/m^3 (burgundy).
The areas where odours may be detected for 1% of the time is indicated in blue.

Figure 12: Annual Average TMA Concentrations, uncontrolled drier emissions; micrograms per cubic metre

Scale range from 1 µg/m^3 (blue) to 10 µg/m^3 (burgundy).

The areas where odours may generally be detected are indicated in blue and green.

Figure 13: 90-percentile TMA Concentrations, uncontrolled drier emissions; micrograms per cubic metre
Scale range from 1 µg/m^3 (blue) to 50 µg/m^3 (burgundy).
The areas where odours may be detected for 10% of the time are indicated in blue and green.

Figure 14: 99-percentile TMA Concentrations, uncontrolled drier emissions; micrograms per cubic metre
Scale range from 5 μg/m^3 (blue) to 100 μg/m^3 (burgundy).
The graphics show that odours will be detected virtually all over the area for 1% of the time.

7.2 CHLORINATED SCRUBBER

Figures 15 and 16 show the estimated annual average and 99-percentile PM10 concentrations as a result of scrubbing the drier gases with a wet chlorinated scrubber.

Figures 17, 18 and 19 show the estimated annual average, 90-percentile and 90-percentile TMA concentrations as a result of scrubbing the gases with a wet chlorinated scrubber.

The figures show that a chemical scrubber will reduce the TMA emissions substantially, but that some odours may still be detected up to 5% of the time, i.e. about 440 hours per year.

Figure 15: Annual Average PM10 Concentrations, Chlorinated scrubber; micrograms per cubic metre
Scale range from 2 μg/m^3 (blue) to 20 μg/m^3 (burgundy).

Figure 16: 99-percentile daily average PM10 Concentrations, Chlorinated scrubber; micrograms per cubic metre
Scale range from 15 µg/m^3 (blue) to 150 µg/m^3 (burgundy).

Figure 17: Annual Average TMA Concentrations, Chlorinated scrubber; micrograms per cubic metre
Scale range from 0.03 µg/m^3 (blue) to 1 µg/m^3 (burgundy).
The maximum scale is set to TMA odour threshold value. Please note the scale relative to Figure 12.

Figure 18: 95-percentile TMA Concentrations, Chlorinated scrubber; micrograms per cubic metre
Scale range from 1 µg/m^3 (blue) to 10 µg/m^3 (burgundy).
The areas where odours may be detected for 5% of the time are indicated in blue.

Figure 19: 99-percentile TMA Concentrations, Chlorinated scrubber; micrograms per cubic metre
Scale range from 1 µg/m^3 (blue) to 10 µg/m^3 (burgundy).
The areas where odours may be detected for 1% of the time are indicated in blue.

7.3 THERMAL TREATMENT

Figure 20 shows the estimated 99-percentile TMA concentrations as a result of scrubbing the gases with a wet chlorinated scrubber and thermal treatment.

For the odorous compounds the minimum concentrations of the graphic scales were set with published odour detection limits as the minimum display value where possible. The graphics indicate, therefore, the areas where concentrations may exist above the odour detection levels (See Sections 10 and 11 below).

Summarised results are given in Table 2. The Table also shows the maximum concentrations of each scenario at the residential areas most affected by emissions from the plant.

The figure shows that thermal treatment of flue gases will reduce odorous emission to below the odour detection limit so that no odours should be detected beyond the boundary of Afro Fishing's site.

Figure 20: 99-percentile TMA Concentrations, Thermal treatment; micrograms per cubic metre

Scale range from 0.1 µg/m^3 (blue) to 1 µg/m^3 (burgundy)

The graphics show that no odours will generally be noticed. Such areas would have been indicated in red colours (scale)

7.4 SUMMARISED RESULTS

The results of the dispersion modelling study are summarised in Table 2 below.

The maximum and annual averaged ground-level concentrations of the various pollutants under different air pollution abatement scenarios are given, as well as where these concentrations may occur. In addition, the equivalent concentrations in the residential areas to the south-east and west of Afro Fishing's operations are given.

	Uncontrolled emissions				Chemical scrubber				Thermal treatment
	Annual average		99-percentile		Annual average		99-percentile		99-percentile
	Max	where	Max	where	Max	where	Max	where	Max
PM10	86.9	200 m West	860	460 m West South-west	9.8	200 m West	91.8	460 m West South-west	
SO_2	23.4		287		9.1		111		
NO_2	3.3		48.9						
CO	0.8		11.8						
H_2S	0.092		1.3						
TMA	5.2		49.3						0.26
	SE	W	SE	W	SE	W	SE	W	
PM10	17.2	22.7	420	256	1.3	1.9	31	34	
SO_2	4	10.1	164	186					
NO_2	0.1	1.6	21.6	32					
CO	0.1	0.4	5.2	7.8					
H_2S	0.016	0.025	0.5	0.6					
TMA	1	1.5	32.6	23.7					

Table 2: Summarised ground-level concentrations; All units are µg/m^3

Numbers marked in red indicate exceedences of official ambient air quality standards. Please see Section 10 below.

8 DISCUSSION

The results of any computer model are only as reliable as the quality of the input data.

8.1 EMISSIONER

As was stated in Section 6 above, the proposed fish meal production plant has not been designed in detail as yet, but only on an order-of-magnitude basis to obtain a mass balance for the process. LAQS, therefore, made some assumptions based on the following:

-- Combustion characteristics of LSO
-- Its experience in dealing with a wide variety of boilers
-- The planned principles of operation of the proposed plant
-- Expected emission limits that may be imposed on the planted

As a result there is a reasonable degree of uncertainty in the estimated emissions used in this study. The following must be noted:

-- The volume of gas generated in the combustion of any fuel is dependent on the composition of that fuel, its combustion rate, the completeness of combustion and the quantity of excess air introduced to the combustion zone.

LAQS based its calculations on the expected combustion rate of LSO of 1.2 tons per hour (averaged to 9 600 tons per annum) as obtained from Afro Fishing's mass balance. The calculated volumes will, therefore, vary as fuel composition combustion rate changes.

-- LAQS assumed the flue gas conditions, i.e. velocity and temperature, for the boiler stacks, based on its experience with boiler sin general. LAQS assumed a typical stack height of 15 metres. Lower stacks will result in less time for dispersion of pollutants and will result in higher maximum ground-level concentration closer to the source. Taller stacks will have in opposite effect, i.e. lower maximum ground-level concentrations further from the source.

-- LAQS assumed that the TMA emission factor given by AP-42 is correct and based its calculation of total annual TMA emissions on the basis that Afro Fishing processes fresh fish scrap material only. As the emission factor for the processing of stale fish is approximately 11.6 times higher, the emissions of TMA may increase drastically if stale fish scrap materials are processed.

-- LAQS focused on odorous emission from Afro Fishing's operations only. Other sources of odorous gases may exist within the Mossel Bay harbour precinct as it is a commercial harbour. These sources may be small, they were not included in this study, although their localised emission may results in odours from time-to-time that cannot be connected to Afro-Fishing's operations.

-- LAQS assumed destruction efficiencies of chemical scrubbing and thermal treatment of the drier gas according to efficiencies stated in AP-42. Where a range of efficiency was given LAQS used the lower value in order to create a "worst-case" scenario.

All of the emissions on which this study is based must be regarded as worst-case conditions due to the following reasons:

-- LAQS assumed that Afro Fishing's processes to its maximum planned capacity, i.e. processing 25 tons per hour of fresh fish scrap, burning 1.2 tons of LSO per hour, operating for 24 hours per day and for 330 days per year. This is the worst-case that is expected to occur as the production of fishmeal from industrial fish is directly related to the availability of such fish.

-- As the plant has not been designed in detail yet, it is not possible to determine conditions that could possibly be expected to occur at the planned production rates.

   Suffice to state that there is a linear relationship between emissions and ground-level concentrations in the sense that any change in emission will result in an equal change in ground-level concentrations, i.e. halving the emission will result in halving the ground-level concentrations.

-- Afro Fishing will operate the fishmeal production process according to the rate at which fish is caught by its fishing fleet. If there is no consistency in the catch rate there will not be consistency in the fishmeal processing rate. Due to the expected variability of fish deliveries, there is no expected trend in operations that can be defined clearly with the result no seasonal variation in emissions can be defined in the dispersion model.

-- Industry generally schedules a period during the operation year for routine maintenance. The planned annual shutdown is from mid-December to mid-January, but this schedule can be adapted should the availability of fish demand full operation during this period.

8.2 ENVIMET

The wind and temperature data provided by the Garden Route District Municipality is comprehensive and only a few minor gaps exist in the data set. It is, therefore, regarded as a reliable meteorological data set.

The distribution of winds at the monitoring station located in Mossdustria is shown graphically in Figure 21 below. It shows that the predominant wind directions are easterly and westerly, which implies that pollutants will disperse mainly in these two directions from the sources included in this study.

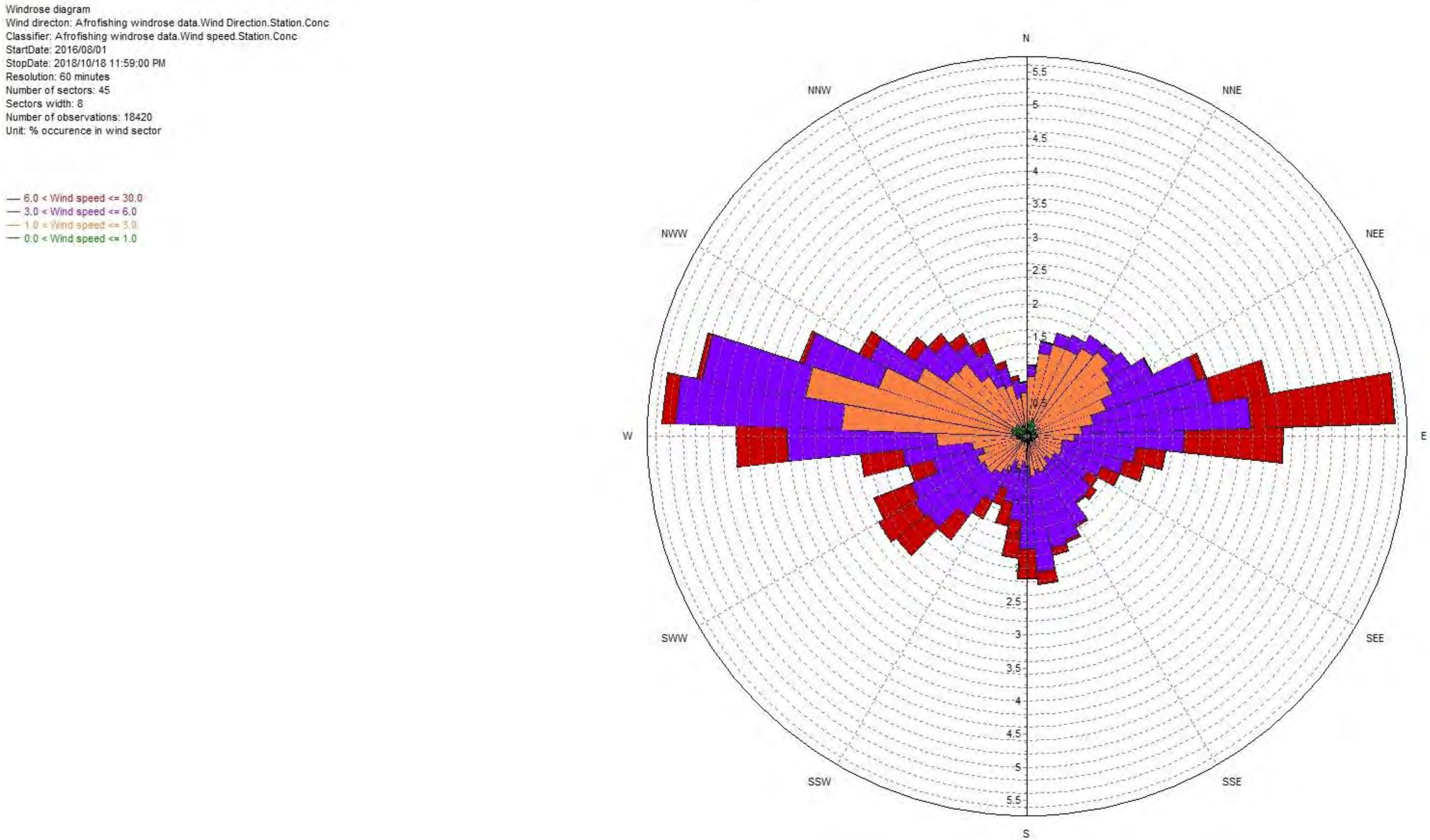

Figure 21: Mossel Bay Wind Rose

8.3 PLANNER

As was stated previously, the user provides no direct data input to Planner. It uses Aermod, the latest USEPA approved Gaussian plume dispersion model, and there is no reason to doubt the reliability of the dispersion calculations.

9 IMPACT ON OVERALL AIR QUALITY

Ambient air quality standards for some pollutants were published by the Department of Environmental Affairs (DEA) in Government Notice No. 1210 on 24 March 2009 (GN1210). Of the pollutants discussed in this study, ambient air quality standards for Hg are not available, there are standards for; PM10, CO, NO_2 (a sub-set of NOx) are included and the limits are:

PM10

Annual average:	40 µg/m^3, no exceedences
Maximum daily concentration:	75 µg/m^3, 4 exceedences

SO_2

Annual average limit	50 µg/m^3, no exceedences
1-hour maximum	350 µg/m^3, 88 exceedences

NOx (as NO_2)

Annual average limit	40 µg/m^3, no exceedences
1-hour maximum	200 µg/m^3, 88 exceedences

CO

8-hour running average	10 mg/m^3 (10 000 µg/m^3), 11 exceedences
1-hour maximum	30 mg/m^3, (30 000 µg/m^3), 88 exceedences

No ambient air quality standards for H_2S and trimethylamine have been defined.

The number of exceedences mentioned is approximately 1% of the time, i.e. daily exceedences of 4 times per year are marginally more than 1% of the time (3.65). Similarly, 88 exceedences of hourly limits form approximately 1% of the total number of hours per year (1% of 8 760 is 87.6). As a result LAQS modelled 99-percentile concentrations to reflect the maximum level below which concentrations may occur for 1% of the time.

When the results are interpreted it must be borne in mind that LAQS followed a conservative approach by modelling worst-case conditions, given the uncertainties in estimating emission as discussed in Section 8 above.

9.1 PM10 PARTICULATE MATTER

9.1.1 Uncontrolled Emissions

The highest annual average concentration of PM10 is estimated to be 86.9 µg/m^3, which is in excess of the ambient air quality standard. This estimated maximum annual average concentration will occur approximately 200 metres west of the centre of Afro Fishing's planned operations.

The maximum 99-percentile daily concentration was shown to be 860 µg/m^3, which is well in excess of the ambient air quality standard. This estimated maximum annual average concentration will occur approximately 460 metres west of south-west of the centre of Afro Fishing's operations.

The maximum annual average concentration of PM10 at the residential area south-east of Afro Fishing's site is estimated to be 17.2 µg/m^3, i.e. below the air quality standard, and the corresponding 99-percentile daily concentration is estimated to be 420 µg/m^3 which is well in excess of the air quality standard.

The maximum annual average concentration of PM10 at the residential area west of Afro Fishing's site is estimated to be 22.7 µg/m^3, i.e. below the air quality standard, and the corresponding 99-percentile daily concentration is estimated to be 256 µg/m^3 which is in excess of the air quality standard.

9.1.2 Emissions From Chemical Scrubber

LAQS estimated that 90% of the particulate matter resulting from the drying operations will be collected in the wet chemical scrubber, thus substantially reducing the total particulate emissions from the proposed plant.

Under these conditions, the highest annual average concentration of PM10 is estimated to be 9.8 µg/m^3, which is well below the ambient air quality standard. This estimated maximum annual average concentration will occur approximately 200 metres west of the centre of Afro Fishing's planned operations.

The maximum 99-percentile daily concentration was shown to be 91.8 µg/m^3, which is in excess of the ambient air quality standard. This estimated maximum annual average concentration will occur approximately 460 metres west of south-west of the centre of Afro Fishing's operations.

The maximum annual average concentration of PM10 at the residential area south-east of Afro Fishing's site is estimated to be 1.7 µg/m^3, i.e. well below the air quality standard, and the corresponding 99-percentile daily concentration is estimated to be 63.7 µg/m^3 which is also well below the air quality standard.

The maximum annual average concentration of PM10 at the residential area west of Afro Fishing's site is estimated to be 4.1 µg/m^3, i.e. well below the air quality standard, and the corresponding 99-percentile daily concentration is estimated to be 75.3 µg/m^3 which is at the air quality standard.

9.2 SULPHUR DIOXIDE

As the two boilers are expected to be the only sources of SO_2 emissions, no reduction will be achieved by the installation of the chemical scrubber.

The highest annual average concentration of SO_2 is estimated to be 23.4 µg/m^3, which is below the ambient air quality standard. This estimated maximum annual average concentration will occur approximately 200 metres west of the centre of Afro Fishing's operations.

The maximum 99-percentile hourly concentration was shown to be 287 µg/m^3, which is also the ambient air quality standard. This estimated maximum annual average concentration will occur approximately 460 metres west of south-west of the centre of Afro Fishing's operations.

The maximum annual average concentration of SO_2 at the residential area south-east of Afro Fishing's site is estimated to be 4.0 µg/m^3, i.e. well below the air quality standard, and the corresponding 99-percentile daily concentration is estimated to be 164 µg/m^3 which is also below the air quality standard.

The maximum annual average concentration of SO_2 at the residential area west of Afro Fishing's site is estimated to be 10.1 µg/m^3, i.e. well below the air quality standard, and the corresponding 99-percentile daily concentration is estimated to be 186 µg/m^3 which is also below the air quality standard.

9.3 NITROGEN DIOXIDE

As is the case with SO_2, no reduction of NO_2 emissions will be achieved by the installation of a chemical scrubber.

The highest annual average concentration of NO_2 is estimated to be 3.3 µg/m^3, which is well below the ambient air quality standard. This estimated maximum annual average concentration will occur approximately 200 metres west of the centre of Afro Fishing's operations.

The maximum 99-percentile hourly concentration was shown to be 48.9 µg/m^3, which is also well below the ambient air quality standard. This estimated maximum annual average concentration will occur approximately 460 metres west of south-west of the centre of Afro Fishing's operations.

The maximum annual average concentration of NO_2 at the residential area south-east of Afro Fishing's site is estimated to be 0.1 µg/m^3, i.e. well below the air quality standard, and the corresponding 99-percentile daily concentration is estimated to be 21.6 µg/m^3 which is also below the air quality standard.

The maximum annual average concentration of NO_2 at the residential area west of Afro Fishing's site is estimated to be 1.6 µg/m^3, i.e. well below the air quality standard, and the corresponding 99-percentile daily concentration is estimated to be 32 µg/m^3 which is also below the air quality standard.

9.4 CARBON MONOXIDE

Carbon monoxide is a combustion product with the result that no reduction in emissions is expected after a chemical scrubber is installed.

The highest 8-hour average concentration of CO is estimated to be 0.8 µg/m^3, which is well below the ambient air quality standard. This estimated maximum annual average concentration will occur approximately 200 metres west of the centre of Afro Fishing's operations.

The maximum 99-percentile hourly concentration was shown to be 11.8 µg/m^3, which is also well below the ambient air quality standard. This estimated maximum annual average concentration will occur approximately 460 metres west of south-west of the centre of Afro Fishing's operations.

The maximum annual average concentration of CO at the residential area south-east of Afro Fishing's site is estimated to be 0.1 µg/m^3, i.e. well below the air quality standard, and the corresponding 99-percentile daily concentration is estimated to be 5.2 µg/m^3 which is also below the air quality standard.

The maximum annual average concentration of CO at the residential area west of Afro Fishing's site is estimated to be 0.4 µg/m^3, i.e. well below the air quality standard, and the corresponding 99-percentile daily concentration is estimated to be 7.8 µg/m^3 which is also below the air quality standard.

9.5 HYDROGEN SULPHIDE

Currently there are no ambient air quality standards for H_2S.

Under uncontrolled emissions, the highest annual average concentration of H_2S is estimated to be 0.092 µg/m^3 and it is estimated that this is concentration will occur approximately 200 metres west of the centre of Afro Fishing's operations. This estimated concentration is well below the odour threshold limits of 0.7 µg/m^3 with the result to no odour due to H_2S emissions are expected,

The maximum 99-percentile hourly concentration was shown to be 1.3 µg/m^3, and it is estimated that this is concentration will occur approximately 460 metres west of south-west of Afro Fishing's site. This area is located in the harbour precinct and is marginally above the odour detection threshold, but well below the H_2S odour recognition threshold of 6.7 to 46.2 µg/m^3.

The maximum annual average concentration of H_2S at the residential area south-east of Afro Fishing's site is estimated to be 0.016 µg/m^3, i.e. well below the odour threshold limit, and the corresponding 99-percentile daily concentration is estimated to be 0.5 µg/m^3 which is also below the odour threshold limit.

The maximum annual average concentration of H_2S at the residential area west of Afro Fishing's site is estimated to be 0.025 µg/m^3, i.e. well below the odour threshold limit, and the corresponding 99-percentile daily concentration is estimated to be 0.6 µg/m^3 which is also below the odour threshold limit.

9.6 TRIMETHYLAMINE

It is LAQS's opinion that the emission of TMA will be the greatest risk to the detection of odours in the area. As such, the maximum ground-level concentration is not as pertinent as the area over which the odour threshold limit is exceeded. The minimum scale defined for figures 12 to 14 and 17 to 19 was set approximately to the odour detection level, implying that are areas where the odour threshold limit may be exceeded will be indicated.

As a result LAQS investigated the impact under the following three different scenarios:

-- Uncontrolled emissions

-- Emissions from a chemical scrubber serving the drier operations

-- Emissions under thermal treatment of the drier gases

9.6.1 Uncontrolled emissions

The highest annual average concentration of TMA is estimated to be 5.2 µg/m^3, which is in excess of the odour threshold limit. While this estimated maximum annual average concentration is expected to occur approximately 200 metres west of the centre of Afro Fishing's planned operations, Figure 12 indicates that odours will generally be detected in two areas located to the east and west of Afro Fishing's site.

While no detectable TMA odours are expected in the residential area to the south-east of the site, odours will generally be detected downwind to the east and west of the site.

The maximum 90-percentile concentrations are shown in Figure 13 and shows that odours will be detectable over an extended area for 10% of the time. Of note is the extended area to the west of Afro Fishing's site where odours may be detected for 10% of the time, or an estimated 790 hours per annum.

Figure 14 shows that odours will be detectable virtually all over Mossel Bay for 1% of the time, i.e. 79 hours of the time.

9.6.2 Emissions From Chemical Scrubber

As is expected, the substantial reduction in emissions from a chemical scrubber resulted in a substantial decrease in the odour threshold footprint of the proposed fishmeal plant.

Figure 17 shows that all estimated annual averaged ground-level concentrations of TMA are below the odour threshold level, the maximum annual average concentration being less than 0.1 µg/m^3.

However, Figure 18 shows the areas where odours will exceed the odour threshold limit for 5% of the time, i.e. approximately 400 hours per year. This area extends into the town centre to the west of Afro Fishing's site.

The 99-percentile ground-level concentrations, i.e. the concentrations where odours will be detected for 1% of time, or 79 hours per year, are shown in Figure 19. The figure shows that odours will be detected over an extended area, including some residential areas to the west of the site.

9.6.3 Thermal Treatment

As discussed in Section 6.2.2, the USEPA states that thermal treatment of the drier gas will result in the destruction of virtually all of the odorous components and LAQS assumed this reduction to be 99.9%.

The resulting 99-percentile ground-level concentrations are shown in Figure 20. It shows that no odours will be detectable anywhere as a result of the destruction of the odorous compounds. Please note that the scale of this Figure has been reduced drastically to show estimated ground-level concentrations of TMA, none of which exceed the odour detection level.

The maximum annual average ground-level concentration of TMA is estimated to be 0.026 $\mu g/m^3$ and the maximum 99-percentile value is estimated to be 0.38 $\mu g/m^3$.

9.7 PLUME VISIBILITY

Recalculating the estimated annual emission of TPM from the two boiler stacks to expected flue gas concentrations shows that the approximate concentration will be 60 mg/m^3 at stack conditions.

As a general rule-of-thumb the visibility of an industrial plume commences at about 50 - 60 mg/m^3, depending on the colour of the particulates emitted, the particle size distribution, concentration of water vapour that could condense as steam, etc. LAQS is, therefore, of the opinion that boiler stack emissions may be visible, but borders on the value where it may be clearly visible.

Should a wet chemical scrubber only be used as an odour control technology, it is expected that a clearly visible steam plume from the stack will be visible.

As an alternative to wet chemical scrubbing, thermal treatment of drier gases will reduce emission of the odorous compounds. However, particulates generated during the drying process will not be reduced in the thermal process with the result that it is likely that the thermal treatment stack will have a visible plume.

10 EXPOSURE LIMITS

10.1 OCCUPATIONAL HEALTH STANDARDS

As stated previously no ambient air quality standards have been set for TMA and H_2S. The American Conference of Industrial Hygienists (ACGIH) and the USA's National Institute of Occupational Safety and Health (NIOSH) both defined threshold limits for the exposure of workers to these two gases. Two levels are defined and these are:

Time-weighted average (TWA): The TWA concentration is the level of a chemical substance to which a worker can be exposed to for 8 hours per day, day after day for a working lifetime without adverse effects

Short-term exposure limit (STEL): STEL is the concentration to which workers may be exposed continuously for a short period of time (typically 15 minutes) without suffering from irritation, chronic or irreversible tissue damage, or narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue or materially reduce work efficiency.

	TWA		STEL	
	ppm	mg/m^3	ppm	mg/m^3
TMA	5	12 (12 000 $\mu g/m^3$)	15	36 (36 000 $\mu g/m^3$)
H_2S	1	1.4 (1 400 $\mu g/m^3$)	5	7.0 (7 000 $\mu g/m^3$)

Table 3: Occupational Health Exposure Limits

Taking its definition into account, the TWA values are of note as they specify the levels to which workers may be exposed day after day without any adverse effects. As can be seen from the Table above, these values are orders of magnitude higher than the maximum concentrations derived from the dispersion model's estimations. From an occupational health point of view LAQS is of the opinion that emissions of TMA and H_2S from Afro Fishing's operations will not pose any health risk to workers in areas exposed to these gases in and around the harbour area.

10.2 GENERAL PUBLIC

The United States of America Environmental Protection Agency's National Center for Environmental Assessment operates the Integrated Risk Information System (IRIS). The IRIS system defines reference dosages (RfD) and reference concentrations (RfC) for various substances.

The inhalation Reference Concentration (RfC) is analogous to the oral RfD and is likewise based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. The inhalation RfC considers toxic effects for both the respiratory system (portal-of-entry) and for effects peripheral to the respiratory system (extra-respiratory effects). It is expressed in units of mg/m^3. In general, the RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily inhalation exposure of the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

Inhalation RfCs were derived according to the Interim Methods for Development of Inhalation Reference Doses (EPA/600/8-88/066F August 1989) and subsequently, according to Methods for Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry (EPA/600/8-90/066F November 1994). These values are revised from time to time.

The RfC for H_2S is set at $2x10^{-3}$ mg/m^3 (2 $\mu g/m^3$). No RfC has been defined for TMA.

The highest annual average H_2S concentration estimated by the dispersion model is 0.092 $\mu g/m^3$ at a point approximately 200 metres west of the centre of Afro Fishing's operations. This maximum concentration is well below the RfC value with the result that LAQS is of the opinion that it is unlikely that health risks due to H_2S emissions would exist.

11 ODOURS

The ability to perceive an odour varies widely among individuals. More than a thousand-fold difference between the least and the most sensitive individuals in acuity have been observed in studies conducted by the Iowa State University in the USA. Differences between individuals are, in part, attributable to age, smoking habits, gender, nasal allergies, head colds, etc. In addition, their surroundings may influence the perceived odour, e.g. scented air fresheners used in homes may mask some odours. As a result it is quite common for members of the same community to experience odours differently and report accordingly, usually resulting in a wide spread of odour descriptors and intensities. This is particularly common when odours are detected by untrained persons.

Generally, the olfactory sensory nerves atrophy from the time of birth to the extent that only 82 percent of the acuity remains at the age of 20; 38 percent at the age of 60 and 28 percent at the age of 80. Consequently, olfactory acuity and like or dislike of an odour decrease with age.

Some investigators have defined odour threshold as the point where there is a detectable difference from background. Another definition of an odour threshold value (OTV) is the minimum identifiable odour or recognition threshold.

Both may be properly considered odour thresholds. However, experience has shown that the *detection threshold* (first change from background) is less reliable and difficult to reproduce as it often relies on a poorly defined judgment of the observer. Often there is confusion as to the definition of the first change as well as changes that can occur in the background odour.

The *recognition odour threshold* can be defined as the concentration at which 50 percent of the human panel can identify the odorant or odour and such concentrations may be orders of magnitude higher than the detection threshold values.

Different compounds have different OTVs. Some OTVs may be very low, e.g. low parts per billion (ppb) range, while others are substantially higher, e.g. parts per million (ppm) range.

It is possible for an odorous compound with a relatively high odour threshold to be present in concentrations above that level, thus masking the presence of other odorous compounds. As the gases travel through, and disperse into, the atmosphere, the concentration of that compound may reduce to a level below its odour threshold at which point it may no longer be detected and other odorous compounds may come to the fore. As a result the perceived odours may change over distance and time.

11.1 ODOUR CHARACTERISTICS

Odours are usually described by the following four parameters:

-- **Odour detection threshold** is the lowest odorant concentration necessary for detection by a certain percentage of the population, normally 50%. This concentration is defined as 1 odour unit.

-- **Odour intensity** is the perceived strength of an odour above its threshold. In the USA it is usually determined by an odour panel and is described in categories which progress from “not perceptible”, then “very weak”, through to “extremely strong”.

-- **Hedonic tone** is the degree to which an odour is perceived as pleasant or unpleasant. Such perceptions differ widely from person to person, and are strongly influenced, inter alia, by previous experience and emotions at the time of odour perception.

-- **Odour character** is basically what the odour smells like. It allows one to distinguish between different odours.

11.2 HEDONIC EVALUATION

Panels of trained observers were used in the USA to characterise various odours and classify them on a scale ranging from "highly unpleasant" to "very pleasant". The scale used for these evaluations ranged from -4 (highly unpleasant) to +4 (very pleasant).

The following odour descriptors and equivalent evaluations resulted:

Cadaverous (dead animal)	-3.75
Putrid, foul, decayed	-3.74
Sewer odour (typically H_2S)	-3.68
Cat urine	-3.64
Faecal (like manure)	-3.36

Rancid	-3.14
Fermented (rotten fruit)	-2.76
Ammonia	-2.47
Sulphurous	-2.45
Fishy	-1.98

A substantial degree of correlation between odours and unpleasantness resulted from similar studies conducted in the UK.

11.3 ODOUR DETECTION LIMITS

According to research conducted on emissions from animal feeding operations by the Iowa State University in the USA, the following odour threshold values and odour recognition values apply to H_2S, ethyl mercaptan, methyl mercaptan and TMA:

Compound	Detection limit, ppm		Recognition limit, ppm	
	ppm	µg/m³, 25°C	ppm	µg/m³, 25°C
Hydrogen sulphide	0.00047	0.7	0.0047	7.0
Ethyl mercaptan	0.0003	1.4	0.001	2.5
Methyl mercaptan	0.0011	1	0.0022	2.2
Trimethylamine		0.8		0.8

Table 3: Odour Threshold Values

The following can be derived from the table:

-- Hydrogen sulphide has an extremely low odour detection limit (equivalent to 0.7 $\mu g/m^3$ at 25°C) and its recognition threshold is only one order of magnitude higher at approximately 7 $\mu g/m^3$ at 25°C. This implies that an average person may detect its typical rotten egg odour at fairly low concentrations.

-- Equally, ethyl mercaptan has an extremely low odour detection limit, but its odour recognition level is lower than that of H_2S.

-- While the odour detection limits of methyl mercaptan is relatively high when compared to the others, its odour recognition level is also lower than that of H_2S.

-- With its distinctive fishy odour, TMA is both detected and recognised at very low concentrations.

12 CONCLUSIONS

From the results it can be seen that uncontrolled emissions of particulate matter will lead to ground-level concentrations that will exceed the ambient air quality standards. While this is not the case with SO_2 emissions, they are expected to result in high ground-level concentrations (82% of the hourly air quality standard) and may prompt the authorities to require a degree of reduction.

By far the greatest source of particulate matter emissions (95%) is the drying process of fish meal while the sulphur content of the LSO is the main contributing source to SO_2 emissions.

While it is expected that passing the drier gases through a wet scrubber will result in a degree of reduction, no such reduction can be expected if the drier gases are only treated thermally to reduce odorous emissions. Some form of particulate control will, therefore, be required.

It is generally accepted that odours will always be generated during fishmeal production processes. The chance of odour generation can be reduced substantially by taking the following steps:

-- Processing of fish within 24 hours of harvesting

-- Judicious application of modern technology

-- Thorough and frequent maintenance of process equipment

If these steps are complemented with an effective extraction system to collect odorous gases and proper treatment of the collected gases is carried out, e.g. by thermal treatment, a minimum of detectable odours should be generated and, if they are, escape the confines of the plant buildings.

The annual average ground-level concentration, as shown in Figure 20, indicate that no discernible odours would be detectable on Afro Fishing's site if a proper extraction system is designed and the drier gases are treated thermally.

Should chemical scrubbing be used as the odour abatement method, Figures 18 and 19 shows that some odours will be detected over a fairly large area for an appreciable period of time and could lead to complaints.

Regardless of the odour control technology used, and taking into account that stack conditions were assumed, LAQS estimates that the TMA emission threshold, i.e. the annual emissions above which odours may be detected in the area, is approximately 0.6 tons per annum. This threshold limit will change should the following change:

-- Annual production rate

-- Stack height

-- Flue gas flow rate and temperature

As described in Section 9 above some uncertainty exists in the outcome of this study due to the scarcity of reliable emissions data.

This air quality impact assessment was conducted largely on the back of assumed data as no detailed design of the process has been carried out. Emissions were, therefore, based on basic mass balance calculations and not operational data.

The outcome of this dispersion modelling study should be interpreted with care. It is, in LAQS's opinion, a worst-case scenario that gives annual averaged concentrations that could potentially occur if Afro Fishing were to operate at full capacity and all of LAQS's assumptions were valid.

13 RECOMMENDATIONS

It is of paramount importance that all process equipment in the fishmeal plant is cleaned and sanitised at regular intervals to minimise the formation of odours between production runs. It is recommended that a cleaning operating procedure and schedule is defined for this purpose.

Even though the main odorous compound emitted from Afro Fishing's operations are expected to consist of amines, there is no easy method for measuring such compounds and costs running to a few million Rand may be incurred if continuous monitoring of amines is required. Nevertheless, continuous monitoring of H_2S will show trends on increasing or decreasing emissions over time. It is recommended that consideration be given to the installation of a continuous H_2S monitoring device, the outcome of which can be used as proxy for the estimation of TMA emissions, should these exist.

14 DECLARATION OF INDEPENDENCE

In terms of Chapter 5 of the National Environmental Management Act of 1998 specialists involved in Impact Assessment processes must declare their independence and include abbreviated Curriculum Vitae.

I, C H Albertyn, do hereby declare that I am financially and otherwise independent of the client and their consultants, and that all opinions expressed in this document are substantially my own.

INSTITUTE OF PROFESSIONAL ENVIRONMENTAL PRACTICE
CHRIS ALBERTYN
QUALIFIED ENVIRONMENTAL PROFESSIONAL
No. 06010019

C H Albertyn, PrEng, CEng, QEP

15 ABBREVIATED CURRICULUM VITA

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First names Christiaan Horn

Date of birth 10 March 1950

University of Pretoria, South Africa: BEng (Chem) 1983.

Engineering Council of South Africa Registration No: 870276

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My experience in the field of environmental investigations, management and control measures extends over a period of more than 40 years and I have conducted air quality investigations for numerous corporate clients and all levels of government departments.

I compiled air quality management plans for the Eden District Municipality, the Nelson Mandela Bay Municipality (Port Elizabeth), the Buffalo City Metropolitan Municipality (East London), contributed to the plan for the Limpopo Province and recently revised the air quality management plan for the Eden District Municipality. Each of these projects included the compilation of extensive emissions inventories, covering all of the possible sources in each area.

Multi-disciplinary projects undertaken include the following:

-- Coordination of a multi-disciplinary team of specialists to assist a waste disposal company to assess their operations for implementation of operating procedures and installation of equipment to attain regulatory compliance.

-- Assessment of a wood pelletizing plant with the aim of optimising process efficiency, increase product recovery, optimise water usage and minimise atmospheric emissions.

-- Modification and optimising of the effluent treatment activities of a tannery to reduce the potential of odorous emissions.

I have assisted a number of industries in their applications for atmospheric emission licences (AELs) by carrying out specialist air quality impact assessments that were based largely on detailed dispersion modelling studies. In addition to these studies, I carried out various specialist dispersion modelling studies for a number of industries, both locally and abroad. I currently carry out all cumulative dispersion modelling studies for the Coega Development Corporation's industrial development zone in Port Elizabeth.