ExxonMobil

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Fife Ethylene Plant

Environmental Monitoring Programme

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This document assesses the impact of emissions (air, noise & vibration) from Fife Ethylene Plant on the local community and environment, with the aim of defining an appropriate forward monitoring plan for these emissions.

Contents

1. Introduction

ExxonMobil Chemical Ltd (EMCL) Fife Ethylene Plant (FEP) undertakes environmental monitoring in order to;

- understand the scale of the risk to the environment and to human health and wellbeing so as to assess environmental risk and inform associated decision-making
- identify where mitigation measures are required and monitor the effectiveness of existing mitigations
- detect changes to environmental risk so as to allow effective intervention
- comply with legal obligations and international agreements

This Environmental Monitoring Programme focuses on FEP's emissions to air, and of noise and vibration during routine and process upset conditions. It aims to review existing monitoring data in order to assess the impacts of air, noise & vibration emissions on the environment and communities and define what environmental monitoring is required to effectively manage the impacts going forward.

2. Principles

Suitable environmental monitoring is that which is;

- Of a level and quality that is sufficient to assess the environmental risks posed by FEP
- A means to monitor the effectiveness of the controls used to mitigate environmental risks
- Clearly documented and performed to a recognised standard
- Commensurate with the level of environmental risk posed

3. Environmental Monitoring

3.1. Information Sources

There are several possible sources of information which inform environmental impact assessment;

1. Source data
    a. Sampling of emissions/throughput
    b. Continuous monitoring of emission/throughput
    c. Fence line monitoring
    d. Emissions calculation
    e. Inspection/audit of mitigations – can provide indication of the effectiveness of controls/mitigations put in place and indicate where they may be change
2. Receptor data
    a. Offsite monitoring (e.g. at sensitive receptors)
    b. Public observations - can provide a subjective interpretation on environmental impact, however the information may not be impartial and reports can be biased. This input is used primarily to provide consideration to monitoring techniques.
3. Modelled data

Each data source offers advantages, while also containing a level of uncertainty. It is advisable that the uncertainty of monitoring sources is taken into consideration when assessing monitoring data in order to ensure that it has been accounted for.

3.2. Available Data for Impact Assessment

FEP has undertaken environmental monitoring of its activities prior to its commissioning in 1986 and throughout the subsequent 33 years of operation. Over time, environmental understanding, associated monitoring methods and acceptable standards have improved and this is identifiable through the changes in monitoring seen at the site.

The following sections detail the current measurements and monitoring data that have, and are being undertaken currently to inform impact assessment.

3.2.1 Air Quality

There are 19 emission points at FEP which are listed in the sites environmental operating permit. They include the cracking furnaces, the boilers, the gas turbine, vents and flares (both FEP's elevated flare and any material FEP sends to the Shell FNGL ground flares). In addition to point source emissions, plant wide monitoring of emissions occurs to capture any potential leaks or releases.

A summary of the main existing air quality monitoring data that are used to assess and monitor FEP's impact on local air quality is below;

Type of Monitoring	Scope of Monitoring	Standard of Monitoring	Frequency of Monitoring
Source data: Continuous monitoring of emission/throughput	Furnaces: - smoke - O2 - CO - fuel composition - fuel rate	- BS2742:1969 Continuous online measurements	Continuous
	Gas Turbine: - O2 - fuel composition - fuel rate	Continuous online measurements	Continuous
	Boilers: - O2 - fuel composition - fuel rate	Continuous online measurements	Continuous
	Flare: - smoke - flow rate - composition - steam rate	- BS2742:1969 Continuous online measurements	Continuous
Source data: Sampling of emission/ throughput	Furnaces: - NOx - SOx	Direct measurement with Testoterm 350 flue gas analyser	Quarterly

Type of Monitoring	Scope of Monitoring	Standard of Monitoring	Frequency of Monitoring
	- CO2 - O2 - CO		
	Gas Turbine: - NOx - SOx - CO2 - O2 - CO	Direct measurement with Testoterm 350 flue gas analyser	Quarterly
	Boilers: - NOx - SOx - PM - O2 - CO	- BS EN 14792 - BS EN 14791 - BS EN 13284-1 - BS EN 14789 - BS EN 15058	6-monthly
	Vents: - H2S	- Drager tube	Weekly
	Plant wide: - VOC - Mercury		Annually
Source data: Calculation	Furnaces: - NOx (mass) - CO2 (mass)	As agreed in writing with SEPA	Annually
	Gas Turbine: - SOx (mass) - CO2 (mass) - TOC (mass)	As agreed in writing with SEPA	Annually
	Boilers: - NOx (mass) - SOx (mass) - PM (mass) - CO2 (mass) - VOC (mass) - CO (mass)	As agreed in writing with SEPA	Annually
	Flares: - NOx (mass) - CO2 (mass) - TOC (mass) - VOC (mass)	As agreed in writing with SEPA	Annually
	Vents: - CO2 (mass) - H2S (mass) - TOC (mass)	As agreed in writing with SEPA	Annually
Receptor data: offsite monitoring	8 Locations (3 community, 4 fenceline, 1 offsite); - VOC's - PM	Undertaken by the National Physics Laboratory - EN ISO 16017-1 - EN ISO 16017-2	21-Aug to 1-Oct 2008

Type of Monitoring	Scope of Monitoring	Standard of Monitoring	Frequency of Monitoring
		- Partisol Plus Model 2025 Sequential Air Samplers (QPAS/B/546) - UKAS ISO 17025	
Modelling Data	2009: • Impact assessment during normal operation • Assessment under flaring scenario 2019: • Impact assessment during normal operation • Assessment under assumed 'worst-case' scenario (365 days, 300T/H, black smoke)	ADMS Dispersion model EU, UK Legislative Assessment Criteria WHO Guidelines	2009, 2019

In addition to monitoring undertaken by FEP, a system of Local Air Quality Management (LAQM) has been in place in the UK since 1997. The role of the LAQM review and assessment process is to review local air quality and identify all relevant locations where the air quality objectives are being or are likely to be exceeded. Where an area of exceedance is identified, the local authority is required to declare an Air Quality Management Area (AQMA) and implement an Air Quality Action Plan to improve air quality within the areas.

Fife Council has examined the results from monitoring in the Fife Council area and concluded that concentrations of all Air Quality Standard pollutants (outside identified Air Quality Management Areas) are all below the objectives at relevant locations, therefore there is no need to undertake further detailed assessment (1). A report is published annually by Fife Council which incorporates monitoring data from 4 automatic monitoring sites, 40 diffusion tubes, coastline sampling and data from the Grangemouth petrochemical sites (which are within an identified Air Quality Management Area). The report also discusses the Regional Air Model which is used to predict and monitor air quality throughout Fife.

The following table summarises additional sources of data used to assess and monitor FEP's impact on local air quality is below;

Additional sources of baseline information and trends (2)	
Key facts regarding air quality together with datasets and interactive maps.	www.scottishairquality.co.uk/
State and trend information and key messages.	www.environment.gov.scot/our-environment/air/

The Scottish Pollutant Release Inventory (SPRI) – The database and map of annual mass releases of specified pollutants to air, water and land from certain SEPA-regulated industrial sites.	www.sepa.org.uk/environment/environmental-data/spri/
The Air Quality in Scotland website provides access to technical reports, including the Scottish Air Quality Database Annual Report which provides a summary of air quality monitoring carried out on behalf of Government and local authorities and summarises trends in air quality monitoring for certain pollutants.	http://www.scottishairquality.scot/news/
Maps and datasets for Air Quality Management Areas and LAQM tools and guidance.	www.scottishairquality.co.uk/laqm/
Air quality data from the present day back to 1986 from sites monitoring at hourly and less frequent intervals.	www.scottishairquality.co.uk/data/
Air quality information produced by individual local authorities – each local authority is required to review and assess air quality in their area annually (this process identifies where an AQMA may be required).	www.scottishairquality.co.uk/news/reports?view=laqm

Data from FEP, Fife Council and Shell FNGL is also provided to the Independent Air Quality Management Review Group who provide advice and recommendations to Fife Council regarding the monitoring of air emissions arising from the operations at the Mossmorran plants and the Braefoot Bay terminal facilities. They do this by independently reviewing the air quality data as well as considering the potential impact that any major plant changes could have on air quality. They produce annual reports to present their findings of the review and any recommendations they may have.

3.2.2. Noise & Vibration

FEP currently conducts full sitewide noise surveys on a minimum 4 yearly frequency in order to ensure noise mapping is maintained for personnel protection. Any change to the plant that may affect the resulting noise profile must also be assessed.

Beyond the site boundary extensive community noise monitoring has been conducted to assess the impact of the plant on the receiving environment and communities. The below image summarises the monitoring completed from 2012 to date with substantial discussion detailing the monitoring outcomes that have been used to assess the impact of noise and vibration on communities and influence monitoring scope.

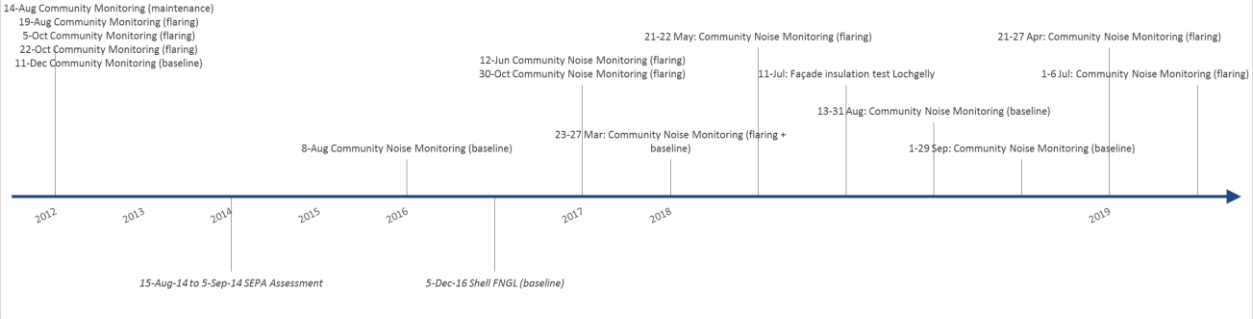

Figure 1: Timeline of available Community Noise Assessments

Monitoring of community noise was, under the IPC Authorisation (pre-2000), carried out by SEPA quarterly and the results were reported in tabular and graphical form to Fife Council Environmental Health Department as well as ExxonMobil and Shell NGL at Mossmorran.

With the introduction of the PPC permit, it was agreed with SEPA that the quarterly monitoring would cease (due to consistent results showing that the site was having no effect on the local community).

Between 2005 – 2007 a series of ten environmental noise investigations were commissioned by FEP to study acoustic conditions in the vicinity of the site. The studies concentrated on noise measured at 6 points around the site perimeter and beyond, some of which were directly in line with the nearest noise sensitive areas (i.e. housing to the east of the plant). In addition, periods of specific activity (including a shut-down, and de-coke operation) were assessed to determine if there was any impact on local communities. The reports concluded that *"there was no obvious environmental impact from the operations controlled by ExxonMobil as far as noise was concerned".* The conclusions were 'supported by the references and guidance within BS 4142'.

Due to its variable character, industrial noise can be difficult to assess. BS 4142 '*A Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas'* promotes a method for assessing whether industrial noise is likely to give rise to complaints from people living nearby. The standard supports current UK planning guidance and Environment Agency requirements on noise impact assessments.

The standard uses comparisons between the measured background levels of a location (measured as the LA90) and the noise levels from the activity (measured as LAeq). BS 4142 suggests that in general a difference of 5dB is likely to be marginal, whilst an increase in 10dB will likely give rise to complaints. Tonal or impulsive characteristics are likely to increase the likelihood of complaints and this is taken into account by the assessor applying 'penalties'. The conclusion of *"there was no obvious environmental impact from the operations controlled by ExxonMobil as far as noise was concerned"* indicates that the comparison of FEP activities, against background noise, was not significant.

In August 2008, during planned maintenance, SEPA undertook noise monitoring at locations in Westerton, Camilla and at the foot of the flare stack. The monitoring was not completed to any referenced standard, however it was concluded that flaring activity '*was likely to increase the level of noise at the existing and proposed residential areas'*. A second assessment was scheduled for the end of the maintenance period during the night time period and it would have assessed the impact of flaring against appropriate assessment criteria. However the second assessment was cancelled due to unfavourable weather conditions (high winds and heavy rain).

At the next scheduled maintenance (August 2012, four years later), during plant shutdown and start-up, a series of four noise assessments were undertaken by Environmental Scientifics Group (ESG) on behalf of FEP to determine the impact of flaring noise on communities. In addition, a further noise monitoring survey was completed during normal operations in December of 2012 to establish baseline noise levels when flaring was not occurring. The noise monitoring occurred at 5 noise sensitive receptors around the site as shown in the figure below. A summary of the assessment findings is included in Table 1: Summary of Noise Assessment Reports 2012 below.

Figure 2: Noise Sensitive Receptors at which noise monitoring has been undertaken.

Table 1: Summary of Noise Assessment Reports 2012

Date	Summary of Findings
19-Aug-12 Maintenance Activities (Flaring)	Flaring off activities were not audible at Mossbank Poultry Farm. Exxon plant noise especially flaring off activities was evident at monitoring location Dorloch Cottage. Noise from the Plant at Watson Street, Cowdenbeath was not audible. Road traffic noise along the A92 contributes significantly to the local ambient noise environment in the general area and is audible at locations in Lochgelly, Cowdenbeath and at the poultry farm.
05-Oct-12 Plant Start-Up (Flaring)	During the monitoring exercise it was not possible to quantify and ascertain meaningful noise receptor measurements from Watson Street, Cowdenbeath and Watters Crescent, Lochgelly, as the dominant noise source in the area of these receptors is road traffic on the A92.

22-Oct-12 Plant Start-Up (Flaring)	Production and Flaring off activities were not audible at Mossbank Poultry Farm and Little Raith Farm. Due to other noise sources it was not possible to gain meaningful results at Dorloch Cottage during day time hours and at Watson Street Cowdenbeath during day and night time hours. Road traffic is a constant and predominate ambient noise source in the area of Watson Street Cowdenbeath and as such masks Exxon's production noise. During night time hours when other ambient noise sources are suppressed four noise measurements were taken at Dorloch Cottage during this monitoring exercise all noise measurements were below 45 dB(A). The noise measurements taken at Watters Crescent Lochgelly remained below 45 dB(A) in the evening, and production and flaring off noise was only audible in-between road traffic noise.
29-Oct-12 Plant Start-Up (Flaring)	Adverse weather conditions made it impossible to conduct a meaningful noise survey
11-Dec-12 Normal Operations (baseline)	The ambient noise at the Poultry Farm, Lochgelly and Cowdenbeath is likely to be greatly influenced by road traffic noise. This is likely to mask noise emitted by the plant. The amount of masking at Lochgelly and Cowdenbeath is likely to ensure plant noise is inaudible during normal operations. At Mossbank Poultry Farm the plant has been audible during 'lulls' in local traffic movement and different wind directions but was not audible during this monitoring period.

In 2014, SEPA undertook noise monitoring in Lochgelly inside a resident's home at their request following complaint. No recognised standard was used for this monitoring and the subsequent report stated that *'the unattended measurements taken by the MATRON should be taken with caution as the MATRON measures all noise (including traffic, talking, etc.) and not just that specific to the Mossmorran Complex. Without undertaking attended measurements it is difficult to determine the contribution of the specific noise from The Mossmorran Complex to the overall noise level'.* (3) The measurements taken identified some elevated levels of noise, however no flaring occurred over the monitoring period (15-Aug-14 to 5-Sep-14).

Noise Monitoring 2016

A further baseline noise monitoring assessment was completed by Environmental Scientifics Group on behalf of FEP in August 2016. This assessment was completed to a modified BS4142:2014 standard and was undertaken at the same noise sensitive receptors used for the 2012 assessments (see Figure 2) as well as several points around the plant boundary. The assessment concluded;

'The results show that the site noise during normal operations, has no impact during the day or night periods at any of the NSRs identified. This is partially due to high traffic flows on nearby roads.'

Environmental Scientifics Group repeated a similar assessment on behalf of Shell FNGL in December 2016 and the results were consistent.

Noise Monitoring 2017

On the 12th June 2017, an unplanned flaring event occurred and responsive noise monitoring was initiated to capture data from the event. Environmental Scientifics Group, on behalf of FEP, responded and conducted noise monitoring at 4 of the 5 noise sensitive receptors identified in

Figure 2 (Little Raith Farm was not accessible at short notice). The assessment was completed to a modified BS4142:2014 standard and concluded that;

'Allowing for the noise generated by the wind blowing through trees and vegetation, the flaring operation would appear to have minimal impact on the noise levels measured at all of the receptors. At Lochgelly and Cowdenbeath, the flaring was just audible between traffic flows. The flaring was clearly audible at Dorloch Cottage and barely detectable at Mossbank Poultry Farm.'

However, during the course of the flaring, and the subsequent process upset which occurred on the 17th June, FEP received an unprecedented number of complaints (28 and 26 respectively) from the community, many of which referenced noise and vibration. Up to this point, complaints typically numbered <5 during flaring episodes and this correlated with the results obtained during assessments which indicated minimal noise impact from flaring.

Noise monitoring was again completed by Environmental Scientifics Group in October 2017 during a 3 day process upset which resulted in flaring. Their assessment concluded *'The results show that, on the day of monitoring, the site noise during flaring operations has minimal impact during the day periods at any of the NSLs identified except for Dorloch Cottage. This can be partially attributed to the high traffic flows on nearby roads.'* FEP received 5 complaints from the community which was more consistent with previous events.

Noise Monitoring 2018

Following the June flaring events, the potential source of vibration mentioned by communities was investigated and concluded to be most likely the presence of low frequency noise (ground borne vibration was demonstrated to be technically unfeasible due the distances involved and above ground operational presence). On this basis it was considered that more thorough acoustic assessment may assist in confirming the low frequency noise hypothesis.

Robin Mackenzie Partnership (RMP Acoustics) a specialised acoustic consultancy division of Edinburgh Napier University was engaged by FEP to investigate the potential low frequency noise aspect during flaring. In March 2018 a short process upset resulting in flaring enabled acoustic monitoring to be undertaken over a five day period while flaring occurred and once flaring had ceased. Their assessment was performed at the noise sensitive receptors identified in Figure 2 and the associated report concluded;

'A significant low frequency tonal component was identified around the 25Hz 1/3 octave band. This tonal component does not appear to follow typical point source hemispherical attenuation i.e. 6dB per doubling of distance. This may be due to wind direction/speed, however to confirm this further investigation is necessary.

'..At Positions 4 & 5 [Lochgelly & Cowdenbeath] the BS 4142 assessment is significantly affected by road traffic noise which cannot be excluded from the measurements and we would therefore consider it is not an accurate assessment of the flaring activity impact. The BS 4142 assessment at Positions 4 & 5 is in reality an assessment of the road traffic noise, which dominates the measured LAeq, and is not an assessment of the plant flaring activity, which resides in a different spectral zone and does not significantly affect the broadband LAeq measurements.'

A second process upset in May 2018 enabled a NANR45 assessment (see 4.2.4. Acceptable Noise & Vibration Emission Levels for a description of this technique) to be conducted, with the

assistance of community members in Lochgelly who allowed their home to be used for the monitoring. The assessment report concluded that;

'Chart 1 indicates that the flaring event in May 2018 did not exceed the NANR45 (12.5Hz-160Hz) criteria indicating that low frequency disturbance may occur. However, at 200Hz the internal noise level would exceed an extended criterial curve. Graph 2 indicates that the NANR45 criteria is exceeded at 160Hz with the windows open, however this may be due to the influence of road traffic noise. Graph 3 confirms that the NANR45 (indicated by the red line) criteria was not exceeded at any point. Graph 4 indicates that the NANR45 extended curve was exceeded until approximately 9pm. The dip in level between 10pm and 8am may be due to reduction in traffic flow on the A92 during the night time period.'

The report recommended that a façade analysis was conducted to determine to what extent the detected low tonal frequency component penetrated building facades. This was undertaken in July 2018 and the report concluded;

'During the flaring event peaks were identified internally at 20Hz and 200Hz third octave bands. A façade sound insulation deficiency was measured at 200Hz when using the simulated flare source as well as the flaring event itself. No such deficiency was apparent when a pink noise source was used. The deficiency was not due to low frequency ~25Hz flare noise interacting with the house structure giving rise to the 200Hz reading. The apparent insulation dip is most likely to be due to the flare energy in the 160Hz bandwidth contributing to the internal 200Hz reading due to the interaction with the building structure as it passes through.'

In addition to the façade test, RMP Acoustics were requested by FEP to predict internal noise levels from previous flaring events and to determine if any correlation could be identified that would help identify the source of the low frequency peaks at 20Hz and 200Hz. Their assessment concluded;

'A correlation between elevated hydrocarbon flare rate and the 200Hz third octave band was found during the flaring event on the 25th of March 2018.'

This confirmed the presence of low frequency noise vibration and initiated further investigation into the source of the low frequency noise. While a correlation with elevated flare rate was found at 200Hz, contribution from other sources included steam flow and ground flare rate could not be quantified. In addition, no correlation was found between any aspect of flaring and the 20Hz frequency. Without a better understanding of the source of the low frequency noise engineering solutions could not be targeted to ensure reduction or elimination of the noise. Further data was required, however opportunities to monitor during flaring were limited as no planned flaring events were scheduled in the near future, and unplanned flaring is not predictable. RMP Acoustics were maintained to respond as soon as possible if and when an opportunity for monitoring occurred.

From August to September 2018 continuous acoustic monitoring was undertaken in Lochgelly to measure background noise level in order to establish a comprehensive reference database of broadband and spectral background noise levels with the aim of providing a reference for future flare event measurements. The assessment identified;

'The spectral nature of the background noise at the measurement location has been assessed and it was found that road traffic noise is dominant above 400Hz. This also indicates that when an A weighting is applied the low frequency energy in the flare source measurements is not a

dominant factor in the A weighted broadband level. This suggests that a spectral method of low frequency assessment would be more appropriate for monitoring and quantifying future flaring events.'

No further flaring events occurred over the course of 2018 so further acoustic analysis was not able to be completed. Based on the acoustic data for flaring that was available from March 2018 and May 2018, RMP Acoustics were requested by FEP to undertake comprehensive data analysis comparison to identify possible correlations in order to identify the root cause of the noise. Their report was issued in March 2019 and concluded;

'Correlation was noted with elevated hydrocarbon and steam rates with noise measurement data particularly in the 20 and 25Hz third octave bands during the March 2018 flaring event.

Correlation was noted during the May flaring event, however due to the lower flare rates during this event the correlation was less conclusive.

It was not possible to make a distinction between noise generated by hydrocarbon flow rate and steam flow rates as steam and hydrocarbon flow rates are proportional. Ideally during a future event the steam flow would be altered and/or ceased for a short period to determine the relative contribution of the hydrocarbon and steam to the noise levels.

Another variable affecting the measured noise at the measurement location is likely present due to the inconsistency of the correlations noted. It is deemed likely that wind direction and speed can affect the propagation of noise at this distance.

No correlation between the analysed noise and the ground flaring rates have been noted in the charts. Ground flaring rates were consistent throughout the March event.'

While not conclusive, the analysis pointed to several priority areas to focus future monitoring including steam rates to elevated flare, flow rate to ground flares and elevated flare and varied weather conditions.

Noise Monitoring 2019

In April 2019, a process upset occurred resulting in flaring and RMP deployed and began acoustic monitoring within hours. Monitoring occurred continuously at noise sensitive receptors in Cowdenbeath and Lochgelly, and periodically at the remaining receptors identified in Figure 2 for the period of flaring 21st – 27th April 2019. The assessment was performed to BS4142:2014 and/or NANR45 adapted standards. During this event, there was opportunity to assess the priority areas identified from the March analysis including various steam to hydrocarbon ratio's and varying rates to the elevated and ground flares. Spot measurements were taken at the flare source. Analysis of the April results showed a correlation between the measured low frequency noise at a specific steam to hydrocarbon ratio range at the elevated flare.

In July 2019, planned maintenance was undertaken during which noise monitoring against NANR45 criteria was undertaken. An additional continuous monitor was placed close to the flaring sources to confirm contribution of flaring source to noise profile. The key finding from the monitoring was that a reduced flow rate to the elevated flare resulted in reduced noise levels at the surrounding residential properties. A clear correlation was established between

the increase in elevated hydrocarbon flow/steam rates and the increase in low frequency noise at the source.

However, long term measurements at Lochgelly show a change in low frequency noise level not replicated in the source noise output likely due to a change in wind conditions which has a significant effect on the results.

4. Assessment of Impact

An assessment of environmental impact considers both the consequences of emissions as well as the probability, or likelihood that the emission may occur and at what levels. The scenario that is assessed can be acute (failure of abatement equipment), or chronic (persistent exceedance of acceptable emission levels) as applicable. When assessing the impact of emissions, the following dimensions are considered;

- Vulnerability of the receiving environment and reversibility of impacts
- Contributory sources of emissions (beyond the plant boundary)
- Source, duration, size/scale and intensity of the emission
- Effectiveness of mitigative measures on the emission
- Acceptability criteria for the emission (if defined)
- Actual or perceived effect upon the environment (incl. human health)

The availability of high-quality data to support the assessment often varies, however it should be proportionate to the nature and scale of the emission. In instances where data may be unavailable, conservative assumptions can be made in order to determine whether further data is necessary to assess the impact. For example, if a conservative, 'worst-case' assumption on an emission source is made and the outcome of the assessment indicates that the impact is acceptable, further data is not required as it will only confirm that the impact is acceptable. However, if a conservative assumption identifies that there is potential for an unacceptable impact, additional data serves to quantify and/or qualify the impact and indicate what mitigations are necessary to manage the emission impacts to acceptable levels.

An overview of the data that has been used in the assessment of impact is provided in Section 3.2. Available Data for Impact Assessment. The following sections discuss the impact assessment for air quality, noise & vibration.

4.1. Air Quality

4.1.1. Receiving Environment & Contributory Sources

FEP is located approximately 3km south-east of the town of Cowdenbeath in Fife. The area surrounding the plant is predominantly farmland, with small populations totalling approximately 155,000 surrounding the plant within a 10km radius (refer Figure 3: Radial 5km and 10km demarcation from FEP).

Air quality is classified as 'good' in the areas surrounding Mossmorran (4) . The review of all other local developments did not identified any locations where there may be a risk of the air quality objectives being exceeded and so no additional air quality assessment was recommended (1).

The primary contributors to air quality impacts in Fife are from transport (1) (4). There are several key transport motorways transgressing the area including the M90, A92 and A91, as well as busy residential areas that may experience congestion or high variation in traffic flows. Other industrial contributors include the dockyards (Rosyth), Arms Firm (Glenrothes), waste incineration (Dundee), opencast mining (Kelty, Crossgates) and the Grangemouth Complex comprising of refining, chemical, pharmaceutical , cement and wood treatment facilities. Other contributory sources include flights (flight paths recently changed increasing air traffic in the

area), railways, ports, poultry farms, commercial sources (e.g. biomass combustion, solid fuel burning), domestic (heating, burning etc.) and fugitive sources such as construction and agricultural emissions.

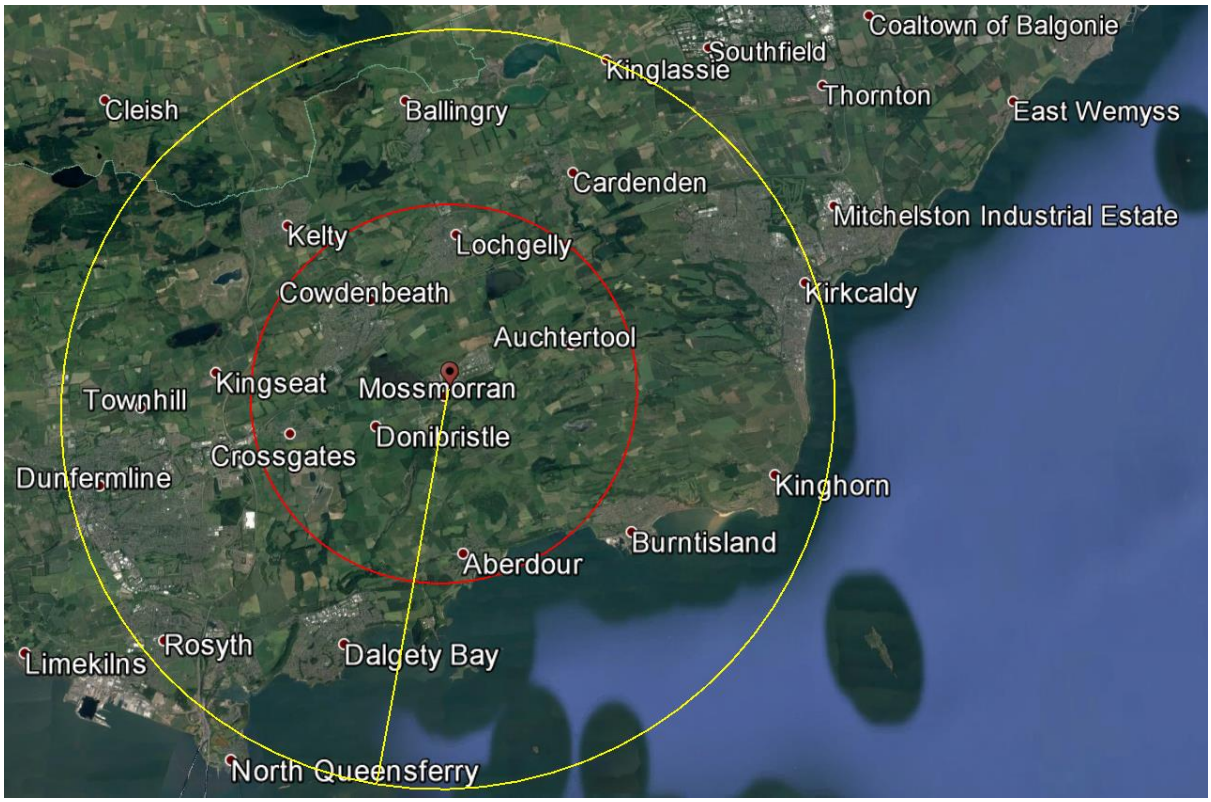

Figure 3: Radial 5km and 10km demarcation from FEP

4.1.2. Sources of emission from FEP

There are 19 emission points at FEP which are listed in the site's environmental operating permit. They include the cracking furnaces, the boilers, the gas turbine, vents and flares (both FEP's elevated flare and any material FEP sends to the Shell FNGL ground flares).

The emissions are consistent with those associated with combustion equipment and include;

- Sulphur dioxide (below the UK Pollutant Reporting Inventory threshold for emissions)
- Carbon Dioxide
- Nitrogen Dioxide
- Volatile Organic Compounds (below the UK Pollutant Reporting Inventory threshold for emissions)
- Carbon Monoxide
- Particulate Matter (below the UK Pollutant Reporting Inventory threshold for emissions)

All emissions occur within permitted rates/levels which have been established based on European Best Available Techniques and consideration of surrounding contributory sources.

Other emissions (such as H2S) are monitored primarily from an operational perspective to ensure ongoing safety of site workers.

During flaring, additional combustion occurs at either the Shell FNGL ground flares and/or the elevated flare. Emissions from flaring are consistent with typical combustion as detailed above. The material sent to flare is of known composition (gas chromatograph analyser in situ). During exceptional circumstances (such as loss of steam), smoke (or soot) may be emitted from the flare. This occurred once in 2009, once in 2012, for 27 minutes in 2017 and for 110 minutes in 2019 so is not considered a frequent or regular emission.

In addition to point source emissions, there are minor diffuse emissions including those from transport vehicles at the site, flange or valve fugitives, tank breathing etc.

4.1.3. Mitigating Measures

Mitigative measures that eliminate, or where that is not practicable, reduce emissions from activities at FEP are clearly defined in European Best Practice Reference Documents which are legally binding in the UK.

Fit-for-purpose monitoring (as described in Section 3.2.1 Air Quality) enables the effectiveness of mitigative measures to be assessed and any changes assessed timely. An overview of the existing measures utilised to eliminate, reduce and/or control emissions are included below;

- Sulphur dioxide
    - Fuel selection, monitoring
- Carbon Dioxide
    - Maximising energy efficiency/monitoring key energy variables, control systems, fuel selection, recovery and reuse of hydrogen, heat recovery
- Nitrogen Dioxide
    - Burner steam control, use of spent air, control systems, monitoring, fuel selection, combustion optimisation
- Volatile Organic Compounds
    - LDAR programs, closed loop vapour return, No Oil To Sewer policies, combustion optimisation, control systems
- Carbon Monoxide
    - Combustion optimisation, optimisation of thermal decoking
- Particulate Matter
    - Combustion optimisation, optimisation of thermal decoking

4.1.4. Acceptable Air Quality Levels

Extensive legislation exists defining acceptable levels of emissions throughout Europe and the UK. These are summarised below;

- Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe
    - Sets limit values, or target levels for selected pollutants that are to be achieved by Member States
- The Air Quality Standards (Scotland) Regulations 2010
    - Transpose Directive 2008/50/EC into UK legislation and sets legally binding Air Quality Standards (AQS)

- The Air Quality (Scotland) Regulations 2000 as amended and the Air Quality (Scotland) Amendment Regulations 2016
    - Provide health-based criteria and derives Air Quality Objectives (AQO) policy targets
- The Environment Act
    - Part IV requires Local Authorities to periodically review air quality through the Local Air Quality Management process

In addition to statutory standards there are also multiple sources of applicable air quality guideline for example;

- Air Quality Guidelines for Europe, the World Health Organisation (WHO)
- Environment Assessment Levels

4.1.5. Actual or Perceived effect on the Environment

Extensive and detailed air quality modelling has been undertaken by a specialist consultant (Wood PLC) to determine the actual effects of emissions on local air quality. Modelling is a globally accepted standard in which to undertake air quality impact assessment as it allows;

- A picture of the air quality in a zone may be obtained - in contrast to the limitations in the spatial coverage of air quality measurements.
- The relation between air concentrations and the emissions causing these can be made explicitly and quantitatively by modelling, which is most important for supporting air quality management.
- Models are the only available tool if the impact on air quality of possible future sources or of alternative future emission scenarios is to be investigated.

The principal conclusion of the Wood PLC 2019 assessment is that, as there are no predicted exceedances of any acceptable Air Quality Standard, Air Quality Objective or Environmental Assessment Levels during normal operation of FEP and during flare event scenarios, the risk of adverse impacts on human health due to activities (including flaring) at FEP are negligible. This conclusion is entirely consistent with the conclusion of the 2009 modelling study.

Smoky flaring instances, while uncommon, have also been considered in the model. Inverse modelling demonstrates that, for flaring emissions to exceed an acceptable standard, particulate emissions (soot) from the elevated flare would need to be at a level that would account for approximately 84% of the total UK emissions of PM2.5. Such an outcome is implausible, even at 365 days of continuous smoky flaring.

Feedback from communities on the perception of air quality varies. Reviews of social media indicate concern from a limited audience (<50), particularly during flaring events, of the impact of associated air emissions (in particular smoke which is an uncommon occurrence). In the last 10 years, records indicate FEP has received less than 10 community complaints relating specifically to air quality/health concerns. It is unclear how many complaints SEPA have received specific to health concerns as this data has not been released.

Stakeholder engagement undertaken over Jun-Aug 2019 indicated that communities were not aware of the extent, or detail of existing data on local air quality. A non-technical summary of the 2019 modelling assessment was provided to numerous community stakeholders (including

NHS Fife) which received positive feedback, and only one clarification query related to ozone which has subsequently been addressed in the modelling report. There were no other requested follow-ups or clarifications requested from stakeholders with regards to the negligible health impacts.

4.2. Noise & Vibration

4.2.1. Receiving Environment & Contributory Sources

The most immediate noise sensitive receivers are personnel working on the plant, while the area immediately surrounding the Ethylene Plant is predominantly farmland. The nearest offsite noise sensitive receiver is Dorloch Cottage located approximately 1500m to the South East. Other offsite noise sensitive receivers include housing adjacent to a Poultry Farm 1600m to the South West; Cowdenbeath 2000m to the North West, Little Raith Farm 2500m to the North East and Lochgelly 3000m to the North North East. Cowdenbeath and Lochgelly (see Figure 2: Noise Sensitive Receptors at which noise monitoring has been undertaken.)

Figure 4: Radial 5km delineation from the plant

The noise environment on the plant is regularly monitored to ensure compliance with health and safety limits for workers. Background noise at offsite receptors Dorloch cottage and Little Raith farm consists mainly of road traffic noise from the distant A92 and B925 and of activity associated with the Mossmorran site. The noise environment at the Poultry Farm is dominated by road traffic noise from the B295 and distant A92. At Cowdenbeath and Lochgelly the noise environment is dominated by road traffic from the A92. (5)

Other contributing noise sources in the area include;

- Goathill rock quarry in Donibristle undertakes surface extraction activities, including blasting and stone crushing, with associated heavy vehicle haulage
- Surrounding agricultural farming activities and vehicles (tractors, combines)
- Air traffic travelling to/from Edinburgh Airport (recent increase in 2019)
- The trainline and associated use through Crossgates/Cowdenbeath
- Windfarms and associated weather (high winds)

- Construction (e.g. new build domestic/commercial facilities)

4.2.2. Sources of Emission FEP

ExxonMobil carry out regular on-site noise monitoring for health and safety purposes and have noise contour maps for the site - this information has been used to identify the main sources of noise across the site. The main sources include major equipment such as the gas turbine, and refrigeration compressors steam turbine drivers as well as steam letdown valves, cooling tower circulation pump and air compressor. The noise levels associated with the listed areas are representative of those measured in close quarters and do not relate to noise levels at nearby receptors or at the site boundary.

Baseline noise monitoring undertaken in 2016 during normal operating conditions concluded that;
'The results show that the site noise during normal operations, has no impact during the day or night periods at any of the NSRs identified. This is partially due to high traffic flows on nearby roads.'

This was further reinforced when continuous monitoring was undertaken from August to September 2018 in Lochgelly during normal operating conditions where it was found that;
'The spectral nature of the background noise at the measurement location has been assessed and it was found that road traffic noise is dominant above 400Hz.'

Periodic or infrequent sources of noise include vents, furnace decoking activities and flaring. All of these sources have been captured in noise monitoring and flaring is demonstrated to have the most significant associated noise and vibration emissions. Details and quantification of the noise emitted from flaring activities is summarised in Section 3.2. Available Data for Impact Assessment.

4.2.3. Mitigating Measures

Mitigative measures that eliminate, or where that is not practicable, reduce emissions from activities at FEP can be summarised as the control of noise at source, monitoring and protection against over-exposure.

The following hierarchy of techniques are used to implement noise mitigations at FEP:

1. Design and engineering standards for plant
    - Ensures acceptable noise emission criteria for equipment is established
2. Physical controls
    - Includes acoustic enclosures, insulation etc.
3. Preventative maintenance
    - All potential noise sources, such as pumps, compressors, blowers and airfins, are included in the site's preventative maintenance schedule. The preventative maintenance programme ensures that all equipment on site is operating under optimum conditions.
4. Recording, investigating and responding to complaints
    - Identifies potential changes in noise levels and generation. Informs monitoring surveys
5. Work place health monitoring surveys
    - The site has had a regular programme of workplace noise surveys since commissioning, now formalised on a 5 year rolling basis. These are used to identify any changes in noise levels and generation. As well and health and safety

requirements, findings are used by the plant to ensure there are no cases of 'noise creep' where (possibly due to aging equipment) noise levels increase slowly over time.

6. Noise monitoring at local receptors (see Section 3.2.2. Noise & Vibration).
    - Fit-for-purpose monitoring (as described in Section 3.2.1 Air Quality) enables the effectiveness of mitigative measures to be assessed

4.2.4. Acceptable Noise & Vibration Emission Levels

The ratio between the quietest audible sound and the loudest tolerable sound is a million to one in terms of the change in sound pressure. Because of the wide range, a scale based on a logarithmic basis is used in noise level measurement. The scale used is the decibel (dB) scale which extends from 0 to 140 decibels (dB) corresponding to the intensity of the sound pressure level. The ear has the ability to recognise a particular sound depending on the pitch or frequencies found at the source. Microphones cannot differentiate noise in the same way as the ear; and to counter this weakness the noise-measuring instrument applies a correction to correspond more closely to the frequency response of the ear. The correction factor is called "A Weighting" and the resulting measurements are written as dB(A). "A Weighting" refers to the noise level that represents the human ear's response to sound. The dB(A) is internationally accepted and has been found to correspond well with people's subjective reaction to noise.

British Standard 4142:2014

BS4142:2014 *Methods for rating industrial and commercial sound* (BS 4142) is widely accepted in the UK and is based on simple A-weighted sound level measurements. This standard provides a methodology for;

- Assessing noise from a new fan or piece of equipment to be installed
- Assessing the potential impact of a new commercial or industrial enterprise on surroundings
- Assessing the likelihood of complaint from residents arising from a new industrial or commercial development
- Quantifying whether existing complaints based on subjectivity have an objective basis for action

BS 4142 does not allow a nuisance to be determined. It is also not appropriate for use in certain circumstances, for example, to quantify the impact of low frequency noise.

Longer term noise monitoring undertaken in Lochgelly in 2018 by a specialist acoustic consultant during normal operating conditions concluded that;
'The spectral nature of the background noise at the measurement location has been assessed and it was found that road traffic noise is dominant above 400Hz. This also indicates that when an A weighting is applied the low frequency energy in the flare source measurements is not a dominant factor in the A weighted broadband level. This suggests that a spectral method of low frequency assessment would be more appropriate for monitoring and quantifying future flaring events.'

On this basis, BS 4142 is considered to be useful in quantifying whether existing complaints based on subjectivity have an objective basis for follow-up action, however alternate noise criteria should be found for monitoring and quantifying low frequency noise (vibration).

DEFRA NANR45

The NANR45 Criterion and *Procedure for the Assessment of Low Frequency Noise Complaints* (6) was developed by the Acoustics Research Centre, Salford University for DEFRA. It is based on field noise measurements inside peoples' homes who complain of low frequency noise, and laboratory noise experiments that include results from a wider range of participants.

Assessing noise against the NANR45 criteria is invasive to residents. It requires sound recordings and detailed one-third octave band noise measurements be made over a multiple day timespan inside residents' homes.

The Environmental Protection Authority of New South Wales published a paper at the 12th International Commission on Biological Effects of Noise (ICBEN) Congress on Noise as a Public Health Problem entitled, *Assessing low frequency noise from industry – a practical approach* (7), in which they suggest using the NANR45 criterion with a correction factor applied to each one-third octave band to translate the indoor criterion to an outdoor criterion. The correction factor is based on a general noise reduction for a typical residence in NSW, but they also suggest the use of a building specific noise reduction. A specific noise reduction for a residence (typical) in Lochgelly was established by a specialist acoustic consultant on behalf of FEP and this approach has been utilised to determine the extent of low frequency noise (vibration) effects from FEP. FEP appreciates the cooperation of the Lochgelly residents to allow this data to be collected.

4.2.5. Actual or perceived effect on the Environment

The noise environment around the plant, excluding any contribution from the flares, is dominated by road traffic noise on the surrounding minor roads and A92 to the north. Other plant activities are audible at Dorloch Cottage and Little Raith Farm when there is no flaring activity.

During flaring activities, flare noise is clearly audible at Dorloch Cottage, Little Raith Farm and The Poultry farm. These three receptors are the closest to the Mossmorran complex and to the south of the A92 motorway. The intensity of the flare noise at these three positions is not consistent between or during flaring events. This is likely due to fluctuations in hydrocarbon and steam flow rate as well as wind speed and direction. Flare noise is particularly prominent during the evening and night time periods as the background noise levels due to road traffic noise are reduced.

At receptors north of the A92 (Lochgelly, Cowdenbeath) monitoring data consistently concludes that traffic dominates the noise profile above 400Hz. Specialised acoustic monitoring has confirmed the presence of low frequency noise associated with the flare to be present, however variable/s other than flaring rates are known to affect the low frequency noise levels in these areas. The extent of the contribution of low frequency noise from flaring versus other contributing sources has not been confirmed by monitoring data to date. An assessment of noise levels at Lochgelly & Cowdenbeath during a major flaring event (April 2019) against NANR45 criteria for the assessment of low frequency noise concluded that the predicted internal levels were within criteria with minor (0.1 and 0.9dB) calculated exceedances at 25Hz and 50Hz. The data also showed an exceedance of the extrapolated 200Hz however this is not due to externally measured noise but rather a lack in the measured attenuation of the façade at 200Hz. Overall the measured impacts to date do not indicate major variance against criteria.

The perception of noise during flaring may be inferred from complaints or social media, however this is understandably a subjective interpretation on environmental impact and may not be impartial and reports can be biased (8). This input has been used primarily to provide consideration to monitoring techniques (for example the transition to full frequency analysis to follow-up on references to vibration/low frequency noise). Complaints received by FEP from the community during flaring, summarised below, are low in relation to the total surrounding population (less than 10/155,000 for the majority of flaring events with a maximum of 35/155,000). It is understood that SEPA have also received complaints from the community but an analysis of how many, where from and whether they relate to noise and/or vibration has not been qualified or made available. The complaint data shows two major peaks in complaints (June 2017 and April 2019), which correlate with the two longest duration unplanned flaring events – significantly less (5) complaints were received for a longer duration planned event in September 2016. There is no correlation between complaint data and flow rate to flares or complaint data and recorded noise intensity. It is not possible to determine whether the received noise complaints are exacerbated by only duration, or other factors such as light, media coverage, or opinion towards the plant.

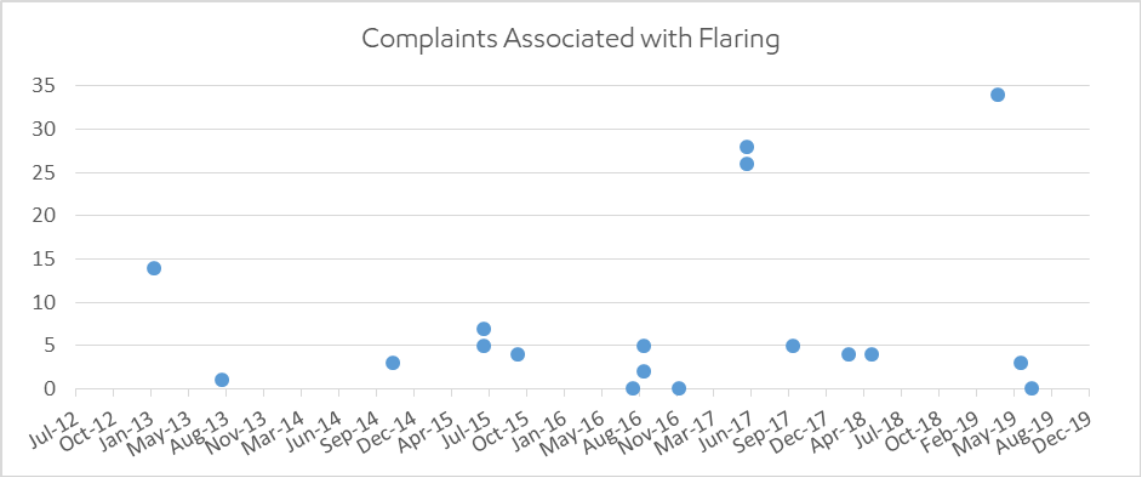

Figure 5: Record of complaints received in relation to flaring events

5. Conclusions

5.1. Air Quality

There is sufficient available monitoring in place to confirm the effectiveness of existing mitigative measures and monitor emissions for any substantial change. There is sufficient monitoring available to confirm compliance with all emission limits set in the environmental permit.

Highly detailed modelling confirms that the actual risk of adverse impacts on human health due to activities (including flaring) at FEP are negligible. This includes consideration of an unrealistic extended duration, heavy smoking flaring scenario.

The perceived impact of emissions on air quality vary, however stakeholder engagement has indicated high receptiveness from the community to existing data which has assisted in addressing concerns to a level that required no additional follow-up.

5.2 Noise and Vibration

Transition to an alternate noise monitoring methodology in 2018 has significantly increased the level of understanding of noise emitted during flaring events, allowing for identification of fit-for-purpose mitigative measures focused on the source of specific noise tones (see FEP Flaring BAT Evaluation 2019).

However the relationship between noise and vibration associated with flaring and flow rates, wind direction, wind speed and low frequency noise levels is still not fully understood. Continued monitoring during events at the source position along with higher resolution meteorological data should allow for a better understanding of these relationships and confirm the source(s) of flaring noise and the effectiveness of associated mitigative measures.

Future additional monitoring would allow the correlation at a range of elevated hydrocarbon flow rates to be further analysed with the aim of determining the elevated flow rates which meet the NANR 45 criteria and a reduced noise impact on the residential properties.

6. Forward Monitoring Plan

6.1. Air Quality

There are no actual air quality impacts that would require monitoring in addition to that currently undertaken.

There is some variation in the perception of air quality impacts from the facility that are best addressed through improved communication of the substantial existing datasets which are not currently well understood.

6.2. Noise & Vibration

A continuation of the targeted acoustic studies is proposed to;

- Better understand the relationships between noise and vibration associated with flaring and flow rates, wind direction, wind speed and low frequency noise
- Confirm the source(s) of flaring noise and variables affecting the flare noise profile
- Confirm the effectiveness of associated mitigative measures
- Establish levels of elevated flaring below which noise impacts are not anticipated to occur

The specialist acoustic consultant (RMP Acoustics) have identified that the most appropriate guidance for assessing low frequency noise at the positions north and directly adjacent to the A92 is located in the DEFRA sponsored research NANR 45: 2011 undertaken by the University of Salford 'Proposed criteria for the assessment of low frequency noise disturbance'. The alternative BS 4142:2014 assessment methodology undertaken at Lochgelly and Cowdenbeath would not be appropriate as the influence from constant road traffic noise on the broadband A-weighted levels used in this methodology is significant. This results in a poor correlation between noise impact and the rating level as calculated in BS 4142:2014.

Due to the nature of unplanned flaring events, it is difficult to define monitoring timelines as it is not guaranteed when conditions will be conducive to monitoring. Data shall be collected on a responsive basis (during events) in accordance with the existing Reactive Noise Monitoring agreement in place between RMP Acoustics and FEP which states that RMP will endeavour to mobilise continuous noise monitoring equipment as soon as practicable at defined locations and undertake spot measurements.

Following major facility changes outlined in the FEP Flaring BAT Evaluation 2019, namely replacement of the elevated flare tip in 2020, longer term continuous monitoring is proposed during commissioning of the equipment in order to optimise its performance and confirm its expected effectiveness.

FEP will continue to work closely with acoustic specialists to respond to emerging information and adapt the monitoring program as required to achieve the highlighted objectives.

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Appendices

1. Stakeholder Engagement

FEP engaged many key stakeholders during the development of this monitoring plan to discuss air quality, noise and vibration actual and perceived impacts. A summary of this engagement including identification of key stakeholders, method of engagement and any actions/follow-ups or observations are included in the table below.

Stakeholder	Date & Forum	Method of Engagement	Comments
NHS Fife	NHS Fife Chief Executive contacted and declined **08-Aug-19:** NHS Fife Consultant in Public Health Medicine	Onsite visit with Operations Manager, Environmental Engineer and External Affairs Manager. Verbal overview of plant and process. Opportunity for site walk around	Advised no evidence exists to link FEP to any health impact. No further follow-ups or information requested.
Fife Council	**31-May-19:** Cllr (Environment, Protective Services & Community Safety Committee) **12-Jun-19:** *Fife Council:* *Cllr (Lab)* ▪ *Cllr (SNP)* ▪ *Cllr (SNP)* ▪ *Chief Executive* ▪ *Interim CO* ▪ *Cllr (Lab)* **28-Nov-19:** Cllr (Environment, Protective Services & Community Safety Committee)	Face-to-face meeting with External Affairs Manager and Environmental Engineer to discuss community perception of environmental issues. Face-to-face discussion at Fife Council buildings with Plant Manager, Environmental Engineer and External Affairs Manager. Answered queries around perceived air quality and amenity impacts. Advised of upcoming non-technical summary on air quality modelling and conclusion on proposed monitoring. Provided update on noise data to date and proposed ongoing monitoring.	Invited to present Wood PLC Non-Technical Summary (Air Quality) and noise update at an upcoming Fife Council Environment Committee. Agree that community perception and communications are a focus area. No further follow-ups or information requested.
Councillors & MSP's	**27-Jun-19:** *Cllr Allie Bain* *Cllr Altany Craik* *Hill of Beath CC (x2)*	Face-to-face onsite meeting with Plant Manager, Operations (Process) Manager, External Affairs Manager and Community Liaison Officer.	No further follow-ups or information requested.

Stakeholder	Date & Forum	Method of Engagement	Comments
Councillors & MSP's	*Lumphinnans CC (x1)* *Auchtertool CC (x1)* *Cowdenbeath CC (x2)* *Burntisland CC (x2)* *Lochgelly CC (apology)* *Annabelle Ewing (apology)* *Mark Ruskell (apology)* *Alexander Stewart (apology)* *Alex Rowley (apology)* *David Torrance (apology)* *Lesley Laird (apology)* *Cllr Darren Watt (apology)* *Cllr Kathleen Leslie (apology)* *Cllr Ross Vettraino (apology)*	Open discussion on plant process and any community queries or concerns.	No further follow-ups or information requested.
	28-Jun-19: Lesley Laird Meeting (Specific Agenda Item) No attendee list provided	Face-to-face meeting chaired by Lesley Laird and Wilson Sibbett with FEP Plant Manager, Environmental Engineer, External Affairs Manager and Community Liaison Officer. Specific agenda slot for discussion of air modelling non-technical summary attended by representative of Wood PLC. Provided update on findings of noise data to date.	Requested non-technical summary/overview of FEP BAT Evaluation commitments. No further follow-ups or information requested.
MAG	**28-Jun-19:** Lesley Laird Meeting (Agenda slot confirmed) No attendee list provided	Face-to-face meeting chaired by Lesley Laird and Wilson Sibbett with FEP Plant Manager, Environmental Engineer and External Affairs Manager. Specific agenda slot for discussion of air modelling non-technical summary attended by representative of Wood PLC. Provided update on findings of noise data to date.	Queried whether ozone had been considered in the air quality model. Wood PLC answered verbally during meeting and provided additional technical supplement to non-technical summary in response. Advised of noise monitoring assessment undertaken in 2014 in Lochgelly which was

Stakeholder	Date & Forum	Method of Engagement	Comments
	18-Jul-19: Site visit MAG Member (Declined) MAG Member (Declined)		subsequently reviewed during the development of this monitoring plan.
IAQMRG	Meeting requested late June - declined **30-Jul-19:** Scheduled meeting (Specific agenda slot) *Independent Chair, University of St Andrews* *Business Support Assistant, Fife Council* *Manager, Fife Council* *Head of Workplace Exposure, Institute of Occupational Medicine* *Specialist 1, SEPA* *Consultant Public Health, NHS Fife* *Cllr. (SNP), Fife Council* *Burntisland Community Council* *Aberdour Community Council (apology)* *Cowdenbeath Community Council (apology)* *Cllr (SNP), Fife Council (apology)* *Lead Officer Air & Quality Team, Fife Council (apology)* *Cllr (SNP), Fife Council (apology)*	Face-to-face meeting at Dunfermline City Chambers chaired by Professor Wilson Sibbett with FEP Environmental Engineer and External Affairs Manager. Specific agenda slot for discussion of air modelling non-technical summary attended by representative of Wood PLC. Open discussion on air quality.	Requested further information on; • The use of models to assess air quality; their standardisation and appropriate methodology for assessing air quality impacts versus monitoring • The effects of ground flare contribution to air quality (lower lying emission source) • The effects of wind turbines on air quality • Any queries already raised by stakeholders with regards to air quality Queries were answered verbally by representative of Wood PLC and provided as an addendum to the Non-Technical Summary by Wood PLC on 22-Aug-19 for inclusion in the 2018 report.
Safety Liaison	**13-Jun-19:** Quarterly meeting **12-Sep-19:** Next meeting (post submission)	Quarterly meeting with Plant Manager and External Affairs Manager. Wood PLC Non-Technical Summary report (draft) discussed.	No further follow-ups or information requested.
Community members	**4-Jul-19**: Public release of NTS via Twitter for comment Release of NTS to employees for comment (70% local)	Link to the Wood PLC Non-Technical Summary uploaded to Twitter inviting comment and queries. Uploaded to ExxonMobil UK Website with interaction invited via Twitter.	1 comment received. No further follow-ups or information requested. No further follow-ups or information requested.

Stakeholder	Date & Forum	Method of Engagement	Comments
	16-Jul-19: Hill of Beath Community Council Meeting	Link to the Wood PLC Non-Technical Summary emailed to employees and contractors inviting comment and queries. Attended HoB face-to-face meeting with Plant Manager, External Affairs Manager and Community Affairs Officer. Provided Wood PLC Non-Technical Summary and invited follow-up questions.	No further follow-ups or information requested.

2. Non-Technical Summary: Air Modelling

Air quality assessment of flaring activities at Fife Ethylene Plant: non-technical summary

Objective: This note provides a non-technical summary of the investigation into how flaring at Fife Ethylene Plant (FEP) might impact local air quality. It looked at a worst case scenario and calculated associated emissions to compare against international Air Quality Objectives.

How were the impacts of flaring on local air quality investigated?

We used a computer program to undertake 'dispersion modelling', a technique which tracks how materials released into the atmosphere are moved around by the wind and mixed with the surrounding air. This can be used to predict the amount (or 'concentration') of a pollutant that you could breathe in after it is emitted from an emission source. Using a range of conservative assumptions which produced a **hypothetical, unrealistically high worst-case scenario** (flaring rates tripled and flaring at this rate occurring 365 days of the year with black smoke), **we estimated the maximum ground level concentration of pollutants that could occur where members of the public are present as a result of emissions from FEP.**

Predictions were compared against Air Quality Objectives (AQOs) set by international bodies, including the World Health Organisation (WHO), the European Commission and the Scottish Government to protect human health from air pollution.

By ensuring the program considered **worst-case assumptions**, we were able to increase confidence that our findings would be within the AQOs during actual operation if the program indicated this was the case.

In addition to emissions from FEP, our investigation also accounted for the emissions from the neighbouring Shell Fife FNGL Plant and other non-industrial sources, such as roads, or emissions from people burning gas in their homes.

We also considered how the wind turbines near to FEP might change how the emissions are mixed in the atmosphere by including data on their location and type in the computer program. Finally, we compared the results from the computer program against previous monitoring results provided by the Mossmorran & Braefoot Bay Independent Air Quality Monitoring Review Group.

What pollutants are emitted from the flare?

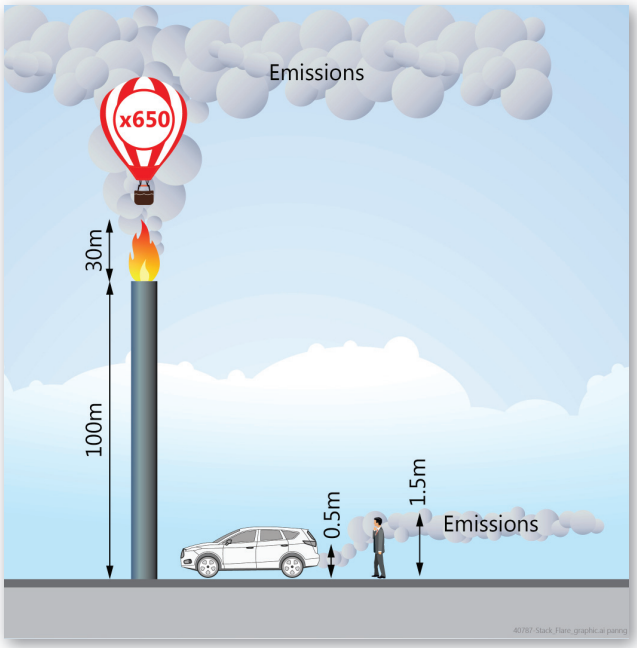
The gas flared at FEP primarily consists of the same type of compounds (known as 'hydrocarbons') that are found in the natural gas used to heat homes or to cook with, though in different quantities. When these compounds are burnt in the flare, they are mainly converted to carbon dioxide and water vapour. Neither of these are harmful to health at concentrations typically found in the atmosphere.

However, flaring can cause other materials to be created, such as nitrogen dioxide, which can affect human health when they are above certain concentrations, and it is these emissions which are considered 'pollutants'. In some cases, particularly when a large volume of gas is sent to the flare over a very short period, a process known as 'incomplete combustion' can occur. When this happens, other pollutants such as particulate matter (or 'soot') can be formed, which makes the flare look smoky. Our computer program assumed there was no steam injected to the flare, resulting in incomplete combustion and a heavily smoking flame throughout the year to represent an **extremely unlikely worst-case scenario**. We considered emissions of nitrogen dioxide, carbon monoxide, particulate matter, unburnt hydrocarbons, benzene, toluene, ethyl benzene and xylene.

We assumed a heavily smoking flame occurred 24 hours a day, 365 days a year

What we found out

The computer model predicted concentrations of all air pollutants emitted from FEP were well below their Air Quality Objectives and, as such, unlikely to have an impact on air quality and human health. The predicted concentrations were much lower than those from other emission sources, such as cars and domestic heating. This conclusion is consistent with previous studies and monitoring data reported by SEPA and the Mossmorran & Braefoot Bay Independent Air Quality Monitoring Review Group. Whilst other emission sources, such as traffic, might emit a lower amount of material than a flare, these emissions occur at ground level and much closer to areas where people are present. This means there is less chance for the pollutants to mix with non-polluted air before you breathe them in. The FEP flare emissions are released 100 metres above ground level, whilst the heat released by the flare is equivalent to that which could keep approximately 650 hot air balloons in the air.



Due to this heat, the emissions continue to rise further away from the ground after they are emitted, which means there is a lower risk to health due to improved mixing and dilution within the air.

We found most pollutants emitted from the flare were predicted to contribute less than 10% of the Air Quality Objective at ground level with many being less than 1%.

Figure 1: Predicted concentrations of nitrogen dioxide

Figure 2: Predicted concentrations of fine particulate matter

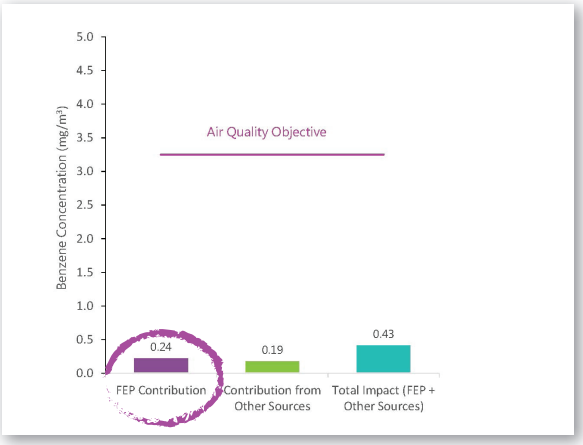


Figure 3: Predicted concentrations of benzene

What do the findings mean?

Due to the low values produced when assessing an unrealistic worst-case scenario, it is highly unlikely for FEP to impact the local air quality of people in Fife.

Based on the worst case scenario investigation conditions and the low levels found, there does not appear to be any scientific merit in undertaking further studies, such as air quality monitoring. It would be difficult for monitoring equipment to detect many of the values predicted to occur at ground level from the flare emissions.