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Department of Sustainability, Environment, Water, Population and Communities



National Pollutant Inventory

**Emission estimation technique manual
for**

**Oil and Gas
Extraction and Production
Version 2.0**

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Emission Estimation Techniques for Oil & Gas Extraction & Production

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1 Introduction

National Pollutant Inventory (NPI) Emission Estimation Technique (EET) manuals provide guidance to assist facility reporters to report emissions and transfers of NPI substances to the NPI. This manual describes the procedures and recommended approaches to estimating emissions and transfers from the Oil and Gas industry.

NPI substances are those that, when emitted at certain levels, have the potential to be harmful to human health or the environment. Australian state and territory governments have legislated that industry will report these emissions on an annual basis. Reportable NPI substances are listed in the NPI Guide and are classified into six categories, with different reporting thresholds. If your facility trips a threshold in a reporting year for an NPI substance, all emissions of that substance to air, water and land from your facility must be reported. Transfers of NPI substances must also be reported for each substance tripped in Categories 1, 1b and 3. Reporting of transfers depends on whether the NPI substance is transferred to a mandatory or voluntary reporting transfer destination. For more information on the NPI program, please consult the NPI Guide, which is available from the NPI website at www.npi.gov.au.

The ANZSIC code and ANZSIC code descriptions that apply to this Manual are as follows:

EET MANUAL	Oil and Gas Extraction and Production
2006 ANZSIC code and description	0700 Oil and Gas Extraction

The ANZSIC code is part of NPI reporting requirements. The NPI Guide contains an explanation of the ANZSIC classification system. Under Clause 14 of the *NPI National Environment Protection Measure* (NPI NEPM), a facility is only required to report under the NPI if the ANZSIC code for one or more activities undertaken at the facility is included by the Commonwealth on a published list as an industry type required to report. The NPI publishes a list of participating ANZSIC codes under the NPI NEPM (NPI, 2006). That list does not include an ANZSIC code for oil and gas exploration activities (production activities are included). Therefore, emissions associated with oil and gas exploration are not currently required to be reported. It is, however, recommended that the list of relevant ANZSIC codes under the NPI NEPM (NPI, 2006) are checked prior to reporting each year as the NPI NEPM is subject to review and change. Both field development and normal operation activities are reportable under the NPI.

This manual has been developed through a process of national consultation involving state and territory environmental authorities and key industry stakeholders. Particular thanks are due to Pacific Environment for their role in developing this manual.

2 Process Description

The first step in estimating emissions and transfers of NPI substances from a facility is to create a facility process diagram (such as the examples presented in Figure 1 and Figure 2), which will help determine points in the process where emissions and transfers may occur. Note that the diagrams provided in Figure 1 and Figure 2 are simplified examples that are for illustrative purposes only. A facility diagram should include all activities and equipment at your facility that could release, or lead to the release of NPI-reportable substances (including activities not specific to the oil and gas industry, such as power generation and vehicles). Materials handled and waste streams should be considered when developing your process description, as this will help you to determine substance usage and transfers.

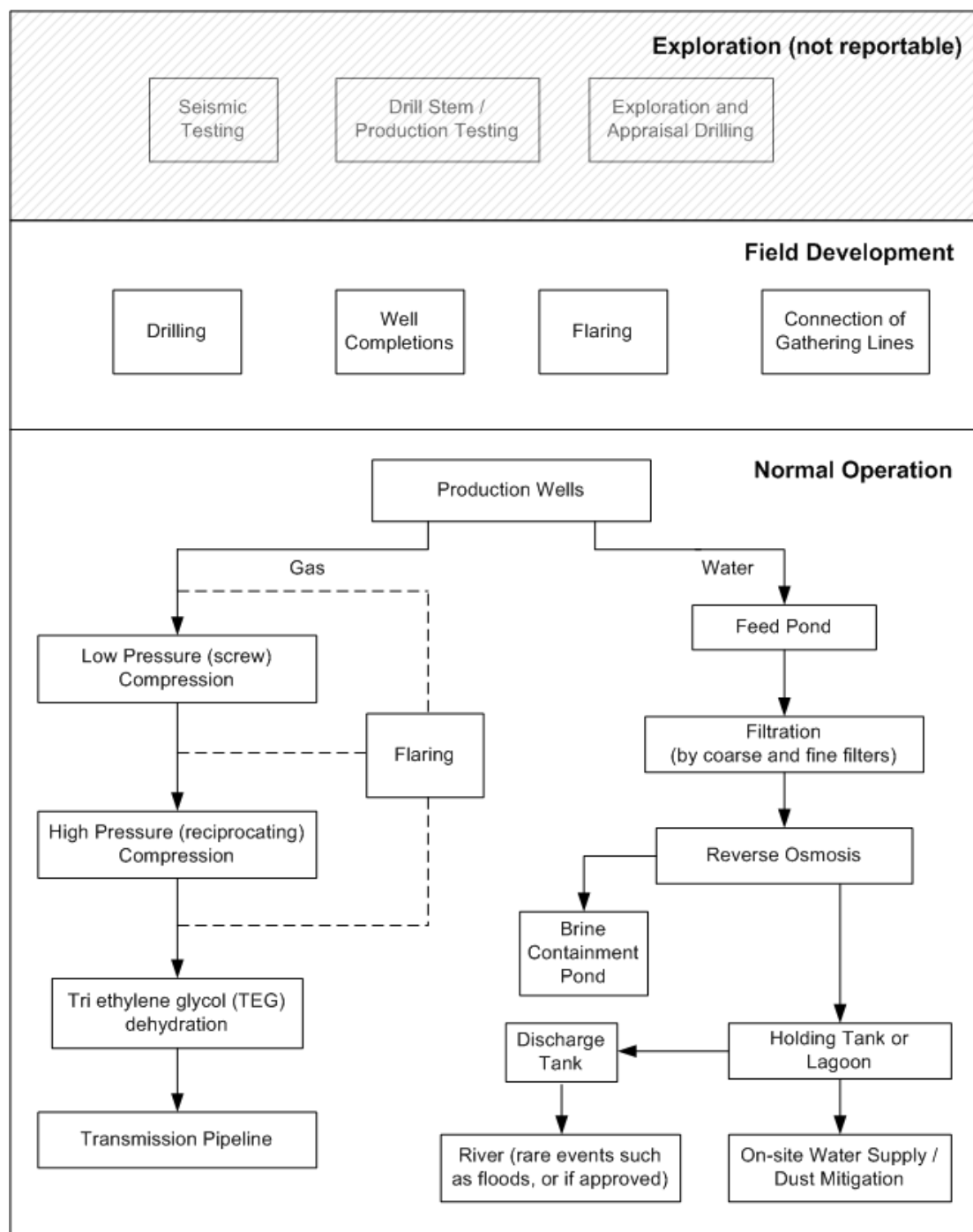


Figure 1: Example Gas Extraction and Production Facility Process Diagram

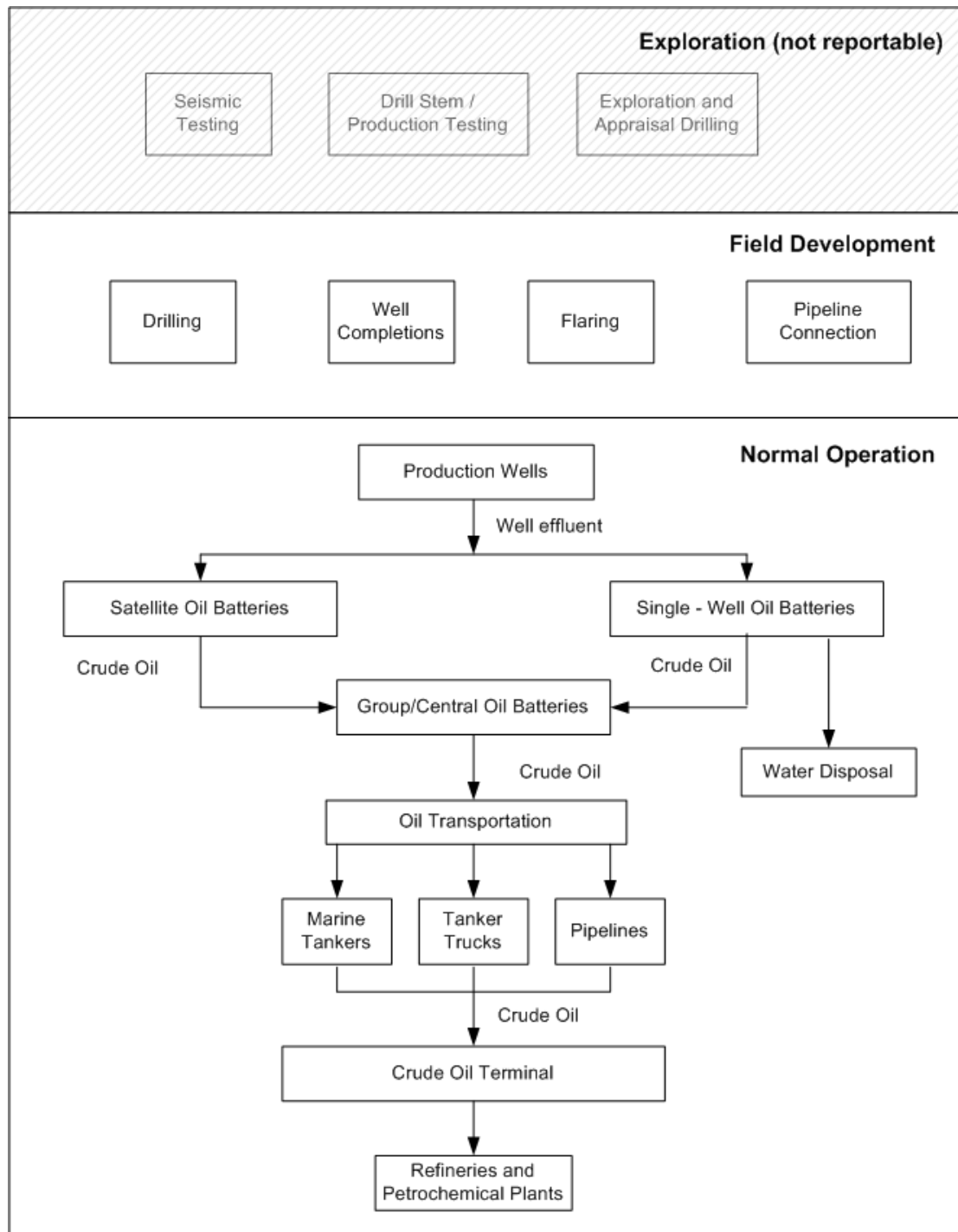


Figure 2: Example Oil Extraction and Production Facility Process Diagram

Table 1 shows the coverage of relevant substance emissions and transfers in this and other NPI Manuals.

Table 1 – Location of Emission Sources in this Manual and Coverage under NPI

Emission Source	Section of This Manual	Coverage under Other NPI Manuals
Emissions to Air		
Fugitive Emissions of Volatile Organic Compounds	5.1	
Estimating Fugitive and Venting Emissions Based on a Greenhouse Gas (Methane) Emissions Inventory	5.1.1	
Process fugitives	5.1.2	
Venting waste gas	5.1.3	
Speciation of total VOC emissions	5.1.4	
Gas dehydration	5.1.5	
Loading crude product onto tankers	5.1.6	
Storage tanks	5.1.7	<i>Fuel and Organic Liquid Storage</i>
Venting from Crude Oil Storage Tanks on a Floating Production, Storage and Offloading Facility	5.1.8	
Fuel Combustion	5.2	
Flaring	5.2.1	
Power generation	5.2.2	<i>Combustion in Boilers Combustion Engines</i>
Vehicle exhaust	0	<i>Combustion Engines</i>
Dust Emissions	5.3	<i>Fugitive Emissions Mining</i>
Emissions to Water		
Emissions to water	6	
Emissions to Land		
Drilling fluids	7.1	
Spills and leaks	0	
Transfers		
Transfers of NPI substances	8	

2.1 Gas

Gas is produced from both 'conventional' (Section 2.1.1) and 'unconventional' (Section 2.1.2) geological formations, which are described further below.

2.1.1 Conventional Natural Gas

'Conventional natural gas' is trapped in structures in the rock that are caused by folding and/or faulting of sedimentary layers. It consists primarily of methane, but also ethane, propane, butane, pentanes and heavier hydrocarbons.

2.1.2 Unconventional Natural Gas

'Unconventional natural gas' is generally produced from geological systems where the gas needs to be released from the rock. It is typically divided into the following categories:

- **Coal Seam Gas (CSG):** Methane gas which is stored in the matrix of the coal as well as the fracture spaces of the rock (cleats) and is held there by water pressure.
- **Tight Gas:** Held in low permeability and low porosity sandstones and limestones, and its lack of permeability does not allow the gas to migrate out of the rock.
- **Shale Gas:** Organically-rich sedimentary rocks (gas is trapped in the rocks which is also the reservoir) which typically have low permeability due to their laminated nature.

2.2 Crude Oil

A mixture of hydrocarbons that exist in the liquid phase in natural underground reservoirs and remains liquid at atmospheric pressure and ambient or elevated temperature after passing through surface separation facilities.

3 Thresholds

The NPI Guide provides guidance on how to determine if your facility has tripped any of the NPI reporting thresholds. Details of industry specific threshold information for each NPI substance category are provided below.

3.1 Category 1, 1a and 1b

If the usage¹ of a Category 1, 1a or 1b substance exceeds the reporting threshold, emissions of that substance must be reported for all operations/processes relating to the facility. In addition, any transfers of Category 1 and 1b substances to a mandatory reporting transfer destination must be reported if the thresholds are exceeded.

The following industry-specific activities may trigger the reporting threshold for Category 1, 1a or 1b substances:

- produced formation water (PFW)
- use of production chemicals added to the PFW (such as scale inhibitor) or in the process used to treat gas or oil
- crude oil/gas throughput
- fuel usage
- use of drilling fluids
- other solids emitted to land.

Table 2, Table 3 and Table 4 show the minimum amount of PFW, gas and oil, respectively, handled over one reporting year (based on the typical composition data, as provided in Appendix B), that will trigger the reporting thresholds for each individual substance.

The composition data provided represent averages from numerous Australian and international sources, and should only be used in the absence of composition data that has been determined for each oil or gas production site through direct measurement techniques. Site-specific composition data (which may include other substances) may be used if approved by the relevant environmental agency.

Note that all sources of NPI substances should be considered when determining whether thresholds are triggered and the data in Table 2, Table 3 and Table 4 should be used only as a guide to determine whether further calculations are necessary.

¹ Use of a substance means the handling, manufacture, import, processing, coincidental production or other use of the substance. However, a substance is taken not to be used if:

- it is incorporated in an article in a way that does not lead to emission of the substance to the environment
- or
- it is an article for sale or use that is handled in a way that does not lead to emission of the substance to the environment.

Table 2 – Minimum Amount of PFW Handled to Trigger the Category 1, 1a and 1b Reporting Thresholds

Substance ^a	Category 1, 1a, or 1b Usage Threshold (t)	Indicative Required Throughput of PFW ^a (kL)
Arsenic and compounds	10	1.00×10^{10}
Benzene	10	1.00×10^7
Cadmium and compounds	10	1.59×10^9
Chromium (III) compounds	10	1.43×10^9
Copper and compounds	10	1.35×10^9
Ethylbenzene	10	1.41×10^8
Lead and compounds	10	1.52×10^9
Manganese and compounds	10	5.88×10^6
Mercury and compounds	0.005	5.00×10^6
Nickel and compounds	10	1.01×10^9
Phenol	10	2.78×10^6
Toluene	10	6.67×10^6
Total VOC	25	7.29×10^6
Xylenes (individual or mixed isomers)	10	1.16×10^7
Zinc and compounds	10	1.59×10^9

a. The list of substances is not exhaustive, and is based on the typical composition data provided in Appendix B. The associated indicative required throughput is also based on the typical composition data provided in Appendix B. The makeup of PFW will vary significantly between conventional and non-conventional operations, and by location.

Table 3 – Minimum Amount of Gas Handled to Trigger the Category 1 and 1a Reporting Thresholds

Substance	Category 1 or 1a Usage Threshold ^a (t)	Indicative Required Throughput of Gas Conventional Gas (t)	Coal Seam Gas ^a (t)
Benzene	10	1.93×10^4	4.58×10^6
Ethylbenzene	10	4.44×10^5	1.05×10^8
n-Hexane	10	2.65×10^3	4.56×10^5
Toluene	10	3.50×10^4	8.31×10^6
Total VOC	25	1.95×10^2	4.62×10^4
Xylenes (individual or mixed isomers)	10	1.48×10^5	3.51×10^7

a. The list of substances is not exhaustive, and is based on the typical composition data provided in Appendix B. The associated indicative required throughput is also based on the typical composition data provided in Appendix B. The composition of gas will vary significantly between conventional and non-conventional operations, and by location.

Table 4 – Minimum Amount of Oil Handled to Trigger the Category 1 and 1a Reporting Thresholds

Substance ^a	Category 1 or 1a Usage Threshold (t)	Indicative Required Throughput of Oil ^a		
		Heavy Oil (t)	Light Oil (t)	Water/Oil (t)
Benzene	10	1.07×10^3	8.26×10^3	8.26×10^3
Ethylbenzene	10	1.96×10^4	6.25×10^4	6.25×10^4
n-Hexane	10	1.33×10^3	4.35×10^2	4.35×10^2
Toluene	10	2.91×10^3	9.52×10^3	9.52×10^3
Total VOC	25	8.33×10^2	8.45×10^1	8.45×10^1
Xylenes (individual or mixed isomers)	10	2.69×10^3	3.03×10^4	3.03×10^4

b. The list of substances is not exhaustive, and is based on the typical composition data provided in Appendix B. The associated indicative required throughput is also based on the typical composition data provided in Appendix B. The composition of oil may vary by location.

Typical composition data for a variety of fuel types are provided in the latest version of the *Emission Estimation Technique Manual for Fuel and Organic Liquid Storage*. It is recommended that the composition of drilling fluids and any chemicals added to PFW be sourced from records such as Safety Data Sheets (SDSs, also known as Material Safety Data Sheets, or MSDSs).

3.2 Category 2a and 2b

The NPI reporting thresholds for Category 2a and 2b substances are based on amount of fuel (including extracted gas) and/or waste combusted during the reporting period. If your facility trips any of the Category 2a or 2b thresholds you must estimate and report any emissions of all substances listed under these categories. Guidance in determining if your facility triggers reporting of Category 2a or 2b substances is provided in the NPI Guide.

3.3 Category 3

The Category 3 reporting thresholds are based on the actual amount of total nitrogen and/or total phosphorus emitted to water and/or transferred to a mandatory reporting transfer destination.

You must report emissions and transfers to mandatory destinations of both total nitrogen and total phosphorus if either of the following reporting thresholds is exceeded:

- 15 tonnes per year for total nitrogen and/or
- 3 tonnes per year for total phosphorus.

4 Guidance for Defining Facilities

This section provides guidance to define oil and gas facilities for the purposes of NPI reporting and should be considered complementary to the definition of a facility provided in the NPI Guide.

When defining facility boundaries, the concept of operational control should be considered. Clause 3 of the NPI NEPM states that an 'Occupier' in relation to any facility means a person who is in occupation or control of the facility whether or not that person is the owner of the facility. A business entity is the occupier of a facility where that business entity has operational control of the facility. Clause 3A of the NPI NEPM states that a business entity that controls a facility has operational control of the facility if the entity, or one of its subsidiaries, has full authority to introduce and implement its operating policies at the facility. This means that if an upstream or downstream process connected to the facility is operated by another entity that has separate operational control (such as for a transmission pipeline), then it should not be included in the facility, and reporting responsibility falls to the operator of that process.

The NPI Guide states that a facility may be located on a single site or on adjacent or contiguous sites owned or operated by the same person. Additionally, the NPI requires sites less than 2 km apart to be regarded as one facility unless residential areas are situated between the sites.²

Although oil and gas operations can cover large areas (petroleum leases), an oil and gas production facility could be defined as a production/processing/compression facility and all associated (connected and commissioned) production wells/reservoirs.

If there are a number of small processing facilities that service production wells/reservoirs in a single region (i.e., a nodal compression design), and they are connected to a larger facility, all connected and commissioned wells/reservoirs, small compression facilities and large compression facilities could be reported as one facility (if under the operational control of the one occupier). If production/processing/compression facilities are not all connected to a larger facility, then the separation distances between the sites outlined in the NPI Guide should be used to determine whether the facilities can be defined as a single facility for NPI reporting.

Please note that when considering Figure 3 for the conventional oil and gas extraction sector, a facility could comprise a single production/processing facility connected to a reservoir. The diagram is intended to highlight the need to assess separation distances between facilities that are not connected, but under the operational control of the same occupier.

To ensure that you have correctly characterised your facility/facilities for NPI reporting, please contact your state or territory environmental agency before finalising your facility boundary definitions.

² For sites between 2 km and 10 km apart the occupier can choose to report as one or two facilities unless residential areas are situated between the sites. Sites more than 10 km apart should be treated as separate facilities. In determining the distance between sites, the shortest distance between site boundaries should be used rather than the geographical centres of the sites.

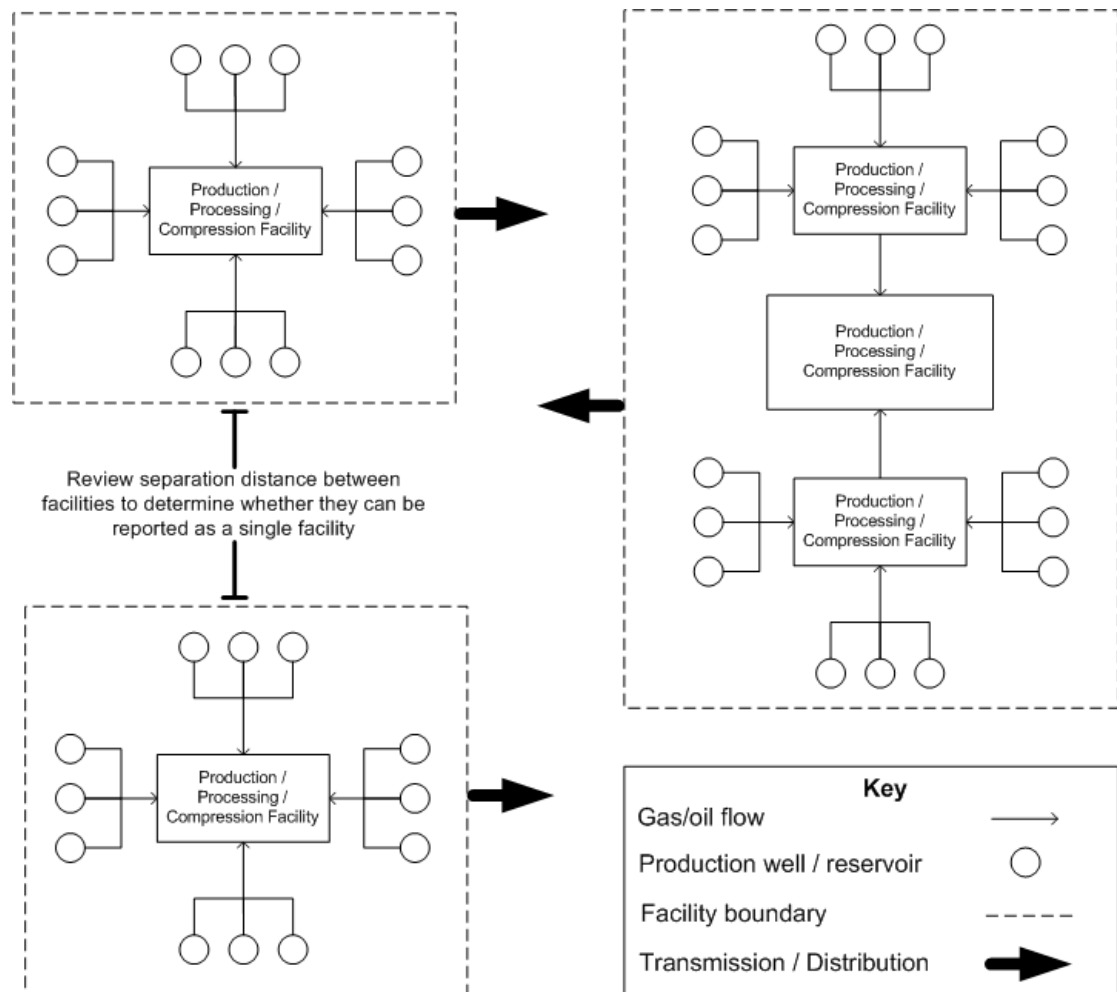


Figure 3: Facility Boundaries Examples

5 Emissions to Air

Air emissions are categorised under the NPI as:

- point source emissions - emissions which flow into a vent or stack and are emitted through a single point source into the atmosphere
- fugitive emissions - emissions that are not released via a vent or stack.

5.1 Fugitive Emissions of Volatile Organic Compounds

Fugitive emissions of Total Volatile Organic Compounds (TVOCs) from equipment leaks and venting waste gas can be estimated using methods detailed in this section. When TVOC emissions have been estimated, emissions of individual, speciated NPI VOCs should be estimated using the methods set out in section 5.1.4.

5.1.1 Estimating Fugitive and Venting Emissions Based on a Greenhouse Gas Emissions Inventory

An existing greenhouse gas emissions inventory for a facility can be used to determine fugitive and vented emissions of NPI substances. Many NPI reporters have an in-depth understanding of fugitive/vented methane emissions as part of greenhouse gas reporting, such as for National Greenhouse and Energy Reporting (NGER). The total amount of gas lost can then be used to determine emissions of the substances (total VOC, benzene, etc.) that are required to be reported under NPI. Refer to Section C.2 of Appendix C for an example of how VOC emissions can be calculated. If there is no greenhouse inventory for the facility and there is insufficient information available to use Section 5.1.3, then please refer to the latest version of the NGER Technical Guidelines (DIICCSRTC, 2012) for guidance on developing an inventory of methane emissions for your facility.

The NPI emissions based on the greenhouse gas (methane) inventory are estimated using the following equation:

$$E_i = ME \div \frac{C_M}{100} \times C_i$$

where:

E_i	=	Emissions of NPI substance i	(kg/yr)
ME	=	Total mass of methane emissions	(kg/yr)
C_M	=	Concentration of methane in the gas	(wt %)
C_i	=	Concentration of NPI substance i in the gas	(kg/kg)

In the absence of site specific composition data, the compositions provided in Appendix B may be used.

5.1.2 Process Fugitives

If a comprehensive greenhouse gas emissions inventory is not available for the facility, fugitive emissions can be estimated using the methods provided in this section. Process fugitive sources within the oil and gas extraction and production sectors include:

- valves
- flanges
- pumps
- connectors
- compressors
- drains (onshore).

Two methods of calculation are available to estimate fugitive emissions, depending on the level of site-specific data available. These methods are described below. It is likely that Method 1 will be suitable for the majority of facilities.

Method 1

Fugitive emissions of total VOCs from general leaks can be estimated using the following emission factor:

Total VOC from general leaks = 7.0×10^{-3} kg/t throughput.

This emission factor was developed by APPEA (1997) for characterising fugitive emissions from the oil and gas extraction and production industry in Australia. The composition of the emitted Total VOC can be calculated using the technique presented in Section 5.1.4.

Method 2

In this method, process fugitive emission factors are presented on a 'per individual source' basis. However, the factors are most valid for estimating emissions from a population of equipment, and are not intended for use when estimating emissions from an individual piece of equipment over a short time period (e.g. several hours).

These average emission factors have been derived from the US EPA (1995) and API (1996) and are provided in Table 5. The definitions in Table 6 should be used when determining the type of 'service' a particular piece of equipment is in, so that the appropriate emission factors are used.

The following data are required for this method:

- number of each type of component (e.g. valves, flanges, etc.) in each process unit
- service each component is in (e.g. gas, light liquid, heavy liquid, water/oil)
- average weight fraction of TOC within the service
- operational hours in the reporting year for each type of equipment and service.

Process fugitive emissions can be calculated for each equipment type and service using the following equation:

$$E_{\text{TOC}} = F_A \times W_{\text{TOC}} \times N \times H$$

where:

- E_{TOC} = Emissions of TOC from all sources grouped in a particular equipment type and service (e.g. valves in light liquid service) (kg/yr)
- F_A = Applicable average emission factor for the given equipment type and service (kg/hr/source)
- W_{TOC} = Average weight fraction of TOC for the service (-)
- N = Number of pieces of equipment for the given equipment type and service (-)
- H = Operational hours in the reporting year for the given equipment type and service (hr/yr)

The total facility process fugitive emissions will then be the sum of TOC emissions calculated for each equipment type and service.

The composition of the emitted TOC (including total VOC emissions) can be calculated using the technique presented in Section 5.1.4. An example calculation is provided in Section C.1 of Appendix C.

Table 5 – Emission Factors for Oil and Gas Processes - Average TOC

Equipment Type	TOC Service Emission Factor (kg/hr/source)			
	Gas	Heavy Oil	Light Oil	Water/Oil
Valves ^a	4.5×10^{-3}	8.4×10^{-6}	2.5×10^{-3}	9.8×10^{-5}
Pump Seals ^a	2.4×10^{-3}	NA ^c	1.3×10^{-2} ^e	2.4×10^{-5}
Others ^a	8.8×10^{-3}	3.2×10^{-5}	7.5×10^{-3}	1.4×10^{-2}
Connectors ^{a,d}	2.0×10^{-4}	7.5×10^{-6}	2.1×10^{-4}	1.1×10^{-4}
Flanges ^a	3.9×10^{-4}	3.9×10^{-7}	1.1×10^{-4}	2.9×10^{-6}
Open-ended Lines ^a	2.0×10^{-3}	1.4×10^{-4}	1.4×10^{-3}	2.5×10^{-4}
Drains (onshore) ^b	3.2×10^{-2}	3.2×10^{-2}	3.2×10^{-2}	3.2×10^{-2}

a. Source: US EPA (1995) & API (1996).

b. Source: *NPI Manual for Petroleum Refining*.

c. Insufficient data available.

d. Defined as non-flanged connectors.

e. Applicable to agitator seals where no other data is available.

Table 6 – Definition of Material Moved by or Through Different Types of Equipment

Service Type	Definition
Gas/vapour	Material is in a gaseous state at operating conditions.
Light liquid	Material is in a liquid state in which the sum of the concentrations of individual constituents with a vapour pressure over 0.3 kilopascals (kPa) at 20°C, is greater than or equal to, 20 weight percent (wt %).
Heavy liquid	Material does not fall under the classifications for gas/vapour or light liquid service.
Water/Oil	Water streams in oil service with a water content greater than 50%, from the point of origin to the point where the water content reaches 99%. For water streams with water content greater than 99%, the emission rate is considered negligible.

Source: API (1996)

5.1.3 Venting Waste Gas

If a comprehensive greenhouse gas emissions inventory is not available for the facility, vented emissions can be estimated using the method provided in this section. The amount of waste gas vented can be calculated using a mass balance approach as described below:

$$GV = GP - (GS + GF + GFI)$$

where :

GV	=	Mass of gas vented	(kg)
GP	=	Mass of gas produced	(kg)
GS	=	Mass of gas sold/processed	(kg)
GF	=	Mass of gas lost as fugitive emissions	(kg)
GFI	=	Mass of gas flared	(kg)

If there is insufficient information available to use this method, refer to Section 5.1.1. The composition of the emitted total VOC can be calculated using the technique presented in Section 5.1.4

5.1.4 Speciation of Total Volatile Organic Compound Emissions

Once total VOC emissions have been estimated, emissions must be speciated into NPI-listed substances.

Default speciation data, reflecting “typical” speciated composition of NPI listed organic compounds for oil and gas facilities, are provided in Appendix B. If site-specific speciation data are available, these should be used in preference to the default speciation data provided.

If the Total Organic Compounds (TOC) emission rate has been calculated, the speciation factors can be used to calculate the total VOC emission rate using the following equation:

$$E_{\text{VOC}} = E_{\text{TOC}} \times \text{WP}_{\text{VOC}}$$

where:

- E_{VOC} = The total VOC mass emission rate from the piece of equipment (mass/time)
- E_{TOC} = The TOC mass emission rate from the piece of equipment (mass/time)
- WP_{VOC} = The VOC speciation fraction obtained from speciation data, as a fraction of TOC (-)

Once the total VOC emission rate has been calculated, the speciation factors can be used to calculate emissions of NPI listed organic substances using the following equation:

$$E_i = E_{\text{VOC}} \times (\text{WP}_i / \text{WP}_{\text{VOC}})$$

where:

- E_i = The mass emission rate of pollutant *i* from the equipment (mass/time)
- E_{VOC} = The total VOC mass emission rate from the piece of equipment (mass/time)
- WP_i = The speciation fraction of pollutant *i* obtained from speciation data, as a fraction of TOC (-)
- WP_{VOC} = The VOC speciation fraction obtained from speciation data, as a fraction of TOC (-)

An example calculation is provided in Section C.1 of Appendix C.

5.1.5 Gas Dehydration

Glycol dehydration is the most common process for removing water vapour from natural gas. It is frequently used to prevent the occurrence of hydrates in gas gathering systems, and at gas processing plants to satisfy sales specifications.

Assuming that gas vented from the dehydration process is not combusted, emissions and usage of ethylene glycol/methanol can be estimated to be equal to the amount of ethylene glycol/methanol purchased each year. This also assumes that stock movements remain relatively constant over time, which is a reasonable assumption for most facilities. Note that if ethylene glycol/methanol is emitted to water rather than air, it should be reported as an emission to water.

5.1.6 Loading Crude Product onto Tankers

Emissions from crude oil loading operations can be estimated using the emission factors provided in Table 7.

Table 7 – Emission Factors for Crude Oil Loading Operations - Total VOC

Emission Source	Emission Factor (kg/m ³ transferred)
Rail Tank Cars/Tank Trucks Loading Losses ^a	
Submerged loading (dedicated normal service)	0.24
Submerged loading (vapour balance service)	0.40
Splash loading (dedicated normal service)	0.58
Splash loading (vapour balance service)	0.40
Marine Vessel Loading Losses ^b	
Ships/Ocean barges	0.073
Barges	0.12

a. Source: Table 5.2-5 of Section 5.2 of AP42 (US EPA, 2008).

b. Source: Table 5.2-6 of Section 5.2 of AP42 (US EPA, 2008).

The composition of the emitted total VOC can be calculated using the technique presented in Section 5.1.4.

5.1.7 Storage Tanks

Fugitive emissions from storage tanks include evaporative losses from filling and transfer operations as well as standing losses. For the purposes of fugitive emissions estimation, storage tanks are:

- fixed roof tanks
- floating roof tanks
- variable vapour space tanks.

The latest version of the *Emission Estimation Technique Manual for Fuel and Organic Liquid Storage* provides guidance on the estimation of emissions from facilities storing liquid fuels and organic liquids. Emission factors are listed for each tank type by climatic zone and fuel type in an Appendix of that Manual.

The *Emission Estimation Technique Manual for Fuel and Organic Liquid Storage* also provides reference to the US EPA TANKS 4.09D software to estimate emissions from fuel and organic liquid storage, which can be used to produce more accurate estimates of emissions from fuel and organic liquid storage. A user manual for TANKS 4.09D is provided in an Appendix of the Manual.

TANKS 4.09D requires information such as the physical characteristics of the storage tanks, typical atmospheric conditions (such as wind speeds and temperatures), the contents of the tank and throughput.

5.1.8 Venting from Crude Oil Storage Tanks on a Floating Production, Storage and Offloading facility

Venting from the crude oil storage tanks on a floating production, storage and offloading facility (FPSO) may be estimated using the following emission factor:

TOC vented from crude oil storage tanks on a FPSO = 0.022 kg/day/m³ of stored crude.

This factor is derived from Table 5.2-6 of Section 5.2 of AP 42 (US EPA, 2008), and relates to TOC losses from tankers in transit to refineries.

The composition of the emitted TOC (including total VOC emissions) can be calculated using the technique presented in Section 5.1.4.

5.2 Fuel Combustion

Fuel combustion activities that may be relevant to this industry include flaring, on-site power generation and fuel combustion in on-site vehicles. Each of these emission sources is described in further detail below.

5.2.1 Flaring

Gas is flared on oil and gas production installations for safety reasons. For example, a lack of process or transport capacity for gas, a continuous surplus gas flow, start ups, maintenance and emergency (need for pressure relief) could all lead to flaring actions.

The emissions of pollutants from flaring are either unburnt fuel or by-products of the combustion process.

In the absence of site-specific data, the emission factors presented in Table 8 may be used to estimate emissions from flaring.

Emission factors from the US EPA AP42, the California Air Resources Board (CARB) and the European Pollutant Release and Transfer Register (E-PRTR) Guidelines indicate that emissions of metals from flaring are negligible.

Table 8 – Emission Factors for Flaring

Substance	Gas kg/t of gas ^a	Liquids/Oil kg/t of liquid/oil ^a
Carbon monoxide (CO)	8.7 ^b	18
Oxides of nitrogen (NO _x)	1.5 ^b	3.7
Total VOCs	15 ^c	3.0
Particulate matter: PM _{2.5} , PM ₁₀ (non-smoking flares)	0 ^e	ND
Particulate matter: PM _{2.5} , PM ₁₀ (lightly smoking flares)	0.056 ^f	ND
Particulate matter: PM _{2.5} , PM ₁₀ (average smoking flares)	0.25 ^f	ND
Particulate matter: PM _{2.5} , PM ₁₀ (heavily smoking flares)	0.38 ^f	ND

a. Source: US EPA (1991).

b. Converted to SI units from lb/10⁶ Btu of gas to kg/t of gas using conversion factors (1050 Btu/ft³ and 359 ft³/lbmol) and a gas molecular weight of 16 lb/lbmol.

c. Based on assumed gas composition of 70% CH₄, 30% VOC by weight and destruction efficiency of 95%.

d. Section 3.3.2, Appendix A, E&P Forum (1994).

e. Based on soot, assumed to apply to PM_{2.5} and PM₁₀. Zero values should not be reported.

f. Converted from µg/L to kg/t of gas using conversion factors (359 ft³/lbmol, 28.32 L/ft³ and 2204.6 lb/t) and a gas molecular weight of 16 lb/lbmol.

The default emission factors of CO, NO_x, PM₁₀ and PM_{2.5} for gas flaring presented in Table 8 can be adjusted based on molecular weight (once site-specific gas composition is known). Approval must be obtained from your state or territory environmental agency to use this method. The emission factors can be adjusted using the following approach:

For CO, NO_x, PM_{2.5} and PM₁₀:

$$EF_C = \frac{EF_d}{\left(\frac{MW_{\text{gas-adjusted}}}{MW_{\text{gas-original}}}\right)}$$

Where:

EF _C	= Emission factor for CO, NO _x , PM _{2.5} or PM ₁₀ corrected by new gas molecular weight.	(kg of CO, NO _x , PM _{2.5} or PM ₁₀ /t of gas flared)
EF _d	= Emission factor for CO, NO _x , PM _{2.5} or PM ₁₀ based on original gas molecular weight.	(kg of CO, NO _x , PM _{2.5} or PM ₁₀ /t of gas flared)
MW _{gas-adjusted}	= Molecular Weight of gas adjusted based on new gas molecular weight	(kg/mol)
MW _{gas-original}	= Molecular Weight of gas based on original gas molecular weight of 16 kg/mol	(kg/mol)

The total VOC default emission factor for gas flaring presented in Table 8 can be adjusted based on percentage of total VOC present in the gas (once site-specific gas composition is known), and the destruction efficiency. Approval must be obtained from your state or territory environmental agency to use this method. The following equation can be used to adjust the emission factor:

$$EF_{\text{VOC}} = \frac{P_{\text{VOC}}}{100} \times \left(1 - \frac{\text{DE}}{100}\right) \times 1000$$

Where:

EF _{VOC}	= Emission factor for total VOC	(kg total VOC /t of gas)
P _{VOC}	= Percentage of total VOC in gas	(%)
DE	= Destruction efficiency of total VOC (default 95%)	(%)

The composition of the emitted total VOC can be calculated using the technique presented in Section 5.1.4.

5.2.2 Power Generation

Stationary diesel engines are used to supply mechanical power to operate drilling (rotary table), mud pumping and hoisting equipment, and may also be used to operate pumps or auxiliary power generators. Gas fired combustion engines are used in the natural gas industry at gas wells, pipeline compressor and storage stations.

The latest version of the *Emission Estimation Technique Manual for Combustion in Boilers* provides emission estimation techniques to estimate emissions associated with fuel combustion in boilers. That Manual presents default emission factors for various combinations of process, fuel and pollution control devices used at Australian facilities.

The latest version of the *Emission Estimation Technique Manual for Combustion Engines* provides emission estimation techniques to estimate emissions associated with fuel combustion in stationary engines. That Manual presents default emission factors for stationary engines.

5.2.3 Vehicle Exhaust

The latest version of the *Emission Estimation Technique Manual for Combustion Engines* provides emission estimation techniques to estimate emissions associated with fuel combustion in vehicles. This Manual presents emission factors for road transport vehicles and industry vehicles, respectively.

5.3 Dust Emissions

Fugitive emissions of particulate matter can be generated by a number of sources including the movement of vehicles over various surfaces, drilling and wind erosion of exposed areas.

When total suspended particulate emissions have been estimated, speciation is performed using the weight fractions of trace metals in the emissions. In the absence of other information, particulate emissions from fugitive sources can be assumed to have the same concentration as at the source.

A list of naturally occurring concentrations of elements reportable under the NPI in various materials may be found in the latest version of the *Emission Estimation Technique Manual for Mining*.

5.3.1 Wheel Generated Dust on Unpaved Roads

EETs for wheel generated dust on unpaved roads are provided in the latest version of the *Emission Estimation Technique Manual for Mining*.

An EET is provided for unpaved roads at industrial sites and for light duty vehicles. Both EETs are based on vehicle kilometres travelled and are derived from Chapter 13.2.2 of AP 42 (US EPA, 2006).

The EET for industrial sites requires data for the vehicle gross mass and the silt content of the road material to calculate dust emissions. The EET for light vehicles requires vehicle speed, silt content and moisture content data for the road material to calculate dust emissions.

In the absence of site-specific data, information on vehicle mass and moisture and silt contents for US mines can be found in Section 11.9 (Table 11.9-3) of AP 42 (US EPA, 1998a). Typical silt content values of surface material on industrial unpaved roads are provided in Section 13.2.2 (Table 13.2.2-1) of AP 42 (US EPA, 2006).

5.3.2 Wheel Generated Dust on Paved Roads

Wheel generated dust can also be generated from paved roads. An EET for estimating dust emissions from paved roads is presented in Section 13.2.1 of AP 42 (US EPA, 2011). This EET is based on vehicle kilometres travelled and requires data for the road surface silt loading and average weight of the vehicles travelling on the road.

In the absence of site-specific data, information on vehicle mass and silt content for US mines can be found in Section 11.9 (Table 11.9-3) of AP 42 (US EPA, 1998a). The typical silt content values for paved roads at industrial facilities are provided in Section 13.2.2 (Table 13.2.2-1) of AP 42 (US EPA, 2006).

5.3.3 Drilling

An EET for drilling is provided in the latest version of the *Emission Estimation Technique Manual for Mining*.

The default TSP emission factor is sourced from Table 11.9-4, Section 11.9 of AP 42 (US EPA, 1998a). The PM₁₀ emission factor has been derived using the default PM₁₀ fraction sourced from SPCC (1983). These default emission factors are based on number of holes drilled.

5.3.4 Open Area Wind Erosion

A variety of EETs for wind erosion from open areas is provided in Section 3.2.5 of the latest version of the *Emission Estimation Technique Manual for Fugitive Emissions*.

That manual provides a default method for estimating particulate matter emissions based on the amount of area exposed (in ha). Two additional methods for estimating emissions from open areas are also described. Those methods, although more accurate, require site-specific information that may not be available in all cases.

6 Emissions to Water

Within the oil and gas extraction and production industry, emissions to water may occur due to:

- discharge of treated PFW
- drilling fluid losses
- spills and leaks.

PFW may either be re-injected or treated and discharged from the facility. At onshore facilities, PFW is likely to be treated at a common point while offshore facilities are likely to discharge PFW from a number of points.

It should be noted that the re-injection of PFW is classified as a transfer under the NPI if the PFW has been modified. Guidance on determining which wastewater streams are classified as transfers is provided in Section 4 of the *NPI Guide* and Section 8 of this Manual.

Discharges of triggered NPI substances are considered emissions to water if emitted to surface waters (lakes, rivers, dams, estuaries), coastal or marine waters, or contained in stormwater runoff.

Most facilities emitting NPI substances to water are required by their State or Territory environment authority to closely monitor and measure these emissions. Existing sampling data can be used to calculate annual emissions to the NPI and is generally the most accurate method for determining emissions. Direct measurement data can be supplemented by a range of data including manufacturers' specifications for treatment packages and material/chemical mass balance.

The mass balance EETs provided in Section 7 may be used to estimate emissions to water associated with drilling fluid losses and spills and leaks.

7 Emissions to Land

Within the oil and gas extraction and production industry, emissions to land may occur due to:

- drilling fluid/other drilling additive losses
- spills and leaks.

Emission estimation techniques for these sources are provided below.

7.1 Drilling Fluid/Other Drilling Additive Losses

Losses of drilling fluids (or other chemicals and materials used to aid well development), and the NPI substances they contain, may be estimated using a mass balance. The mass balance needs to take into account:

- total volume of drilling fluid/additive used
- down hole losses (such losses are required to be reported as releases to land)
- volume of drilling fluid/additive recovered.

The first step is to determine the volume of losses to the environment. These losses are likely to include down-hole losses (most likely to land) and other losses (which could be to land or water).

The equation to determine the volume lost to the environment is:

$$V_L = V_T - V_R$$

Where:

V_L	=	Volume lost to the environment	(L)
V_T	=	Total volume of fluid/additive used	(L)
V_R	=	Volume of fluid/additive recovered	(L)

In order to estimate the emission of NPI substances to the environment, the 'Volume lost to the environment' for each relevant NPI substance must be multiplied by the concentration of that NPI substance in the drilling fluid/additive. Only substances that exceed an NPI reporting threshold need to be considered.

The concentration of NPI substances in drilling fluids/additives will vary according to the type and manufacturer of drilling fluid/additive used. It is recognised that information on the composition of these materials is not readily available. Therefore, information on the concentration of NPI substances in drilling fluids and additives will need to be derived from suppliers and manufacturers, or by direct measurement of NPI substances in liquid and solid materials that have been injected.

The equation to estimate the emission of NPI substances to the environment is:

$$E = V_L \times C \div 1,000,000$$

Where:

E	=	Emission of NPI substance	(kg)
V_L	=	Volume lost to the environment	(L)
C	=	Concentration of NPI substance in drilling fluid/additive	(mg/L)

7.2 Spills and Leaks

A mass balance EET can also be applied to emissions of NPI substances as a result of accidental spills and leaks.

A mass balance requires consideration of:

- the total volume of material spilled or leaked
- the volume of material recovered.

The difference between these volumes would be considered to be emissions to the environment.

As with drilling fluids, the proportion of NPI substances within the material must be determined. Emissions of NPI substances to the environment can then be estimated by multiplying the volume of material lost to the environment by the proportion of NPI substances present in the spilled material.

Information on the composition of spilled materials may be obtained from either suppliers or manufacturers, or through direct measurement.

8 Transfers of NPI Substances

General information regarding transfers of NPI substances can be located in the NPI Guide and the Transfers Information Booklet.

For each substance triggered in Category 1, Category 1b or Category 3, any transfers of that substance within the waste streams are required to be reported.

Within the oil and gas extraction and production industry, mandatory transfers may include:

- reinjection of modified Produced Formation Water (PFW) and gas
- disposal of pond sludge to landfill
- discharge to an off-site treatment facility
- discharge to an off-site sewerage system
- discharge to a destination for containment, such as balancing pond or other long term purpose built waste storage facility.

Voluntary transfers may be reported where the NPI substances in the waste are to be used for reuse, recycling, reprocessing, purification, partial purification, immobilisation, remediation or energy recovery. As noted in the Transfers Information Booklet, individual substances in effluent used for irrigation (or in spreading of solids) will only be considered as reuse when evidence exists that the substance, in the concentration range present, provides a demonstrable benefit to the receiving land. Otherwise it should be reported as an emission to land. In general, total nitrogen and total phosphorous will be considered beneficial, while substances such as mercury or lead will not.

Within the oil and gas extraction and production industry, voluntary transfers may include:

- reuse of treated PFW, including irrigation or dust mitigation
- recycle/reuse of salt following on-site brine treatment.

While the reinjection of PFW is classed as a transfer if it has been modified, any NPI substances contained in production chemicals that are added to the PFW (such as scale inhibitor) must be reported as an emission (most likely to land) if the substance's reporting threshold is exceeded.

9 Next Steps for Reporting

This manual has been written to reflect the common processes employed by oil and gas extraction and production facilities. To ensure a complete report of the emissions and transfers from the facility, it may be necessary to refer to other EET manuals and guidance material such as:

- *Emission Estimation Manual for Combustion in Boilers*
- *Emission Estimation Manual for Combustion Engines*
- *Emission Estimation Manual for Fuel and Organic Liquid Storage*
- *Emission Estimation Manual for Fugitive Emissions*
- *Emission Estimation Manual for Mining*
- *Emission Estimation Manual for Petroleum Refining*
- *Transfers Information Booklet.*

When estimates of substance emissions and transfers from the facility are complete, report the emissions and transfers according to the instructions in the NPI Guide.

10 References

API, 1996, *Calculation Workbook for Oil and Gas Production Equipment Fugitive Emissions*, API Publication 4638, American Petroleum Institute, Washington, DC.

APIA, 2011, *API Fact Sheet 2 – 2011*, The Australian Pipeline Industry Association, Kingston, ACT.

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<http://www.epa.gov/ttn/chie/ap42/ch11/final/c11s09.pdf>

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<http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s0202.pdf>

US EPA, 2008, *Emission Factor Documentation for AP-42, Section 5.2 Transportation and Marketing of Petroleum Liquids*, United States Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC, USA.
<http://www.epa.gov/ttnchie1/ap42/ch05/final/c05s02.pdf>

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<http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s0201.pdf>

Wray, H. A. 1992, *Manual on flash point standards and their use: methods and regulations*, American Society for Testing and Materials, Philadelphia, PA.

The following EET Manuals and guidance material were referenced in this Manual and are available at the NPI Homepage (<http://www.npi.gov.au>) or from your local state or territory environmental authority:

- *Emission Estimation Manual for Combustion in Boilers*
- *Emission Estimation Manual for Combustion Engines*
- *Emission Estimation Manual for Fuel and Organic Liquid Storage*
- *Emission Estimation Manual for Fugitive Emissions*
- *Emission Estimation Manual for Mining*
- *Emission Estimation Manual for Petroleum Refining*
- *Transfers Information Booklet*.

The following software has been referenced in this Manual:

TANKS 4.09D

This software may be downloaded from the USEPA at the following website:
<http://www.epa.gov/ttnchie1/software/tanks/>

Appendix A: Definitions and Abbreviations

ANZSIC	Australian and New Zealand Standard Industrial Classification
AP- 42	AP-42, Fifth Edition, Compilation of Air Pollutant Emission Factors
API	American Petroleum Institute
APIA	Australian Pipeline Industry Association
APLNG	Australia Pacific LNG Project
APPEA	Australian Petroleum Production and Exploration Association
ASTM	Australian Standard Test Method
CARB	California Air Resources Board
CSG	Coal Seam Gas
DIICCSRTE	Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education
EET	Emission Estimation Technique
EF	Emission factor
Emission	For the purpose of NPI reporting means the release of a substance to the environment, whether in pure form or contained in other matter, and whether in solid, liquid or gaseous form. It does not include the transfer of a substance; however, it does include the release of a substance to the environment, during transfer and from a transfer destination.
E-PRTR	European Pollutant Release and Transfer Register
Facility	Any building, land or offshore site from which an NPI substance may be emitted, together with any machinery, plant, appliance, equipment, implement, tool or other item used in connection with any activity carried out.
FPSO	Floating Production, Storage and Offloading Facility
LNG	Liquefied Natural Gas
Mandatory reporting transfer destination	For the purposes of NPI reporting, mandatory reporting transfer destination means destination for containment, including landfill, tailings storage facility, underground injection or other long term purpose-built waste storage structure; an off-site destination for destruction; an off-site sewage system; or an off-site treatment facility which leads solely to one or more of the above.
MSDSs	Material Safety Data Sheets
NEPM	National Environment Protection Measure
NGER	National Greenhouse and Energy Reporting
NPI	National Pollutant Inventory
ORS	Online reporting system
PFW	Produced Formation Water – Water that is present within the oil or gas reservoir, which is extracted with the oil or gas. This water may also be called; produced water, formation water, associated water or incidental water.
PM	Particulate Matter
PM _{2.5}	Particulates which have an aerodynamic diameter equal to or less than 2.5 micrometres ($\leq 2.5 \mu\text{m}$)
PM ₁₀	Particulates which have an aerodynamic diameter equal to or less than 10 micrometres ($\leq 10 \mu\text{m}$)
RVP	Reid Vapour Pressure
SDSs	Safety Data Sheets
SPCC	State Pollution Control Commission
t	Tonne
TET	Transfer emission technique
TEG	Tri ethylene glycol
TOC	Total Organic Compounds
Total VOC	Total Volatile Organic Compounds For the purpose of NPI reporting, total VOC are defined as any chemical compound based on carbon chains or rings with a vapour pressure greater than 0.01 kPa at 293.15 K (i.e. 20°C), that participate in atmospheric photochemical reactions. Specifically excluded are: carbon monoxide,

methane,
acrylamide,
benzene hexachloro,
biphenyl,
chlorophenols,
n-dibutyl phthalate,
ethylene glycol,
di-(2-ethylhexyl) phthalate (DEHP),
4,4-methylene bis 2,4 aniline (MOCA),
methylenebis,
phenol, and
toluene-2,4-diisocyanate.

Transfer	The transport or movement, on-site or off-site, of substances contained in waste for: containment; destruction; treatment that leads to: reuse, recycling or reprocessing; purification or partial purifications; remediation; or immobilisation; energy recovery.
TSP	Total Suspended Particulate
Usage	The handling, manufacture, import, processing, coincidental production or other use of the substance.
US EPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds
Voluntary reporting transfer destination	Means a destination for reuse, recycling, reprocessing, purification, partial purification, immobilisation, remediation or energy recovery.

Appendix B: Composition Data

B.1 Produced Formation Water

A typical composition for produced formation water is provided in Table 9. This composition should only be used if site-specific data is unavailable. Other substances that may be present in PFW include, but are not limited to:

- ammonia (total)
- boron and compounds
- chlorine and compounds
- cobalt and compounds
- fluoride compounds
- polycyclic aromatic hydrocarbons (expressed as B[a]P_{eq})
- selenium and compounds.

Table 9 – Typical Produced Formation Water Composition Data

Substance	Concentration (mg/L)
Arsenic and compounds	0.0010
Benzene	1.0
Cadmium and compounds	0.0063
Chromium (III) compounds	0.0070
Copper and compounds	0.0074
Ethylbenzene	0.071
Lead and compounds	0.0066
Manganese and compounds	1.7
Mercury and compounds	0.0010
Nickel and compounds	0.0099
Phenol	3.6
Toluene	1.5
Total VOC	3.431
Xylenes (individual or mixed isomers)	0.86
Zinc and compounds	0.0063

Source: APPEA (1998)

B.2 Oil

Typical compositions for oil are provided in Table 10. These compositions should only be used if site-specific data are unavailable.

Table 10 – Typical Oil Composition Data Based on Total Organic Compounds

Substance	Composition (kg/kg)		
	Heavy Oil	Light Oil	Water/Oil
Benzene	9.4×10^{-3}	1.2×10^{-3}	1.2×10^{-3}
Ethylbenzene	5.1×10^{-4}	1.6×10^{-4}	1.6×10^{-4}
n-Hexane	7.5×10^{-3}	2.3×10^{-2}	2.3×10^{-2}
Toluene	3.4×10^{-3}	1.1×10^{-3}	1.1×10^{-3}
Total VOC	3.0×10^{-2}	3.0×10^{-1}	3.0×10^{-1}
Xylenes (individual or mixed isomers)	3.7×10^{-3}	3.3×10^{-4}	3.3×10^{-4}

Source: API (1996)

Crude oil may also contain NPI heavy metals, boron and fluoride, and the estimation of emissions of these substances should be considered.

B.3 Gas

Typical compositions for conventional gas and coal seam gas are provided in Table 11. These compositions should be used if site-specific data are unavailable. The data for coal

seam gas could also be used as a representation of tight gas or shale gas if no other data are available.

Table 11 – Typical Gas Composition Data

Substance	Composition (mass %)	
	Conventional Gas	Coal Seam Gas ^a
Benzene	$5.18 \times 10^{-2} \text{ e}$	$2.18 \times 10^{-4} \text{ e}$
Ethyl-benzene	$2.25 \times 10^{-3} \text{ e}$	$9.50 \times 10^{-6} \text{ e}$
n-Hexane	$3.78 \times 10^{-1} \text{ b}$	$2.19 \times 10^{-3} \text{ e}$
Methane	$7.91 \times 10^1 \text{ b}$	$9.46 \times 10^1 \text{ c}$
Toluene	$2.85 \times 10^{-2} \text{ e}$	$1.20 \times 10^{-4} \text{ e}$
Total VOCs	$1.28 \times 10^1 \text{ b}$	$5.41 \times 10^{-2} \text{ d}$
Xylenes (individual or mixed isomers)	$6.76 \times 10^{-3} \text{ e}$	$2.85 \times 10^{-5} \text{ e}$

a. May be used for shale gas or tight gas if site-specific gas composition data is unavailable.

b. Source: APIA (2011).

c. Average methane mass percentage sourced from APIA (2011), APLNG (2010), Arrow Energy (2012), QGC (2009) and Santos (2009).

d. Average total VOC mass percentage sourced from APLNG (2010), Arrow Energy (2012), QGC (2009) and Santos (2009).

e. Speciated from total VOC using mass fraction of total VOC and given substance sourced from API (1996).

Appendix C: Example Calculations

This section provides example calculations for determining emissions from various sources. It is intended to provide guidance on determining emissions from a range of sources. It must be noted that total facility emissions are determined by calculating emissions from individual sources, and then adding each of these estimates for a cumulative total.

C.1 Process Fugitives – Method 2

An example facility equipment inventory is shown in Table 12.

Table 12 – Facility Equipment Inventory

Equipment	Number
Valves	1,000
Open-ended lines	500
Pump seals	600
Connectors	560
Flanges	230
Others	430

Of the 1,000 valves, 350 are in light oil service. It is ascertained that on average, the light oil stream is 80 weight percent (wt %) TOC and 20 weight percent (wt %) water vapour. It is estimated that these valves operate for 7,400 hours per year. The light oil service emission factor for valves from Table 5 is 2.5×10^{-3} kg/hr/source.

The following equation from Section 5.1.1 is applied to calculate the TOC emission rate:

$$\begin{aligned}
 E_{\text{TOC}} &= F_A \times W_{\text{TOC}} \times N \times H \\
 &= 2.5 \times 10^{-3} \times 0.8 \times 350 \times 7,400 \\
 &= 5,000 \text{ kg/yr}
 \end{aligned}$$

The composition of the emitted TOC (including total VOC emissions) can then be calculated using the speciation fractions provided in Table 10 for light oil and the equations from Section 5.1.4, as shown in Table 13.

Table 13 – Speciated NPI Substances

TOC Emission Rate (kg/year)	NPI Substance	Weight Fraction of Substance for Light Oil (kg/kg)	NPI Substance Emissions (kg/yr)
5,000	Benzene	1.2×10^{-3}	6.2
5,000	Ethylbenzene	1.6×10^{-4}	0.83
5,000	n-Hexane	2.3×10^{-2}	120
5,000	Toluene	1.1×10^{-3}	5.7
5,000	Total VOCs	3.0×10^{-1}	1,600
5,000	Xylenes (individual or mixed isomers)	3.3×10^{-4}	1.7

This process would be carried out for all component streams at the facility, providing a facility-wide fugitive emission estimate.

C.2 Estimating Fugitive and Venting Emissions Based on a Greenhouse Gas Emissions Inventory

A CSG processing facility has a fugitive and venting inventory of 730,000 kg/yr of methane (reported through NGER). The facility's gas is 96% methane by weight, and the composition of NPI substances is not known.

The NPI emissions based on the greenhouse (methane) inventory are estimated using the following equation:

$$E_i = ME \div \frac{C_M}{100} \times C_i$$

where:

E_i	=	Emissions of NPI substance i	(kg/yr)
ME	=	Total mass of methane emissions	(kg/yr)
C_M	=	Concentration of methane in the gas	(wt %)
C_i	=	Concentration of NPI composition i in the gas	(kg/kg)

Using the aforementioned equation, the total emissions of VOC (using the typical composition for CSG provided in Table 11) are derived as follows:

$$E_{VOC} = ME \div \frac{C_M}{100} \times C_{VOC}$$

$$E_{VOC} = 730,000 \frac{\text{kg methane}}{\text{year}} \div \frac{96 \text{ kg methane}}{100 \text{ kg gas}} \times 5.41 \times 10^{-4} \frac{\text{kg VOC}}{\text{kg gas}}$$

$$E_{VOC} = 411.4 \frac{\text{kg VOC}}{\text{year}}$$

However, if it is known that the concentration of VOC in the CSG is 0.01% (or 1×10^{-4} kg/kg), then that value should be used instead of 5.41×10^{-4} kg/kg.