Australian Government
Department of the Environment and Water Resources

National Pollutant Inventory

Emission estimation technique manual

for

Intensive livestock - beef cattle Version 3.1 May 2007

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Erratum for intensive livestock – beef cattle emission estimation technique (EET) manual

(Version 3.1 – May 2007)

Page	Outline of alteration
50,51	Clarification of alternative reporting arrangement for owner occupiers of beef cattle feedlots, with respect to contact and facility details.

(Version 3.0 – November 2006)

The ammonia emission factor has been revised from 82.4 kg to 70 kg.

Specific changes to the revised version (2.1) are outlined below:

Page	Outline of alteration
7,8	SCU from 120 to 143 as a result of emission factor from 82.4 kg to 70 kg
16	Table 5
18-19	Example 5 calculations using updated emission factor
41	Example 11
42-45	Example 12
46-47	Appendix D and E worksheets reflect updated emission factor
50-52	Appendix F simplified reporting form for smaller operations only reporting ammonia emissions.

Version 2.0 - 23 February 2001 – Previous version issued December 1999. The revised version (2.0) has had extensive revision and the major changes are outlined below. General changes are:

- steps outlined for all major calculations and these are transposed to new examples and worksheets.
- use of ammonia emission factor rather than the previous more complex calculations.

Specific changes are:

Page	Outline of alteration
2 Table 1	New table outlining manual.
5 Figure 1	Updated process diagram to highlight main emission sources.
7 Example 1	Simplified calculation using an ammonia emission factor developed from data in manual. Previous example is now in appendix C (example 11).
9 Example 2	Updated Category 2 threshold calculation for single fuel usage to reflect steps used AND new fuel data as in NPI guide.
10 Table 2	More comprehensive fuel data that is the same as in NPI guide. Fuel threshold levels for single fuel usage is also provided.
11 Example 3	New example for fuel thresholds using more than one fuel type with updated fuel property data.
12 Table 3	Deleted manganese from Category 2b list – manganese is not a 2b substance.
13 Table 4	Changed default nitrogen level in water to 250 mg/L based on reference check.
14 Example 4	Altered and simplified Category 3 threshold calculation highlighting that it is only required for emissions to water bodies.
17	New table of ammonia emission factors based on default data in the tables to

Table 7	simplify facility ammonia emission estimation.
18 Example 5	Replaces and simplifies previous example 3. Based on emission factors in Table 7. The previous example 3 is now example 12 in Appendix C
19	Changed PM_{10} emission factor from 17.3 tonnes PM_{10}/1000 head of cattle to 11.7 tonnes PM_{10}/1000 SCU stock capacity. This is in line with more relevant research as detailed in the manual.
20 Example 6	Updated PM_{10} calculation to reflect new cattle emission factor (see above) and updated emission factors in combustion engines EET manual version 2.1 (6 Sep 2000). Aimed to add more realism to example.
25	Added various references so that all data in manual has its source listed.
39	Appendix C now includes Example 11 and 12, which in the previous version of the manual were Example 1 and 3.
46-49	Appendices D to F are new worksheets which aim to simplify the threshold and emission calculations required by facilities.

EMISSION ESTIMATION TECHNIQUES
FOR
INTENSIVE LIVESTOCK – BEEF CATTLE
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EMISSION ESTIMATION TECHNIQUES
FOR
INTENSIVE LIVESTOCK – BEEF CATTLE
LIST OF FIGURES, TABLES AND EXAMPLES

1.0 Introduction

The purpose of emission estimation technique (EET) manuals is to assist Australian manufacturing, industrial and service facilities to report emissions of listed substances to the National Pollutant Inventory (NPI). This manual describes the procedures and recommended approaches for estimating emissions from facilities engaged in intensive beef cattle production; that is, the operation of beef cattle feedlots.

A beef feedlot is a confined area with watering and feeding facilities where cattle are completely hand or mechanically fed for the purpose of production (ARMCANZ, 1997).

Feedlot operations consist of a number of activities including feedstock storage, feeding systems, animal housing, disposal of biological matter, waste removal/storage and waste treatment.

EET MANUAL:	Intensive livestock – beef cattle	
HANDBOOK:	Intensive livestock (beef cattle)	
ANZSIC CODE:	1993	0125
	2006	0143

Note that the ANZSIC code is part of NPI reporting requirements.

This manual has been developed through a process of national consultation involving state and territory environmental authorities and key industry stakeholders. Particular thanks is due to the Australian Lot Feeders Association (ALFA) and its members for their assistance in the development of this manual

1.1 Manual outline

The following table outlines the various sections in the manual. If you are a NPI reporter you may wish to proceed directly to the section most applicable to your operation:

- smaller operations – smaller feedlot operations that have only a small or no combustion (such as boilers) or fuel storage can proceed directly to appendix G.
- medium and large operations – operators of these facilities should take note of various sections of this manual; and, in particular, the worksheets in appendices D to F. These facilities should report using the standard NPI reporting form (available from the NPI web site), or the electronic reporting tool, not the form in appendix G.

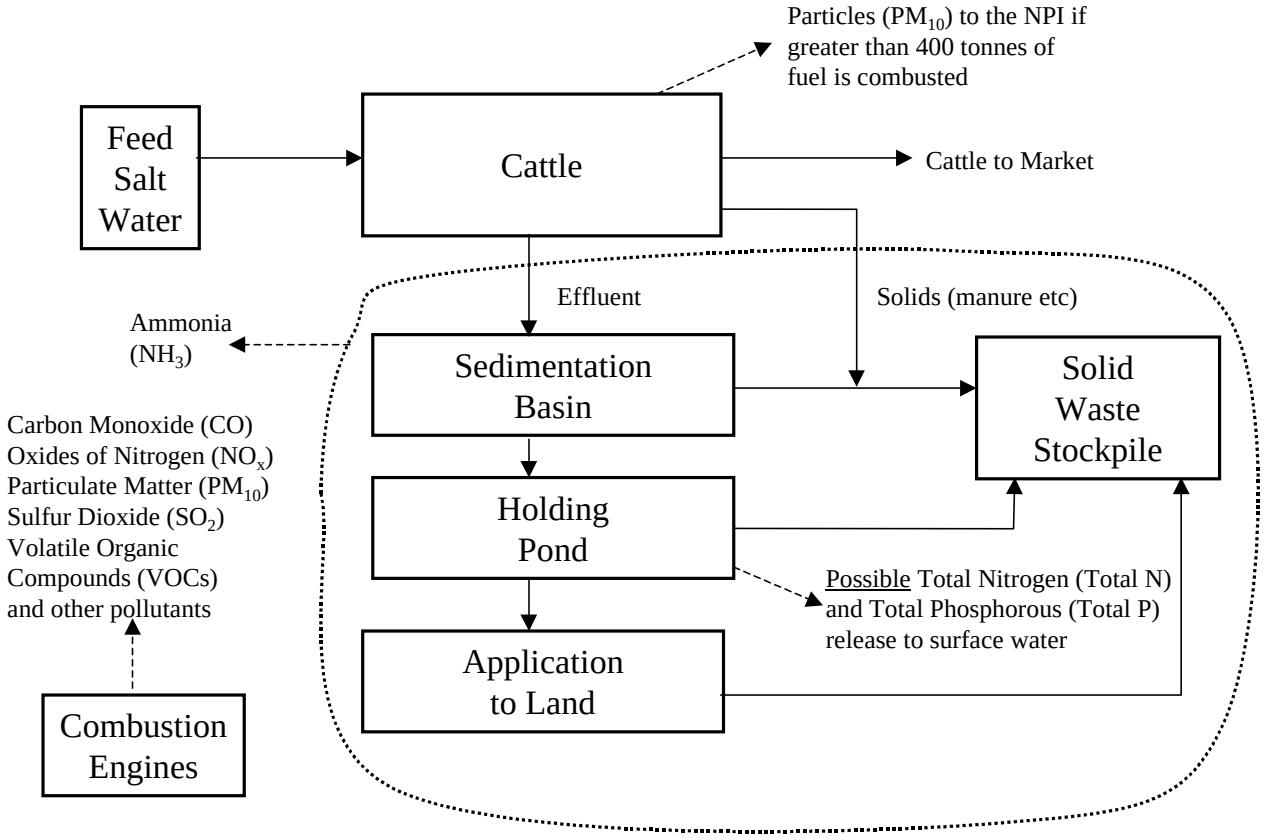
Table 1 - Outline of this manual

Section	Description
2.0 Processes and emissions	A brief overview of the beef cattle feedlot process and its emissions.
3.1 Transfers	Discusses material transfers with respect to the feedlot industry. In general, transfers are exempt from NPI reporting.
3.2 NPI substance reporting	Outlines substances on the NPI list that are likely to require reporting. Various thresholds determine if a substance is reported. Category 1, 2 and 3 substances are discussed in Sections 3.2.1, 3.2.2 and 0 respectively.
3.3 Emissions to destinations	Calculating emission to air such as ammonia and particulate matter 10 microns or less (PM_{10}) emissions. Sections 3.3 and 3.4 detail the expected emissions to air and water respectively from the industry. These sections also describe the sources of these emissions and where emission estimation techniques for each of these sources are to be found.
4.0 Glossary of technical terms and abbreviations	Glossary of technical terms and abbreviations used in this manual.
5.0 References	References used in the development of this manual
Appendix A	An overview of the four general types of emission estimation techniques: sampling or direct measurement; mass balance; engineering calculations and emission factors, as well as example calculations to illustrate their use. Reference to relevant sections of this Appendix is recommended in understanding the application of these techniques with particular respect to the beef cattle feedlot industry.
Appendix B	Discussion of the reliability and uncertainty involved with each of the techniques presented in Appendix A.
Appendix C	Variables and symbols used throughout this manual and detailed examples of threshold and emission estimation calculations.
Appendix D	Worksheet to assist in determining if Category 1, 2 and 3 thresholds are exceeded.
Appendix E	Worksheet to assist in estimating ammonia emissions.
Appendix F	Worksheet to assist in estimating PM_{10} dust emissions.
Appendix G	Simplified reporting form for smaller operations that only need to report emissions of ammonia.

2.0 Processes and emissions

This manual covers the beef cattle feedlot industry. These operations consist of a number of activities such as feedstock storage, feeding systems, animal housing, disposal of biological matter, vehicle operation, waste removal/storage and waste treatment. Some facilities may generate their own power by fuel combustion.

Figure 1 - Beef cattle feedlots: inputs and emissions



3.0 Reportable emission sources

This section outlines how to determine the emissions from your facility. Reporting emissions involves 2 steps:

1. Determining if the appropriate threshold is exceeded (see 3.2).
2. Estimating the emissions from your facility for substances whose threshold is exceeded.

An important point to understand is that transfers of substances are not currently classed as emissions. Transfers are discussed in 3.1.

The information you need to complete this reporting is:

- the stock capacity of your facility in Standard Cattle Units (SCU)
- the amount of fuel your facility used; *and*
- the amount of water, if any, that flowed from your waste water storage area to surface water bodies. Surface water includes dry water bodies.

If you have this information and the appropriate EET manuals, the worksheets in appendices D, E and F will allow you to estimate your facility's emissions.

If your facility has emission data available that is determined from your specific facility this data can be used instead of the industry average data that is used as the basis of the techniques outlined in this manual. This data may include:

- the nitrogen and phosphorous levels in your waste water storage facility
- the amount of water irrigated onto your farm or facility per SCU stock capacity; *and*
- fine dust emissions (or particulate matter, PM_{10}) from your facility per SCU stock capacity.

Contact your state or territory NPI Unit (contact details inside the front cover of the NPI Guide) for further details about using alternative techniques or parameters.

3.1 Transfers

Under the NPI, transfers are not currently reported. The following are classed as transfers:

- discharges of substances to sewer;
- deposit of substances to landfill; and
- removal of substances from a facility for destruction, treatment, recycling, reprocessing, recovery, or purification.

For feedlots, NPI substances contained in water for on-site irrigation of effluent and waste-water are an emission. Any NPI-listed substances, for which reporting thresholds are triggered, must be reported.

Effluent and waste-water sent off-site for application on another facility is defined as a transfer and the emissions from this are required to be reported by the receiving facility. The receiving facility only has to report to the NPI if it exceeds reporting thresholds and is an industry required to report to the NPI.

The definition of transfer has been clarified by the NPI Implementation Working Group (IWG) as: 'All emissions of listed substances, except those which are directed to, and contained by, purpose

built facilities, are to be reported to the NPI. This applies irrespective of whether the substances' fate is within or outside a reporting facility boundary. With respect to receipt of NPI-listed substances, such receiving facilities are to be operating in accordance with any applicable State or Territory government requirements.'

3.2 NPI substance reporting thresholds

The beef cattle feedlot industry potentially has NPI reporting requirements associated with the following NPI reporting thresholds:

- Category 1 - ammonia from animals (see Section 3.2.1 for guidance on how to determine whether or not reporting on this is required for your facility)
- Category 2 - emissions to air associated with fuel combustion (see Section 3.2.2); *and*
- Category 3 - total nitrogen or total phosphorus releases surface water (see Section 0**)**.

The Category 1 threshold is based on use of a substance and this is outlined more fully in the NPI Guide. In summary use is the purchase, production or handling of material that contains the Category 1 NPI substance.

3.2.1 Pollutant substance use - Category 1 threshold

The substances listed under Category 1 and 1a have extremely limited use as inputs into the beef cattle feedlot industry. There are only minor quantities of chemicals used for cleaning and veterinary purposes but it is unlikely these substances would exceed the 10 tonnes per year Category 1 NPI reporting threshold. However, it is likely that most facilities will trigger the 10 tonnes per year limit for ammonia as a consequence of ammonia in manure. If the capacity of a facility is more than 143 SCU the ammonia use threshold of 10 tonnes will be exceeded. An estimate of the ammonia use, in this case production of ammonia, can also be made. See Example 1 for details.

Example 1 - Category 1 ammonia threshold calculations

A beef cattle farmer has a stock capacity of 1500 Standard Cattle Units (SCU). Is the Category 1 threshold (10 tonnes/year) for ammonia exceeded for the facility? (NB: 1 SCU = 600 kg)

If the feedlot has a stock carrying capacity of more than 143 SCU the ammonia emissions for the facility have to be reported. This facility has to report ammonia emissions.

An estimate of the ammonia use, in this case production, by the above facility is on the next page. This is an estimate of the ammonia emission from the facility using the industry average data provided in this manual.

Example 1 - Category 1 ammonia threshold calculations (cont.)

From Table 5 and Table 6 the amount of nitrogen release by cattle and various feed lot process steps and the proportion of the nitrogen released converted to ammonia is detailed. An approximate emission factor from combining the data from these tables is 0.07 tonnes ammonia/SCU/year.

Ammonia use from intensive beef cattle raising

= cattle held x emission factor

= 1 500 SCU x 0.07 tonnes Ammonia/SCU/year

= 105 tonnes per year of ammonia use.

Therefore the ammonia threshold is exceeded and ammonia emissions have to be reported by the feedlot. In this case the 'use' of ammonia is an approximation of the emission of ammonia.

Ammonia is a category 1 substance and its use on a feedlot is generally the co-production of ammonia as a by-product of raising cattle as discussed above. If other ammonia containing material, for example fertilisers, are used by the facility the ammonia component of these materials should be included as part of the use of ammonia, and ammonia emissions from the fertiliser estimated.

See Example 11 in Appendix C for full details of this example.

3.2.2 Fuel usage - Category 2 threshold

The Category 2 threshold is based on energy consumed or fuel used at a facility. It consists of 2 levels, a and b. The Category 2a threshold for fuel usage is triggered if:

- a facility burns 400 tonnes or more of fuel or waste per year; or
- a facility burns 1 tonne or more of fuel or waste per hour.

The Category 2b threshold is triggered if:

- a facility burns 2000 tonnes or more of fuel or waste per year; or
- a facility uses 60 000 megawatt hours (MWh) or more of energy in a year; or
- a facility's maximum potential power consumption is rated at 20 megawatts (MW) or more at any time during the year.

If a <u>single</u> fuel is used at a facility then the Category 2 threshold is exceeded if the quantity used is greater than that outlined in Table 2. This involves 4 steps:

Step 1

Determine the quantity of fuel used in the reporting year.

Tonnes (t) for solids, litres (L) for liquids and MJ for Natural Gas.

Step 2

Compare the amount of fuel used to the threshold levels in Table 2 for Category 2a substances.

Step 3

Compare the amount of fuel used to the threshold level in Table 2 for Category 2b substances.

Step 4

If Category 2a is NOT exceeded by annual fuel use examine maximum hourly use also detailed in Table 2.

If Category 2a or 2b thresholds are not exceeded from the annual fuel usage determine the maximum amount of fuel used in a single hour in the reporting year - litres (L) for liquids and MJ for Natural Gas.

Example 2 - Is the category 2 threshold tripped for a facility only using diesel?

Facility A only uses Diesel. From the fuel bills for the year it is determined the diesel used was 850 000 (8.5E+05) L.

Step 1

Determine the quantity of fuel used in the reporting year.

Facility A uses 850 000 (8.50E+05) L of diesel and no other fuel.

Step 2

Compare the amount of fuel used to the threshold levels in Table 2 for Category 2a substances. Facility A uses more than 478 000 (4.78E+05) L of diesel and therefore trips the Category 2a threshold. Facility A has to report on the emissions of all Category 2a substances from ALL sources.

Step 3

Compare the amount of fuel used to the threshold level in Table 2 for Category 2b substances.

Facility A uses less than 2 390 000 (2.39E+06) L of diesel and therefore does not trip the Category 2b threshold. Facility A has to report on the emissions of ALL Category 2a substances from ALL sources, but not Category 2b substances unless it desires to do so.

Step 4

If Category 2a is NOT exceeded by annual fuel use examine maximum hourly use also detailed in Table 2.

Step 4 is not required as the Category 2a threshold is already exceeded. If not an estimate of the maximum fuel used in 1 hour would be made. If more than 1 200 (1.20E+03) L of diesel is used in 1 hour then Category 2a is tripped no matter how much fuel is used in the reporting year.

Scientific notation is used; e.g. 7.38E-02 represents 7.38×10^{-2} or 0.0738 and 7.38E+02 represents $7.38 \times 10^{+2}$ or 738.

Table 2 - Approximate fuel usage required to trigger Category 2 thresholds

Fuel type	Category 2a (minimum limits)	Category 2b (minimum limits)	Fuel density[1]
Diesel	4.78E+05 L per reporting year OR 1.20E+03 L in any one hour during the reporting year	2.39E+06 L per reporting year	8.36E-01 kg/L
Petrol	5.41E+05 L per reporting year OR 1.35E+03 L in any one hour during the reporting year	2.71E+06 L per reporting year	7.39E-01 kg/L
Natural gas	1.78E+07 MJ per reporting year OR 4.44E+04 MJ in any one hour in the reporting year	8.88E+07 MJ per reporting year	2.25E-02 kg/MJ
LPG	7.84E+05 L per reporting year OR 1.96E+03 L in any one hour in the reporting year	3.92E+06 L per reporting year	5.10E-01 kg/L
Biogas	3.67E+05 m^3 per reporting year OR 9.17E+02[2] m^3 in any one hour in the reporting year	1.83E+06 m^3 per reporting year	1.09 kg/m^3
Solid fuel e.g. coal or wood	400 tonnes per reporting year OR 1 tonne in any one hour in the reporting year	2 000 tonnes per reporting year	Not applicable

Notes

1. Density values are average values from fuel suppliers and are listed in the current version of the NPI Guide (September 2006). More accurate data can be attained from your fuel supplier.
2. To convert from kg to tonnes use the conversion factor 1 tonne = 1000 kg.
3. Scientific notation is used; e.g. 7.38E-02 represents 7.38 x 10^{-2} or 0.0738 and 7.38E+02 represents 7.38 x 10^{+2} or 738.

If more than 1 type of fuel is used by a facility, e.g. diesel and natural gas, then the weight of fuel has to be determined to determine if the Category 2 thresholds are exceeded. This is completed by multiplying the amount of each fuel used by its density from Table 2. The weight of fuels used is then converted to tonnes. The worksheet in Appendix D assists the completion of this calculation. The steps below outline the calculation steps required and Example 3 illustrates the method.

Step 1

Determine the amount of each fuel type used during the reporting period.

Step 2

Determine the mass of each fuel used in tonnes using the density data in Table 2.

To convert from kg to tonnes use the conversion factor 1 tonne = 1000 kg.

Step 3

Compare the total mass of fuel used to the Category 2 threshold limits.

The category 2 threshold limits are: Category 2a 400 tonnes per year and Category 2b 2000 tonnes per year.

Step 4

If Category 2a is NOT exceeded by annual fuel use examine maximum hourly use.

If Category 2a or 2b thresholds are not exceeded from the annual fuel usage determine the maximum mass of fuel used in a single hour in the reporting year. If more than 1 tonne per hour is used the Category 2a threshold is exceeded.

Example 3 - Determining if the Category 2 threshold is exceeded when more than one fuel type is used

The facility uses 150 000 (1.50E+05) L of diesel, 1 000 000 (1.00E+06) MJ of natural gas and 3 T of firewood during the reporting year. The natural gas is only used occasionally but for periods of two hours at a time at a rate of 50,000 (5.00E+04) MJ per hour.

Step 1

Determine the amount of each fuel type used during the reporting period.

From the details above the amount fuel used is:

Fuel	Amount	Units
Diesel	150 000	L
Natural gas	1 000 000	MJ
Firewood	3	T

Step 2

Determine the mass of each fuel used in tonnes using the density data in Table 2.

The mass of fuel is determined from the fuel density and then converting the value to tonnes (T).

Fuel (T)	Amount	x Density/conversion factor	= Mass (T)
Diesel (kg/T)	150 000 (L)	x 0.836 (kg/L) / 1000 (kg/T)	= 125
Natural gas	1 000 000 (MJ)	x 0.0225 (kg/MJ) / 1000 (kg/T)	= 23
Firewood	3 T	-	= 3
TOTAL	-	-	151 T

Example 3 - Determining if the Category 2 threshold is exceeded when more than one fuel type is used (cont.)

Step 3

Compare the total mass of fuel used to the Category 2 threshold limits.

The total fuel used, 151 tonnes, in the reporting year is less than the 2a (400 tonnes) and 2b (2 000 tonnes) annual usage threshold.

Step 4

If Category 2a is NOT exceeded by annual fuel use examine maximum hourly use.

The hourly usage of natural gas is 50 000 (5.00E+04) MJ which is greater than the 2a hourly threshold component of 44 400 MJ of natural gas. Therefore the Category 2a threshold is exceeded and Facility A has to report on the emissions of ALL Category 2a substances from ALL sources, but not Category 2b substances unless it desires to do so.

To determine the mass of natural gas used in ***Step 4*** use the natural gas density as below:

Fuel	Amount per hour	x Density/conversion factor	Mass (T)
Natural gas	50 000 (MJ)	x 0.0225 (kg/MJ) / 1000 (kg/T)	1.12 T

Scientific notation is used; e.g. 7.38E-02 represents 7.38×10^{-2} or 0.0738 and 7.38E+02 represents $7.38 \times 10^{+2}$ or 738.

If a facility triggers the Category 2a threshold, ALL Category 2a pollutants from all sources need to be reported. If a facility triggers the Category 2b threshold, Category 2a AND Category 2b pollutants need to be reported. Category 2 substances are listed in Table 3.

Table 3 - NPI-listed Category 2 substances

Category 2a substances	Category 2b substances
Carbon monoxide	**all Category 2a substances PLUS**
Fluoride compounds	Arsenic & compounds
Hydrochloric acid	Beryllium & compounds
Oxides of nitrogen	Cadmium & compounds
Particulate matter (PM_{10})	Chromium (III) compounds
Polycyclic aromatic hydrocarbons	Chromium (VI) compounds
Sulfur dioxide	Copper & compounds
Total volatile organic compounds	Lead & compounds
	Magnesium oxide fume
	Mercury & compounds
	Nickel & compounds
	Nickel carbonyl
	Nickel subsulfide
	Polychlorinated dioxins & furans

3.2.3 Total nitrogen and phosphorus to water - Category 3 threshold

Category 3 substances are total nitrogen and total phosphorus and only have to be reported if they are emitted to rivers, creeks and other water bodies. Water bodies include watercourses that only flow intermittently. If effluent from feed lot operations reaches water bodies and exceeds the

thresholds of 15 tonnes for total nitrogen and 3 tonnes for total phosphorus per reporting year then the amount emitted has to be estimated and reported to the NPI.

From discussions with the industry, feedlots are not generally permitted to discharge effluent to surface waters and hence would not be required to report Category 3 substances. Effluent is generally directed to holding ponds and wastewater treatment processes and the liquid from the ponds is generally used for irrigation purposes.

Given that feedlots are not generally permitted to routinely release effluent or treated effluent to surface waters, it is likely that the only event that would cause such a release would be an unplanned situation such as extreme rainfall events or leaks/breaks in a settlement pond wall. In such events, it is unlikely that the Category 3 reporting thresholds would be exceeded, but an estimate of the total phosphorus and total nitrogen released is needed to make a definitive assessment.

Table 4 provides typical concentrations for Category 3 substances in effluent retention ponds. If continuous monitoring of your facility indicates the concentrations in Table 4 are not correct then data from your monitoring can be used. Data in Table 4 may be used as a starting point to determine whether releases of such effluent could lead to a Category 3 reporting threshold being exceeded.

If you do not measure the flow of effluent from your retention ponds to watercourses then some estimate has to be made of this flow to complete the threshold calculations. It maybe useful to estimate the proportion of the effluent pond that overflowed to the water body.

Table 4 - Default concentrations for Category 3 NPI listed substances in beef cattle feedlot effluent retention ponds

Category 3 NPI listed substances	Concentration (mg/L)[1]
Total nitrogen	2.50E+02
Total phosphorus	1.00E+02

Note

1. Source: Reference 7 page 7.6.
2. Scientific notation is used; e.g. 7.38E-02 represents 7.38 x 10^{-2} or 0.0738 and 7.38E+02 represents 7.38 x 10^{+2} or 738.

The steps involved in determining if the Category 3 threshold is exceeded are:

Step 1

Estimate the flow of effluent to water bodies.

This may involve a broad estimate based on the proportion of the effluent pond that overflows to water bodies for any particular overflow event. If effluent does not flow to a water body then the Category 3 threshold does not need to be examined.

Step 2

Estimate the total nitrogen and total phosphorus concentrations in your facility's effluent.

If the total nitrogen and total phosphorus concentrations in retention ponds are not available use the values in Table 4.

Step 3

Estimate the quantity of total nitrogen and total phosphorus that flows to the water body.

This is determined from the volume of overflow multiplied by the concentration of nitrogen and phosphorus in the effluent water.

Step 4

Check the total nitrogen and total phosphorus flows against the Category 3 thresholds.

The thresholds are 15 and 3 tonnes for total nitrogen and total phosphorus, respectively.

Example 4 - Category 3 threshold calculations

A spill of approximately 20% of the effluent treatment pond has occurred to the local creek. The volume of the treatment pond is 50 ML and the spill was untreated except by screening. Has a Category 3 threshold been exceeded?

If individual feedlot specific data is unavailable then, using the concentrations of total nitrogen and total phosphorus in the effluent for typical feedlot effluent pond from Table 4 above:

Step 1

Estimate the flow of effluent to water bodies.

The flow from the effluent pond is approximately 20 % of the 50ML pond.

Volume = 20/100 x 50 ML x 1 000 000 L/ML

= 10 000 000 L

= 1E+07 L

Step 2

Estimate the total nitrogen and phosphorus concentrations in your facilities effluent.

The total nitrogen and total phosphorus levels in the effluent pond are not known, so the values in Table 4 are used.

Concentration of nitrogen = 250 mg/L

Concentration of phosphorus = 100 mg/L

Example 4 - Category 3 threshold calculations (cont.)

Step 3

Estimate the quantity of total nitrogen and phosphorus that flow to the water body.

Total amount released	= concentration x volume released
Total nitrogen released	= (250 mg/L x 10 000 000 L) / (1 000 000 000 mg/tonne)
	= 2.5 tonnes released
Total phosphorus released	= (100 mg/L x 10 000 000 L) / (1 000 000 000 mg/tonne)
	= 1 tonne released

Step 4

Check the total nitrogen and phosphorus flows against the Category 3 thresholds

These releases are less than the Category 3 thresholds of 15 tonnes per annum for total nitrogen and 3 tonnes per annum for total phosphorus. Therefore, in this situation, no reporting of Category 3 substances would be required.

3.3 Emissions to air

Section 3.3.1 provides guidance on the characterisation of emissions of ammonia to air from beef feedlot operations. Section 3.3.2 provides guidance on characterising emissions to air of Category 2 substances.

3.3.1 Ammonia (NPI Category 1 substance)

Ammonia is released to air from most steps of the feedlot operations, from the sheds through to the final effluent treatment and disposal processes (i.e. land application of effluent). Accurately estimating the quantities of ammonia emitted can be difficult and/or expensive. Although there are no standard methods for estimating the quantity of ammonia released to the atmosphere from a feedlot, the Queensland Department of Primary Industries has provided references that provide the information in Table 4 to Table 6 to estimate ammonia emissions. It should be noted that the 'Percentage of Total Nitrogen Volatilised' is expressed as a percentage of the total nitrogen input at each production stage. In the absence of site specific data, the information provided in Table 4 to Table 6 can be used as default values to calculate the ammonia losses from beef cattle feedlots.

Table 5 - Default emission factors for total nitrogen in beef cattle feedlots

Component	Emission factor (kg Total N/SCU/yr)
Freshly excreted manure	65 [4]
Manure remaining on pad	25.6
Run-off to retention pond	0.39

Notes:
1. Sources: Reference 8 page 663, Reference 9 page 2.1 and 2.2 and Reference 10 page 4-10.
2. Source: Reference 9 page 10.2. Approximately 18% of the freshly excreted manure (that has not been volatilised) is transferred to the retention pond as run-off. The other 82% (that has not been volatilised) remains on the feedlot pad until it is scraped off into manure stockpiles.
3. References acquired through advice from Qld DPI: Reference 6.
4. Source: Reviewing Ammonia Emissions Factors for Feedlots, page 22

Table 6 - Percentage of total nitrogen volatilised (as NH_3) from various stages of an intensive beef cattle feedlot

Component	Percentage of total nitrogen volatilised from total nitrogen present at each Stage [1]
1. Fresh manure	60
2. Manure remaining on pad	80
3. Manure stockpile	30
4. Retention pond	26
5. Irrigation (on-site)	25
6. Soil (post irrigation)	25

Notes:
1. Source: Reference 9 page 10.2
2. References acquired through advice from Qld DPI: Reference 6.

The default data in Table 4 to Table 6 is used to calculate the ammonia emission factor based on stock capacity of the feedlot in Table 7 and outlined in Example 5. Appendix E is a worksheet that assists in the estimation of ammonia emissions. If data other than the default data is used to estimate ammonia emissions the steps to estimate ammonia emissions are more complicated and are outlined in Example 12 in Appendix C.

Table 7 - Ammonia emission factors based on default data in Table 4 to Table 6 above

Ammonia source	Ammonia emission factor (kg ammonia / SCU)
1. Fresh manure loss	47.4
2. Manure on pad surface	15.8
3. Manure stockpile	3.8
4. Retention pond	0.1
	Ammonia emission factor[3] (kg ammonia / SCU / (kL water irrigated per SCU)
5. Irrigation (on-site)[2]	0.036
6. Soil (post irrigation)[2]	0.163

Notes:
1. Source: Based on data provided in Table 4 to Table 6 above.
2. If effluent water is not used for on-site irrigation, e.g. it is transferred to another facility; ignore ammonia released from irrigation – source 5 and 6 above.
3. This assumes that the N level in the effluent water is as in Table 4. If the amount of water irrigated from the effluent pond is unknown a default value to use is 1 kL/SCU/year.
4. Scientific notation is used; e.g. 7.38E-02 represents 7.38×10^{-2} or 0.0738 and 7.38E+02 represents $7.38 \times 10^{+2}$ or 738.

To calculate emissions of ammonia for the purposes of NPI reporting the following steps should be followed:

Step 1

Determine if the ammonia NPI reporting threshold is exceeded.

Refer to Example 1 in Section 3.2.1. For most feedlot operations the ammonia threshold will be exceeded and emission estimates have to be made and reported to the NPI. Example 11 in Appendix C has full details of ammonia threshold calculations.

Step 2

From Table 7 determine which activities are relevant to your feedlot operation.

Most facilities will have to estimate ammonia emissions from process steps 1 to 4 in Table 6 and Table 7. Some facilities will not have to estimate emissions involved with on-site irrigation, steps 5 and 6 in Table 6 and Table 7. The key issue is that it is only on-site releases of ammonia that are reported.

Step 3

Multiply the ammonia emission factor by the stock capacity (SCU).

For the activities determined in step 2 multiply the ammonia emission factor by the SCU stock capacity. For the irrigation activities (5 and 6 from Table 6 and Table 7), if applicable, also consider the amount of water used for on-site irrigation. If site specific data is available use the more detailed technique outlined in Example 12 to estimate ammonia emissions

Step 4

Add ammonia emissions from different parts of the process.

Sum the ammonia emissions from different parts of the feedlot process. This is the ammonia emissions, in kilograms (kg), reported to the NPI. The EET technique used is number 4 using emission factors and this is also reported to the NPI. The usage figure for ammonia is for feedlot operations is the same as the emission figure calculated above and is also included in the appropriate section of the NPI reporting form. In estimating emissions for NPI reporting consideration should be given that only 2 significant figures are reported to the NPI.

Example 5 – Ammonia emission estimation for feedlot cattle

Estimate the ammonia emissions for the feed lot operator outlined in Example 1. The operator irrigates with 3 ML of water from the effluent pond to their own facility.

Step 1
Determine if the ammonia NPI reporting threshold is exceeded.

From the calculation in Example 1 the ammonia threshold is exceeded for this operation. More than 10 tonnes of ammonia is used by the facility in the reporting year.

Step 2
From Table 7 determine which activities are relevant to your feedlot operation.

For this facility all the process steps outlined in Table 7 release ammonia.

Step 3

Multiply the ammonia emission factor by the stock capacity (SCU).

The irrigation level used by the facility for <u>on-site</u> irrigation is:

$$\text{water irrigated / SCU/year} = \frac{3\ \text{ML / year}}{1000\ \text{kl / ML}} \div 1500 \quad \text{SCU} = \quad 2\ \text{kL} \quad / \quad \text{SCU}$$

If the irrigation level is not determined by your facility use the default value of 1 kL/SCU.

Example 5 – Ammonia emission estimation for feedlot cattle (cont.)

Ammonia from manure and retention ponds

Ammonia source	Stock capacity (SCU)		Ammonia emission factor (kg/SCU/year)		Ammonia released (kg/year)
1. Fresh manure loss	1 500	×	39	=	58 500
2. Manure on pad surface	1 500	×	13	=	19 500
3. Manure stockpile	1 500	×	3.2	=	4800
4. Retention pond	1 500	×	0.1	=	150

Ammonia from irrigation of effluent water

Ammonia source	Stock capacity (SCU)		Volume irrigated (kL/SCU)		Ammonia emission (kg/kL/year)		Ammonia released (kg/year)
5. On-site irrigation	1 500	x	2	x	0.036	=	108
6. From soil after irrigation	1 500	x	2	x	0.163	=	489

TOTAL Ammonia emissions (kg/year) 83 547kg/year

Step 4
Add ammonia emissions from different parts of the process.

The ammonia emissions from all the sources at the facility are 89 061 kg/year. If other ammonia is emitted from the facility add this to the total determined from the cattle operations of the facility.

3.3.2 Category 2 substances

An important aspect to realise is that emissions of Category 2 substances only have to be reported if the Category 2 threshold is exceeded, as outlined in 3.2.2 and demonstrated in Example 2 and Example 3. For guidance on the estimation of emissions from fuel combustion, refer to the *Emission estimation technique manual for combustion in boilers.* For combustion engines (e.g. diesel engines), refer to the *Emission estimation technique manual for combustion engines version 2.1*.

If the Category 2 threshold is triggered all Category 2 substance emissions from all sources are reported to the NPI. For the feedlot industry this relates in particular to the release of PM_{10} dust. Estimation of PM_{10} emissions from feedlot floors can be complex. The most accurate method is through sampling and guidance on the approaches to sampling is found in the *Emission estimation technique manual for fugitive emissions.* If you do not complete sampling at your facility a conservative estimate of PM_{10} emissions can be made using an emission factor of 11.7 tonnes of PM_{10}/1000 stock capacity per annum (Reference 11).

The steps for estimating fuel combustion emissions are:

Step 1

If a Category 2 (2a or 2b) fuel use threshold is exceeded proceed to the next step.

This is discussed in Example 2 and Example 3 in 3.2.2 of this manual. Further information can be attained from the NPI Guide. The fuel data in Table 2 will be of assistance for estimating the mass of fuel used by the feedlot facility.

Step 2

Estimate emissions of specified Category 2 substances from combustion sources.

This is completed using techniques outlined in the combustion engines EET manual and the combustion in boilers EET manual.

Step 3

Estimate emissions of specified Category 2 substances from non-combustion sources.

For feedlot operations this involves estimating the PM_{10} and other Category 2 substances. Emissions of PM_{10} dust is from the movement of cattle which is part of the day-to-day operation of the feedlot process.

Step 4

Add the Category 2 substance emissions from various sources.

Specifically for the feedlot industry this means adding the various sources of PM_{10} dust, i.e. from combustion and non-combustion sources.

Example 6 illustrates the use of emission factors to calculate emissions from combustion and other sources.

Example 6 - PM_{10} emissions from feed yards that exceed the Category 2 NPI reporting threshold

To maintain a feedlot with a stock capacity of 25 000 SCU, a beef cattle farmer uses a combination of fuels to power a boiler, various on-site vehicles, feed mixers and pen cleaning equipment. In detail 5 150 000 MJ of natural gas were used in an uncontrolled boiler, 200 kW tractor type vehicles were used for 30 000 hours, feed mixers of 50 kW size were used for 500 hours and pen cleaning equipment with and engine less than 450 kW used 20 000 L of Diesel. Total diesel use on-site was 350 000 L for the reporting year.

What are the reportable emissions of PM_{10} for this feedlot?

Step 1

If a Category 2 (2a or 2b) fuel use threshold is exceeded proceed to the next step.

From the data in Table 2 the quantity of fuel used is below. See Example 2 and 3.2.2 for more details on examining Category 2 thresholds.

Natural gas (boiler)	= 5 150 000 MJ	= 115 875 kg	= 116 tonnes
Diesel (vehicles and other engines)	= 350 000 L	= 292 600 kg	= 293 tonnes
TOTAL fuel burnt			= 409 tonnes

Example 6 - PM10 emissions from feed yards that exceed the Category 2 NPI reporting threshold (cont.)

The annual amount of fuel burnt exceeds the Category 2a reporting threshold. Therefore, reporting of emissions of all Category 2a substances (listed in Table 2) to air, water and land is required under the NPI. The *Emission estimation technique manual for combustion in boilers* can be used to estimate the emissions from the boiler and the *Emission estimation technique manual for combustion engines* can be used to estimate emissions from diesel use.

This example only addresses PM_{10} emissions. Other category 2 substances can be calculated in a similar manner.

Step 2

Estimate emissions of specified Category 2 substances from combustion sources.

Emissions from natural gas combustion

Natural gas used = 5 150 000MJ / 38.9 MJ/m^3
= 132 390 m^3

Using the *Emission estimation technique manual for combustion in boilers* (Version 2.1)

PM_{10} (from natural gas in boiler) = Fuel used per year x Emission Factor
= 132 390 m^3/yr x 121.6 kg (PM_{10})/1.00E+06 m^3
= 16.1 kg (PM_{10})/yr

Emissions from diesel combustion - vehicles

One type of vehicle is used, a 200 kW track type tractor. The vehicles are used for 30 000 hours. Using the *Emission estimation technique manual for combustion engines Version 2.1* (Table 5 p17) PM_{10}
= Power x hours x Emission Factor
= 200 x 30 000 x 1.7E-03 kgPM_{10}/kWh
= 10 200 kg (PM_{10})/yr

Emissions from diesel combustion – stationary engines

The PM_{10} dust emissions from the stationary engines used by the facility are determined using the *Emission estimation technique manual for combustion engines Version 2.1*.

i) Feed mixer

= Power x hours x Emission Factor
= 50 x 500 x 1.34-03 kg PM_{10}/kWh
= 34 kg (PM_{10})/yr

Example 6 - PM10 emissions from feed yards that exceed the Category 2 NPI reporting threshold (cont.)

ii) Pen cleaning

= Fuel used x emission factor
= 20 000 L x 1.00E-03 m^3/L x 5.10E+00 kg PM_{10} / m^3 fuel
= 102 kg PM_{10} dust

Step 3

Estimate emissions of specified Category 2 substances from non-combustion sources.

Emissions from cattle feed yards

In the absence of site-specific dust emission data, the default emissions factor for feedlot fugitive dust (i.e. 11.7 tonnes of PM10/1000 SCU per annum) can be used.

Stock capacity = 25 000 SCU/yr

PM_{10} (from cattle feed yard) = Throughput per year x emission factor
= 25 000 SCU/yr x 11.7 tonnes (PM_{10})/1000 SCU
= 292.5 tonnes (PM_{10})/year
= 292 500 kg PM_{10} / year

Step 4

Add category 2 substance emission from various sources.

Total PM_{10} emissions per annum

Total PM_{10} emissions = PM_{10} (diesel - vehicles) + PM_{10} (diesel - stationary engines) + PM_{10} (natural gas) + PM_{10} (cattle feed yard)
= 10 200 + 136 + 16 + 292 500 kg PM_{10} /yr
= 302 852 kg PM_{10}/yr.

Note: Even though the dust from the cattle yard is the major source of the PM_{10} emissions, NPI reporting for PM_{10} (and all category 2 substances) is only triggered by fuel usage, as outlined in section 3.2.2 of this manual and the *NPI guide*.

Scientific notation is used; e.g. 7.38E-02 represents 7.38 x 10^{-2} or 0.0738 and 7.38E+02 represents 7.38 x 10^{+2} or 738.

3.4 Emissions to water

As feedlots are generally prohibited to discharge effluent to surface waters it would only be in the event of an accidental or unplanned release or of a significant run off from irrigation of sludge or effluent that reporting of total nitrogen and total phosphorus may be required.

However, as discussed in Section 3.2.3, even if such releases do occur, it is unlikely that any such reporting would be required. However, if there is the potential for emissions of total nitrogen and total phosphorus to surface waters to exceed the Category 3 reporting thresholds, the calculation methodology outlined in Section 3.2.3 of this manual should be used to assess whether or not reporting is required.

If the Category 3 thresholds are exceeded the quantity determined in section 3.2.3 is the emission of total nitrogen and total phosphorus reported to the NPI.

4.0 Glossary of technical terms and abbreviations

Term	Definition
ANZSIC	Australian and New Zealand Standard Industrial Classification
CEMS	Continuous Emission Monitoring System
EEA	European Environment Agency
EET	Emission Estimation Technique
EF	Emission Factor
EFR	Emission Factor Rating
IWG	Implementation Working Group
NEPM	National Environment Protection Measure
NPI	National Pollutant Inventory
VOCs	Volatile Organic Compounds
PM_{10}	Particulate matter with an equivalent aerodynamic diameter of 10 micrometres or less (i.e. ≤10μm)
SCU	Standard Cattle Unit. This is an animal with a live weight at exit from the feedlot of 600 kg.
Transfer	Transfers consist of a deposit of a substance into landfill, or discharge of a substance to a sewer or tailings dam, or removal of a substance from a facility for destruction, treatment, recycling, reprocessing, recovery or purification (*NEPM*, Clause 3(3)). At the date of publication of this manual, emissions classed as transfers are not required to be reported under the NPI.
TSP	Total Suspended Particulate
USEPA	United States Environmental Protection Agency

5.0 References

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6. Qld DPI, 1999. Communication between Matt Scholl (PAE) and Ken Casey from the Queensland Department of Primary Industries - Intensive Livestock Environmental Management Services.
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10. Agricultural Waste Management Field Handbook, United States Department of Agriculture Soil Conservation Service, April 1992.
11. Auvermann, Brent. W., Effect of stocking density on fugitive PM_{10} Emissions from a cattle feedyard, Paper No. 99-4192, 199 ASAE Annual International Meeting, Toronto, Ontario, Canada, 1999.
12. FSA Consulting, Reviewing Ammonia Emission Factors for Feedlots, January 2006

The following EET manuals are available from the NPI web site:

- *Emission estimation technique manual for combustion in boilers*
- *Emission estimation technique manual for combustion engines*; and
- *Emission estimation technique manual for fugitive emissions.*

Appendix A - Emission estimation techniques

Estimates of emissions of NPI-listed substances to air, water and land should be reported for each substance that triggers a threshold. The reporting list and detailed information on thresholds are contained in the *NPI Guide.*

In general, there are four types of emission estimation techniques (EET's) that may be used to estimate emissions from your facility.

The four types described in the *NPI Guide* are:

- sampling or direct measurement
- mass balance
- fuel analysis or other engineering calculations *and*
- emission factors.

Select the EET's (or mix of EET's) that is most appropriate for your purposes. For example, you might choose to use a mass balance to best estimate fugitive losses from pumps and vents, direct measurement for stack and pipe emissions, and emission factors when estimating losses from storage tanks and stockpiles.

If you estimate your emission by using any of these EET's, your data will be displayed on the NPI database as being of 'acceptable reliability'. Similarly, if your relevant environmental authority has approved the use of EET's that are not outlined in this handbook, your data will also be displayed as being of 'acceptable reliability'.

This manual seeks to provide the most effective emission estimation techniques for the NPI substances relevant to this industry. However, the absence of an EET for a substance in this manual does not necessarily imply that an emission should not be reported to the NPI. The obligation to report on all relevant emissions remains if reporting thresholds have been exceeded.

You are able to use emission estimation techniques that are not outlined in this document. You must, however, seek the consent of your relevant environmental authority. For example, if your company has developed site-specific emission factors, you may use these if approved by your relevant environmental authority.

You should note that the EET's presented or referenced in this manual relate principally to average process emissions. Emissions resulting from non-routine events are rarely discussed in the literature, and there is a general lack of EET's for such events. However, it is important to recognise that emissions resulting from significant operating excursions and/or accidental situations (e.g. spills) will also need to be estimated. Emissions to land, air and water from spills must be estimated and added to process emissions when calculating total emissions for reporting purposes. The emission resulting from a spill is the net emission, i.e. the quantity of the NPI reportable substance spilled, less the quantity recovered or consumed during clean up operations.

The **usage**[a] of each of the substances listed as Category 1 and 1a under the NPI must be estimated to determine whether the 10 tonnes (or 25 tonnes for VOCs) reporting threshold is exceeded. If the threshold is exceeded, **emissions** of these Category 1 and 1a substances must be reported for all operations/processes relating to the facility, even if the actual emissions of the substances are very low or zero.

[a]Usage is defined as meaning the handling, manufacture, import, processing, coincidental production or other uses of the substances.

A list of the variables and symbols used in this manual may be found in **Appendix C**.

A.1 Direct measurement

You may wish to undertake direct measurement in order to report to the NPI, particularly if you already do so in order to meet other regulatory requirements. However, the NPI does not require you to undertake additional sampling and measurement. For the sampling data to be adequate and able to be used for NPI reporting purposes, it would need to be collected over a period of time, and to be representative of operations for the whole year.

A.1.1 Sampling data

Stack sampling test reports often provide emissions data in terms of kg per hour or grams per cubic metre (dry). Annual emissions for NPI reporting can be calculated from this data. Stack tests for NPI reporting should be performed under representative (i.e. normal) operating conditions. You should be aware that some tests undertaken for a state or territory license condition may require the test be taken under maximum emissions rating, where emissions are likely to be higher than when operating under normal operating conditions.

An example of test results is summarised in Table 8. The table shows the results of three different sampling runs conducted during one test event. The source parameters measured as part of the test run include gas velocity and moisture content, which are used to determine exhaust gas flow rates in m^3/s. The filter weight gain is determined gravimetrically and divided by the volume of gas sampled, as shown in Equation 1 to determine the PM concentration in grams per m^3. Note that this example does not present the condensable PM emissions.

Pollutant concentration is then multiplied by the volumetric flow rate to determine the emission rate in kilograms per hour, as shown in Equation 2 and Example 7.

Equation 1

$$C_{PM} = C_f / V_{m,\,STP}$$

where:

C_{PM} = concentration of PM or gram loading, g/m^3

C_f = filter catch, g

$V_{m,STP}$ = metered volume of sample at STP, m^3

Equation 2

$$E_{PM} = C_{PM} \times Q_d \times 3.6 \times [273 / (273 + T)]$$

where:

E_{PM} = hourly emissions of PM, kg/hr

C_{PM} = concentration of PM or gram loading, g/m^3

Q_d = actual stack gas volumetric flow rate, m^3/s, dry

3.6 = 3600 seconds per hour multiplied by 0.001 kilograms per gram

T = temperature of the gas sample, °C

Table 8 - Stack sample test results.

Parameter	Symbol	Test 1	Test 2	Test 3
Total sampling time (sec)		7 200	7 200	7 200
Moisture collected (g)	g_{MOIST}	395.6	372.6	341.4
Filter catch (g)	C_f	0.0851	0.0449	0.0625
Average sampling rate (m^3/s)		0.000167	0.000167	0.000167
Standard metered volume (m^3)	$V_{m, STP}$	1.185	1.160	1.163
Volumetric flow rate (m^3/s), dry	Q_d	8.48	8.43	8.45
Concentration of particulate (g/m^3)	C_{PM}	0.0718	0.0387	0.0537
Scientific notation is used; e.g. 7.38E-02 represents 7.38×10^{-2} or 0.0738 and 7.38E+02 represents $7.38 \times 10^{+2}$ or 738.				

Example 7 - Using stack sampling data

PM emissions calculated using Equation 1 and Equation 2 (above) and the stack sampling data for Test 1 (presented in Table 8, and an exhaust gas temperature of 150°C (423 K)). This is shown below:

C_{PM} = $C_f / V_{m, STP}$

= 0.0851 / 1.185

= 0.072 g/m^3

E_{PM} = $C_{PM} \times Q_d \times 3.6 \times [273/(273 + T)]$

= 0.072 x 8.48 x 3.6 x (273/423 K)

= 1.42 kg/hr

The information from some stack tests may be reported in grams of particulate per cubic metre of exhaust gas (wet). Use Equation 3 below to calculate the dry particulate emissions in kg/hr.

Equation 3

E_{PM} = $Q_a \times C_{PM} \times 3.6 \times (1 - moist_R/100) \times [273 / (273 + T)]$

where:

E_{PM}	=	hourly emissions of PM in kilograms per hour, kg/hr
Q_a	=	actual (i.e. wet) cubic metres of exhaust gas per second, m^3/s
C_{PM}	=	concentration of PM or gram loading, g/m^3
3.6	=	3600 seconds per hour multiplied by 0.001 kilograms per gram
$moist_R$	=	moisture content, %
273	=	273 K (0°C)
T	=	stack gas temperature, °C

Total suspended particulates (TSP) are also referred to as total particulate matter (total PM). To determine PM_{10} from total PM emissions, a size analysis may need to be undertaken. The weight PM_{10} fraction can then be multiplied by the total PM emission rate to produce PM_{10} emissions. Alternatively, it can be assumed that 100% of PM emissions are PM_{10}; i.e assume that all particulate matter emitted to air has an equivalent aerodynamic diameter of 10 micrometres or less i.e. ≤10μm. In most situations, this is likely to be a conservative assumption, but it may be a suitable technique to obtain a reasonable characterisation of emissions for the purposes of NPI reporting.

To calculate moisture content use Equation 4.

Equation 4

Moisture percentage = 100 x weight of water vapour per specific volume of stack gas/ total weight of the stack gas in that volume.

$$moist_R = \frac{100 * \left(\frac{g_{moist}}{1000 * V_{m,STP}}\right)}{\left(\frac{g_{moist}}{1000 * V_{m,STP}}\right) + \rho_{STP}}$$

where:

$moist_R$	=	moisture content, %
g_{moist}	=	moisture collected, g
$V_{m,STP}$	=	metered volume of sample at STP, m^3
ρ_{STP}	=	dry density of stack gas sample, kg/m^3 at STP {if the density is not known a default value of 1.62 kg/m^3 may be used. This assumes a dry gas composition of 50% air, 50% CO_2}

Example 8 - Calculating moisture percentage

A 1.2m^3 sample (at STP) of gas contains 410g of water. To calculate the moisture percentage use Equation 4.

$$moist_R = \frac{100 * \left(\frac{g_{moist}}{1000 * V_{m,STP}}\right)}{\left(\frac{g_{moist}}{1000 * V_{m,STP}}\right) + \rho_{STP}}$$

$g_{MOIST}/1000 \times V_{m,STP}$ = 410 / (1000 x 1.2)
= 0.342
$moist_R$ = 100 x 0.342 / (0.342 + 1.62)
= 17.4%

A.1.2 Continuous emission monitoring system (CEMS) data

A continuous emission monitoring system (CEMS) provides a continuous record of emissions over time, usually by reporting pollutant concentration. Once the pollutant concentration is known, emission rates are obtained by multiplying the pollutant concentration by the volumetric gas or liquid flow rate of that pollutant.

Although CEMS can report real-time hourly emissions automatically, it may be necessary to estimate annual emissions from hourly concentration data manually. This Section describes how to calculate emissions for the NPI from CEMS concentration data. The selected CEMS data should be representative of operating conditions. When possible, data collected over longer periods should be used.

It is important to note that, prior to using CEMS to estimate emissions, you should develop a protocol for collecting and averaging the data in order that the estimate satisfies the local environmental authority's requirement for NPI emission estimations. To monitor SO_2, NO_x, VOC, and CO emissions using a CEMS, you use a pollutant concentration monitor that measures the concentration in parts per million by volume dry air (ppm_{vd} = volume of pollutant gas/10^6 volumes of dry air). Flow rates should be measured using a volumetric flow rate monitor. Flow rates estimated based on heat input using fuel factors may be inaccurate because these systems typically run with high excess air to remove the moisture out of the kiln. Emission rates (kg/hr) are then calculated by multiplying the stack gas concentrations by the stack gas flow rates.

Table **9** presents example CEMS data output for three periods for a hypothetical furnace. The output includes pollutant concentrations in parts per million dry basis (ppm_{vd}), diluent (O_2 or CO_2) concentrations in percent by volume dry basis (%v, d) and gas flow rates; and may include emission rates in kilograms per hour (kg/hr). This data represents a snapshot of a hypothetical boiler operation. While it is possible to determine total emissions of an individual pollutant over a given time period from this data, assuming the CEMS operates properly all year long, an accurate emission estimate can be made by adding the hourly emission estimates if the CEMS data is representative of typical operating conditions.

Table 9 - Example CEMS output for a hypothetical furnace firing waste fuel oil

Time	O_2 content	Concentration				Gas flow rate (Q)	Production rate of product (A)
	% by volume	SO_2 (ppm_{vd})	NO_x (ppm_{vd})	CO (ppm_{vd})	VOC (ppm_{vd})	m^3/s	t/hour
1	10.3	150.9	142.9	42.9	554.2	8.52	290
2	10.1	144.0	145.7	41.8	582.9	8.48	293
3	11.8	123.0	112.7	128.4	515.1	8.85	270

Hourly emissions can be based on concentration measurements as shown in Equation 5.

Equation 5

$$E_i = (C \times MW \times Q \times 3600) / [22.4 \times ((T + 273)/273) \times 1.00E+06]$$

where:

E_i = emissions of pollutant i, kg/hr

C = pollutant concentration, $ppm_{v,d}$

MW = molecular weight of the pollutant, kg/kg-mole

Q = actual stack gas volumetric flow rate, m^3/s

3600 = conversion factor, s/hr

22.4 = volume occupied by one mole of gas at standard temperature and pressure (0°C and 101.3 kPa), m^3/kg-mole

T = temperature of gas sample, °C

Actual annual emissions can be calculated by multiplying the emission rate in kg/hr by the number of actual operating hours per year (OpHrs) as shown in Equation 6 for each typical time period and summing the results.

Equation 6

$$E_{kpy,i} = \sum (E_i \times OpHrs)$$

where:

$E_{kpy,i}$ = annual emissions of pollutant i, kg/yr

E_i = emissions of pollutant i, kg/hr (from Equation 5)

OpHrs= operating hours, hr/yr

Emissions in kilograms of pollutant per tonne of product produced can be calculated by dividing the emission rate in kg/hr by the activity rate (production rate (tonnes/hr) during the same period. This is shown in Equation 7 below.

It should be noted that the emission factor calculated below assumes that the selected time period (i.e. hourly) is representative of annual operating conditions and longer time periods should be used for NPI reporting where they are available. Use of the calculation is shown in Example 5.

Equation 7

$$E_{kpt,i} = E_i / A$$

where:

$E_{kpt,i}$ = emissions of pollutant i per tonne of product produced, kg/t

E_i = hourly emissions of pollutant i, kg/hr

A = production, t/hr

Example 9 illustrates the application of Equation 5, Equation 6 and Equation 7.

Example 9 - Using CEMS data

This example shows how SO_2 emissions can be calculated using Equation 5 based on the CEMS data for Time Period 1 shown in

Table **9**, and an exhaust gas temperature of 150°C (423 K).

$E_{SO2,1}$ = (C x MW x Q x 3600) / [(22.4 x (T + 273/273) x 1.00E+06]
= (150.9 x 64 x 8.52 x 3600) / [22.4 x (423/273) x 1.00E+06]
= 296 217 907 / 34 707 692
= 8.53 kg/hr

For Time Period 2, also at 150°C

$E_{SO2,2}$ = 8.11 kg/hr

For Time Period 3, also at 150°C

$E_{SO2,3}$ = 7.23 kg/hr

Say representative operating conditions for the year are:

Period 1 = 1500 hr

Period 2 = 2000 hr

Period 3 = 1800 hr

Example 9 - Using CEMS data (cont.)

Total emissions for the year are calculated by adding the results of the three Time Periods using Equation 6:

$E_{kpy,SO2}$ = $E_{SO2,1}$ x OpHrs + $E_{SO2,2}$ x OpHrs + $E_{SO2,3}$ x OpHrs

= (8.53 x 1500) + (8.11 x 2000) + (7.23 x 1800) kg

= 42 029 kg/yr

Emissions, in terms of kg/tonne of product produced when operating in the same mode as time period 1, can be calculated using Equation 7

$E_{kpt,SO2}$ = E_{SO2} / A

= 8.53 / 290

= 0.0294 kg SO_2 emitted per tonne of product produced

When the furnace is operating as in time periods 2 or 3, similar calculations can be undertaken for emissions per tonne.

Scientific notation is used; e.g. 7.38E-02 represents 7.38 x 10^{-2} or 0.0738 and 7.38E+02 represents 7.38 x 10^{+2} or 738.

A.2 Mass balance

A mass balance identifies the quantity of substance going in and out of an entire facility, process, or piece of equipment. Emissions can be calculated as the difference between input and output of each listed substance. Accumulation or depletion of the substance within the equipment should be accounted for in your calculation.

Mass balance calculations for estimating emissions to air of NPI-listed substances can be represented conceptually by Equation 8.

Equation 8

$E_{kpy,i}$ = Amount in_i - Amount out_i

where:

$E_{kpy,i}$ = emissions of pollutant i, kg/yr

Amount in_i = amount of pollutant i entering the process, kg/yr

Amount out_i = amount of pollutant i leaving the process as a waste stream, article or product, kg/yr

The term "Amount out_i" may actually involve several different fates for an individual pollutant. This could include the amount recovered or recycled, the amount leaving the process in the manufactured product, the amount leaving the process in wastewater, the amount emitted to the atmosphere, or the amount of material transferred off-site as hazardous waste or to landfill. A thorough knowledge of the different fates for the pollutant of interest is necessary for an accurate emission estimate to be made using the mass balance approach.

The amount of a particular substance entering or leaving a facility is often mixed within a solution as a formulation component or as a trace element within the raw material. To determine the total weight of the substance entering or leaving the process, the concentration of the substance within

the material is required. Using this concentration data, Equation 9 can be applied as a practical extension of Equation 8.

Equation 9

$$E_{kpy,i} = [(Q_{in} \times C_{in}) - (Q_{pr} \times C_{pr}) - (Q_{rec} \times C_{rec}) - (Q_{waste} \times C_{waste})] / 1.00E+06$$

where:

$E_{kpy,i}$ = emissions of pollutant i, kg/yr

Q_{in}, Q_{pr}, Q_{rec}, Q_{waste} = quantity of raw material, product, recycled material or waste respectively, that is processed (generally expressed in kg for solids, L for liquids)

C_{in}, C_{pr}, C_{rec}, C_{wast} = concentration of substance i in the raw material, product, recycled material or waste respectively, that is processed annually (usually mg/kg for solids, mg/L for liquids)

10^6 = conversion from milligrams to kilograms.

Wastewater treatment may precipitate the reportable chemical in a sludge. Facilities are often required to obtain data on the concentration of metals or other substances in sludges as part of their licensing requirement and this data can be used to calculate the emissions as kilograms of sludge multiplied by the concentrations of the substance in the sludge. Although listed substances in sludges transferred off-site do not require reporting, determining this loss can assist with determining other process losses or may require reporting if the sludge is disposed of on-site.

For many chemicals used and emitted during chemical processes, some degradation in treatment may occur so that the entire chemical is not transferred to the sludge. Facilities can estimate the amount of reportable compounds in the sludge by using measured data, or by subtracting the amount biodegraded from the total amount removed in treatment. The amount of removal can be determined from operating data, and the extent of biodegradation might be obtained from published studies. If the biodegradability of the chemical cannot be measured or is not known, reporting facilities should assume that all removal is due to absorption to sludge.

A.3 Engineering calculations

An engineering calculation is an estimation method based on physical/chemical properties (e.g. vapour pressure) of the substance and mathematical relationships (e.g. ideal gas law).

A.3.1 Fuel analysis

Fuel analysis is an example of an engineering calculation and can be used to predict SO_2, metals, and other emissions based on application of conservation laws, if fuel rate is measured. The presence of certain elements in fuels may be used to predict their presence in emission streams. This includes elements such as sulfur that may be converted into other compounds during the combustion process.

The basic equation used in fuel analysis emission calculations is the following:

Equation 10

$$E_{kpy,i} = Q_f \times C_i/100 \times (MW_p / EW_f) \times OpHrs$$

where:

$E_{kpy,i}$ = annual emissions of pollutant i, kg/yr

Q_f = fuel use, kg/hr
OpHrs= operating hours, hr/yr
MW_p = molecular weight of pollutant emitted, kg/kg-mole
EW_f = elemental weight of pollutant in fuel, kg/kg-mole
C_i = concentration of pollutant i in fuel, weight percent, %

For instance, SO_2 emissions from fuel oil combustion can be calculated based on the concentration of sulfur in the fuel oil. This approach assumes complete conversion of sulfur to SO_2. Therefore, for every kilogram of sulfur (EW = 32) burned, two kilograms of SO_2 (MW = 64) are emitted. The application of this EET is shown in Example 10.

Example 10 - Using fuel analysis data

This example shows how SO_2 emissions can be calculated from fuel combustion based on fuel analysis results, and the known fuel flow of the engine. $E_{kpy,SO2}$ may be calculated using Equation 10 and given the following:

Fuel flow (Q_f) = 20 900 kg/hr
Weight percent sulfur in fuel = 1.17 %
Operating hours = 1500 hr/yr

$E_{kpy,SO2}$ $= Q_f \times C_i/100 \times (MW_p / EW_f) \times OpHrs$

$= (20\ 900) \times (1.17/100) \times (64 / 32) \times 1500$

$= 733\ 590$ kg/yr

A.4 Emission factors

In the absence of other information, default emission factors can be used to provide an estimate of emissions. Emission factors are generally derived through the testing of a general source population (e.g. boilers using a particular fuel type). This information is used to relate the quantity of material emitted to some general measure of the scale of activity (e.g. for boilers, emission factors are generally based on the quantity of fuel consumed or the heat output of the boiler). Emission factors require 'activity data' that is combined with the factor to generate the emission estimates. The generic formula is:

$$\text{Emission Factor}\left(\frac{\text{mass}}{\text{unit of activity}}\right) * \text{Activity Data}\left(\frac{\text{unit of activity}}{\text{time}}\right) = \text{Emission Rate}\left(\frac{\text{mass}}{\text{time}}\right)$$

For example, if the emission factor has units of '*kg pollutant/m^3 of fuel burned*', then the activity data required would be in terms of '*m^3 fuel burned/hr*', thereby generating an emission estimate of '*kg pollutant/hr*'.

An emission factor is a tool used to estimate emissions to the environment. In this manual, it relates the quantity of substances emitted from a source, to some common activity associated with those emissions. Emission factors are obtained from US, European, and Australian sources and are usually expressed as the weight of a substance emitted, divided by the unit weight, volume, distance, or duration of the activity emitting the substance (e.g. kilograms of sulfur dioxide emitted per tonne of fuel burned).

Emission factors are used to estimate a facility's emissions by the general equation:

Equation 11

$$E_{kpy,i} = [A \times OpHrs] \times EF_i \times [1 - (CE_i/100)]$$

where :

$E_{kpy,i}$ = emission rate of pollutant i, kg/yr

A = activity rate, t/hr

OpHrs = operating hours, hr/yr

EF_i = uncontrolled emission factor of pollutant i, kg/t

CE_i = overall control efficiency of pollutant i, %.

Emission factors developed from measurements for a specific process may sometimes be used to estimate emissions at other sites. Should a company have several processes of similar operation and size, and emissions are measured from one process source, an emission factor can be developed and applied to similar sources. It is necessary to have the site specific emission factor reviewed and approved by State or Territory environment agencies prior to its use for NPI estimations.

Appendix B - Emission estimation techniques: acceptable reliability and uncertainty

This section is intended to give a general overview of some of the inaccuracies associated with each of the techniques. Although the National Pollutant Inventory does not favour one emission estimation technique over another, this section does attempt to evaluate the available emission estimation techniques with regards to accuracy.

Several techniques are available for calculating emissions from beef cattle feedlot facilities. The technique chosen is dependent on available data, and available resources, and the degree of accuracy sought by the facility in undertaking the estimate.

B.1 Direct measurement

Use of stack and/or workplace health and safety sampling data is likely to be a relatively accurate method of estimating air emissions from beef cattle feedlot facilities. However, collection and analysis of samples from facilities can be very expensive and especially complicated where a variety of NPI-listed substances are emitted, and where most of these emissions are fugitive in nature. Sampling data from a specific process may not be representative of the entire manufacturing operation, and may provide only one example of the facility's emissions.

To be representative, sampling data used for NPI reporting purposes needs to be collected over a period of time, and to cover all aspects of production.

In the case of CEMS, instrument calibration drift can be problematic and uncaptured data can create long-term incomplete data sets. However, it may be misleading to assert that a snapshot (stack sampling) can better predict long-term emission characteristics. It is the responsibility of the facility operator to properly calibrate and maintain monitoring equipment and the corresponding emissions data.

B.2 Mass balance

Calculating emissions from beef cattle feedlot facilities using mass balance appears to be a straightforward approach to emission estimation. However, it is likely that few Australian facilities consistently track material usage and waste generation with the overall accuracy needed for application of this method. Inaccuracies associated with individual material tracking, or other activities inherent in each material handling stage, can result in large deviations for total facility emissions. Because emissions from specific materials are typically below 2 percent of gross consumption, an error of only ± 5 percent in any one step of the operation can significantly skew emission estimations.

B.3 Engineering calculations

Theoretical and complex equations, or models, can be used for estimating emissions from beef cattle feedlot processes. Use of emission equations to estimate emissions from beef cattle farming facilities is a more complex and time-consuming process than the use of emission factors. Emission equations require more detailed inputs than the use of emission factors but they do provide an emission estimate that is based on facility-specific conditions

B.4 Emission factors

Every emission factor has an associated emission factor rating (EFR) code. This rating system is common to EET's for all industries and sectors. They are based on rating systems developed by the United States Environmental Protection Agency (USEPA), and by the European Environment

Agency (EEA). Consequently, the ratings may not be directly relevant to Australian industry. Sources for all emission factors cited can be found in the reference section of this document. The emission factor ratings will not form part of the public NPI database.

When using emission factors, you should be aware of the associated EFR code and what that rating implies. An A or B rating indicates a greater degree of certainty than a D or E rating. The less certainty, the more likely that a given emission factor for a specific source or Category is not representative of the source type. These ratings notwithstanding, the main criterion affecting the uncertainty of an emission factor remains the degree of similarity between the equipment/process selected in applying the factor, and the target equipment/process from which the factor was derived.

The EFR system is as follows:

A - Excellent

B - Above Average

C - Average

D - Below Average

E - Poor

U - Unrated

Appendix C - Variables and symbols used and detailed examples

Table 10 - Variables and symbols used in the manual

Variable	Symbol	Units
Conversion from kilograms to tonnes	10^3	kg/tonne
Conversion from milligrams to kilograms	10^6	mg/kg
Density of air	ρ_a	kg/m^3
Density of material	ρ_m	kg/L
Dry density of stack gas sample	ρ_{STP}	kg/m^3 at STP
Activity rate	A	units/hr, e.g. t/hr
Surface area	area	m^2
Overall control efficiency	CE_i	% reduction in emissions of pollutant i
Filter catch	C_f	grams
Concentration of pollutant i	C_i	kg/L
Concentration of pollutant i in material	C_i	kg/L
Concentration of substance i in the raw material, product, recycled material or waste respectively, that is processed annually	C_{in}, C_{pr}, C_{rec}, C_{waste}	(usually mg/kg for solids, mg/L for liquids)
Concentration of PM_{10}	C_{PM10}	$grams/m^3$
Uncontrolled emission factor for pollutant i	EF_i	kg of pollutant/tonne
Total emissions of pollutant i per hour	E_i	kg/hr
Emissions per tonne	$E_{kpt,i}$	kilograms of pollutant i per tonne of fuel consumed
Annual emissions of pollutant i	$E_{kpy,i}$	kg/yr
Elemental weight of pollutant in fuel	EW_f	kg/kg-mole
Molecular weight of pollutant i	MW_i	kg/kg-mole
Operating hours	OpHrs	hr/yr
PM_{10}		Particulate matter with an equivalent aerodynamic diameter of 10 micrometres or less (i.e. $\leq 10\mu m$)
Pollutant concentration	ppm_{vd}	volume of pollutant gas/10^6 volume of dry air
Saturation vapour pressure of pollutant i	$P_{sat,i}$	kilopascals (kPa)
Total pressure	P_t	kPa
Vapour pressure of pollutant i	$P_{vap,i}$	kPa

Variable	Symbol	Units
Volumetric flow rate,	Q	m^3/s
Volumetric flow rate of stack gas	Q_a	actual cubic metres per second (m^3/s)
Volumetric flow rate of stack gas	Q_d	dry cubic metres per second (m^3/s)
Fuel used	Q_f	t/hr
Material entering the process	Q_{in} or Amount in_i	kg/hr
Material leaving the process	Q_{out} or Amount out_i	kg/hr
Ideal gas constant	R	$kPa.m^3$ /(kgmol).K
Standard temperature & pressure	STP	0^oC (273 K) and 1 atmosphere 101.3 kPa
Temperature	T	^{o}Celsius (^oC) or Kelvin (K)
Total suspended particulates or Total particulate matter (total PM)	TSP or PM	mg/m^3
Metered volume at STP	$V_{m,STP}$	m^3
Total VOC emissions	E_{VOC}	kg/L
Moisture collected	g_{moist}	grams
Moisture content	$moist_R$	%
Percentage weight of pollutant i	$Wt\%_i$	%
Pollutant concentration	ppm_{vd}	volume of pollutant gas/10^6 volume of dry air
Saturation vapour pressure of pollutant i	$P_{sat,i}$	kilopascals (kPa)
Total pressure	P_t	kPa
Vapour pressure of pollutant i	$P_{vap,i}$	kPa
Volumetric flow rate,	Q	m^3/s
Volumetric flow rate of stack gas	Q_a	actual cubic metres per second (m^3/s)
Volumetric flow rate of stack gas	Q_d	dry cubic metres per second (m^3/s)
Fuel used	Q_f	t/hr
Material entering the process	Q_{in} or Amount in_i	kg/hr
Material leaving the process	Q_{out} or Amount	kg/hr

Variable	Symbol	Units
	out_i	
Ideal gas constant	R	$kPa.m^3$ /(kgmol).K
Standard temperature & pressure	STP	0^oC (273 K) and 1 atmosphere 101.3 kPa
Temperature	T	^{o}Celsius (^oC) or Kelvin (K)
Total suspended particulates or Total particulate matter (total PM)	TSP or PM	mg/m^3
Metered volume at STP	$V_{m,STP}$	m^3
Total VOC emissions	E_{VOC}	kg/L
Moisture collected	g_{moist}	grams
Moisture content	$moist_R$	%
Percentage weight of pollutant i	$Wt\%_i$	%

Below is a detailed example to determine the threshold for ascertaining whether determination of ammonia emissions from cattle feed lot operations is required.

Example 11 - Category 1 threshold calculations

A beef cattle farmer has a herd of cattle equivalent to 1500 Standard Cattle Units (SCU). Is the Category 1 threshold for ammonia exceeded for the facility? (NB: 1 SCU = 600 kg)

If site specific manure data for total nitrogen excretion is not available, then the default value from Table 45 of this manual can be used (65 kg Total Nitrogen/SCU/year). Based on the volatilisation data in 6 of this manual, a default amount of 88%[a] total nitrogen is volatilised to ammonia in the overall feedlot process.

Therefore

Amount of ammonia produced per SCU

= Total nitrogen x fraction volatilised x $MW_{ammonia}/EW_{nitrogen}$

= 65 kg Total N/SCU/year x 0.88 x 17/14

= 69 kg of ammonia per SCU per year

Annual amount of ammonia;

= Herd capacity x annual ammonia per SCU

= 1 500 SCU x 69 kg ammonia per SCU per year x 1 tonne/1000 kg

= 103.5 tonnes of ammonia per year.

The amount of ammonia produced exceeds the Category 1 reporting threshold. Therefore, reporting of emissions of ammonia to air, water and land is required under the NPI

Note: Based on this data, the minimum herd capacity required to trigger the Category 1 threshold is:

= 10 tonnes/105 tonnes of ammonia x 1500 SCU

= 143 SCU (143 SCU @ 600 kg each)

[a] The default value of 88% was calculated using the data from Table 7 in this manual, and assuming that the ammonia emissions consisted of losses from fresh manure, feedlot pad, manure stockpile, retention pond and some irrigation of effluent on-site.

Below is a detailed example of the determination of ammonia emissions from feedlot facilities.

Example 12 - Ammonia emissions calculations

The beef feedlot operator in Example 1 has calculated that reporting is required for emissions of ammonia. The operator has an equivalent herd size of 1500 SCU. The farmer applies 3.0 ML/yr of water from the effluent pond on site. Some water from the effluent ponds is also provided to a neighbouring farm. Estimate the amount of ammonia released to the atmosphere from the facility.

If site-specific data is available, then this data should be used for these calculations. However, in the absence of such information, the default data given in this manual may be used. (This example assumes that there are no on-site data available).

1. Fresh manure losses

From Table 5 the amount of total nitrogen produced each year from freshly excreted manure of lot fed beef cattle is equal to 65 kg Total N/SCU/year. So for a 1 500 SCU feedlot

Annual amount of nitrogen produced = 1500 SCU x 65 kg N/SCU/year

= 97 500 kg N/year.

From Table 6, 60% of the nitrogen in the excreted fresh manure is lost to volatilisation. So the amount of nitrogen volatilised = 60% of 97 500 kg N/year

= 0.6 x 97 500 kg N/year.

= 58 500kg N/year

Amount of ammonia released from fresh manure

= nitrogen x $MW_{ammonia}/EW_{nitrogen}$

= 58 500 kg/year x 17/14

= 71 036 kg/year of ammonia

= 71.04 tonnes/year of ammonia

2. Ammonia losses from pad surface

From Table 5, the amount of total nitrogen remaining on pad after volatilisation and run-off is 25.6 kg N/SCU/year.

Annual amount of nitrogen on pad = 1500 SCU x 25.6 kg N/SCU/year

= 38 400 kg N/year

From Table 6, 80% of the nitrogen remaining on the pad is lost to volatilisation. So the amount of nitrogen volatilised = 80% of 38 400 kg N/year

= 0.8 x 38 400 kg N/SCU/year

= 30 720 kg N/year

Example 12 - Ammonia emissions (cont.)

Amount of ammonia released from pad surface

= nitrogen x $MW_{ammonia}/EW_{nitrogen}$

= 30 720 kg/year x 17/14

= 37 303 kg/year of ammonia

= 37.30 tonnes/year of ammonia

3. Manure stockpile

Amount of nitrogen entering stockpile

= 37 303 kg N/year – 30 720 kg N/year volatised

= 6 583 kg N/year

From Table 6, 30% of the nitrogen in the manure stockpile is lost to volatilisation. So the amount of nitrogen volatised

= 30% of 6 583 kg N/year.

= 0.30 x 6 583 kg N/year.

= 1 975 kg N/year.

Amount of ammonia released from manure stockpiling

= nitrogen x $MW_{ammonia}/EW_{rogen}$

= 1 975 kg N/year x 17/14

= 2 398 kg/year of ammonia

= 2.4 tonnes/year of ammonia.

5. Retention pond

From Table 5, amount of nitrogen entering pond

= 0.4 kg N/SCU/year.

Annual amount of nitrogen entering pond

= 1 500 SCU x 0.4 kg N/SCU/year

= 600kg N/year.

From Table 6, 26% of the nitrogen in the retention pond is lost to volatilisation. So the amount of nitrogen volatised:

= 26% of 600 kg N /year.

= 0.26 x 600 kg N /year.

= 156 kg N /year

Example 12 - Ammonia emissions (cont.)

Amount of ammonia released from the retention pond

= nitrogen x $MW_{ammonia}/EW_{nitrogen}$

= 156 kg N/year x 17/14

= 189 kg N/year

= 0.189 tonnes/year of ammonia.

Note: Alternatively, if site-specific data for the average concentration of total nitrogen in each pond were available, the following calculation could be carried out:

Amount of ammonia = Effluent concentration x %volatilisation released annually x annual throughput of the pond

6. Irrigation of effluent from pond

Under the definition by the Implementation Working Group for the NPI, irrigation of the effluent to a neighbour's property is considered as a transfer. However the irrigation of effluent on-site must be included in the calculations for ammonia production.

In the absence of site-specific data Table 4 provides a default value of 250 mg/L for the concentration of total nitrogen data in effluent ponds for Australian feedlots.

From Table 6, 25% of the nitrogen in the irrigation water is volatilised to ammonia. Therefore, total nitrogen volatilised is

= %volatilised x conc of N x amount irrigated

= 0.25 x 250 mg/L x 3 000 000 L/yr x 1 kg/1 000 000 mg

= 187.5 kg N/year

So, ammonia volatilised from the irrigation of pond effluent

= nitrogen x $MW_{ammonia}/EW_{nitrogen}$

= 187.5 kg N/year x 17/14

= 227 kg/year of ammonia

= 0.23 tonnes/year of ammonia

Example 12 - Ammonia emissions (cont.)

7. Soil losses after irrigation

From Table 6, 25% of the nitrogen remaining in the effluent that reaches the soil is then volatilised.

Amount of nitrogen in soil

= 0.85 x concentration of N x amount irrigated

= 0.85 x 250 mg/L x 3 000 000 L/yr x 1 kg/1 000 000 mg

= 637.5 kg N/year

So, total nitrogen volatilised = %volatilised x amount in soil

= 0.25 x 637.5 kg N/year

= 159 kg N/year

Therefore, ammonia volatilised from soil after irrigation

= nitrogen x $MW_{Ammonia}/EW_{Nitrogen}$

= 159 kg /year x 17/14

= 193 kg/year of ammonia

= 0.20 tonnes/year of ammonia

TOTAL amount of ammonia released to air (kg) reported to the NPI

Total NH_3 released

= fresh manure + pad + stockpile + retention pond +
irrigation + post irrigation soil losses

= 71 036 kg/yr + 37 303 kg/yr + 2 398 kg/yr +
189 kg/yr + 227 kg/yr + 193 kg/yr

= 111 346 kg/yr

Note: The emissions from irrigation (to neighbour) and from the sludge (sold off-site) are classed as transfers and hence are not reportable to the NPI. Emissions from the spreading of manure sludge from ponds (on-site) are considered to contain mainly inorganic nitrogen and organic nitrogen that is bound and, hence, there will be minimal emissions of ammonia. There is currently no published data available to estimate these emissions.

Appendix D - Worksheet to assist in Category 1, 2, and 3 threshold calculations

Category 1

Category 1 substances are reported if their use is more than 10 tonnes per reporting year – see the NPI guide for more details. In brief 'use' is defined as the handling, manufacture, import, processing, coincidental production, or other use of a substance.

For the feedlot industry this relates to ammonia produced from animal waste as well as other Category 1 substances that may be 'used' by the facility. Unless other data is available below provides and estimate of 'use' of ammonia

Stock capacity of cattle (SCU)	x	Ammonia emission factor (t Ammonia/SCU/year)	=	Ammonia 'used' per year (t Ammonia/year)
	x	0.07	=	

Category 2

Complete the following table to determine the annual fuel usage for the facility and use this to assist determining if the Category 2a or 2b threshold is exceeded.

Fuel type (Unit)	Quantity used	Units	x	Conversion factor	=	Fuel use (tonnes)
Diesel (litres)		litres	x	8.36E-04 (tonnes/litre)	=	
Petrol (litres)		litres	x	7.39E-04 (tonnes/litre)	=	
Natural gas (MJ)		MJ	x	2.25E-05 (tonnes/MJ)	=	
LPG (litres)		litres	x	5.10E-04 (tonnes/litre)	=	
LPG (tonnes)		tonnes	x	1.00	=	
Biogas (m^3)		m^3	x	1.09E-03 (tonnes/m^3)	=	
Solid fuel (tonnes)		tonnes	x	1.00	=	
TOTAL	-	-	-	-	-	

Category 3

If effluent flows from your retention pond to a water body use the table below to estimate total nitrogen and total phosphorus thresholds and determine if the threshold is exceeded.

Substance emitted	Volume to water body (ML)	x	Factor (tonnes/ML)	=	Emitted (tonnes)
Total nitrogen		x	250	=	
Total phosphorus		x	100	=	

Note: Scientific notation is used; e.g. 7.38E-02 represents 7.38 x 10^{-2} or 0.0738 and 7.38E+02 represents 7.38 x 10^{+2} or 738.

Appendix E - Worksheet to estimate ammonia emissions

If you have not got facility specific emission data and wish to use the average figures based on the data in Table 4 to Table 6 and summarised in the emission factors listed in Table 7. The emission calculations are the same as the threshold 'use' calculations outlined in Appendix D except that emissions are reported in kilograms not tonnes.

The table below estimates the emissions of ammonia in kilograms (kg).

Stock capacity of cattle (SCU)	x	Ammonia emission factor (kg Ammonia/SCU/year)	=	Ammonia emitted per year (kg Ammonia/year)
	x	70	=	

If you want to examine emission from the different steps in your facility or have site specific data to use then the table below can be used. The data provided is the industry standard data and should be replaced by your own facility's data if it is available.

Ammonia source	Cattle (SCU)	x	Ammonia emission factor (kg Ammonia / SCU)			=	Ammonia emissions (kg)
1. Fresh manure loss		x	47.4			=	
2. Manure on pad surface		x	15.8			=	
3. Manure stockpile		x	3.8			=	
4. Retention pond		x	0.1			=	
-	-	x	**Volume irrigated on facility land (kL/SCU)**	**x**	**Ammonia emission factor[3] (kg ammonia / SCU / kL water irrigated per SCU)**	=	-
5. From on-site irrigation[2]		x	1.00	x	0.036	=	
6. From soil after irrigation[2]		x	1.00	x	0.163	=	
TOTAL	-	-	-	-	-	-	

Note: Scientific notation is used; e.g. 7.38E-02 represents 7.38×10^{-2} or 0.0738 and 7.38E+02 represents $7.38 \times 10^{+2}$ or 738.

Appendix F - Worksheet to estimate PM_{10} dust emissions and summarise Category 2 emissions

If you do not have site specific PM_{10} dust data the table below assists in the calculation of PM_{10} dust from cattle movements.

Stock capacity of cattle (SCU)	x	PM_{10} dust emission factor (kg PM_{10} dust /SCU/year)	=	PM_{10} dust emitted per year (kg PM_{10} dust /year)
	x	11.7	=	

If your facility exceeds the Category 2a or 2b threshold then the emissions of all the relevant Category 2 substances from all sources has to be estimated and reported to the NPI. Table 3 contains the list of Category 2 substances to be reported if the appropriate threshold is exceeded. The NPI Guide contains further details. In particular PM_{10} dust from all sources has to be estimated and reported to the NPI if the Category 2a or 2b threshold is exceeded.

Use the Combustion Engines and Combustion in Boilers EET manuals to estimate the combustion products that have to be reported to the NPI. In addition to PM_{10} dust from combustion PM_{10} dust from the movement of cattle has to be estimated and added to that from combustion. The table below summarises the Category 2a substances reported to the NPI. The TOTAL emissions are reported as emissions to air on the NPI reporting form.

Category 2a substances	Combustion sources (kg)	+	Non-combustion sources (kg)	=	TOTAL (kg)
Carbon monoxide		+		=	
Fluoride compounds		+		=	
Hydrochloric acid		+		=	
Oxides of nitrogen		+		=	
Particulate matter (PM_{10})		+		=	
Polycyclic aromatic hydrocarbons		+		=	
Sulfur dioxide		+		=	
Total volatile organic compounds		+		=	

If the Category 2b threshold is exceeded then emission estimates from all the Category 2a substances are reported and the emission estimates from the Category 2b substances as in the next table.

Category 2b substances	Combustion sources (kg)	+	Non-combustion sources (kg)	=	TOTAL (kg)
Arsenic & compounds		+		=	
Beryllium & compounds		+		=	
Cadmium & compounds		+		=	
Chromium (III) compounds		+		=	
Chromium (VI) compounds		+		=	
Copper & compounds		+		=	
Lead & compounds		+		=	
Magnesium oxide fume		+		=	
Mercury & compounds		+		=	
Nickel & compounds		+		=	
Nickel carbonyl		+		=	
Nickel subsulfide		+		=	
Polychlorinated dioxins & furans		+		=	

Appendix G – Simplified NPI reporting form

The following is a simplified reporting form that is intended for smaller operations that only expect to report emissions of ammonia. Larger operations, and/or those with a requirement to report additional substances (such as a result of combustion or fuel storage), should estimate their emissions using the worksheets in this manual, and the standard reporting form available from the NPI web site (or the NPI reporting tool).

Once you have completed this form you should forward it to the NPI office in your state or territory. Contact details are available from the NPI web site, or phone free-call 1800 657 945 for advice.

Step 1 – Does your farm exceed the reporting threshold?

If the average number of standard cattle units (SCU) in a year (One SCU = One 600kg beast) is 143 or more you need to report emissions of ammonia to the NPI. For NPI reporting purposes "year" is a financial year.

Use the table below to enter your SCU's each month:

Month	**Example stock held (SCUs)**	**Your numbers stock held (SCUs)**
July	600	
August	600	
September	500	
October	400	
November	100	
December	100	
January	0	
February	0	
March	150	
April	450	
May	900	
June	1000	
TOTAL	4800	
AVERAGE SCU (Total/12)	400	

If your AVERAGE SCU is 143 or more you need to report emissions of ammonia from your farm.

Step 2 – Estimate your ammonia emissions

Take your AVERAGE SCU from step 1 and multiply it by the ammonia emission factor. The result in kg is the estimated emissions of ammonia from your farm that must be reporting to the NPI.

Example **Stock numbers (SCUs)**	**X**	**Ammonia emission factor (kg ammonia/SCU/Year)**	**=**	**Ammonia emitted per year (kg ammonia/year)**
400	X	70	=	28,000

Your stock numbers (SCUs)	**X**	**Ammonia emission factor (kg ammonia/SCU/Year)**	**=**	**Ammonia emitted per year (kg ammonia/year)**
	X	70	=	

Step 3 – Provide your farm details

Please complete the following. **Information marked with an * will appear on the NPI public web site**

Facility details	
Registered details (as per company or business registration)	
Registered name* [1]	
Registered address Street address	
City, State, Postcode	
Australian Company Number (ACN)*	
Australian Business Number (ABN)	
Feedlot details	
Physical location of the farm	
Name of farm*[1]	
Farm address* Street Address	
City, State, Postcode	
Contact details for feedlot	
Public contact name* [2]	
Position title* [2]	
Phone* [3]	
Fax	

Email address* [4]	
Web address*	
Postal address Street or Postbox	
City, State, Postcode	
If you are an owner-occupier: [1] – and your registered name or farm name is the name of the owner-occupier, you may use an alternative descriptive name (such as the name of the property). [2] – you may use a generic term such as "Manager" or "Environmental Manager". [3] – you may use the phone number of your industry association if you have received their approval to do so. [4] – you may use the email address of your industry association if you have received their approval to do so.	
Technical contact – the person who completes this form	
Technical contact name	
Position title	
Phone	
Fax	
Email address	
Number of employees working at this farm	
Description of main activities	
Pollution control/emission reduction activities – please note anything you do at the farm to reduce emissions.	

Step 4 - Certification

I hereby certify that to the best of my knowledge the information on this form has been provided using all due care and diligence.

Name …… Position …….…….

Signature …… Date ……..