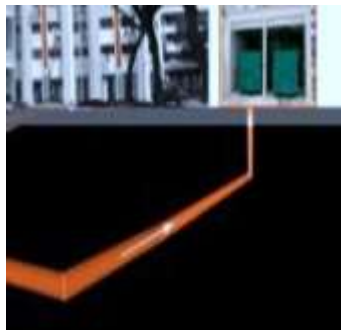
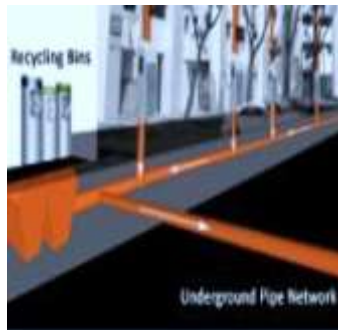


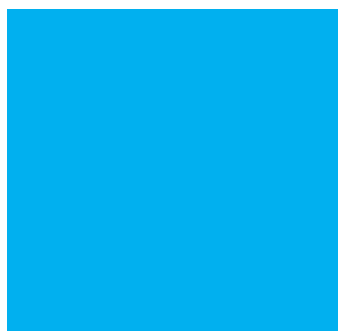


EPD REPORT 2016

NATIONAL ENVIRONMENT AGENCY

Environmental Protection Division

Annual Report 2016



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foreword

Ananda Ram Bhaskar
Director-General
Environmental Protection Division

The National Environment Agency (NEA) was established on 1 July 2002.

NEA took over the operational functions of environmental protection and public health from the then Ministry of the Environment (ENV) so that ENV could focus on strategic and policy planning. For better synergy, the Meteorological Services Department, which used to be part of the Ministry of Transport, was integrated into NEA. ENV was subsequently renamed as the Ministry of the Environment and Water Resources (MEWR).

Within NEA, the Environmental Protection Division (EPD)'s role is to ensure that Singaporeans continue to enjoy a quality living environment for generations to come by implementing programmes to monitor, prevent and control environmental pollution. In addition, it spearheads new initiatives to enhance resource efficiency including waste minimisation, recycling, energy efficiency, and energy conservation. EPD will also continue to develop its programme on radiation protection and nuclear science. The key achievements and progress of EPD's programmes and initiatives in 2016 are outlined in this Report.

introduction

Singapore developed its industrial base and achieved high rates of economic growth over a span of four decades. With forward planning policies in place, environmental programmes being implemented at a very early stage to promote environmental sustainability.

The Anti-Pollution Unit (APU) under the Prime Minister's Office and the Ministry of the Environment (ENV) were formed in 1970 and 1972 respectively to ensure that Singapore's rapid economic growth and industrialisation could be achieved with minimum impact to the environment. APU was subsequently merged with ENV in 1986. ENV was renamed as the Ministry of the Environment and Water Resources (MEWR) in September 2004 and its operational functions were taken over by its two statutory boards viz. the National Environment Agency (NEA), which was formed on 1 July 2002, and the Public Utilities Board (PUB), Singapore's National Water Agency. The two statutory boards safeguarded the environment and environmental health by planning, developing and operating sewerage, drainage and solid waste disposal facilities, controlling air and water pollution, hazardous chemicals and toxic wastes, and providing environmental public health services and public health education.

The Environmental Protection Division (EPD) of NEA is responsible for directing the protection and management of the environment, and promoting resource conservation. EPD is headed by the Director-General for Environmental Protection (DGEP), who is appointed under the Environmental Protection and Management Act (EPMA), and is responsible for the administration of the EPMA. The EPMA is a consolidation of laws relating to environmental pollution control. DGEP is also responsible for the administration of the Energy Conservation Act (ECA)

and Radiation Protection Act (RPA). The ECA mandates energy efficiency requirements and energy management practices to promote energy conservation, improve energy efficiency and reduce environmental impact. The RPA is an act to control and regulate the import, export, manufacture, sale, disposal, transport, storage, possession and use of ionising and non-ionising radiation irradiating apparatus, and radioactive materials. Apart from the EPMA and its subsidiary legislations, EPD also plays a major role in the administration of the Hazardous Waste (Control of Export, Import and Transit) Act, and the Transboundary Haze Pollution Act.

EPD comprises the following departments that are responsible for different aspects of environmental protection. The departments come together to provide a holistic management of the environment in Singapore.

- Pollution Control Department (PCD)
- Central Building Plan Department (CBPD)
- Energy Efficiency and Conservation Department (EECD)
- Waste and Resource Management Department (WRMD)
- Radiation Protection and Nuclear Science Department (RPNSD)

The organisation chart of EPD (2016) is found in **Appendix 1**. The functions of the various EPD departments, and their key initiatives and programmes, are detailed in the subsequent chapters and in **Appendices 2 to 6**.

highlights of 2016

Key Events that involved EPD Departments

On 12 July 2016, at the CleanEnviro Summit Singapore 2016, twenty companies received the **3R Packaging Awards** from the Minister for the Environment and Water Resources, Mr Masagos Zulkifli Bin Masagos Mohamad, in recognition of their notable efforts and achievements in reducing packaging waste.

A total of 28 hotels were recognised for their 3R efforts during the 3R Awards and Seminar for Hotels held on 24 October 2016. The biennial awards serve to recognise participants of the 3R Programme for Hotels which have performed well in solid waste management and the 3Rs.

The EENP Awards 2016 – Industry Energy Efficiency Sharing Session, took place on 4 October and attracted more than 450 participants. Minister Masagos Zulkifli Bin Masagos Mohamad presented the EENP Awards to ten companies, two energy managers, two public agencies and one school for their commitment to and achievements in energy efficiency.

The EENP Awards Ceremony was followed by industry energy efficiency sharing sessions, where EENP Award recipients and other industry professionals shared their best practices, case studies, new technologies and solutions in energy efficiency and energy management.

New/Extended Initiatives

In 2016, the overall rate of recycling was 61%. Working towards the targeted recycling rate of 70% by 2030, NEA introduced several initiatives in 2016 that were targeted at reducing electrical and electronic waste (e-waste), packaging and food waste. These include a study on the collection, recycling and management of e-waste, collaboration with industry on the national voluntary partnership for e-waste recycling, the launch of a food waste minimisation guidebook for food retail establishments, the implementation of on-site food waste treatment machines at hawker centres, as well as a pilot project for the collection and transportation of food waste for co-digestion with used water sludge. The industry was also consulted on possible regulated systems for more sustainable packaging waste management.

Other initiatives in 2016 aimed at promoting the 3Rs include the Clean & Green Singapore (CGS) Carnival which was held from 5 to 7 November 2016.

As part of efforts to increase oversight of the Used Cooking Oil (UCO) industry, NEA rolled out a new licensing scheme for the collection of UCO from 1 December 2016. The licensing scheme will ensure that UCO collectors meet waste collection standards, including standards for the proper collection, storage and transportation of UCO. Collectors who wish to collect UCO will have until 1 June 2017 to obtain a General Waste Collector (GWC) Licence from NEA. All food establishments, such as food retail establishments and food manufacturers, will be required to engage licensed collectors for UCO collections by 1 June 2017.

In 2008, NEA introduced the Mandatory Energy Labelling Scheme (**MELS**), which empowered households with information on energy consumption of appliances to make better purchasing choices and encouraged suppliers to bring in more energy efficient appliances as technology improves. NEA also introduced the Minimum Energy Performance Standards (**MEPS**) for household appliances such as air-conditioners and refrigerators in 2011. This was subsequently raised in 2013 and extended to clothes dryers in 2014 and lamps in 2015.

In September 2016, MEPS for air-conditioners were raised from 1-tick to 2-ticks. Purchasing a 2-ticks air-conditioner, instead of a 1-tick air-conditioner, can help households save \$100 annually in electricity bills. NEA also announced that MEPS for refrigerators would be

raised by between 5 per cent and 13 per cent, depending on the refrigerator category, from December 2017 onwards.

In 2016, NEA sought feedback from the industry to enhance the ECA with the following new requirements to improve the energy management practices in the industrial sector and to improve energy efficiency of common industrial energy consuming equipment and systems:

- i. Structured energy management system (EnMS) for existing facilities
- ii. Regular energy efficiency opportunities assessments (EEOAs) for existing facilities
- iii. Energy efficient design of new facilities
- iv. Energy performance measurement requirements for new facilities
- v. Minimum Energy Performance Standards (MEPS) for common industrial equipment & systems

There was no disagreement from the industry on the broad thrust of the proposals and the industry's feedback showed commitment to improve energy efficiency. The ECA would be amended in 2017, taking into consideration the industry feedback.

NEA also facilitated the formation of an industry-led food manufacturing energy efficiency committee to share and promote best practices among companies in this sector. This was on the back of a benchmarking study of the performance of energy consuming systems in the food manufacturing industry which was completed in March 2016.

Increasing public awareness on the importance and ways of conserving energy is key to reducing energy wastage in households. In 2016, NEA rolled out a series of public messaging initiatives with the theme "Save Energy Save Money". The aim was to encourage households to practise simple energy-saving measures.

Waste Management Infrastructure

NEA awarded the Request for Proposal (RFP) for the development of the Pilot Mechanical and Biological Treatment (MBT) facility to a consortium comprising Hangzhou Jinjiang Group Co. Ltd. and Eastern Green Power Pte. Ltd. on 21 December 2016.

Construction of Singapore's 6th Waste-To-Energy (WTE) Plant has commenced in early 2016. The project financial close was achieved on 16 May 2016.

NEA launched the Expression of Interest (EOI) in September 2016 to shortlist consultants to participate in the consultancy tender for the development of the Integrated Waste Management Facility (IWMF). The EOI submissions are under evaluation.

The Design and Build tender for the construction of the two viaducts for the landlocked Tuas View Basin site was awarded in June 2016. The viaducts, when completed by end 2018 will provide access for the construction and operation of the IWMF and PUB's Tuas Water Reclamation Plant (TWRP).

NEA (WRMD) awarded a tender to AECOM Singapore Pte Ltd in February 2016 to conduct feasibility studies on implementation of district pneumatic waste conveyance systems (DPWCSs) at Kampong Bugis and Marina Bay. The implementation of the DPWCSs would improve land and labour productivity for refuse collection and improve living conditions with a cleaner and more pleasant living environment.

Formation of Separate Technical Agencies

Following consultation with the building industry stakeholders, NEA and PUB had been operating as two separate technical agencies, with NEA handling environment related matters and PUB handling water related matters since 1 January 2017. Separate building plan submissions will have to be made to NEA for pollution control and environmental health matters, and

to PUB for sewerage and drainage matters. Separate clearances will be issued by NEA and PUB. The separation will improve our service to the building and construction industry.

Cooperation with the International Atomic Energy Agency (IAEA)

In accordance with the reporting obligations of Contracting Parties to the Convention of Nuclear Safety (CNS), NEA submitted Singapore's National Report to the International Atomic Energy Agency (IAEA) Secretariat on 3 August 2016 for peer review at the Convention meetings. Singapore has been a party to the CNS since 15 December 1997. The CNS aims to achieve and maintain a high level of nuclear safety worldwide, establish and maintain effective defences in nuclear installations against potential radiological hazards, and prevent accidents having radiological consequences.

As the national focal point to the IAEA for technical cooperation, RPNSD prepared Singapore's Country Programme Framework (CPF) for the period from 2016

to 2020, which was signed by Mr Foo Kok Jwee, Ambassador and Resident Representative of Singapore to the IAEA, and Mr Dazhu Yang, IAEA Deputy Director General and Head of the Department of Technical Cooperation on 5 December 2016. The CPF is the frame of reference for the medium-term planning of technical cooperation between Singapore and the IAEA and identifies priority areas where the transfer of nuclear technology and technical cooperation resources will be directed to support national development goals. The 5-year CPF identified several priority areas namely safety and security, health and nutrition, industrial applications/radiation technology, water and the environment, and sterile insect technology.

Introduction of Permit System for Exemption from No-Work Rule

In January 2017, NEA introduced a Permit System to allow contractors to apply for exemption from the No-Work Rule on Sundays and Public Holidays. However, only quieter construction works will be allowed to be carried out at selected construction sites on Sundays and Public Holidays. Such activities will be limited to specific types of work such as safety inspections, indoor painting, planting and wall plastering. Contractors must obtain a permit from NEA before carrying out such works.

The permits, which will give contractors the flexibility to schedule some quieter construction work on Sundays and Public Holidays, will be granted only for specific construction phases and on a case-by-case basis,

subject to stringent conditions.

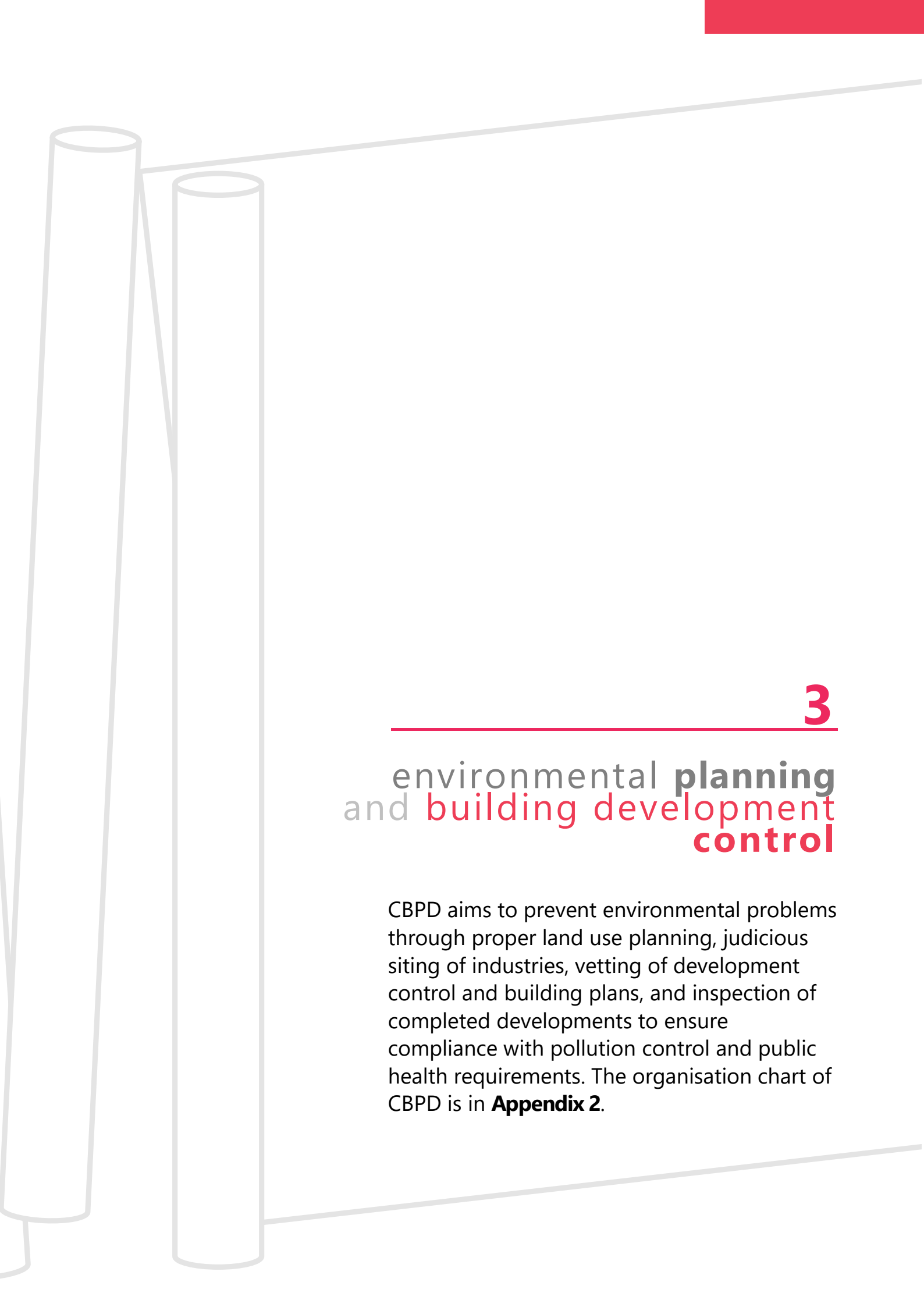
Contractors must adhere to noise limits, which are more stringent than the current limits for Sundays and Public Holidays, install real-time noise monitoring meters, and may only work during approved hours. Further, all work within 50 metres of residential areas is prohibited. Contractors that do not comply with the permit conditions will have their permits revoked and may face enforcement action.

The permit will allow contractors to expedite their works and shorten the period that occupants of nearby residential and noise sensitive premises are exposed to possible noise nuisance.

Restriction of Hazardous Substances (RoHS) in Electrical and Electronic Equipment

NEA implemented the Singapore RoHS initiative to help restrict the amount of hazardous substances entering the environment at the end of the lifespan of the EEE. On 1 June 2016, NEA gazetted the control of six hazardous substances for six household electrical and electronic equipment (EEE) viz. mobile phones, portable computers, refrigerators, air conditioners, panel televisions and washing machines under the Environmental Protection and Management Act (EPMA).

Under the initiative, manufacturers, importers and distributors are required to ensure that the six controlled EEE are Singapore RoHS compliant. The control measures will come into effect on 1 June 2017, after giving the industries a one-year transition period for compliance with the requirements. NEA will conduct post-market surveillance to ensure that the six EEE which are placed on the market comply with Singapore RoHS requirements.



3

environmental planning and building development control

CBPD aims to prevent environmental problems through proper land use planning, judicious siting of industries, vetting of development control and building plans, and inspection of completed developments to ensure compliance with pollution control and public health requirements. The organisation chart of CBPD is in **Appendix 2**.

Environmental Land Use Planning

Environmental problems can be prevented through proper land use planning and the use of appropriate controls and technologies. NEA adopts an integrated approach in the planning control of new developments to ensure that environmental considerations and factors are incorporated at the land use planning, development control, building plan and commissioning stages. This will minimise pollution and mitigate pollution impact on the surrounding developments to achieve a quality environment.

The Urban Redevelopment Authority (URA), which is the land use planning authority in Singapore, consults the Central Building Plan Department (CBPD) on the environmental requirements related to land use planning. The Jurong Town Corporation (JTC), Housing & Development Board (HDB), Economic Development Board (EDB) and private sector developers also consult CBPD on the compatibility of industrial activities within an industrial development, siting for new industrial developments and information related to buffer distances so that these environmental considerations can be factored into the planning and design of the proposed developments at an early stage.

CBPD also assesses and evaluates the hazard and pollution impacts of the proposed industries to ensure that they do not pose any health and safety concerns and pollution problems. The proposed industrial plant will only be allowed to be set up if it is sited in an appropriate industrial estate that is compatible with the surrounding land use, and can comply with the chemical safety and pollution control requirements.

In 2016, CBPD processed a total of 43,678 submissions, of which 9,910 were land use and development control submissions. The breakdown of the respective submissions processed is shown in **Table 3.1**.

Major Planning Proposals

CBPD evaluated 43 Quantitative Risk Assessment (QRA) studies of chemical plants storing, using and/or transporting hazardous substances. Clearances for these proposed developments were granted after they

had demonstrated compliance with the stipulated chemical safety criteria and technical requirements.

In addition, CBPD evaluated 15 Pollution Control Study (PCS) reports of industrial developments engaging in activities that could potentially cause environmental pollution. These industrial developments were given clearances after they had demonstrated compliance with the stipulated pollution control requirements.

Development Control and Building Plan Clearance

Technical requirements to prevent and/or mitigate environmental impacts are imposed at the Development Control (DC) and Building Plan (BP) clearance stages. This is to ensure that appropriate control measures could be implemented in the development's layout planning, design, operation, and maintenance in order to comply with environmental requirements and guidelines.

Upon the completion of building and construction works, the Qualified Person (QP) in charge of the development would arrange with CBPD for a site inspection to verify that all chemical safety and pollution control requirements imposed at the building plan stage have been duly complied with. Thereafter, CBPD grants the Temporary Occupation Permit (TOP) clearance or Certificate of Statutory Completion (CSC) clearance.

During the year, CBPD processed 12,265 building and detailed plans, and issued 12,761 TOP/CSC clearances.

Table 3.1
Breakdown of Applications Processed in 2016

Classification	Applications
Pre-Consultation	8,684
Land Use / Development Control	9,910
Quantitative Risk Assessment	43
Pollution Control Study	15
Building & Detailed Plan	12,265
TOP / CSC Clearance	12,761
Total	43,678

pollution **control**

PCD is responsible for air, water, and construction noise pollution control; as well as hazardous substances and toxic waste control. It carries out monitoring of ambient air as well as inland and coastal water quality. It is also responsible for the formulation and implementation of joint programmes to mitigate transboundary pollution in the region. The organisation chart of PCD is in **Appendix 3**.

As the division responsible for environment protection, EPD takes a serious view of any violation of our regulations. Details of the contraventions and follow up actions can be found in **Appendix 7**.

Air Pollution Control

Overview

The Pollution Control Department (PCD) administers the Environmental Protection and Management Act (EPMA) and its Regulations to control air pollution from industrial and trade premises.

The Environmental Protection and Management Act and its Regulations

Air pollution in Singapore is regulated under the EPMA and its Regulations. The Environmental Protection and Management (Air Impurities) Regulations 2000, which came into force since 1 January 2001 and last updated on 1 July 2015, stipulate emission standards for air pollutants. The purpose of the standards is to minimise the pollutant emissions from industries so that our ambient air quality continues to remain within acceptable levels. The standards are listed in **Appendix 8**.

Industries which have the potential to cause serious air pollution are classified as Scheduled Premises under the EPMA. The list of Scheduled Premises is in **Appendix 9**. The owner or occupier of any Scheduled Premises is required to obtain a Written Permission (WP) from PCD before commencement of operation. PCD grants the WP only after all pollution control requirements have been complied with.

The list of prosecutions in 2016 related to air pollution incidents is as follows:

	Offender	Offence description
1	Eastman Chemical PPU	EPMA 11 (1) Emission of dark smoke from chimney of premises
2	Panasonic App Refrigeration Devices Singapore	EPMA 11 (1) Emission of dark smoke from chimney of premises
3	Prime Evolve Singapore Pte Ltd	EPMA 11 (1) Emission of dark smoke from chimney of a premises
4	Sembcorp Cogen Pte Ltd	EPMA 11 (1) Emission of dark smoke from chimney of a premises
5	Shell Eastern Petroleum (Pvt) Limited	EPMA 11 (1) Emission of dark smoke from chimney of a premises

	Offender	Offence description
6	Shell Eastern Petroleum (Pvt) Limited	EPMA 11 (1) Emission of dark smoke from chimney of a premises
7	Kim Hock Corporation Pte Ltd	EPMA 12 (1) Emitted air impurities exceeding the allowable limits
8	Aircon Materials Asia Pte Ltd	EPMA 14(2) Use of open fire to dispose of accounting documents and other unwanted materials
9	Aw Ban Chye of Sin Hup Huat Sesame Oil Pte Ltd	EPMA 14(2) Use of open fire to dispose of refuse in a trade premises
10	Eco Garden Pte Ltd	EPMA 14(2) Use of open fire to dispose of waste wood in a trade premises

Compliance Testing and Checking At Factories

PCD carries out regular inspections on industrial and non-industrial premises to ensure compliance with pollution control requirements.

During the year, 10,430 inspections were conducted on industrial premises (e.g. factories, trade premises, etc.) and 3,268 inspections on non-industrial premises (e.g. farms, domestic premises, etc.).

Under PCD's source emission testing scheme, industries are required to conduct source emission tests to monitor their emissions regularly, and take remedial measures to comply with the prescribed air emission standards. During the year, 189 companies were required to conduct source emission tests. Altogether, they conducted a total of 1,098 tests comprising 353 isokinetic tests and 745 tests on gaseous emissions. One company failed the prescribed standards and a warning letter was issued. During the year, PCD also conducted 78 fuel analyses, 584 smoke observations of chimneys and online monitoring. Of these, one company failed to comply with the prescribed dark smoke standards and it was later prosecuted. In addition, 3 warning letters were also issued.

Air Pollution Control Equipment

Industries are required to install air pollution control equipment to comply with emission standards. During the year, the installation of 112 units of air pollution control equipment was approved. The types of equipment approved are listed in **Table 4.1**.

Table 4.1
Air Pollution Control Equipment Approved in 2016

Equipment	Units
Spray Painting Booth	29
Scrubber	39
Dust collector	20
Miscellaneous	24
Total	112

Fuel Burning Equipment

Prior to any installation of fuel burning equipment by industries, checks on the technical details of fuel burning equipment are conducted to ensure that fuel burning equipment are designed to comply with the environmental requirements and guidelines. During the year, the installation of 41 units of fuel burning equipment was approved. The types of equipment approved are listed in **Table 4.2**.

Table 4.2
Fuel Burning Equipment Approved in 2016

Equipment	Units
Boiler	18
Furnace	1
Oven/Dryer	5
Miscellaneous	17
Total	41

Continuous In-Stack Monitoring System

Major emitters such as the oil refineries, power stations and refuse incineration plants have been required to install in-stack continuous emission monitors, which are linked to PCD by telemetry. This is to enable PCD to monitor their emissions continuously on a real-time basis and to be alerted to emissions exceeding the allowable limits. The typical pollutants monitored are Particulate Matter (PM), Sulphur Dioxide (SO₂), Oxides of Nitrogen (NO_x), Carbon Monoxide (CO) and Hydrogen Chloride (HCl). The emission data are transmitted in real-time to NEA's telemetric stack monitoring system. The system records the emission

and sends out SMS alerts to NEA officers whenever emission from any plant exceeds the allowable limits.

Control of Fugitive Odorous Emissions

Fugitive or residual emission of odorous substances can be a major source of smell nuisance from factories. These factories are required to install odour control equipment to minimise the nuisance. Officers on the ground conduct inspections regularly and place emphasis on nuisance issues during factories inspections to ensure that the odorous emissions are under control.

Complaints and Incidents of Air Pollution

During the year, PCD received 929 complaints on air pollution, of which none was verified as incidents of air pollution. The main causes of these incidents were poor maintenance, improper operation and/or overloading of air pollution control equipment.

PCD required the owners or occupiers to take immediate remedial action to comply with the allowable emission limits.

Control of Vehicular Emissions

Control of Smoky and Idling Vehicles

PCD is responsible for carrying out enforcement operations against smoky and idling vehicles on the roads. In 2016, a total of 8,796 and 664 vehicles were caught for emitting excessive smoke and idling engines respectively.

In addition to the daily enforcement operations against smoky and idling vehicles on the roads, NEA also conducts joint enforcement blitz with Land Transport Authority (LTA) and Traffic Police (TP) to raise public awareness and further clampdown on smoky and idling vehicles. In 2016, PCD received 3,510 feedback on smoky vehicles and 6,952 feedback on idling engines.

NEA will continue to work closely with authorised vehicle inspection centres such as VICOM, JIC and STA and fleet owners to educate motorists to maintain their vehicles properly and not to leave their engines idling when stationary. Anti-idling engine signage has been installed at hotspots to also forewarn motorists that it is an offence to leave their vehicle engines idling when stationary.

In addition, NEA has worked with TP and the driving schools to incorporate eco-driving tips in the Basic Theory syllabus so as to educate learner drivers on the need to carry out proper and regular vehicle maintenance, as well as to practise good driving habits in order to reduce emissions.



Enforcement officer conducting smoke measurement on a smoky vehicle

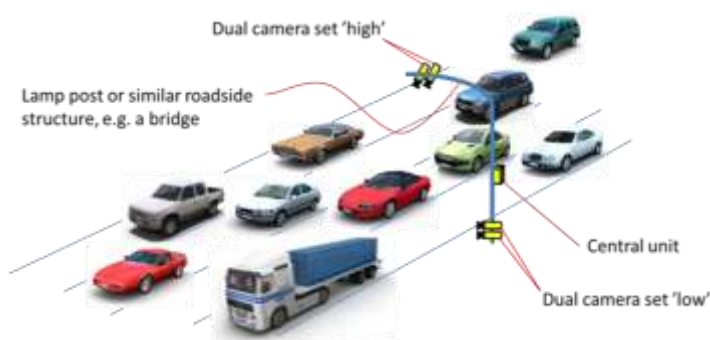


PCD enforcement officers issuing a warning letter and pamphlet to a motorist



Anti-idling vehicle signage at a residential carpark

NEA is test-bedding various Remote Smoke Detection (RSD) technologies to automate detection of smoky vehicles on the roads round the clock. RSD will be coupled with a licence plate number recognition system. This will help to reduce reliance on manpower and increase productivity. A schematic diagram of the system is shown below:



Vehicle Emission Standards

With the continuing growth of vehicle population in Singapore, total emissions from vehicles have to be kept in check through the implementation of stringent emission standards for new vehicles. Over the years, NEA has tightened the emission standards in tandem with advances in automotive technology.

In Singapore, diesel vehicles account for about half of the total PM_{2.5} emissions. To bring down the PM_{2.5} levels in Singapore to within acceptable standards, NEA will be tightening the emission standards for all new vehicles as summarised in **Table 4.3**. Besides reducing PM_{2.5} levels, this will also reduce the levels of

other pollutants such as NO₂ and ozone in the ambient air.

Table 4.3

Current and Future New Vehicle Emission Standards

Vehicle Type	Current Emission Standard	Future Emission Standard	Effective Date
Petrol vehicles	EURO IV	EURO VI	Sep 2017
Diesel vehicles	EURO V	EURO VI	Jan 2018
Motorcycles	EURO III	EURO IV	Jan 2018* Jan 2020**

* For large motorcycles above 200 cc

**For small motorcycles of 200 cc and below

In addition, in-use vehicles are required to undergo mandatory periodic inspections. These vehicles are tested for compliance with limits stipulated in the regulations for in-use vehicles. This is to ensure the proper maintenance of engines and efficacy of catalytic converters.

Since 1 January 2007, the chassis dynamometer smoke test (CDST) has been used to test diesel vehicles during their mandatory periodic inspections. The CDST measures smoke emission level of a diesel-driven vehicle under actual driving conditions. The CDST system places a diesel vehicle under simulated "load" conditions to measure its smoke emission. This is a more accurate reflection of the actual performance of a diesel-driven vehicle on the road.

A stricter emission standard for in-use diesel vehicles has been implemented since 1 July 2014. The smoke opacity limit for in-use diesel vehicles has been tightened from 50 Hartridge Smoke Units (HSU) to 40 HSU since 1 July 2014.



Vehicle undergoing CDST

Noise Standards for New and In-Use Motor Vehicles

All new and in-use motor vehicles must comply with vehicle noise emission standards stipulated in the regulations. The prevailing noise emission standards are listed in **Table 4.4**.

Table 4.4
Noise Emission Standards

Type of Vehicle	Registration Standard for New Vehicle (dBA)	Enforcement Standard for In-use Vehicle (dBA)
Motorcycle	94	99
Motorcar	96 100 (rear engine)	103
Light Goods Vehicle (vehicle weight not exceeding 3.5 tons)	97	103
Heavy Goods Vehicle (vehicle weight exceeding 3.5 tons)	99	107

In 2016, NEA received 45 public feedback on noisy vehicles which were mainly due to illegal modifications to the exhaust system. NEA will continue to work with LTA to take enforcement action against the errant vehicle owners.

Control of Automotive Fuel Quality

The quality of fuel used by vehicles in Singapore is controlled because of its impact on vehicular emissions. Unleaded petrol was introduced in January 1991 and leaded petrol was phased out on 1 July 1998.

To reduce smoke emission from diesel vehicles, the permissible sulphur content in diesel was reduced from 0.3% to 0.05% by weight on 1 March 1999. Smoke emission from diesel-driven vehicles is harmful as the fine particulate matter present in smoke has a significant health impact on people. The reduction of the sulphur content in diesel paved the way for the introduction of the more stringent Euro II emission standards on 1 January 2001. A reduction of the sulphur content in diesel to 0.005% by weight was effected in December 2005 when Singapore implemented the Euro IV emission standard for new diesel vehicles, which took effect from 1 October 2006. A further reduction of the sulphur content in diesel to 0.001% by weight was effected on 1 July 2013 and petrol to 0.005% by weight on 1 October 2013 to pave the way for the implementation of Euro V emission standards for new diesel vehicles and Euro IV emission standards for petrol, which took effect from 1 January 2014 and 1 April 2014 respectively.

Moving forward, the EURO V standard for diesel has been implemented on 1 January 2017 (except density and T95 which will be effective from 1 January 2018). EURO V for petrol will be implemented on 1 July 2017 (except aromatics which will be effective from 1 December 2018).

Compressed Natural Gas (CNG) Vehicles

As at end 2016, there are 2,738 CNG vehicles comprising 1,034 CNG taxis, 1,682 CNG cars, 14 CNG buses and 8 CNG goods vehicles. There are 4 CNG stations in operation as at end 2016. They are located at Jurong Island, Mandai Link, Serangoon North, old Toh Tuck Road.



CNG refuelling station at Serangoon North

Government Financial Incentives

To reduce pollution from vehicles, the Government has been promoting the use of environmentally friendly vehicles through the Carbon Emissions-based Vehicle Scheme (CEVS). CEVS was introduced on 1 January 2013 as a carbon mitigation measure for the transport sector. Under this scheme, buyers of lower carbon emission cars will benefit from rebates while buyers of

high carbon emission models will pay a surcharge. The scheme was revised on 1 July 2015 to further encourage vehicle buyers to shift to low carbon emission models by shifting the bands towards lower range of CO₂ and increasing the amount of rebate/surcharge for the lowest/highest emission band. As taxis generally clock higher mileage than cars, the revised CEVS rebate and surcharge for taxis will be higher by 50% to encourage taxi companies to adopt lower carbon emission models for their fleet.

The Early Turnover Scheme was introduced on 24 April 2013 to incentivise owners of Pre-Euro/Euro I Cat C diesel vehicles to replace their older and more polluting vehicles with newer models that comply with more stringent emission standards. Under this scheme, owners can register a replacement vehicle by paying a discounted Prevailing Quota Premium (PQP) without the need to bid for a new Cat C COE. Owners are also allowed to transfer the remaining unused COE period and/or a proportion of the remaining 20-year lifespan at deregistration to the replacement vehicle, capped at 10 years. The scheme was enhanced on 1 Aug 2015 to extend the scheme to Euro II and III Cat C diesel vehicles until 31 July 2017. Higher incentives were

offered for switching to the latest Euro VI-compliant models.

Approval of Off Road Diesel Engines (ORDE)

ORDEs are any equipment or machinery with diesel engines such as cranes, excavators, forklifts, power generators, etc. which are not allowed to travel on public roads. Since 1 July 2012, all newly-imported off-road diesel engines for use in Singapore must comply with the EU Stage II, US Tier II or Japan Tier I ORDE emission standards. In 2016, PCD approved a total of 6,145 units of ORDE.

2016 Sulphur Dioxide (SO₂) Emission Inventory

The sources of SO₂ emissions in Singapore include refineries, power stations, other industries, and other minor sources such as vehicles, airport and construction activities.

The 2016 SO₂ emission inventory which is developed based on extensive emissions data collected from various sources are shown in **Table 4.5** and **Table 4.6**.

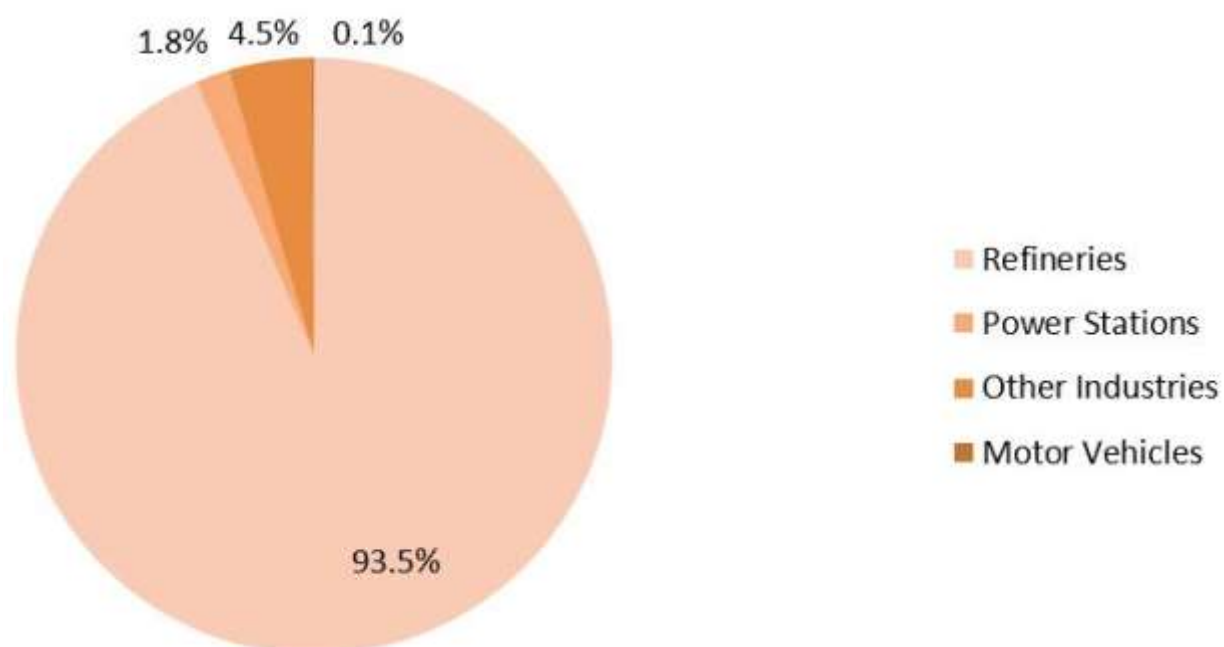
Table 4.5
SO₂ Emission Inventory for 2016

Sources	Emitters	SO ₂ Emissions (tonnes)	Contribution of SO ₂ Emissions
Refineries	Singapore Refining Company (SRC)	24,141	93.5%
	Shell	24,491	
	ExxonMobil (JI)	12,899	
	ExxonMobil (Pioneer Road)	14,326	
Power Stations	Tuas Power (fuel changed from oil to gas in May 2013)	0	1.8%
	Power Seraya	69	
	Senoko Power	0	
	Tuas Power Biomass-Clean Coal Co-generation (started operation in Mar 2013)	1,419	
Other Industries	ExxonMobil Petrochemical	1,844	4.5%
	Linde Syngas	642	
	Sembcorp Utilities and Terminals	7	
	Petrochemical Corporation of Singapore	95	
	Mitsui Phenol	16	
	Evonik Methionine	57	
	Other Fuel Oil Users	988	
	Industrial Diesel Users	10	
Motor Vehicles	Diesel Vehicles	29	0.1%
	Petrol Vehicles	79	
Total		81,112	100%

Table 4.6
SO₂ Emissions from Plants for the Past 5 Years

		2012	2013	2014	2015	2016	Remarks
Refineries	Shell	31,267	26,908	25,818	27,701	24,491	
	Exxonmobil	26,683	25,917	21,593	23,904	27,225	
	SRC	26,768	25,346	24,992	22,996	24,141	
Power Plants	Power Seraya	8,557	8,979	30	66	69	Reduction of SO ₂ emissions due to the change of fuel oil to natural gas
	Tuas Power	16,064	1,343	11	0	0	
	Senoko Power	5,963	286	0.05	0	0	
	BMCC	-	652	1,175	1,273	1,419	Started operation in Mar 2013
	Minor Emitters	3,673	2,192	3,031	3,913	3,659	
Others	Vehicular Sources	966	891	115	110	108	Reduction of SO ₂ emissions due to diesel oil and petrol sold must have sulphur content of less than 0.001% and 0.005% since 1 July 2013 and 1 Oct 2013 respectively
Total Emissions		119,941	92,514	76,765	80,111	81,112	

2016 Percentage Contribution of SO₂ Emissions



Water Pollution Control

Overview

Water quality of the inland and coastal waters remained good in 2016. All inland waters supported aquatic life.

Acts and Regulations

The Environmental Protection and Management Act (EPMA) and the Sewerage and Drainage Act (SDA) and their regulations are used to control the discharge of wastewater from domestic, industrial, agricultural and other premises into public sewers and watercourses. The Environmental Protection and Management (Trade Effluent) Regulations (TER) and the Sewerage and Drainage (Trade Effluent) Regulations stipulate the standards for trade effluent discharged into watercourses and public sewers respectively. The discharge standards stipulated in both the regulations are in **Appendix 10**.

Industries must comply with the discharge standards. Where necessary, they have to install on-site treatment plants to treat their effluent to the stipulated standards. Industries may also apply to PUB for permission to discharge trade effluent, which contain biodegradable pollutants, as measured by biochemical oxygen demand (BOD) and total suspended solids (TSS), into the public sewers on payment of a tariff when the BOD and TSS exceed the stipulated limits. The current schedule of trade effluent tariffs is in **Appendix 11**.

In general, industries with the potential to cause pollution are located in designated industrial estates such as Jurong/Tuas Industrial Estates, which are outside water catchments and served by public sewers. Only clean or light industries are allowed within water catchments but they must be sited in proper industrial estates served by public sewers.

Sampling of Trade Effluents

During the year, PCD collected 156 trade effluent samples for analysis. Of these, 3 samples or about 1.9 % failed to comply with the stipulated standards. PCD required the offenders to take measures to prevent recurrence. Enforcement action was taken on the company for the 2 consecutive failed samples while a warning letter was issued to the company for the failed sample, which was rectified subsequently, post the initial sampling.

Complaints and Incidents of Water Pollution

PCD received 326 complaints on water pollution during the year, of which two were found to be substantiated. Enforcement action and a warning letter was taken and issued respectively for these two cases. PCD also took legal actions against several companies found violating the regulations by PCD's officers

during their inspections. Most of the violations were illegal discharge or spillage of industrial wastewater or chemical/oil into drains. The offenders were required to clean up the pollution and legal action was also taken against them for causing pollution.

The compound fines and court prosecutions related to water pollution in 2016 are reflected in **Table 4.7**.

Hazardous Substances and Toxic Wastes Control

PCD controls the import, export, transport, sale, storage and use of hazardous substances. PCD also controls the disposal of toxic industrial wastes. The controls implemented ensure the safe and proper management of hazardous substances and toxic industrial wastes in Singapore.

Besides regulatory controls, PCD also works with international organisations, relevant government agencies and industry groups to organise seminars and briefings to help companies and traders manage hazardous substances and toxic industrial wastes safely.

Hazardous installations, which store hazardous substances in bulk quantities, are also required to carry out safety audits to systematically identify and rectify weaknesses in their management systems and practices of handling hazardous substances

Hazardous Substances Control

The import, export, transport, sale, storage and use of hazardous substances are controlled under the Environmental Protection and Management Act and the Environmental Protection and Management (Hazardous Substances) Regulations.

Any person planning to import, export, transport, sell, store or use hazardous substances must obtain a Hazardous Substances Licence or Permit from PCD. The substances controlled under the Environmental Protection and Management Act are listed in **Appendix 12**.

During the year, PCD issued 1,091 Hazardous Substances Licences and 1,843 Hazardous Substances Permits. PCD also electronically processed a total of 54,448 inward/outward declarations for the import/export of hazardous substances and products containing hazardous substances through the TradeNet computerised network system.

Also, under the Environmental Protection and Management (Hazardous Substances) Regulations, PCD's approval is required to transport hazardous substances in quantities exceeding the limits stipulated in the Regulations. The stipulated limits for each

Table 4.7

Compound Fines and Court Prosecutions related to Water Pollution in 2016

S/N	Offender	Offence description	S/N	Offender	Offence Description
1	PB Tankers	EPMA 10(4)(a) Discharge of trade effluent exceeding BOD & COD limits into watercourse	14	Malaysian Feed-mills Farms Pte Ltd	EPMA 15(1) Discharge of trade effluent into controlled watercourse
2	BDP-Bernard (Asia Pacific) Pte Ltd	EMPA 15(1) Discharge of trade effluent into open drain	15	Newcon Builders Pte Ltd	EPMA 15(1) Discharge of trade effluent (wastewater with bonding agent) into open drain
3	Boustead Projects Limited	EPMA 15(1) Discharge of oily wastewater into a controlled watercourse	16	N & N Agriculture Pte Ltd	EPMA 15(1) Discharge of trade effluent into watercourse
4	Chemical Industries (Far East) Limited	EPMA 15(1) Discharge of trade effluent into watercourse	17	Poh Wah Scaffolding & Engineering Pte Ltd	EPMA 15(1) Discharge of oily wastewater into open drain
5	Dolphin Engineering Pte Ltd	EPMA 15(1) Discharge of trade effluent (white liquid) into watercourse	18	Power Work Pte Ltd	EPMA 15(1) Discharge of trade effluent into open drain
6	Eng Lee Engineering Pte Ltd	EPMA 15(1) Hydraulic oil leaked from a faulty jacking cylinder at the manhole shaft into the open drain	19	Proserv Far East Pte Ltd	EPMA 15(1) Discharge of trade effluent (green liquid) into watercourse
7	Esteem Performance Pte Ltd	EPMA 15(1) Discharge of soapy waste water from washing activities in front of the workshop into open drain	20	Rebound Ace Spore Pte Ltd	EPMA 15(1) Discharge of trade effluent (blue wastewater) into open drain
8	Fongnam Engineering & Construction Pte Ltd	EPMA 15(1) Discharge of trade effluent (whitish discharge) into open drain	21	Sinohydro Corporation Ltd	EPMA 15(1) Discharge of trade effluent (wastewater containing polymer) into open drain
9	Golden Bridge Foods Manufacturing Pte Ltd	EPMA 15(1) Discharge of polluting matter (food waste) into open drain	22	Smart Energy Pte Ltd	EPMA 15(1) Discharge of oily wastewater into open drain
10	Jing Ying Car Wash Pte Ltd	EPMA 15 (1) Discharge of soapy wastewater into open drain	23	Wallstan Pte Ltd	EPMA 15(1) Discharge of trade effluent (blue wastewater) into open drain
11	Khaiseng Fish Farm & Trading Pte Ltd	EPMA 15(1) Discharge of trade effluent into watercourse	24	Yew Chuan Renovation Contractor Pte Ltd	EPMA 15(1) Discharge of trade effluent (wastewater with paint) into open drain
12	LSA Contract Services Pte Ltd	EPMA 15(1) Discharge of trade effluent (wastewater with white paint) into open drain	25	Zeon Chemical Singapore Pte Ltd	EPMA 15(1) Discharge of trade effluent into open drain
13	Malaysia Dairy Industries Ptd Ltd	EPMA 15(1) Discharge of trade effluent (milky water) into open drain			

hazardous substance are listed in **Appendix 13**.

During the year, PCD issued 545 transport approvals. Requirements on packaging, maximum allowable quantity, route, timing and emergency plans were imposed to ensure the safe transportation of hazardous substances.

During the year, PCD conducted 357 inspections to audit the records of hazardous substances kept by the holders of Hazardous Substances Licences and Permits. Of these, 8 were found to be in breach of the Environmental Protection and Management Act and the Environmental Protection Management (Hazardous Substances) Regulations. As a result, PCD issued written warnings to these 8 offenders.

Application of Hazardous Substances Licence/ Permit and Toxic Industrial Waste Collector Licence via the Internet

Applicants can submit electronic applications for hazardous substances licences/permits and toxic industrial waste collector licences via the Internet and check the status of their electronic applications online. The website address is: <https://eservices.nea.gov.sg/pcls/>

All the necessary guidance and information for filling up the electronic application are available on-line to applicants. Applicants need not travel to PCD to collect application forms, seek clarification or submit application forms.

Training for Tanker Drivers

Drivers of road tankers and tank containers carrying hazardous substances and dangerous petroleum products are required to undergo a special training course jointly organised by Singapore Civil Defence Force (SCDF) and PSA Institute. Those who successfully complete the course are granted a HAZMAT Transportation Driver Permit (HTDP). All drivers conveying controlled hazardous substances listed in the Environmental Protection and Management (Hazardous Substances) Regulations are required to possess a HTDP that is valid for 2 years. They are also required to undergo a one-day course every 2 years as a form of refresher training for the renewal of their HTDP.

Toxic Industrial Wastes Control

The Environmental Public Health (Toxic Industrial Waste) Regulations require all toxic industrial waste collectors to be licensed. Approval is also required to transport toxic industrial wastes exceeding the quantities stipulated in the Regulations.

The Environmental Public Health (Toxic Industrial Waste) Regulations were reviewed and amended in 2009. The scope of wastes covered under the Schedule

of the Regulations was expanded in order to keep pace with new industries and emerging environmental issues. Some of the requirements imposed under the Regulations were amended to remove legislative procedures that were no longer valid or relevant in the current context. Regulations were also amended to offer composition fines for less severe offences. Previously such offences were prosecuted in court. The amended Environmental Public Health (Toxic Industrial Waste) Regulations came into effect from 1 July 2009.

The types of toxic industrial wastes controlled under the Regulations are listed in **Appendix 14**

During the year, PCD issued or renewed licences to 229 toxic industrial waste collectors to carry out treatment, reprocessing and disposal of toxic industrial wastes. PCD also required licensed toxic industrial waste collectors to obtain approval to transport toxic industrial wastes that exceeded specified quantities.

Control of Tanker Cleaning Activities

Since 4 April 1993, Singapore has implemented a scheme to tighten control on tanker cleaning activities and the disposal of sludge and slop oil generated from tanker cleaning activities. Under the scheme, the Maritime and Port Authority (MPA) will only issue permits to contractors who are registered with PCD, to carry out tanker cleaning activities in designated areas.

Sludge and slop oil generated from tanker cleaning activities are required to be sent to approved reception facilities for treatment and disposal.

Also under the scheme, any ship or vessel entering Singapore in a "clean condition" for repairs would be allowed entry only if there is proof that the sludge from its tanker cleaning activities had been disposed of at approved facilities.

During the year, 32 companies were registered to carry out tanker cleaning activities. About 37,360 tonnes of oily sludge were sent to the approved reception facilities for treatment and disposal.

Collection of Industrial Waste Chemicals

The main types of industrial waste chemicals are waste solvents, spent etchants, acids, alkalis and expired chemicals. PCD encourages the recovery, reuse and recycling of waste chemicals to reduce the amount of wastes requiring treatment and disposal.

During the year, licensed collectors collected about 478,990 tonnes of waste chemicals from local industries for proper treatment and disposal.

Control of Biohazardous Wastes

Biohazardous wastes from hospitals and polyclinics are controlled under the Environmental Public Health (Toxic Industrial Waste) Regulations. Biohazardous

wastes are segregated at source and stored in colour-coded plastic bags. The wastes are then put in secured containers and collected by four licensed biohazardous waste disposal companies for disposal in dedicated high temperature incinerators.

In 2016, about 40,260 cubic metres of biohazardous wastes were collected and disposed of locally by licensed biohazardous waste disposal companies.

Terrain Decontamination

In the event that a chemical or radiological agent is released, the Singapore Civil Defence Force (SCDF) will carry out the initial response to save lives and mitigate the source of release, including preliminary site decontamination of the affected area. Once the area is secured, NEA will move in to carry out terrain decontamination to restore the affected area to normalcy as soon as possible. Recall exercises were conducted regularly to test the operational readiness of the decontamination service provider. NEA is also building up the required capability for biological agent incidents.

Environmental Noise Management

Industrial Noise Control

PCD controls noise from factories by siting them in designated industrial estates and where necessary, requiring them to implement noise abatement measures to comply with allowable boundary noise limits. PCD conducts regular checks on factories to ensure noise control equipment is operated and maintained properly. The boundary noise limits for factory premises are in **Appendix 15**.

During the year, PCD received 357 complaints of noise pollution from factories, of which one case was substantiated. A warning letter was issued to the offender. The offender was also advised to be more considerate towards their neighbours and to take measures to ensure that they comply with the allowable noise limits at all times.

Traffic Noise from Expressways

In land-scarce and highly urbanised Singapore, some degree of traffic noise pollution could be inevitable. Nevertheless, measures are being considered by the Agencies such as NEA, LTA, URA, etc. to keep traffic noise to a minimum:

- tightening noise emission standards for vehicles;
- using noise-absorptive porous asphalt material for road surfacing;
- siting multi-storey car parks, electrical substations or other non-residential structures to screen traffic noise from residential buildings;
- setting minimum set back distances between

residential developments and transport infrastructure (e.g. expressways, rail tracks, etc.); and

- designing new flat layouts to have noise sensitive rooms such as living rooms and bedrooms facing away from traffic.

Construction Noise Control

PCD enforces the Environmental Protection and Management (Control of Noise at Construction Sites) Regulations to control noise pollution from construction sites. Under the regulations, construction sites are required to abide by a set of maximum permissible noise limits. In addition, construction sites within 150m of noise sensitive premises such as residential buildings are not allowed to carry out work during the following prohibited period:

- For sites that commenced work between 1 September 2010 to 31 August 2011, no work is allowed from 10.00pm on Saturday or eve of public holiday to 10.00am on Sunday or public holiday;
- For sites that commenced work on or after 1 September 2011, no work is allowed from 10.00pm on Saturday or eve of public holiday to 7.00am on Monday or the day after the public holiday.

The permissible noise limits for construction sites are in **Appendix 16**.



NEA officer using a noise meter to monitor construction noise

There was a 30.7% reduction in the number of complaints on construction site noise pollution, from 14,942 complaints in 2015 to 10,373 in 2016. The majority of the complaints were against construction noise at night and on Sundays and public holidays. These complaints came mainly from residents staying within 150m of the construction sites.

The decrease in complaints generally followed the reduction in the number of construction sites in 2016.

With the more stringent prohibition of work on Sundays / public holidays implemented from 1 September 2011 onwards, the number complaints received during the prohibited period saw a reduction of about 77%, from 5,172 in 2011 to 1,175 in 2016.

Of the 10,373 complaints against construction noise that PCD received in 2016, 711 complaints against 639 construction sites were substantiated, i.e. the noise levels had exceeded the permissible noise limits or work was carried out during the prohibited periods on Sundays / public holidays. Among the substantiated cases, the main cause of exceeding the permissible noise limits was concreting work carried out late at night. The errant contractors were prosecuted and reminded to reschedule their activities to ensure compliance with the permissible noise limits.

The 10 companies with the highest number of noise offences are reflected in [Table 4.8](#).

Quieter Construction Fund

In March 2014, NEA launched the Quieter Construction Fund (QCF), a \$10 million funding scheme to support Singapore-registered companies to adopt the use of quieter construction equipment, noise control equipment and encourage innovative solutions to mitigate noise and hence, reduce the impact of construction noise on sensitive premises to achieve a quieter living environment. The application period was for 2 years from 1 April 2014 to 31 March 2016.

In view of the encouraging take-up rate of the QCF, NEA had extended applications for the QCF for another 2 years from 1 April 2016 to 31 March 2018. In addition, the funding cap has also been increased from \$100,000 to \$200,000. The maximum disburseable funding for buying or leasing of quieter construction equipment has been also increased from \$50,000 to \$150,000 and \$6,000 to \$9,000 respectively, depending on the equipment cost. Details of the funding criteria for the different types of equipment are shown in [Table 4.9](#).

To further encourage companies to tap on the QCF to adopt quieter construction solutions, NEA has been stepping up its efforts to actively engage the industry through seminars and meetings with stakeholders, outreach efforts at construction related events and walk-in consultation clinics for potential applicants.

As of Dec 2016, 70 applications have been approved with a total amount of more than \$2.7 million to be disbursed.

Table 4.9

New Funding Criteria for the Quieter Construction Fund

Equipment Category	Purchase / Lease Cost	Funding %
Quieter Construction Equipment (purchase)	≤ \$100,000 per equipment	Up to 50%, capped at <u>\$30,000</u> per equipment
	> \$100,000 and ≤ \$200,000 per equipment	Up to 30%, capped at <u>\$50,000</u> per equipment
	> \$200,000 per equipment	Up to 25%, capped at <u>\$150,000</u> per equipment
Quieter Construction Equipment (leasing)	≤ \$30,000 per equipment	Up to 50%, capped at <u>\$9,000</u> per equipment
	> \$30,000 per equipment	Up to 30%, capped at <u>\$20,000</u> per equipment
Noise Control Equipment	≥ \$5,000 per Project Site	Up to 50% per Project Site
Innovative Solution	≥ \$5,000 per Project Site	Up to 50% per Project Site

Table 4.8
Companies with Highest Number of Noise Offences in 2016

S/N	Company	Total No. of Violations	Project Sites	No. of Violations	Offence Descriptions
1	Woh Hup Pte Ltd	16	371 Beach Road (City Gate)	4	
			15 Cairnhill Road	3	
			Pasir Ris Grove / Pasir Ris Drive (Coco Palms)	3	
			26 Duke Road	1	Exceed permissible noise limits
			81 Pasir Ris Heights	1	Work during prohibited period
			251 Pasir Panjang Road	1	Failure to comply with Notices
			Robinson Road (SBF Centre)	1	
			Woodlands Avenue 6 (Woodlands Glen)	1	
			Woodlands Square	1	
2	Samsung C & T Corporation	16	Peck Seah Street	9	
			1 Havelock Square	5	Exceed permissible noise limits
			605A Upper Changi Road	1	Failure to comply with Notices
			5 Shenton Way	1	Work during prohibited periods
3	Authentic Builder Pte Ltd	15	Faber Walk	13	Exceed permissible noise limits
			Punggol Central	1	Failure to comply with Notices
			River Valley Road	1	Work during prohibited periods
4	SEF Construction Pte Ltd	13	5 Marine Parade Central	7	Exceed permissible noise limits
			Jalan Bukit Merah	5	Failure to comply with Notices
			29 Berrima Road	1	Work during prohibited periods
5	Greatearth Construction Pte Ltd	11	Mandalay Road	9	Exceed permissible noise limits
			Prince Charles Crescent	2	Failure to comply with Notices
6	GLG Engineering Pte Ltd	10	Pasir Ris Drive 3	5	Work during prohibited periods
			Woodlands Avenue 5	5	Exceed permissible noise limits
7	Rich Construction Company Pte Ltd	10	681 Punggol Drive	8	Exceed permissible noise limits
			Tampines Street 45	2	Work during prohibited periods
8	Daiya Engineering & Construction Pte Ltd	9	727 & 729 Bukit Timah Road	4	
			50 Choa Chu Kang Avenue 3	2	
			4 Jalan Asuhan	1	Exceed permissible noise limits
			14 Peel Road	1	Work during prohibited periods
9	Hexacon Pte Ltd	9	Victoria Park Road	1	
					Exceed permissible noise limits
			Tampines Avenue 4 & 5	9	Failure to comply with Notices
10	Gennal Industries Pte Ltd	8			Work during prohibited periods
			1 Nanson Road	6	
			68 Orchard Road	1	Exceed permissible noise limits
			298 Tiong Bahru Road	1	Work during prohibited periods

environmental **monitoring**

Singapore has, over the years, maintained a high standard of environmental quality despite the increase in industrialisation and urbanisation.

One of the key strategies to keep the environment clean is the regular monitoring and assessment of the quality of the air and water. This has helped in the development and review of pollution control measures.

Ambient Air Monitoring

Ambient air quality in Singapore is routinely monitored through the Telemetric Air Quality Monitoring and Management System (TAQMMS).

The system — comprising remote air quality monitoring stations linked to a Data Management System (DMS) via dial-up telephone lines or wireless connections, provides an efficient means of obtaining air quality data. The locations of the monitoring stations are shown in **Chart 5.1**.

Automatic analysers and equipment are deployed at the stations to measure the concentrations of major air pollutants such as sulphur dioxide (SO₂), oxides of nitrogen (NO_x), carbon monoxide (CO), ozone and particulate matter (PM₁₀ & PM_{2.5}).

Following the recommendations of the Inter-agency Advisory Committee chaired by NEA to review Singapore's air quality targets, MEWR/NEA have adopted the World Health Organisation Air Quality Guidelines (WHO AQG) for PM₁₀, NO₂, CO and ozone, and the WHO AQG's Interim Targets for PM_{2.5} and SO₂ as Singapore's air quality targets for 2020. The 2020 air quality targets are summarised in **Appendix 17**.

In 2016, the air quality generally remained good. NO₂ and CO were within the World Health Organisation Air Quality Guidelines (WHO AQG) while SO₂, PM_{2.5}, PM₁₀ and ozone were within the WHO Interim Targets. The WHO AQG are also summarised in **Appendix 17**.



Jurong Hill Ambient Air Monitoring Station

On 1 April 2014, PM_{2.5} was incorporated into the Pollutant Standards Index (PSI) as its sixth pollutant parameter, in addition to particulate matter (PM₁₀), sulphur dioxide (SO₂), nitrogen dioxide (NO₂), carbon monoxide (CO) and ozone (O₃). Based on the new PSI, air quality was 'Good' for 7.5%, 'Moderate' for 91.5% and 'Unhealthy' for 1% in the year of 2016 as shown in **Table 5.1**.

Sulphur Dioxide

Sulphur dioxide is an undesirable by-product from the combustion of sulphur-containing fuels and from petroleum refining processes. Exposure to high levels of sulphur dioxide has the potential to impair respiratory function and aggravate existing respiratory and cardiovascular diseases.

The maximum daily mean levels of sulphur dioxide are shown in **Chart 5.3**. In 2016, the daily mean sulphur dioxide levels were within the WHO Interim Target-1 of

Chart 5.1
Location of Air Quality Monitoring Stations

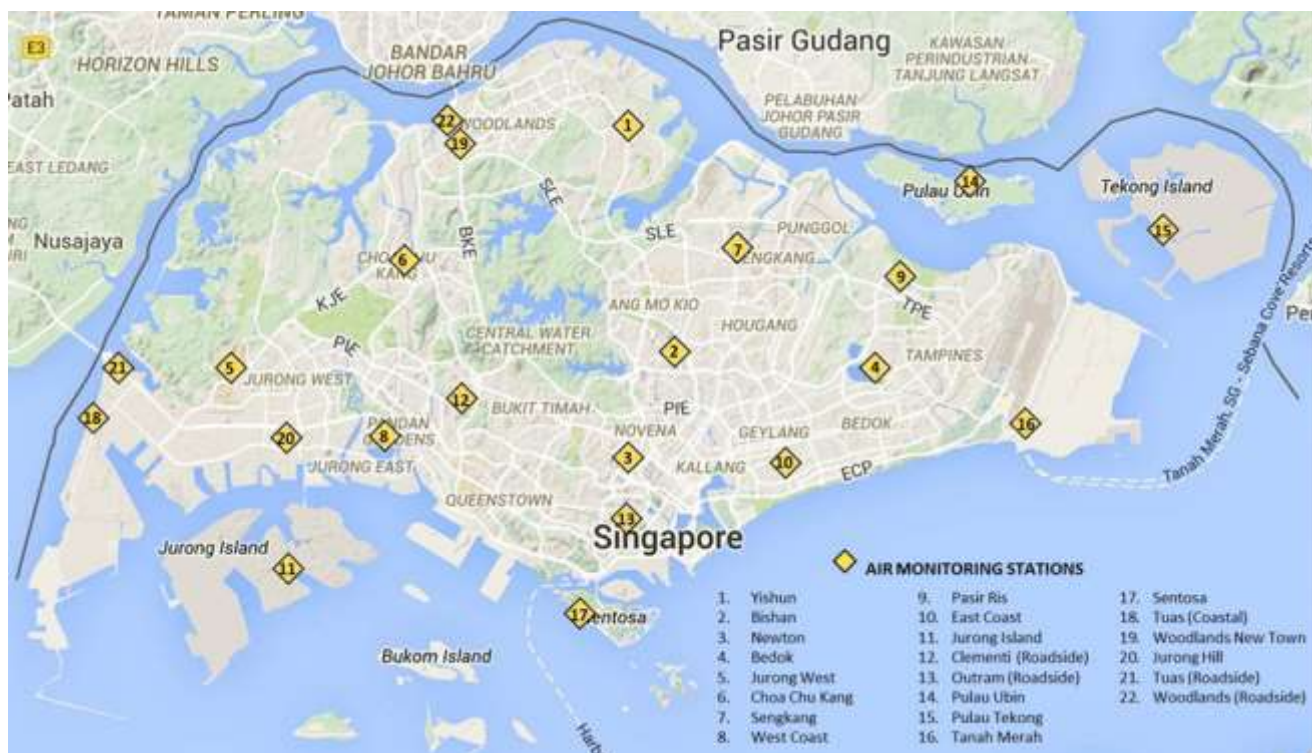
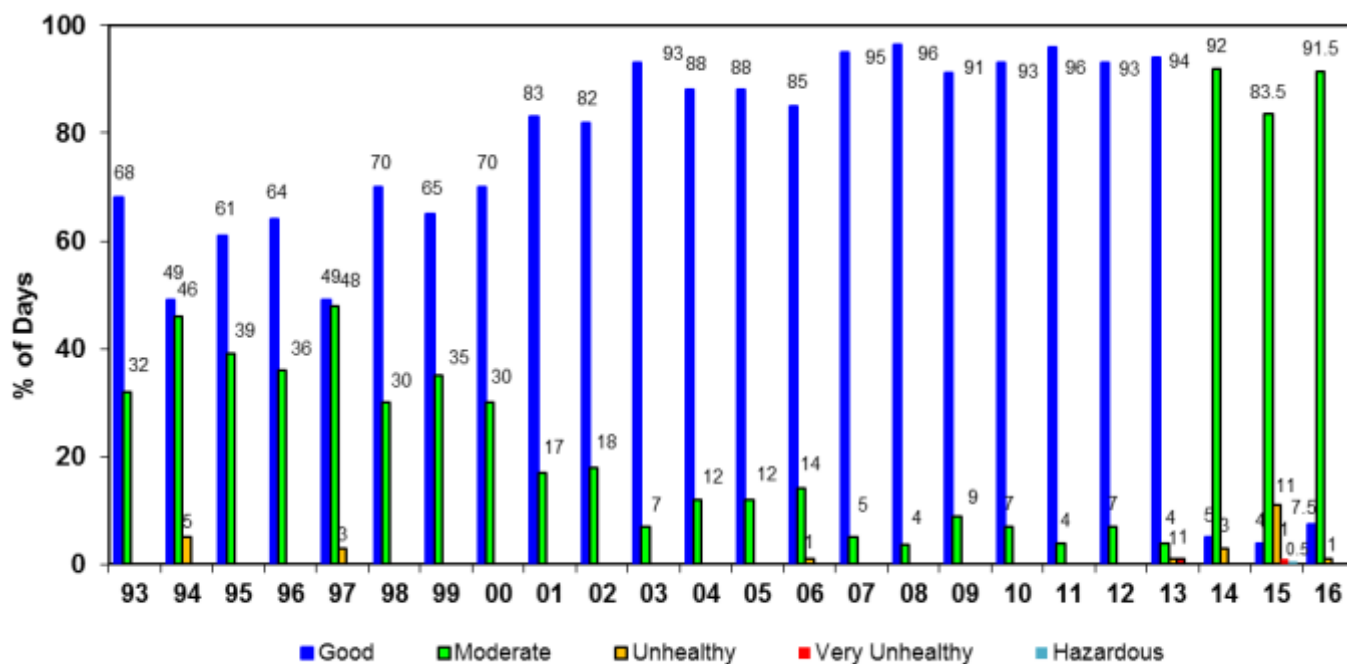


Table 5.1
Summary of Pollutant Standards Index (PSI)

Year	Days	No. of days in which the PSI was classified as				
		Good (0-50)	Moderate (51-100)	Unhealthy (101-200)	Very Unhealthy (201-300)	Hazardous (>300)
2015	365	14	305	40	5	1
2016	365	27	335	4	0	0

Year	Days	Percentage				
		Good (0-50)	Moderate (51-100)	Unhealthy (101-200)	Very Unhealthy (201-300)	Hazardous (>300)
2015	365	4	83.5	11	1	0.5
2016	365	7.5	91.5	1	0	0

Chart 5.2
Air Quality in Terms of PSI



Note:

1. Air quality for 2014 to 2016 is based on the new PSI.
2. Air quality in 1994, 1997, 2006, 2013, 2015 and 2016 was affected by transboundary haze from plantation and forest fires in Indonesia.

125 $\mu\text{g}/\text{m}^3$ but exceeded the WHO Interim Target-2 of 50 $\mu\text{g}/\text{m}^3$ and the WHO Air Quality Guideline of 20 $\mu\text{g}/\text{m}^3$.

Nitrogen Dioxide

Nitric oxide accounts for the bulk of the nitrogen oxides emitted by man-made sources. Nitric oxide is oxidised in the atmosphere to form nitrogen dioxide. High levels of nitrogen dioxide increase the risk of respiratory infection and impair lung functions in asthmatics.

The annual average levels of nitrogen dioxide in the ambient air are shown in **Chart 5.4**.

In 2016, the annual average level of nitrogen dioxide was 26 $\mu\text{g}/\text{m}^3$, well within the WHO AQG of 40 $\mu\text{g}/\text{m}^3$.

Respirable Particulate Matter (PM₁₀ and PM_{2.5})

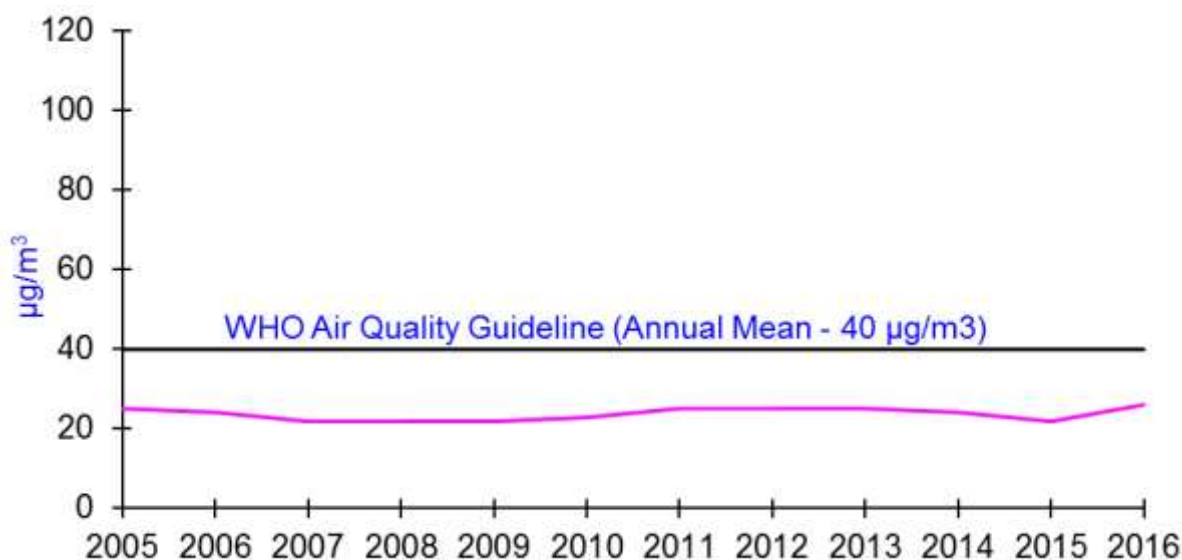
Respirable particulate matter, PM₁₀, refers to particulate matter of size 10 μm or below in aerodynamic diameter. PM_{2.5} refers to fine particulate matter of 2.5 μm or less in aerodynamic diameter. PM_{2.5} particles have serious health implications as they are able to penetrate into the deeper regions of the respiratory tract. At elevated levels, the particles cause breathing and respiratory problems, and aggravate existing respiratory and cardiovascular diseases.

In 2016, PM₁₀ and PM_{2.5} levels were affected by transboundary smoke haze. The annual mean PM₁₀ level of 26 $\mu\text{g}/\text{m}^3$ exceeded the WHO AQG of 20 $\mu\text{g}/\text{m}^3$, but was well within the WHO Interim Target-2 level of 50 $\mu\text{g}/\text{m}^3$. **Chart 5.5** shows the levels of PM₁₀ in the ambient air.

Chart 5.3
Maximum 24-hour Mean Sulphur Dioxide Levels



Chart 5.4
Annual Average Levels of Nitrogen Dioxide



The annual average level of PM_{2.5} in 2016 of 15 µg/m³ exceeded the WHO AQG of 10 µg/m³ but was within the WHO Interim Target-2 level of 25 µg/m³. **Chart 5.6** shows the annual average levels of PM_{2.5} in the ambient air.

Motor vehicles and industries are major sources of PM_{2.5} in Singapore. A multi-pronged approach involving the introduction of stringent vehicular emission standards (Euro IV standards), introduction of better quality fuel (i.e. Ultra Low Sulphur Diesel), and more stringent enforcement action against smoke emissions from motor vehicles and industries have been implemented to bring down the ambient levels of PM_{2.5} over time.

Low-Level Ozone

Ozone in the stratosphere is desirable as it protects life on Earth by absorbing much of the harmful ultraviolet radiation from the sun. However, ozone occurring in the lower atmosphere is a health hazard. Ozone can severely irritate eyes, mucous membranes and the respiratory system in humans.

Low-level ozone is mainly produced by the complex reactions of nitrogen oxides and volatile organic compounds catalysed by sunlight.

In 2015, the maximum 8-hour mean ozone level of 152 µg/m³ exceeded the WHO AQG of 100 µg/m³ but, was within the WHO Interim Target level of 160 µg/m³. The ozone trend is shown in **Chart 5.7**.

Carbon Monoxide

Carbon monoxide is a colourless and odourless gas with a higher affinity than oxygen for haemoglobin in blood. Hence, when inhaled, it can deprive body

tissues of oxygen.

Exposure to moderate levels of carbon monoxide may cause nausea and impair vigilance. In excessive doses, it can cause death through asphyxiation. The sources of carbon monoxide range from vehicular emissions and cigarette smoke, to the incomplete combustion of fuels. Vehicular emission accounts for most of the carbon monoxide in the air.

Carbon monoxide is measured at both ambient and roadside air monitoring stations. The 2016 ambient carbon monoxide level of 2.2 mg/m³ (maximum 8-hour mean) and the roadside carbon monoxide level of 3.8 mg/m³ (maximum 8-hour mean) were well within the WHO AQG of 10mg/m³.

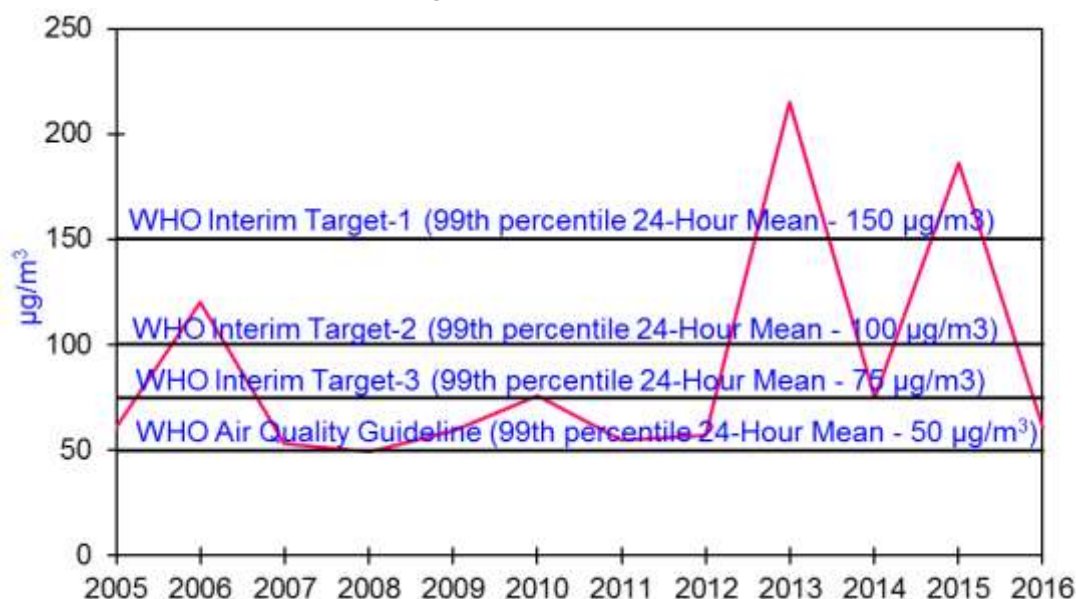
Pollution from Vehicles

Lead compounds, such as tetra-ethyl lead and tetra-methyl lead, used to be added to petrol as anti-knock agents. The combustion of leaded petrol results in the emission of lead particulates into the air. If imbibed in large quantities, lead can cause irreversible damage to the brain and other organs. Foetuses and children are particularly sensitive to the deleterious effects of lead as their nervous systems are still developing.

Lead levels in petrol have been progressively reduced since the 1980s. In January 1991, unleaded petrol was introduced in Singapore. On 1 July 1998, leaded petrol was phased out.

The efficacy of these measures in reducing lead concentrations in the air is evident from **Chart 5.8**. From roadside levels of as high as 1.4 µg/m³ in 1984, the lead level has stabilised at around 0.1 µg/m³ since 1992. The lead level was well within the WHO guideline of 0.5 µg/m³.

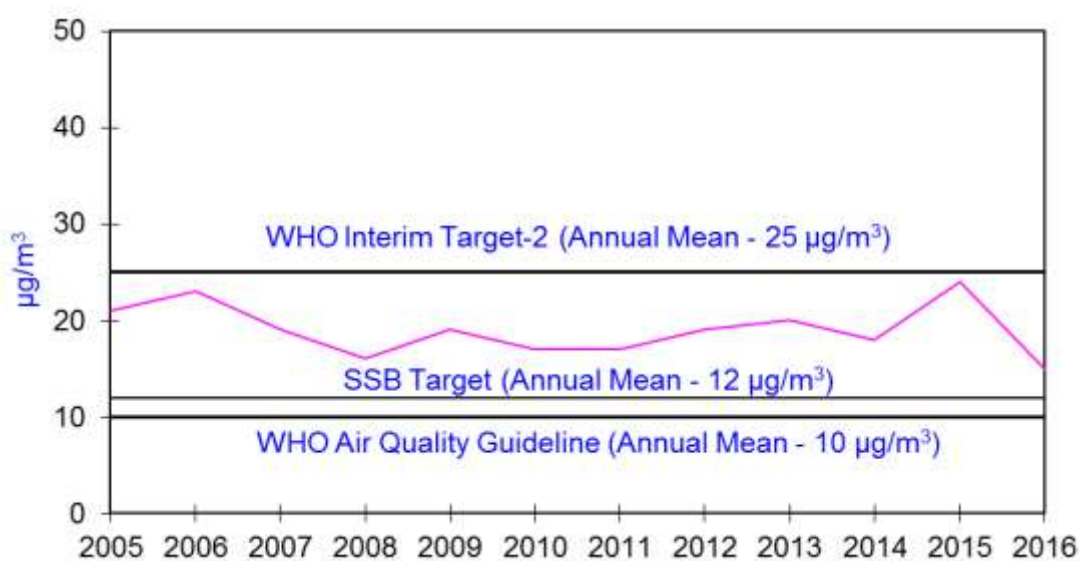
Chart 5.5
Levels of Respirable Particulate Matter (PM₁₀)



Note:

1. Chart shows daily mean levels (99th percentile)
2. PM₁₀ levels in 2006, 2013, 2015 and 2016 were affected by transboundary smoke haze from plantation and forest fires in Indonesia

Chart 5.6
Annual Average Levels of Particulate Matter (PM_{2.5})



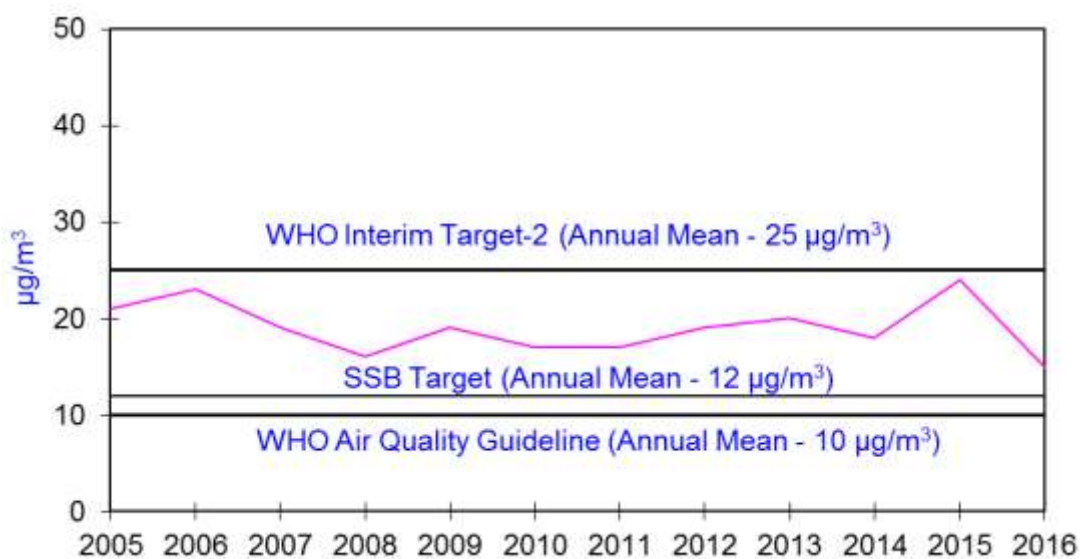
Note: PM_{2.5} levels in 2006, 2013, 2015 and 2016 were affected by transboundary smoke haze from plantation and forest fires in Indonesia.

Chart 5.7
Levels of Ozone



Note: Chart shows the maximum 8-hr mean.

Chart 5.6
Annual Average Levels of Particulate Matter (PM_{2.5})



Note: PM_{2.5} levels in 2006, 2013, 2015 and 2016 were affected by transboundary smoke haze from plantation and forest fires in Indonesia.

Chart 5.7
Levels of Ozone



Note: Chart shows the maximum 8-hr mean.

Water Quality Monitoring

PCD regularly monitors the water quality of various inland water bodies and coastal areas. The monitoring points are shown in **Charts 5.9** and **5.10**.

Water Quality in Water Catchment Areas

The water quality of 49 streams and 9 ponds in the water catchment areas is monitored quarterly.

Water quality of the 15 reservoirs within the water catchment areas is jointly monitored by PCD and PUB.

The water quality, based on the measured levels of dissolved oxygen (DO), biochemical oxygen demand (BOD) and total suspended solids (TSS), remained good in 2016. The monitoring data are shown in **Table 5.2**.

Water Quality in Non-Water Catchment Areas

Water quality of 16 rivers and streams in non-water catchment areas is monitored quarterly. Physical, chemical and microbiological parameters are analysed to assess the water quality. Results of the monitoring, as given in **Table 5.2**, revealed that the water quality of the rivers and streams remained good.

Monitoring of Coastal Waters

Water samples are collected monthly from 36 sampling points along the Straits of Johor and 12 sampling points along the Straits of Singapore. These samples are subjected to physical, chemical and microbiological examinations.

Table 5.3 shows the monitoring results for enterococcus counts in the coastal waters.

Continuous Water Quality Monitoring System for Coastal Waters

A real-time, continuous water quality monitoring system for the coastal waters of Singapore was fully commissioned in 2014. The system comprises 8 buoy-based monitoring stations with sensors for key water quality parameters. The locations of the stations are in **Chart 5.11**. Data from the stations is transmitted real-time to an Operational Management System (OMS) which processes and manages the data. The OMS also incorporates water quality models for forecasting water quality and to predict, backtrack and identify pollution sources and determine coastal areas affected by oil or chemical spill incidents.

Recreational Water Quality

NEA introduced new water quality guidelines for recreational beaches on 1 August 2008. The guidelines were developed based on the World Health Organisation's water quality guidelines for recreational use, which were released in 2003. Under the revised guidelines, primary contact activity is only allowed when the 95th percentile enterococcus bacteria counts in the beach water do not exceed 200 counts/100 ml.

Under the annual water quality review conducted in 2016, all 7 beaches (Sentosa Island, Seletar Island, Sembawang Park, Changi, East Coast Park, Pasir Ris and Punggol) monitored by NEA met the revised guidelines and were graded "Good".

Chart 5.8
Lead Levels (1983 to 2016)

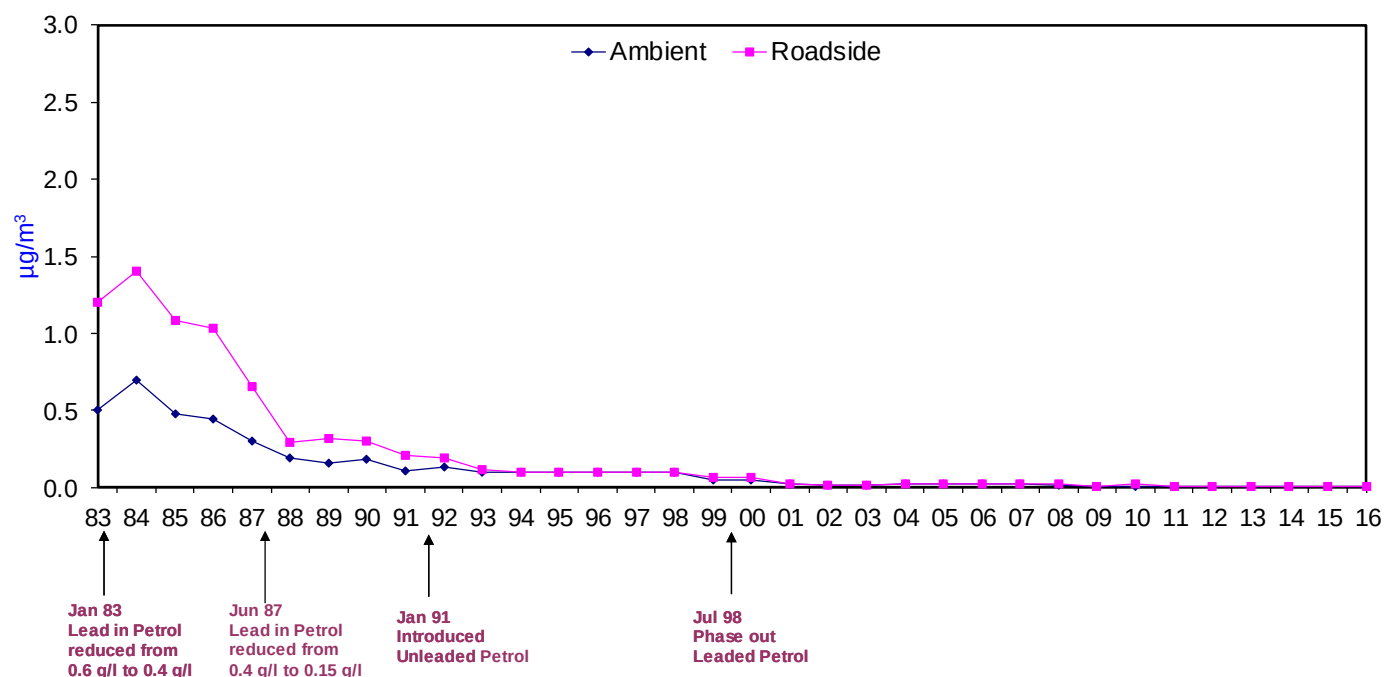


Chart 5.9
Locations of Non-Catchment
and Seawater Sampling Points



Chart 5.10
Locations of Catchment
Sampling Points

Table 5.2
Monitoring Results of Inland Waters

Parameter Monitored	Water Catchment Streams		Non-Water Catchment Rivers/Streams
	Percentage Of Time		
Dissolved Oxygen (> 2 mg/l)	2015	100%	100%
	2016	99%	95%
Biochemical Oxygen Demand (< 10 mg/l)	2015	98%	97%
	2016	97%	92%
Total Suspended Solids (< 200 mg/l)	2015	100%	100%
	2016	100%	95%

Table 5.3
Monitoring Results of Coastal Waters

Parameter		Straits of Johor East	Straits of Johor West	Straits of Singapore
		Percentage of Time		
Enterococcus Count (<200 per 100 ml)	2015	100%	97%	98%
	2016	98%	97%	98%

Chart 5.11
Monitoring Locations and Water Quality Parameters Measured





6

energy efficiency and conservation

EECD is responsible for promoting energy efficiency to industry, the public sector and households. The organisation chart of EECD is in **Appendix 4**.

As a small island state with limited energy resources, Singapore imports fuel to meet most of our energy needs. The burning of fossil fuels results in the emission of air pollutants, which have to be treated as they can impact ambient air quality. Fossil fuel burning also emits carbon dioxide (CO₂), a greenhouse gas that contributes to global warming and climate change.

In Singapore, energy is priced to reflect its true cost. This right pricing approach encourages the efficient use of energy.

To mitigate the impact of greenhouse gases on the environment, Singapore has also adopted cleaner energy sources to fuel electricity demand, by moving away from petroleum products to natural gas¹, which is less carbon intensive. We have also made improving energy efficiency a key strategic thrust of our mitigation plan. A higher energy efficiency can improve Singapore's economic competitiveness, since there will be overall cost savings from reduced energy bills. These strategies will help reduce Singapore's emissions intensity by 36% below 2005 levels by 2030, and to stabilise its greenhouse gas (GHG) emissions with the aim of peaking around 2030, as articulated in the Climate Action Plan published in 2016.

Promoting Good Corporate Energy Management Practices

Mandatory energy management requirements for energy-intensive users in the industrial sector were introduced on 22 April 2013 under the Energy Conservation Act (ECA). Under the ECA, companies operating energy-intensive industrial facilities, which consume 54 TJ or more of energy annually in at least two out of the three preceding calendar years, are required to register themselves with NEA and comply with the following requirements:

- Appoint at least one energy manager²,
- Monitor and report energy use and greenhouse gas (GHG) emissions of their facilities annually, and
- Develop energy efficiency improvement plans and update the plans annually.

As of end December 2016, there were 180 companies operating 229 energy intensive industrial facilities regulated under the ECA.

Analysis of the 2015 submissions³ revealed varying levels of rigour in energy management, varying levels of ambition in energy efficiency improvements and room for improvement in the energy efficiency of common energy consuming systems such as compressed air system, chilled water system and boiler.

Based on the energy efficiency improvement plans submitted in 2015, companies achieved an annual energy efficiency improvement rate of 0.4% in 2014. This is a good start, although we still lag behind leading developed countries like Belgium and the Netherlands. Companies there have managed to achieve energy efficiency improvement rates of 1% to 2% annually. Singapore's most energy-intensive facilities, which collectively accounted for more than 50% of Singapore's final energy consumption, play a key role in improving the overall energy performance of the industrial sector.

In 2016, NEA sought feedback from the industry to enhance the ECA with the following new requirements to improve the energy management practices in the industrial sector and to improve energy efficiency of common industrial energy consuming equipment and systems:

- i. Structured energy management system (EnMS) for existing facilities
- ii. Regular energy efficiency opportunities assessments (EEOAs) for existing facilities
- iii. Energy efficient design of new facilities
- iv. Energy performance measurement requirements for new facilities
- v. Minimum Energy Performance Standards (MEPS) for common industrial equipment & systems

The proposal will require existing facilities to put in place structured energy management, identify of energy efficiency opportunities and promote implementation of opportunities identified. For new energy-intensive facilities and major expansion projects, the requirements entail the consideration of energy efficient design, as well as tools and instruments for monitoring energy performance and use, early in the design and construction phase of new

¹ Singapore's efforts in energy efficiency began in the 1990s where there was a switch from oil-fired power generation plants to high-efficiency gas-fired combined cycle plants.

² The energy manager is required to hold a Singapore Certified Energy Manager (Professional Level) certificate issued by The Institution of Engineers, Singapore.

³ Analysis was based on 218 energy-intensive facilities operated by 171 companies, which submitted their first energy use reports and energy efficiency improvement plans in 2015.

Table 6.1
Revised ECA Requirements

Proposed Requirements	Requirements	Details
Enhanced energy management practices for existing facilities	- Facilities consuming $\geq 500\text{TJ/yr}$: - Implement a structured Energy Management System (EnMS) by 2021 - Conduct energy efficiency opportunities assessments (EEOAs) 1st EEOAs by 2021 and every 6 years thereafter - Cover energy-consuming systems that account for at least 80% of total consumption - Facilities consuming ≥ 54 to $< 500\text{TJ/yr}$ - Implement a structured EnMS by 2022 - Conduct EEOAs 1st EEOAs by 2021 - Review every 3 years the need for subsequent EEOAs - Cover energy-consuming systems that account for at least 80% of total consumption	
Energy performance measurement requirements for new facilities & major expansions	- All new energy-intensive facilities & major expansions $\geq 54\text{TJ/yr}$ - Design and construction phase (from 2018) - Plan for and install instruments and meters at system level - Operations phase - Report energy use and energy performance indicators based on measured data * Cover energy-consuming systems that account for at least 80% of total consumption	
Energy efficient design of new facilities & major expansions	- All new energy-intensive facilities & major expansions $\geq 54\text{TJ/yr}$ - Design phase (from 2018) - Review facility design, develop economically feasible energy/carbon efficiency measures for incorporation into the new facility - Report findings	
MEPS for common industrial equipment & systems	- MEPS to be introduced for single speed 3-phase induction motors (from 2018) - MEPS to be extended to other common industrial equipment and systems over time	

facilities. In addition, MEPS are proposed for energy consuming systems found commonly in manufacturing facilities.

There was no disagreement from the industry on the broad thrust of the proposals and the industry's feedback showed commitment to improve energy efficiency. Companies were of the view that more should be done to spur the adoption of energy management practices and energy efficient technologies, and sought greater Government support through incentives and capability building programmes. NEA is cognizant of the needs of the industry and would review its schemes regularly to better support the industry.

The revised requirements, after taking into consideration industry's feedback, can be found in the **Table 6.1**.

Promoting the Adoption of Energy Efficient Technologies and Measures

Energy Audits

Companies are encouraged to carry out energy audits

on existing facilities. Energy audits are detailed assessments of a facility's energy consumption and development of energy efficiency improvement plans. Up to 50% of the cost of an energy audit is co-funded by NEA, subject to a cap of \$200,000.

In 2016, applications by owners and operators of 7 manufacturing plants and 1 building were approved under the Energy Efficiency Improvement Assistance Scheme (EASE). Low energy prices in 2016 have weakened the incentive for companies to undertake energy audits and invest in energy efficiency.

The improvements in energy efficiency arising from the audits were expected to save \$4.31 million annually and will benefit the companies while reducing CO₂ emissions. A total of \$2.04 million has been approved for 77 energy studies since 2012. The energy efficiency measures from the appraisals are estimated to generate about \$65 million in annual savings if implemented. More details are given in **Table 6.2**.

Public Sector Taking the Lead in Environmental Sustainability (PSTLES) Initiative

The public sector is taking the lead in using resources

Table 6.2
Estimated Annual Savings from Recommended Energy Efficiency Measures Identified in EASE Studies

	2012	2013	2014	2015	2016
No. of EASE projects approved	25	19	20	5	8
Estimated annual energy savings from projects approved in that year (\$'million)	11.67	26.49	21.05	1.48	4.31
Estimated CO ₂ reduction from projects approved in that year (kilo-tonnes)	24.48	47.48	97.45	4.30	34.52

more efficiently. The PSTLES initiative, which was introduced in 2006, was enhanced in November 2014 to encourage public sector agencies to take greater ownership of their own environmental sustainability efforts. Under the revised framework, each Ministry has appointed a sustainability manager, set Ministry-wide sustainability targets and developed a resource management plan.

Improving energy efficiency is a key thrust under the PSTLES initiative. Public agencies are encouraged to adopt the Guaranteed Energy Savings Performance (GESP) contracting model when carrying out retrofits of their major energy consuming equipment like chilled water plant. Under the GESP contract model, an Energy Services Company (ESCO) is engaged to carry out energy audit as well as identify and implement the energy efficiency improvement measures. The ESCO shall also guarantee the efficiency improvements and the annual energy savings over a three to five-year period. As of end December 16, the number of government building owners that have adopted the GESP contracting model is shown in **Table 6.3**.

Beyond improving building energy efficiency, all agencies are also encouraged to adopt other environmentally sustainable practices. They include implementing waste recycling programmes and participating in the Water Efficient Building, Eco-Office and Green Mark initiative developed by PUB, Singapore Environment Council and the Building and Construction Authority respectively.

Building Capability to Drive and Sustain Energy Efficiency Efforts and to Develop the Local Knowledge Base and Expertise in Energy Management

Energy Efficiency National Partnership (EENP)

The EENP is a voluntary partnership programme for companies that wish to be more energy efficient, thereby enhancing their long-term business competitiveness and reducing their carbon footprint. The EENP aims to support companies in their energy efficiency efforts through learning network activities, provision of energy efficiency-related resources, incentives and recognition. Since the launch of the EENP in April 2010, the number of EENP partners has increased from 49 founding partners to 235 companies as of end December 2016, from sectors such as the electronics, wafer fabrication, refinery/petrochemicals and pharmaceuticals.

The EENP seeks to encourage businesses to put in place energy management systems and adopt practices and measures to improve energy efficiency. It provides training to develop energy efficiency competencies within the industry, and includes a recognition system to award EENP Partners which have done well in energy efficiency improvement.



Table 6.3
Buildings that adopted GESP contract model

Total no. of building owners that have called GESP contracts for their retrofit works	28
No. of building owners that have implemented or are implementing the identified energy efficiency improvement measures	19
No. of building owners with GESP project at tender evaluation phase or energy audit phase	9
Total no. of building owners that have called GESP contracts for their retrofit works	22
No. of building owners that have implemented or are implementing the identified energy efficiency improvement measures	17
No. of building owners with GESP project at tender evaluation phase or energy audit phase	5

Energy Efficiency National Partnership (EENP) Awards—Industrial Energy Efficiency Sharing Session 2016

The flagship event under the Learning Network in 2016 was the EENP Awards 2016 – Industry Energy Efficiency Sharing Session, which took place on 4 October 2016 and attracted more than 450 participants. Minister Masagos Zulkifli Bin Masagos Mohamad presented the EENP Awards to ten companies, two energy managers, two public agencies and one school for their commitment to and achievements in energy efficiency. The EENP Awards Ceremony was followed by industry energy efficiency sharing sessions, where EENP Award recipients and other industry professionals shared their best practices, case studies, new technologies and solutions in energy efficiency and energy management. In addition, 20 companies and organisations showcased their energy efficiency-related products, solutions and services at an exhibition co-located with the EENP Awards 2016. The energy efficiency achievements of EENP Awards 2016 recipients were also showcased at the conference.

The EENP Awards aim to foster a culture of sustained energy efficiency improvement in industry by identifying and sharing best practices for companies to emulate.

In total, 29 EENP learning events were conducted in 2016. These learning events included Share & Learn sessions organized by NEA and EE courses conducted by different training providers.

Table 6.4 shows the recipients of the EENP Awards 2016:

Singapore Certified Energy Manager (SCEM) Programme

The SCEM programme offers a formal training and certification system in the area of energy management. Designed for engineering professionals who intend to become energy managers, the programme provides an in-depth understanding of the key energy issues in the industrial sector. It helps participants to develop the technical skills and competencies needed to manage energy use within the organisations they serve.

The programme is jointly administered by NEA and The Institution of Engineers, Singapore (IES) under a Steering Committee, which is supported by a Curriculum and Examinations Board. Registration of certified energy managers is undertaken by the SCEM Registry under the IES. There are 2 certifiable training levels for SCEM, namely, the Associate and Professional Levels. As of end December 2016, 1066 candidates qualified for SCEM certification, of which 736 were certified SCEMs.

An initiative to develop reference manuals for 4 SCEM (Professional Level) modules was completed in FY2016.

The reference manuals covering energy management and economics, energy measurement and appraisal, air-conditioning and mechanical ventilation systems, and building envelope and lighting system will help candidates undergoing SCEM training with their course work and serve as reference materials (with local case studies) for practising energy managers and engineers.

Energy Efficiency Benchmarking Study

The benchmarking study of the performance of energy consuming systems in the food manufacturing industry was completed in March 2016. The assessment framework used in the study, a best practice guide and the final report of the benchmarking study was published in the e2Singapore website in May 2016.

As a follow-up to the benchmarking study, NEA facilitated the formation of an industry-led food manufacturing energy efficiency committee to share and promote best practices among companies in this sector.

Raising Public Awareness to Encourage Energy Efficient Behaviour and Practices

Mandatory Energy Labelling Scheme

In January 2008, NEA introduced the Mandatory Energy Labelling Scheme (MELS) for household air-conditioners and refrigerators. Energy labelling helps households to compare the energy efficiency of energy consuming products, thereby empowering them to make more informed purchasing decisions. The



Motor Driven Systems is one of the modules under the SCEM programme

Table 6.4
Energy Efficiency National Partnership (EENP) Awards 2016 Recipients

Award Category	Recipients
Excellence in Energy Management	German Centre for Industry & Trade Pte Ltd Molex Singapore Pte Ltd Singapore Management University
Best Practices	Asia Pacific Breweries (Singapore) Pte Ltd ExxonMobil Asia Pacific Pte Ltd Lucite International Singapore Pte Ltd
Best Practices (Honourable Mention)	ExxonMobil Asia Pacific Pte Ltd GLOBALFOUNDRIES Singapore Pte Ltd & Edwards Technologies Singapore Keppel Shipyard Limited LHT Holding Limited Molex Singapore Pte Ltd
Outstanding Energy Manager of the Year	Mr Eric Leung – ASM Technology Singapore Mr Mohamed Shahril Bin Jaffar – Panasonic Appliances Refrigeration Devices Singapore
Best Energy Efficiency Practices in the Public Sector (Large Building)	Ministry of Manpower National Institute of Education
Best Energy Efficiency Practices in the Public Sector (School)	St. Andrew's Junior College



Minister Masagos Zulkifli delivering the opening address



Participants at the Energy Efficiency Sharing Session



Recipients of the EENP Awards 2016 posing for a group photo with Minister Masagos, Mr Choi Shing Kwok, Permanent Secretary (MEWR), Mr Ronnie Tay, CEO (NEA), Mr Gilbert Tan, CEO (e2i), Mr Bernard Nee, Deputy CE (EMA) and Mr Lim Wey-Len, Director (RDD, EDB)

scheme was extended to clothes dryers in April 2009 and televisions in April 2014. In September 2014, the design of the energy label and the energy rating system were revised to better differentiate the more energy efficient models in the market. MEPS was extended to the following types of lamps in July 2015:

- Incandescent lamps (tungsten filament and tungsten halogen)
- Compact fluorescent lamps with integrated ballasts (CFLi) and
- Non-directional light emitting diode (LED) lamps.

In September 2014, the design of the energy label and energy rating system were revised to better differentiate the more energy efficient models in the market.

Minimum Energy Performance Standards (MEPS)

Minimum Energy Performance Standards (MEPS) were introduced for household appliances to raise the average energy efficiency of products in the market. Under the regulations, only appliances that meet the minimum energy efficiency standards are allowed for sale in Singapore. This helps to protect consumers from being locked into the high energy costs of operating inefficient appliances.

MEPS for household refrigerators and air-conditioners were first implemented in September 2011, and raised in 2013. MEPS were also extended to clothes dryers in April 2014 and lamps in July 2015. In September 2016, MEPS for air-conditioners were raised from 1-tick to 2-ticks. From December 2017, MEPS for refrigerators will be further raised to remove the least energy efficient 1-tick refrigerator models.



Energy Label for lamps

Since the introduction of mandatory energy labelling in 2008 and MEPS in 2011, the average energy efficiency of air-conditioners and refrigerators have improved by 13 and 26 per cent respectively. This translates to more than \$100 million in cost savings for households and is equivalent to the annual energy cost of about 85,000 4-room housing units.

E2Singapore Website

The E2Singapore (E2S) website is a one-stop website for all energy efficiency (EE) information in Singapore. It contains up-to-date information on EE-related events, case studies resources, programmes, as well as news articles relevant to the households, transport, buildings and the industry sectors.

Programmes and Campaigns

Increasing public awareness on the importance and ways of conserving energy is key to reducing energy wastage in households. In 2016, NEA rolled out a series of public messaging initiatives with the theme "Save Energy Save Money". The aim was to encourage households to practise simple energy-saving measures. Energy-saving tips were printed on posters and banners and put up at HDB void decks, hawker centres, appliance retail stores, schools and online.

NEA also published a resource efficiency guide for new home owners. This was distributed via renovation companies and SP Services Centre at HDB Hub, and made available online on the E2Singapore and NEA websites.

In addition, NEA developed an interactive game module for deployment at public libraries. The main aim was to raise the awareness of energy saving practices amongst children.



EECD enforcement officer checking energy label

At the annual Clean and Green Singapore Carnival, NEA set up an "Eco Home" with simple messages on actions that households can do to save electricity and water, and reduce and recycle waste. The public were also encouraged to bring a copy of their SP Services Bill to take part in the "Save Electricity and Water Challenge", where they can win small prizes if they demonstrated savings in their electricity and/or water consumption.



Eco Home at Clean and Green Singapore Carnival 2016



Banner displayed at Empress Market



Save Electricity and Water Challenge at Clean and Green Singapore Carnival 2016



Resource Efficiency Guide at SP Services



Interactive game module on display at Central Public Library in April 2016



Interactive game module on display at Bishan Public Library in May 2016

and **solid waste resource management**

WRMD is tasked with the responsibility of providing refuse disposal services (incineration plants and landfill), licensing general waste collectors, enforcing against illegal dumping of waste and regulating refuse collection services for domestic and trade premises. It is also responsible for formulating and implementing policies and programmes on waste minimisation and recycling in order to reduce the quantity of waste disposed of at the incineration plants and landfill, as well as raising standards and productivity of the waste management industry. The organisation chart of WRMD is in **Appendix 5**.

Singapore's main challenge in solid waste management is the limited land available for waste disposal.

This is not sustainable with waste generation projected to continue to increase with rising affluence and population growth. The NEA, which oversees Singapore's solid waste management system, has therefore adopted the following strategies as shown in the diagram below for a more sustainable solid waste management.



NEA's Solid Waste Management Strategies

WRMD formulates and implements policies and programmes on waste minimisation and recycling; plans, develops and regulates waste disposal facilities; regulates the waste collection industry and public waste collection scheme and enforces against illegal dumping of waste.

Structure of Waste and Resource Management Department (WRMD)

NEA's WRMD comprises seven sections which work closely together to sustain a viable, affordable and efficient solid waste management system for Singapore. These sections are as follows: -

1. Recycling
2. Regulation
3. Private Waste Facilities
4. Waste Reclamation
5. Planning
6. 6th Waste-to-Energy Plant
7. Integrated Waste Management Facility (IWMF)

Further details on the key functions of each section are provided in the WRMD Organisation Chart in **Appendix 5**.

Promoting Waste Minimisation and Recycling

Over the past four decades, the amount of solid waste generated in Singapore has increased in tandem with population and economic growth. The 3Rs (reduce, reuse, recycle) are key components of our solid waste management system as they cut waste sent for final disposal, thereby reducing the demand for land to build waste disposal facilities.

Progress of Waste Recycling in Singapore

Singapore has been actively promoting the 3Rs since the early 1990s. In the Sustainable Singapore Blueprint 2015 (SSB 2015), we target to achieve an overall national recycling rate of 70% by 2030. The overall recycling rate in 2016 was 61%. In tandem with Singapore's economic growth and increase in population, the amount of solid waste generated in 2016 increased to 7.81 million tonnes, up by 140,700 tonnes from 7.67 million tonnes in 2015. The amount of waste recycled in 2016 also increased by 119,300 tonnes, while the amount of waste disposed of increased marginally by 21,400 tonnes. The increase in the amount of waste recycled was largely due to an uptick in the amount of construction debris recycled. More premises started segregating food waste for recycling and food waste recycled increased by 7,000 tonnes. On the whole, the overall recycling rate increased slightly as compared to 2015. The trend of the overall recycling rate is shown in **Chart 7.1** and the waste and recycling statistics for 2016 are shown in **Table 7.1**.

Our domestic waste recycling rate increased to 21 per cent in 2016, up from 19 per cent in 2015. The increase in the domestic waste recycling rate was due to a drop in the amount of domestic waste generated, from 2.13 million tonnes in 2015 to 2.09 million tonnes in 2016; and an increase in the amount of domestic waste recycled, from 403,500 tonnes in 2015 to 435,600 tonnes in 2016.

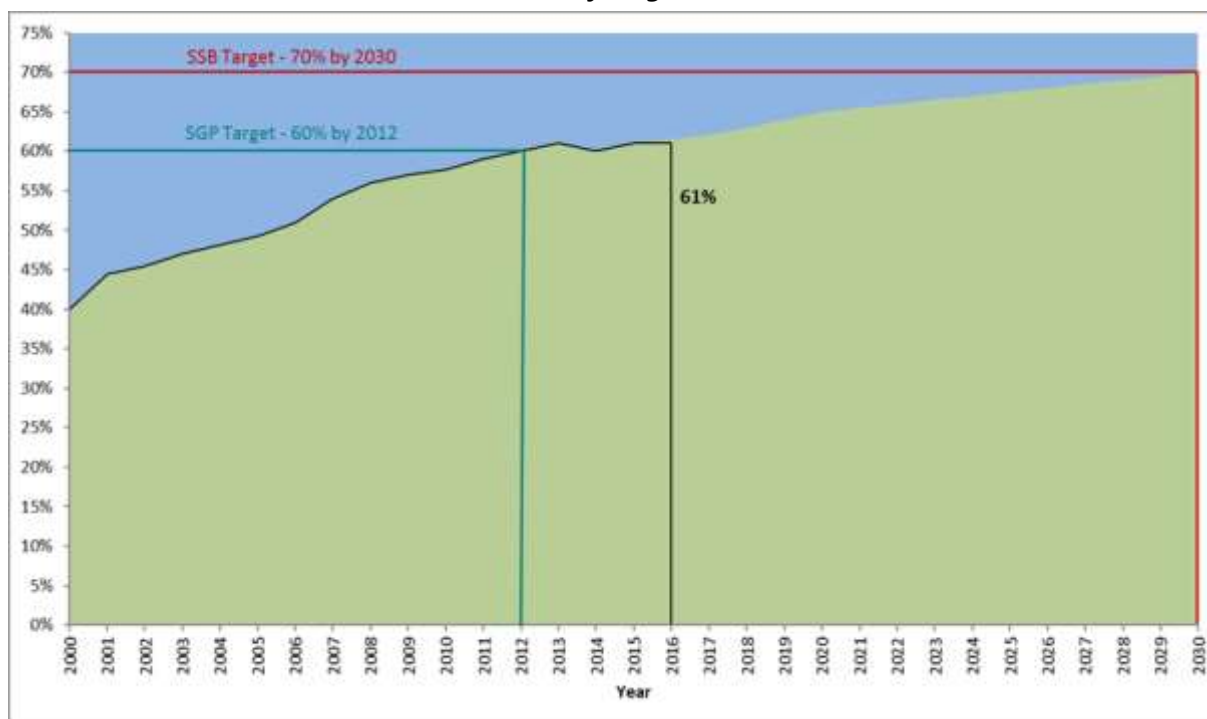
Initiatives to Promote the 3Rs

NEA has put in place various programmes to promote the 3Rs in the community, work place and public places.

National Recycling Programme – HDB and Landed Property Estates

The National Recycling Programme (NRP) was launched in April 2001 with the provision of recycling bags for fortnightly door-to-door collection. From 2014, each Housing & Development Board (HDB) block and landed home is provided with a commingled recycling bin with increased collection frequency – weekly for landed homes and thrice a week or more for HDB estates. Garden waste from landed homes is collected weekly for recycling. In addition, incentive

Chart 7.1
Overall Recycling Rate



Note:

SSB: Sustainable Singapore Blueprint 2015, SGP: Singapore Green Plan

Table 7.1
Types and Amounts of Waste Disposed Of and Recycled in 2016

Waste Stream	Disposed (tonnes)	Recycled (tonnes)	Generated (tonnes)	Recycling Rate
Construction and demolition waste	9,700	1,585,700	1,595,400	99%
Ferrous Metal	6,000	1,351,500	1,357,500	99%
Non-ferrous Metals	1,300	95,900	97,200	99%
Used Slag	4,100	247,000	251,100	98%
Scrap Tyres	3,000	29,700	32,700	91%
Wood/Timber	119,100	411,600	530,700	78%
Horticultural Waste	111,500	209,000	320,500	65%
Paper/Cardboard	576,000	607,100	1,183,100	51%
Glass	57,600	14,700	72,300	20%
Food waste	679,900	111,100	791,000	14%
Ash & Sludge	199,000	28,300	227,300	13%
Plastics	762,700	59,500	822,200	7%
Textile/Leather	139,800	10,900	150,700	7%
Others (includes stones, ceramics & rubber)	375,500	7,000	382,500	2%
Total	3,045,200	4,769,000	7,814,200	61%

Note:

Metals recovered from Incineration Bottom Ash for recycling is excluded from waste disposed. Wood and horticultural waste recycled include 361,500 tonnes used as fuel in biomass power plants.

schemes are available to encourage residents to recycle. Recycling for HDB residents has been made more convenient with the addition of a recycling chute in HDB flats launched from 2014.

Recycling Receptacles in Condominiums/Private Apartments

Before November 2008, it was not mandatory for condominiums/private apartments to have recycling programmes in their premises. As such, it was inconvenient for residents to recycle as they did not have easy access to recycling receptacles.

Hence, the Environmental Public Health Act (EPHA) and the Environmental Public Health (General Waste Collection) Regulations were amended on 1 November 2008 to require the provision of recycling receptacles in condominiums/private apartments.

In addition, the Code of Practice on Environmental Health was updated to incorporate the provision of recyclables storage and collection system in new strata titled developments.

Recycling Bins at Public Places

As part of a trial to encourage recycling, NEA has provided recycling bins next to litter bins in public places with high pedestrian traffic in the Central-South region of Singapore to facilitate the recycling of

common waste items such as flyers, newspapers, drink cans and plastic/glass bottles. The recycling bins are commonly located near MRT stations, selected bus stops and traffic junctions. The presence of recycling bins also helps to remind the public of the need to recycle.

3R Initiatives for Corporates

The 2nd 3R Awards and Seminar for Hotels, co-organised by NEA and the Singapore Hotel Association (SHA), was held at Mandarin Oriental, Singapore, on 24 October 2016. The biennial awards recognise the participants of the 3R Programme for Hotels which have performed well in solid waste management and the 3Rs.

28 hotels were recognised for their 3R efforts, up from 25 hotels in 2014, with three hotels receiving the Distinction award for outstanding performance and 11 hotels receiving the Merit award for commendable achievement.

Presentations on reducing food loss in the hotel food supply chain and the standard for quantification and reporting of food loss and waste were delivered at the 3R Seminar that followed the awards ceremony. A mini exhibition showcased the avenues and technologies available for waste minimisation and recycling in the hotel industry, such as cleaning supplies that had less packaging and closing the loop with products made

Recycling bin in HDB estates



Refuse bin and recycling bin in landed estates

Recycling at Public Places: Twin bins at places with high pedestrian traffic in the Central-South region



Recycling chute at Treelodge@Punggol





Group photo of Senior Minister of State (MEWR) Dr Amy Khor, President (SHA) Mr Albert Teo, Assistant Honorary Secretary (SHA) Mr Chris Teo, Chief Executive Officer (NEA) Mr Ronnie Tay, Director-General of Environmental Protection (NEA) Mr Ram Bhaskar and Executive Director (SHA) Ms Margaret Heng with the Distinction and Merit award

from recycled plastic bottles. The event ended with a tour on the notable 3R practices by Mandarin Oriental, Singapore.

The 3R Guidebook for Hotels, as well as the 3R Guidebook for Shopping Malls, were updated with new information and case studies. Similarly, a 3R Guidebook for Offices was produced for corporate bodies to implement 3R practices in their office premises. These guidebooks are available on NEA website at <http://www.nea.gov.sg/energy-waste/3rs/3r-guidebooks>.

Recycling at Industrial Estates

While large industrial premises have the capability and scale to implement their own cost-effective waste reduction and recycling programmes, the smaller factory premises such as those in JTC's flatted and terraced industrial estates, often do not. JTC provides recycling bins at convenient locations, such as lift lobbies of individual factory blocks as well as skip tanks at common areas on the ground floor for workers and cleaners to deposit recyclable waste. Designated areas within bin centres are also set aside for the collection of wooden pallets for reuse or recycling.

A guidebook on waste minimisation for industries is available on NEA's corporate website to help companies reduce waste through the practice of the 3Rs, i.e. Reduce, Re-use, and Recycle. The guidebook may be found at www.nea.gov.sg/3R.

Schools Recycling Corner Programme

In the Schools Recycling Corner Programme, recycling corners are set up in schools where recycling bins are provided and educational materials made available to raise awareness of waste minimisation and recycling among students.

Various recycling schemes for schools were organised throughout the year by the private sector to support the recycling programme in schools. For example, SembWaste Pte Ltd's "Sembcorp Go Green Fund" competition rewarded the top three schools that collected the most recyclables with cash prizes, and the next eight schools with tokens of appreciation.

In addition, Tetra Pak's recycling programme for primary and secondary schools and junior colleges encouraged students to collect used drink cartons. The top five schools with the highest tonnage collected in 2016 were awarded with products made of recycled materials. Students from the top three winning schools also went on a sponsored educational trip to Tetra Pak's partner paper mill in Malaysia.

Clean and Green Singapore

At the Clean and Green Singapore (CGS) held from 5 to 7 Nov 2016, the public was given a glimpse into how waste and recyclables were managed in Singapore, as well as the practices that they could adopt to minimise the waste they generate, so as to extend the lifespan of



School Recycling Corner Programme

Semakau Landfill beyond 2035. The public could also try their hand at upcycling common household items and purchase upcycled items at the inaugural Eco Fair.

Public Sector Taking the Lead in Environmental Sustainability (PSTLES)

All public sector agencies are required to implement recycling programmes at their premises. Under the enhanced PSTLES 2.0 framework, large public sector buildings with a gross floor area greater than 10,000 m² are required to report the weight of waste and recyclables generated at their premises from FY2015. All large public premises submitted their FY2015 Resource Management Plan (RMP) and waste and recyclables data by Nov 16. A waste reduction target will be determined in FY2016.

A demonstration fund was set up to assist public premises in implementing food waste pilot projects at their premises.

3R Fund

The 3R Fund is a scheme launched in April 2009 to encourage companies and organisations to implement projects to reduce, reuse and recycle waste. Projects eligible for funding should result in an increase in the quantity of solid waste reused or recycled, or in a reduction in the quantity of solid waste generated. As of the end of 2016, a total of 40 projects have been supported for funding.

E-waste

The amount of electrical and electronic waste (e-waste) generated in Singapore is growing as technological advancement is leading to faster product replacement. E-waste may contain valuable and scarce materials, but also trace amounts of hazardous substances, which may pose pollution and health concerns if not properly disposed of.

Study on Collection, Recycling and Management of E-Waste

In March 2016, NEA commissioned a study on the collection, recycling and management of e-waste. The study includes a survey of the entire local e-waste collection and recycling value chain, and an analysis of the e-waste management systems in other countries, to inform the design of a viable system in Singapore. Through the study and stakeholder consultations, NEA aims to develop a comprehensive and effective system for the management of e-waste for Singapore. The study is expected to conclude in late 2017.

National Voluntary Partnership

NEA has been working closely with industry partners and communities to increase public awareness and encourage the recycling of e-waste through voluntary programmes led by industry partners. Individuals, households and businesses are encouraged to use the recycling programmes voluntarily offered by industry stakeholders.

In 2016, NEA formed a national voluntary partnership for e-waste recycling with interested stakeholders, to gather and enhance existing programmes under one umbrella. The programme seeks to build public awareness of e-waste recycling and make e-waste recycling more convenient.

NEA is inviting interested stakeholders from the whole e-waste value chain to become members of the voluntary partnership. Stakeholders include producers, retailers, collectors and recycling service providers, etc. As of 31 December 2016, NEA has formed partnerships with 9 companies. To encourage partners to implement or expand on their programmes to increase e-waste recycling awareness and provide convenient recycling services for the public, a fund has been established to support the voluntary partnership. More information about the National Voluntary Partnership is available on the following website: <http://www.nea.gov.sg/energy-waste/3rs/e-waste-lamp-battery-recycling/national-voluntary-partnership>.

Food Waste

In 2016, 791,000 tonnes of food waste were generated in Singapore, of which 111,100 tonnes (14%) was recycled. The rest of the food waste was disposed of at the wastes-to-energy plants and then landfilled. NEA is exploring ways to manage food waste in a holistic way that promotes the reduction of food wastage as well as the segregation of food waste at source and use of innovative means to treat or recycle the food waste.

Food Waste Reduction

The preferred method to manage food waste is to avoid generating it in the first place.

NEA launched a Food Wastage Reduction Outreach Programme on 23 November 2015 to encourage the public to prevent and reduce food wastage at source. The programme aims to encourage consumers to engage in smart food purchase, storage and preparation habits. Doing so would help households conserve valuable resources while enjoying cost savings.

Under this programme, posters and educational videos on food wastage are featured through various media channels, such as digital and mobile media platforms, at bus-stop shelters, in newspapers and on television. The posters and educational videos emphasise the potential savings from avoiding food wastage and what the money could then be spent on. Customised educational materials are also being produced for households to provide tips on reducing food wastage within the home. The public can access an online handy guide to

reducing food wastage, available at www.cgs.sg/FWRguide, which provides a wide range of useful tips on how to reduce food wastage at home and when dining out.

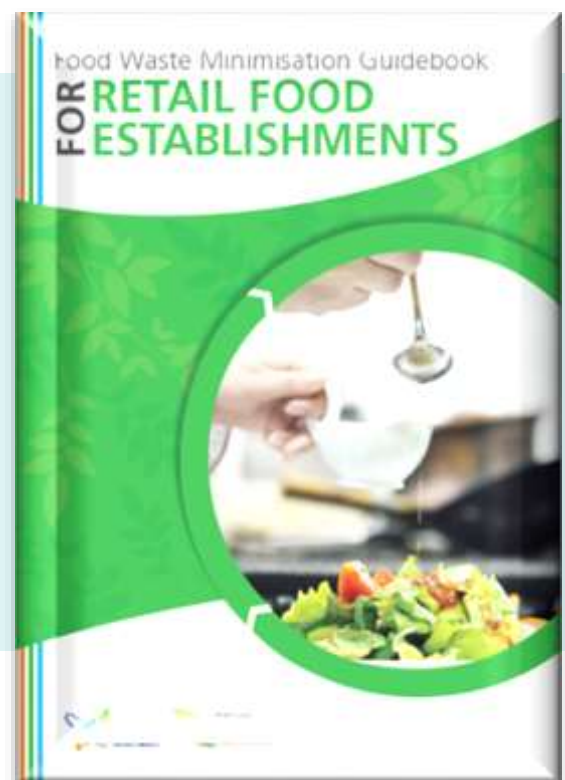
NEA is partnering various organisations and food retail businesses, such as Cold Storage/Giant, PRIME, Sheng Siong, NTUC FairPrice and SUBWAY, to raise greater awareness among consumers on how they can play a role in reducing food wastage. These companies have displayed collateral materials (such as posters and table-top stickers) to remind and encourage consumers not to waste food. In addition, the table-top stickers were placed at five hawker centres including Tiong Bahru Market and Block 628 Ang Mo Kio Avenue 4 Market and Food Centre, which are piloting the on-site food waste treatment systems.

Additionally, NEA is working with various stakeholders in the food supply chain to develop guides to help food retail and manufacturing establishments as well as supermarkets to minimise food waste. The food waste minimisation guidebook for food retail establishments was launched on 24 October 2016 as a step towards reducing food waste across the supply chain. NEA also encourages these establishments to donate their unsold and excess food to food distribution organisations, such as Food Bank Singapore, Food from the Heart and Willing Hearts. To address food safety concerns, guidelines on the proper handling and re-distribution of unsold and excess food have also been incorporated into the guidebook. Similar guidebooks would also be



Left: Love Your Food Handy Guide

Right: Food waste minimisation guidebook for Food Retail Establishments





Pilot food waste and used water sludge co-digestion project

developed for food manufacturing establishments and supermarkets.

The concerted publicity and outreach efforts for food wastage reduction communicated the need for a collective effort from the community to curb the problem of food wastage in Singapore.

Food Waste Treatment/Recycling

Food waste that cannot be avoided should be treated or recycled as far as possible. To support successful food waste treatment or recycling, food waste must be separated from contaminants, such as disposable cutlery, as these interfere with the treatment/recycling process. Segregation of food waste is best done at source (i.e. at the point of generation) as it is less efficient to separate it once it is mixed with general waste.

On-site Food Waste Treatment Pilots at Hawker Centres

In May 2015, NEA called a tender for a two-year (one-year, with the option to extend for another year) on-site food waste recycling pilot at two hawker centres, Blk 628 Ang Mo Kio Avenue 4 Market and Food Centre (AMK 628 Market) and Tiong Bahru Market. The tender was awarded and the pilot was launched on 21 January 2016.

The objective of this pilot project is to assess the economic viability and operational feasibility of two different types of on-site food waste treatment systems. The food waste treatment machine at AMK 628 Market is able to convert one tonne of food waste into non-

potable water within 24 hours, which can then be reused for self-cleansing of the machine. The machine at Tiong Bahru Market grinds the food waste fed into it with microorganisms, to convert the food waste into liquid bio-fertiliser.

Off-site Food Waste and Used Water Sludge Co-Digestion Pilot

In August 2015, NEA called a tender for a pilot project to collect and transport food waste for co-digestion. The aim is to assess the viability of collecting and transporting source-segregated food waste to an off-site treatment facility, where the food waste will be co-digested with used water sludge. The pilot project involves the collection of source-segregated food waste from various premises and the food waste is transported to Public Utilities Board's (PUB) demonstration facility located at the Ulu Pandan Water Reclamation Plant. The demonstration facility is designed to treat up to 40 tonnes of combined food waste and used water sludge, and produce more biogas from the anaerobic digestion process as compared to the treatment of used water sludge alone, thereby enhancing energy recovery. The pilot project commenced in December 2016. If successful, the process could potentially be implemented at the future co-located NEA's Integrated Waste Management Facility and PUB's Tuas Water Reclamation Plant.

On-site Food Waste Treatment at Our Tampines Hub

NEA worked with People's Association to implement on-site food waste treatment at the integrated development at Our Tampines Hub (OTH). In November

2016, Phase 1 of OTH was launched, including a closed loop system for food waste management for the development. OTH is working towards zero waste by converting food waste generated from the entire development into fertiliser or non-potable water, using an advanced on-site food waste treatment system. The fertiliser will then be used in the community gardens and also distributed free to residents who need it.

Singapore Packaging Agreement

The Singapore Packaging Agreement (SPA) is a joint initiative by government, industry and NGOs to reduce packaging waste, which constitutes about one-third by weight of Singapore's domestic waste. NEA introduced the first SPA in July 2007, which lasted 5 years. The second SPA came into effect in July 2012, and will last

their products. This will help conserve resources and ultimately reduce waste generation. As of end 2016, the database, which is accessible at www.nea.gov.sg/SPA, displays the packaging weight benchmarks for sixteen product categories.

3R Packaging Awards 2016

The annual 3R Packaging Awards serves to recognise SPA signatories who have made notable efforts and achievements in reducing packaging waste. In 2016, twenty companies received the 3R Packaging Awards from the Minister for the Environment and Water Resources, Mr Masagos Zulkifli Bin Masagos Mohamad, at the CleanEnviro Summit Singapore 2016 on 12 July 2016.



Logo of the Singapore Packaging Agreement

Introduction of Mandatory Requirements for Packaging Waste Management

To provide impetus for more actions to be taken to reduce waste, it was announced at the 3R Packaging Awards 2016 presentation ceremony that mandatory requirements for more sustainable packaging waste management would be implemented within the following three to five years.

From December 2015 to May 2016, NEA engaged various stakeholders to gather their views on the possible introduction of mandatory requirements that could be considered for Singapore. The response from the industry was generally positive, with companies recognising the need for a mandatory framework to create a level playing field and provide impetus for more actions to be taken to reduce waste.

NEA would take the feedback from the industry into consideration in working out the details of the mandatory requirements.

Mandatory Waste Reporting for Large Commercial Premises

In April 2014, the Environmental Public Health Act was amended to require large commercial premises to report waste data and submit waste reduction plans (including setting of targets), affecting hotels with more than 200 rooms and shopping malls with net lettable areas of more than 50,000 square feet. The reporting exercise would help to enhance awareness among operators of the potential for improving their premises' waste management systems.



Food waste treatment system at Our Tampines Hub

till end June 2020. As of the end of 2016, the second SPA has garnered 181 signatories, and boasts a cumulative reduction of 32,000 tonnes of packaging waste, with cumulative savings of more than S\$75 million in material costs.

In October 2015, NEA launched a packaging benchmarking database which allows companies to compare the packaging weight of their products against the benchmarks ('Lightest', 'Median', and 'Heaviest') of similar products sold locally. The aim is to enable businesses to discover the potential for improving their packaging design and use of materials, and spur them to take action to reduce the amount of packaging in



Twenty signatories recognized for their efforts and achievements in reducing packaging waste at the 3R Packaging Awards 2016.

In the second round of waste reporting, all 261 affected premises (94 hotels and 167 malls) submitted their waste reports, comprising waste data collected from January to December 2015, by 31 March 2016.

Best practices from the top performers included making efforts to recycle less common types of waste such as food waste, e-waste and horticultural waste and providing electronic newspapers for guests instead of hardcopy newspapers.

NEA provided owners of premises with significant waste generation and low recycling rates, advice on understanding waste profiles and how to kick-start waste reduction programmes. NEA also shared information on potential cost savings from waste reduction and provided guidance on possible 3R initiatives that could be implemented.

Recycling Facilities

Sarimbun Recycling Park

NEA operates the Sarimbun Recycling Park (SRP) that provides land for the recycling of bulky wastes such as wood/horticulture and construction & demolition waste. NEA also works with URA and JTC to provide land for the setting up of recycling plants in industrial estates. Some of these plants recycle e-waste, plastic waste and wood waste.

REMEX Metal Recovery Facility

In June 2014, NEA awarded a tender to M/s REMEX Mineralstoff GmbH (REMEX) to develop and operate a metal recovery facility, to recover ferrous and non-ferrous metals from incineration bottom ash (IBA) generated by the incineration plants. It is part of NEA's long-term strategy to manage solid waste in Singapore, and also aligns with the Government's plans to move towards a resource efficient society.

The 1.4-hectare facility can process up to 1,800 tonnes of IBA per day. Compared to other facilities run by REMEX in Europe, the facility in Singapore is able to achieve similar output using a much smaller land space. This land efficiency is especially valuable in Singapore.

Before REMEX started operations, only ferrous metals between 10mm and 300mm in size were recovered from IBA using magnetic separators at the WTE plants. Now, non-ferrous metals such as aluminium and copper can be recovered using sieving techniques and eddy current separators. Unrecovered ferrous metals larger than 4mm are also extracted from the IBA.

The facility started operation in July 2015. The recovery of metals from IBA helps to minimise waste sent to the landfill.

Pilot Mechanical and Biological Treatment Facility

In December 2016, NEA awarded a tender to a consortium comprising Hangzhou Jinjiang Group Co. Ltd. and Eastern Green Power Pte. Ltd. to develop a pilot commercial mechanical-biological treatment (MBT) facility. The pilot facility will be privately financed, built, owned and operated. Recyclables such as metals, plastics and glass will be recovered at the plant.

The pilot MBT facility is part of the government's efforts to introduce alternative processes to improve recycling and resource recovery from domestic and trade waste (DTW) currently sent for incineration directly. The pilot facility will be designed to process 500 tonnes of DTW per day. It is estimated that the pilot facility will be able to recover about 15 per cent of the waste treated as recyclables, which will amount to more than 500,000 tonnes of recyclables recovered over 20 years.

The pilot facility is expected to take approximately two years to construct and to be operational by end-2018.

NEA will assess whether the technology can complement the current waste treatment technologies adopted by Singapore and its potential as an alternative treatment technology for DTW.

Waste Disposal

In Singapore, all waste that is not recycled is either disposed of at the WTE plants or landfilled at the offshore Semakau Landfill. In 2016, the total quantity of waste collected and disposed of in Singapore was 3.13 million tonnes or 8,560 tonnes per day on average, which was a 1.87% increase from the previous year's daily average. The daily average amount of waste collected from 2012 to 2016 is shown in [Chart 7.2](#).

Waste Disposal Facilities

NEA's waste disposal facilities include the two Government-owned WTE plants viz. Tuas Incineration Plant and Tuas South Incineration Plant, the offshore Semakau Landfill, and the Tuas Marine Transfer Station. Two other WTE plants, viz. Senoko Waste-to-Energy Plant and Keppel Seghers Tuas Waste-to-Energy Plant, are owned by Keppel Infrastructure Trust and operated by Keppel Infrastructure.

Waste-to-Energy Plants

In 2016, 2,915,615 tonnes of waste were disposed of at the WTE plants. The quantity disposed at each WTE plant in 2016 is shown in [Table 7.2](#).

In 2016, about 1,200,000 MWh of electricity was generated by the WTE plants using heat produced from the incineration process. 918,000 MWh, or 77% of the electricity generated, was exported to the national grid. This constitutes approximately 2% of the total electricity consumed in Singapore.

The quantity of scrap metal recovered from the WTE plants in 2016 amounted to 22,293 tonnes. These were sold to steel mills for reprocessing into steel products.

Semakau Landfill

In 2016, Semakau Landfill (SL) received 217,224 tonnes of non-incinerable waste and 583,744 tonnes of incineration ash. Since July 2015, incineration bottom ash (IBA) from the WTE plants has been sent for further processing at the REMEX metal recovery facility. The processed IBA is then landfilled. [Table 7.3](#) shows the quantity of incineration ash from the WTE plants and metal recovery facility that was sent to SL.

6th Waste-to-Energy Plant

NEA awarded the contract for the development of the 6th WTE Plant to TuasOne Pte Ltd (TuasOne) under the



Construction & Demolition waste recycling



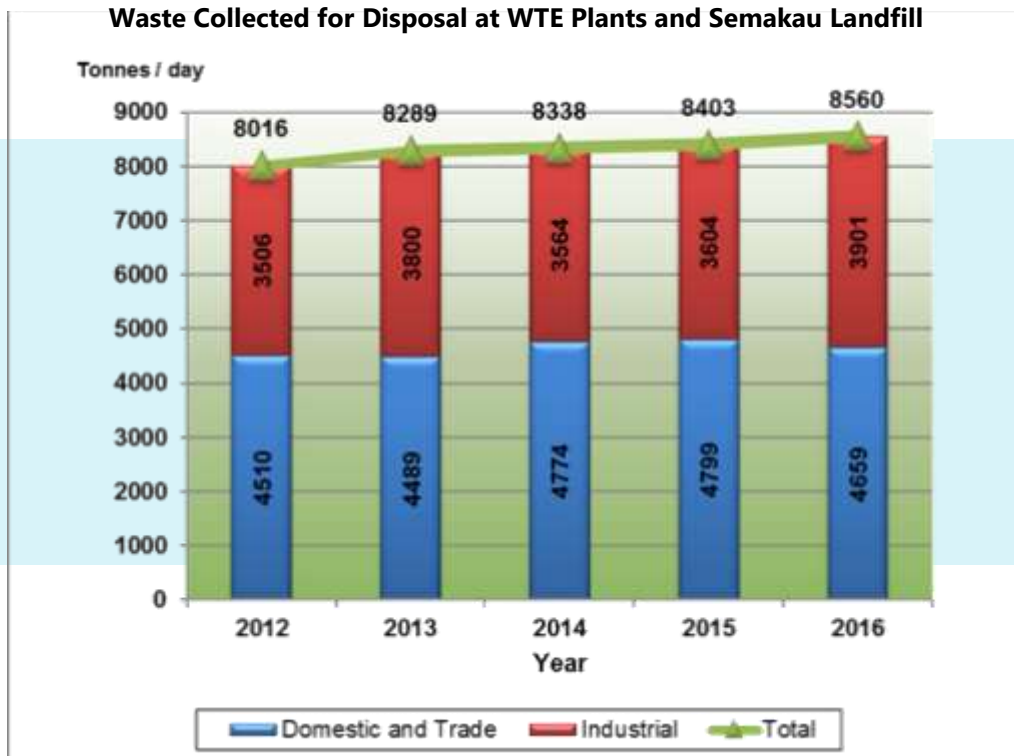
Horticultural waste recycling



Artist's impression of 6th WTE Plant (Courtesy of Hyflux Ltd)

Chart 7.2

Waste Collected for Disposal at WTE Plants and Semakau Landfill



Public-Private-Partnership (PPP) scheme, using the design-build-own-operate (DBOO) model. The tender for the project was awarded on 14 September 2015.

TuasOne, a special purpose company formed by the consortium comprising Hyflux Ltd (Hyflux) and Mitsubishi Heavy Industries Ltd (MHI) signed the Waste-to-Energy Services Agreement (WESA) with NEA on 26 October 2015. Under the WESA, TuasOne would develop the 6th WTE Plant at Tuas South Ave 3 and provide a contracted incineration capacity of 3,600 tonnes per day exclusively to NEA for a period of 25 years from 2019 to 2044. The plant would be capable of producing electricity for the plant's operation and export an excess electricity of 2,880 MWh daily to the grid.

TuasOne achieved financial close for the project on 16 May 2016. The plant construction has commenced since early 2016. It has successfully completed the site

piling works and construction of the stack windshield. The other civil and structural works have been progressing smoothly within schedule.

The scheduled Project Commercial Operation Date of the Plant is in May 2019.

Integrated Waste Management Facility (IWMF)
In addition to the 6th WTE Plant, NEA is planning the development of an Integrated Waste Management Facility (IWMF) to meet Singapore's long term waste management needs. The IWMF will be co-located with PUB's Tuas Water Reclamation Plant (TWRP) at the 68ha Tuas View Basin site, to maximise process and non-process synergies as well as optimise land use footprint. Unlike the existing WTE facilities, the IWMF will be equipped with several state-of-the-art solid waste treatment technologies that will enable it to effectively handle multiple waste streams and optimise resource and energy recovery. The waste streams that IWMF will

Table 7.2

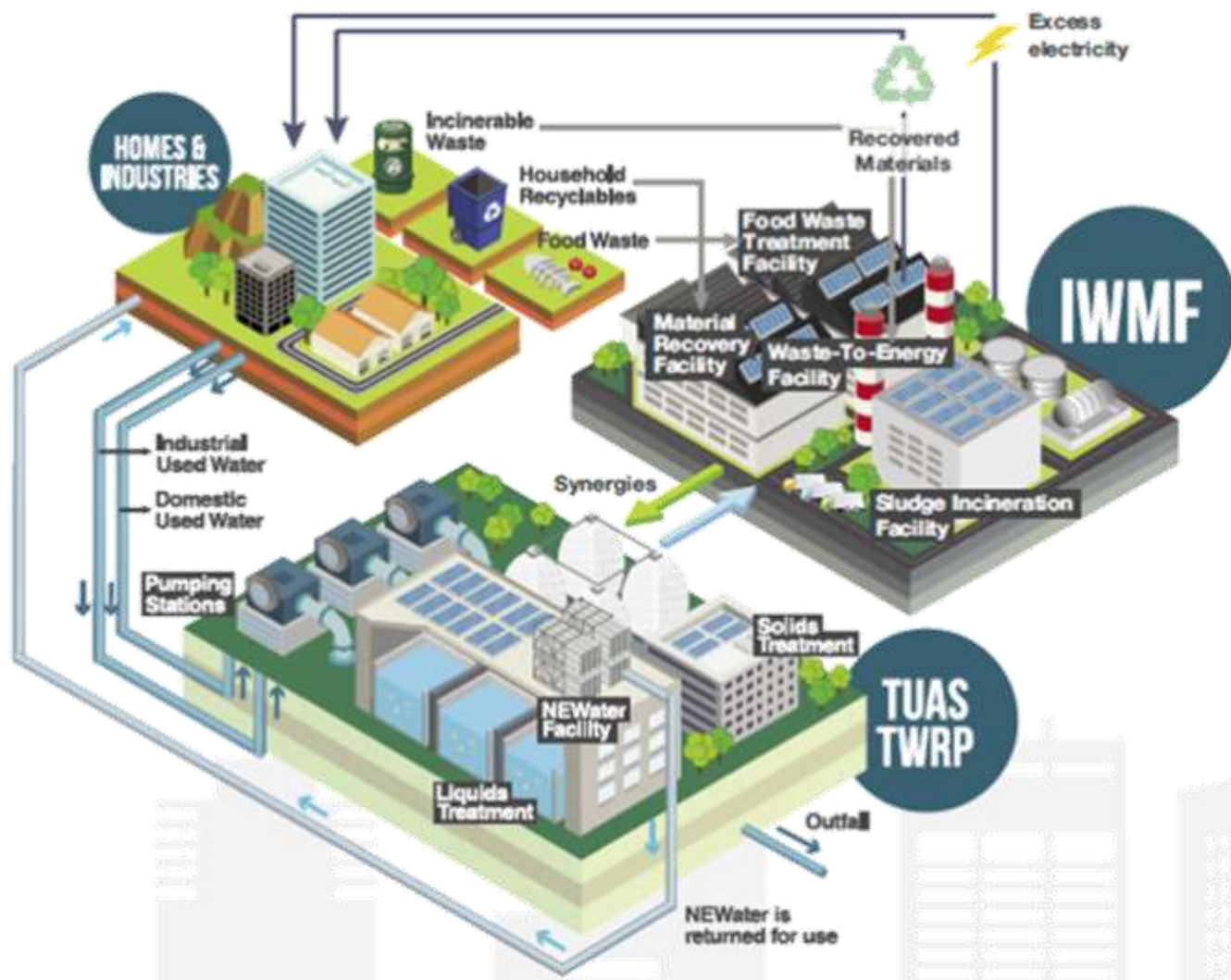
Waste Disposed at the WTE Plants in 2016

S/N	WTE Plant	Tonnes
1	Tuas South Incineration plant	1,297,342
2	Senoko Waste-to-Energy Plant	869,464
3	Tuas Incineration Plant	493,054
4	Keppel Seghers Waste-to-Energy Plant	255,755
Total		2,915,615

Table 7.3

Incineration Ash sent to Semakau Landfill

S/N	Source of Incineration Ash	Tonnes
1	Incineration ash from the WTE plants	179,608
2	Processed Incineration Bottom Ash from REMEX Metal Recovery Facility	404,136
Total		583,744



IWMF and its co-location with TWRP.

be handling include incinerable waste, recyclables collected under the National Recycling Programme, source segregated food waste and dewatered sludge from the TWRP. The IWMF is planned to be constructed in phases with the first phase scheduled to be completed by end 2022/early 2023.

NEA has launched the Expression of Interest (EOI) in September 2016 to engage consultants to come on board as Owner's Engineer to assist in the development of the IWMF from mid-2017 onwards.

NEA has also engaged its Multi-Disciplinary Consultant to manage and supervise the construction of two proposed viaducts to provide road access for the Tuas View Basin site to facilitate the construction and operational needs of the IWMF and the TWRP. The Design and Build (D&B) tender was awarded in Jun 2016. The construction works have commenced and the viaducts are scheduled to be completed by Dec 2018

Waste Collection

Public Waste Collection Scheme

Singapore was originally divided into nine geographical sectors for waste collection companies to bid for the licence to provide waste collection services for domestic and trade premises. In May 2012, it was announced that the nine sectors would be consolidated into six to help the waste collection companies reap cost savings from economies of scale, and reduce the duplication of resources while ensuring that the market remains competitive. As of 2016, there are seven geographical sectors. The boundaries of these seven sectors are shown below.

The consolidation exercise will be completed in 2018 when a combined new contract is implemented for the Pasir Ris – Tampines and Bedok sectors. The final six sectors are shown on the following page.

Public Waste Collectors and the Uniform Fee System

There were four Public Waste Collectors (PWCs) in 2016. The four PWCs and the expiry dates of their contracts for each sector are listed in [Table 7.4](#).



Legend

■ Sembwaste
 ■ Veolia ES
 ■ Colex
 ■ 800 Super

Boundaries of Singapore's current seven geographical sectors for waste collection.



Final six sectors after the consolidation exercise, which will be completed in 2018

Table 7.4
The Public Waste Collectors for the Seven Sectors

No	Sector	PWC	Contract Expiry Date
1*	Pasir Ris – Tampines	Veolia ES Singapore Pte Ltd	30 Jun 2018
2*	Bedok	SembWaste Pte Ltd	31 Oct 2018
3	Jurong	Colex Environmental Pte Ltd	31 Mar 2020
4	Clementi – Bukit Merah	Veolia ES Singapore Pte Ltd	31 Dec 2020
5	City – Punggol	SembWaste Pte Ltd	30 Jun 2021
6	Ang Mo Kio – Toa Payoh	800 Super Waste Management Pte Ltd	30 Sep 2021
7	Woodlands – Yishun	SembWaste Pte Ltd	31 Dec 2021

Note:

* These two contracts will be consolidated after their expiry in 2018.

Since 2012, all households pay the same public waste collection fees for the same tier of service provided by the PWCs. In 1 January 2015 when new contracts were implemented in all sectors, the fee was set at \$7.00 for flats/apartments and \$23.19 for landed premises. NEA reviews the public waste collection fees every 2 years, and the next review will be in Jan 2017.

The next round of new contracts which would start from 2018.

Licensed General Waste Collectors (GWCs)

NEA licenses General Waste Collectors (GWCs) in Singapore. It is an offence for a person or company to collect or transport waste as a business without a valid GWC Licence.

The EPH (GWC) Regulations and Code of Practice (GWC) were amended and came into effect on 1 December 16 to effect the licensing regime for used cooking oil collection.

All UCO collectors will have until 1 June 2017 to obtain their licence. The licensing scheme would ensure that UCO collectors meet waste collection standards, including standards for the proper collection, storage and transportation of UCO. All food establishments, such as food retail establishments and food manufacturers, would be required to engage licensed collectors for UCO collection by 1 June 2017.

District Pneumatic Waste Conveyance System

A Pneumatic Waste Conveyance System (PWCS) is an automated waste collection system. It conveys waste by air suction from individual buildings, through a network of pipes, to a central station. The system is fully enclosed and does not require manual handling and transfer of waste. In this regard, there are environmental benefits such as higher efficiency in waste collection and providing a cleaner living environment to residents. In November 2015, NEA called a tender to conduct feasibility studies for the implementation of a district-

level PWCSs (DPWCSs) at Marina Bay Zone 1 and Kampong Bugis Precinct. AECOM was awarded the contract on 24 February 16. The study would also identify suitable locations to house the DPWCS central stations at Kampong Bugis. Implementing PWCS at a district level serving several developments would maximise benefits of the system and reduce manpower for waste collection and refuse truck traffic.

To support the greater adoption of PWCS in Singapore, a PWCS Standard Working Group was formed in September 2016 to develop guidelines and standards for PWCSs. The Working Group comprises NEA, HDB, SPRING Singapore and relevant stakeholders.

radiation protection and nuclear science

RPNSD is responsible for the safe use of ionising and non-ionising radiation in Singapore as well as the implementation of various international conventions relating to radiological and nuclear matters which Singapore has ratified. The organisation chart of RPNSD can be found in **Appendix 6**.

The Radiation Protection and Nuclear Science Department (RPNSD) is responsible for radiation protection in Singapore. It administers and enforces the Radiation Protection Act and Regulations to ensure the safe and secure use of radioactive materials and irradiating apparatus, through a system of licensing, inspection and enforcement.

The department, formerly known as the Centre for Radiation Protection and Nuclear Science (CRPNS), was formed on 1 July 2007 through a merger of the Health Sciences Authority's Centre for Radiation Protection and the National Environment Agency/Pollution Control Department's Nuclear Science and Technology Unit. The merger aimed to streamline controls on radioactive and nuclear materials as well as ensure that Singapore continues to fulfil its obligations under the various international agreements which Singapore had signed with the International Atomic Energy Agency (IAEA). The department was renamed Radiation Protection and Nuclear Science Department (RPNSD) with effect from 1 August 2013 to better reflect its regulatory role.

On 1 July 2014, RPNSD's role was expanded to support the development of capabilities in nuclear safety, emergency preparedness and response, radiation monitoring as well as radiochemistry. The department was re-structured to comprise two sections, viz. Regulation, and Radiation Monitoring and Services, to better coordinate the expanded scope of work under the department.

RPNSD Functions

The key functions of RPNSD are listed as follows:

- Administer and enforce the Radiation Protection Act (RPA) and its Regulations;
- License the import, export, sale, possession, use and transport of radioactive materials and irradiating apparatus;
- Ensure the safe use of ionising and non-ionising radiation;
- Monitor radiation dose exposure for radiation workers;
- Provide radiation-related and consultancy services (e.g. calibration of survey meters and radioactivity testing);
- Control the disposal of radioactive waste;
- Implement international conventions relating to nuclear safety, security and safeguards that Singapore is a party to;
- Jointly respond with Singapore Civil Defence Force to radiological emergencies.

Regulation

RPNSD's Regulation Section comprises three units, namely the Ionising Radiation Control Unit, the Non-Ionising Radiation Control Unit, and the Nuclear Science and Technology Unit. This Section undertakes the responsibility of administering and enforcing the Radiation Protection Act and its associated Regulations in Singapore, as well as ensuring that Singapore fulfils her obligations to relevant international conventions and agreements.

Ionising Radiation

In Singapore, the import, export, manufacture, handling, sale, possession, use and transport of irradiating apparatus and radioactive materials are controlled under the Radiation Protection Act (RPA) and its regulations. **Table 8.1** provides a breakdown of ionising radiation licences issued in 2016.

In 2016, RPNSD carried out 868 inspections, of which 427 were on industrial facilities and 441 were on medical, dental and veterinary facilities. RPNSD also processed 17 cases of transit and 116 cases of transshipment of radioactive materials which were transported through our ports.

Non-Ionising Radiation

The RPA and its Regulations require that the following types of equipment that generate non-ionising radiation be subjected to control:

Group 1

- Ultraviolet lamps for irradiation of any part of the living human body
- Microwave ovens
- Foetal heart monitoring non-imaging ultrasound apparatus
- Any industrial ultrasound apparatus with power output of not more than 50 W



Inspector conducting checks on the storage of Iridium-192 non-destructive testing (NDT) industrial radiography projectors

Table 8.1
Number of Ionising Radiation Licences
Issued in 2016

Type	Description	No.
L1	Manufacture, possess for sale or deal in ionising radiation irradiating apparatus	165
L2	Manufacture, possess for sale or deal in radioactive materials	133
L3	Keep or possess ionising radiation irradiating apparatus for use (other than sale)	4,290
L4	Keep or possess radioactive materials for use (other than sale)	254
L5	Use ionising radiation irradiating apparatus	2,649
L6	Use radioactive material	651
L6A	Transport radioactive materials	29
L7A	Import a consignment of ionising radiation irradiating apparatus	2,379
L7B	Export a consignment of ionising radiation irradiating apparatus	2,053
L8A	Import a consignment of radioactive materials	1,796
L8B	Export a consignment of radioactive materials	1,983
R1	Register as a radiation worker to perform radiation work under the supervision of a licensee	10,935

- Medical diagnostic imaging ultrasound and therapeutic ultrasound apparatus
- Magnetic resonance imaging (MRI) apparatus
- Entertainment lasers
- High power lasers (Class 3b and Class 4)

The control of these types of equipment is enforced through the dealer licences for Group 1 equipment, and through both the dealer and possession licences for Group 2 equipment. Users of entertainment lasers as well as Class 3b and Class 4 lasers are also required to apply for user licences. All these licences are issued with attached conditions to ensure the safe use of the equipment. In addition, import licences are required for Group 1 and 2 equipment, while export licences are required for Group 2 equipment. **Table 8.2** provides a breakdown of non-ionising radiation licences issued in 2016.

In 2016, RPNSD carried out 67 inspections on facilities which emit non-ionising radiation, 3036 inspections on laser pointers, 43 inspections on microwave ovens, and

Table 8.2
Number of Non-Ionising Radiation Licences
Issued in 2016

Type	Description	No.
N1	Manufacture, possess for sale or deal in non-ionising radiation apparatus	438
N2	Keep or possess non-ionising radiation irradiating apparatus for use (other than sale)	9,881
N3	Use an non-ionising radiation irradiating apparatus	5,538
N4A	Import a consignment of non-ionising radiation irradiating apparatus	4,473
N4B	Export a consignment of non-ionising radiation irradiating apparatus	4,668
TradeNet Endorsements*	Approval granted to parts or accessories of controlled items, excluding X-ray tubes	7,903

*Endorsements cover all TradeNet licences, i.e. L7A, L7B, L8A, L8B, N4A and N4B.

provided 139 consultancy services to industries that use radiofrequency or microwave radiation.

RPNSD also participated in international conferences and meetings such as the World Health Organisation (WHO) International Advisory Committee (IAC) Meeting on Electromagnetic Field, the WHO InterSun programme Advisory Committee meeting, and the 8th International Non-Ionising Radiation Workshop by the International Commission on Non-Ionising Radiation Protection (ICNIRP). Participating in such events has allowed us to build capability in the area of non-ionising radiation and keep abreast of the latest developments in international non-ionising radiation standards.

Nuclear Science and Technology

Singapore is a party to various international instruments to promote international and regional co-operation in nuclear safety, security and safeguards. RPNSD is the national focal point to the IAEA for the conventions and agreements as listed in **Table 8.3**.

The Nuclear Science and Technology Unit in RPNSD is responsible for ensuring that Singapore fulfils its obligations to these conventions and agreements. The unit also contributes to international and regional efforts in strengthening nuclear safety, monitors international developments pertaining to nuclear safety since the Fukushima Daiichi nuclear accident in 2011, and tracks regional developments in nuclear energy. The Fukushima Daiichi nuclear accident highlighted the potential

transboundary impact from a nuclear or radiological incident. This underscored the importance for Singapore to maintain its strong commitment in promoting regional and international cooperation in nuclear safety related issues.

On the international front, Singapore works closely with the IAEA and supports their efforts in promoting nuclear safety, security and safeguards. In accordance with the reporting obligations of Contracting Parties to the Convention of Nuclear Safety (CNS), NEA submitted Singapore's National Report to the IAEA Secretariat on 3 August 2016 for peer review at the Convention meetings.

Table 8.3

List of conventions and agreements with IAEA

Title	Year of ratification / accession
Regional Co-operative Agreement (RCA) for Research, Development and Training in Nuclear Science and Technology for the Asia and Pacific region	1972
Comprehensive Safeguards Agreement	1977
Convention on Nuclear Safety	1997
Convention on Early Notification of a Nuclear Accident	1997
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	1997
Modified Small Quantities Protocol	2008
Additional Protocol	2008
Convention on the Physical Protection of Nuclear Material and its 2005 Amendment	2014

Singapore has been a party to the CNS since 15 December 1997 which aims to achieve and maintain a high level of nuclear safety worldwide, establish and maintain effective defences in nuclear installations against potential radiological hazards, and prevent accidents having radiological consequences.

In addition, as the national focal point to the IAEA for technical cooperation, RPNSD prepared Singapore's Country Programme Framework (CPF) for the period of 2016 to 2020, which was signed by Mr Foo Kok Jwee, Ambassador and Resident Representative of Singapore to the IAEA, and Mr Dazhu Yang, IAEA Deputy Director General and Head of the Department of Technical Cooperation on 5 December 2016. The CPF is the frame of reference for the medium-term planning of technical cooperation between Singapore and the IAEA and identifies priority areas where the transfer of nuclear technology and technical cooperation resources will be

directed to support national development goals. The 5-year CPF has identified several priority areas, namely safety and security, health and nutrition, industrial applications/radiation technology, water and the environment, and sterile insect technology.

On the regional front, RPNSD actively participates in the regional activities of ASEAN Network of Regulatory Bodies on Atomic Energy (ASEANTOM). Comprising nuclear or radiation regulatory bodies from all 10 ASEAN member states, ASEANTOM was officially recognised as an Annex I (ASEAN Sectoral Ministerial Bodies) entity in 2015. NEA, together with Thailand, initiated the ASEANTOM-IAEA Regional Technical Cooperation Project on Nuclear Emergency Preparedness and Response (EPR) which was approved for implementation in 2016. The IAEA regional project is aimed at supporting the establishment of a regional environmental radiation monitoring network and radioactivity database to integrate EPR planning for nuclear and radiological emergencies. NEA participated in 2 workshops under the regional project in May and December 2016.

On the local front, RPNSD facilitated 4 fellowships and 1 scientific visit in Singapore in the areas of radiation oncology and diagnostic radiology under the IAEA's Technical Cooperation (TC) programme which is aimed at transferring nuclear and related technologies for peaceful uses to developing Member States in 2016. RPNSD supports the TC programme by facilitating fellowships and scientific visits from developing countries for specific training in local institutions.

RPNSD also facilitated the visit of IAEA Director General Mr Yukiya Amano to Singapore in August 2016 and IAEA Director of Technical Cooperation Department (Asia and the Pacific) Ms Najat Mokhtar in November 2016, which further affirmed the warm relations between Singapore and the IAEA.

Radiation Monitoring and Services

The Radiation Monitoring and Services Section comprises the Radiation Services Unit, Radiation Monitoring Unit as well as the National Radiochemistry Laboratory. The establishment of the Radiation Monitoring Unit and National Radiochemistry Laboratory aims to strengthen Singapore's capabilities to monitor and establish radiation levels in the ambient environment. The Radiation Services Unit is responsible for providing monitoring services of radiation dose received by radiation workers in Singapore, as well as radiation services such as calibration of radiation survey meters, quartz fibre electrometers, food analysis and sealed source leak tests.



Thermo-luminescent Dosimeter



Radiation worker wearing a TLD badge

Radiation Services

Thermo-luminescent Dosimeter

In 2016, 61,674 Thermo-Luminescent Dosimeter (TLD) badges were issued to radiation workers in Singapore.

Calibration and Analysis Services

It is a requirement under the RPA and its Regulations that all radiation survey meters and quartz fibre electrometers used for radiation monitoring are calibrated annually. In 2016, RPNSD calibrated 463 radiation survey meters and quartz fibre electrometers. Sealed radioactive sources are also required to undergo leak tests to ensure the safe use of these radioactive sources. In 2016, RPNSD performed 806 leak tests on sealed radioactive sources. RPNSD has a Secondary Standards Dosimetry Laboratory (SSDL) to provide these services.

In addition to radiation protection services, RPNSD also performs gamma ray analysis on both food and non-food samples to certify that the products are free from radioactive contaminants. In 2016, 1419 food and non-food samples were tested by RPNSD.



Survey meter calibration at the Secondary Standards Dosimetry Laboratory

Denmark in January 2016 and September 2016 respectively. The fellowships aimed to equip the officers with the requisite technical knowledge and skills to carry out proper sampling and analytical techniques for the analysis of key radioisotopes in the environment and food items.

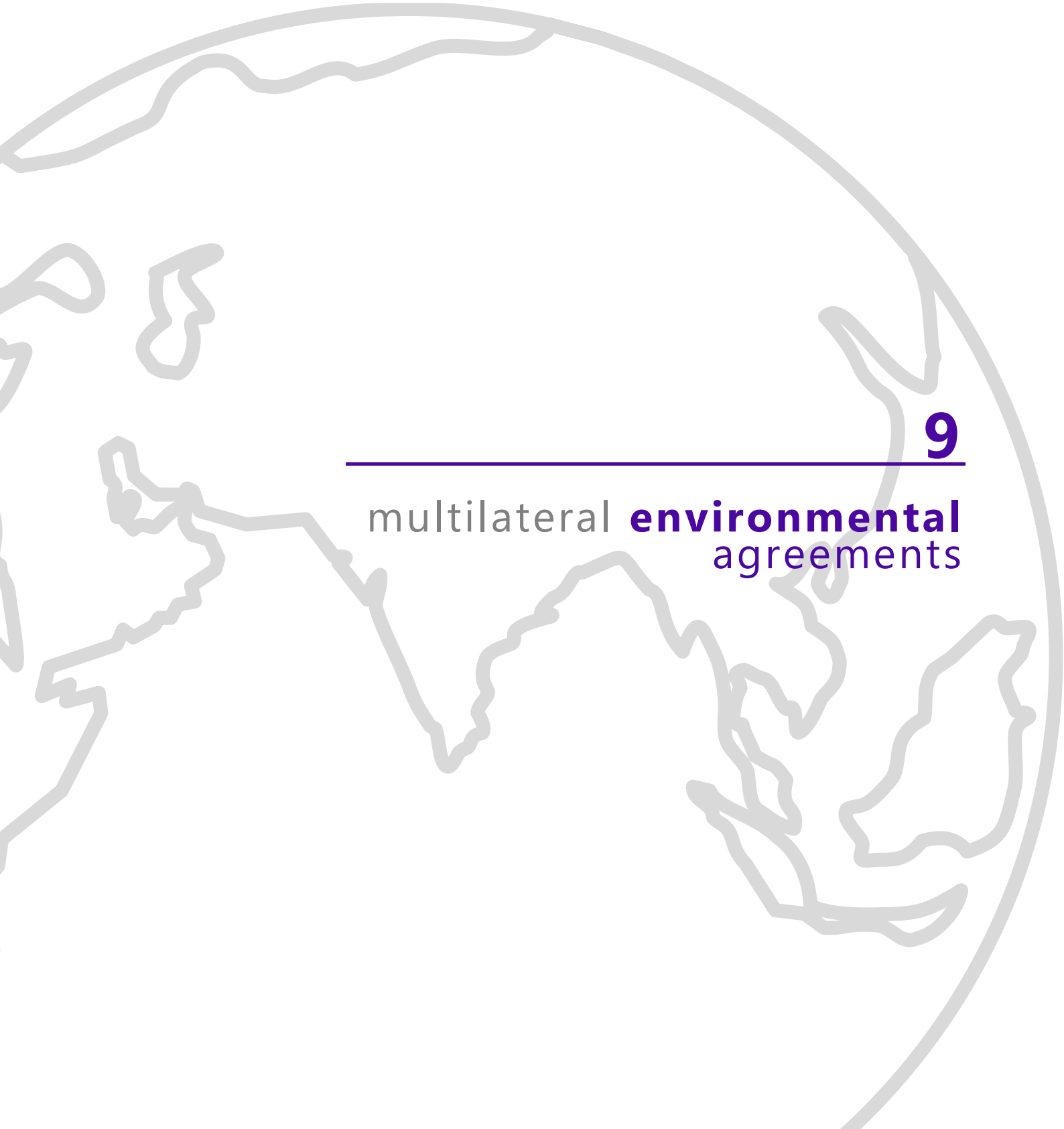


RPNSD officers during the training at Technical University of Denmark

On 30 June 2016, RPNSD called an open tender for the setting up of an Ambient Radiation Monitoring Network (ARMNet) in Singapore. The objective of ARMNet is to establish baseline ambient radiation levels and allow the detection of increases in radioactive substances in the environment, if any, in the future. The ARMNet will thus expand NEA's radioactivity monitoring scope and capability. The monitoring stations will be placed at various locations across Singapore, including coastal areas. The ARMNet is expected to be operational by 2019.

Radiation Monitoring and Radiochemistry

As part of capability development in radiochemistry, RPNSD officers participated in a 4-month and 7-week fellowships with the IAEA and Technical University of

A light gray outline of a world map is centered on the page, showing the continents of North America, South America, Europe, Africa, and Asia. The map is minimalist, with no internal details or shading.

9

multilateral **environmental** agreements

Montreal Protocol on Substances that Deplete the Ozone Layer

Singapore has been a party to the Montreal Protocol on Substances that Deplete the Ozone Layer since 5 January 1989. Since then, Singapore has acceded to 4 amendments made under the Montreal Protocol: the London Amendment on 2 March 1993, the Copenhagen Amendment and the Montreal Amendment on 22 September 2000, and the Beijing Amendment on 10 January 2007.

In line with our obligations as a party to the Montreal Protocol, Singapore has put in place various control measures to manage and reduce the consumption of Ozone Depleting Substances (ODS). Some of these ODS, namely chlorofluorocarbons (CFCs), halons, carbon tetrachloride and methyl chloroform, have already been phased out in Singapore. In 2015, the use of methyl bromide for non-quarantine and pre-shipment (non-QPS) applications has also been phased out.

For Hydrochlorofluorocarbons (HCFCs), a quota allocation framework was introduced in 2013 to enable Singapore to gradually phase out the consumption of HCFCs in Singapore by 2030 under the Montreal Protocol. The framework has enabled Singapore to meet its obligations to the Montreal Protocol for the freeze in HCFC consumption in 2013 and the 10% HCFC consumption reduction in 2015. To prepare Singapore for the HCFC phase out schedule, industries that are currently using HCFCs have been strongly encouraged to replace them with non-ozone depleting substitutes wherever practicable.

The control measures for ODS in Singapore are summarised in **Table 9.1**.

The import and export of ODS are regulated under the Environmental Protection and Management Act (EPMA) and the Environmental Protection and Management (Ozone Depleting Substances) Regulations 2000. Under the Act and its Regulations, a licence is required for the import and/or export of ODS listed in the Schedule of the Act (**Appendix 18**).

During the year, PCD issued 33 Hazardous Substances Licences for the import and export of ODS, and electronically processed 1,039 inward and outward declarations for the import and export of ODS through the TradeNet system.

Basel Convention on the Control of

Transboundary Movements of Hazardous Wastes and Their Disposal

Singapore acceded to the Basel Convention on 2 January 1996. The Hazardous Waste (Control of Export, Import and Transit) Act and its Regulations were enacted and came into operation on 16 March 1998. The Act and its Regulations enable Singapore to fulfil its obligations under the Basel Convention. Under the Act and its Regulations, any person wishing to export, import or transit any hazardous waste scheduled under the Basel Convention is required to apply for a permit from PCD.

In addition, due to the growing global awareness on the e-waste problem, many countries have tightened controls on the transboundary movements of e-waste to prevent the indiscriminate export of hazardous e-waste. With effect from 24 March 2008, NEA has implemented a set of requirements to ensure only legitimate movements of e-waste and used electronic equipment between Singapore and other countries. For hazardous e-waste, in addition to the requirements, importers and exporters are also required to meet the requirements stipulated under the Basel Convention and the Hazardous Waste (Control of Export, Import and Transit) Act. Approval to import hazardous e-waste would only be granted on a case-by-case basis, subject to compliance with stringent requirements.

During the year, PCD processed and issued 34 import, 59 export and 51 transit permits under the Basel Convention.

Stockholm Convention on Persistent Organic Pollutants

The Stockholm Convention on Persistent Organic Pollutants (POPs) seeks to reduce and ultimately eliminate the release of POPs into the environment. POPs are chemicals that are able to withstand degradation or destruction when released into the environment. Under the convention, 26 POPs are controlled, viz. Aldrin, Alpha Hexachlorocyclohexane, Beta Hexachlorocyclohexane, Chlordane, Chlordecone, Dieldrin, Endrin, Heptachlor, Hexabromobiphenyl, Hexa- and hepta-bromodiphenyl ether, Hexachlorobenzene, Lindane, Mirex, Pentachlorobenzene, Polychlorinated biphenyls (PCBs), Tetra- and penta-bromodiphenyl ether, Toxaphene, DDT, Perfluorooctane sulfonic acid and its salts, Endosulfan, Hexabromocyclododecane, Hexachlorobutadiene, Pentachlorophenol and its salts and esters, Polychlorinated naphthalenes and Dioxins

Table 9.1
Summary of Measures to Phase Out Ozone-Depleting Substances

Date	Measure
5 October 1989	Quota Allocation System implemented for Chlorofluorocarbons (CFCs).
5 February 1991	Prohibit the import and manufacture of non-pharmaceutical aerosol products and polystyrene sheets/products containing controlled CFCs.
1 January 1992	(a) Prohibit the use of Halon 1301 for new fire-protection systems. (b) Prohibit the import of Halon 2402.
1 January 1993	Prohibit the import of new air-conditioning and refrigeration equipment using CFC 11 and CFC 12.
1 January 1994	Prohibit the import of Halon 1211 and Halon 1301.
15 April 1994	Prohibit the import of fire-extinguishers filled with Halon 1211.
1 January 1995	All new cars must be equipped with non-CFC air-conditioning systems.
1 April 1995	Prohibit the import of Hydrobromofluorocarbons (HBFCs).
1 January 1996	Prohibit the import of CFCs, carbon tetrachloride and 1,1,1-trichloroethane (methyl chloroform).
1 January 2002	Freeze the consumption of Methyl Bromide (MeBr) for non-quarantine and pre-shipment (non-QPS) applications*.
1 January 2013	(a) Freeze the consumption of HCFCs (Freeze quantity: Annual average consumption in 2009 and 2010). (b) Implement quota allocation framework for gradual phase-out of HCFCs by 1 Jan 2030.
1 January 2015	Phase-out of Methyl Bromide for non-quarantine and pre-shipment (non-QPS) applications

*Note: Quarantine applications – Include treatments to prevent the introduction, establishment, and/or spread of quarantine pests, or to ensure their official control.

Pre-shipment applications – These include non-quarantine methyl bromide applications within 21 days prior to export that are required to meet the official requirements of the importing or exporting countries.

and Furans. Due to their persistence in the environment, POPs can travel long distances and have been found in places far away from the source, such as the Arctic. POPs have been found to bioaccumulate in fatty tissues and biomagnify through the food chain, which could pose a risk to human health and the environment. Under the Stockholm Convention, Parties are required to reduce and/or eliminate the level of POPs in the environment.

Singapore deposited the instruments of ratification and accession with the Secretary-General of the United Nations in New York on 24 May 2005. The Convention entered into force for Singapore on 22 August 2005 (i.e. the 90th day after the date of deposit of the instruments). As part of our obligations to the Stockholm Convention, Singapore has implemented measures to control, reduce and eliminate the use of POPs. The import, export, transport, sale, storage and use of POPs are regulated under the Environmental Protection and Management Act (EPMA) and its Regulations. Furthermore, in keeping with internationally accepted practices to control the emissions of dioxins and furans, Singapore has introduced air emission standards under the Environmental Protection and Management (Air Impurities) Regulations to limit dioxins and furans releases.

In addition, under the obligations of the Stockholm Convention, Parties have to develop a National Implementation Plan (NIP) and transmit their NIP to the Conference of Parties within two years of the date on which the Convention comes into force for the Party. To fulfil this obligation under the Stockholm Convention, NEA had in August 2006 formed a multi-stakeholder working group comprising government organisations, industry representatives, academia and NGOs, which developed a National Implementation Plan (NIP) that identified a set of action plans for Singapore. The NIP was submitted to the Stockholm Convention Secretariat on 22 August 2007 and will be revised periodically to present Singapore's current status with respect to POPs management and control measures, development and implementation of POPs monitoring, and activities related to research and development, awareness-raising and information dissemination.

Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade

The Rotterdam Convention on Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade entered into force on 24 February 2004 and it seeks to regulate the international trade of 47 chemicals using the Prior

Informed Consent (PIC) procedure. Out of these 47 chemicals, 33 are pesticides (including 3 severely hazardous pesticide formulations) and 14 are industrial chemicals.

On 24 May 2005, Singapore deposited its instruments of ratification and accession with the Secretary-General of the United Nations in New York. Like the Stockholm Convention, the Rotterdam Convention entered into force for Singapore on 22 August 2005. Chemicals listed under the Rotterdam Convention are regulated in Singapore under the Environmental Protection and Management Act and its Regulations.

As the Designated National Authority administering the Rotterdam Convention, PCD ensures that the import and/or export of any of the 47 controlled pesticides and chemicals abides by the PIC procedure.

During the year, PCD approved 21 import applications and 10 export applications of chemicals controlled under the Rotterdam Convention.

ASEAN Agreement on Transboundary Haze Pollution

The ASEAN Agreement on Transboundary Haze Pollution entered into force on 25 November 2003 and was officially ratified by all ten ASEAN nations as of October 2014. The objective of the Agreement is to prevent and monitor transboundary haze pollution as a result of land and/or forest fires, which should be mitigated through concerted national efforts and intensified regional and international co-operation.

Transboundary Haze Pollution Act 2014 (THPA)

To tackle the perennial transboundary haze, the Transboundary Haze Pollution Act 2014 (THPA) was enacted to provide NEA with powers to impose penalties on errant companies that have caused or contributed to transboundary haze in Singapore, regardless of whether or not they are based or incorporated in Singapore.

Six companies namely PT Bumi Mekar Hijau (PT BMH), PT Sebangun Bumi Andalas Wood Industries (PT SBAWI), PT Rimba Hutani Mas (PT RHM), PT Bumi Andalas Permai (PT BAP), PT Wachyuni Mandira (PT WYM) and PT Bumi Sriwijaya Sentosa (PT BSS) were identified to have fires within their concession lands in Indonesia that could have contributed to the transboundary haze in September and October 2015. NEA sent Preventive Measures Notices under the THPA to these companies and two companies, PT BSS and PT WYM, responded to these notices.

NEA has also continued to engage Asia Pulp & Paper Company Ltd (APP) pursuant to Section 10 of the THPA to obtain information on its subsidiaries, its related companies and suppliers in Singapore and Indonesia, as well as measures taken by its suppliers in Indonesia to put out fires in their concessions. NEA has received some information and is reviewing the information provided.

In March 2016, a director of one of the Indonesian companies was served with a THPA Notice for him to attend an interview with the NEA. However, he failed to turn up. NEA has obtained a court warrant to secure his attendance when he next enters Singapore, which is in accordance with the legal provisions of the THPA. This means that if the director enters Singapore, he can be detained by NEA officers for the purpose of investigations.

Investigations are on-going.

Convention on Nuclear Safety

Singapore has been a Party to the Convention on Nuclear Safety since 15 December 1997. The Convention aims to legally commit participating States operating nuclear power plants to maintain a high level of safety by setting international benchmarks to which States would subscribe. It is based on Parties' common interest to achieve higher levels of safety which will be developed and promoted through regular meetings. In 2016, NEA submitted Singapore's national report on the implementation of our obligations ahead of the Convention Review Meeting to be held at the IAEA in 2017.

Convention on Early Notification of a Nuclear Accident

Singapore has been a Party to the Convention on Early Notification of a Nuclear Accident since 15 December 1997. The Convention aims to strengthen international co-operation in order to provide relevant information about nuclear accidents as early as necessary so that transboundary radiological consequences can be minimized. NEA serves as the national focal point under this convention and had participated in the Eighth Meeting of the Representatives of Competent Authorities from 6-10 June 2016 at the IAEA in Vienna.

Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency

Singapore has been a Party to the Convention on Assistance in the Case of a Nuclear Accident or

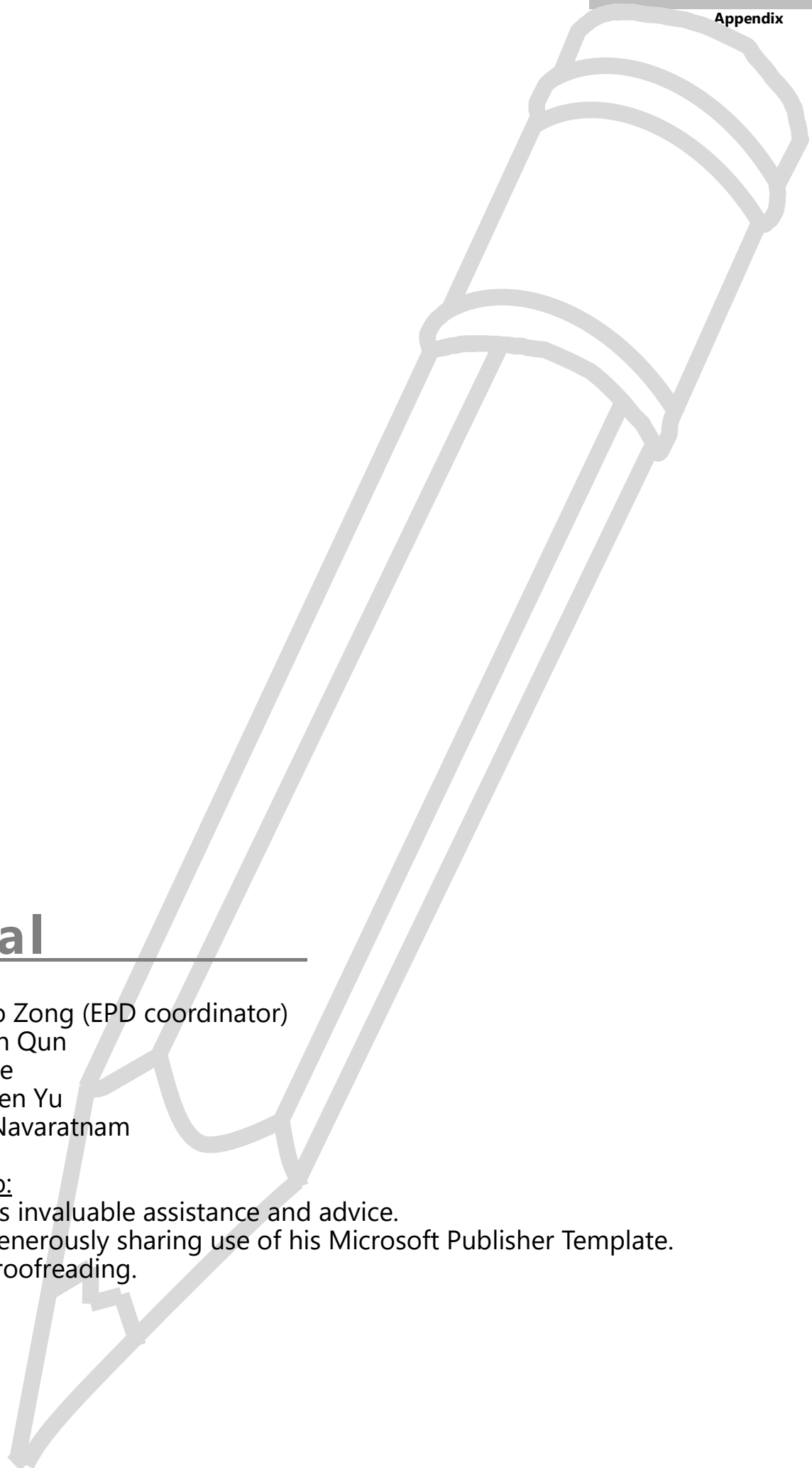
Radiological Emergency since 15 December 1997. This Convention requires that States Parties cooperate between themselves and with the IAEA to facilitate prompt assistance in the event of a nuclear accident or radiological emergency to minimize its consequences and to protect life, property and the environment from the effects of radioactive releases. NEA serves as the national focal point under this Convention.

Convention on Physical Protection of Nuclear Material

Singapore has been a Party to the Convention on the Physical Protection of Nuclear Material since 22 September 2014. The Convention establishes measures related to the prevention, detection and punishment of offences related to nuclear material in international transport. The implementation by the States Parties of the provisions of the Amendment is vitally important for nuclear security and has a major impact in reducing the vulnerability of State Parties to nuclear terrorism. It also seeks to provide cooperation to locate and recover stolen or smuggled nuclear material, mitigate any radiological consequences of sabotage, and prevent and combat related offences. NEA serves as the national focal point under the Convention and has established a licensing regime for the international transport of nuclear materials through Singapore.

Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology For Asia and Pacific

Singapore is a member of the Regional Cooperative Agreement since 1972. It is an intergovernmental agreement for the East Asia and Pacific region under the auspices of the IAEA. The State Parties undertake, in cooperation with each other and with the IAEA, to promote and coordinate cooperative research, development and training projects in nuclear science and technology through their appropriate national institutions. Such projects have contributed significantly in a number of priority areas vital to regional socio-economic development, such as agriculture, healthcare, industry and environmental protection. NEA serves as the national focal point under the agreement.



editorial

CBPD Chan Ho Zong (EPD coordinator)
EECD Tan Guan Qun
PCD Wei Jiahe
RPNSD Ong Chen Yu
WRMD Shaun Navaratnam

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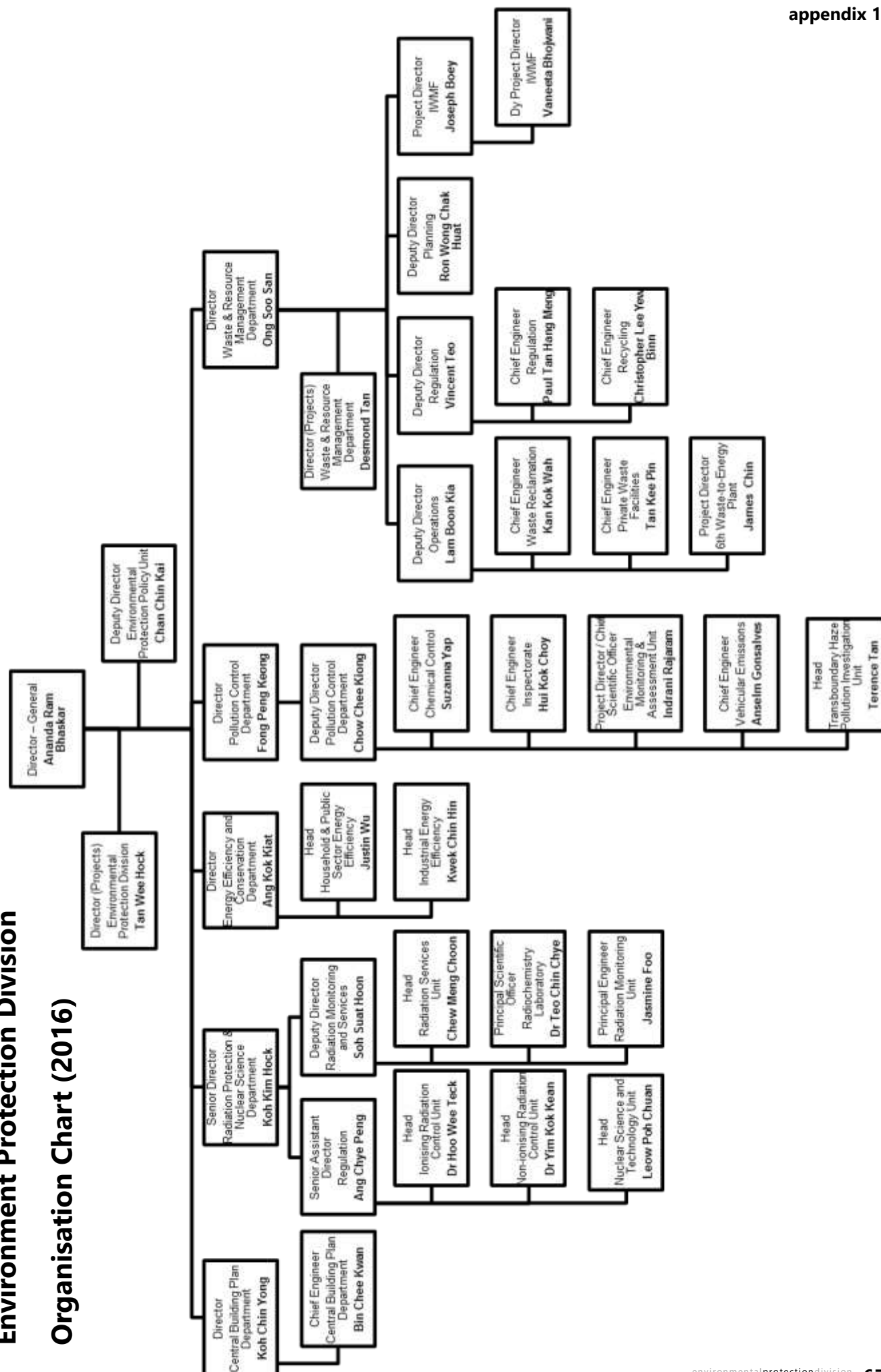
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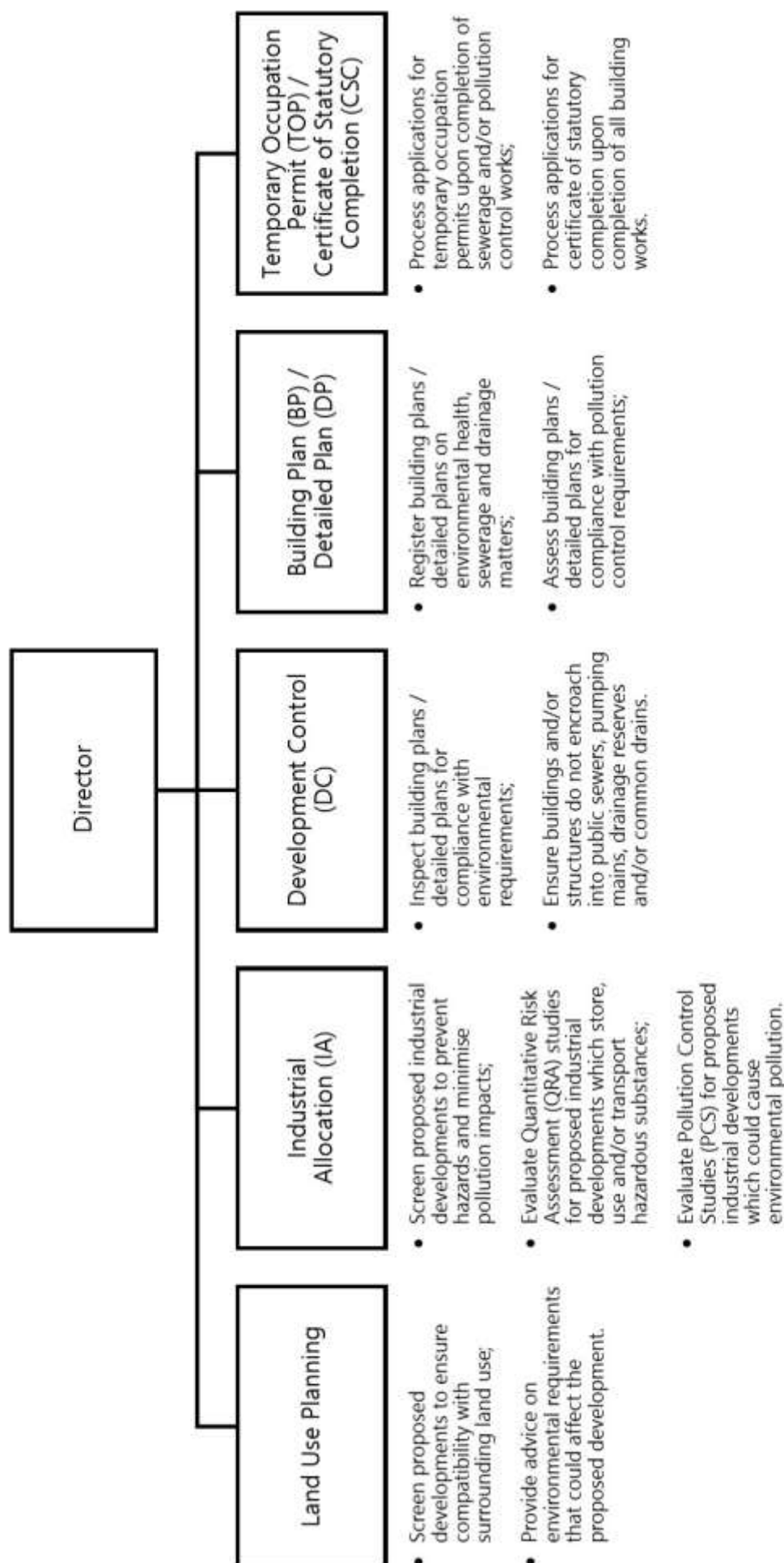
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appendices

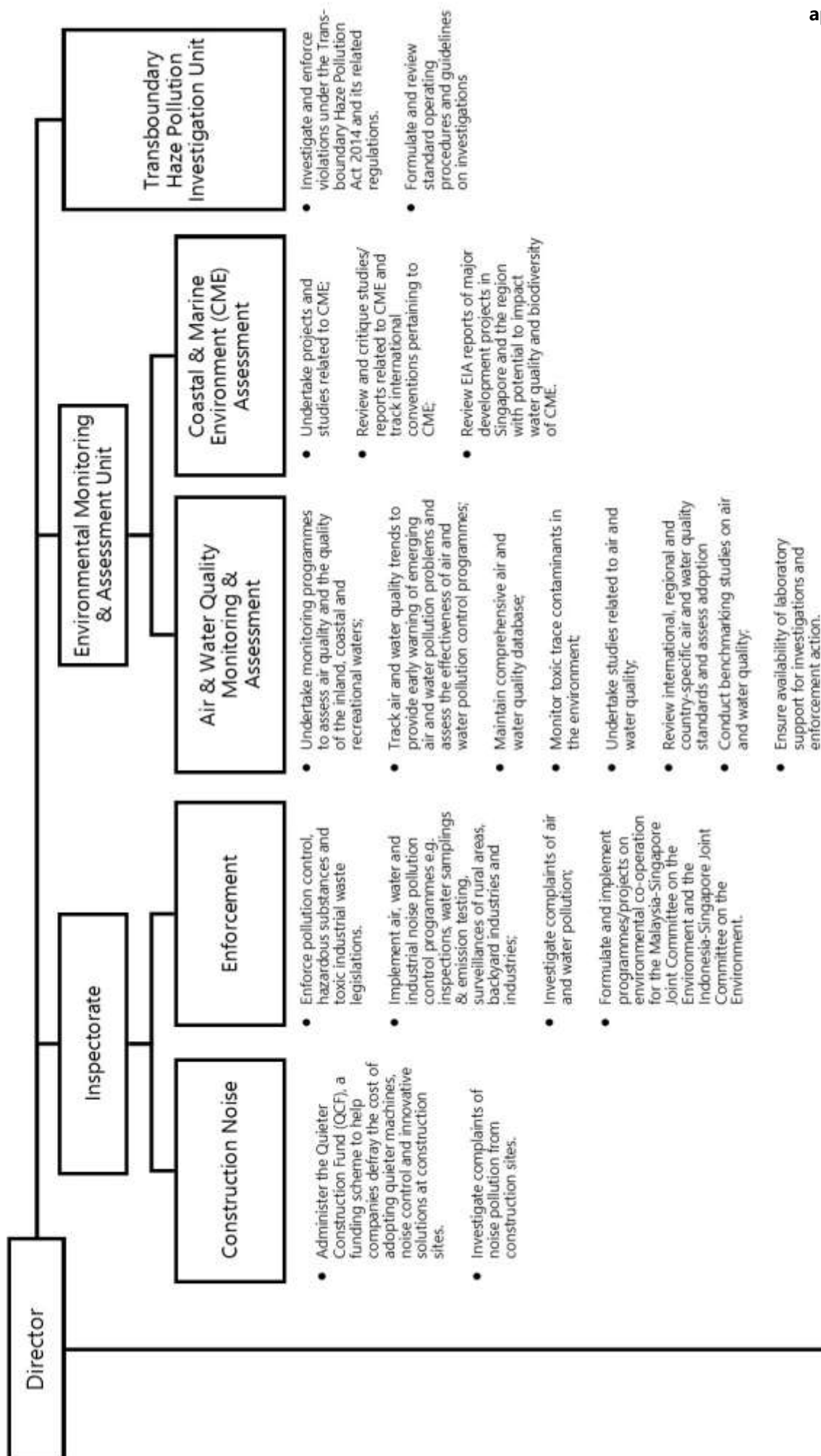
Environment Protection Division Organisation Chart (2016)

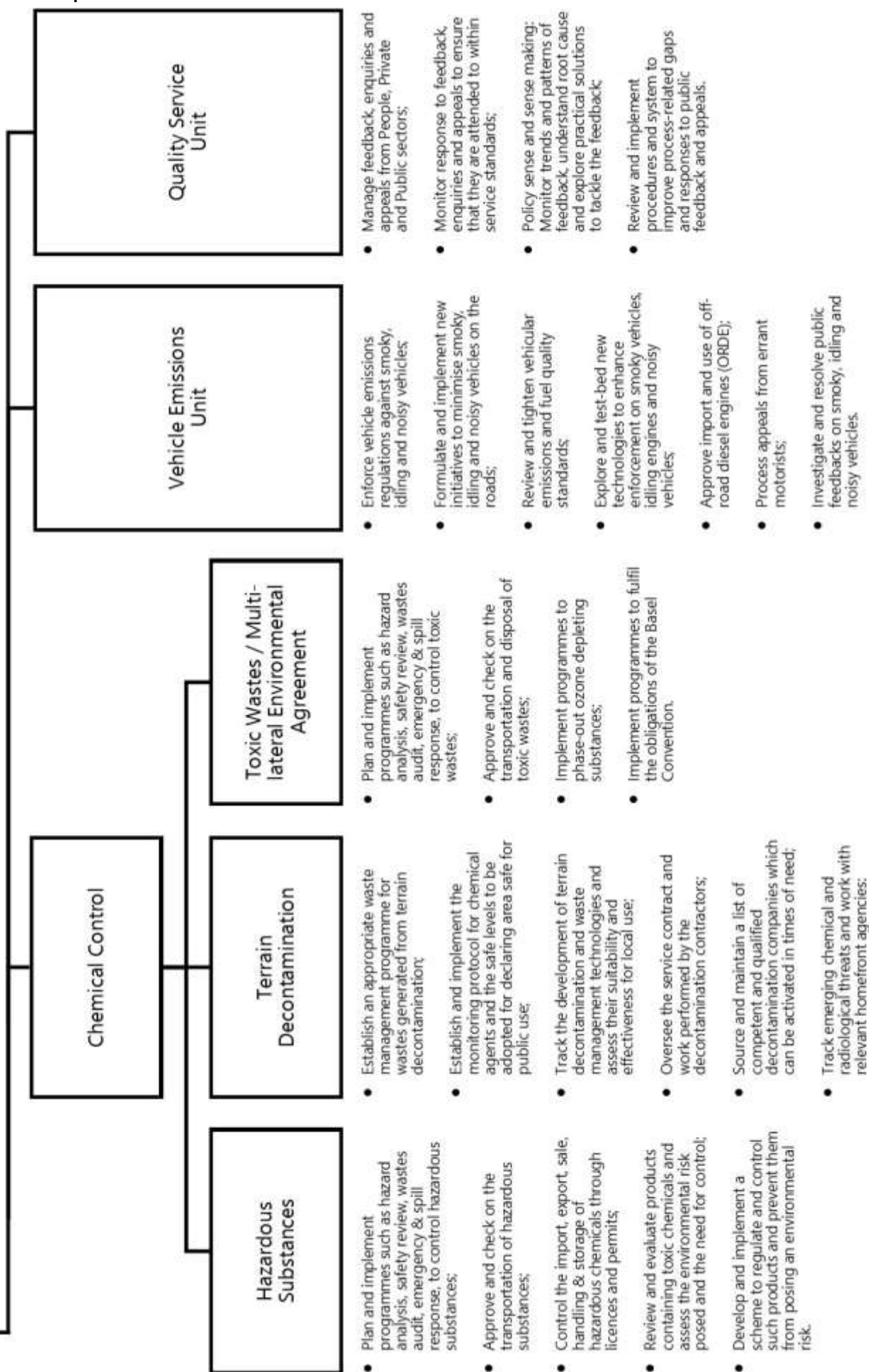


Central Building Plan Department Organisation Chart (2016)

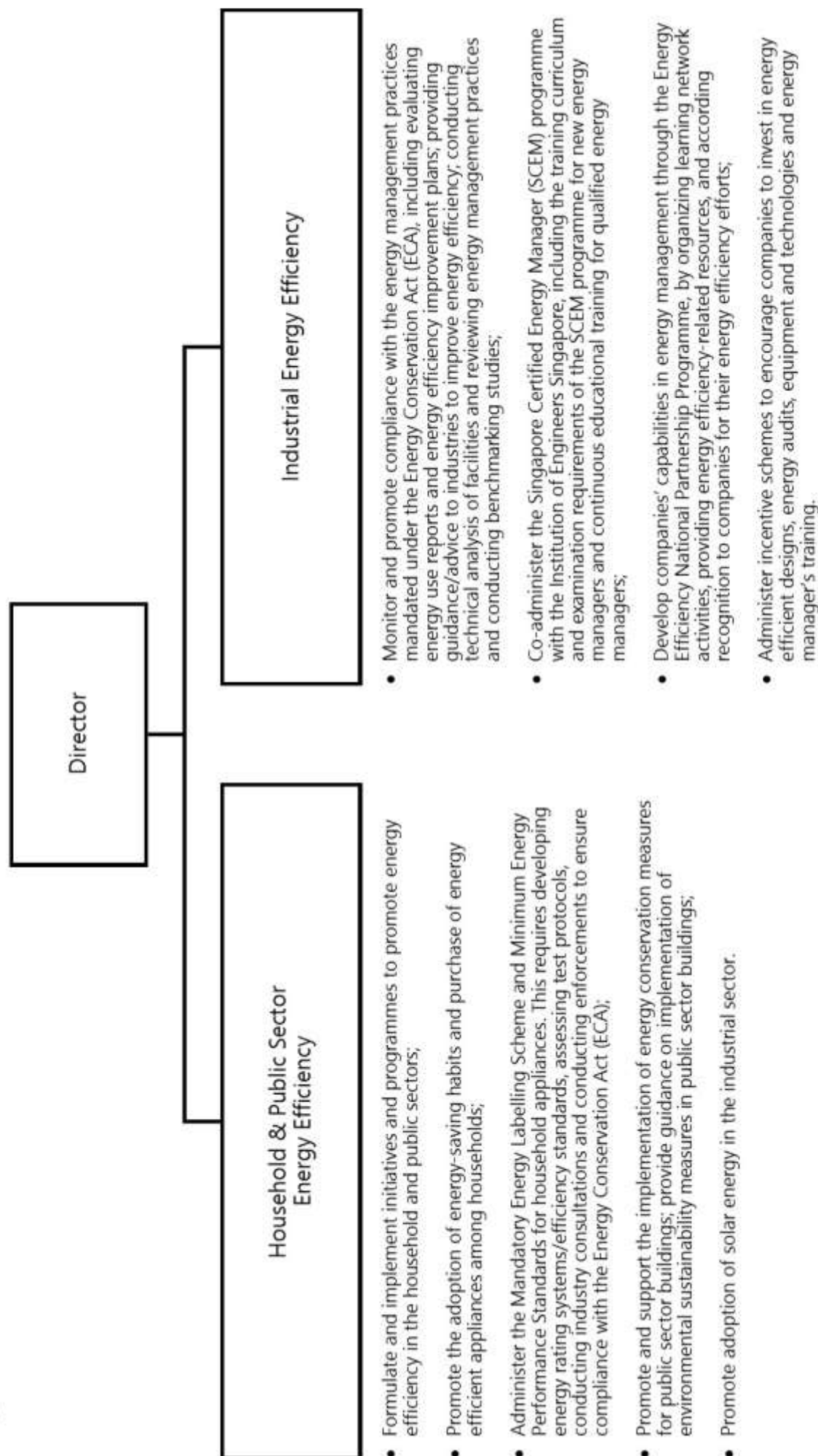


Pollution Control Department Organisation Chart (2016)

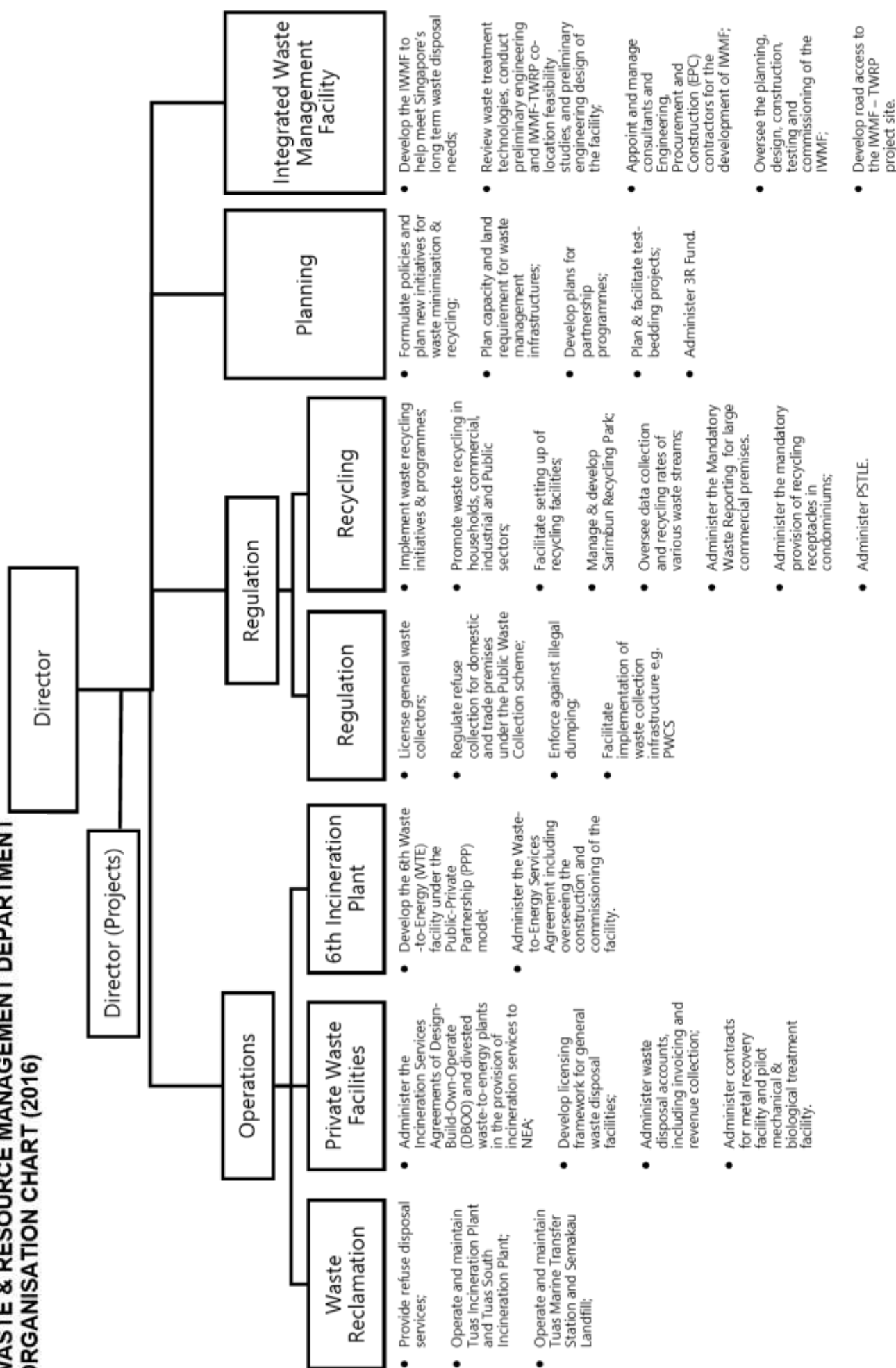




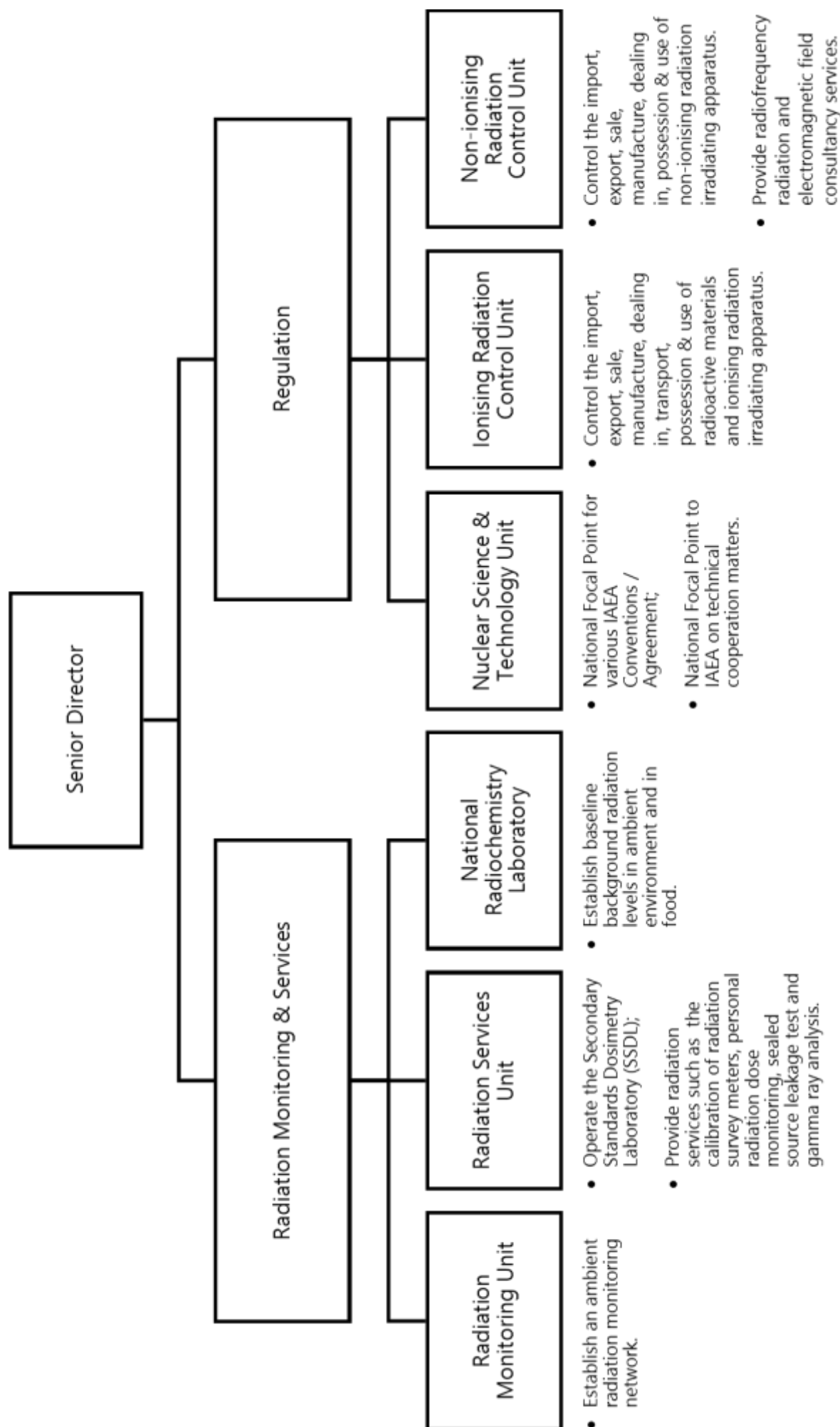
Energy Efficiency and Conservation Department Organisation Chart (2016)



WASTE & RESOURCE MANAGEMENT DEPARTMENT ORGANISATION CHART (2016)



Radiation Protection & Nuclear Science Department Organisation Chart (2016)



Summary of Prosecutions in 2016

appendix 7

S/N	Department	Total no. of Prosecutions	Company	Offence Description	No. of Violations
1	PCD	150 (Only companies with 3 offences or more are listed)	ACP Construction (Pte) Ltd	EPM(Control of Noise at Construction Sites)	3
			Authentic Builder Pte Ltd		9
			BHCC Construction Pte Ltd		7
			Brickford Construction Pte Ltd	Reg 3(1) - Exceeded permissible noise limits	3
			China Construction (S P) Dev. Co Pte Ltd		5
			Chiu Teng Construction Co Pte Ltd		3
			Daiya Engineering & Construction Pte Ltd		3
			Evan Lim & Co Pte Ltd		3
			Gennal Industries Pte Ltd		4
			GLG Engineering Pte Ltd		4
			Gretearth Construction Pte Ltd		8
			Hexacon Construction Pte Ltd		5
			Kajima Overseas Asia Pte Ltd		3
			Ken-Pal (S) Pte Ltd		3
			Magnificent Seven Corporation Pte Ltd		4
			McConnell Dowell South East Asia Pte Ltd		3
			Millennium International Builders Pte Ltd		3
			Obayashi Corporation		3
			Paul Y Construction & Engineering Pte Ltd		5
			Penta Ocean Construction Co Ltd		4
			Precise Development Pte Ltd		5
			Rich Construction Company Pte Ltd		9
			Samsung C & T Corporation		8
			SEF Construction Pte Ltd		11
			Seng Da Construction Pte Ltd		3
			Soil-Build (Pte) Ltd		3
			Straits Construction Singapore Pte Ltd		5
			Tiong Seng Contractors Pte Ltd		4
			Trust-Build Engineering & Construction Pte Ltd		5
			Woh Hup (Pte) Ltd		6
			Yong Xing Construction Pte Ltd		3
			Zheng Keng Engineering & Construction Pte Ltd		3

Summary of Prosecutions in 2016

S/N	Department	Total no. of Prosecutions	Company	Offence Description	No. of Violations
2	PCD	92 (Only companies with 3 offences or more are listed)	China Construction (S P) Dev. Co Pte Daewoo Engineering & Construction Co Ltd Daiya Engineering & Construction Pte Ltd East Asia Engineering & Construction Pte Ltd Gennal Industries Pte Ltd GLG Engineering Pte Ltd Hi Power Engineering Services Pte Ltd Hyundai Engineering & Construction Co Ltd Keong Hong Construction Pte Ltd Lian Beng Construction (1988) Pte Ltd Newcon Builders Pte Ltd Novelty Builders Pte Ltd Samsung C&T Corporation SB Procurement Pte Ltd Shimizu Corporation Singapore Piling & Civil Engineering Pte Ltd Sunray Woodcraft Construction Pte Ltd Tiong Seng Contractors Pte Ltd Vigcon Construction Pte Ltd Welltech Construction Pte Ltd Woh Hup (Pte) Ltd Yong Xing Construction Pte Ltd	EPM(Control of Noise at Construction Sites) Reg 4A(1) - Worked during prohibited period	7 4 6 4 3 6 3 7 3 4 3 3 4 3 3 4 4 3 3 8 3
3	PCD	11 (Only companies with 3 offences or more are listed)	Authentic Builders Pte Ltd Tiong Seng Contractors Pte Ltd Samsung C&T Corporation	Environmental Protection and Management Act, Chapter 94A Section 28(1) – Failed to comply requirement stipulated in Notice; i.e. restricted working hours.	4 4 3

SUBSTANCE	TRADE, INDUSTRY, PROCESS, FUEL BURNING EQUIPMENT OR INDUSTRIAL PLANT	EMISSION LIMITS
(a) Ammonia and ammonium compounds	Any trade, industry or process	30 mg/Nm ³ expressed as ammonia
(b) Antimony and its compounds	Any trade, industry or process	5 mg/Nm ³ expressed as antimony
(c) Arsenic and its compounds	Any trade, industry or process	1 mg/Nm ³ expressed as arsenic
(d) Benzene	Any trade, industry or process	5 mg/Nm ³
(e) Cadmium and its compounds	Any trade, industry or process	0.05 mg/Nm ³ expressed as cadmium
(f) Carbon monoxide	Any trade, industry, process or fuel burning equipment	250 mg/Nm ³
(g) Chlorine	Any trade, industry or process	32 mg/Nm ³
(h) Copper and its compounds	Any trade, industry or process	5 mg/Nm ³ expressed as copper
(i) Dioxins and furans	Any waste incinerator	1.0 ng TEQ/Nm ³ for waste incinerators commissioned before 1st Jan 2001 0.1 ng TEQ/Nm ³ for waste incinerators commissioned on or after 1st Jan 2001
(j) Ethylene oxide	Any trade, industry or process	5 mg/Nm ³
(k) Fluorine, hydrofluoric acid or inorganic fluorine compounds	Any trade, industry or process	10 mg/Nm ³ expressed as hydrofluoric acid
(l) Formaldehyde	Any trade, industry or process	20 mg/Nm ³
(m) Hydrogen chloride	Any trade, industry or process	200 mg/Nm ³
(n) Hydrogen sulphide	Any trade, industry or process	7.6 mg/Nm ³
(o) Lead and its compounds	Any trade, industry or process	0.5 mg/Nm ³ expressed as lead
(p) Mercury and its compounds	Any trade, industry or process	0.05 mg/Nm ³ expressed as mercury
(q) Oxides of nitrogen	Any trade, industry, process or fuel burning equipment	400 mg/Nm ³ expressed as nitrogen dioxide
(r) Particulate substances including smoke, soot, dust, ash, fly-ash, cinders, cement, lime, alumina, grit and other solid particles of any kind	Any trade, industry, process, fuel burning equipment or industrial plant (except for any cold blast foundry cupolas)	i. 50 mg/Nm ³ ; or i. where there is more than one flue, duct or chimney in any scheduled premises, the total mass of the particulate emissions from all of such flue, duct or chimney divided by the total volume of such emissions shall not exceed 50 mg/Nm ³ and the particulate emissions from each of such flue, duct or chimney shall not exceed 100 mg/Nm ³ at any point in time.

Standards of Concentration of Air Impurities

appendix 8

SUBSTANCE	TRADE, INDUSTRY, PROCESS, FUEL BURNING EQUIPMENT OR INDUSTRIAL PLANT	EMISSION LIMITS
(s) Smoke	All stationary fuel-burning sources	Standard Ringelmann No 1 or equivalent opacity (Not to exceed more than 5 mins in any period of one hour, 3 times a day)
(t) Styrene monomer	Any trade, industry or process	100 mg/Nm ³
(u) Sulphur dioxide (non-combustion sources)	Any trade, industry or process	500 mg/Nm ³
(v) Sulphur dioxide (combustion sources)	Any trade, industry or process	1,700 mg/Nm ³ ; or where there is more than one flue, duct or chimney in any scheduled premises, the total mass of the sulphur dioxide emissions from all of such flue, duct or chimney divided by the total volume of such emissions shall not exceed 1,700 mg/Nm ³ on a daily basis.
(v) Sulphur dioxide (combustion sources)	Any trade, industry or process	i. 1,700 mg/Nm ³ ;or ii. Where there is more than one flue, duct or chimney in any scheduled premises, the total mass of the sulphur dioxide emissions from all of such flue, duct or chimney divided by the total volume of such emissions shall not exceed 1,700 mg/Nm ³ on a daily basis.
(w) Sulphur trioxide and other acid gases	The manufacture of sulphuric acid	500 mg/Nm ³ expressed as sulphur trioxide. Effluent gases shall be free from persistent mist.
(x) Sulphur trioxide or sulphuric acid mist	Any trade, industry or process, other than any combustion process and any plant involving the manufacture of sulphuric acid	100 mg/Nm ³ expressed as sulphur trioxide
(y) Vinyl chloride monomer	Any trade, industry or process	20 mg/Nm ³

Note: The concentration of any specified substance (1st column) emitted from any specified operation in any trade, industry, process, fuel burning equipment or industrial plant (2nd column) shall not at any point before mixture with air, smoke or other gases, exceed the specified limits (3rd column).

"dioxins and furans" means polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF), being tricyclic and aromatic compounds formed by 2 benzene rings which are connected by 2 oxygen atoms in PCDD and by one oxygen atom in PCDF and the hydrogen atoms of which may be replaced by up to 8 chlorine atoms;

"mg" means milligram;

"ng" means nanogram;

"Nm³" means normal cubic metre, being that amount of gas which when dry, occupies a cubic metre at a temperature of 0 degree Centigrade and at an absolute pressure of 760 millimetres of mercury;

"TEF" means Toxic Equivalency Factor;

"TEQ"

means Toxic Equivalency Factor;

means Toxic Equivalent, being the sum total of the concentrations of each of the dioxin and furan compounds specified in the first column of the table below multiplied by their corresponding TEF specified in the second column thereof:

Dioxin/Furan	TEF
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	1
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	0.1
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	0.1
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	0.1
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	0.01
Octachlorodibenzo-p-dioxin	0.0001
2,3,7,8-Tetrachlorodibenzofuran	0.1
1,2,3,7,8-Pentachlorodibenzofuran	0.05
2,3,4,7,8-Pentachlorodibenzofuran	0.5
1,2,3,4,7,8-Hexachlorodibenzofuran	0.1
1,2,3,6,7,8-Hexachlorodibenzofuran	0.1
1,2,3,7,8,9-Hexachlorodibenzofuran	0.1
2,3,4,6,7,8-Hexachlorodibenzofuran	0.1
1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.01
1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.01
Octachlorodibenzofuran	0.0001

**List of Premises Classified as Scheduled Premises
under the Environmental Protection & Management Act**

Scheduled Premises are any premises:-

- (a) being used for:
 - (i) cement works, being works for the manufacture or packing of portland cement, similar cement or pozzolanic materials;
 - (ii) concrete works, being works for the manufacture of concrete and of each batch capacity greater than 0.5 cubic metre;
 - (iii) asphalt works, being works for the manufacture of asphalt or tarmacadam;
 - (iv) ceramic works, being works in which any products such as bricks, tiles, pipes, pottery goods, refractories or glass are manufactured in furnaces or kilns fired by any fuel;
 - (v) chemical works, being works in which acids, alkali, chemical fertilizer, soap, detergent, sodium silicates, lime or other calcium compounds, chlorine, chemicals or chemical products are manufactured;
 - (vi) coke or charcoal works, being works in which coke and charcoal is produced and quenched, cut, crushed or graded;
 - (vii) ferrous and non-ferrous metal works, being works in which metal melting process for casting and/or metal coating are carried out;
 - (viii) gas works, being works in which coal, coke, oil or other mixtures or derivatives are handled or prepared for carbonisation or gasification and in which such materials are subsequently carbonised or gasified;
 - (ix) crushing, grinding and milling works, being works in which rock, ores, minerals, chemicals or natural grain products are processed by crushing, grinding, milling or separating into different sizes by sieving, air elutriation or in any other manner;
 - (x) petroleum works, being works in which crude or shale oil or crude petroleum or other mineral oil is refined or reconditioned;
 - (xi) scrap metal recovery works, being works in which scrap metals are treated in any type of furnace for recovery of metal irrespective of whether this is the primary object of any specific premises or not;
 - (xii) primary metallurgical works, being works in which ores are smelted or converted to metal of any kind;
 - (xiii) pulping works, being works in which wood or cellulose material is made into pulp;
 - (xiv) abrasive blasting works, being works in which equipment or structures are cleaned by abrasive blasting;
- (b) on which there is erected any boiler of steam generating capacity of 2300 kilogrammes or more per hour, Incinerator or furnace burning 500 kilogrammes or more of solid combustible material per hour or 220 kilogrammes or more of liquid material per hour;
- (c) being used or intended to be used for storing:-
 - (i) more than 100 tonnes of one or more of the following substances:-
chemicals, chemical products, hydrocarbons or hydrocarbon products which are toxic or which produce toxic gases on burning or on contact with water or air; or
 - (ii) more than 1000 tonnes of one or more of the following substances:-
chemicals, chemical products, hydrocarbons or hydrocarbon products with a flash point lower than 55° C.

**Allowable Limits for Trade Effluent Discharged
into a Public Sewer / Watercourse / Controlled Watercourse**

appendix 10

Items Of Analysis		Public Sewer	Watercourse	Controlled Watercourse
Units in milligram per litre or otherwise stated				
1	Temperature of discharge	45°C	45°C	45°C
2	Colour	-	7 Lovibond Units	7 Lovibond Units
3	pH Value	6 - 9	6 - 9	6 - 9
4	BOD (5 days at 20°C)	400	50	20
5	COD	600	100	60
6	Total Suspended Solids	400	50	30
7	Total Dissolved Solids	3000	-	1000
8	Chloride (as chloride ion)	1000	-	250
9	Sulphate (as SO ₄)	1000	-	200
10	Sulphide (as sulphur)	1	0.2	0.2
11	Cyanide (as CN)	2	0.1	0.1
12	Detergents (linear alkylate sulphonate as methylene blue active substances)	30	15	5
13	Grease and Oil (Total)	-	10	1
	Grease and Oil (Hydrocarbon)	60	10	-
	Grease and Oil (Non-hydrocarbon)	100	-	-
14	Arsenic	5	0.1	0.01
15	Barium	10	2	1
16	Tin	10	-	5
17	Iron (as Fe)	50	10	1
18	Beryllium	5	-	0.5
19	Boron	5	5	0.5
20	Manganese	10	5	0.5
21	Phenolic Compounds (expressed as phenol)	0.5	0.2	Nil

**Allowable Limits for Trade Effluent Discharged
into a Public Sewer / Watercourse / Controlled Watercourse**

Items Of Analysis		Public Sewer	Watercourse	Controlled Watercourse
Units in milligram per litre or otherwise stated				
22	*Cadmium	1	0.1	0.003
23	*Chromium (trivalent and hexavalent)	5	1	0.05
24	*Copper	5	0.1	0.1
25	*Lead	5	0.1	0.1
26	*Mercury	0.5	0.05	0.001
27	*Nickel	10	1	0.1
28	*Selenium	10	0.5	0.01
29	*Silver	5	0.1	0.1
30	*Zinc	10	1	0.5
31	*Metals in Total	10	1	0.5
32	Chlorine (Free)	-	1	1
33	Phosphate (as PO ₄)	-	5	2
34	Calcium (as Ca)	-	-	150
35	Magnesium (as Mg)	-	-	150
36	Nitrate (NO ₃)	-	-	20

Note: * The concentration of Toxic Metal shall not exceed the limits as shown, individually or in total.

'Controlled Watercourse' means a watercourse from which potable water supplied by PUB under the Public Utilities Act is obtained but does not include a watercourse from which water is pumped into a main of the PUB.

The trade effluent discharged must not include:-

- (1) Calcium carbide.
- (2) Petroleum spirit or other inflammable solvents.
- (3) Materials that may give rise to fire or explosion hazards.
- (4) Materials that may be a hazard to human life, a public nuisance, injurious to health or otherwise objectionable.
- (5) Refuse, garbage, sawdust, timber, or any solid matter.
- (6) Pesticides, fungicides, insecticides, herbicide, rodenticide or fumigants.
- (7) Radioactive material.

The trade effluent discharged into a public sewer must not include rainwater, storm water, ground water or other form of street drainage, subsurface drainage, roof drainage or yard drainage.

The trade effluent shall be analysed in accordance with the latest edition of 'Standard Methods for the Examination of Water and Wastewater' published jointly by the American Water Works Association and the Water Pollution Control Federation of the United States.

The fees to be levied for discharge of biodegradable trade effluent into the public sewers are as follows:-

Concentration (mg/l)	Fee at \$ per cubic metre or part thereof	
	BOD	TSS
401 - 600	0.21	0.15
601 - 800	0.42	0.30
801 - 1000	0.63	0.45
1001 - 1200	0.84	0.60
1201 - 1400	1.05	0.75
1401 - 1600	1.26	0.90
1601 - 1800	1.47	1.05
1801 - 2000	1.68	1.20
2001 - 2200	1.89	1.35
2201 - 2400	2.10	1.50
2401 - 2600	2.31	1.65
2601 - 2800	2.52	1.80
2801 - 3000	2.73	1.95
3001 - 3200	2.94	2.10
3201 - 3400	3.15	2.25
3401 - 3600	3.36	2.40
3601 - 3800	3.57	2.55
3801 - 4000	3.78	2.70

Note: BOD = Biochemical Oxygen Demand (5 days at 20°C)
TSS = Total Suspended Solids

Trade effluent with BOD and TSS each in excess of 4000 mg/l shall be treated to below this standard at the factory prior to discharge into the public sewers.

Prior approval is required to dispose of organic sludge at designated Water Reclamation Plants/Sludge Treatment Works on the payment of a fee at a rate of \$7.00 per cubic meter or part thereof.

Organic sludge means the organic matter in trade effluent which has a minimum solid content of 3 per cent by weight or a maximum moisture content of 97 per cent by weight.

List of Controlled Hazardous Substances

(Hazardous Substances Listed in the 2nd Schedule of the EPMA)

Substance	Exclusion
1) 1,2-dibromoethane (EDB)	
2) Acetic acid	Substances containing not more than 80%, weight in weight, of acetic acid; Preparations and solutions for photographic use.
3) Acetic anhydride	
4) Acetyl bromide	
5) Alachlor	
6) Allyl isothiocyanate	
7) Alkali metal bifluorides; Ammonium bifluoride; Potassium fluoride; Sodium fluoride; Potassium silicofluoride; Sodium silicofluoride; Silicofluoric acid	Preparations containing not more than 0.3%, weight in weight, of potassium fluoride in radiator protectors; Preparations containing not more than 0.96%, weight in weight, of potassium fluoride in photographic chemicals; Substances containing not more than 3%, weight in weight, of sodium fluoride or sodium silicofluoride as a preservative; Substances containing sodium fluoride intended for the treatment of human ailments.
8) Ammonia	Preparations and solutions of ammonia containing not more than 10%, weight in weight, of ammonia; Refrigeration equipment; Photographic and plan developers; Hair colour dyes; Perm lotions; Smelling bottles.
9) Ammonium chlorate	
10) Anionic surface active agents	Preparations containing less than 5% by weight of anionic surface active agents; Preparations containing anionic surface active agents which are not less than 90% biodegradable under a test carried out in accordance with that part of the OECD method which is referred to as "Confirmatory Test Procedure" in European Communities Council Directive No. 73/405/EEC (C) or other equivalent test methods acceptable to the Director-General.
11) Antimony pentachloride	Polishes
12) Antimony trihydride	
13) Arsenical substances, the following: Arsenic acid Arsenic sulphide Arsenic trichloride Arsine Calcium arsenite Copper arsenate Copper arsenite Lead arsenate Organic compounds of arsenic Oxides of arsenic Potassium arsenite Sodium arsenate Sodium arsenite Sodium thioarsenate	Pyrites ores or sulphuric acid containing arsenical poisons as natural impurities; Animal feeding stuffs containing not more than 0.005%, weight in weight, of 4-hydroxy-3-nitrophenyl-arsonic acid and not containing any other arsenical poison; Animal feeding stuffs containing not more than 0.01%, weight in weight, of arsanilic acid and not containing any other arsenical poison; Animal feeding stuffs containing not more than 0.0375%, weight in weight, of carbarsone and not containing any other arsenical poison.

List of Controlled Hazardous Substances

appendix 12

(Hazardous Substances Listed in the 2nd Schedule of the EPMA)

Substance	Exclusion
14) Asbestos in the form of crocidolite, actinolite, anthophyllite, amosite, tremolite, chrysotile and amphiboles and products containing these forms of asbestos	Asbestos in the form of chrysotile in any vehicle brake or clutch lining installed in any vehicle registered before 1st April 1995.
15) Boric acid; Sodium borate	Boric acid or sodium borate in medicinal preparations, cosmetics, toilet preparations and substances being preparations intended for human consumption; Preparations containing boric acid or sodium borate or a combination of both where water or solvent is not the only other part of the composition.
16) Boron tribromide	
17) Boron trichloride	
18) Boron trifluoride	
19) Bromine; Bromine solutions	
20) Cadmium-containing silver brazing alloy	
21) Captafol	
22) Carbamates	Benomyl; Carbendazim; Chlorpropham; Propham; Thiophanate-methyl; Preparations containing not more than 1%, weight in weight, of propoxur and not containing any other carbamate; Preparations containing not more than 1%, weight in weight, of methomyl and not containing any other carbamate.
23) Carbon monoxide	Gas mixtures containing carbon monoxide weighing less than 1 metric tonne; Gas mixtures containing carbon monoxide as by-products from combustion activities.
24) Carbon tetrafluoride	
25) Chlorinated hydrocarbons, the following: Aldrin; Benzene hexachloride (BHC); Bromocyclen; Camphechlor; Chlorbenside; Chlorbicyclen; Chlordane; Chlordecone; Chlordimeform; Chlorfenethol; Chlorfenoson; Chlorfensulphide; Chlorobenzilate; Chloropropylate; Dicophane (DDT); pp'-DDT; Dicofol;	Paper impregnated with not more than 0.3%, weight in weight, of benzene hexachloride or gamma - BHC provided it is labelled with directions that no food, wrapped or unwrapped, or food utensils are to be placed on the treated paper, and that it is not to be used where food is prepared or served.

List of Controlled Hazardous Substances

(Hazardous Substances Listed in the 2nd Schedule of the EPMA)

Substance	Exclusion
25) Chlorinated hydrocarbons, the following (continued): Dieldrin; Endosulfan; Endrin; Fenazaflor; Fenson; Fluorbenzide; Gamma benzene hexachloride (Gamma - BHC), also known as lindane HCH (mixed isomers); HEOD [1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a- octahydro-1, 4 (exo): 5,8 (endo)-dimethano naphthalene]; HDDN [1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4 (exo):5,8 (endo)-dimethano naphthalene]; Heptachlor; Hexachloroethane; Isobenzan; Isodrin; Kelevan; Methoxychlor [1,1,1-trichloro-2,2-di-(p-methoxyphenyl) ethane]; Mirex; Polychlorinated butadienes; Tetrachlorodiphenylethane [TDE; 1,1-dichloro-2,2-bis (p-chlorophenyl) ethane]; Tetradifon; Tetrasul; Toxaphene; Allied chlorinated hydrocarbon compounds used as pesticides (insecticides, acaricides, etc.).	Paper impregnated with not more than 0.3%, weight in weight, of benzene hexachloride or gamma - BHC provided it is labelled with directions that no food, wrapped or unwrapped, or food utensils are to be placed on the treated paper, and that it is not to be used where food is prepared or served.
26) Chlorine	Chlorine used for chlorination of water in swimming pools.
27) Chlorine trifluoride	
28) Chlorobenzenes, the following: Monochlorobenzene; Meta-dichlorobenzene; Ortho-dichlorobenzene Trichlorobenzene; Tetrachlorobenzene; Pentachlorobenzene; Hexachlorobenzene.	

List of Controlled Hazardous Substances
(Hazardous Substances Listed in the 2nd Schedule of the EPMA)

Substance	Exclusion
29) Chlorophenols, the following: Monochlorophenol; Dichlorophenol; Trichlorophenol; Tetrachlorophenol; Pentachlorophenol and its salts and esters.	Substances containing not more than 1%, weight in weight, of chlorophenols.
30) Chlorophenoxyacids; their salts, esters, amines, which include but are not limited to - 2,4,5-T and its salts and esters.	
31) Chloropicrin	
32) Chlorosilanes, the following: Hexachlorodisilane; Phenyltrichlorosilane; Tetrachlorosilane.	
33) Chlorosulphonic acid	
34) Chromic acid	Substances containing not more than 9%, weight in weight, of chromic acid; Photographic solutions containing chromic acid in individual containers containing not more than 15 kilograms each of such solutions and of aggregate weight of not more than 500 kilograms of such solutions.
35) Cyanides	Ferrocyanides; Ferricyanides; Acetonitrile; Acrylonitrile; Butyronitrile; 2-Dimethylaminoacetonitrile; Isobutyronitrile; Methacrylonitrile; Propionitrile.
36) Diborane	
37) Dibromochloropropane	
38) Diethyl sulphate	
39) Dinitro-ortho-cresol (DNOC) and its salts (such as ammonium salt, potassium salt and sodium salt)	
40) Dinosam; its compounds with a metal or a base	
41) Dinoseb and its salts and esters, which includes but is not limited to - Binapacryl	
42) Diquat; its salts	
43) Drazoxolon; its salts	Dressings on seeds.
44) Dustable powder formulations containing a combination of - Benomyl at or above 7 percent, carbofuran at above 10 percent, thiram at or above 15 percent.	

List of Controlled Hazardous Substances
(Hazardous Substances Listed in the 2nd Schedule of the EPMA)

Substance	Exclusion
45) Endothal; its salts	
46) Epichlorohydrin	
47) Ethyl mercaptan	Substances containing less than 1%, weight in weight, of ethyl mercaptan
48) Ethylene dichloride	
49) Ethylene imine	
50) Ethylene oxide	Mixtures of inert gases and ethylene oxide comprising not more than 12%, weight in weight, of ethylene oxide contained in cylinders of water capacity less than 47 litres and for aggregate of not more than 3 numbers of such cylinders.
51) Ferric chloride	
52) Fipronil	Formulated products containing Fipronil approved for household use and belonging to Table 5 of the WHO Recommended Classification of Pesticides by hazard.
53) Fluorine	
54) Fluoroacetamide	
55) Formaldehyde	Substances containing not more than 5%, weight in weight, of formaldehyde; Photographic glazing or hardening solutions.
56) Formic acid	Substances containing not more than 5%, weight in weight, of formic acid.
57) Germane	
*58) Hexabromocyclododecane (HBCD)	
59) Hydrazine anhydrous; Hydrazine aqueous solutions	
60) Hydrochloric acid	Substances containing not more than 9%, weight in weight, of hydrochloric acid.
61) Hydrofluoric acid	Preparations or solutions containing not more than 2%, weight in weight, of hydrofluoric acid.
62) Hydrogen chloride	
63) Hydrogen cyanide; Hydrocyanic acid	Preparations of wild cherry; In reagent kits supplied for medical or veterinary purposes, substances containing less than the equivalent of 0.1%, weight in weight, of hydrocyanic acid.
64) Hydrogen fluoride	
65) Hydrogen selenide	
66) Isocyanates	Polyisocyanates containing less than 0.7%, weight in weight, of free monomeric diisocyanates; Pre-polymerised isocyanates in polyurethane paints and lacquers; Hardeners and bonding agents for immediate use in adhesives.
67) Lead compounds in paint	Lead compounds in paint in which the lead content is not more than 0.06% by weight of the paint; Lead compounds in paint in which the container is affixed with an appropriate label. The labels to be used for paints containing lead compounds are in accordance with Part IV of the Second Schedule.

List of Controlled Hazardous Substances
(Hazardous Substances Listed in the 2nd Schedule of the EPMA)

appendix 12

Substance	Exclusion
68) Lead tetra-ethyl and similar lead containing compounds in petrol intended for use in Singapore as fuel for motor vehicles	
69) Mercury compounds including inorganic mercury compounds, alkyl mercury compounds, alkyloxyalkyl and aryl mercury compounds, and other organic compounds of mercury	
70) Mercury	
71) Mercury in Clinical Thermometers	
72) Mercury and its compounds in batteries	Batteries other than mercury oxide batteries, zinc carbon batteries containing more than 0.001% by weight of mercury per cell and alkaline batteries, except those in button form, containing more than 0.025% by weight of mercury per cell.
73) Mercury in fluorescent lamps (primarily for lighting purposes)	Compact fluorescent lamps containing mercury not exceeding 5 mg; Linear or circular fluorescent lamps containing mercury not exceeding 10 mg.
74) Metanil yellow (sodium salt of metanilylazo-diphenylamine)	Dye-indicators used in laboratories
75) Methyl chloride	
76) Methyl mercaptan	Substances containing less than 1%, weight in weight, of methyl mercaptan
77) Monomethyltetrachloro diphenyl methane	
78) Monomethyl-dichloro-diphenyl methane	
79) Monomethyl-dibromodiphenyl methane	
80) Neonicotinoid compounds used as pesticides, the following: Imidacloprid	Formulated products containing Imidacloprid approved for household use and belonging to Table 5 of the WHO Recommended Classification of Pesticides by Hazard.
81) Niclofolan	
82) Nicotine sulphate	
83) Nitric acid	Substances containing not more than 9%, weight in weight, of nitric acid.
84) Nitric oxide	
85) Nitrobenzene	Substances containing less than 0.1%, weight in weight, of nitrobenzene; Soaps containing less than 1%, weight in weight, of nitrobenzene; Polishes and cleansing agents.
86) Nitrogen trifluoride	

List of Controlled Hazardous Substances

(Hazardous Substances Listed in the 2nd Schedule of the EPMA)

Substance	Exclusion
87) Ozone depleting substances, namely:	Products containing any ozone depleting substance other than the following products:
(a) Chlorofluorocarbons, the following: Chloroheptafluoropropane; Chloropentafluoroethane; Chlorotrifluoromethane; Dichlorodifluoromethane; Dichlorohexafluoropropane; Dichlorotetrafluoroethane; Heptachlorofluoropropane; Hexachlorodifluoropropane; Pentachlorofluoroethane; Pentachlorotrifluoropropane; Tetrachlorodifluoroethane; Tetrachlorotetrafluoropropane; Trichlorofluoromethane; Trichloropentafluoropropane; Trichlorotrifluoroethane.	(a) in the case of chlorofluorocarbons - (i) air-conditioners in vehicles registered on or after 1st January 1995 or intended for such vehicles; (ii) equipment for domestic or commercial refrigeration or air-conditioning installed on or after 1st January 1993, or heat pump equipment, which contains any chlorofluorocarbon substance as a refrigerant or in any insulating material of such equipment; (iii) refrigerators that have a compressor rating which exceeds one horsepower; (iv) non-pharmaceutical aerosol products; (v) insulation boards, panels or pipe covers; (vi) polystyrene sheets or finished products;
(b) Halons, the following: Bromochlorodifluoromethane; Bromochloromethane; Bromotrifluoromethane; Dibromotetrafluoroethane;	(b) in the case of Halons, portable fire extinguishers; and
(c) Hydrochlorofluorocarbons, the following: 1,1-dichloro-1-fluoro-ethane; 1,1-dichloro-2,2,3,3,3-pentafluoropropane; 1,3-dichloro-1,2,2,3,3-pentafluoropropane; 1-chloro-1,1-difluoro-ethane; Chlorodifluoroethane; Chlorodifluoromethane; Chlorodifluoropropane; Chlorofluoroethane; Chlorofluoromethane; Chlorofluoropropane; Chlorohexafluoropropane; Chloropentafluoropropane; Chlorotetrafluoroethane; Chlorotetrafluoropropane; Chlorotrifluoroethane; Chlorotrifluoropropane; Dichlorodifluoroethane; Dichlorodifluoropropane; Dichlorofluoroethane; Dichlorofluoromethane; Dichlorofluoropropane; Dichloropentafluoropropane; Dichlorotetrafluoropropane;	(c) in the case of bromotrifluoromethane, fire protection systems with building plans approved after 17th June 1991 and installed after 31st December 1991.

List of Controlled Hazardous Substances

appendix 12

(Hazardous Substances Listed in the 2nd Schedule of the EPMA)

Substance	Exclusion
87) Ozone depleting substances, namely:	Products containing any ozone depleting substance other than the following products:
(c) Hydrochlorofluorocarbons, the following (continued): Dichlorotrifluoroethane; Dichlorotrifluoropropane; Hexachlorofluoropropane; Pentachlorodifluoropropane; Pentachlorofluoropropane; Tetrachlorodifluoropropane; Tetrachlorofluoroethane; Tetrachlorofluoropropane; Tetrachlorotrifluoropropane; Trichlorodifluoroethane; Trichlorodifluoropropane; Trichlorofluoroethane; Trichlorofluoropropane; Trichlorotetrafluoropropane; Trichlorotrifluoropropane;	(a) in the case of chlorofluorocarbons - (i) air-conditioners in vehicles registered on or after 1st January 1995 or intended for such vehicles; (ii) equipment for domestic or commercial refrigeration or air-conditioning installed on or after 1st January 1993, or heat pump equipment, which contains any chlorofluorocarbon substance as a refrigerant or in any insulating material of such equipment; (iii) refrigerators that have a compressor rating which exceeds one horsepower; (iv) non-pharmaceutical aerosol products; (v) insulation boards, panels or pipe covers; (vi) polystyrene sheets or finished products;
(d) Hydrobromofluorocarbons, the following: Bromodifluoroethane; Bromodifluoromethane; Bromodifluoropropane; Bromofluoroethane; Bromofluoromethane; Bromofluoropropane; Bromohexafluoropropane; Bromopentafluoropropane; Bromotetrafluoroethane; Bromotetrafluoropropane; Bromotrifluoroethane; Bromotrifluoropropane; Dibromodifluoroethane; Dibromodifluoropropane; Dibromofluoroethane; Dibromofluoromethane; Dibromofluoropropane; Dibromopentafluoropropane; Dibromotetrafluoropropane; Dibromotrifluoroethane; Dibromotrifluoropropane; Hexabromofluoropropane; Pentabromodifluoropropane; Pentabromofluoropropane; Tetrabromodifluoropropane; Tetrabromofluoroethane; Tetrabromofluoropropane; Tetrabromotrifluoropropane; Tribromodifluoroethane; Tribromodifluoropropane;	(b) in the case of Halons, portable fire extinguishers; and (c) in the case of bromotrifluoromethane, fire protection systems with building plans approved after 17th June 1991 and installed after 31st December 1991.

List of Controlled Hazardous Substances

(Hazardous Substances Listed in the 2nd Schedule of the EPMA)

Substance	Exclusion
87) Ozone depleting substances, namely: (d) Hydrobromofluorocarbons, the following (continued): Tribromofluoroethane; Tribromofluoropropane; Tribromotetrafluoropropane; Tribromotrifluoropropane; (e) Carbon tetrachloride (f) 1,1,1-trichloroethane (methyl chloroform) (g) Methyl bromide	Products containing any ozone depleting substance other than the following products: (a) in the case of chlorofluorocarbons - (i) air-conditioners in vehicles registered on or after 1st January 1995 or intended for such vehicles; (ii) equipment for domestic or commercial refrigeration or air-conditioning installed on or after 1st January 1993, or heat pump equipment, which contains any chlorofluorocarbon substance as a refrigerant or in any insulating material of such equipment; (iii) refrigerators that have a compressor rating which exceeds one horsepower; (iv) non-pharmaceutical aerosol products; (v) insulation boards, panels or pipe covers; (vi) polystyrene sheets or finished products; (b) in the case of Halons, portable fire extinguishers; and (c) in the case of bromotrifluoromethane, fire protection systems with building plans approved after 17th June 1991 and installed after 31st December 1991.
88) Oleum	
89) Orange II [sodium salt of p-(2-hydroxy-1-naphthylazo) benzenesulphonic acid]	Dye-indicators used in laboratories
90) Organic peroxides	Car puttys; Substances and preparations containing not more than 3%, weight in weight, of organic peroxides; Solutions of not more than 60%, weight in weight, of methyl ethyl ketone peroxides and total aggregate weight of less than 50 kilograms of such solutions.
91) Organo-tin compounds, the following: Compounds of fentin Cyhexatin Tributyl tin compounds	
92) Paraquat; its salts	Preparation in pellet form containing not more than 5%, weight in weight, of salts of paraquat ion.
93) Perchloromethyl mercaptan	Substances containing less than 1%, weight in weight, of perchloromethyl mercaptan
94) Perfluorooctane sulfonate (PFOS)	

List of Controlled Hazardous Substances
(Hazardous Substances Listed in the 2nd Schedule of the EPMA)

appendix 12

Substance	Exclusion
95) Phenols, the following: Catechol; Cresol; Hydroquinone; Octyl phenol; Phenol; Resorcinol.	Preparations containing less than 1%, weight in weight, of phenols; Phenols which are intended for the treatment of human ailments and other medical purposes; Soaps for washing; Tar (coal or wood), crude or refined; Photographic solutions containing hydroquinone in individual containers containing not more than 15 kilograms each of such solutions and of aggregate weight of not more than 500 kilograms of such solutions.
96) Phosgene	
97) Phosphides	
98) Phosphine	
99) Phosphoric acid	Substances containing not more than 50%, weight in weight, of phosphoric acid.
100) Phosphorus compounds used as pesticides (insecticides, acaricides, etc.), which includes but is not limited to: Chlorpyrifos; Methamidophos; Methyl-parathion; Monocrotophos; Parathion; Phosphamidon.	Acephate; Bromophos; Iodofenphos; Malathion; Pirimiphos-methyl; Temephos; Tetrachlorvinphos; Trichlorfon; Preparations containing not more than 0.5%, weight in weight, of chlorpyrifos and not containing any other phosphorus compound; Preparations containing not more than 0.5%, weight in weight, of dichlorvos and not containing any other phosphorus compound; Materials impregnated with dichlorvos and not containing any other phosphorus compound for slow release; Preparations containing not more than 1%, weight in weight, of azamethiphos and not containing any other phosphorus compound.
101) Phosphorus oxybromide	
102) Phosphorus oxychloride	
103) Phosphorus pentabromide	
104) Phosphorus pentachloride	
105) Phosphorus pentafluoride	
106) Phosphorus trichloride	
107) Polybrominated biphenyls	
108) Polybrominated diphenyl ethers (PBDEs)	
109) Polychlorinated biphenyls	
110) Polychlorinated terphenyls	
111) Potassium hydroxide	Substances containing not more than 17%, weight in weight, of potassium hydroxide; Accumulators; Batteries.
112) Prochloraz	
113) Pyrethroid compounds used as pesticides, the following: Fenvalerate	Formulated products containing Fenvalerate approved for household use and belonging to Table 5 of the WHO Recommended Classification of Pesticides by Hazard.
114) Sodium azide	Air bag devices in motor vehicles

List of Controlled Hazardous Substances
(Hazardous Substances Listed in the 2nd Schedule of the EPMA)

	Substance	Exclusion
115)	Sodium hydroxide	Substances containing not more than 17%, weight in weight, of sodium hydroxide; Made-up formulated preparations either liquid or solid for biochemical tests.
116)	Sulphur in diesel intended for use in Singapore as fuel for motor vehicles or industrial plants	Sulphur in diesel in which the sulphur content is 0.001% or less by weight.
117)	Sulphur in petrol intended for use in Singapore as fuel for motor vehicles or industrial plants	Sulphur in petrol in which the sulphur content is 0.005% or less by weight.
118)	Sulphur tetrafluoride	Substances containing not more than 9%, weight in weight, of sulphuric acid; Accumulators; Batteries; Fire extinguishers; Photographic developers containing not more than 20%, weight in weight, of sulphuric acid.
119)	Sulphur trioxide	
120)	Sulphuric acid	
121)	Sulphuryl chloride	
122)	Sulphuryl fluoride	Tetraethyl lead, tetramethyl lead and similar lead containing compounds
123)	Tetraethyl lead, tetramethyl lead and similar lead containing compounds	
124)	Thallium; its salts	Titanium tetrachloride
125)	Titanium tetrachloride	
126)	Tris(2,3-dibromo-1-propyl)phosphate	Tungsten hexafluoride
127)	Tungsten hexafluoride	

Note: List is updated as at 08 Oct 2014

*Take effect from 01 Nov 2014

You may view or download the complete list of the PCD controlled chemicals sorted in the [numerical \(HS codes\)](#) or [alphabetical \(chemical names\)](#) order at NEA's website.

Environmental Protection and Management (Hazardous Substances) Regulations

appendix 13

The Schedule

- The storage and use of these hazardous substances require a Hazardous Substances Permit
- The transportation of these hazardous substances, in quantities exceeding those shown, requires a Transport Approval

Substance	Qty (kgs)	Substance	Qty (kgs)
1,2-dibromoethane (EDB)	0	Isocyanates	500
Acetic acid	1000	Lead tetra-ethyl and similar lead containing compounds in petrol intended for use in Singapore as a fuel for motor vehicles	0
Acetic Anhydride	500	*Mercury	0
Acetyl bromide	0	Mercury compounds including inorganic mercury compounds, alkyl mercury compounds, alkyloxyalkyl and aryl mercury compounds, and other organic compounds of mercury	0
*Alachlor	0	Metanil yellow (sodium salt of metanilylazo-diphenylamine)	5000
Allyl isothiocyanate	0	Methyl bromide	50
Ammonia (35% or greater)	500	Methyl chloride	50
Ammonia (less than 35%)	1000	Methyl mercaptan	50
Antimony pentachloride	50	Monomethyltetrachloro diphenyl methane	0
Antimony trihydride	0	Monomethyl-dichloro-diphenyl methane	0
Arsine	0	Monomethyl-dibromo-diphenyl methane	0
Arsenical substances	50	Neonicotinoid compounds used as pesticides	5000
Boric acid; Sodium borate	5000	Nitric acid (95% or greater)	50
Boron tribromide	0	Nitric acid (less than 95%)	1000
Boron trichloride	50	Nitric oxide	0
Boron trifluoride	50	Nitrogen trifluoride	50
Bromine, Bromine solutions	50	Oleum	50
Captafol	0	Orange II [sodium salt of p-(2-hydroxy-1-naphthylazo) benzenesulphonic acid]	5000
Carbamates except Bendiocard, BPMC (Fenobucarb), Mercaptodimethur (Methiocarb)	0	Organic peroxides	500
Carbon monoxide	1000	Organo-tin compounds	0
Carbon tetrafluoride	500	Perchloromethyl mercaptan	50
Chlorinated hydrocarbons	0	Perfluorooctane sulfonate (PFOS)	0
Chlorine	500	Phenols	500
Chlorine trifluoride	50	Phosgene	0
Chlorobenzenes	0	Phosphides	0
Chlorophenols	0	Phosphine	0

Environmental Protection and Management (Hazardous Substances) Regulations

appendix 13

The Schedule

- The storage and use of these hazardous substances require a Hazardous Substances Permit
- The transportation of these hazardous substances, in quantities exceeding those shown, requires a Transport Approval

Substance	Qty (kgs)	Substance	Qty (kgs)
Chlorophenoxyacids; their salts, esters, amines	0	Phosphorus compounds except Dimethoate, Fenchlorphos, Fenitrothion, Phenthoate, Profenophos, Prothiophos, Quinalphos	0
Chlorosilanes	50	Phosphorus oxybromide	0
Chlorosulphonic acid	50	Phosphorus oxychloride	50
Chromic acid	50	Phosphorus pentabromide	0
Cyanides	50	Phosphorus pentachloride	50
Diborane	50	Phosphorus pentafluoride	50
Dibromochloropropane	50	Phosphorus trichloride	50
Diethyl sulphate	500	Polybrominated biphenyls	0
Epichlorohydrin	50	Polybrominated diphenyl ethers	0
Ethyl mercaptan	50	Polychlorinated biphenyls	0
Ethylene dichloride	0	Polychlorinated terphenyls	0
Ethylene imine	0	Potassium hydroxide	1000
Ethylene oxide	50	Prochloraz	0
Ferric chloride	1000	Pyrethroid compounds used as pesticides	5000
Fipronil	5000	Sodium azide	0
Fluorine	0	Sodium hydroxide	1000
Fluoroacetamide	0	Sulphur in diesel intended for use in Singapore as a fuel for motor vehicles or industrial plants	0
Formic acid	1000	Sulphur tetrafluoride	0
Germane	0	Sulphur trioxide	50
*Hexabromocyclododecane (HBCD)	0	Sulphuric acid	1000
Hydrazine anhydrous, Hydrazine aqueous solutions	50	Sulphuryl chloride	0
Hydrochloric acid	1000	Sulphuryl fluoride	0
Hydrofluoric acid	500	Tetraethyl lead, tetramethyl lead and similar lead containing compounds	0
Hydrogen chloride	500	Titanium tetrachloride	1000
Hydrogen cyanide; Hydrocyanic acid	0	Tris(2,3-dibromo-1-propyl)phosphate	0
Hydrogen selenide	0	Tungsten hexafluoride	0

Note: List is updated as at 08 Oct 2014

*Take effect from 01 Nov 2014

Definition and exemptions of Hazardous Substances in 2nd Schedule will also be extended to the above list. The list is subject to changes/review from time to time. The latest list can be obtained from the said Act and its Regulations.

**Environmental Public Health
(Toxic Industrial Waste) Regulations**

The Schedule

List of Toxic Industrial Wastes	Prescribed Quantity For Generation Per Year	Prescribed Quantity For Transportation Per Trip
<i>Acids</i>		
1. Spent inorganic acids, e.g. hydrochloric acid, sulphuric acid, nitric acid, phosphoric acid, hydrofluoric acid, boric acid and pickling acid	1,000 l	250 l
2. Spent organic acids, e.g. acetic acid, formic acid, benzoic acid and sulphonic acid	1,000 l	250 l
<i>Alkalis</i>		
1. Spent alkaline solutions	1,000 l	250 l
2. Spent ammoniacal solutions	1,000 l	250 l
3. Metal hydroxide sludges and oxide sludges	1,500 kg	300 kg
<i>Antimony and its Compounds</i>		
1. Spent antimony potassium tartrate	0 kg	0 kg
<i>Arsenic and its Compounds</i>		
1. Timber preservative residues containing arsenic	0 kg	0 kg
2. Wastes containing gallium arsenide	0 kg	0 kg
<i>Asbestos</i>		
1. Asbestos wastes from asbestos/cement manufacturing processes	1,500 kg	300 kg
2. Empty sacks/bags which have contained loose asbestos fibre	1,500 kg	300 kg
3. Asbestos wastes generated from industrial activity, demolition, renovation and delagging works and ship repairing	1,500 kg	500 kg
<i>Cadmium and its Compounds</i>		
1. Plating effluents and residues containing cadmium	1,000 l	250 l
2. Wastes containing cadmium from Ni/Cd battery manufacturing	0 kg	0 kg
<i>Chromium Compounds</i>		
1. Plating effluents and residues containing chromium	1,000 l	250 l
2. Timber preservative residues containing chromium	0 kg	0 kg
3. Spent and aqueous solutions containing chromic compounds	1,000 l	250 l
4. Tannery effluents and residues containing chromium	1,000 l	250 l
<i>Copper Compounds</i>		
1. Plating effluents and residues containing copper	1,000 l	250 l
2. Spent etching solutions containing copper from printed circuit board manufacturing	1,000 l	250 l
3. Timber preservative residues containing copper	0 kg	0 kg

**Environmental Public Health
(Toxic Industrial Waste) Regulations**

The Schedule

List of Toxic Industrial Wastes	Prescribed Quantity For Generation Per Year	Prescribed Quantity For Transportation Per Trip
<i>Cyanides</i>		
1. Plating effluents and residues containing cyanides	0 kg	0 kg
2. Heat treatment residues containing cyanides	0 kg	0 kg
3. Spent quenching oils containing cyanides	0 kg	0 kg
4. Spent processing solutions containing cyanides from photographic processing	0 kg	0 kg
<i>Fluoride Compounds</i>		
1. Timber preservative residues containing fluorides	0 kg	0 kg
2. Spent ammonium bi-fluoride	1,000 l	250 l
<i>Isocyanates</i>		
1. Spent di-isocyanates, e.g. toluene di-isocyanate (TDI) and methylene di-isocyanate (MDI) from polyurethane foam-making process	1,000 l	250 l
<i>Laboratory Wastes</i>		
1. Obsolete laboratory chemicals	0 kg	0 kg
2. Toxic chemical wastes from chemical analysis	0 kg	0 kg
<i>Lead Compounds</i>		
1. Ash, residues and sludges containing lead and lead compounds	1,500 kg	300 kg
2. Spent organo-lead compounds, e.g. tetraethyllead (TEL) and tetramethyllead (TML)	0 kg	0 kg
3. Waste lead-acid batteries, whole or crushed	10,000 kg	1,000 kg
<i>Mercury and its Compounds</i>		
1. Effluents, residues or sludges containing mercury from chlor-alkali industry	0 kg	0 kg
2. Wastes containing mercury from equipment manufacturing involving the use of metal mercury	0 kg	0 kg
3. Spent catalysts from chemical processes containing mercury	0 kg	0 kg
4. Spent organo-mercury compounds	0 kg	0 kg
<i>Metal Catalysts</i>		
1. Spent metal catalysts from chemical processes and petroleum refining, e.g. catalysts containing chromium and cobalt	0 kg	0 kg
<i>Nickel Compounds</i>		
1. Plating effluents and residues containing nickel	1,000 l	250 l

**Environmental Public Health
(Toxic Industrial Waste) Regulations**

The Schedule

List of Toxic Industrial Wastes	Prescribed Quantity For Generation Per Year	Prescribed Quantity For Transportation Per Trip
<i>Organic Compounds containing Halogen</i>		
1. Spent halogenated organic solvents, e.g. trichloroethylene, 111-trichloroethane, perchloroethylene, methylene chloride, tetra-chloromethane and 112-trichloro-122-trifluoroethane	10,000 l	1,000 l
2. Residues from recovery of halogenated organic solvents	7,500 kg	1,500 kg
3. Packaging materials or residues containing chlorobenzenes and/or chlorophenals and their salts	0 kg	0 kg
<i>Organic Compounds not containing Halogen</i>		
1. Spent non-halogenated organic solvents, e.g. benzene, toluene, xylene, turpentine, petroleum, thinner, kerosene, methanol, ethanol, isobutanol, isopropanol, methyl ethyl ketone, methyl isobutyl ketone, isopropyl ether, diethyl ether, hexane, dimethyl sulphide and dimethyl sulphoxide	10,000 l	1,000 l
2. Residue from recovery of non-halogenated organic solvents	7,500 kg	1,500 kg
<i>Organotin Compounds</i>		
1. Sludges, residues, effluents and spent blasting grit generated from removal of paints containing organotin compounds	0 kg	0 kg
<i>Other Wastes</i>		
1. Obsolete/abandoned chemicals and pesticides from storage, manufacturing and trading activities	0 kg	0 kg
2. Used containers, bags and process equipment contaminated by chemicals and pesticides from storage, manufacturing and trading activities	0 kg	0 kg
3. Wastes/residues containing unreacted monomers, e.g. vinyl chloride and styrene monomers, from polymer manufacturing processes	7,500 kg	1,500 kg
4. Tar residues from distilling and tarry materials from refining	7,500 kg	1,500 kg
5. Wastes from toxic waste treatment processes, e.g. wastes and residues from solidification, fixation and incineration processes	7,500 kg	1,500 kg
6. Wastes from toxic chemical drums and tank cleaning activities	1,000 l	250 l
7. Chemical and oil slops from ship tankers	10,000 l	1,000 l
8. Waste from the production, formulation and use of resins, latex, plasticisers, glues/adhesives containing solvents and other contaminants	5,000 l	1,000 l

**Environmental Public Health
(Toxic Industrial Waste) Regulations**

The Schedule

List of Toxic Industrial Wastes	Prescribed Quantity For Generation Per Year	Prescribed Quantity For Transportation Per Trip
<i>Other Wastes (continued)</i>		
9. Wastes from the production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish containing organic solvents, heavy metals or biocides	5,000 l	1,000 l
10. Solid wastes and sludges or obsolete/off specification materials not categorised elsewhere in the Schedule and failing the NEA's landfill disposal criteria	7,500 kg	1,500 kg
<i>Pathogenic Wastes</i>		
1. Pathogenic wastes from hospitals	0 kg	0 kg
2. Pathogenic wastes from healthcare and research institutions, clinics and laboratories	0 kg	0 kg
<i>Pharmaceutical Wastes</i>		
1. Pharmaceutical wastes comprising antineoplastic agents, antibiotics, vaccines and other immunological products, controlled drugs under the Misuse of Drugs Act (Cap. 185) and pharmaceutical wastes containing arsenics, cyanides and heavy metals and their salts	0 kg	0 kg
<i>Phenolic Compounds</i>		
1. Sludges/residues from paint stripping using chemicals containing phenols	1,500 kg	300 kg
2. Residues containing unreacted phenol and formaldehyde from adhesive industry	1,500 kg	300 kg
<i>Polychlorinated Bi-phenyl (PCB) Including Poly-chlorinated Ter-phenyl (PCT)</i>		
1. Spent transformer oil containing PCB and/or PCT	0 kg	0 kg
2. Retrofilled transformer contaminated with PCB and/or PCT	0 kg	0 kg
3. Electrical equipment and parts containing or contaminated with PCB and/or PCT, e.g. capacitors and transformers	0 kg	0 kg
4. Containers and all waste materials contaminated with PCB and/or PCT	0 kg	0 kg
<i>Polyvinyl Chloride (PVC)</i>		
1. All waste materials containing PVC, e.g. PVC insulated wires, PVC pipes and trunking, PVC parts, PVC upholstery and PVC resins	No Requirement	No Requirement
<i>Silver Compounds</i>		
1. Spent processing solutions containing silver from photographic processing	1,000 l	250 l

**Environmental Public Health
(Toxic Industrial Waste) Regulations**

The Schedule

List of Toxic Industrial Wastes	Prescribed Quantity For Generation Per Year	Prescribed Quantity For Transportation Per Trip
<i>Used, Contaminated Oil</i>		
1. Used mineral, lubricating and hydraulic oil from machine cylinders, turbines, switch gears and transformers	10,000 l	1,000 l
2. Spent motor oils from petrol and diesel engines	10,000 l	1,000 l
3. Spent quenching oil from metal hardening	10,000 l	1,000 l
4. Oil recovered from solvent degreasers	5,000 l	1,000 l
5. Spent oil water emulsions, e.g. spent coolants from metal working industries	5,000 l	1,000 l
6. Oil water mixtures (mainly oil), e.g. oily ballast water from ship tankers	10,000 l	1,000 l
7. Oil and sludge from oil interceptors	7,500 kg	1,500 kg
8. Tanker sludges and oil sludges/residues from storage tanks	7,500 kg	1,500 kg
9. Oil sludges containing acid from recovery and recycling of used oil	7,500 kg	1,500 kg
<i>Zinc Compounds</i>		
1. Plating effluents and residues containing zinc	1,000 l	250 l

Boundary Noise Limits for Factory Premises

appendix 15

The maximum permissible boundary noise levels are as follows:

Type of affected premises	Maximum permissible noise level (reckoned as the equivalent continuous noise level over the specified period) in decibels (dBA)		
	Day 7 am - 7 pm	Evening 7 pm - 11 pm	Night 11 pm - 7 am
Noise Sensitive Premises	60	55	50
Residential Premises	65	60	55
Commercial Premises	70	65	60

Type of affected premises	Maximum permissible noise level (reckoned as the equivalent continuous noise level over 5 minutes) in decibels (dBA)		
	Day 7 am - 7 pm	Evening 7 pm - 11 pm	Night 11 pm - 7 am
Noise Sensitive Premises	65	60	55
Residential Premises	70	65	60
Commercial Premises	75	70	65
Factory Premises	75	70	65

Maximum Permissible Noise Levels from Construction Sites

appendix 16

Since 1 Oct 2007, the permissible noise limits for all days at night time (10pm to 7am) and daytime (7am to 7pm) and evening time (7pm to 10pm) for Sundays and Public Holidays for construction sites located within 150m from any residential areas have been tightened. The permissible noise limits are as shown:

Monday to Saturday

Types of affected buildings	7am - 7pm	7pm - 10pm	10pm – 7am
(a) Hospital, schools, institutions of higher learning, homes for aged sick, etc.	60 dBA (Leq 12 hrs) 75 dBA (Leq 5 mins)		50 dBA (Leq 12 hrs) 55 dBA (Leq 5 mins)
(b) Residential buildings located less than 150m from the construction site.	75 dBA (Leq 12 hrs) 90 dBA (Leq 5 mins)	65 dBA (Leq 1 hr) 70 dBA (Leq 5 mins)	55 dBA (Leq 1 hr) 55 dBA (Leq 5 mins)
(c) Buildings other than those in (a) and (b) above.	75 dBA (Leq 12 hrs) 90 dBA (Leq 5 mins)		65 dBA (Leq 12 hrs) 70 dBA (Leq 5 mins)

Sunday and Public Holidays

Types of affected buildings	7am - 7pm	7pm - 10pm	10pm – 7am
(a) Hospital, schools, institutions of higher learning, homes for aged sick, etc.	60 dBA (Leq 12 hrs) 75 dBA (Leq 5 mins)		50 dBA (Leq 12 hrs) 55 dBA (Leq 5 mins)
(b) Residential buildings located less than 150m from the construction site.	75 dBA (Leq 12 hrs) 75 dBA (Leq 5 mins)	-	- 55 dBA (Leq 5 mins)
(c) Buildings other than those in (a) and (b) above.	75 dBA (Leq 12 hrs) 90 dBA (Leq 5 mins)		65 dBA (Leq 12 hrs) 70 dBA (Leq 5 mins)

NEA has implemented the prohibition of construction activities for new construction sites that are located within 150m from residential premises and noise sensitive areas as follows:

- For sites that commenced work between 1 Sep 2010 and 31 Aug 2011, no construction work are allowed from 10pm on Sat to 10am on Sun, and from 10pm on the eve of a Public Holiday to 10am on a Public Holiday.
- For sites that started work on or after 1 Sep 2011, no work allowed from 10.00pm on Saturday or eve of public holiday to 7.00am on Monday or the day after the public holiday.

WHO Air Quality Guidelines

appendix 17

Pollutants	Averaging Time	WHO Guidelines			
		AQG	WHO IT-1	WHO IT-2	WHO IT-3
Gaseous Pollutants					
Sulphur Dioxide (SO ₂)	24 Hours	20 µg/m ³	125 µg/m ³	50 µg/m ³	-
	10 Minutes	500 µg/m ³	-	-	-
Carbon Monoxide (CO)	8 Hours	10 mg/m ³	-	-	-
	1 Hour	30 mg/m ³	-	-	-
Nitrogen Dioxide (NO ₂)	Annual Mean	40 µg/m ³	-	-	-
	1 Hour	200 µg/m ³	-	-	-
Ozone (O ₃)	8 Hours	100 µg/m ³	160 µg/m ³	-	-
Particulate Pollutants					
PM ₁₀ (Particles that are 10 micrometers or smaller)	Annual Mean	20 µg/m ³	70 µg/m ³	50 µg/m ³	30 µg/m ³
	24 Hours	50 µg/m ³	150 µg/m ³	100 µg/m ³	75 µg/m ³
PM _{2.5} (Particles that are 2.5 micrometers or smaller)	Annual Mean	10 µg/m ³	35 µg/m ³	25 µg/m ³	15 µg/m ³
	24 Hours	25 µg/m ³	75 µg/m ³	50 µg/m ³	37.5 µg/m ³
Lead	Annual Mean	0.5 µg/m ³	-	-	-

Environmental Protection and Management (Ozone Depleting Substances) Regulations 2000

The Schedule

Annex A

Group I		
CFCl ₃	CFC-11	Trichlorofluoromethane
CF ₂ Cl ₂	CFC-12	Dichlorodifluoromethane
C ₂ F ₃ Cl ₃	CFC-113	Trichlorotrifluoroethane
C ₂ F ₄ Cl ₂	CFC-114	Dichlorotetrafluoroethane
C ₂ F ₅ Cl	CFC-115	Chloropentafluoroethane
Group II		
CF ₂ BrCl	Halon-1211	Bromochlorodifluoromethane
CF ₃ Br	Halon-1301	Bromotrifluoromethane
C ₂ F ₄ Br ₂	Halon-2402	Dibromotetrafluoroethane

Annex B

Group I		
CF ₃ Cl	CFC-13	Chlorotrifluoromethane
C ₂ FCl ₅	CFC-111	Pentachlorofluoroethane
C ₂ F ₂ Cl ₄	CFC-112	Tetrachlorodifluoroethane
C ₃ FCl ₇	CFC-211	Heptachlorofluoropropane
C ₃ F ₂ Cl ₆	CFC-212	Hexachlorodifluoropropane
C ₃ F ₃ Cl ₅	CFC-213	Pentachlorotrifluoropropane
C ₃ F ₄ Cl ₄	CFC-214	Tetrachlorotetrafluoropropane
C ₃ F ₅ Cl ₃	CFC-215	Trichloropentafluoropropane
C ₃ F ₆ Cl ₂	CFC-216	Dichlorohexafluoropropane
C ₃ F ₇ Cl	CFC-217	Chloroheptafluoropropane
Group II		
CCl ₄		Carbon tetrachloride
Group III		
C ₂ H ₃ Cl ₃		1,1,1-trichloroethane (methyl chloroform)

**Environmental Protection and Management
(Ozone Depleting Substances) Regulations 2000**

The Schedule

Annex C

Group I		
CHFCI ₂	HCFC-21	Dichlorofluoromethane
CHF ₂ Cl	HCFC-22	Chlorodifluoromethane
CH ₂ FCI	HCFC-31	Chlorofluoromethane
C ₂ HFCl ₄	HCFC-121	Tetrachlorofluoroethane
C ₂ HF ₂ Cl ₃	HCFC-122	Trichlorodifluoroethane
C ₂ HF ₃ Cl ₂	HCFC-123	Dichlorotrifluoroethane
C ₂ HF ₄ Cl	HCFC-124	Chlorotetrafluoroethane
C ₂ H ₂ FCI ₃	HCFC-131	Trichlorofluoroethane
C ₂ H ₂ F ₂ Cl ₂	HCFC-132	Dichlorodifluoroethane
C ₂ H ₂ F ₃ Cl	HCFC-133	Chlorotrifluoroethane
C ₂ H ₃ FCI ₂	HCFC-141	Dichlorofluoroethane
CH ₃ CFCl ₂	HCFC-141b	1,1-dichloro-1-fluoro-ethane
C ₂ H ₃ F ₂ Cl	HCFC-142	Chlorodifluoroethane
CH ₃ CF ₂ Cl	HCFC-142b	1-chloro-1,1-difluoro-ethane
C ₂ H ₄ FCI	HCFC-151	Chlorofluoroethane
C ₃ HFCl ₆	HCFC-221	Hexachlorofluoropropane
C ₃ HF ₂ Cl ₅	HCFC-222	Pentachlorodifluoropropane
C ₃ HF ₃ Cl ₄	HCFC-223	Tetrachlorotrifluoropropane
C ₃ HF ₄ Cl ₃	HCFC-224	Trichlorotetrafluoropropane
C ₃ HF ₅ Cl ₂	HCFC-225	Dichloropentafluoropropane
CF ₃ CF ₂ CHCl ₂	HCFC-225ca	1,1-dichloro-2,2,3,3,3-pentafluoropropane
CF ₂ CICF ₂ CHCIF	HCFC-225cb	1,3-dichloro-1,2,2,3,3-pentafluoropropane
C ₃ HF ₆ Cl	HCFC-226	Chlorohexafluoropropane
C ₃ H ₂ FCI ₅	HCFC-231	Pentachlorofluoropropane
C ₃ H ₂ F ₂ Cl ₄	HCFC-232	Tetrachlorodifluoropropane
C ₃ H ₂ F ₃ Cl ₃	HCFC-233	Trichlorotrifluoropropane
C ₃ H ₂ F ₄ Cl ₂	HCFC-234	Dichlorotetrafluoropropane
C ₃ H ₂ F ₅ Cl	HCFC-235	Chloropentafluoropropane
C ₃ H ₃ FCI ₄	HCFC-241	Tetrachlorofluoropropane
C ₃ H ₃ F ₂ Cl ₃	HCFC-242	Trichlorodifluoropropane
C ₃ H ₃ F ₃ Cl ₂	HCFC-243	Dichlorotrifluoropropane
C ₃ H ₃ F ₄ Cl	HCFC-244	Chlorotetrafluoropropane
C ₃ H ₄ FCI ₃	HCFC-251	Trichlorofluoropropane
C ₃ H ₄ F ₂ Cl ₂	HCFC-252	Dichlorodifluoropropane
C ₃ H ₄ F ₃ Cl	HCFC-253	Chlorotrifluoropropane
C ₃ H ₅ FCI ₂	HCFC-261	Dichlorofluoropropane
C ₃ H ₅ F ₂ Cl	HCFC-262	Chlorodifluoropropane
C ₃ H ₆ FCI	HCFC-271	Chlorofluoropropane
Group II		
CHFBr ₂		Dibromofluoromethane
CHF ₂ Br	HBFC-22B1	Bromodifluoromethane
CH ₂ FBr		Bromofluoromethane
C ₂ HFBr ₄		Tetrabromofluoroethane
C ₂ HF ₂ Br ₃		Tribromodifluoroethane
C ₂ HF ₃ Br ₂		Dibromotrifluoroethane
C ₂ HF ₄ Br		Bromotetrafluoroethane

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Annex C

Group II (continued)	
$C_2H_2FBr_3$	Tribromofluoroethane
$C_2H_2F_2Br_2$	Dibromodifluoroethane
$C_2H_2F_3Br$	Bromotrifluoroethane
$C_2H_3FBr_2$	Dibromofluoroethane
$C_2H_3F_2Br$	Bromodifluoroethane
C_2H_4FBr	Bromofluoroethane
C_3HFBr_6	Hexabromofluoropropane
$C_3HF_2Br_5$	Pentabromodifluoropropane
$C_3HF_3Br_4$	Tetrabromotrifluoropropane
$C_3HF_4Br_3$	Tribromotetrafluoropropane
$C_3HF_5Br_2$	Dibromopentafluoropropane
C_3HF_6Br	Bromohexafluoropropane
$C_3H_2FBr_5$	Pentabromofluoropropane
$C_3H_2F_2Br_4$	Tetrabromodifluoropropane
$C_3H_2F_3Br_3$	Tetrabromodifluoropropane
$C_3H_2F_3Br_3$	Tribromotrifluoropropane
$C_3H_2F_4Br_2$	Dibromotetrafluoropropane
$C_3H_2F_5Br$	Bromopentafluoropropane
$C_3H_3FBr_4$	Tetrabromofluoropropane
$C_3H_3F_2Br_3$	Tribromodifluoropropane
$C_3H_3F_3Br_2$	Dibromotrifluoropropane
$C_3H_3F_4Br$	Bromotetrafluoropropane
$C_3H_4FBr_3$	Tribromofluoropropane
$C_3H_4F_2Br_2$	Dibromodifluoropropane
$C_3H_4F_3Br$	Bromotrifluoropropane
$C_3H_5FBr_2$	Dibromofluoropropane
$C_3H_5F_2Br$	Bromodifluoropropane
C_3H_6FBr	Bromofluoropropane
Group III	
CHClBr	Bromochloromethane

Annex E

Group I	
CH_3Br	Methyl bromide



NATIONAL ENVIRONMENT AGENCY

40 Scotts Road, #12-00, Environment Building, Singapore 228231