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Doc 9184

Airport Planning Manual Part II — Land Use and Environmental Management

Fourth Edition, 2018



Approved by and published under the authority of the Secretary General

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AMENDMENTS

Amendments are announced in the supplements to the *Products and Services Catalogue*; the Catalogue and its supplements are available on the ICAO website at www.icao.int. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

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FOREWORD

The purpose of this part of the manual is to provide guidance material on land-use planning in the vicinity of airports and on environmental management regarding airport development and operations. It was originally based on conclusions of the Special Meeting on Aircraft Noise in the Vicinity of Aerodromes held in 1969 and on the current practices of several States. It incorporates guidance material on airport environmental aspects as recommended by the Eighth Air Navigation Conference held in 1974.

"Land-use Planning" and "Environmental Management" are terms of relevance used by airport planners for planning the airport and its environs with a view to ensuring the safety of aircraft operations. Since these issues have evolved considerably in recent years, it was necessary to update the information included in previous editions of the manual and to reflect in the title the evolution of the environmental activities at and around airports.

This publication reflects updates from the Committee on Aviation Environmental Protection (CAEP) that were first presented to CAEP/4 in 1998. Further updates have since been added and this final version of the manual was approved at the CAEP/10 meeting in February 2016.

It is intended that the manual be kept up to date. Future editions will be improved based on the results of the work of ICAO and of comments and suggestions received from the users of this manual. Readers are therefore invited to give their views, comments and suggestions on this edition. These should be directed to the Secretary General of ICAO.

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Chapter 1

GENERAL

1.1 THE AIRPORT AND ITS ENVIRONS

1.1.1 The compatibility of an airport with its environs is an ideal that can be achieved by proper planning of the airport, management of pollution-generating sources, and land-use planning of the area surrounding the airport. The aim is to provide the best possible conditions for the needs of the airport, the community in the surrounding area and the ecology of the environment.

1.1.2 Airport planning is an integral part of an area-wide comprehensive planning programme. The location, size and configuration of the airport needs to be coordinated with patterns of residential, industrial, commercial, agricultural and other land uses of the area, taking into account the effects of the airport on people, flora, fauna, the atmosphere, water courses, air quality, soil pollution, rural areas (such as deserts) and other facets of the environment.

1.1.3 Within the comprehensive planning framework, airport development and operations should be coordinated with the planning, policies and programmes for the area where the airport is located and vice versa. In this way, the social and economic impact, along with the environmental effects of the airport, can be evaluated to ensure to the greatest extent possible that the airport environs are compatible with the airport and, conversely, that the physical development and use of the airport is compatible with the existing and proposed patterns of land use.

1.1.4 To the extent that safety and operational considerations permit a choice, decisions on runway alignment and other airport development should take into account their potential effects on the environment in order to prevent or minimize environmental conflicts. In effect, "land-use control" is a term which describes only a portion of the total planning process, and even highly innovative controls can have little impact unless they are imposed within the context of sound policies and careful planning. "Land-use planning" or "planning for compatible land uses which takes into account the needs of airport development" more adequately describes the process of achieving an optimum relationship between an airport and its environs.

1.2 THE NEED FOR ENVIRONMENTAL MANAGEMENT

1.2.1 In recent years there has been increased public concern regarding the protection of the natural environment from the impact of transportation, and consequently, a growing emphasis on the need to employ effective measures to minimize such impacts. Since pollution may be generated within an airport as well as within the area surrounding it, environmental management practices should be applied at the airport and its environs.

1.2.2 The natural environment has been defined as including:

- a) air, land and water;
- b) all layers of the atmosphere;

- c) all living organisms, including both plants and animals; and
- d) the interacting natural systems referred to in a) to c).

These components interact in an ecosystem, and disruption to one may have a profound effect on the entire system. To lessen local and global impacts, it is important that the civil aviation industry endeavours to control harmful environmental impacts. This includes operational impacts like emissions and noise, as well as the management of solid and hazardous wastes emanating from paints, lubrication oils, sludge, solvents, toxic chemicals, etc., handled at airports.

1.2.3 Pollution occurring in and around the airport can have an effect on human health and the ecology of a broad area surrounding an airport. Efforts should be made towards pollution prevention in the first instance and impact management in the second instance. Environmental management thus provides a means of either decreasing pollution at the source or reducing the potential for negative environmental impacts. Environmental management controls may include items such as air and water quality guidelines, aircraft engine or ground-sourced noise limits, waste management plans, environmental emergency plans, and environmental management plans.

1.2.4 Airport operators can reduce the environmental impact of their operations by incorporating environmental management plans and procedures with land-use planning. There are several important components of environmental management at an airport, such as noise mitigation, emissions reduction and pollution prevention. A certain amount of emissions and noise are inevitable from aircraft operations, but can be minimized. Pollution prevention can be defined as “the use of materials, processes or practices that reduce or eliminate the creation of pollutants and wastes at the source.” It includes practices that reduce the use of hazardous and non-hazardous materials, energy, water or other resources. Adequate pollution prevention pre-empts the need for remedial or clean-up actions later.

1.2.5 Appropriate planning and infrastructure decisions at airports help to facilitate good environmental management. By planning for intended growth and development, estimations can be made about the type and extent of potential future environmental impacts to allow for a more integrated approach to environmental management. Refer to Chapter 4.

1.2.6 The purpose of the Airport Planning Manual (APM) is to provide effective practices at an airport to reduce the potential environmental effects caused by the airport and its operations. Part 2 of this manual (APM Part 2) is focused on the land use and environmental management on and around an airport. The scope of APM Part 2 does not include information about reducing the impacts of aircraft in-flight but only on impacts from ground sources. APM Part 1 is focused on master planning at airports and is primarily focused on operational safety and efficiency. The recommendations and considerations for airport planning from APM Part 1 should be considered in conjunction with the information provided in APM Part 2 to minimize environmental impacts.

1.3 THE NEED FOR LAND-USE PLANNING

1.3.1 The need for land-use planning in the vicinity of an airport was recognized in the early history of civil aviation and focused on use and control of land. This has included height control of possible hazards or obstacles to flight into or out of airports. The objectives of these measures was to ensure the safety of people in the air and on the ground, to maintain efficient airport operations, and to limit environmental impacts to local communities.

1.3.2 Though land-use planning continues to focus on possible hazards or obstacles to flight, modern land-use planning includes several additional considerations;

- a) land-use zoning that encourages compatible land-uses in the vicinity of an airport;
- b) reducing the environmental impact from aviation activities, including noise exposure to the local communities;
- c) managing habitat and accumulated solid waste on which wildlife may feed and thus could cause a hazard to approaching or departing aircraft (ref. *Airport Services Manual*, Part 3 — *Wildlife Control and Reduction* (Doc 9137));
- d) eliminating light pollution or glint/glare effects that might affect a pilot's interpretation of navigational aids, or air traffic control tower personnel's ability to visually monitor aircraft; and
- e) monitoring activities that could compromise the safe flight of aircraft such as electrical interference with radio communications and navigation aids; and
- f) minimizing the impact of wind turbulence from obstacles in the vicinity of the runway, etc.

1.3.3 Aircraft noise can have a significant impact on local communities and is therefore a major factor influencing land-use planning in the vicinity of airports. The goal is to minimize the population affected by aircraft noise by introducing compatible land-use zoning around airports. Compatible land-use planning is also a vital instrument in ensuring that the gains achieved by the reduced noise of the latest generation of aircraft and improved operational measures are not offset by further residential development and encroachment around airports.

1.3.4 Compatible land-uses in noise-affected areas near airports can include commercial, industrial and agricultural activities. Incompatible land-uses include noise-sensitive areas such as residential homes, schools, hospitals and libraries.

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Chapter 2

ENVIRONMENTAL IMPACTS ASSOCIATED WITH AVIATION ACTIVITIES

2.1 GENERAL

This chapter deals with environmental issues related to airport and aircraft operations. It identifies most of the major environmental issues that may be directly associated with air transport and civil aviation in particular. However, this does not necessarily mean that all of the subjects are suitable for consideration in this manual. Excluded are issues concerning the conditions for passengers and crew (such as the effects of smoking, ozone, high altitude radiation, or noise and vibration within the cabin) and issues concerning the working conditions of airline or airport employees. These are defined as occupational health and safety issues. For each environmental issue presented, a brief description is provided, including a summary of past and present ICAO activities aimed at mitigating the issue, as well as comments on the relevant activities of other organizations, whenever pertinent.

2.2 AIRCRAFT NOISE

2.2.1 Since the introduction of jet aircraft, noise has been considered to be perhaps the most important local environmental impact associated with civil aviation. Noise levels in the vicinity of airports are affected by two opposing trends: the replacement of noisy aircraft by quieter ones and the increasing number of aircraft movements. As a result, the level of impact from aircraft noise may decline at some airports but increase at others. In some cases, the level of impact from noise related to aviation activities has prevented the expansion of airport capacity, thereby limiting airport growth and contributing to airport congestion. Because of this and other environmental concerns, some States limit aircraft operations at airports based on environmental considerations, rather than on airport capacity. In other words, the standard “operational airport capacity” has been replaced by capacity restrictions based on environmental parameters such as noise exposure.

2.2.2 Other noise sources that occur on and around airports may include (but not be limited to) aircraft engine testing, auxiliary power units (APUs) used during ground operations, other equipment such as ground power units (GPUs) and ground support vehicles and equipment (GSE).

2.2.4 Annex 16 — *Environmental Protection*, Volume I — *Aircraft Noise* sets the International Standards and provides Recommended Practices for noise certification of subsonic jet and large propeller-driven aircraft, small propeller-driven aircraft, helicopters and tilt-rotor aircraft. The ICAO Committee on Aviation Environmental Protection (CAEP) maintains and reviews Annex 16, Volume I, and develops new noise Standards and Recommended Practices as technology advances. Annex 16, Volume I, also includes guidelines for noise certification of auxiliary power unit (APU) installations and associated systems, as well as recommendations for noise monitoring and assessment around airports.

2.2.5 A worldwide policy has been developed, at ICAO, to define and implement operating restrictions on aircraft that are either non-noise-certificated or only meet the requirements of Annex 16, Volume I, Chapter 2. These were adopted in 1990 with Resolution A28-3¹ and nearly all States now prohibit the operation of these aircraft in their territories.

1. Superseded by Resolution A33-7.

2.2.6 In 2001, the ICAO Assembly unanimously endorsed the concept of the balanced approach to aircraft noise management and in 2007, the 36th ICAO Assembly reaffirmed the balanced approach principle in Resolution A36-22: "Consolidated statement of continuing ICAO policies and practices related to environmental protection". The balanced approach to noise management developed by ICAO consists of identifying the noise problem at an airport and then analysing the various measures available to reduce noise through the exploration of principal elements, namely reduction at source, land-use planning and management, noise abatement operational procedures and operating restrictions, with the goal of addressing the noise problem in the most cost-effective manner. The recommended practices to assist States in implementing the balanced approach are included in the *Guidance on the Balanced Approach to Aircraft Noise Management* (Doc 9829).

2.3 AIR QUALITY IN THE VICINITY OF AIRPORTS

2.3.1 Air quality in the vicinity of airports can vary greatly depending on local climatic conditions and can be impacted by sources such as road traffic, aircraft engine emissions, emissions from airport motor vehicles and emissions from other sources (e.g. heating/power plants incinerators and construction).

2.3.2 Air pollution refers to a condition of the air quality marked by the presence therein of one or more air contaminants that can:

- degrade the air quality from its normal state;
- endanger the health, safety or welfare of persons;
- interfere with normal enjoyment of life or property;
- endanger the health of animal life; or
- cause damage to plant life or to property.

2.3.3 Air pollution is an environmental problem in many countries, especially in urban areas, and is generally recognized to contain:

- **Carbon dioxide (CO₂)** which is produced by the combustion of hydrocarbon fuels;
- **Carbon monoxide (CO)** is a product originating from the incomplete combustion of hydrocarbon fuels;
- **Oxides of nitrogen (NO_x)** result from high-temperature oxidation of atmospheric nitrogen and is composed of a mixture of NO and NO₂. This takes place in the high temperatures and pressures of aircraft engines, road vehicles and other internal combustion sources, and to a lesser extent in other combustion and natural sources (such as lightning);
- **Volatile organic compounds (VOC)** are low boiling point organic chemicals which can be both man-made and naturally occurring. Fugitive emissions and odours from aircraft fuel tanks, oil tanks and other fuel storage facilities can release VOCs into the local area with some recognized as carcinogens. Chronic exposure to some VOCs can cause health problems;

- **Hydrocarbons (HC)** cover a wide range of pure hydrocarbons that consist of only carbon and hydrogen (alkanes paraffins), alkenes (olefins), alkynes (acetylenes), terpenes, etc.) whose sources include fuelling activities and also arise from the incomplete combustion of fuels in vehicle engines, etc.;
- **Particulate matter (PM)** consists of liquid or solid substances that are suspended in the atmosphere and can be generated during jet fuel combustion, ground-based combustion sources (ground power units, power stations, ground transport), tyre and brake wear, and runway, taxiway and road surface erosion;
- **Sulphur oxides (SO_x)** are produced by the oxidation of the sulphur in road vehicle and aircraft fuels during the combustion process. It is the main cause of “acid rain” and has an impact on human health as well as being detrimental to ecosystems;
- **Ozone (O₃)** is a secondary pollutant formed when NO_x, CO and VOCs react in the atmosphere in the presence of sunlight. It is a component of photochemical smog and is an irritant gas which can cause health problems, such as irritation to the nose, eyes and throat, as well as respiratory problems, and has damaging effects on plant and animal life; and
- **Lead (Pb)** is a pollutant resulting from the use of leaded fuels in piston-engine aircraft. It impacts local-scale air quality, human health and the local ecosystem.

2.3.4 Common sources of pollution at airports include:

- a) aircraft engine emissions, in which the principal pollutant is CO₂, while other pollutants are NO_x, CO, unburned hydrocarbons and PM;
- b) engine emissions from airport motor vehicles used by airport operators, air carriers and other businesses based at an airport;
- c) engine emissions from surface access traffic comprising of passengers' and visitors' motor vehicles, cargo and delivery trucks, service and public transport vehicles;
- d) engine emissions from railways and maritime sources, as appropriate;
- e) particulate emissions from vehicle tyre and brake wear;
- f) emissions from heating/power plants, backup power generators, and incinerators, such as fires set for the purpose of training rescue and firefighting crews;
- g) fuel handling and storage tanks;
- h) particulates arising from surface erosion of runways, taxiways, airport and surface access roads;
- i) natural sources; and
- j) construction emissions.

2.3.5 Annex 16 — *Environmental Protection*, Volume II — *Aircraft Engine Emissions* contains the Standards for the control of gaseous emissions through engine certification schemes. It establishes the limits for the emission of NO_x, CO, unburned hydrocarbons, and smoke from new turbojet and turbofan engines. These are measured in an engine isolated in a test cell at power levels following a specific reference landing and take-off (LTO) cycle, for the purpose of

technology comparison. The emissions certification values are provided in the ICAO Engine Emissions Databank (EEDB), and are publicly available. Sulphur levels in aviation and road traffic fuels are controlled by the specification of those fuels.

2.3.6 The operational flight cycle is much more complex than the simplified reference LTO cycle used for ICAO certification purposes, hence in 2007, ICAO published a preliminary version of the *Airport Air Quality Manual* (Doc 9889), which was further developed and published in 2011 (available from www.icao.int). Doc 9889 provides details on how to estimate emissions affecting air quality in the vicinity of airports, as well as examples of measurement methods, mitigation options and interrelationships associated with methods for mitigating environmental impacts.

2.3.7 The need to reduce air pollution emanating from emissions of airport motor vehicles, surface access traffic and other sources has attracted the attention of most governments and some intergovernmental organizations. However, the extent of any air pollution problem will vary from one airport to another depending on a number of factors, but, in particular, on the location of the airport and the availability of public transport facilities serving the airport.

2.4 GLOBAL ENVIRONMENTAL ISSUES ARISING FROM AIRPORT USE

2.4.1 Greenhouse gas (GHG) emissions are gases which persist in the atmosphere, can trap heat and cause an increase in global temperatures, and which have the ability to affect the climate and sea levels. GHGs were defined by the Kyoto Protocol to include CO₂, methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF₆). GHGs are primarily generated by fuel combustion. Of the six GHGs, only CO₂ and N₂O are direct products of jet fuel combustion. GHGs can also be emitted in an airport environment indirectly from other sources, such as electrical power generation and ground access vehicles.

2.4.2 The ozone layer protects the earth from harmful ultraviolet radiation and is being depleted as a result of complex chemical reactions involving man-made gases. The leading causes of ozone depletion are chlorofluorocarbons (CFCs) and halons, foams, solvents and man-made chemicals that are commonly used in air conditioners and refrigerators.

2.4.3 Airlines and airports use CFCs and other ozone-depleting substances (such as chlorinated solvents and oxides of nitrogen) in air-conditioning and chilling systems, degreasers in heavy maintenance operations, cleaning of avionics circuit boards, fumigation operations, and fire extinguishers on aircraft and in computer rooms. The Montreal Protocol on Substances that Deplete the Ozone Layer was signed in 1987; it commits signatories to reduce the production and consumption of ozone depleting substances.

2.5 ENVIRONMENTAL ISSUES ARISING FROM CONSTRUCTION AND EXPANSION OF AIRPORTS OR ASSOCIATED INFRASTRUCTURE

2.5.1 The environmental issues described in this section are mainly concerned with land use, soil erosion, impacts on surface and subsurface water drainage, and the impact on flora and fauna.

2.5.2 Environmental issues arise not only when new airports are being developed but also when existing airport facilities are expanded or redeveloped. The nature of the issues varies from one airport to another.

2.5.3 As a consequence of vegetation clearing and interference with watershed patterns, land on an airport or within its vicinity may be vulnerable to soil erosion by natural elements and, to a limited degree, by aircraft jet blast. This problem can mostly be prevented by replanting, ideally, with endemic species that are less attractive to birds; however, in arid areas it may be necessary to take artificial erosion protection measures, such as facing of escarpments, paving of taxiway shoulders and lining of drains.

2.5.4 Particular consideration should be given to possible water pollution during the construction phases of airports. Construction activities with the potential to cause stream pollution include clearing, grubbing and pest control. For instance, the clearing of vegetation generally results in greater soil erosion into streams. Pest control, particularly the use of sprays, can introduce long-life toxic chemicals into the water. Fuel spillages from equipment and chemicals used in building and pavement construction work can disrupt the hydrological balance of waterways in the area. Changes to the natural drainage patterns of an area due to the construction of an airport can overload certain streams and give rise to flooding. Diversion of flow may cause streams to dry up.

2.5.5 The siting of some airports may require the modification of the shorelines of rivers, lakes and the sea. In planning such airports, careful consideration should be given to possible environmental problems associated with water currents, silt deposits, impacts on marine or fresh water life and marine or stream erosion.

2.5.6 The utilization of land for airport purposes can also cause disturbances to flora and fauna. Airport development work frequently entails clearing and cutting back of trees and other vegetation, changes to the topography of the area, and interference with watershed patterns. Thus airports may destroy the natural habitat and feeding grounds of wildlife and may deplete certain flora that are vital to the ecological balance of the area.

2.5.7 There are also potential impacts on human populations. For example, airport construction may destroy sources of food, water or firewood, or may cause agricultural land loss, a major concern in certain areas of the world.

2.5.8 An important consideration related to airport operational safety is the prevalence and habits of birds in the area and the associated risk of aircraft bird strikes. Bird hazards at proposed new airports can be minimized by careful selection of the site to avoid established bird migration routes and areas naturally attractive to birds and by using the land surrounding the airport for purposes which will not attract concentrations of birds to the area. At existing airports, the bird problem may be controlled by scaring techniques and by making the airport and its environment unattractive to birds. The subject of bird strike reduction is covered in detail in the *Airport Services Manual* (Doc 9137), Part 3 — *Wildlife Control and Reduction*.

2.5.9 As far as these environmental issues are concerned, airport construction is not significantly different from any large construction site. In many countries, the issue is governed by general legislation on planning and development of construction sites.

2.6 WATER AND SOIL POLLUTION IN THE VICINITY OF AIRPORTS

2.6.1 Water pollution can result from direct or indirect discharge of substances into the aquatic environment, leading to alterations in the properties of the natural ecosystems and water chemistry and having subsequent effects on human health. Surface water is most often affected, as pollutants run off the airport pavements and enter into the streams, rivers, lakes, etc. However, subsurface water may also become contaminated when leaks or spills of fluids seep through the soil into the groundwater.

2.6.2 Airports use a variety of chemicals in their day-to-day operations. If not properly controlled, these contaminants may have harmful effects on nearby surface and/or subsurface (ground) water. Water contaminants at airports and their sources include:

- a) glycol, from de-icing/anti-icing of aircraft;
- b) pavement de-icers, from de-icing/anti-icing of runways, aprons, and taxiways;
- c) fuel, from spills during refuelling and leaks from pipes or tanks;
- d) fire suppressant chemicals and foams dispersed in firefighting exercises;
- e) dust, dirt and hydrocarbons from paved surfaces; and
- f) herbicides and pesticides.

2.6.3 The servicing of aircraft and ground vehicles can result in the discharge of industrial effluents, e.g. paint stripping, metal coating, detergents from aircraft, and vehicle and pavement washing.

2.6.4 The discharge of chemical pollutants can disturb aquatic life and diminish water quality in three primary ways:

- a) *Toxic effect*: Even a small amount of certain contaminants can be toxic to plants and animals as it can cause either short- or long-term (acute or chronic toxicity) consequences;
- b) *Eutrophication*: Excessive levels of nutrients can result in prolific algae and plant growth which, in turn, can choke up water bodies, causing long-term degradation in water quality; and
- c) *Oxygen depletion*: The release of certain chemicals in water bodies can lead to the consumption of large quantities of oxygen, causing the water to become oxygen-deficient which is detrimental to aquatic life.

2.6.5 Attention should be given to any change in the ecosystem of desert areas. Deserts are particularly fragile ecosystems. Specific attention should be directed to the loss of natural plants upon which animals feed.

2.6.6 If the airport has a water desalination plant the concentrated saline solution generated should be treated as waste matter. The treatment and disposal of this waste should be considered during the planning phase of the airport facilities.

2.7 WASTE AT AIRPORTS

2.7.1 The disposal of environmentally harmful materials used in aircraft servicing and maintenance (e.g. oils, cleaning fluids and paints) and of waste from the airport and incoming aircraft should be managed effectively.

2.7.2 Although airports are not usually considered as industrial complexes, daily activities, such as movement of aircraft and ground vehicles, fuelling operations, aircraft maintenance and repair work (including painting and metalwork), engine test cell operations, and ground vehicle maintenance, are all sources of airport industrial waste.

2.7.3 Waste management at an airport may require permits and registration due to State and local requirements.

2.7.4 Waste from terminal buildings can be one of the single largest waste streams on an airport site. Waste management practices should include the provision for segregation at site or co-mingling of compatible recyclable material depending on the recycling service providers in the vicinity of the airport.

2.8 ENVIRONMENTAL EMERGENCIES ARISING FROM ACCIDENTS/INCIDENTS INVOLVING DANGEROUS GOODS AND HAZARDOUS MATERIALS

2.8.1 In order to ensure that responses to environmental emergencies are implemented quickly, it is important to establish an environmental emergency plan. The types of environmental emergencies at airports include, but are not limited to, fuel and chemical spills and incidents involving dangerous goods or hazardous materials that may affect the environment. The objective of the environmental emergency plan is to provide a complete and immediate response to an environmental incident.

2.8.2 Many aircraft are not structurally able to withstand a landing at maximum take-off mass. In the event of an emergency requiring an overweight landing, it is sometimes necessary to burn excess fuel, and in rare circumstances dumping fuel for safety reasons, to evaporate into the atmosphere. Air traffic control (ATC) establishes specific areas where fuel can be dumped in case of such an emergency.

2.8.3 Environmental remediation activities must be considered after any emergency release, to ensure that the environment is protected. Environmental site assessments may be performed to determine the extent, if any, of the impact caused by the emergency.

Chapter 3

ENVIRONMENTAL MANAGEMENT MEASURES AND CONSEQUENCES

3.1 GENERAL

3.1.1 Implementation of environmental management measures at airports and surrounding areas is in the best interest of the airport operators, the community and the natural environment. These measures may include compliance with international standards and national and/or local regulations. They are implemented by airports, often in collaboration with airport stakeholders. When planning infrastructure development, an airport operator should consider how environmental management should be integrated to minimize the impact on operations.

3.1.2 Some measures limit pollution at its source while others reduce its effect on communities and ecosystems. An environmental management system (EMS) is seen as the best method to incorporate environmental management into all levels of corporate operations and decision-making processes. This is discussed further in 3.9.2 of this chapter. A well-planned EMS at an airport can help manage environmental impacts. Chapter 4 provides more guidance on the infrastructure that can be planned and built to enable and enhance the environmental management of an airport.

3.2 ENVIRONMENTAL MANAGEMENT

3.2.1 The environmental management activities of an airport can be divided into four basic categories:

- a) planning;
- b) operations and monitoring;
- c) mitigation and remedial measures; and
- d) environmental awareness.

3.2.2 Most of the environmental activities at airports involve planning and monitoring, including:

- a) environmental assessments;
- b) monitoring and compliance;
- c) environmental audits, where necessary; and
- d) environmental emergency contingency plans.

3.2.3 The environmental assessment process has proven to be an important part of any airport development project. Potential environmental impacts can be identified before they occur and before irrevocable decisions on the design of a project are made. Mitigation of environmental impacts can and should be made an integral part of the planning process. In this regard, reference is made to *Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes* (Doc 10031).

3.2.4 Monitoring and compliance programmes assess air quality, water quality, soil and groundwater quality, noise levels, etc. These programmes are designed to detect developing problems in the early stage before environmental impacts become significant and to identify the source of the problem.

3.2.5 Periodic inspections should be undertaken in order to provide a thorough assessment of the environmental implications of operations and management practices at a given point in time, and to determine the degree of compliance with applicable regulations, guidelines and codes of practice. The inspections are used to assess whether the monitoring and compliance programmes are functioning properly and to identify any problems not previously detected. They also provide a basis for action plans, and are valuable tools for identifying opportunities for enhancing environmental management practices as a whole.

3.2.6 The ultimate goal of a proactive environmental strategy is to prevent the creation of environmental impacts, but there may be a need for *mitigation* and *remedial measures* to correct situations resulting from material handling and management practices of the past.

3.2.7 The objective of an *environmental awareness* programme is to promote increased environmental consciousness and to make individuals aware of their own environmental protection responsibilities, both in decision-making and in the day-to-day work of the airport. This is accomplished primarily through employee education, training and incentives.

3.3 ENVIRONMENTAL MANAGEMENT SYSTEMS

3.3.1 Achieving and demonstrating sound environmental performance require managing the impacts of activities, products and/or services on the environment, taking into account environmental policies and objectives. Legislation is becoming more stringent, with economic policies aiming to foster environmental protection, and there is a growing awareness of environmental issues among society at large.

3.3.2 Many organizations carry out environmental reviews or audits to assess their environmental performance. Organizations can use a series of standards¹ for environmental management, which can be integrated with other management requirements, to assist them in achieving their environmental goals.

3.3.3 The *Report on Environmental Management System Practices in the Aviation Sector* (Doc 9968), published in 2012², describes the function of an EMS and presents case studies from the aviation industry where EMS principles were used to manage environmental impacts. Airports, for example, reported that they were using EMS to manage: hazardous and solid waste, water, national environmental regulations, air emissions and noise. Many of these airports had integrated their EMS with other airport management systems, including safety or quality management systems.

3.3.4 There are a number of benefits of implementing an EMS. Doc 9968 cited the top three benefits as:

- 1) enhance reputation and image among stakeholders, including local communities, customers, and regulators;
- 2) enhance compliance or mitigate risk of environmental impacts and regulatory violations resulting from airport activities, products, and services; and
- 3) environmental improvements, enabling organizations to better achieve organizational goals and vision.

1. Such as ISO 14001, Guidance on Implementation of Environmental Management Systems (EMS).

2. <http://www.icao.int/environmental-protection/Pages/environment-publications.aspx>

Other organizations have identified the following benefits of EMS implementation, including:

- a) improved management efficiency by consolidating all environmental programmes into one system;
- b) reduced costs by adopting proven, well-developed approaches to environmental management; and
- c) increased flexibility to meet changes in legislation and stakeholder concerns.

3.3.5 Airports in general have an obligation to protect the physical environment by evaluating the impacts of their policies and regulatory decisions on the environment, and by promoting and meeting environmental standards while serving the public to optimal satisfaction and safety. EMS provides airports with efficient and effective methods for achieving environmental standards and objectives while also establishing credibility and strengthening public perceptions.

3.4 ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF AIRPORT DEVELOPMENT PROJECTS

3.4.1 An environmental impact assessment is part of the planning and approval process that identifies the environmental effects of a proposed project. This approach allows for the environmental impacts of the proposed projects to be identified in order to allow for, where necessary, the modification of plans and incorporation of measures to minimize or eliminate any potential adverse effects on the environment.

3.4.2 Preparatory work should start with determining what environmental regulations apply in terms of both the environmental impact assessment itself, and also those related to the impacts that are to be assessed. It would also be prudent to identify relevant stakeholders at an early stage and continually engage with them throughout the process, regardless of the size of the project.

3.4.3 The environmental impact assessment report should contain the details that are needed to make informed decisions with respect to the environment. Gathering information on the current situation and the development of project(s) should begin as early as possible.

This can be achieved by:

- a) identifying all project components for the purpose of refining the scope of the project and the scope of the environmental assessment;
- b) evaluating alternatives to the project that may achieve the airport development objective with fewer adverse environmental impacts;
- c) defining the “do nothing” scenario to provide the “base case” against which the impacts of the project(s) can be assessed; and
- d) identify core context assumptions of the project:
 - 1) the proposed date the development will come into service;
 - 2) the expected life-time of the development;
 - 3) agreed “milestone” dates that need to be assessed as part of the EIA;

- 4) key impact influencers for these milestone years, such as traffic forecasts, etc.;
- 5) the legislation, regulations and agreements that apply.

3.4.4 A vital part of any assessment is the effective documentation, communication and reporting of the assessment process and the results, and this should be constantly reviewed during all phases of the EIA process.

3.4.5 The environmental assessment process should include:

- a) a detailed project description;
- b) details of alternatives that are being considered or not and the rationale;
- c) an environmental description, including:
 - 1) a list of the environmental regulations and agreements that are applicable;
 - 2) a project environment interaction analysis and all associated impact; and
 - 3) mitigation measures.

A final report should be prepared which details all the phases and results of the environmental assessment. The environmental impact assessment report must be clear, concise and suitable for public scrutiny, if required.

3.4.6 The next stage should be to carry out a detailed and organized environmental screening of the project based on specific terms of reference and any approved modifications/additions. A report should be drafted presenting the process and results in a screening report suitable for public scrutiny and decision-making.

3.4.7 For the environmental assessment process, it is necessary to develop a description of both the physical and social environments, within which the project will be situated. This should include:

- a) context, study area, and site plan;
- b) definition of the types of environmental and social impacts that are expected and their relative magnitude, including any cumulative effects that need to be considered in the assessment;
- c) physical environment:
 - 1) physiography and local topography;
 - 2) soil;
 - 3) landscaping;
 - 4) surface water/drainage basins;
 - 5) groundwater/aquifer;
 - 6) air quality and emissions;
 - 7) atmosphere/weather/climate;

- 8) vegetation/crops;
 - 9) terrestrial species/habitat;
 - 10) aquatic species/habitat;
 - 11) avifauna migration routes; and
 - 12) ecological systems.
- d) social environment:
- 1) land use;
 - 2) light emissions;
 - 3) impact on the community;
 - 4) recreational uses;
 - 5) aesthetics;
 - 6) employment;
 - 7) economic;
 - 8) municipal services;
 - 9) noise;
 - 10) archaeological, cultural, heritage and historical factors; and
 - 11) planning framework.

3.4.8 Project-environment interaction analyses require identification of the environmental components listed which may be affected by both the project construction and/or operational activities. A matrix should be used to identify the interaction between activities and general categories of environmental components involved.

3.4.9 The identification of possible impact points is followed by an impact analysis. This will require a general description of each potential impact, the determination of valued ecosystem components, and the prediction and evaluation of impacts.

3.4.10 Specifically, the potential impacts of the proposed activities on the environmental components should be described. Any particular concerns of the public or extraordinary circumstances regarding environmental or social impacts should be noted. Through further detailed analysis and consideration of mitigation measures, impact predictions regarding specific project-environment interactions should be developed.

3.4.11 Ultimately, the environmental assessment should provide clear and realistic projections regarding the type and extent of the impact. The assessment should conclude by summarizing decisions regarding the environmental impacts of the project, the specific mitigating measures and monitoring requirements. A recommended environmental assessment decision should be provided, reflecting the options selected among those presented.

3.4.12 The environmental assessment report should be organized in such a manner that information (procedures, findings, etc.) for each of the key stages of the assessment is presented. A table of contents with major headings similar to the following would be appropriate:

- Name of the proposal
- Description of project activities
- Description of the environment
- Environmental impacts (including any cumulative environmental impacts)
- Proposed mitigation measures
- Determination of significance
- Expert government agencies consulted (expert help, if required)
- Public consultation (including methods and results, if required)
- Approximate date of implementation
- Decision and rationale
- Consultant/expert contact (name, title, and address)

3.4.13 An ongoing environmental management programme should detail individual monitoring processes required to evaluate the effectiveness of the mitigation measures, as well as determine the accuracy of the environmental assessment. This programme is not always required for every project. The decision-maker should identify and implement a follow-up programme if one of the following situations occurs:

- a) the project involves new or unproven technology;
- b) the project involves new or unproven mitigation measures;
- c) the assessment was based on a new assessment technique or model, or there is some uncertainty about the assessment's conclusion.

3.4.14 Communication with stakeholders is an essential aspect to finalizing the assessment process, and the final report and supporting documentation may be used to inform them of the outcome and to highlight the process and gain their support for the process. Active engagement with stakeholders and public groups about the process reduces the chance of questions and concerns at a later date.

3.5 NOISE MANAGEMENT

3.5.1 Noise emissions generated on or in the vicinity of airports are unavoidable due to the nature of aircraft and ground operations. In 2001, the ICAO Assembly endorsed the concept of a "balanced approach" to aircraft noise management ([Appendix C of Assembly Resolution A35-5](#)) and subsequent ICAO Assembly Resolutions³. This consists

3. <http://www.icao.int/about-icao/Pages/Assembly.aspx>.

of identifying the noise problem at an airport and then analysing the various measures available to reduce noise through the exploration of four principal elements, namely reduction at source (quieter aircraft), land-use planning and management, noise abatement operational procedures and operating restrictions.

3.5.2 To reduce noise at source (quieter aircraft), States, manufacturers and research institutions have undertaken research which has led to considerable aircraft engine and airframe performance improvements and reduction of aircraft engine source noise. As a result, modern aircraft are significantly quieter than earlier generations of aircraft. With this in mind, before an aircraft is permitted to operate, it must receive noise certification to required standards granted by the State of Registry. Aircraft noise certification provisions are detailed in Annex 16 — *Environmental Protection*, Volume I — *Aircraft Noise* and the *Environmental Technical Manual on the use of Procedures in the Noise Certification of Aircraft* (Doc 9501, Volume I), which provides practical guidance to certifying authorities on the implementation of the technical procedures of Annex 16.

3.5.3 Land-use planning and management is an effective means to ensure that the activities nearby airports are compatible with aviation. Its main goal is to minimize the population affected by aircraft noise by introducing land-use zoning around airports. Compatible land-use planning and management is also a vital instrument in ensuring that the gains achieved by reduced noise of the latest generation of quiet aircraft are not offset by encroachment and further residential development closer to the airports. In addition, with a view to promoting a uniform method of assessing noise around airports, ICAO recommends the use of the methodology contained in *Recommended Method for Computing Noise Contours around Airports* (Circular 205). This is discussed in more detail in Chapters 5 to 7 of this manual.

3.5.4 Noise abatement procedures, to further reduce the population adversely affected by aircraft noise, have been employed to reduce noise levels around airports. Noise abatement procedures enable reduction of perceived noise during aircraft operations and can be achieved at comparatively low cost. There are several methods, including preferential runways and routes, as well as noise abatement procedures for take-off, approach and landing. The appropriateness of any of these measures depends on the physical layout of the airport and its surroundings, but in all cases, the procedure must give priority to safety considerations. ICAO's noise abatement procedures are contained in the *Procedures for Air Navigation Services — Aircraft Operations* (PANS-OPS, Doc 8168), Volume I — *Light Procedures*, Part V. In addition to noise abatement procedures, operating restrictions are discussed in 3.2.9.

3.5.5 Acoustical barriers can only provide a benefit in a fairly limited number of situations. A wall or berm between residences and an airport will only be effective against ground-based noise sources such as aircraft taxiing and apron vehicles, and will generally not shield residences from the noise during aircraft take-off, landing and flyover. Furthermore, a wall needs to be placed very close to the residences (within about 20 m) and needs to be built sufficiently high to block the line-of-sight between the noise source and receiver.

3.5.6 If the airport has a large buffer area between it and areas affected by ground-based noise, a forested area can provide better noise mitigation than bare land. The forest buffer would need to be at least 100 m deep and care would need to be taken not to create a wildlife hazard for aviation.

3.5.7 The use of a noise barrier or enclosure to reduce the noise from aircraft engine run-ups is discussed in 4.6.2 of this manual.

3.5.8 Sound insulation can be used to improve the aircraft noise intrusion levels within buildings affected by aircraft noise. Whether retrofitted to existing buildings or required a part of a building code for new constructions, sound insulation clearly can only improve the internal noise levels of a residence, hospital or school. Furthermore, as the benefits of sound insulation are negated if a building occupant opens external windows or doors, in many climates, sound insulation will need to be accompanied by the provision of alternative ventilation for habitable spaces. Further discussion on sound insulation can be found in the land-use planning sections of this manual in Chapter 7.

3.5.9 Operational restrictions on aircraft have been responsible for the introduction of night curfews and restriction of operations of certain aircraft types due to noise considerations. States, guided by the ICAO Assembly Resolutions, have also phased out or banned operations of noisier aircraft types (for example, the phase-out of Chapter 2 aircraft), mentioned as well in *Guidance on the Balanced Approach to Aircraft Noise Management* (Doc 9829).

3.6 AIR QUALITY MANAGEMENT

3.6.1 Some degree of air pollution associated with an airport may be unavoidable, and this can be managed with proper pre-development planning, environmental impact assessment and mitigation measures.

3.6.2 Detailed guidance on the management of air quality at airports is provided in the *Airport Air Quality Guidance Manual* (Doc 9889), which should be consulted if more specialized information is required. A brief overview is provided in this section and more detail on infrastructure for air quality management is provided in Chapter 4.

3.6.3 Airport-related emissions sources that affect airport air quality (AAQ) can be divided into four groups — aircraft, aircraft handling and support vehicles, infrastructure and stationary sources, and landside access traffic. An overview of each of these is provided below covering regulation, technology and infrastructure, and operational measures.

Aircraft

3.6.4 The aircraft's main engines and to a lesser degree the auxiliary power unit (APU) are the primary sources of gaseous emissions from aircraft, though particulate emission sources include brakes and tyres, as well as the engines and APU.

3.6.5 Most aircraft emissions that affect AAQ are subject to the Standards contained in Annex 16, Volume II, which provides SARPs on instruments and methods used for measuring aircraft engine emissions from a range of engine types. Over the past decades, engine technology has continued to improve and ICAO's Standards are continuing to evolve, in particular, NO_x Standards have become increasingly more stringent. ICAO continues to develop new Standards for other emissions.

3.6.6 Operational procedures that reduce aircraft emissions are addressed in detail in the manual on *Operational Opportunities to Reduce Fuel Burn and Emissions* (Doc 10013). These procedures are generally under control of the aircraft operator and air navigation service providers (ANSP), but are subject to the aircraft performance and airport runway characteristics and the prevailing meteorological conditions.

3.6.7 Airport facilities and operations can facilitate efficient aircraft operations, such as:

- a) providing an efficient runway and taxiway layout;
- b) providing fixed electrical ground power (FEGP) and preconditioned air (PCA) installed at terminal gates, while remote stands can enable a parked aircraft's auxiliary power unit (APU) to be switched off; and
- c) using towing operations to delay the start-up of the aircraft engines, provided this does not create delays which could contribute to congestion.

3.6.8 Air pollution originating from aircraft engine testing and maintenance facilities may be controlled through the use of test cells equipped with afterburners and catalytic converters.

Aircraft handling and support vehicles

3.6.9 Aircraft handling can include towing vehicles while GSE covers all vehicles providing services to aircraft, such as fuelling, baggage, catering and stairs. A number of steps can be taken to decrease emissions from aircraft handling and GSE, and increase the fuel efficiency of these vehicles. These include:

- a) maintaining the vehicles and conducting regular emissions tests;
- b) avoiding unnecessary idling by shutting off engines when operation is stopped for periods of more than one minute;
- c) reducing driving distances by planning routes;
- d) accelerating smoothly;
- e) driving at optimum speeds;
- f) using alternative low-sulphur diesel fuels;
- g) converting vehicles to natural gas, propane, hybrid-electric or electric power;
- h) using oxidation catalysts and particulate traps which can reduce hydrocarbon and particulate mass emissions up to 95 per cent; and
- i) encouraging purchase of fuel-efficient vehicles, the use of alternative energy sources, such as ethanol and propane, or electric vehicles, and providing the infrastructure to refuel or recharge them.

3.6.10 Environmental impacts should be considered when selecting vehicles. A common mitigation measure is conversion of airport vehicles with internal combustion engines to vehicles utilizing alternative fuels. Alternatives include hybrid-electric (vehicles that partially utilize electric motors) and electric vehicles. The environmental benefits of these options depend on the ultimate source of electricity.

Infrastructure and stationary sources

3.6.11 These sources include incinerators, heating and air-conditioning plants, firefighting training, and certain construction or maintenance works (e.g. smoke from asphalt paving plant or refuse burning).

3.6.12 The main ways to reduce AAQ emissions from these sources include the modernizing of equipment and optimizing the energy efficiency of operations and building use. The latter is addressed in more detail in 3.7 below.

Landside access traffic

3.6.13 The transport of people (and cargo) to and from (and within) an airport area presents another source of emissions that impact AAQ. In certain situations, rail transport, "people movers" and careful design of an airport layout can all contribute significantly to the minimization of the environmental impacts and operating costs arising from such transport needs.

3.6.14 The provision of an excellent public transport system may be outside the scope of the airport authority, but there is the possibility of encouraging airport employees to use public transport. Provision can be made for intermodal interchange facilities in the layout, planning and design of new airports and in the extensions of existing infrastructure,

particularly terminals. Passengers may be provided linkage to light, conventional or high-speed rail systems as well as regional and local bus facilities, the latter being particularly appropriate for employee access. The provision of such facilities should go hand-in-hand with the development of an airport public transport strategy appropriate to local conditions and consistent with a policy of cooperation with transport providers. Airports should coordinate with municipalities to ensure convenient intermodal transport is considered in municipal plans.

Ambient air quality regulation

3.6.15 In most jurisdictions, regional or national authorities provide regulations on ambient air quality for the protection of human health and the environment which are usually based upon the guidelines of the World Health Organization. Ambient air quality regulations provide indications of levels of pollutant concentrations considered acceptable in occupied locations and usually include NO₂, CO, O₃, SO₂, some organic compounds (e.g. benzene (C₆H₆), and PM.

3.6.16 Note that, in contrast to the ambient air quality regulations, emissions certification applies to individual sources such as road vehicles or aircraft, etc. Furthermore, emissions and ambient air quality regulations do not always target exactly the same pollutants — for instance, ICAO engine certification provides limits to NO_x emissions (including NO and NO₂ — though reported as if it were all NO₂), whereas most State ambient air quality standards specify maximum concentrations of NO₂. Similarly, the ICAO smoke number (SN)⁴ Standard is not consistent with PM₁₀ and PM_{2.5} concentrations regulated for ambient air.

3.6.17 To achieve compliance with ambient air quality regulations, an airport operator will normally have an “air quality management” plan in place. Air quality management involves measuring ground level pollutant levels and assessing compliance with the relevant regulation. If limits are exceeded, it is then necessary to identify and, where possible, quantify the emissions sources that are impacting air quality in the area where the exceedance is occurring. This involves developing an inventory of sources and then carrying out a modelling exercise of the likely dispersion to estimate the expected pollutant concentrations. In most cases, this modelling will be a complex and involved process, as the contributions from local roads and industry will also need to be considered as well as the variable nature of some emission sources. As a result, air quality modelling is normally carried out by specialists.

3.6.18 The results of the modelling should indicate those emissions sources that have the greatest impact on the air quality in the area of concern, allowing the airport operator to prioritize and target these areas for mitigation action.

3.7 GREENHOUSE GAS EMISSIONS MANAGEMENT

Drivers

3.7.1 In some States, airports are subject to GHG emissions regulation. In those States, applicable airports must inventory and report emissions, and a few are subject to GHG emissions caps. In the European Union, for example, some airports with large ground based emissions sources such as power stations, are subject to the local Emissions Trading Scheme.

3.7.2 Many airports address GHG emissions on an unregulated or voluntary basis. Drivers for such action might include company policy on environmental stewardship, corporate social responsibility or proactive steps to curtail government regulation.

4. This Standard is currently under review by ICAO.

Inventory

3.7.3 An airport GHG inventory is a report of the sources and amounts of GHG emissions at an airport. An airport GHG inventory should be divided according to the ownership and control of emissions sources. The World Resources Institute GHG Protocol provides three categories for emissions management:

- Scope 1 emissions are from sources that are owned or controlled by the airport operator, such as airport power or heating plants, airport fleet vehicles, construction, and firefighting training.
- Scope 2 emissions are those from the off-site generation of electrical power (and heating or cooling) purchased by the airport operator.
- Scope 3 emissions are those from airport-related activities from sources not owned or controlled by the airport operator, including aircraft, most ground support equipment and most ground access vehicles.

3.7.4 Under most jurisdictions, an airport operator may only be responsible for Scopes 1 and 2 emissions. If unregulated, an airport operator may choose which Scope 3 emissions to include. Some, for example, might exclude aircraft emissions or only include those during the take-off and landing cycle (usually below 3 000 ft).

Mitigation

3.7.5 The GHG emissions at airports are dominated by the CO₂ emitted from burning fossil fuels, thus airports should be developed and operated to minimize these emissions. Most of the mitigation measures to address local air quality in 3.3 above and those to improve energy management in 3.7 below, will also benefit the total GHG emissions associated with an airport.

3.8 WATER MANAGEMENT

3.8.1 Airports are usually subject to State or local environmental regulations or operational permits, which may include both water quantity and quality discharge limits. Waste water, including sewage, may be treated on site before being discharged or directed to non-potable uses, such as landscape irrigation. Alternatively, untreated waste water may be delivered to the local municipal treatment system.

Storm water

3.8.2 Airport storm water run-off will generally need to be collected and treated before being discharged so as not to pollute groundwater or nearby bodies of water. The primary products which can be found in untreated storm water include suspended solids, fuel, oil and greases, heavy metals and de-icing chemicals. Settling ponds can be used to control discharge flow rates and for the removal of solids. Further treatment may be required depending on the types and levels of contaminants. The nature of airport operations will influence the type and extent of waste water treatment required.

3.8.3 When planning water management facilities, the following issues need to be considered:

- a) oils and fuel should be contained and segregated at their source;

- b) the use of desalinated water can cause piping system corrosion so the aggression index for the water should be monitored;
- c) where and how to discharge into natural water systems;
- d) water quality monitoring of airport surface run-off, as water could be stored for long periods in underground or elevated reservoirs not frequently cleaned or liable to contamination; and
- e) water conservation practices to reduce the use of potable water and harvest rain water.

3.8.4 In order to determine the type of practices to be incorporated in a water management programme, the airport developer and operator should conduct a review of the site conditions. This review should include the following:

- a) topography;
- b) presence of bodies of water;
- c) storm water discharge points, including infrastructure and natural bodies of water;
- d) drains, culverts and catch basins;
- e) paved areas and buildings;
- f) aircraft and vehicle service areas; and
- g) operational areas and activities, e.g. fuelling, de-icing and maintenance areas.

Petroleum and chemical management

3.8.5 Large quantities of petroleum and chemical products, which are potential sources of water pollution are stored and handled at airports. The following paragraphs outline management practices that may be employed in maintenance areas, aprons, fuel farms, and de-icing areas.

3.8.6 Aircraft maintenance areas, as well as automotive and equipment service areas, should be provided with oil-water separators which are, in turn, connected to sanitary sewers leading to the municipal waste treatment plant serving the airport.

3.8.7 It is important to manage water originating from aprons as it is likely to contain many contaminants including hydrocarbons from spills. Grease and suspended solids from various sources such as aircraft, service vehicles and minor aircraft maintenance may also be present. The airport pollution control programme should therefore focus on:

- a) strict enforcement of storage regulations to control pollution at its source and to minimize hazards that could result in spills;
- b) removal of spilled oil and fuel through immediate containment and spill recovery;
- c) maintenance activities in hangars, where possible, that are protected by oil-water separators and to reduce aircraft maintenance on the aprons;
- d) washing of equipment in dedicated areas; and

- e) immediate cleaning of all spills of fuel, oil, or other dangerous goods by using environmentally sound absorbents, which are subsequently removed from the airport by handlers who are licensed and trained disposers.

3.8.8 Airport personnel must regularly check all relevant access pits and sumps, monitor the removal of any fuel or oil found therein, and always respond to spill reports, analysing them for common causes in order to prevent future spills. Trucks used for fuelling operations should be inspected every six months and hydrant pits used for transferring fuel from the underground piping systems should be checked on a routine basis for any accumulation of fuel.

3.8.9 Another water pollution problem can be the presence of underground oil-saturated soils at fuel farms. Several potential sources of oil contributing to the oil-saturated soil beneath a fuel farm:

- a) leakage from storage tanks;
- b) leakage from distribution lines;
- c) leakage from mechanical equipment which penetrates cracks and joints in the slabs beneath the equipment; and
- d) leakage through the joints in the storm water drainage pipe used to transport condensate from the fuel storage tanks to the oil-water separator system.

3.8.10 A number of steps can be taken to solve the problem of underground oil-saturated soils. It may be necessary to consult a specialist in this area.

De-icing management

3.8.11 Aircraft de-icing fluids, if released into receiving waters, can be a potential pollution problem as well as a potential hazard to aquatic life due to its toxicity and biochemical oxygen demand (BOD). This is primarily due to the ethylene or propylene glycol chemicals which are widely used in current de-icing fluids, although less toxic, non-glycol based alternatives are under development. Excess de/anti-icing fluid running off an aircraft, if allowed to mix with other surface run-off, poses the risk of contaminating the groundwater. Furthermore, the fluids can also have an adverse effect on the pavement surface friction characteristics. Therefore, it is imperative that only an optimum quantity of the fluids be used. All excess fluids must be properly collected to prevent groundwater contamination. To prevent contamination of water courses, all surface run-off from de-icing areas and sometimes taxiways and runways must be adequately treated before being discharged into storm water drains. For further information on aircraft de-icing, including environmental considerations, please refer to the *Aerodrome Design Manual* (Doc 9157), Part 2 — *Taxiways, Aprons and Holding Bays*, Chapter 3.

3.8.12 To minimize the effects of the spent fluids, the following precautions should be exercised:

- a) reduce chemical usage by:
 - 1) centralizing spray operations;
 - 2) using designated de-icing pads; and
 - 3) recapturing, filtering, and/or recycling glycol in leak-free tanks;
- b) proper drainage on the apron and sweepers to clean up residual fluids;

- c) create spill response plans and ensure that all users are properly trained on chemicals and procedures; and
- d) maintain the facility in good order, including:
 - 1) pavement conditions;
 - 2) storage area; and
 - 3) run-off control.

3.8.13 Winter operations management plans should be filed at the beginning of the season and should include the following areas:

- a) site responsibilities;
- b) site specifications;
- c) glycol storage and handling;
- d) glycol application;
- e) containment;
- f) collection and storage of effluent;
- g) means of disposal; and
- h) reporting plan.

Further information on de-icing is available in the *Manual of Aircraft Ground De-icing/Anti-icing Operations* (Doc 9640).

3.9 WASTE MANAGEMENT

3.9.1 Waste management is concerned with the reduction of both hazardous and non-hazardous wastes. Some countries have legal provisions for how to deal with different waste streams. Waste management at airports is often a service performed by a contractor, and in accordance with the local regulations.

3.9.2 In general, the 4Rs — reduce, reuse, recycle and recover — are good practices for any workplace. Airport waste can be divided into nine general categories of waste, including (1) municipal solid waste (MSW); (2) construction and demolition waste (C&D); (3) green waste (e.g. from landscape management); (4) food waste (domestic); (5) waste from aircraft flights (i.e. deplaned waste); (6) lavatory waste; (7) spill clean-up and remediation waste; (8) hazardous material; and (9) International Catering Waste (ICW). A waste management programme should include three practices: planning, procedures and special provisions.

3.9.3 **Planning.** Airports should establish a dedicated plan and programme for the management of waste. This plan should consist of the following:

- a) a description of design intent, as well as anticipated wastes, their volumes, and disposal or treatment methods;

- b) construction details for new infrastructure such as incinerators or landfills, including an overall landfill development plan, and a site closure plan;
- c) a clear description of the chain of authority, organizational structure, job descriptions and job responsibilities for all personnel;
- d) an itemized list of mandatory regulatory reporting requirements;
- e) an itemized list of internal, written reporting requirements and record-keeping;
- f) a waste minimization, reuse and recycling plan (i.e. reduce or eliminate operations/processes that generate solid waste, redesign processes to minimize waste, substitute products for waste reduction), as well as a plan to either maximize municipal recycling capacity for airport and deplaned waste, or develop that capacity at the airport;
- g) a description of health and environmental monitoring programmes and related reporting requirements;
- h) a description of routine landfill, composting, or incineration operational procedures;
- i) a description of health and environmental monitoring programmes and related reporting requirements;
- j) a hazardous materials and emergency procedure plan; and
- h) training of all employees in waste management concepts, including day-to-day procedures, equipment operating instructions, safe practices and emergency procedures.

3.9.4 **Procedures.** It is important that the waste management plan incorporate the following procedural elements:

- a) describe procedures for the reduction, reuse and recycling of airport and deplaned waste;
- b) choose sustainable products and services;
- c) compost organic wastes;
- d) provide training for proper material handling to reduce waste and spills, and equip waste transport vehicles with anti-spill equipment;
- e) centralize responsibility for waste management and establish written procedures for loading/unloading and transfer operations;
- f) track waste to allow for better management (this applies to all utilities); create a spreadsheet or tracking system that does the following, especially for wastes that leave airport property:
 - 1) identifies waste streams;
 - 2) evaluates the process generating the waste;
 - 3) prioritizes waste streams;
 - 4) prepares inventory reports; and
 - 5) maintains records on waste production and disposal costs;

- g) isolate hazardous wastes by containment and prevent mixing of hazardous and non-hazardous wastes;
- h) isolate liquid waste from solid waste;
- i) separate biomedical wastes with infection potential for special treatment and disposal; and
- j) segregate incompatible materials/wastes to avoid dangerous reactions in the event of a spill.

3.9.5 **Special provisions.** It should be noted that in the management of hazardous wastes, special provisions may be required. These provisions can include the following:

- a) perimeter security fence;
- b) security alarms on the gate and security fence;
- c) designated vehicle wash-off area;
- d) a dedicated building or storage sheds for materials storage;
- e) safety control devices such as fire and gas alarms;
- f) installation of ventilation systems, non-spark electrical controls and fire extinguishers;
- g) specialized training of personnel; and
- h) implementation of a wildlife hazard management programme including location of airport waste storage and facilities.

3.9.6 An effective waste management programme can be enhanced by employee awareness of the three waste management practices. An awareness programme can include training, participation in special events, information sessions and informative newsletters. Employees should stay current on changes and new information to ensure adherence to policies and procedures. The concept of segregation of recyclable solid waste components should be communicated to all parties. It is possible to recycle and remanufacture both solid and hazardous wastes into other products. Segregation and recycling policies should be mandatory.

3.10 ENERGY MANAGEMENT

3.10.1 The majority of energy used at an airport is associated with the provision of heating, ventilation, air conditioning and lighting. The essential services such as airfield lighting and instrumentation actually use a relatively small amount of energy. It has been estimated that energy costs account for about five per cent of the operating costs of a modern airport. These costs can be reduced through energy efficient design of new airport facilities.

3.10.2 To assess energy and environmental performance in existing facilities, suitable indicators are required. The actual choice of the indicators will depend on the size of the airport, but suitable indicators may include:

- a) energy consumption per:
 - 1 000 passengers;

- air transport movement;
 - tonne of cargo movement;
 - traffic unit (TU)⁵;
- b) pollutants released:
- directly per 1 000 passengers/TU; and
 - indirectly per 1 000 passengers/TU.

3.10.3 Actual energy consumption, or the best available estimate, separated by energy source should be recorded. This data should be reported annually so that performance improvements can be demonstrated and compared to other indicators, such as traffic, finance and employment. Indicators based on measures of consumption and pollutants are essential for reports on environmental effects. In addition, indicators based on cost are essential from a financial management viewpoint.

3.10.4 An airport energy audit or assessment may be conducted by qualified airport personnel, outside consultants, or through coordination with an energy provider. Audits typically analyse energy use and building characteristics for multiple airport facilities, and result in a list of measures that can increase energy efficiency. Often, the cost of the audit and implementing measures can be offset by the cost savings from reduced energy usage, or through coordination with energy providers. Energy audits can also identify opportunities to increase an airport's use of renewable energy sources, or pursue more substantial programmes to increase energy efficiency and energy security (e.g. micro grids and smart grids). To be effective, energy audits should be carried out at regular intervals as per international standards⁶.

3.10.5 In order to heighten awareness of energy efficiency within the airport and interested communities, some airports adopt an energy policy guidance statement. Turning these statements into effective action requires a clear definition of responsibility for energy efficiency. Ideally, each operational manager will have this responsibility, with expert knowledge being provided by engineering and energy specialists. Examples of policy statements are as follows:

- a) "This airport aims to use energy as effectively as possible in the pursuit of its corporate objectives."
- b) "This airport will always consider the environmental impact of its direct and indirect energy consumption."
- c) "This airport is committed to the efficient use of energy in all its activities."

3.10.6 An effective energy strategy will include a statement of objectives to make all personnel aware of what the organization is committed to achieve. It should integrate environmental performance as well as financial considerations. An energy strategy should consider the following:

- a) **Choice of energy source:** in the context of an effective energy management plan, the choice of energy source will result from a range of different factors (e.g. resilience, energy security, costs, mandates, available resources, environmental impact, and legislation). It is up to each organization to consider these factors when deciding which energy mix best meets its needs. When making decisions, it is important to consider both the direct and indirect environmental effects. For example, using

5. A traffic unit (TU) is either an enplaned passenger, a deplaned passenger, or 100 kg of enplaned or deplaned cargo.

6. Such as ISO 50001.

electricity may have a negligible environmental effect locally, but its effect may be significant elsewhere if the power is generated by the combustion of fossil fuels.

- b) **Effective utilization and management of energy:** A key aim must be to conserve energy and still meet the operational objectives of the airport. The focus of an energy strategy should be to improve energy efficiency. To do this, it is necessary to understand where, how and why energy is used. This is one of the objectives of the energy audit.

3.10.7 All control points related to heating and air conditioning systems should be checked, including the heating and cooling temperatures, control of humidity, and boiler adjustments. While such actions are simple, the combined effect of incorrect settings could mean the use of ten per cent more energy than is necessary. Other simple procedures include checking the insulation of pipework, duct work and buildings themselves (building envelope, ventilation, etc.). All these measures can optimize the performance of the system. Where a comprehensive building management system is installed, many checks and adjustments can be carried out from a central control room. Once the existing plant is operating efficiently and as much waste is eliminated as possible, further capital investment may be considered, including investments in additional sophisticated control systems, variable speed drives for fans and pumps, heat recovery systems, and new boiler plants.

3.10.8 The lighting of buildings accounts for a major part of the energy consumption at an airport. Sometimes it is possible to reduce the requirement for artificial lighting by the introduction of more natural lighting — providing this does not add significantly to heat or cooling loads. Smart meters on individual buildings can have similar effects on a smaller scale.

3.10.9 Where artificial lighting is installed, it should be appropriately controlled and should use the most efficient, suitable light source. Paying close attention to the location of lighting and operating on the basis of time, ambient light levels, occupancy, etc., can lead to very worthwhile savings and can be self-financing. Since most light fittings produce heat, recovering this heat ensures that it does not add to the air conditioning loads of the building.

3.11 ENVIRONMENTAL EMERGENCIES⁷

3.11.1 Emergencies include fuel and chemical spills, and incidents involving dangerous goods or hazardous materials that may affect the environment. In order to respond effectively to environmental emergencies, the airport emergency plan and environmental emergency plan should include specific procedures to deal with such emergencies. These plans and procedures should be coordinated, and must clearly identify a predetermined sequence of communication and actions to deal with the various types of environmental emergencies. The plans and procedures must incorporate the elements of command, communication and coordination.

3.11.2 Environmental emergency planning should include the following:

- a) General:
- Table of contents;
 - Record of agreements;
 - Purpose of the plan;

7. Also see the *Airport Services Manual* (Doc 9137), Part 7 — *Airport Emergency Planning*.

- Geographic location of airport;
- Environmentally sensitive areas;
- Emergency telephone list; and
- Grid and reference maps.

b) Actions:

- Persons of authority — site roles;
- Major types of airport environmental emergencies;
- Site management/spill clean-up and restoration and remediation;
- Site hazardous materials inventory;
- Emergency equipment on site;
- Spill clean-up contractors, agencies and specialists;
- Monitoring, reporting and follow-up procedures;
- Media relation guidelines; and
- Training protocol.

3.11.3 Environmental emergency planning should incorporate the following steps for emergency response:

- a) **Secure:** Establish a hazard zone that will keep non-emergency response personnel out of danger.
- b) **Approach:** Approach from upwind to avoid coming in contact with vapours.
- c) **Identify:** Utilize placards and labels on containers to provide information on the product involved. The United Nations Product Identification Number (PIN) will provide information for personnel protection and spill response information. The exact identity of the products involved can also be found by examining the shipping documents.
- d) **Assess:** The following points should be considered:
 - Is there a fire?
 - Is there a spill or a leak?
 - What are the weather conditions?
 - What is the terrain like?
 - What is at risk: people, property or the environment?

e) **Respond:**

- Respond in an appropriate manner.
- Establish lines of communication.
- Establish line of command.
- Ensure coordination.

3.11.4 It is important that the airport emergency plan be tested on a regular basis and that corrective measures be taken immediately after an exercise or real incident where deficiencies in procedures are identified.

Chapter 4

INFRASTRUCTURE FOR ENVIRONMENTAL MANAGEMENT

4.1 GENERAL

Introductory comments

4.1.1 This chapter provides high-level guidance material on the infrastructure that can be included in an airport design which can enable and facilitate environmental management by the airport operator. The focus of this chapter is on facilities and infrastructure usually included in an Airport Master Plan.

4.1.2 While some consider airspace and its design to be airside “infrastructure”, those subjects lie outside the scope of this manual. Additionally, operational concepts are discussed in detail within the *Operational Opportunities to Reduce Fuel Burn and Emissions* (Doc 10013).

4.1.3 It should be noted that aviation safety is of paramount importance when considering airport infrastructure changes. For further information on ICAO aviation safety requirements, please refer to Annex 14 — *Aerodromes*. Risk management approach can be used to assess infrastructure and environmental management options. For further information on ICAO's guidance on using a risk management approach, see the *Safety Management Manual (SMM)* (Doc 9859).

4.1.4 At the national and regional levels, airport system planning can aid environmental management by accommodating future demand and distributing operations in a manner that reduces adverse environmental effects at individual airports. This also ensures that expected demand and capacity are addressed and overcapacity is avoided, which could result in unnecessary environmental impacts. The potential for impact reduction is particularly high at airports that are capacity-constrained or attempting to reduce a local environmental impact. The primary purpose of airport system planning is to study the performance and interaction of an entire aviation system to understand the interrelationship of the member airports. The “system” can be the airports of a metropolitan area, a State, or several bordering States. System planning involves examining the interaction of the airports with the aviation user requirements, economy, population, and surface transportation within a specific geographic area.

Overarching considerations

4.1.5 Some issues need consideration regardless of the infrastructure being developed. Airport planners and infrastructure designers should consider the ecosystem services of the existing environment when considering projects. Ecosystem services are the provision of services by the ecosystem itself, such as treatment of storm- water through wetlands. These services can be economically valued and incorporated into infrastructure planning.

4.1.6 Another overarching consideration is the life cycle cost and management of infrastructure being planned and designed. This will assist with better decision-making with regard to costs and best practices for long-term asset management.

Chapter structure

4.1.7 This chapter is organized into five subsections: Airport-wide, Airside, Passenger Terminal Facilities, Airline/Airport Support Buildings, Landside, and Environmental Aspects. The first four subsections present guidance on the infrastructure that can be included in an airport design, which can enable and facilitate environmental management organized by airport component (e.g. runway layout, terminal building, and landside facilities). Within each component, infrastructure options are discussed and the environmental benefits of the options are highlighted. The fifth subsection (Environmental Aspects) is environmental aspect-focused and re-emphasizes the prior information in terms of the environmental aspect that the infrastructure option benefits the most.

Airport siting

4.1.8 Appropriate siting of new airports is of vital importance to ensure that future environmental impacts can be avoided or mitigated. When considering a new airport site, many environmental and land-use planning-related considerations should be taken into account, including (but not limited to):

- meteorological conditions (e.g. prevailing wind direction);
- required space for airfield operations;
- required space for off-airfield impacts;
- geological conditions;
- potential natural or artificial obstacles;
- airfield layout;
- runway / taxiway layout;
- apron layout;
- ground transport access to the airport;
- location and design of terminals;
- locations of hangars and related installations;
- access to and reliability of utilities and services — e.g. waste water treatment;
- value of existing ecosystem services at proposed site; and
- existing and planned land uses in the vicinity of the site.

4.1.9 For new and existing airports, many of the above considerations, including managing the expected future requirements of an airport, can also be performed through the master planning process, as per the *Airport Planning Manual* (Doc 9184), Part 1 — Master Planning.

4.2 AIRPORT-WIDE

4.2.1 Landscaping

Plant species selection

4.2.1.1 Grass and other plant species should be selected taking into account the following considerations:

- Plants and landscape should not create a wildlife hazard.
- Type and extent of irrigation should be considered when determining the type of plants to include. Landscaping that requires little or no irrigation (xeriscaping) should be considered. Endemic or native plant species are usually best adapted to local climate and may require the least maintenance and watering. Temporary irrigation may be required to establish plants.
- Some plantings, such as trees that provide shade, can reduce local temperatures or solar heat loading during hot weather; however, care must be taken with regard to tree height to avoid penetrating protected airspace surfaces.

Wildlife hazard management

4.2.1.2 Wildlife at airports can be a hazard to safe aircraft operations. Though the airport operator is usually responsible for managing the hazard, wildlife management coordination with airport neighbours should be considered. An airport operator should develop a management plan to reduce the attraction of animals and prevent them from crossing the aerodrome perimeter. The *Airport Services Manual* (Doc 9137), Part 3 — *Wildlife Control and Reduction* should be taken into account during airport design in order to optimize future operational wildlife management actions. Some documents, such as the Airports Council International's *Wildlife Hazard Management Handbook* (second edition, 2013) can also provide useful information.

4.2.1.3 Items of particular importance regarding wildlife hazard management and the avoidance of providing water, food and shelter, include the following:

- water bodies, wetlands and drainage systems;
- plant species selection;
- structures or land forms;
- landfills and waste management; and
- activities on and off the site of the airport.

4.2.2 Storm water management infrastructure

Surface water quantity and quality control

4.2.2.1 To ensure a normal surface water discharge flow rate (hydrograph) is maintained, site drainage needs to be considered prior to all developments taking place. In some instances, settling ponds or vegetated swale drains can be installed to slow the rate of surface waters flowing off the site to a rate closer to the “natural” or predevelopment hydrograph.

4.2.2.2 Water quantity management also has the added benefit of collecting natural and artificial litter thereby allowing time for suspended sediments and pollutants to drop out of the water improving water quality. Pollution management systems designed to address the pollutants anticipated from airport operations should be installed in such a way as to be easily accessed and maintained. These systems typically include: oil/water separators, sediment traps, and de-icing facility drainage and recovery systems. Pollution management systems that mimic natural processes can be most effective and easier to maintain.

4.2.2.3 Systems should be designed for future conditions including potential for increased intensity of storms due to climate change.

4.2.2.4 For occupied buildings, waste water or sanitary drainage systems should be kept separate from storm water and surface water systems.

4.2.2.5 Settling ponds should be designed and located so as to not attract birds and wildlife, as discussed in 4.2.1.

Groundwater management

4.2.2.6 Attention should be paid to subsurface, groundwater (aquifer) management. Management of groundwater should aim to ensure that normal subsurface flows are maintained and the risk of contamination to the subsurface water bodies is reduced. For more information, please see the *Airport Services Manual* (Doc 9137), Part 2 —*Pavement Surface Conditions*.

4.2.2.7 Due to the large volumes of aviation fuel and other potentially hazardous products stored in and around airports, special attention should be given to ensure that the integrity of fuel storage and delivery systems are maintained. The use of oil/water separators and pavement sealer can be used to reduce the risks of contaminated surface waters from effecting groundwater. If the groundwater bodies are contaminated, then remediation works should be conducted to reduce pollutant levels to what is legally accepted.

4.2.2.8 Subsurface flow disruptions could include utility tunnels, trenches, dewatering activities and borrow pits. Activities such as these can interrupt the natural movement of the subsurface waters resulting in the interruption of subsurface water bodies' downslope. The placement of aviation facilities that have the potential to contaminate the aquifer may render downslope water supplies unstable.

4.2.2.9 Instances of groundwater rising to the surface as springs or as vernal or ephemeral ponds can be very important to the endemic biota and should be preserved where possible. This may also provide a water resource for the airport but should be monitored to ensure that it does not develop into a wildlife attractant.

4.2.2.10 In conjunction with construction activities where the ability for surface water to naturally percolate through the ground's surface is removed, natural groundwater recharge can be established. Through careful planning and design of features such as swale drains, groundwater recharge can be re-established with the added benefit of natural surface water hydrographs, also maintained post-construction activities. New landscape features, such as swale drains, should be monitored to ensure they do not develop into a wildlife attractant.

4.2.3 Pavement materials

Consideration should be given to the types of materials used for pavements, including runways, taxiways and aprons. The use of recycled materials in pavements, and recently developed techniques using warm-mix asphalt, can reduce the cost and impact of building pavements. The *Aerodrome Design Manual* (Doc 9157), Part 3 — *Pavements*, provides guidance on airport pavements.

4.3 AIRSIDE

4.3.1 Airfield layout

4.3.1.1 The layout of an airfield has a strong correlation with environmental management of an airport and its environs. Specifically included in the airfield layout context is runway layout, taxiway layout, airport capacity, hold pads/parking positions, and airfield lighting, each addressed below.

Runway layout

4.3.1.2 Runway characteristics such as orientation, length, placement, and threshold location can affect where the off-airport areas of high noise and emissions concentrations will be, as well as on-airport operational efficiency and the associated emissions. For more information, please see the *Aerodrome Design Manual* (Doc 9157), Part 1 — *Runways*. The following issues should be taken into account when designing the runway layout:

- prevailing wind direction;
- minimizing the distance of the runway(s) to the terminal(s) and cargo areas to reduce taxi fuel consumption;
- off-airport geographical features such as water bodies and elevated areas;
- off-airport land use (both existing and planned) such as residential and other noise-sensitive areas;
- allowing space for appropriately sized surface water drainage; and
- sensitive ecosystems such as wetlands, where impacts should be avoided.

Taxiway layout

4.3.1.3 An efficient taxiway layout can reduce aircraft fuel burn and emissions. Simulation modelling can be used to test possible taxiway layouts for efficiency and identify potential bottlenecks that can be mitigated during planning. Additionally, planning for possible future infrastructure needs while designing for current requirements should facilitate future development without the need for reconstruction or less than ideal geometry (e.g. plan for dual parallel taxiway separation if there is an expectation it may be needed in the future). Taxiway features to consider can include:

- dual taxiways that provide additional direct routes, which can help avoid holds or rerouting due to aircraft taxiing in an opposite direction;
- additional taxiways at runway entrances can provide space for intersection departures and optimal queuing and sequencing of aircraft, minimizing ground delay and idling;
- intersections and connections that allow efficient access from terminal and cargo areas to runway threshold;
- high speed exits or rapid exit taxiways (RET) can reduce runway occupancy time and allow landing aircraft to exit at higher speeds over more traditional perpendicular exits. More information on siting RETs can be found in the *Aerodrome Design Manual* (Doc 9157), Part 2 — *Taxiways, Aprons and Holding Bays*;
- placing RET and traditional taxiway exits at locations which minimize runway occupancy time for a large component of the current and planned fleet;
- end-around taxiways that can eliminate runway crossings, reduce taxi times and improve safety during peak periods; and
- Siting taxiways to avoid noise exposure to nearby noise-sensitive areas.

Airport capacity

4.3.1.4 An airport should be designed and built with sufficient capacity to meet demand, otherwise operational inefficiencies and delays can impact fuel burn and emissions. A general planning rule of thumb is that when an airport reaches 60 per cent of its capacity, planning for additional capacity should commence and when it reaches 80 per cent, design work for additional capacity should begin.

4.3.1.5 While runway, apron, and terminal capacity are fundamental, some airports could be limited by other issues such as ground transport access. In addition to the above suggested practice, additional lead time should be considered for surrounding infrastructure to support the airport, e.g. roads, water mains, and clearance of sites.

Hold bays/parking positions and related infrastructure

4.3.1.6 Aircraft holding bays and parking positions can be placed in the most appropriate position to increase efficiency and to reduce the need for long-distance aircraft relocation. See the *Aerodrome Design Manual* (Doc 9157), Part 2 — *Taxiways, Aprons and Holding Bays*.

4.3.1.7 New technologies for aircraft taxiing could have the potential to reduce fuel burn and emissions. Provisions may need to be made to include additional airside infrastructure for deployment of such vehicles.