THE JAMAICA AIR QUALITY MANAGEMENT PROGRAMME (JAQMP)

PREPARED BY
THE NATIONAL ENVIRONMENT AND PLANNING AGENCY

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GLOSSARY

Al	Aluminium
AMANDA	Applications Management and Data Automation
APB	Applications Processing Branch
APD	Air Pollutant Discharge
APDL	Air Pollutant Discharge Licence
APTI	Air Pollutant Training Institute
AQ	Air Quality
AQEC	Air Quality Evaluation Committee
Br	Bromine
CEO	Chief Executive Officer
Cl	Chlorine
CO	Carbon monoxide
CO_2	Carbon dioxide
COHb	Carboxyhaemoglobin
EB	Enforcement Branch
EHU	Environmental Health Unit
EMB	Environmental Management Subdivision Branch
Hb	Haemoglobin
HIA	Health Impact Assessment
IT	Information Technology Branch
JAQM	Jamaica Air Quality Management
JBI	Jamaica Bauxite Institute
KMR	Kingston Metropolitan Region
MOH	Ministry of Health
MOTW	Ministry of Transport and Works
MET	Meteorological
Na	Sodium
NAAQS	National Ambient Air Quality Standards
NEPA	National Environment and Planning Agency
NOx	Nitrogen oxides
NMIA	Norman Manley International Airport
NRCA	Natural Resources Conservation Authority
O_3	Ozone
OPM	Office of the Prime Minister
PAHO	Pan- American Health Organization
Pb	Lead
PM_{10}	Particulate Matter with aerodynamic diameter of 10 micrometres or less
PMA	Pollution Monitoring and Assessment
PRTR	Pollutant Release and Transfer Register
PUBED	Public Education and Corporate Communication Branch
SO_2	Sulphur dioxide
SOP	Standard Operating Procedure

SPPB	Strategic Planning and Policy Branch
SRC	Scientific Research Council
TSP	Total Suspended Particulates
USEPA	United States Environmental Protection Agency
UWI	University of the West Indies
V	Vanadium
VOC	Volatile Organic Compound
WHO	World Health Organization
XRF	X-ray fluorescence

Jamaica Air Quality Management Programme

Summary

The Jamaica Air Quality Management Programme is a strategic document geared towards achieving a quality of ambient air that is amenable to human and environmental health. The programme is designed to monitor those standards called criteria pollutants whose levels are important as it relates to public and environmental health in general.

The impact of air quality in some sectors of the society is a growing health and environment concern and the Government through its various agencies is responding to this concern. National Ambient Air Quality Standards and Air Quality Regulation have been gazetted and twenty-seven (27) facilities so far have been licensed based on these environmental laws.

This strategic document seeks to address the licensing of facilities in Jamaica as well as establishing a national air monitoring network that measures the criteria pollutants to support analysis of air quality parameters and health effect studies. It is a compilation of the approach being undertaken to achieve comprehensive management of air quality for the next six years.

The programme includes plans for licensing of air pollution sources, compliance monitoring, air shed development, research, review mechanisms, data management and quality assurance strategies. It identifies all the links, partnerships and functional units that are necessary for the effective management of air quality with the various stakeholders and the community showing the current situation and the activities planned to address them.

The final section of the document describes the capacity development needs of the stakeholders of the air quality management programme and provides a detailed budget for the first two years of the programme based on current market prices. One feature of the

Natural Resources Conservation Authority (NRCA) Air Quality Regulations, (2006) is the annual payment of discharge fees, as of 2010, based on annual pollutant loads, that is an identifiable revenue stream for funding elements of the programme.

Recognizing that the Agency's goal is the development of expertise in the various thematic areas, the programme is designed to focus on the development of competence in these phases. The approach adopted here is to engage a local environmental consultant during the first year. In addition to the exposure that the Officers in the Agency will be provided, benefits will accrue due to the attainment of familiarity with the different issues that will emerge. It is anticipated that after five to fifteen years, the wider range of experiences gained will contribute to a higher level of expertise in this subject area in Jamaica and the National Environment and Planning Agency (NEPA) in particular.

The development and expansion of technical knowledge, abilities and skills related to air quality management is intended to focus on subject areas that include source characterization, dispersion, ambient air quality monitoring, reviewing of licence applications, evaluation of air quality assessments, quality assurance and quality control for ambient and source monitoring, data management, risk assessment and risk management.

The programme for the next six years is sub-divided in phases that will span three cycles of the institutional corporate planning process, 2010 – 2016 that will aim to:

(I) Obtain a well-equipped mobile laboratory to facilitate response to pollution incidents and citizen complaints due to air emissions

(II) Develop and/or establish links with the local and international community in the analysis of air contaminants such as volatile organic compounds, dioxins, furans, mercury, lead

(III) Develop an in-house cadre of technical personnel with the relevant expertise in monitoring, air dispersion modelling, meteorology, forecasting and risk assessment

(IV) Establish a national air quality index

(V) Establish the emissions inventory to provide public access

(VI) Collaborate with the Ministry of Health in establishing the absence or presence of correlation between exposure to emission and deposition to public health through epidemiological studies

(VII) Participate in a regional air monitoring network

NEPA is mandated to capture information from stakeholders on the source characteristics such as emission inventory methods, estimation of emissions, witnessing and executing of source testing, dispersion of the emissions through the screening and detailed techniques and receptor modelling are important factors in the dispersion phase.

With the focus placed on the reviewing of licence applications and ambient air quality in the limited air sheds, the Agency has started to prepare a programme to address issues related to sustainability.

The administration of the programme will be effected by an administrative structure and procedures designed to achieve the set goals. The Natural Resources Conservation Authority will administer the legal requirements and support the budget and receive reports from the Chief Executive Officer who will chair the Oversight and Steering Committee.

The programme will be administered by an Oversight and Steering Committee, an Air Quality Evaluation Committee similar to the NRCA Technical Review Committee and Working Groups. The Working Groups will report to the Air Quality Evaluation Committee on the progress, goal attained and implementation of recommendations regarding the tasks assigned.

The start up budget required for the programme is JA$ 42,000,000.00 with a yearly recurring expense of approximately $2,000,000.00. The economic constraints will define the availability of funding for capital and recurrent expenditure. The funding of the programme will require a mix of funds from NEPA, the NRCA, donor agencies such as the Pan American Health Organization, the United Nations Development Programme and the Secretariat of the Stockholm Convention.

1.0 Introduction

Jamaica promulgated the first Air Quality Regulations in 1996, the Natural Resources Conservation Authority (NRCA) Ambient Air Quality Standards. Subsequently, in 2006 the NRCA Air Quality Regulations were promulgated to control air pollution from major and significant facilities. Under these Regulations, NEPA/NRCA issues Air Pollutant Discharge (APD) licences. To date, twenty seven (27) Air Pollutant Discharge Licences have been issued to the facilities (see Appendix 1). Under the conditions of the licences issued, facilities are required to monitor and report on the air quality at the sensitive receptors around their facilities based on the dispersion of the air emissions generated and discharged. The National Environment and Planning Agency is responsible for conducting verification monitoring of these facilities, in order to validate the results submitted by the facilities. However, there are gaps in the capacity of the Agency to deal with such monitoring both in terms of human resources and equipment.

It is important that the data collected are systematically documented and analyzed. These elements are only part of a broader air quality management program for the country. This document seeks to set out and to describe all the elements of an air quality management program for Jamaica. The gaps in the system that are revealed herein will form the basis for a proposal for funding towards a comprehensive national air quality management programme. The implementation of a management programme will focus on the achievement of its defined goals.

1.1 Air Quality Issues

The main sources of air emissions in Jamaica are:

- Industrial activities
- Transportation industry
- Environmental accidents
- Domestic sources
- Agriculture
- Fires

Air pollution has adverse effects on human health, wildlife, aquatic ecosystem, the built environment and on critical resources, such as ground water, forests, agricultural productivity and cultural resources. Poor air quality is experienced in urban areas and near some industrial facilities due to the generation and discharge of air emissions such as gases; namely sulphur oxides (SO_2) and nitrogen oxides (NOx), particulate matter (PM), fumes, smoke, lead, nickel, arsenic, some contributing to malodours.

Increased fuel use from industrial expansion and increased motor vehicle use affect air quality, as these activities release NOx, volatile organic compounds (VOCs), PM, ozone, carbon monoxide (CO) and SOx. Some of the increased health effects in the last decade such as respiratory tract infections, eye irritations, cardiovascular disease and skin irritations have been attributed to worsening air quality.

Fires from industrial, household, agricultural and municipal sources release gases such as CO, toxic chemicals such as dioxins and furans and particulates into the air that may affect individuals and communities over a wide area.

Compliance with the NRCA Air Quality Regulations accompanied by stringent enforcement will address both the major and significant industrial air pollution sources in Jamaica. There are currently no regulations for control of vehicular emissions.

1.2 Managing Air Quality for Sustainable Development

Sustainability with regards to good Air Quality will be assured if the National Ambient Air Quality Standards are monitored and maintained within the permissible limits for the pollutants as outlined in Appendix 2.

The Government of Jamaica has developed a Vision 2030 Strategy whereby Jamaica will be the place of choice to live, work and conduct business. This has implications for air quality.

The elements of sustainable development – society, environment, governance and economy, are inextricably linked. If air quality is at an unacceptable level, then the

human wellbeing will be impaired through increased morbidity and mortality and consequently economic activity will be negatively affected through reduced productivity. Additionally, investors may be discouraged from investing in a climate of poor environmental health leading to issues of competitiveness in trade.

Solutions for existing air quality problems to prevent exacerbation and suppress the release of other pollutants are essential

Although air quality regulations are in effect in Jamaica, capacity needs to be built for the review and processing of applications for licences and the monitoring and enforcement of conditions in the licences granted. The need exists for a data collection and management system to inform sound decision making by the regulator and the regulated community as well as the general public. In sustainable development planning, we must not lose sight of the materials balance principle for where pollutants are released into the air; it will surface again in the water, soil or biodiversity. Human health is paramount and we should not negate the role of solid waste management in the control of air pollutants. Rotting of organic matter contributes to the release of methane and carbon dioxide which are green house gases. Some waste material such as mercury (present in fluorescent light bulbs or used in mining gold) can travel thousands of miles on air currents before being deposited into marine sediments and find its way into the human tissue through the food chain.

The limits set in the standard may change due to new information regarding technological changes at the operational and analytical levels and health effects among the population.

1.3 Goals of Jamaica's Air Quality Management Programme

The goals of the air quality management programme in Jamaica for the next six (6) years include the following:

- To protect public health and welfare
- To prevent degradation of air quality in unpolluted areas in the country
- To control the emission of green house gases and priority pollutants
- To provide data and information to guide policy development and decision making.

- To provide information to the public on the status of priority air pollutants to guide personal and business decisions as well as educational initiatives
- To control pollution and satisfy environmental requirements
- To comply with the Government of Jamaica's obligation regarding international agreements

1.4 Requirements for Fulfilling the Limitations in Air Quality Management in Jamaica

Air Quality Management in Jamaica requires a determined effort to satisfy all the requirements in a sustained manner as outlined below:

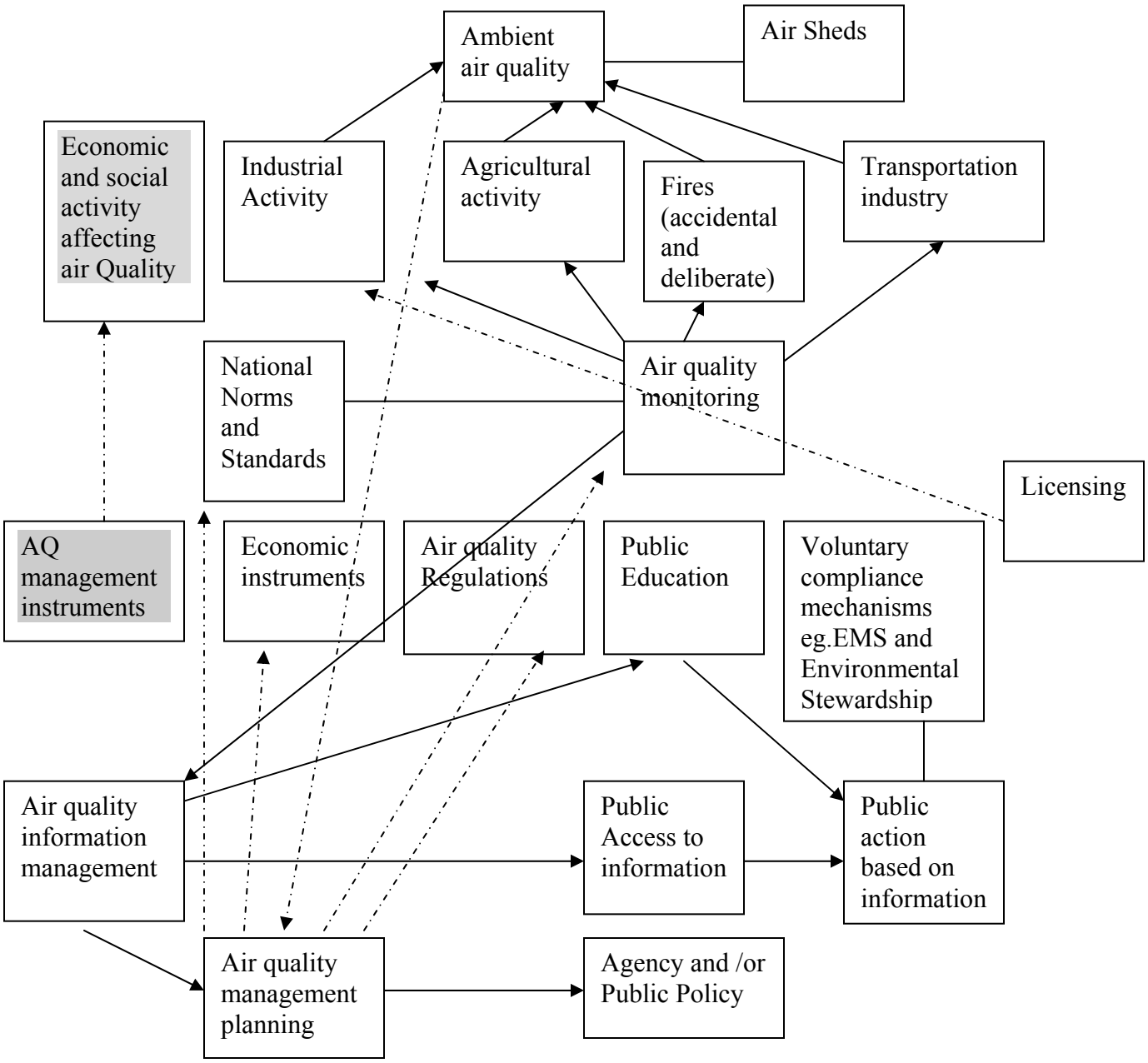
- Establishing the existence of links between epidemiological and air emissions data and their resultant effects on communities
- Addressing the lack of background ambient data and their relationship with health impact assessment
- Assessing the impact of pollutants in those cases where the permissible limits in the Standards are exceeded
- Identifying the facilities not originally included in the Air Pollutant Discharge Licence (APDL) system and developing plans to address their emissions
- Scheduling reviews of the air quality guideline document and recommending amendments
- Revisiting the need for additional training sessions or workshops
- Determination of Air Sheds
- Generation of air shed modelling Information and dispersion model
- Amending the Guideline document to address requirement for Health Impact Assessment (HIA)
- Where dispersion model over predicts pollutant fall-out, instituting the requirements for facilities to conduct ambient monitoring for direct measurements

These requirements will be addressed in the various phases of implementation of the programme through the different working groups assigned by the JAQMP Steering Committee and the Air Quality Evaluation Committee (AQEC).

2.0 Conceptual Framework

The Conceptual Framework presented in Figure 1 seeks to indicate the dynamic relationships among the elements that are associated with air quality management in Jamaica. International best practices will inform air quality management planning, instrument selection, standards and norms.

Figure 1: Conceptual Framework



3.0 Partnerships for Air Quality Management in Jamaica

The successful implementation of the Jamaica Air Quality Management Programme (JAQMP), the achievement of clean air in Jamaica and its maintenance, will be inextricably linked to the successful development and maintenance of a dynamic partnership. Collaboration among critical stakeholders will be necessary at all phases of the development and implementation of the JAQMP in the following areas:

- Strategic planning for air quality management
- Technical expertise as applied to air quality monitoring and analysis of results
- Air Quality data sources
- Research
- Capacity Building
- Epidemiological studies
- Policy direction
- Communication
- JAQMP steering and oversight
- Discharge of responsibility by the regulated community
- Funding
- Community

3.1 Strategic Planning for Air Quality Management

A partnership is critical for the definition of goals, setting of objectives, outputs and timelines and to function as a catalyst and focal point for the transformation of the vision for air quality in Jamaica into implementable or a realistic plan and desired outputs and targets. This role is filled by the Air Quality Evaluation Committee (AQEC). This committee is comprised of a team within NEPA headed by the Senior Manager for the Environmental Management Sub-Division and supported by consultants in the field of AQM. This committee reports to the Chief Executive Officer, who in turn will liaise with the NRCA Board. The committee will manage the JAQM programme and as such will define and liaise with segments of the wider partnership as required.

3.2 Technical expertise as applied to air quality monitoring and analysis of results

Although NEPA is the principal institution with responsibility for air quality management, the agency's present capacity for air quality monitoring is very limited and in any case, to be cost effective, entities that are in possession of air quality monitors must be encouraged to support the air quality monitoring programme. Collection, analysis, interpretation of data will require support from various entities, including UWI, which have passive monitors. As a requirement under the AQ discharge licences, facilities are required to monitor and collect air quality data at specified intervals. The Bureau of Standards and the Scientific Research Council are two other entities which will play a role in monitoring and analysis of results. The involvement of partners in monitoring and analysis will help to ensure more robust data sets and consequently more reliable information will be generated.

3.3 Air Quality data sources

Data will be needed from a variety of sources to meet the requirements for different elements of the management programme. Data will be required from the health sector, the regulated community, NEPA, NMIA (providing Met data to be used for dispersion modelling), JBI, MOH, MOT, UWI and SRC.

3.4 Research

Some of the research that is envisaged involves the research into monitoring methods and case studies of how other jurisdictions operate in specific areas. Some research (monitoring and assessment) needs to be conducted to determine if pollutants that are being detected locally could have moved in from other territories. Academia or funding partners may be asked to support this area.

3.5 Capacity Building

Training needs have been identified and even where staff within NEPA has been trained previously, an urgent need will be the on-going honing of competence through routine application of procedures. Communities will require some training or sensitization in the interpretation and application of the PRTR database when that is established. Partners

within UWI, PAHO, private consultants, Jamaica Bauxite Institute, the NRCA Board and international development partners, such as PAHO, may be asked to provide support in this area either through technical or financial support.

3.6 Epidemiological Studies

Part of the purpose for monitoring and analysis of air quality data is to determine the effects of air pollution on people within communities. The way in which data have been collected over the years in the health sector has not been capturing critical data to make the epidemiological and health connections. For example the health sector records will capture which patients have cardio-vascular or respiratory tract infection but there is no indication of where the patient was located when the condition was triggered (home, in transit, work etc.) The Ministry of Health, PAHO and NEPA will be important partners in this area.

3.7 Policy Direction

The analysis and interpretation of air quality data will provide information that can influence policy in Jamaica. The partnership to influence policy direction or change as it regards air quality, human health and development and education will include NEPA's senior management through the CEO to the NRCA and OPM. There will of course be opportunities for lateral linkages with other policies such as those of the Transport Authority.

3.8 Communication

Communication will be required at various levels. NEPA will be a key stakeholder in the area of communication and public awareness but the media will be pulled in to support. Communication will be necessary among all levels of the partnerships and those details will be worked out as the programme unfolds. Multiple channels will be used to ensure the broadest reach within the limits of resource availability.

3.9 JAQMP Steering and Oversight

Another partnership unit in the JAQMP takes the form of an Air Quality management oversight Committee (JAQMP oversight committee) that will provide direction and oversight to the JAQMP and will have specific responsibility for the evaluation of the programme as progress is made. The oversight committee will be comprised of representatives from UWI, Jamaica Bauxite Institute, PAHO, MOH-EHU and the CEO for NEPA. Some members of the AQEC will also participate on the oversight committee

3.10 Discharge of responsibility by the regulated community

The regulated communities have specific responsibilities articulated in the terms of their licences. NEPA will continue to partner with these entities to ensure that they discharge their obligations with utmost responsibility and in a timely manner.

3.11 Funding Partnerships

The JAQMP is a broad programme to be implemented over six years. The monitoring equipment is costly. As previous sections alluded, funding support will be critical to the successful implementation of the programme. Areas such as capacity building/training, equipment including air quality software for the AMANDA system and other aspects are itemized in the budget for the JAQMP. NEPA will look to its partners (NRCA, International Development Partners) and will continue to look for opportunities for funding support in the future.

3.12 Community

Communities will be involved through the Pollution Release and Transfer Register (PRTR) into which the air quality data will feed as part of the data management system. Access to information will help communities to take decisions about the activities of their daily lives that are impacted by air quality.

4.0 Community and Air Pollution

Air pollution in Jamaica is generated mainly from industrial activities and motor vehicles. There are other sources such as municipal dumps, backyard burning, forest fires as well as some that can be described as extra-territorial. Other jurisdictions have established relationships between activities, dispersion, fallout and damage to health and property. The extent of the impact on the economy and public health is virtually unknown. The mechanism to generate such information is in its developmental stage.

With the pattern of the development of land settlements in the vicinity of industrial facilities, roads and their construction and other sources that generate air emissions, the communities are exposed to any such air contaminants that are generated

4.1 Industrial sources

The main industries that contribute to air pollution in Jamaica are: bauxite\alumina, power (electricity) and steam generation, cement manufacturing, limestone quarrying, chemical processing, agro-processing, sugar manufacturing and petroleum refining. The rapid growth in the motor vehicle fleet has also contributed to the deterioration in air quality in urban centres, particularly in the Kingston Metropolitan Region (KMR) and town capitals. The petroleum refinery, cement manufacturing plant, power and steam generating plants are located in or in the vicinity of urban centres.

The direct impact of air pollution on community health in Jamaica is difficult to assess due to the lack of data related to the sources of generation, level of exposure of the affected population and the measured effect on mortality and morbidity rates. It is known that upper respiratory tract infections and cardio-vascular diseases are results of such exposure. However, there are gaps in the data as they relate to the physiology of the exposed, the toxicity levels and the dose-response dynamics.

The community of stakeholders in urban areas have been concerned about poor visibility, mal-odours and other air contaminants especially those located near specific facilities such as bauxite alumina refineries, mining areas and sulphuric acid plant. There are

reports of increased incidence of respiratory diseases in urban areas as well as in the vicinity of bauxite alumina plants in Jamaica.

4.2 Mobile Sources

Mobile sources emit nitrogen oxides (NOx), volatile organic compounds (VOCs), carbon monoxide (CO), sulphur dioxide (SO_2) and particulate matter into the atmosphere. In the presence of sunlight, VOCs and NOx undergo photochemical and thermal reactions that result in the formation of photochemical smog. VOC emissions from mobile sources include organic compounds such as benzene that are known carcinogens. The particulate emissions from motor vehicles can enter the human respiratory tract and these are sometimes carcinogenic and toxic.

The motor vehicle fleet in Jamaica doubled from 171,000 in 1993 to 348,000 in 1999 and rose to 453,084 by 2003; approximately 2.6 times the amount in 1993. Gasoline consumption also doubled from approximately 2 to 4 million barrels between 1993 and 2003. Of great concern though is the level of sulphur content in diesel (5000 ppm).

The results of a survey[1] of air particulates at 23 sites across Jamaica for total suspended particulates (TSP), aluminium (Al), bromine (Br), chlorine (Cl), sodium (Na), lead (Pb), and vanadium (V) analyzed by neutron activation (NAA) and X-ray fluorescence (XRF) were reported. The geometric mean of the TSP values obtained, 35 $\mu g/m^3$, are well within the World Health Organisation's Standard of 60 $\mu g/m^3$ for TSP, but in areas of high vehicular traffic density, the TSP values exceeded this limit. The correlation coefficient between Br and Pb concentrations in the particulates was 0.92 and the Br/Pb ratio of 0.38 compares well with a ratio of 0.39 found in commercial petrol indicating that the exhaust from vehicular traffic is the major source of Pb in atmospheric particulate matter in Jamaica.

[1] Davis M. et al "*Suspended particulates in the Jamaican atmosphere"*, Centre for Nuclear, Environmental Geochemistry and Health (1997), 19, 23-28

Information from the Ministry of Health indicates that there is a decline in the total discharges and prevalence of respiratory disease in general and asthma in particular among the age cohort 0-6 years. The data are presented in Table 1.

Table 1: Respiratory, Infectious and Parasitic Discharge, Period 2003 to 2007

Item	Year				
	2003	**2004**	**2005**	**2006**	**2007**
Total Asthma Discharges Among Children 0-6 Years	1042	830	1352	752	474
Asthma Prevalence Per 10,000 Population(Children 0-6 Years)	4	3.1	5.1	2.8	1.8
Total Discharges For Respiratory Diseases In Jamaica	11,606	10,300	10,966	7,745	5,983
Respiratory Disease Prevalence Per 10,000 Population	44.1	39	41.3	29	22.3
Total Discharges For Respiratory Diseases Children 0-6 Years	6,005	4,928	5,500	3,548	2,256
Respiratory Disease Prevalence Per 10,000 Population Children 0-6 Years	22.8	18.6	20.7	13.3	8.4

Source: Information from the Ministry of Health, Jamaica, 2009

It is likely that the elimination of lead from gasoline could be a contributory factor for the noted decline.

4.3 Non-Point Sources

Another source of air pollution is fire generated from sources such as dump sites, where such fires may last over several days, resulting in toxic air pollutants, dust and smoke. One can almost certainly locate the solid waste dump site by following the smoke screen observed in any township or

community. The smoke emanating from the Riverton City Waste Disposal Facility in the Kingston Metropolitan Area has been associated with the dense smog observed sometimes along the Spanish Town Road as well as over the Washington Gardens, Cooreville Gardens and Duhaney Park areas during the nights and early mornings. Results from air monitoring exercises conducted by the Ministry of Health's Environmental Control Division over a four week period in 1989 indicated that the levels of particulate matter in these areas where approximately seven to thirteen times above the limits, 150 micrograms per cubic metre ($\mu g/m^3$), recommended by both the National Ambient Air Quality Standards and the USEPA. The average readings over a period for selected sites using a high volume sampler were more than 1,000$\mu g/m^3$ and in some cases over 2,000$\mu g/m^3$. Data obtained in 2009, on particulate matter from ambient air samples collected at selected sites in the vicinity of the Riverton Landfill, indicating fall-out are presented in Table 5. By comparison, air samples collected at the same time at the University of the West Indies indicated levels of particulate matter within the range of 770 – 870 $\mu g/m^3$. In applying the Air Quality Standard of 150 $\mu g/m^3$, it was noted that concentrations in the peripheral areas of the Riverton City dump site ranged between approximately eight to fifteen times higher (1270 – 2230 $\mu g/m^3$), while those collected at the University of the West Indies, some six miles (9.7km) from the study area, showed that concentrations were approximately five to six times more than the allowable limit. Silva (1988) postulates that this situation, along with other sources of air pollution, may well be a major contributor to the high incidence of respiratory tract infections recorded for Kingston. It also, he argues, constitutes a major cause of discomfort and irritation, especially for those suffering from ailments such as asthma and certain eye conditions.

Table 2: Concentration of Particulate Matter in Air Samples Collected at Selective Sites in Fall-Out Areas of the Riverton Landfill, 2009

Location	Concentration of Particulate Matter, $\mu g/m^3$
Hermes Engineering,	1550

161 Spanish Town Road	
Hardware and Lumber 697 Spanish Town Road	2230
Asphalt Paving Co. Ltd. 707 Spanish Town Road	1270
Cremo Ltd. 282 Spanish Town Road	1340
Ferry Police Station, Mandela Highway	1290

4.4 Health Impacts

The low burn temperature and incomplete combustion of refuse when burnt contribute to fires at landfills and waste disposal sites. This emits a variety of pollutants that have the potential to affect the health of people exposed to the air emissions discharged. The risk or degree of harm depends on a variety of factors including:

- type(s) of refuse being burnt;
- concentration of pollutants discharged in the air emissions ;
- sensitivity or pre-disposition of the individual exposed;
- duration of exposure; and
- the ratio of the products of combustion in the smoke plume.

Although there are many harmful pollutants produced in landfill, waste disposal and household garbage fires, the pollutants of most concern are: particulates, carbon monoxide, acrolein and formaldehyde.

4.4.1 Particulates.

Smoke consists of the products of the incomplete combustion of the fuel source. All particles exist in either aerosol or solid form at normal temperatures. The characteristics of smoke particles are influenced by the fuel being burnt and the characteristics of the fire. It is often difficult to separate the effects of particles from those of gases that may also be present. Exposure to smoke particles can, however, reduce the ability to breathe,

and reduce resistance to disease. Existing respiratory conditions may also be aggravated. Those with a greater pulmonary sensitivity, for example asthmatics, may show a much greater reduction in lung function than others.

4.4.2 Carbon Monoxide.

Carbon monoxide (CO) is an odourless, colourless and tasteless gas produced through the incomplete combustion of biomass fuels and is less abundant than carbon dioxide (CO_2). It is poisonous to humans. Carbon monoxide is readily absorbed from the lungs into the bloodstream, where it is bound to the haemoglobin (Hb) molecules in the blood in preference to, and more strongly than, oxygen, forming carboxyhaemoglobin (COHb). COHb replaces the capacity of the red blood cells to transport oxygen. Generally, a level of *5%* carboxyhaemoglobin results from 3 to 4 hours exposure to CO concentrations of 35 ppm and may result in people showing signs of disorientation or fatigue.

Carbon monoxide poisoning produces headache, weakness, dizziness, confusion, and changes to heart rhythm. It is a common by-product of the incomplete combustion of fuels such as paper, cardboard and wood.

CO is produced more abundantly from smouldering combustion of forest fuels. Immediately following the cessation of flaming combustion, maximum levels of CO are produced. This phenomenon coincides with suppression activities, especially where direct attack methods are being used. As the flames subside, CO is released at the highest rate and, typically, continues at a high rate during the first few minutes of the die down period. For fires burning under high drought conditions, the smouldering combustion can be self-sustaining and consume deep into the duff and in some cases soil, where the organic component of the soil makes up more than *30%* of the total. Tremendous amounts of smoke can he produced under severe conditions, sometimes sustained for days and weeks.

4.4.3 Aldehydes.

A few aldehydes are extremely irritating to the mucous membranes of the human body. Some, such as formaldehyde, are potentially carcinogenic and in combination with other irritants may cause an increased risk of carcinogenesis.

Formaldehyde is one of the most abundantly produced compounds of this class and is released proportionally to many of the other compounds of incomplete combustion. In the human body, formaldehyde is transformed rapidly to formic acid, which is removed very slowly. The ability of scavenger cells in the lungs to engulf foreign bacteria is decreased through exposure to aldehyde compounds. These may accentuate infections of the respiratory system. Exposure to low atmospheric concentrations of formaldehyde causes irritation to the eyes, nose and throat, coughing, bronchial spasm and irritation of the lungs, and dermatitis. Discomfort increases rapidly with increasing exposure. Asthmatic symptoms may occur due to the development of allergic sensitivity and kidney damage may occur with prolonged or excessive exposure.

Acrolein, another aldehyde, is also emitted during incomplete combustion of forest fuels and in smoke from cigarettes. It is approximately ten (10) times more abundant than formaldehyde. According to Dost (1986), acrolein concentrations could be as high as 0.23 to 23 mg/m^3 near fires and likely to increase the irritant character of smoke near fire lines. The threshold levels of acrolein that cause irritation and health effects are 0.07 mg/m^3 for odour perception, 0 13 mg/m^3 for eye irritation, *0.3* mg/m^3 for nasal irritation and eye blinking, and 0.7 mg/m^3 for decreased respiratory rate (WHO, 1991) In animal studies, both respiratory tract function and histopathological effects have been observed at 0.5 - 0.8 mg/m^3 continuous exposure. (WHO, 1991). Exposure to low concentrations of acrolein can cause irritation of the respiratory system, nose and eyes, salivation, watering of the eyes (lacrimation), and mild intoxication (narcosis). Higher concentrations have been found to cause fluid on the lungs (lung oedema).

4.4.4 Other Pollutants.

The following pollutants may also be present in air emissions discharged from burning. These include ammonia; benzo (a) pyrene, hydrogen bromide, hydrogen chloride, hydrogen cyanide; hydrogen fluoride, isocyanates, nitrogen oxides, phenol and sulphur dioxide. These are all toxic to humans in some way, depending on the concentration and level of exposure. They can result in irritation to the eyes, nose, throat and skin as well as cause respiratory problems. Some are also carcinogenic.

4.5 Community Involvement

Information on the objectives of this programme, emissions from licensed facilities, air shed monitoring will be made available to the community based on the principle that the 'Community Needs to Know'. The Agency will establish the country's emissions inventory through its data management function and will invite comments from air quality consultants and other stakeholders to assist the improvement of the programme. It is anticipated that the community will serve as first responders for the Agency in the reporting of incidents that release air pollutants and assist in minimizing their contribution to such releases as well.

In the development of the Air Quality Regulations, extensive consultations were conducted with the communities identified to be affected by air pollutants. NEPA introduced the concept of Regulatory Impact Assessment. Using this mechanism, the air quality issues in Jamaica, the extent of the problem, the need to address the issues and the best approach to adopt were considered. This concept will be used to retain confidence in the approach.

5.0 Air Quality Monitoring Plan

Within the framework of managing air quality in Jamaica, the NEPA is tasked to lead the programme. The Pollution Monitoring and Assessment (PMA) Branch at the NEPA has the primary responsibilities for conducting ambient air quality monitoring and addressing pollution incidents with respect to air emissions. The Air Quality Monitoring Plan will address the need for increased monitoring capabilities and thereby improve the effectiveness of the Agency in the protection of the environment. The Plan presents a summary of the current monitoring capacity and layout the strategy for the next three (3) years of the programme. The plan should present both short and long term solutions to problems identified.

The Air Quality Monitoring Programme commenced in 2004. Since then, the monitoring of ambient air quality for critical air pollutants such as particulate matter measured as Total Suspended Particulates (TSP) and Particulate Matter < 10 microns (PM_{10}), sulphur dioxide (SO_2) and nitrogen oxides (NOx) as nitrogen dioxide (NO_2). Other important parameters which have not been monitored include carbon monoxide (CO), dioxins, furans, lead, mercury, volatile organic compounds and ozone (O_3). There are two noteworthy aspects, namely, the establishment of an air quality management system and the relationships between components and the technical knowledge and skills related to air quality management.

The 1996 National Ambient Air Quality Standards (NAAQS) Regulations apply to the group of pollutants known as critical air pollutants for which there are permissible limits for TSP, SOx, NOx, CO, lead, photochemical oxidants measured as ozone.

5.1 Current Status

Ambient air quality monitoring is presently being conducted at three locations; 10 Caledonia Avenue (NEPA – Head Office), 110 Old Hope Road (PMA Branch) and Harbour View. Pollutants assessed include TSP at all three locations and PM_{10} at the Cross Road and Hope Road locations.

On February 13 2007, in response to several complaints of dust nuisance from industrial activity, a fourth monitoring site (for TSP) was added in Discovery Bay, St. Ann. Monitoring at this site was eventually discontinued due to a lack of functional monitoring equipment. The final monitoring date for Discovery Bay was September 24, 2009.

Sampling for SO_x and NO_x gases was suspended in September 2007 due to a lack of functioning equipment.

5.2 Objectives

The Air Quality Monitoring Programme is designed to:

- identify gaps in the existing monitoring activities
- build the Agency's capacity to monitor air quality
- procure air monitoring equipment for critical air pollutants and other selected air pollutants of interest
- maintain air monitoring equipment to provide reliable and accurate data
- develop and run models to identify suitable ambient monitoring stations in each air shed.
- provide information on pollutant levels to guide policy decisions
- map point sources and pollutant releases.
- review and assess data submitted by air discharge licensee
- develop standards for $PM_{2.5}$
- detect releases from pollution incidents and non-point sources
- procure, commission and maintain a well-equipped mobile laboratory to facilitate response to pollution incidents and citizen complaints due to air emissions
- develop and/or establish links with the local and international community in the analysis of air contaminants such as VOCs, dioxins, furans, mercury, lead
- plan the inclusion of real-time monitoring of air quality
- provide data to support the establishment of a national air quality index

5.3 Air Quality Management Systems

It is imperative that the relationships between components of the air quality management systems are identified and the relations established and synchronized. The components of concern are:

i. Sources/emissions
ii. Dispersion/deposition
iii. Monitoring
iv. Effects of air pollution
v. Sources and receptor modelling
vi. Assessment of Information
vii. Regulations and policies

5.4 Ambient Monitoring Standards

The results of the ambient air monitoring exercises are assessed against the National Ambient Air Quality Standards for Jamaica that are presented in Appendix 2. It is important to note that in interpreting these Standards, there are certain specific considerations that should be applied. These include:

- all air quality measurements specified in mass per unit volume are to be corrected to 25˚C and 101.3 kilopascals,
- TSP- all particles and aerosols with aerodynamic diameter of 100 micrometres or less and can be measured by the high volume sampling method,
- $PM_{10,}$ refers to particles with aerodynamic diameter of 10 micrometres or less and can be measured by a PM_{10} sampler.

The secondary standards for sulphur dioxide are designed to protect public health and welfare. They represent the long term goal for air quality and provide the basis for an anti-degradation policy for unpolluted areas of the country and for continuing development of pollution control technology.

5.5 Implementation

The implementation of the ambient air monitoring programme will be phased in over the period 2010 -2016 with a revision each year. The current monitoring regime will continue and will be incorporated into the new strategy. This will ensure that historical data are not lost while improvements are put in place. This will involve collaboration with other agencies and institutions using existing and new monitoring sites.

5.5.1 Collaboration with other Agencies and Institutions

To implement the programme requires a multi-disciplinary approach that is likely to involve government agencies and institutions beyond our territorial boundaries. Without accurate information from such bodies, tracking of long-range transport and deposition from other countries into our jurisdiction and also intra-island transport and deposition of air emissions would be time-consuming and costly for NEPA. In addition, such collaboration at varying levels would contribute to the exchange of information on emerging technologies and impacts resulting in a revamped approach to monitoring air quality.

Real-time monitoring in the development and maintenance of a National Air Quality Index is intended to provide information as a national service to assist in the improvement of the air quality to the vulnerable in those communities that are likely to be exposed to gases and particulates.

The Ministry of Health is currently a partner in this programme with a particular interest in the impact of exposure to air emissions on the population through health impact assessments. These assessments will focus on the vulnerable groups whose members include the elderly, the young and the challenged in the population with compromised cardio-vascular and respiratory systems.

The Ministry of Transport has the responsibility to develop Motor Vehicle Emission Regulations to address poor air quality issues especially in urban areas and growth

centres. The NRCA has developed Motor Vehicle Emission Standards and revised them in 2003. These were subsequently submitted to the Ministry of Transport.

The monitoring of road intersections to detect motor vehicular emissions of TSP, VOCs, SOx, CO and NO_x would be necessary in the monitoring of the quality of air in urban and growth centres.

5.5.2 Ambient Monitoring Sites

As noted in the Air-Ambient-Guideline 2006 document, the selection of ambient monitoring sites includes:

- developing and understanding the monitoring objectives and appropriate data quality objectives
- identifying the spatial scale most appropriate for the monitoring objectives of the site
- identifying the general locations where the most sites should be placed
- identifying specific monitoring sites

The type of ambient monitoring stations selected for the sites will be determined on the basis of the most suitable category of the following four that synchronizes with the pre-determined monitoring objective. The categories are:

- **Compliance Stations** - used to assess compliance with a granted licence.
- **Population Exposure Stations** - used to assess population exposure to pollutants.
- **Background Stations** – used in remote areas; minimal influences from air pollutants.
- **Special purpose monitoring stations** – usually short term.

For populations >500,000 persons, more than four (4) monitoring sites are required to monitor adequately the exposure of the urban population to particulate matter. NEPA currently has two stations set up within the Kingston Metropolitan Area, an urban centre that exceeds 500,000 residents.

It must be noted that the three air monitoring sites at which NEPA monitors TSP and PM_{10} were chosen based on ease of access, wind direction, terrain, the presence of industrial activity and possible source points, availability of electricity and the security of the monitoring equipment. These criteria were used at the initial commencement of the programme. Future identification of sites will include the aforementioned considerations in addition to:

- available resources and monitoring costs
- logistics
- security of personnel and equipment
- meteorological considerations
- topography
- pollutant considerations
- instrument enclosure requirements
- electrical needs
- sample inlet line characteristics
- sample probe placement characteristics
- distance from roadways
- air dispersion modelling
- emission points

Additionally, any information garnered from the dispersion modelling of various pollutants from point sources will aid in determining compliance stations together with the consideration on the prioritization of different air sheds.

5.5.3 Expansion of Monitoring Sites

Consideration has been given to expanding the existing monitoring programme to sections of the island outside of the Corporate Area. The extent of the expansion of monitoring sites hinges on the capacity of the Branch to facilitate this function. Therefore, the programme will be implemented on a phased basis to coincide with the

availability of equipment and the improvement in technical expertise. Initial expansion is being proposed for:

- Montego Bay, St. James
- Mandeville, Manchester
- Portmore, St. Catherine
- Ocho Rios, St. Ann
- Discovery Bay, St. Ann
- May Pen, Clarendon
- Negril Westmorland

5.5.4 Ambient Monitoring Procedures

The operating procedures utilized for ambient monitoring of gases and particulates are guided by the manufacturers' recommendations outlined in the accompanying manuals. In addition to equipment calibration and verification by the Jamaica Bureau of Standards, quality assurance measures will continue to be implemented to aid in the identification and control of errors in analyzing for the pollutants.

Recommendations such as annual calibrations will continue to be strictly adhered to in accordance with the internal calibration schedule.

Internal and external quality assessments are incorporated in the analysis of the parameters and include evaluation of the quality assurance data obtained and independent performance audits

Quality control measures in the field take into account the location of the samplers and analyzers, handling, use of field blanks, avoidance of cross contamination and monitoring flow rates within the acceptable range.

5.5.5 Monitoring Schedule

Monitoring schedules will be prepared and conducted in accordance with the guidelines for measuring specific parameters, namely:

1. Every six days for TSP, PM_{10} and lead

2. Continuous monitoring for sulphur dioxide, photochemical oxidants, carbon monoxide and nitrogen dioxide

5.5.6 Maintenance of Equipment

The calibration requirements of the equipment are identified in the instruction manuals provided with each. In addition, it is recommended that annual calibrations be conducted. A calibration and maintenance schedule must be developed and implemented.

5.6 Response to Pollution Incidents

While the PMA Branch has the primary responsibility to respond to pollution incidents, with respect to air pollution, liaison with the Enforcement Branch and or the Pollution Prevention Branch will be necessary for complete assessment, review and restoration. The standard response time to pollution incidents is within twenty-four (24) hours of receipt of the complaint as stipulated.

5.7 Compliance Monitoring

Verification checks of licensed facilities (private and public industries) will be conducted at least once per year or as required through the examination of reports submitted to the NEPA. Investigating officers will be required to use the form noted below during the inspection of facilities. Included in these checks will be the examination of any monitoring equipment being utilized at the ambient monitoring stations.

The compliance checklist will identify monitoring equipment, compliance plans, modification & maintenance records, stack testing capabilities etc. See Table 3. The data obtained in Compliance Reports will be used to create a map of population exposure, aid in the creation of air sheds and identify the most suitable ambient monitoring sites.

Table 3: **Compliance Checklist**

Name of Facility (Licensee):	( ) existing Plant ( ) Major Modification ( ) New Plant	Existing air pollutant discharge Licence Number:
Type of Facility	Date of Site Visit:	File #:
( )Major ( ) Significant	Location:	Project Name:
Parish:	Watershed:	Major Land Uses nearby:
Air shed:		
Compliance History		
Date of last visit:	Was Facility in Breach? ☐ YES ☐ NO	Details (Attach report if necessary)
Air Pollution Incidents		
Have there been any Pollution Incidents in past year?		Date and Time of Incidents
Were these reported to NEPA?		Details (Attach report if necessary)

SOURCE INFORMATION				
1. Are sources listed in the application still in use				
Compliance questions	**Yes**	**No**	**N/A**	**Comments**

1. Are current conservation activities being instituted				
2. Is there any device or procedure being developed or currently in place to reduce emissions to the community				
3. Is the Sulphur content of the fuel in use at the prescribed level that is required in the permit				
AMBIENT MONITORING EQUIPMENT				
1. Is the equipment used in carrying out the process maintained and kept in good repair according to the manufacturer's recommendations, or in such better manner or at such greater frequency as operational experience may show to be appropriate.				
2. Are all the sampling and monitoring equipment required to comply with the terms and conditions of the licence, being inspected and calibrated in accordance with the manufacturer's recommendations, or in such better manner or at such greater frequency as operational experience may show to be appropriate				
3. Is there safe and adequate access to all sampling and monitoring points?				
RECORDS KEEPING				
4. Are there any amendments to records				
5. Is the original result legible and is the amendment signed in by authorized person to do so				
6. Copy of Licence(s) present on site				
7. The Licensee must maintain a log of all written				

complaints and verbal complaints received that specifically refer to air pollution concerns associated to the permitted facility. Is a complaints log maintained?				
MODIFICATION/MAINTENANCE TO EXISTING EQUIPMENT				
8. Are there current modifications or maintenance being carried out on process equipment?				
9. Do these modifications or maintenance have implications for emissions discharge?				
10. Was this action reported to NEPA as required in conditions of AQ discharge permit granted to facility?				
11. Is any device installed to mask emissions of any air contaminant?				
MONITORING OF EMISSIONS				
12. The Licensee shall make available a map to be on site showing emission point sources. Is emissions point source map available on site?				
13. Sulphur Dioxide monitored continuously				
14. Nitrous oxides monitored continuously				
15. Total Suspended Particulate (TSP) monitored every six days or more				
16. Particulate Matter (10microns) PM_{10} monitored every six days or more				
17. Carbon Monoxide monitored continuously				
18. Any indication of green house gases that are being emitted that were not reported.				
COMPLIANCE PLAN				

19. Has facility begun implementation of compliance plan?				
20. Is the facility adhering to compliance plan set forth in application?				
STACK TESTING (compliance required penultimate year before renewal of permit)				
21. Sampling ports adequate for test methods applicable to the facility				
22. Safe sampling platforms or other suitable and safe structures or equipment, permanent or temporary, mobile or stationary				
23. Safe access to sampling platforms				
24. Testing equipment and utilities for sampling				

5.7 Data Management

NEPA is mandated to capture information from stakeholders on the source characteristics such as emission inventory methods, estimation of emissions, witnessing and executing of source testing. A robust data management system that is reliable, secure, accessible to users is being considered for development.

The Agency has a database for all ambient air measurements; weights, atmospheric pressure and temperature that will continue to be recorded, stored in a field data collection log, entered in a database in the Windows Excel format.

The existing database will be expanded to allow for easy dissemination of information on request and to accommodate data generated from remote sensing techniques. Such a database that can manage and process the various inputs will be required for greater utility value. The development of a National Air Quality Index and participation in regional air quality networks will rely on reliable air quality data for forecasting.

5.8 National Emissions Inventory & Pollutant Release and Transfer Register (PRTR)

Pollutant Release and Transfer Registers (PRTR) are environmental databases or inventories of potentially hazardous substances and or pollutants released into the environment (air, water and soil). The information provided in reports submitted to the Agency and data collected during ambient monitoring will be incorporated into the database. The National Emissions Inventory will track air quality within defined air sheds.

5.9 Tracking the Effectiveness of the Air Quality Regulations

NEPA is mandated to capture information from stakeholders on the source characteristics such as emission inventory methods, estimation of emissions, witnessing and executing of source testing. Dispersion of the emissions through the screening and detailed techniques and receptor modelling are important factors in the dispersion phase.

To evaluate the effectiveness of the NRCA Air Quality Regulations, a system developed to evaluate the data generated from the monitoring activities will serve as a platform critical to the process. Evaluation and performance measures and/or indicators will allow the assessment of the effectiveness of NEPA's air quality programme for Jamaica. Special attention would be given to the following:

- changes in the emissions inventory
- trends in ambient air quality
- discharge fees
- processing time for licences
- trends in violations, warnings, penalties, rates of achievement of compliance plans and other targets.

6.0 Air Shed Development Plan

Air sheds are areas where the movement of air tends to be limited by topography or meteorology. Air shed planning, by extension, is a stakeholder-driven process to coordinate and manage the activities affecting air quality in a defined area and a tool being used for the Air Quality Management Programme.

The air shed planning process consists of, but is not limited to, six fundamental stages:

1. Evaluation of the need for a plan
2. Identification and engagement of stakeholders
3. Investigation of planning synergies
4. Determination of priority sources
5. Development of the plan
6. Implementation, monitoring and reporting

Each step in the process, although fostering the development of an ideal plan, may be subject to modification due to the dynamics of the country's environment. Therefore, careful consideration would have to be made by the Air Quality Management Working Group that is given the task by the Air Quality Evaluation Committee to develop the regional plans for the country.

6.1 Evaluation of the Need for a Plan

The following considerations should be made when evaluating the need for an Air shed plan in a community or area in Jamaica:

- How severe are the air quality problems?
- What are the numbers and kinds of emission sources?
- What are the prospects for growth and future degradation of air quality?
- Is there community support for Air shed planning?
- What are the relative benefits of the planning process and what resources are available to conduct it?

Prior to the development of an air shed, necessary information such as dispersion modelling reports, ambient air quality monitoring data and significant emission points are essential to make an evaluation of the need for the plan in an area. Data and statistics on morbidity and mortality rates in relation to respiratory illnesses occurring in communities will be solicited from the Ministry of Health and other relevant agencies. Lack of data from private institutions is identified as a gap. The Agency will devise a strategy to obtain this information.

Ambient monitoring and modelling data need to be updated to give the decision makers critical wind and dispersion data. A significant gap in this area is the absence of carbon monoxide emissions from vehicular traffic and would be addressed in the monitoring plan of the JAQMP. Maps are being developed to provide current information on point, volume and area sources, flue types and flue rates of emissions discharged from licensed facilities in the country. This will enable the Committee to:

- determine the number and types of emission sources,
- determine a realistic projection on growth and degradation of air quality, and
- apply conditions for mitigation in future licences, policies and development plans of the country.

An important stakeholder in air shed planning is the community to be targeted for implementation. Awareness of the community in the areas selected would be raised through interaction with the members. Community support is vital for success. The community, with the technical support of the Agency, will be responsible for the continued development of individual plans.

The benefits of such a plan are the improvement in health and environment conditions for the residents, migratory workers and visitors, and Jamaica. The determination of required resources will be unique for each area and hence, an overall assessment will be made in the JAQMP and included in the budget.

The evaluation of the need for a plan is necessary because many areas in Jamaica may require a different type of management structure or additions to the Air shed plan.

6.2 Identification and Engagement of Stakeholders

In the identification and engagement of stakeholders in the defined air sheds, the following will be taken into consideration, but not limited to**:**

- Community structure and mandate
- Leadership
- Participation and
- Decision making process

After the first step of the process has been completed clear indicators of which areas and approach to the areas designated for air shed plans will have been indentified. Management structures in each area will have to be determined for smaller communities where resource allocation is significant. The way forward is to engage the community through community focus groups or youth groups and for them to form a committee. Provide the necessary basic training for persons in terms of data collection and reports. These communities will be categorized into regions and a member of the JAQMP committee responsible for the technical support and management of each region. He or she will liaise with his region and all necessary information as well as data and reports will be submitted to him and presented to the plan monthly meeting of the AQEC for review and guidance. The head of the community's committee will also be invited to the meetings. The necessary information will be filtered back to the community and if any technical and financial support is needed it will be identified and way forward suggested, and the submission prepared and made to the board of the Agency.

The AQEC committee will take direct responsibility for large regions and communities such as the corporate area and Spanish Town.

Leadership of the program falls under the purview of the Environmental Management Subdivision Branch of the National Environmental and Planning Agency (NEPA). Participation of all the previously mentioned stakeholders will be vital to the success of the plan. In developing a plan for an area we may need to do a modelling report as well as other additional information may be needed that cannot be sourced from the Agency. The

awareness of this coordinated effort will be made extremely clear as well as incentives and reimbursements will be included in the budget of the JAQMP.

6.3 Investigation of Planning Synergies

Energy, transportation and development activities are directly related to the release of air emissions and can directly affect air shed management plans. Hence, the importance of creating synergies as a part of the planning strategies, within various agencies in government, is important to the overall success of the plan. Due to the wide variety of technical support and expertise available from the staff members of NEPA, investigation of planning strategies will not be difficult to execute. All existing and developing plans that bear relevance to air shed plans will be reviewed and necessary recommendations made to satisfy the stakeholders. In the development of air sheds, existing development orders and local area plans play an important role in the determination of likely economic activities such as industrialization that may occur. Such thorough reviews would contribute to the setting of realistic targets for air sheds. The outcome of the review process will influence the decision that may affect making necessary adjustments and compromise to achieve the various goals of the different plans.

In the event that difficulties and gaps remain that may need to be resolved, the AQEC will be able to make necessary submissions to the Authority to procure the required resources.

6.4 Determination of Priority Sources

A vital step in the planning process is to confirm the pollutants of concern from the evaluation of the need for a Plan (See 6.1) and to identify the corresponding priority emission sources that require action. At this stage, air shed goals should be clearly defined. For instance, one goal could be continuous improvement across all sectors as opposed to targeting the single largest air pollutant source. Another consideration to be taken into account is the determination of what is achievable in the short- and long term: for example, realizing “some early winners" versus larger reductions in emissions that will take more time to implement. There are a number of techniques for use in the identification of priority sources depending on their complexity. These are:

- Emissions Inventory
- Additional Information on priority sources:
    1. Local air quality and meteorological monitoring data are needed to assess the conditions under which poor air quality is experienced
    2. Detailed "micro" emission inventories to more accurately characterized local sources and support dispersion modelling studies.
    3. Dispersion and/or receptor models for estimating how much various sources affect air quality

This step in the process will be expounded upon in the meteorological data and monitoring plans of the JAQMP. All creation of data bases, collection, analysis and interpretation of data will be made by the AQEC after implementation. The development of emission inventories and collection of meteorological data as well as dispersion models are all fundamental tools of the entire JAQMP. Sources of funding as well as procurement requirements will be vital in the initial stages of implementation. All these tools will determine priority sources, guide decision making for improvement and the highlighting of focus areas in proposed air sheds.

6.5 Development of the Plan

Continued development and improvement of individual plans for air sheds will be high on the agenda of the AQEC. This continued development will be divided as follows:

- Air Quality Management Goals
- Indicators and Targets
- Strategies and Actions
- Plan drafting and sign-off

Although individual goals are going to be developed for each identified air shed, they should be aligned with the overall goals of the JAQMP.

The individual Working Groups will be expected to set targets and use indicators in the air shed to determine the strategies and actions to be taken to meet them. The AQEC will

assist in giving guidance and technical support as well as ensuring that the goals that are set are realistic, conform with the overall plan and attainable within the agreed timelines.

All planning strategies together with details of the availability of resources will be submitted to the AQEC. Where feasible, the proposals would then be submitted to the Authority for ratification.

6.6 Implementation, Monitoring and Reporting

The implementation of air shed plans will be subject to the completion of relevant databases, carrying out of activities outlined in the monitoring plan and the development of the infrastructure for the monitoring and meteorological stations. If the setting up of an electronic or remote sensing monitoring system which flows into a database is successful, then monitoring will fall squarely on the shoulders of the Agency. If this system is not successful, monitoring will be done by a number of owners of air pollutant sources external to the Agency. These sources include facilities, communities and government agencies.

Data are expected to be submitted in the form of reports and manually put into the Agency's existing database. This could slow down significantly the process and could affect the non-achievement of set timelines for the implementation of various sections of the Air Shed development Plan and the JAQMP.

Monthly Reports will be prepared by the Environmental Management Subdivision branch of NEPA and submitted to the AQEC committee to be reviewed and used at the monthly meeting to guide decision making and acquire information about trends and developments in an Air shed.

The suggested approach by the committee will be to create a model Air shed in the Kingston region and study and develop it for at least two years and then use the model for future expansion to other areas of the island.

7.0 Meteorological Data

There is a direct relationship between meteorological data and the spread of pollutants as well as the amount of fallout that takes place from an emission source. This is because the upper and lower atmospheres are the main transmitters of air pollutant emissions. Just as the weather can be forecasted, so can fallout from emissions using credible and relevant meteorological data.

7.1 AERMET/AERMOD

The Air Dispersion Modelling software developed by Lakes Environmental has been adopted for use in Jamaica. It is one of several that are available on the market. This model is used as an easy-to-use and robust tool that can predict fallout of pollutants emitted from sources. However for its accurate functioning, this tool needs at least a year's worth of credible meteorological data.

The current situation for the country is the use of meteorological data from the Norman Manley International Airport (NMIA) and the Meteorological (MET) office to run dispersion models for the emission points from the facilities that the NRCA has licensed. According to guidelines on dispersion modelling, the use of upper air data from the NMIA is sufficient to conduct proper modelling of source emission points. However the AQMP committee will seek to encourage and recommend for enforcement, the implementation of met stations at locations across the island to ensure the accurate collection of lower air data. It should be noted that MET stations are not a current requirement in the licences issued to the facilities and Air Quality Regulations. This is identified as a gap and the committee will recommend the necessary amendments to the licences assuming the necessary amendments to the regulations. There is at least one major facility in every parish across the island. Part of the plan is to identify a major source and adjoin a met station for the collection of data.

Data from the Norman Manley International are adequate for Kingston and its surroundings. The committee will seek to develop a strong partnership towards the sharing of data with the NMIA so that model runs can be conducted as required.

If possible the committee will seek to develop a shared database system with NMIA to have the available up-to-date data that are required for dispersion modelling.

7.2 Dispersion Modelling in Air Shed Development

Dispersion modelling will be used as an important tool in determining the characteristics, setting goals and defining the air shed. Dispersion modelling will determine the highest level of fallout for emissions from significant emission points in the air shed. This will act as guide to properly locate ambient monitoring stations. It can also act as a guide to identifying which emission has the greatest effect on an air shed and enable the committee to create the important links with health effects in that air shed.

7.3 What is planned?

The budget for the AQMP plans will make allowance for the procurement of two MET stations in the preliminary stages of the programme. This will only begin to solve the significant gap in lack of quality lower air data. Further on in the programme funding needs to be identified for the procurement of more stations based on needs. The MET stations could be placed in the Kingston Metropolitan Area, Montego Bay, Clarendon, St. Ann and in the Old Harbour Bay /Port Esquivel areas. These five areas have the highest cluster of emission points and licensed facilities, based on mapping data. From these two stations adequate lower air data can be acquired to model emissions from the various points in the region. Simultaneously with this, the committee will pursue the addition of this requirement of including MET stations at facilities and make the requisite amendment to the Air Quality Regulations.

8.0 Quality Assurance

Quality Assurance refers to 'all the planned and systematic activities implemented to provide adequate confidence that an entity will fulfil requirements for quality'[1]. Quality Assurance must be present at every step in the measurement of a pollutant, even during the assessment of the data collected. It should include the following aspects:

8.1 Quality Control

Quality Control includes all technical and operational activities used to identify or measure the effectiveness of data generated from monitoring activities. Quality control is aimed at identifying sources of error during analysis and allowing for mitigation to ensure that errors in measurement are within the acceptable range. It therefore provides an input into the overall Quality Assurance leading to confident results. Measures of analytical quality control may include:

8.1.1 Parameter Testing Methods and Instrument Specification

There are minimum performance standards for equipment utilized for air quality monitoring of the criteria air pollutants. These performance standards and methods are indicated in the Fourteenth & Fifteenth Schedules of the NRCA Air Quality Regulations August 2006 (Table 4 and 5 below).

Table 4: Minimum Performance Specifications for Ambient Air Quality Monitoring of Criteria Pollutants

Specification	**SO2**	**NO2**	**CO**	**O3**	**TSP**	**PM10**	**Pb**
Reference Method	Pararosaniline Method	Chemilumine-scence	Non-dispersive IR Gas filter correlation spectroscopy	Ultraviolet photometry	Manual High Volume sampler	HiVol sampler	HiVol sampler
Operating Range	0 to 0.5 ppm	0 – 0.5 ppm	0 – 50 ppm	0.01 – 0.5 ppm	2 – 750 g/m3	U p to 300 g/m3	7.5 g/m3
Minimum Detection Limit	0.010 ppm	0.010 ppm	1.0 ppm	0.010 ppm	2 g/m3	0.07 g/m3	0.07 g/m3
Noise	0.005 ppm	0.005 ppm	0.5 ppm	0.005 ppm	NA	NA	NA
Zero drift (24 h)	0.02 ppm	0.02 ppm	1.0 ppm	0.02 ppm	NA	NA	NA
Span Drift (24 h)					NA	NA	NA
20% of upper range 80% of upper range	20.0 % 5.0 %	20 % 5 %	10 % □2.5 %	20 % □5.0 %			
Precision 20% of upper range limit 80% of upper range limit	0.010 ppm 0.015 ppm	0.02 ppm 0.03 ppm	0.5 ppm 0.5 ppm	0.01 ppm 0.01 ppm	3%	5 g/m3 for conc. . 80 g/m3 and 7% for conc. > 80 □g/m3	5 – 6% within lab RSD 7-9% between lab RSD
Accuracy Annual	15% 95% CI 20%	10%	95% CI 20%	10% 95% 20%	10%	PD 7% for flow rate	Not specified
Completeness (minimum averaging period)	75% (hourly)	90% (hourly)	75% (8h block)	90% (hourly)	75% (Quarterly)	75% (Quarterly)	75% (Quarterly)
Averaging time	1 h	1 h	1 h	1 h	24 h	24 h	24 h

Table 5: FIFTEENTH SCHEDULE (Regulation 35) Methods for Monitoring Ambient Air Pollutant Concentrations

Pollutant	**Averaging time**	**Method**
TSP	24 hours	Any method complying with Particulate (TSP) reference method in Title 40, Code of Federal Regulations, Part 50, Appendix B
PM_{10}	24 hours	Any method complying with reference method in Title 40, Code of Federal Regulations, Part 50, Appendix J
CO	Continuous	Any method complying with reference or equivalent methods in Title 40, Code of Federal Regulations, Part 50, Appendix C, and Part 53, Subpart B
SO_2	Continuous	Any method complying with reference or equivalent methods in Title 40, Code of Federal Regulations, Part 53, Subpart B
SO_2	24 hours	Any method complying with reference method in Title 40, Code of Federal Regulations, Part 50, Appendix A
NO_2, NO	Continuous	Any method complying with reference method in Title 40,

8.2 Guidelines, Regulations and Standard Operating Procedures for Ambient Air Quality Monitoring

The Air-Ambient-Guideline Document and the NRCA Air Quality Regulations August 2006 lay the foundation for the selection of monitoring sites, instruments, sampling frequency, reporting and compliance with the Air Quality Regulations. Also illustrated within these documents are the standards to which licensed facilities must adhere to.

The manufacturers of the monitoring instruments also provide a manual for maintaining the efficiency of the monitor; i.e. operation, cleaning methods and calibration schedules. Both the manufacturers' suggestions and the Regulations should be considered in the creation of monitoring, maintenance and repair schedules.

Although not every activity in the field/laboratory needs to be documented, those activities that could potentially introduce measurement uncertainties, or significant variance, should be documented as a standard operating procedure (SOP).

8.3 Quality Assessment

Assessment of the quality system must be conducted both internally and externally. Internal assessments should be in the form of audits, periodic calibrations, control charts *inter alia*. Externally assessments should include independent performance audits and evaluation of internal quality assessments.

8.3.1 Internal Quality Audit

An audit of the quality control programme must be conducted annually, according to a schedule. The aim is to identify any non-conformance (problems) in the quality control system. Once identified corrective actions (solutions) should be incorporated into the quality assurance programme. An audit should include, but not be limited to:

- Review of control charts
- Checks for adherence to maintenance and calibration schedule.
- Checks for the use and records of field blanks, standards and replicates.
- Balances being verified by the Bureau of Standards
- Updated database and log book

8.4 Chain of Custody

Every company/organization must include a chain of custody form for sampling exercises in which samples are transferred. The chain of custody form is a means of keeping a record of who has samples from collection to analysis. The form must be signed and dated. These records must be kept for inspection. Internal quality audits should verify that forms are being completed in accordance with the monitoring schedule

8.5 Quality Control Charts

Control charts must be created for monitoring equipment or analyzers that are used to generate data. For Particulate Matter these may be generated using standard weights. The standards should be weighed several times and the average of the values obtained used to chart the upper and lower limits about the respective means. Prior to each monitoring exercise, standards must be used to verify that the standards fall within the upper and lower limits of the control charts.

8.6 Facilities & Documentation

The Selection of monitoring sites and the number of sites is important in correctly monitoring Air Quality. The Guideline document indicates the minimum requirements for the selection of sites, depending on the parameter of interest.

Ambient air quality monitoring may require the use of a laboratory for analysis. In such a case the room used should be in a location which excludes environmental influences such as wind. All records (temperature, pressure, time among other things) should be stored in an electronic database as well as a designated log book.

8.7 Field Checks

Quality control is required not only in the laboratory but also in the field. Efforts must be undertaken to ensure that errors in measurement are minimized. Field checks should include but not be limited to:

- Ensuring that the monitor is placed in an open location as indicated in the Air-Ambient-Guideline 2006 Document.

- Ensuring that the flow rate of the monitors is fairly constant within guideline limits (i.e. ± 20%)
- Using field blanks (For example, using an additional filter paper that is treated the same as the filter paper used for sampling with the exception of not being run in the monitor. Changes in the mass of this blank will be accounted for in the calculation of the pollutant concentration. This aids in ensuring that errors in measurement are minimized.)
- Avoiding cross contamination; this may occur before or after monitoring.
- Documenting environmental conditions (such as temperature and pressure) on each sampling day.
- Inspecting the housing for instruments; air conditioning, seals *inter alia*.

8.8 Instrument Maintenance, Calibration and Repair

Preventative maintenance must be done on a daily basis. Other general maintenance such as cleaning and repair may be conducted on a monthly basis or as required. Major repairs must be conducted by service contractors or the manufacturer as the case may be.

Ambient Air Quality Monitors should be calibrated at least once every quarter and or according to the maintenance schedule. In addition to this, monitors should be re-calibrated whenever a change is made to the equipment. Calibration of the High Volume samplers, utilized for particulate monitoring, should be conducted using a calibration kit purchased with the instruments. A manometer is used to verify the efficiency of the monitor. Basic calibration of the gas monitors involves the use of a scrubber. The procedure is conducted similar to that of sampling. The scrubber (a drying chemical) removes or converts pollutants so that only clean air enters the analyzer. This method should be employed when calibrating an instrument at zero and should be used for all the continuous monitors (NOx, SOx and CO).

8.9 Measurement Uncertainty

Measurement uncertainty is the ambiguity of a result that arises from random and systematic errors (instrument detection limit, precision, etc.) All these will affect the end result of pollutant concentrations. To guard against this, an uncertainty value must be

calculated where necessary for the analytical procedure and the error associated with each individual conducting the analysis. This is achieved by identifying all sources that contribute to uncertainty, quantifying each and assessing the effect it will have on the end result. Results must therefore be reported with its calculated error and the confidence interval with which it is associated.

9.0 Air Quality Data Management

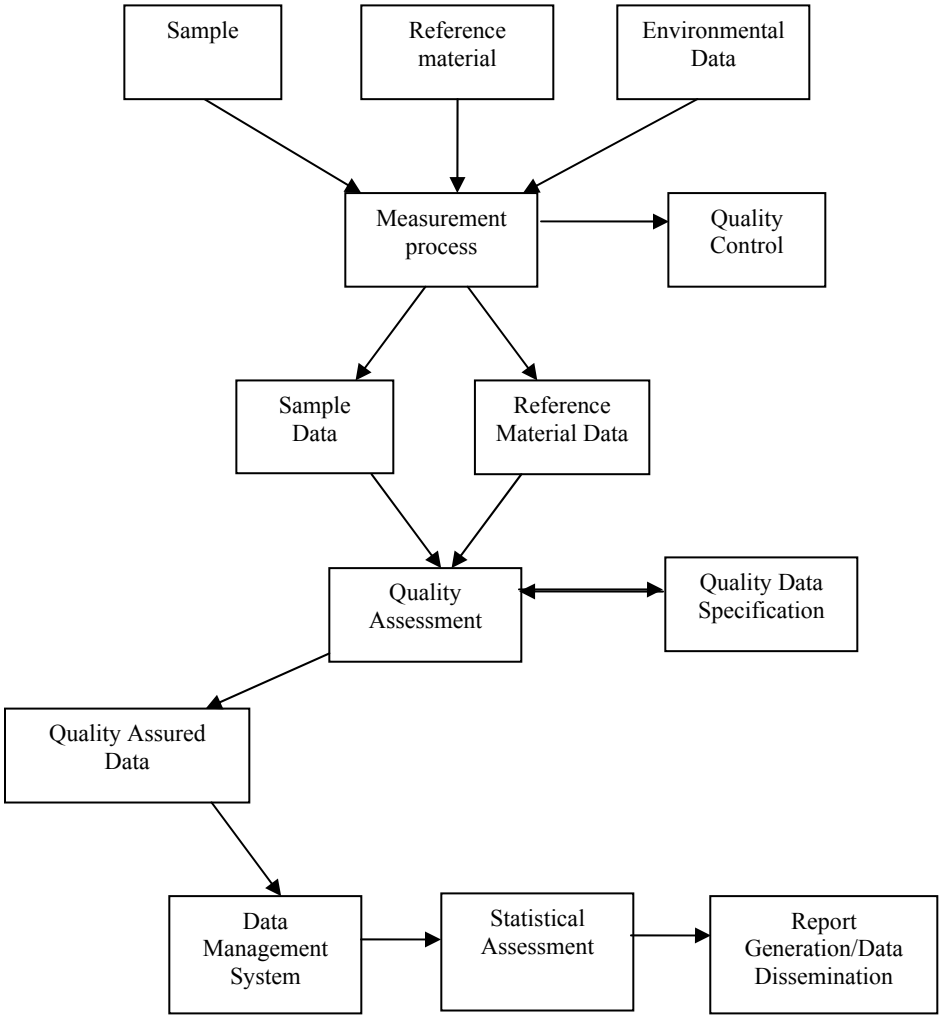
This chapter provides information on the incorporation of quality assurance in the collection of air quality data and describes the protocol for management of data once they have been collected and verified.

Data management and quality assurance are inextricably linked; in fact, there can be no proper management of data without quality assurance measures to guide data collection processing and presentation. Quality assurance begins with the choice of monitoring sites, the choice of instrument and equipment, the level of personnel expertise, equipment maintenance and calibration and follows through to the storage, analysis and distribution of the data. Once data have been acquired, it is often impossible and if not so, it is costly to make corrections to inaccuracies that result from anomalies which are embedded in the process. Figure 2 shows how quality assurance is embedded in the data management process for air quality.

Data management practice should take into account the acquirement, storage, validation correction, changes and completeness of data sets. Today, air quality data are largely collected online as opposed to manually logging the data as was widely used in the past; although it is also possible to use both methods simultaneously. In the event that manual entry is used, there should be precautions in place to ensure that the integrity of the data is maintained throughout the process.

The Pollution Monitoring and Assessment Branch has primary responsibility for collecting and managing air quality data. This includes ambient data as well as those received from air pollutant discharge Licensees.

Figure 2: Process Flow for Air Quality Data Generation and Management



9.1 Data Collection and Analysis

The collection and analysis of air quality data require continuous monitors, data loggers and gravimetric assessment in the laboratory. The technology used to collect the data will greatly influence the methods employed in managing the data.

9.1.1 Continuous Data Acquisition

It is important that data which are acquired digitally are precise, accurate and the quality assurance programme should take this into consideration. The frequency with which data are downloaded should be of such that it minimizes data loss in the event of a total machine failure. In instances where data are downloaded remotely, the ideal is for the instrument to have an internal data logging device which records the data simultaneously with the external output. In this event, the instruments' internal clock will have to be synchronized as closely as possible to the external data collection device in order to prevent time gaps.

9.1.2 Manual Data Collection

There should be no difference in quality between data received remotely and those which are accessed manually. There are times, however, when machines will register faults that could cause them to shut down and this is not registered until the next visit. In this case, valuable data could be lost. Nevertheless, if this is the preferred method or the one that is most available, a protocol should be in place to prevent changes, accidental or otherwise, to the data while in transit.

9.1.3 Data Generated from Gravimetric Assessment

In instances where it is necessary for samples to be collected and taken to the laboratory for evaluation, it will be necessary to ensure that all the required quality assurance protocols are in place in the field as well as during the assessment phase. The data generated from the sample, the field and from quality checks should be deposited into a central database within twenty-four hours. All anomalies associated with this assessment should also be recorded for future reference. It is highly unlikely that this data will be received electronically and it is very useful to maintain a physical log of this information.

9.2 Data Storage

All data collected as part of the air quality monitoring programme and that is received from dischargers should be stored in a central database. The data should include environmental field data, results of assessment, quality assurance output as well as the

data that has been validated. It is advised that the raw data[2] are kept alongside data that have been authenticated; this will provide for later reference where necessary.

Critical to data storage are features that guarantee security, accessibility with levels of authorization to users, capacity to retrieve them when required in a state without being corrupted.

9.3 Data Validation and Gaps

Data validation is the process of ensuring that data generated are suited for the intended purpose. This is generally archived by installing pre-determined check limits and targets to which the data must conform if it is to be considered fit for the purpose. These checks are usually administered with the help of a computer programme and should be applied regularly to improve process speed and ensure dissemination of reliable data.

It is very important to consider all the factors that could and influence the data pattern when data are being validated. Environmental condition, instrument and equipment reliability, source of pollutant are all possible sources that could influence the validity of the data.

Invariably, there will be gaps in the data set. This could be as a result of attrition of personnel, inadequate funding, equipment failure, scheduled maintenance or data that for one reason or another (for example outliers) that must be removed from the set. Unless there is an expressed need to have a complete data set, these gaps should remain. The reporting protocol provides for less than 100 % acceptance and this provision should be utilized.

9.4 Data Handling

It is expected that data will come from two main sources; the ambient monitoring program and the discharge licensees. Data received from licensed facilities will be reviewed within five days of receipt of the post licence report and the data transferred to the database. This data hereafter will be maintained as part of the Agency's data pool.

[2] Data as collected with no changes statistical or otherwise.

In order to maintain integrity, data manipulation should be restricted to a minimum number of personnel, with read only access to partners who are interested in using the data. If possible, the system which tracks changes to the data should be implemented. It is advised that an electronic data management system be utilized in the handling and processing of the air quality data that will be generated, based on the volume that is expected. The software package chosen will depend on the processing and reporting needs of the Agency and this will be determined at the time of purchasing. Also to be determined is the level of sophistication, regarding the types of output the programme is required to generate, which will depend on the required output as well.

The frequency of back-up will depend on the rate at which new data are introduced. Daily input will require daily-back up at the very least. The created files should as far as possible be kept in a different location than the primary data.

Coding of the data is essential to uniquely identify each lot. It means, therefore, that a system of coding will have to be developed for this purpose.

Applications Management and Data Automation (AMANDA) is a data management tool currently used by the Agency. Embedded in JAQMP is the intention to acquire the module for the programme that is necessary to include the air quality data and manage the information.

10.0 Capacity Building

Capacity building as a focus area in the implementation of the programme is aimed at the internal development of technical and information sharing skills among the regulatory agencies including NEPA, licensees and community stakeholders. The Agency currently has two persons capable of conducting ambient air monitoring exercises.

There has and will always be the loss of institutional capacity due to attrition, as is the experience of the Jamaican public and private sectors. Entry level personnel oftentimes require 0-5 years to develop familiarity with the thematic areas and gain a wealth of experience in another additional 5 years. In about 15 years, such personnel would have developed the expertise required. The public sector is mandated to promote and provide conditions for constant and continuous opportunities in the capacity building efforts to ensure sustainability of the programme. The benefit of this would compensate for loss of skills due to promotion, resignation, migration and retirement.

Capacity building will enable development in the following areas:

- Source characterisation which includes emission inventory methods, estimation of emissions, witnessing and execution of source testing
- Dispersion modelling, both screening and detailed as well as receptor modelling
- The principles and methods of ambient air quality monitoring of TSP, PM_{10}, SO_2, CO, NOx, O_3, VOCs, toxic air pollutants (priority air pollutants), meteorology
- Review and processing of licence applications
- Evaluation of air quality assessments for licences, Environmental Impact Assessments and other requirements as necessary
- Quality assurance and quality control for ambient and source monitoring
- Management of air quality data, meteorology and emission inventories
- Air Quality Indices
- Risk assessment and risk management
- Information sharing

Refresher training is essential to maintain the capacity levels required on an on-going basis and would serve as a platform for additional personnel to increase relevant skills, abilities and knowledge in the subject areas.

10.1 Targeted Stakeholders for Capacity Building

The stakeholders from the public and private sectors that would require capacity building opportunities are:

- NEPA
- Ministry of Health
- Jamaica Bauxite Institute
- International Centre for Environment and Nuclear Sciences
- Air Pollutant Discharge Licensees
- Environmental Consultants
- Communities/Public

10.2 Capacity Building Options

NEPA recognizes that the local options to build the capacity required at this time are limited. The Agency will continue to explore the local offerings.

The Air Pollution Training Institute (APTI) of the United States Environmental Protection Agency (USEPA) offers training related to air quality management. The USEPA offers approximately 20 different courses annually through its Air Training Centres and some self- instructing/web courses.

The APTI courses that address the areas needed for the capacity development required for this AQMP are provided in Tables 6 and 7. Table 6indicates the on-line courses identified while Table 7 indicates the class room courses for 2010.

Table 6: APTI On-line courses 2010

Description	Course Number	Course Title	Number of hours
C&W	SI428	Introduction to Boiler Operation	20
CEM	SI476B	Continuous Emission Monitoring Systems - Operations and Maintenance of Gas Monitors	30
EI	SI445	Introduction to Baseline Source Inspection Techniques	25
Eng	RE100	Basic Concepts in Environmental Sciences	NR
Eng	SI412C	Wet Scrubber Plan Review	40
Eng	SI422	Air Pollution Control Orientation Course	30
Eng	SI431	Air Pollution Control Systems for Selected Industries	40
Mon	SI419A	Introduction to Emission Inventories	NR
Mod	SI409	Basic Air Pollution Meteorology	20
Mod	SI410	Introduction to Dispersion Modelling	35
Mon	SI434	Introduction to Ambient Air Monitoring	50
Mon	SI436	Site Selection for Monitoring of SO_2 and PM_{10} in Ambient Air	35
Mon SS	SI433	Network Design and Site Selection for Monitoring $PM_{2.5}$ & PM_{10} in Ambient Air	40
Mon	SI471	General Quality Assurance Considerations for Ambient Air Monitoring	30
Mon	SI473	Beginning Environmental Statistical Techniques	25
Mon	SI473B	Introduction to Environmental Statistics	NR

Table 7: **APTI Classroom Courses 2010**

Description	Course Number	Course Title	Number of days
EI	455	Advanced Inspection Techniques (1992)	3
Eng	345	Emission Capture and Gas Handling System Inspection (1995)	3
Eng	400	Introduction to Hazardous Air Pollutants (1993)	2
Eng EI	445	Baseline Source Inspection Techniques (1996)	3.5
Eng	446	Inspection of Particle Control Devices and Safety Procedures (1994)	2
Eng	452	Orientation to Air Pollution Control and Air Quality Management (APTI #452) Principles and Practice of Air Pollution Control (1996)	3.5
Eng	482	Sources and Control of Volatile Organic Air Pollutants (1989)	4
Mod	423	Air Pollution Dispersion models--Application (1995)	3
Mod	424	Source Receptor Modelling	4
Mon	435	Atmospheric Sampling (1983)	4.5
Mon	464	Analytical Methods for Air Quality Standards (Revised at time of delivery)	5
Mon SS	470	Quality Assurance for Air Pollution Measurement Systems (1994)	4
Mon MC	468	Monitoring Compliance Test and Source Test Observation (1995)	4.5
SS	450	Source Sampling for Pollutants (1995)	5

KEY

CEM Continuous emission monitoring required

C&W Combustion and waste

NR No registration

EI Engineering inspection

Mon Monitoring

Mod Modelling

MC Monitoring compliance

Prmt Permitting

SS Source sampling .

The Agency held sensitization exercises on the NRCA Air Quality Regulations (2006) in 2007 for stakeholders with an additional component for the wider public stakeholders in Jamaica. NEPA intends to repeat this sensitization series and also coordinate local training programmes with selected partners in conducting training exercises after acquiring the requisite skills and expertise.

The objective of the additional component would empower the Jamaican public with knowledge of air quality management procedures, reporting techniques, good observatory skills and general information. The selective stakeholder training would cover the areas presented in Table 8.

Table 8: Topics selected for stakeholder capacity building

Items	Topics	Stakeholders
1	Overview of the rationale for the regulations, their purpose, the general requirements for compliance and how the effectiveness of the regulations will be tracked over time	Senior & Technical public and private sector staff, NGOs, Public
2	Ambient Monitoring Methods, Quality Assurance and Quality Control for Ambient and Source Monitoring, ambient air quality data management & data analysis	Technical public and private sector staff
3	Plans and protocols for air quality assessments (for submitting application for and reporting as part of Air Pollutant Discharge Licence and typical air quality related requirements for Environmental Impact Assessments)	Technical public and private sector staff
4	Air Pollution Meteorology , Screening Dispersion Modelling and Detailed air dispersion modelling	Technical public and private sector staff
5	Submission of Air Pollutant Discharge License Applications	Technical public

		and private sector staff
6	Reporting for Air Pollutant Discharge License Applications	Technical public and private sector staff
7	Enforcement and Legislation Relating to Air Quality Regulations	Technical public and private sector staff, NGOs, public

11.0 Methodology

The methodology being adopted to implement the Programme is presented in Figure 3 and depicts the interrelationships of the work processes.

- The programme will involve the AQEC relating findings and recommendations to the CEO, the facilities and all other stakeholders.
- Working Groups will be assigned task(s).
- The use of monitoring and Air shed plans developed as part of the programmme.
- Development and Review of reports by the various working groups.
- Summary of reports to a monthly AQEC committee to make recommendations.

11.1 The Air Quality Evaluation Committee (AQEC)

The AQEC is a group of personnel consisting of technical and managerial staff from the NEPA. The staff will basically consist of members from the Environmental Management Subdivision (EMB), Pollution, Monitoring and Assessment Branch (PMA), Applications Processing Branch (APB), Public Education and Corporate Communication Branch (PUBED), Enforcement Branch (EB), Strategic Planning and Policy Branch (SPPB) and the Information Technology Branch (IT).

The staff of the NEPA will be partnered with technical staff from other agencies such as Jamaica Bauxite Institute (JBI) and the Ministry of Health (MOH) with plans to include the Ministry of Transport and Works (MOTW) in future.

To complete the committee three consultants, with vast experience and research in the field of air quality, have been chosen. They will participate greatly in the management and guidance of the programme as well as provide valuable experience in the field.

The committee will meet once per month and from this the issues surrounding the air quality programme will be reviewed and discussed in detail. From these meetings is

expected to come a clear way forward on these issues. Along with this the committee will evaluate all the reports and see to it that the objectives are being met as set out in the plan implementation. The working groups that have been assigned will be required to give an update on the progress of the tasks and as soon as any recommendation for change or completion of a task occurs the committee will update the CEO and the Agency.

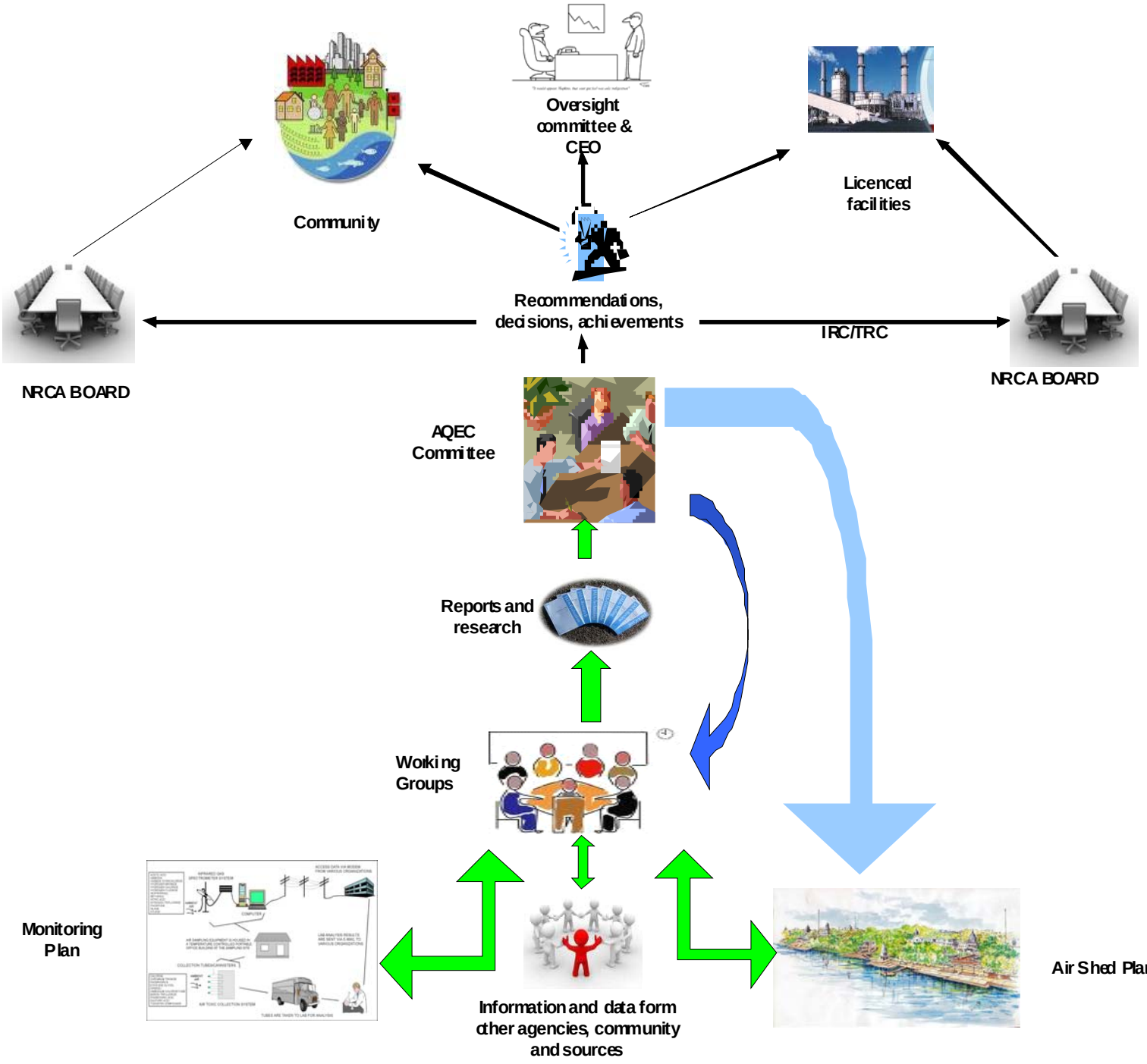
11.2 Working Groups

According to the objectives to be met for each phase of the programme a working group and a group leader will be assigned to work towards these objectives. Some objectives will overlap and so one group may find themselves working on more than one object. The working groups will consist of one or maybe two members of the AQEC and personnel with the technical ability to complete the desired task. The members of the working group will not have to be apart of the AQEC but just general staff from the NEPA and the other agencies. The plan is to also engage the help of University students with the competence to be apart of the groups. This will not be a random choice, when the committee assigns a task for a group it will seek to make the necessary liaisons with all the managers of each member chosen or suggested to be in a group and request their part time service through the CEO. The objectives to be met are mentioned in the implementation phase of the document and will determine the working groups and their functions.

11.3 Tools for the Implementation of the JAQMP

The use of the Air Shed development Plan, the Monitoring Plan, the Data Management and Information Management plan and Quality Assurance methods are all the tools that will be used by the various working groups to achieve the objectives set out in the implementation of the JAQMP. Through these plans and under the watchful eye of the AQEC the programme will be a success.

Figure 3: Methodology Flow Chart



12.0 Implementation of Jamaica's Air Quality Management Programme

The implementation of the Jamaica Air Quality Management Programme (JAQMP) will be achieved in four phases. Each phase will have its own set of objectives which are pre-requisites for the successful implementation of the subsequent phase identified as necessary for the implementation of the following phases.

All phases will be coordinated and centred on the Air Quality Evaluation Committee (AQEC) on a quarterly basis and its monthly meetings. From this, working groups as well as the tasks for each group will be assigned and monitored by the committee. The phases will span an overall estimated time of six years with the first two stages lasting two years. After the six year period the management structure will be revisited and recommendations will be put forward to the Board of the Agency for its restructuring. At the end of each quarter a report will be submitted to the AQM oversight committee consisting of monthly and quarterly reports as well as any recommendations and progress reports from the AQEC committee. The phases are as follows:

Table 9: Phases of implementation of JAQMP

Phase	Activity	Time Period
1	Start up and Set Foundation (SAF)	2010 -2012 yr1-yr2
2	Monitor, Asses and Control (MAC)	2013 -14 yr3-yr4
3	Development and Sustainability (DAS)	yr5
4	Revise, Revisit and Recommend (RRR)	yr6

Note that depending on resource availability or recommendations from the committee monthly meetings objectives schedule to be met for other phases could be met before time or vice versa.

There will also be an internal Agency review meeting before the monthly meetings to review the reports to be presented at the meetings. These meetings may consist of different members of the working groups on the Committee and Branches in the Agency

12.1 *PHASE 1*

The objectives of phase one SAF are:

- Verify data submitted by Applicants for Licences
- Corroborate emissions data with the Ministry of Energy and Mining's data on fuel consumption
- Sensitize licensees to compliance expectations
- Monitor level of compliance at currently licensed facilities
- Issue recommendations for changes to licence conditions as well as locations of monitoring stations for facilities
- Review applications for air pollutant discharge licences
- Explore the possibility of developing the infrastructure to link health effects and pollutant emissions
- Develop database with geo-referenced coordinates of such sources in the model air-shed
- License facilities that emit pollutants that were left out of the loop
- Raise level of awareness for all stake holders of the Air Quality Management Program
- Collect and analyze ambient monitoring data from licensed facilities as well as agency monitors for critical pollutants
- Identify Air shed to be used as a model
- Procure the resources required for the establishment of the Agency's ambient monitoring stations for use in model air shed

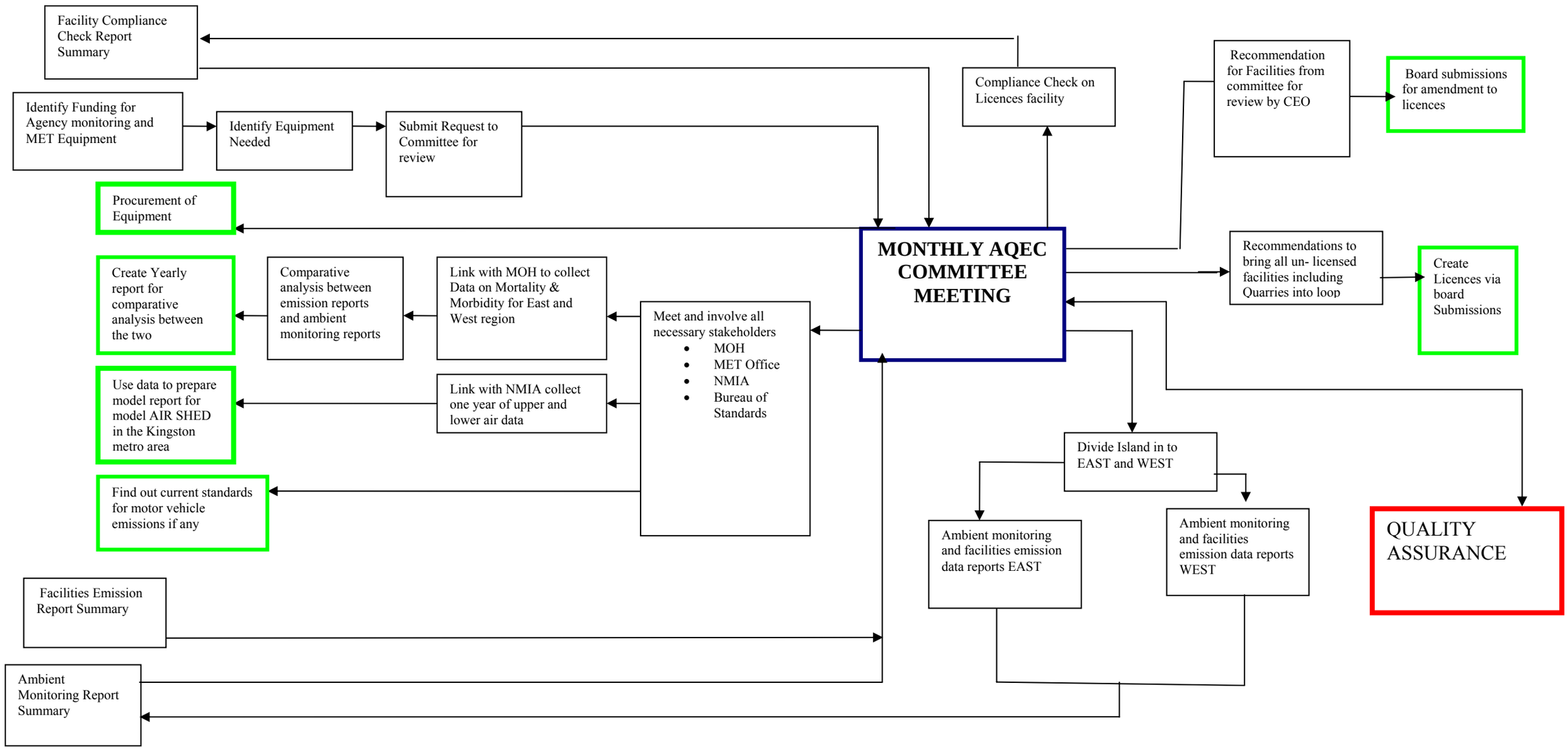
- Include Air Quality Assessment in all Terms of Reference for Environmental Impact Assessment Reports and Health Impact Assessments
- Discuss licence conditions with Licensees in an effort to provide reasons for the inclusion as required
- Recommend granting of amendments to licence conditions as requested by licensed facilities
- Agree with licensed facilities on the locations of their monitoring stations.
- Raise awareness for all stakeholders of Jamaica's Air Quality Management Programme
- Procure and install Agency's ambient and meteorological monitoring stations for use in air shed(s)

Table 10: Working Groups

TASKS	WORKING GROUPS
Chair Person	
Provide Review and recommendations on information for Western region	**NGO/NEPA/EHU/JBI/MTW/MOEM**
Provide Review and recommendations on information for Eastern region	**NGO/NEPA/EHU/JBI/MTW/MOEM**
Policy and Regulations	**NEPA (SPPD)**
Preparation of summary reports for submission to committee monthly meeting	**NEPA (EMS)**
Research and development	**NEPA (EMS)**
Creation and maintenance of any new data bases required	**NEPA (IT, EMS, PMA)**

Update of data base for emissions from facilities and ambient monitoring	**NEPA (IT, EMS, PMA)**
Review of request for Amendment to current licences as well as licensing of new facilities	**NEPA (APB,EMS, Legal))/JBI/EHU**
Procure technical assistance from Donor Agencies	**NEPA (EMS/Projects)**
Site visits and compliance check for licensed facilities and creation of reports	**NEPA (EMS,EB,PMA)**
Agencies Monitoring equipment procurement	**NEPA (EMS,PMA, Projects, Facilities)**
Liaise with MOH and PAHO to establish links between MOH Data, Ambient and Emissions data for the country	**NEPA**
Legal Issues	**NEPA (LEGAL)**

Figure 4: PHASE 1 OF IMPLEMENTATION STRUCTURE FOR AQM
Start up and Set Foundations (SAF) estimated year1- year2



12.2 *PHASE 2*

The objectives of phase two (MAC) are:

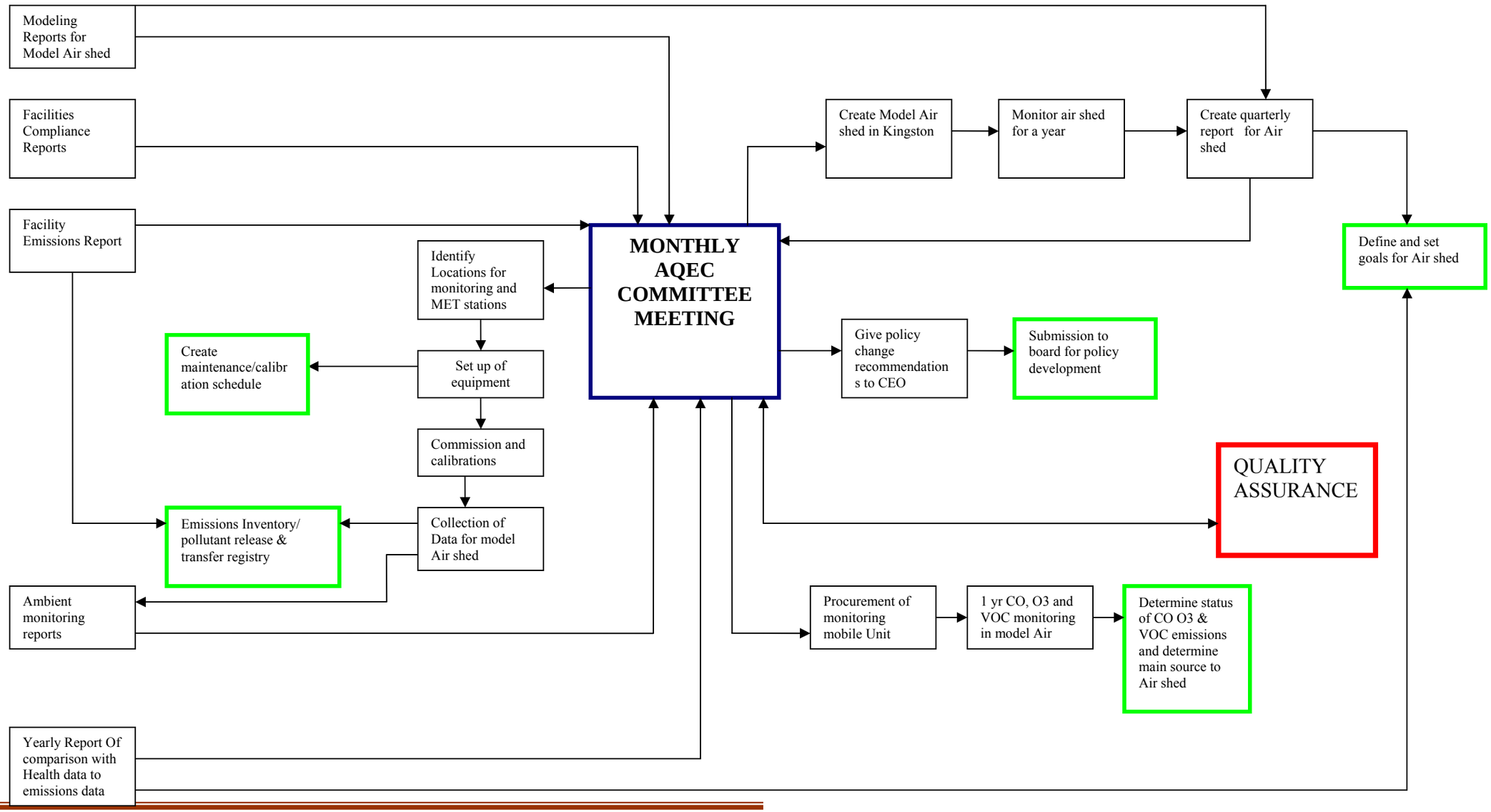
- Commission ambient monitors for Agency in model Air shed
- Develop mechanism to collect relevant health data in selected air shed
- Collect relevant meteorological for use in modelling report for model air shed
- Input data in (Create) Emissions Inventory/Pollutant Release and Transfer Register
- Procure mobile monitoring unit
- Provide information that can guide policy development for Air shed
- Determine status of CO, O_3 and VOC Emissions in model Air shed and the main sources of emissions
- Define and set specific goals for Air shed.
- Identify point and non-point sources of air emissions that were not addressed in the existing Regulations

Table11: Working groups 2

TASKS	WORKING GROUPS
Chair Person	
Provide review and make recommendations on information for Air Sheds in the Western region	**NGO/NEPA/EHU/JBI/MTW/MOEM**
Provide review and recommendations on information for Air Sheds in the Eastern region	**NGO/NEPA/MET/MOEM/MTW/EHU/JBI**
Policy and Regulations	**NEPA (SPPD)**
Preparation of summary reports for submission to committee monthly meeting	**NEPA (EMS)**
Research and development	**NEPA (IT, EMS, PMA)**
Creation of any new data bases required	**NEPA (IT, EMS, PMA)**
Update of data base for emissions from facilities and ambient monitoring	**NEPA (IT, EMS, PMA)**
Amendment of current licences as well as licensing of new facilities	**NEPA (APB,EMS, Legal))/JBI/EHU**
Liaise with donor Agencies	**NEPA (EMS/Projects)**
Editing of Reports	**NEPA (EMS,EB,PMA)**
Site visits and compliance check for licensed facilities and creation of reports	**NEPA (EMS,EB,PMA)**

Agencies Monitoring and MET equipment procurement	**NEPA (EMS, PMA, FACILITIES)**
Making Necessary data links between MOH Data and Emissions data for the country	**PMA**
Verification of discharge fees and incentives	**NEPA (EMS, FINANCE)**
Enforcement Matters	**NEPA (EMS/EB)**

Figure 5:PHASE 2 OF IMPLEMENTATION STRUCTURE FOR AQM
Monitor, Assess and Control (MAC) estimated year3- year4

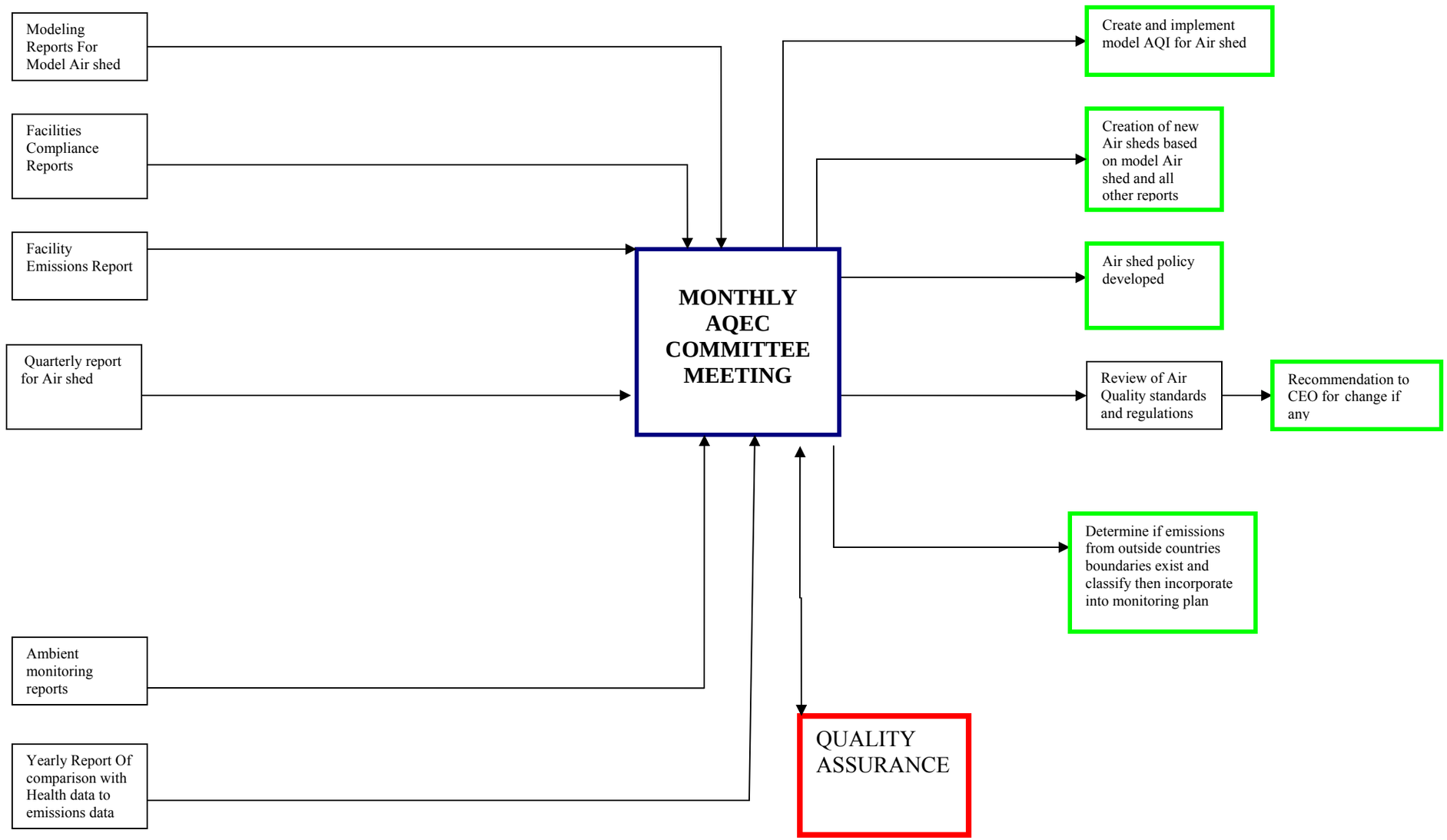


12.3 *PHASE 3*

The objectives of phase three (DAS) are:

- Create and implement model AQI for Air shed
- Establish links between health effects and pollutant emissions
- Creation of new Air sheds based on model Air shed and all other reports
- Select highest priority air shed(s) for agency monitoring and identify required resource needs (met data needs, equipment (air monitoring and met data), on-going supplies, staff, other expenses)
- Air shed policy developed
- Recommendation for change if any to regulations and standards.
- Determine the level of influence of other countries on our air quality
- Incorporate the influence of these pollutants into the monitoring plan.

Figure 6: PHASE 3 OF IMPLEMENTATION STRUCTURE FOR AQM
Development and Sustainability (DAS) estimated year4- year5

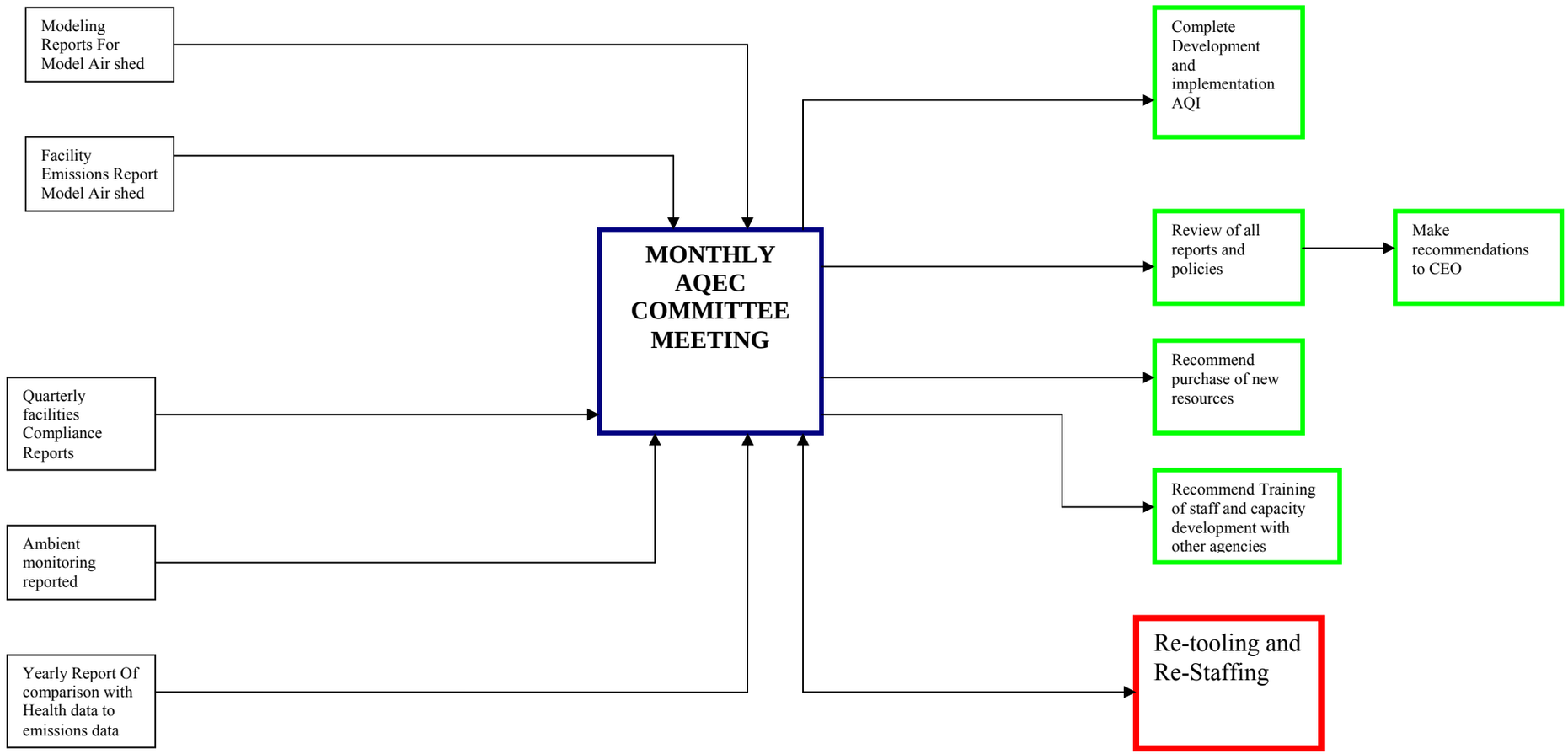


12.4 *PHASE 4*

The objectives of phase three (RRR) are:

- Complete Development and implementation of AQI
- Review achievement of the long term goals of the programme, assess more effective and efficient methods of operations, identify emerging trends in air quality and make recommendations for a revamped AQMP.
- Review of all reporting procedures and policies and make recommendations
- Recommend purchase of new resources to board
- Recommend Training, staffing and networking with other agencies

Figure 7: PHASE 4 OF IMPLEMENTATION STRUCTURE FOR AQM
Revise, Revisit and Recommend (RRR) estimated year6



13.0 Budget

Financial support is vital to successfully implement the programme. Based on this need, a two year budget was developed in order to estimate the cost that will be associated with consultancy support, staffing, training, stakeholder workshops, travelling and procurement of monitoring equipment. This is summarized in Table 12 below and full details given in Appendix 3.

Table 12: Summarized Budget

	Estimated Total Cost (JA)
Workshops	$163,000.00
Training	$950,000.00
Travelling and Accommodation	$1,000,800.00
Equipment	$27,371,772.00
Air Quality Expert	$4,320,000.00
Air Quality Support Staff	$4,800,000.00
Contingency	$1,035,575.60
Data Management Software	$3,115,000.00
TOTAL	**$ 42,756,147.60**

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5. http://www.nepa.gov.jm/regulations/air-ambient-guideline-2006.pdf

6.http://www.nepa.gov.jm/regulations/NRCA_Air_Quality_Regulations_August_2006.pdf

7. http://elsmar.com/pdf_files/QC%20vs%20QA.pdf

8. http://www.cpcb.nic.in/QA_QC.php

9. http://www.bcairquality.ca/reports/pdf/airshedplan.provframework.pdf

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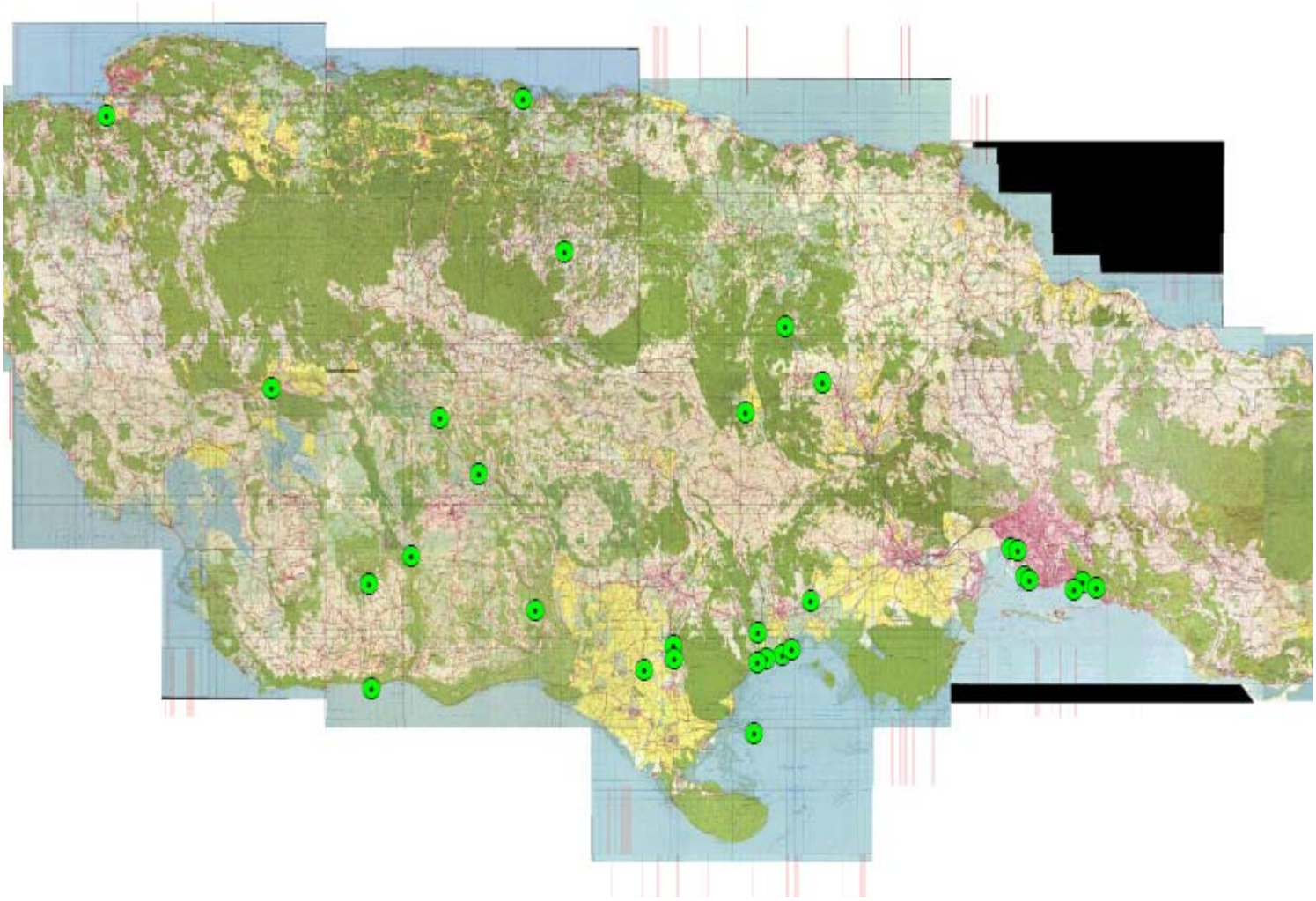
15. http://www.ec.gc.ca/default.asp?lang=En&n=F3622FE4-1

APPENDIX 1

Figure 8: Map of licensed facilities in Jamaica



APPENDIX 2

Table 13: Air Quality Standards for Jamaica

Pollutant	**Averaging Time**	**Standard (Maximum concentration in µg/m^3)[1]**
Total Suspended Particulates (TSP) (a)	Annual 24 h	60 150
PM_{10} (b)	Annual 24 h	50 150
Lead	Calendar Quarter	2
Sulphur Dioxide	Annual 24 h 1 h	80 Primary; 60 Secondary (c) 365 Primary; 280 Secondary (c) 700
Photochemical Oxidants	1 h	235
Carbon Monoxide	8 h 1 h	10000 40000
Nitrogen dioxide	Annual	100

Air Quality Standards

National Air quality standards /norms are required to provide for:

- the control of emissions from point and fugitive sources
- Ambient Air quality monitoring
- Air quality management planning

Air quality information management

APPENDIX 3

Estimated Budget (for first phase of programme)

CATEGORIES **TOTAL (JA$)**

Equipment ……$27,371,772.00

1. Five fully equipped ambient monitoring.
2. Two fully equipped MET stations
3. Calibration and maintenance
4. Installation
5. accessories
6. operation

Training……$950,000.00

1. Introduction to Baseline Source Inspection Techniques
2. Network Design and Site Selection for Monitoring PM2.5 & PM10 in Ambient Air
3. Baseline Source Inspection Techniques
4. Opacity readers training
5. Travelling and accommodation (most courses are available overseas)

Conducting Workshops……$163,000.00

1. Overview of the rationale for the regulations, their purpose, the general requirements for compliance and how the effectiveness of the regulations will be tracked over time
2. Ambient Monitoring Methods, Quality Assurance and Quality Control for Ambient and Source Monitoring, ambient air quality data management & data analysis
3. requirements and protocols for air quality assessments including dispersion Modelling (for submitting application for and reporting as part of Air Pollutant Discharge Licence and typical air quality related requirements for Environmental Impact Assessments)
4. Submission of Air Pollutant Discharge License Applications
5. Enforcement and Legislation Relating to Air Quality Regulations

Consultancy……..$4,320,000.00

1. one consultant
2. 27 ea site visit
3. 27 ea report review per
4. 12 ea min 4hr meetings
5. 2 ea Working group leadership per
6. 8 ea Training workshops per

Staffing……..$4,800,000.00

1. G.I.S and data management staff
2. Monitoring staff

Travelling and Accommodations……$1,000,800.00

1. Twenty Seven site visits for the year to licence facilities for compliance check and monitor stations site checks
2. Accommodations for and average two days for eighteen out of the twenty seven site visits

Data management software……$3,115,000.00

AMANDA module for licence conditions and compliance data, data storage and information storage and accessibility

Contingency……..$1,035,575.60

GRANDTOTAL……$42,756,147.60