# TECHNICAL ANNEX 8

## Strategy of Regional Air Quality Monitoring Network

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# 1. EXISTING AND PLANNED MONITORING STATIONS IN THE REGION

## 1.1 Hong Kong Special Administrative Region

1.1.1 Hong Kong Environmental Protection Department (EPD) currently operates 11 stations for the monitoring of general air quality and 3 stations for roadside air quality across the territory. Parameters that measured in the HKSAR air quality network is listed in Table 1-1 and the equipment used for the measurement is presented in Table 1-2. Locations and site characteristics of the EPD's monitoring stations are shown in Figure 1-1 and Table 1-3 respectively. With effective from 1st January 2001, the Mongkok roadside station had been relocated to the ground level at the junction of Lai Chi Kok Road and Bute Street. EPD also conducted. Organic compounds and toxic air monitoring exercise at the Tsuen Wan and Central/Western stations with the methodology and sampling schedule as shown in Table 1-4.

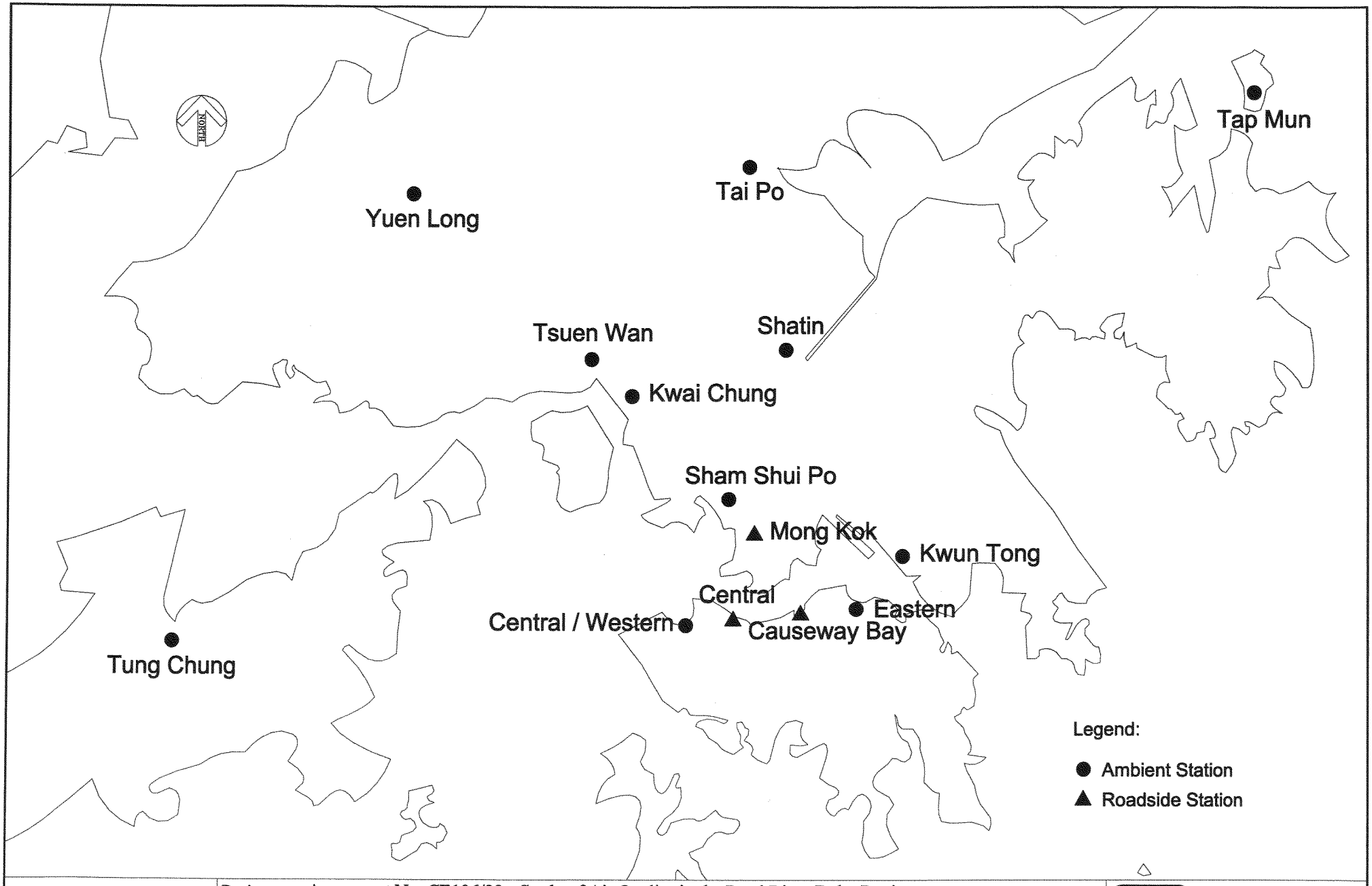
*Table 1-1 Summary of the Parameters Monitored in the HKSAR Air Quality Network*

| | $SO_2$ | NOx | NO | $NO_2$ | CO | $O_3$ | RSP | | TSP | VOC | Met [3] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | | | | | | | Cont [1] | Hi-Vol [2] | | | |
| Air Quality Stations | | | | | | | | | | | |
| Central/Western | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Eastern | ✓ | | | ✓ | | ✓ | ✓ | | | | ✓ |
| Kwai Chung | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Kwun Tong | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Sham Shui Po | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Tsuen Wan | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Sha Tin | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Tai Po | ✓ | | | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Tung Chung | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Yuen Long | ✓ | | | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Tap Mun | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | * |
| Roadside Station | | | | | | | | | | | |
| Causeway Bay | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | | | |
| Central | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | | | |
| Mong Kok | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | ✓ |

*Note:*
*RSP = Suspended particulates in air with an normal aerodynamic diameter less than 10μm*
*[1] hourly "Cont" denotes continuous monitoring*
*[2] daily "Hi-Vol" denotes high-volume sampling*
*[3] "MET" denotes meteorological parameters such as temperature, wind speed, wind direction, relative humidity, atmospheric pressure and precipitation. Data at Tap Mun was measured by Hong Kong Observatory.*
** Meteorological data for Tap Mun are available from HKO.*

*Table 1-2 List of Equipment Used in Measuring Air Pollution Concentration in HKSAR*

| Pollutants | Measurement Principle | Commercial Instrument |
|---|---|---|
| $SO_2$ | UV fluorescene | TECO Model 3A<br>Monitor Laboratories 8850 |
| NO, $NO_2$, $NO_x$ | Chemiluminescence | TECO Model 42, API 200A<br>Monitor Laboratories 8840 |
| $O_3$ | UV absorption | TECO 49, API 400 |
| CO | Non-dispersive infra-red absorption with gas filter correlation | TECO model 48, 48C |
| TSP | Gravimeteric | General Metals 2310 |
| RSP | Gravimeteroc<br>Tapered element oscillating microbalance | Graseby Anderson PM10<br>R&P TEOM series 1400a-AB-PM10 |
| $NO_2$, $O_3$, $SO_2$ | Differential optical absorption spectroscopy | Opsis AR 500 system |

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| | Title: | Locations of the Ambient Air Quality Monitoring Stations in HKSAR | | |
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*Table 1-3 Location and Site Characteristics of the Ambient Air Quality Monitoring Stations in HKSAR*

| Monitoring Station | Address | Area Type | Sampling Height (Above P.D.H.K.) | Above Ground | Date Start Operation |
|---|---|---|---|---|---|
| Central/Western (Upper Level Police Station) | 1 High Street, Sai Ying Pun | Urban : Residential | 78m | 18m (4 floors) | Nov 83 |
| Eastern (Sai Wan Ho Fire Station) | 20 Wai Hang Street, Sai Wan Ho | Urban : Residential | 28m | 17.5m (4 floors) | Jan 99 |
| Kwai Chung (Kwai Chung Police Station) | 999 Kwai Chung Road, Kwai Chung | Urban : Mixed residential/ commercial/industrial | 19m | 13m (2 floors) | Jan 99 |
| Kwun Tong (City District Office) | 6 Tung Yan Street, Kwun Tong | Urban : Mixed residential/ commercial/industrial | 34m | 25m (6 floors) | Jul 83 |
| Sham Shui Po (Police Station) | 37A Yen Chow Street, Sham Shui Po | Urban : Mixed residential/commercial | 21m | 17m (4 floors) | Jul 84 |
| Tsuen Wan (Princess Alexandra Community Centre) | 60 Tai Ho Road, Tsuen Wan | Urban : Mixed residential/ Commercial/industrial | 21m | 17m (4 floors) | Aug 88 |
| Sha Tin (Sha Tin Govt. Secondary School) | 11-17 Man Lai Road, Tai Wai, Sha Tin | New Town : Residential | 27m | 21m (5 floors) | Jul 91 |
| Tai Po (Tai Po Govt. Office Bldg.) | 1 Ting Kok Road, Tai Po | New Town : Residential | 31m | 25m (6 floors) | Feb 90 |
| Tung Chung (Tung Chung Health Centre) | 6 Fu Tung Street, Tung Chung | New Town : Residential | 28m | 21m (4 floors) | Apr 99 |
| Yuen Long (Yuen Long District Branch Offices Bldg.) | 269 Castle Peak Road Yuen Long | New Town : Residential with fairly rapid development | 31m | 25m (6 floors) | July 95 |
| Tap Mun (Tap Mun Police Station) | Tap Mun | Background : Rural | 26m | 11m (3 floors) | Apr 98 |
| Causeway Bay | 1 Yee Woo Street, Causeway Bay | Urban Roadside : Busy commercial area surrounded by many tall buildings | 6.5m | 2m | Jan 98 |
| Central | Junction of Des Voeux Road Central and Chater Road, Central | Urban Roadside : Busy commercial/financial area surrounded by many tall buildings | 8.5m | 4.5m | Oct 98 |
| Mong Kok (Mong Kok Rd. Pumping Station) | 4E Mong Kok Road, Mong Kok | Urban Roadside : Mixed residential/commercial area surrounded by some moderately tall buildings | 7m | 2m (1 floor) | Apr 91 |

** = The Mong Kong Station has been relocated to the Lai Chi Kok Road since January 2001*

*Table 1-4 Sampling and Analysis Methods Used in Measuring Toxic Air Pollutants and Organic compounds*

| Toxic Air Pollutants | Sampling and Analysis Method | Sampling Instrument/Media | Sampling Schedule | Sampling Period |
|---|---|---|---|---|
| Benzene | USEPA Method TO-14 | Xontech 910A / Canister | Every 6 days | 24 hours |
| Perchloroethylene | USEPA Method TO-14 | Xontech 910A / Canister | Every 6 days | 24 hours |
| 1,3-Butadiene | USEPA Method TO-14 | Xontech 910A / Canister | Every 6 days | 24 hours |
| Formaldehyde | USEPA Method TO-11 | Xontech 920 / DNPH coated Sep-Pak Cartridge | Every 12 days | 24 hours |
| Benzo(a)pyrene | USEPA Method TO-13 | Graseby GPSI / PUF XAD-2 Sorbents | Twice per month | 24 hours |
| Dioxin | USEPA Method TO-9/23 | Graseby GPSI / Polyurethane Foam | Twice per month | 24 hours |
| Hexavalent Chromium | CARB SOP MLD 039 | Xontech 925/ Bicarbonate Impregnated Filter | Every 12 days | 24 hours |

## 1.2 Pearl River Delta Economic Zone

Existing Air Quality Monitoring Network

1.2.1 There are existing ambient air quality monitoring stations in all of the major cities within the PRDEZ. The number of the local air quality monitoring stations are different in each cities, depending on its population density, terrain features, industrial operation, economic growth and meteorological characteristics. Criteria pollutants such as hourly sulphur dioxide and nitrogen oxides and daily TSP are the common monitored parameters for these existing stations. With effective from 5th June 2000, all major cities in the Guangdong Province shall need to monitor RSP and starting from 2001 all township shall require to report the daily RSP results to the Provincial Monitoring Centre. Location of the existing ambient air quality stations with the parameters being monitored in PRDEZ is shown in Table 1-5. There is a set of Guo Biao (GB) technical standards governing the sampling and analysis of the pollutants and these sets of GB employed for the operation of the existing network is listed in Table 1-6. A comparison exercise shall be carried out at the early implementation stage to study the variations in the measurement and instruments used in the existing HKSAR and PRDEZ monitoring network. Internationally recognised methodology and equipment, not necessary based on the same equipment nor measurement principle, shall be employed in the region as far as technical feasible.

*Table 1-5 Ambient Air Quality Monitoring Stations in the Region*

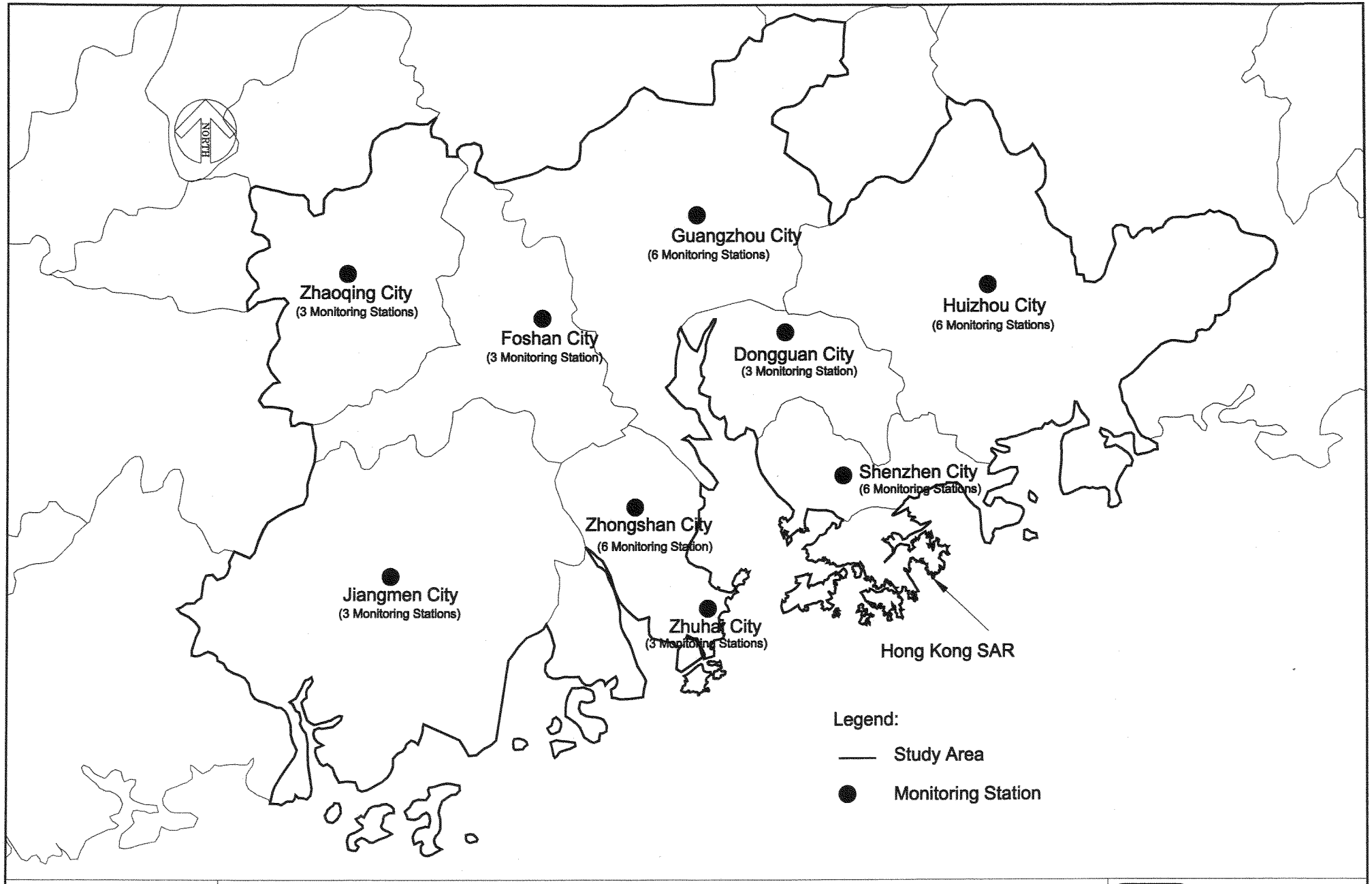
| Monitoring Stations | $SO_2$ | $NO_2$ | $O_3$ | TSP | RSP |
|---|---|---|---|---|---|
| Guangzhou (6 sub-stations) | ✓ | ✓ | ✓ | ✓ | ✓ |
| Shenzhen (6 sub-stations) | ✓ | ✓ | ✓ | ✓ | ✓ |
| Zhuhai (3 sub-stations) | ✓ | ✓ | | ✓ | ✓ |
| Huizhou (6 stations) | ✓ | ✓ | | ✓ | ✓ |
| Dongguan (3 stations) | ✓ | ✓ | | ✓ | |
| Zhongshan (6 stations) | ✓ | ✓ | ✓ | ✓ | ✓ |
| Jiangmen (3 stations) | ✓ | ✓ | | ✓ | |
| Foshan (3 sub-stations) | ✓ | ✓ | ✓ | ✓ | ✓ |
| Zhaoqing (3 stations) | ✓ | ✓ | | ✓ | |

*Table 1-6 GB Employed for the Sampling and Analysis of the Ambient Air Pollutants*

| Pollutants | GB National Standards |
|---|---|
| $SO_2$ | GB 8970-88 Air Quality – Determination of Sulfur Dioxides in Ambient Air – Tetrachloromercurate pararosaniline Method |
| $NO_x$ | GB 8969-88 Air Quality-Determination of Nitrogen Oxides in Ambient Air-Griss-Saltzman Method<br>GB/T 15435-1995 Ambient Air-Determination of Nitrogen Dioxides-Saltzman Method<br>GB/T 15436-1995 Ambient Air-Determination of Nitrogen Oxides-Saltzman Method |
| Ozone | GB/T 15438-1995 Ambient Air-Determination of Ozone-Ultraviolet Photometric Method |
| TSP | GB9802-88 Air Quality-Determination of Total Suspended Particulates-Gravimetric Method<br>GB/T 15432-1995 Ambient Air-Determination of Total Suspended Particulates-Gravimetric Method |
| RSP | GB6921-1986 Ambient Air Concentration Measurement Method |

Planned Air Quality Monitoring Stations in the Region

1.2.2 In February 2000, the Guangdong Province Government announced the "Blue Sky" project in which 35 works items related to improving ambient air quality from 1999 to 2010. These works items included installation of additional local air quality monitoring stations, improvement of existing stations, upgrading existing stations to fully automatic operation mode, setting up of city-wide automatic monitoring network and facilitate announcement of the city-wide air pollution index.

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# 2. PROPOSED AMBIENT AIR QUALITY MONITORING NETWORK IN THE REGION

## 2.1 Introduction

2.1.1 Due to the large variations on topography, population distribution, emission sources, meteorological conditions and political administration, it is difficult to specify the numbers of the air quality monitoring stations in the Region for a long period. Nevertheless, the set up of a regional air quality network shall depend heavily on the objectives of the monitoring exercise with regular review on the spatial and temporal coverage to suit its functional needs.

2.1.2 The primary objective of localised criteria pollutant monitoring is for comparisons with the air quality standards to determine if areas are comply with the state, provincial or local ambient air quality standards. Regional air quality data are needed not only for evaluating ambient air quality compliance but also used to support the development of air quality model evaluation and application, emission inventory evaluation and source apportionment, and forms the basis for air quality control and policy development.

2.1.3 By establishing the objectives of the regional monitoring network then the requirements for station siting and parameters to be monitored could be formulated.

## 2.2 Objectives of the Regional Air Quality Monitoring Programme

2.2.1 The objective of setting up a regional air quality monitoring network is to investigate how the spatial/temporal variations in regional air pollution are related to meteorology, emission sources and receptors. The monitoring stations should locate in areas where potential transport or accumulation of pollutants might occur. The monitoring stations should capture the highest pollutant concentration in the measurements. There are six pollutant groups (RSP, VOC, $NO_x$, $SO_2$, CO and $O_3$) that the regional air quality data could be provided for and they are listed in Table 2-1. Each pollutant to which a particular objective applies to meet the variety of data uses is marked with an X in Table 2-1. The priority of the objectives are listed in ascending order, but such arrangement should be subject to regular review to establish any modifications where necessary.

*Table 2-1 Monitoring Objectives for the Regional Air Quality Network in the Region*

| Priority of the Monitoring Objectives | Pollutants | | | | | | |
|---|---|---|---|---|---|---|---|
| | RSP Mass | RSP Chemical Composition | VOC & Carbonyl | $NO_x$ | $SO_2$ | CO | $O_3$ |
| Evaluation of Air Quality | | | | | | | |
| Determine current air quality standard | X | | | X | X | X | X |
| Establishing progress in compliance of standard | X | | | X | X | X | X |
| Establishing long term air quality trends | X | | X | X | X | X | X |
| Evaluation of Emission from Known Sources | | | | | | | |
| Judging compliance of state or local air quality standard | X | | | X | X | X | X |
| Provide data for environmental assessment | X | X | X | X | X | X | X |
| Control of individual sources | X | X | X | X | X | X | |
| Evaluation and Development of Control Strategy | | | | | | | |
| Evaluate of regional, state and local control measures | X | X | X | X | X | X | X |
| Development of regional, state and local control strategy | X | X | X | X | X | X | X |
| Preparation of Air Quality Improvement/Management Plan | | | | | | | |
| Establish of base line situation | X | | X | X | X | X | X |
| Identify chemical species and emission sources profile | X | X | X | X | X | | |
| Project future years emission and air quality | X | | X | X | X | X | X |
| Protection of Public Health | | | | | | | |
| Air quality indices | X | | | X | X | X | X |
| Determine long term trends | X | X | X | X | X | X | X |
| Provide a basis for involving short-term or emergency control | X | | X | X | X | | |
| Development and Testing of Air Quality Model | | | | | | | |
| Validation and refinement of models | X | | X | X | X | X | X |
| Basic information for receptor models | X | X | X | X | X | X | X |
| Evaluate of regional, state and local control measures | X | | X | X | X | X | X |
| Orientation for Air Pollution Research | | | | | | | |
| Evaluate the health effects on human, plants, animals, etc | X | | X | X | X | X | X |
| Characterisation of source, transport, formation on emissions | X | X | X | X | X | X | X |
| Testing and development of monitoring equipment | X | | X | X | X | | |
| Assess suitability of existing monitoring network | X | | X | X | X | X | X |

2.2.2 Each of these six pollutants groups (RSP, VOC, $NO_x$, $SO_2$, CO and $O_3$) has their own unique characteristic in the regional air quality monitoring exercise. Ozone is the major component of photochemical smog and formed under a complex chain of chemical reactions in the presence of sunlight and warm temperature involving a host of precursors. The key ozone precursors are being oxygen, nitrogen oxides and VOC. Respirable suspended particulate comprises particles with a nominal aerodynamic diameter of 10 micrometers or less. Some of these particles, such as carbon particles, are emitted from combustion sources and can be suspended and transported for long distances. Others, such as sulphates and nitrates, are formed from sulphur dioxide and nitrogen oxides as they get involved in chemical reactions in the atmosphere. Nitrogen dioxide is formed primarily from nitric oxide emitted from combustion sources.

Evaluation of Air Quality

2.2.3 Evaluation of the compliance rate of the state and local air quality standard is the primarily function of the current air quality monitoring data. Local city-based criteria pollutant concentrations shall be the first level information that needed to be collected for this purpose.

Evaluation of Emission from Known Sources

2.2.4 Source-specific regulations had been formulated for large or dominant industrial emissions in PRDEZ and HKSAR. These regulations consist of tailored or negotiated agreements as results of this project that are integrated to the operational process control plan of the various industrial sectors for implementation on a process-by-process basis. Although the responsibility to monitor and control on emissions fall upon the local city-based EPB agency, the objective is to measure the impact of the known sources to the environment in the region.

Evaluation and Development of Control Strategy

2.2.5 The monitoring data are used to demonstrate and characterise the effectiveness of the proposed regional control measures designed specially for industrial areas where emissions are dominant. The demonstration may identify categorical sources or specific sources within an area where additional control is needed for compliance with air quality standard. Non-deteriorated areas and areas subject to growth or industrial re-structure require monitoring to define the baseline conditions. City base monitoring stations are needed to fulfil these requirements.

Preparation of Air Quality Control Plan

2.2.6 Ambient air quality monitoring data are used to determine baseline air quality levels in locations of projected population growth and industrial expansion. Siting considerations need to consider whether special sites are needed to meet these data needs or whether the nearest available monitoring will be adequate. As the monitored results aimed to reflect the county-wide air quality, a wider spatial coverage of the monitoring stations are needed for these objectives.

Protection of Public Health

2.2.7 All air quality monitoring is ultimately oriented to public health and to provide an early warning of air quality deterioration. The information is usually presented in the form of Air Quality Index for an area to keep the public appraised of current levels of air pollutants. In the US, metropolitan areas use county-wide ozone monitoring networks to warn residents when unhealthy ozone concentrations are expected. The siting requirements of this monitoring co-located with the needs for ambient air quality evaluations.

Development and Testing of Air Quality Model

2.2.8 Monitoring data to support air quality model development or validation are generally unique for each project. This is particularly true for initial model development support where the objective is to describe and understand the fundamental of pollutant chemical processes or to develop parameter representing a specific terrain, meteorological condition, or source configuration.

2.2.9 As a general rule, air quality monitoring data to support the regional model development must be intensive and with the widest spatial and temporal coverage possible to provide the flexibility of maximum benefit with due consideration on economic restraints.

Orientation for Air Pollution Research

2.2.10 Air monitoring data are used to improve the scientific tools for measurement, interpretation, and prediction of air pollution impact by the application of air quality models and control measures formulation. To support such research oriented needs, monitored air quality must be representative for the region interested to provide a better understanding of the atmospheric chemistry, meteorology, and the relationship between precursor emissions and pollution formation.

## 2.3 Site Selection and Monitoring Parameters

Guiding Principle

2.3.1 With the objectives established for the end use of the air quality data, the regional air quality monitoring network stations shall be designed to meet all of the following siting considerations:

- To determine the highest concentrations expected to occur in the area covered by the network;
- To determine ambient concentrations representative of human exposure in areas of high population density;
- To determine the impact on ambient pollution levels of significant sources or source categories; and
- To determine general background concentration levels

Type of Monitoring Stations

2.3.2 There shall be three type of monitoring stations to form the monitoring network : regional, local and special purpose air monitoring station. The principle for the spatial coverage of these three types of air quality monitoring stations is referenced to the USEPA document for site selection. (40 CFR, Part 58, Appendix D, CFR 1997).

2.3.3 Location and function of the regional air quality monitoring station (RAMS) could be a sub-set of the local air monitoring station (LAMS). These two sets of monitoring stations are designed to serve the different functional needs for air quality studies in the Pearl River Delta Region in accordance to their individual siting, monitoring parameters and measurement equipment. Location and function of the LAMS shall be as follows:

i. Stations which located in areas of expected maximum pollution concentrations, and emission category;

ii. stations which represent human exposure in urban area (e.g. combine poor air quality with a high population density but are not necessarily located in an area of expected maximum concentration);

iii. design to provide data for national policy analyses and trend analyses; and

iv. provide the public with information about the air quality in major metropolitan areas.

2.3.4 Local air monitoring stations are located to represent micro-scale (10 to 100 m), middle-scale (100 to 500 m), neighbourhood-scale (500 m to 4 km), and urban-scale (4 to 100 km) zone of representation (40 CFR, Part 58, USEPA). These monitors represent a mixture of pollution from many sources within the urban complex, including those from the near-by sources. Micro-scale sites are located right next to a low-level emission source such as roadway, construction site, or chimney. Middle- and neighbourhood-scale sites are often source-oriented, used to evaluate contributions from individual sources and source zone of influence. Urban-scale sites are often located away from highly travelled roads, industries, and residential heating to represent community exposure. Representative urban-scale sites are used to determine compliance with standards.

2.3.5 RAMS are formed from selective LAMS and covered a very large of a geographical area with dimensions of as much as hundreds of kilometres which allow pollutants and precursors considerable mixing and transport in the region.

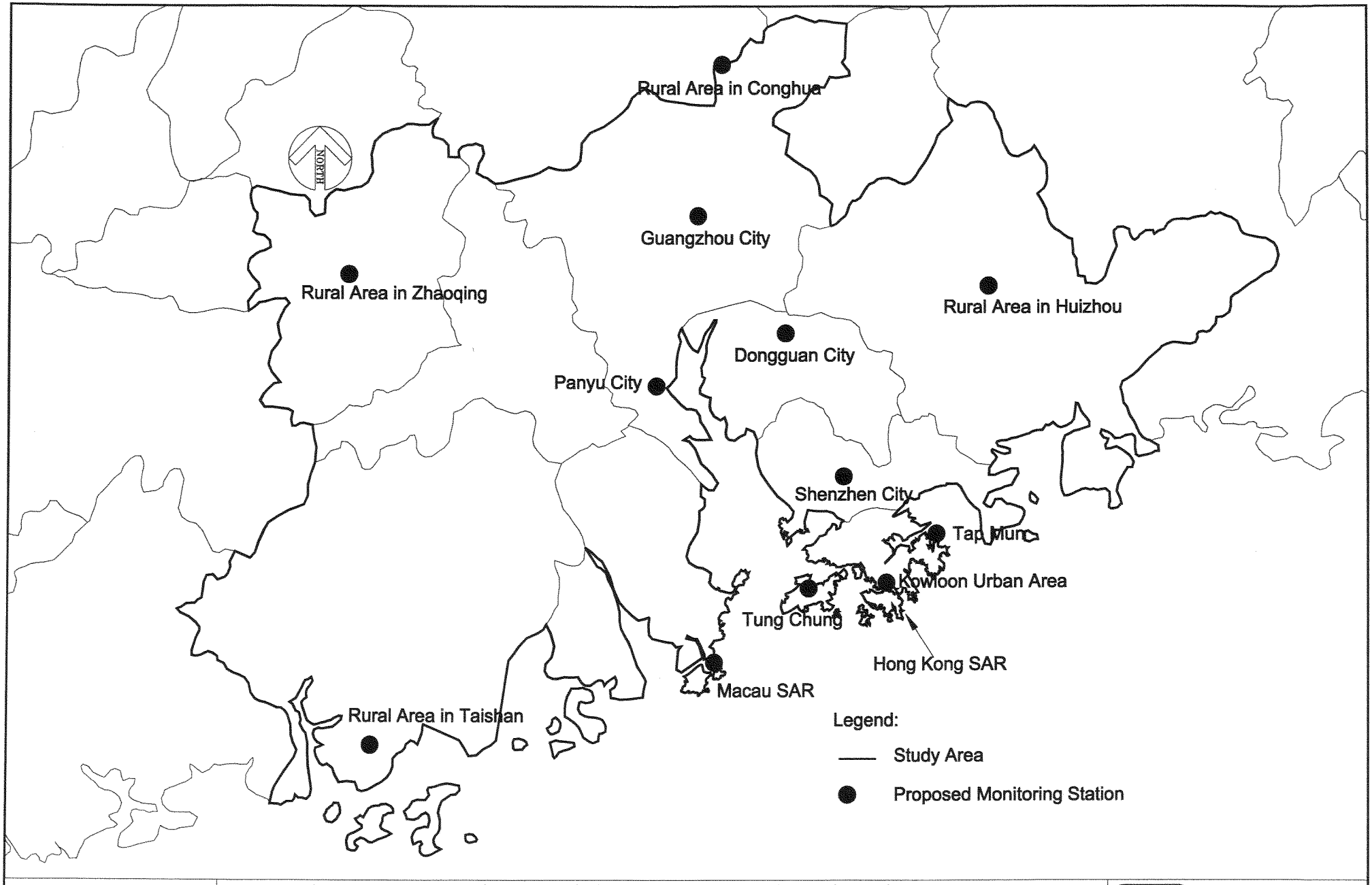
2.3.6 Regional-scale background monitors show consistency among measurements for monitor separations of a few hundred kilometres. Regional-scale RSP is a combination of naturally occurring aerosol from wind blown dust and marine aerosol as well as particles generated in the urban and industrial areas that may be more than a 1,000 km distant. Regional–scale (100 to 1,000 km) sites should be located in rural areas away from populated centres and local emission sources, and at higher elevations.

2.3.7 Measurements from the RAMS are useful for assessing air quality trends and for the evaluation of emissions against air quality standards in the region. The monitoring results shall provide valuable information of the region to develop air quality control measures and evaluate their effectiveness in emissions reduction that described the regional concentration patterns. The monitoring results will also be useful for understanding and defining the processes of long range air quality transportation problem that take hours to occur for the formulation of the air quality improvement plan. Proposed locations of the completed RAMS are shown in Figure 2-1 with the parameters to be monitored presented in Table 2-2.

*Table 2-2 Characteristics of the Proposed Regional Air Quality Monitoring Stations*

| Monitoring Stations | Station Type | Function Group | $SO_2$ | NOx | $O_3$ | RSP | TSP | VOC & Carbonyls | CO | Visibility | Met |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Guangzhou City, PRDEZ | Urban | 1 & 2w | • | • | • | • | • | □ | □ | • | •* |
| Dongguan City, PRDEZ | Urban | 2 | • | • | □ | □ | □ | □ | □ | □ | □ |
| Shenzhen City, PRDEZ | Urban | 1, 2e & 2w | • | • | • | • | • | □ | □ | • | • |
| Panyu District, PRDEZ | Urban | 2w | □ | □ | □ | □ | □ | □ | □ | □ | □ |
| Zhuhai City, PRDEZ | Urban | 1 & 2w | • | • | • | • | • | □ | • | • | • |
| Taishan Area, PRDEZ | Rural | 2e | □ | □ | □ | □ | □ | □ | □ | □ | □ |
| Zhaoqing Area, PRDEZ | Rural | 2w | • | • | □ | □ | □ | □ | □ | □ | □ |
| Huizhou Area, PRDEZ | Rural | 2e | • | • | □ | □ | □ | □ | □ | □ | □ |
| Conghua Area, PRDEZ | Rural | 3 | □ | □ | □ | □ | □ | □ | □ | □ | □ |
| Tap Mun, HKSAR | Rural | 3 | • | • | • | • | | □ | • | - | -* |
| Tung Chung, HKSAR* | Urban | 1, 2e & 2w | • | • | • | • | • | □ | • | - | •* |
| Kowloon Area, HKSAR | Urban | 1, 2e & 2w | • | • | • | • | • | □ | • | - | • |

*Note:* • *= existing monitoring parameters □= New parameters to be monitored*
- *= parameters being monitored by Hong Kong Observatory in urban area*
*Met = meteorological parameters include at least surface wind speed, wind direction, temperature and relative humidity.*
* *= equipped with vertical profiler * = no relative humidity measurement*
*1 = for assessment of regional air quality trend*
*2e = for studying of regional pollutants transportation along North-Easterly and South-Westerly direction*
*2w = for studying of regional pollutants transportation along North-Westerly and South-Easterly direction*
*3 = for monitoring of background pollutants level*

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2.3.8 Tap Mun and Conghua were established as the background monitoring stations as both of them were located at the remote location of the Study area. Two air pollution transportation axises within the Study area had employed to identify the location of the regional monitoring station: along the North-Easterly South-Westerly direction and along the North-Westerly South-Easterly direction. The first axis tends to record the emission from the major stationary emission points along that axis within the Region. The latter axis presented the movement of air quality across the whole region during the prevailing wind direction in the Region.

2.3.9 Implementation of the full scale regional air quality monitoring station shall be carried out by phases taking into the possible constraints of the financial and technical capability development. With the existing monitoring stations are being concentrated in the urban locations of the Study area, rural/background stations that measure the transportation of the regional pollutant should have the highest priority for execution. The core monitoring station and basic criteria pollutants that should be commenced immediately were presented in Table 2-3.

*Table 2-3 Core Stations of the Monitoring Network and the Key Pollutants to be Monitored*

| Monitoring Stations | Station Type | $SO_2$ | $NO_x$ | $O_3$ | RSP | VOC |
|---|---|---|---|---|---|---|
| Taishan Area, PRDEZ | Rural | □ | □ | □ | □ | □ |
| Zhaoqing Area, PRDEZ | Rural | • | • | □ | □ | □ |
| Huizhou Area, PRDEZ | Rural | • | • | □ | □ | □ |
| Conghua Area, PRDEZ | Rural | □ | □ | □ | □ | □ |

*Note:* • = *existing monitoring parameters*
□ = *New parameters to be monitored*

2.3.10 The special purpose monitoring program, which most ac-hoc research type exercise, is used to understand the nature and cause of excessive concentrations measured at the proposed monitoring stations or used to determine the zone of the representation of the urban-scale monitoring station. These monitors may be operated over a short period of time at different locations and may be discontinued as their monitoring objectives are achieved.

Parameters to be Monitored and the Network Siting Criteria

2.3.11 The proposed regional control measures shall have collective reduction benefits for VOC, nitrogen dioxide and sulphur dioxide; therefore their levels are expected to continue to reduce after the implementation of the control strategies. The proposed regional air quality monitoring network was therefore targeted specifically for VOC, ozone, RSP and visibility.

2.3.12 In the existing local air quality monitoring stations, nitrogen oxides and sulphur dioxide were being measured as standard parameters for evaluation of the air quality compliance. The primary objectives for measuring nitrogen oxides and sulphur dioxide in local air quality monitoring station, which will form part of the regional monitoring network should be retained and enhancing the station's technical capabilities to measure ozone precursors and RSP for the regional context.

2.3.13 Unique site constraints affect the air quality significantly, it is necessary to review the local situation of the monitoring station with detailed survey including photographic and written evaluation shall need to be prepared for final decision. Specific location selection criteria applicable to the photochemical assessment monitoring stations are provided in Section 10 of the *Appendix E to Part 58, USEPA 40 CFR Chapter I (July 1999 edition) - Probe and Monitoring Path Siting Criteria for Ambient Air Quality Monitoring,* and shall be followed as far as technically practicable for the sampling exercise.

2.3.14 Regular monitoring programme is neither available for VOC nor ozone precursors in PRDEZ. In HKSAR, VOC and carbonyl was being measured by the USEPA TO-14 and TO-11 method respectively. It is recommended that methodology model on TO-14 or TO-15 to be used to measure VOC and carbonyl concentrations in regional air quality monitoring. There should also be an agreed list of compounds for analysis.

2.3.15 Measurement and analysis for VOC should follow the USEPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition. Compendium Method TO-15 (EPA/625/R-96/01b). Determination of Volatile Organic Compounds in Ambient Air using Specially Prepared Canisters with Subsequently Analysis by Gas Chromatography. This TO15 method measured 55 VOC species. Both methodologies could be used for the VOC monitoring upon finalised on the list of compounds to be analysis.

2.3.16 Measurement and analysis for VOC shall follow the *"Technical Assessment Document for Sampling and Analysis of Ozone Precursors* {EPA/600-R-98/161 dated September 1999}". This document intended to provide detailed guidelines and method descriptions for measuring VOC and ozone precursors that are considered to contribute to the formation of ozone in the right atmospheric conditions. Selection of a suitable sampling location is critical for obtaining representative air sample for subsequent analysis. Due to the source characteristics of VOC and its capacity for the formation of oxidants, monitoring site types for VOC would be regional and local. For the local sites, an important subtype is reactant area where VOC emit.

*2.3.17* The collection and analysis of carbonyl shall follow the USEPA TO5 and TO11A compendium methods for the determination of toxic organic compounds in ambient air: *TO-11A Determination of Formaldehyde in Ambient Air Using Adsorbent Cartridge followed by Performance Liquid Chromatography* and *TO-5 Method for Determination of Aldehydes and Ketones in Ambient Air Using High Performance Liquid Chromatography.*

2.3.18 The monitoring objectives for $NO/NO_x$ are similar as VOC as both pollutants are important for the formation of photochemical pollution. The site location required to meet the $NO/NO_x$ monitoring will be the same as those for VOC. It is the best to collocate the $O_3$, $NO/NO_x$ and VOC measurements in order to understand the $O_3$ formation. These sites should be in areas believed to have high $O_3$, on the upwind edge of a study region, at one or more remote rural site, in some source areas (e.g., downwind of refineries, busy intersections), and between major urban areas that might be affected by a regional cloud.

2.3.19 USEPA published designated reference and equivalent methods for the monitoring and analysis of $NO/NO_x$. Details of these designated reference or equivalent methods could be referenced to USEPA web site (www.epa.gov/ttn/amtic/criteria.html).

2.3.20 Similar to $NO/NO_x$, RSP shall be monitored at all the RAMS in the Region due to it potential in causing significant deterioration of air quality. Measurement and analysis for RSP shall follow the *"Quality Assurance Handbook for Air Pollution Measurement System, Section 2.11 Reference Method for the Determination of Particular Matter as PM10 in the Atmosphere (High Volume PM10 Method)* {EPA-600/R-94/038b dated April 1994}" issued by the USEPA.

2.3.21 As a secondary pollutant, ozone requires considerable elapsed time and large scale mixing of the precursor to form across the Region. This formation requirement reduces the importance of monitoring with small-scale spatial variations as the concentrations do not vary significantly across a city area. The objective of the monitoring is related to ozone status as a product in the photochemical process and requires measurements that represent the regional distribution. The appropriate ozone RAMS sites should be located so that the product nature of the pollutant is emphasised. Details of the US designated reference or equivalent methods for the sampling and analysis of ozone could be referenced to the USEPA web site. (www.epa.gov/ttn/amtic/criteria.html)

2.3.22 Visibility is defined by the United State National Park Service as "the appearance of scenic features when viewed from a distance". Visual range is the common name given to the resulting estimate and for the comparison of visibility data from different sites, visual range estimates can be normalised to a Rayleigh coefficient of 0.01 km-1 (Particle-free atmospheric conditions at an altitude of 1.524 km or 5000 feet. This normalised estimate is called the "Standard Visual Range" (www2.nature.nps.gov/ard/impr/visibility.html). Instrumentation and naked eye are common monitoring procedures for the measurement of visibility depending on the available of funds.

2.3.23 Given the importance of long range transport in the ozone formation process, meteorological conditions are particularly important to the site selection process of the RAMS. Ozone formation is most conducive during warm, dry, and cloudless days with low wind speeds; these conditions most often occur during high-pressure systems. It will be important to consider the winds, in combination with the length of time required for the oxidant to form, and the locations of the major sources of the reactants. Meteorological factors also affect the selection of monitoring sites for primary pollutants, particularly when it is important to monitor the impact of a single, large, elevated source. The frequency of occurrence of certain combinations of wind speed, wind direction, and atmospheric stability will govern when and where the plume from an elevated source of primary pollutants has its greatest ground level impact. Meteorological factors are also important for the location of areas where secondary pollutants reach their highest concentrations. General meteorological parameters as indicated in Table 2-2 is the minimal requirements for the understanding the air pollution episodic events. It is essential to have at least two sets of vertical profiler in the Study area, one in Guangzhou and one in Hong Kong, to provide sufficient spatial coverage for the Region.

2.3.24 Once the capacity for the monitoring of criteria pollutants had been established, objectives of the regional air quality monitoring network could be expanded to include the air toxics in future to support research orientated air quality studies. There are 188 hazardous air pollutants under the control of USEPA and these air pollutants are known to cause or may cause cancer or other serious health effects and adverse environmental and ecological effects. Examples of toxic air pollutants include benzene from motor vehicle fuel, perchlorethlyene employed for dry cleaning processes and methylene chloride used as a solvent and paint stripper by a number of industries. Most of these air toxics are come from human-made sources including mobile and stationary sources as well as indoor application.

## 2.4 Quality Control and Assurance of the Air Quality Data

Overall Quality System of the Network

2.4.1 Ambient monitoring data should accompany by precision and accuracy checks prior to store in the regional aerometric information retrieval system (RAIRS). The quality control (QC) and quality assurance (QA) system should work hard-in-hand to achieve the goal of continuing quality in this regional monitoring programme and aims to provide the monitoring results with international acceptable quality standards.

2.4.2 The USEPA Quality Assurance Handbook specify the minimum quality control (QC) and quality assurance (QA) requirements for a regional air quality monitoring network with a description of the elements found in *40CFR Part 58 : Ambient Air Quality Surveillance, Appendix A "Quality Assurance Requirements for State and Local Air Monitoring Station"*. The operator of the monitoring system is encouraged to develop and maintain their own quality system for this regional air quality monitoring network based on international standard with regular reviews, such that a more extensive system could be ultimately developed and applied to this region. In addition, data quality objectives (DQO), which form part of the standard operation procedures, quantify the measurement shall be developed for this regional network based on local needs and operational constraints.

2.4.3 The QC system is an internal control mechanism and is the responsible of the regional air quality network operator. The system is intended to prevent, identify, correct and define the consequences of difficulties which may affect the precision and accuracy of the measurements and it includes the following activities:

- Prepare and review the standard operation procedures for the sampling and analysis;
- Equipment testing, calibration, maintenance and repairing and spare parts stocking;
- Perform different levels of data validation for air quality data with pre-set quality control limited;

- Operator technical support, supervision, and continuous professional training;
- Regular calibration and performance tests on blanks, duplicate checks and split samples; and
- Documentation in the form of logbook for procedures of filed sampling and laboratory analysis, data validation and processing, and calibration of consumable and equipment.

2.4.4 The QA system is an external audit mechanism that performs on an annual or bi-annual basis by an independent auditor, who is not involved in the set-up and operation of the air quality monitoring. Both system and performance audits should be included as part of the QA function. The results of QA system are data values with guaranteed specified precision, accuracy and validation that would be applied for further air quality studies or for the formulation of control strategies for the Region.

Standard Operation Procedures

2.4.5 Standard Operation Procedures (SOP) is the most important element of the QC/QA system for an air quality monitoring system. A typical format of a SOP is extracted from the *"Technical Assessment Document for Sampling and Analysis of Ozone Precursors* {EPA/600-R-98/161 dated September 1999}". There are 16 technical sub-sections for sample and analysis, a section on QA/QC and a reference section.

2.4.6 The SOP and the DQO should be followed strictly. When the SOP and DQO are not routinely met, rapid resolution of the problem is necessary with contingency in place. These obsolete procedures should be reviewed, refined or replaced with more appropriate methodology to suit local needs.

Audit Procedures of the Quality System

2.4.7 Another important element of the quality system of the regional monitoring network is the audit mechanism which carry out after in place of the QC system and used for the testing of the procedures and activities associated with the monitoring. There are three audit types of the quality system for this regional air quality monitoring network: Technical Systems Audit, Field and Laboratory Performance Audits and Data Quality Audit. The frequency of these audits shall be performed regularly depending on its need or in accordance to the UESPA Quality Assurance Handbook requirements.

2.4.8 The Technical Systems Audit reviews the operational and QC procedures to evaluate the adequacy of the system to meet the specified level of accuracy and precision. The Field and Laboratory Performance Audits establish the predetermined DQO are being achieved throughout the sampling and analysis procedures. Intra-laboratory and inter-laboratory shall be performed as part of this performance audit. The Data Quality Audit evaluates the documentation for data keeping, recording and handling as well as the storage of the data in the aerometric information reporting system (AIRS). System audits ensure that the standard operating procedures are being followed by the operators. System audits should be conducted during the first month of commencing the station operation, and on an annual or bi-annual basis. Performance audit challenge the station and laboratory with known concentrations of standards and calibrators which is traceable to the primary standards. Details of the audits could be refereed to USEPA *Quality Assurance Handbook for Air Pollution Measurement Systems. Volume II – Ambient Air Specific Methods (Interim Edition). {EPA/600/R-94/038a}.*

# 3. PROPOSED IMPLEMENTATION PLAN FOR THE REGIONAL MONITORING NETWORK

## 3.1 Proposed Monitoring Implementation Plan

3.1.1 Success implementation of the regional air quality monitoring network shall require continuous management reviews and technical guidance on all contents of the system. A regional air quality monitoring committee should be set up with representatives from HKSAR and Guangdong Province Government officials to provide management overview and oversee the technical requirements of the system.

3.1.2 The management overview shall include regular meetings to review and evaluate the effectiveness of the current air quality monitoring programme, identify problems or deficiencies related to operation of the monitoring network and suggest corrective actions to be taken by relevant parties. The review shall also provide periodic assessments of the programme as to meet the objectives of the data and to assure that funding will be adequate to continue full implementation of the monitoring network.

3.1.3 Responsibility for overseeing the technical requirements of the system shall include an integrated programme for assessment and technology advancement of the monitoring network which consist of the following two areas:

- Oversee operation of the regional air quality monitoring; and
- Review needs for expanded data analysis

Setting Up of a Regional Air Quality Monitoring Network

3.1.4 Financial implication – Preliminary assessment through discussions with HKSAR leading equipment suppliers indicated that the capital cost for setting up of an individual air monitoring station with the function and equipment list stated in the previous section shall range from 3.5 to 4 million Hong Kong Dollar (2001 price). In additional, there shall be recurring cost for the routine day-to-day operation of the monitoring network including collection and laboratory analysis of samples, checking and maintenance of equipment, and purchase of calibration standards and other related consumables. Initial consultation with Mainland consultants indicated the monthly recurrent cost for the operation of a monitoring station shall be around Twenty Five Thousand RMB (2001 price).

3.1.5 Planning - An implementation plan of the regional air quality monitoring exercise should be developed jointly by the HKSAR and Guangdong Province Governments. This document provides the fundamental framework of the monitoring system and direct advice on the long-term operational principles of the system. The plan also provides guideline to the local monitoring operator on the skeleton of the whole regional network set-up and operation. The programme of the monitoring network should be set up as soon as possible for providing background information to the regional control measures. Detailed site survey as well as evaluation of the monitoring network could be carried out as the first phase of the programme. At the same time, the design of each monitoring should commence so that within half a year, the complete monitoring network could be confirmed. It will take about 4 months to go through the contractual arrangement for the tendering and contract award processes prior to the network could be built in the Region. The commissioning test of the network is expected to be performed about 6 months after the award of the contract. A preliminary implementation plan of the regional air quality monitoring network is indicated in the Figure 3-1 for reference. The implementation of the whole regional network should be built up by phases taking into account of the financial and technical capacity building for the number of stations.

3.1.6 Site Survey – Further to the finalised of the implementation plan, a detailed site selection survey shall be carried out to select the most appropriate monitoring stations with the input from the local monitoring network operator. This initial site survey presented a base line siting situation of the monitoring stations and their surrounding environment shall be reviewed regularly to check the compliance with the USEPA requirements as described in the previous section.

3.1.7 Supervision – To ensure the consistency of the monitoring programme across the whole Region and providing technical support to operators, local co-ordination centres in Hong Kong, Guangzhou, Dongguan, Shenzhen and Zhuhai shall be set up. These co-ordination centres aimed to provide management and technical assistance on day-to-day operation of the monitoring network and to facilitate communications among various monitoring stations as well as advise on the overall strategy of the regional monitoring network.

3.1.8 Regular Revisions – Annual system and performance audits shall be carried out under the supervision of the management committee on all the monitoring stations to evaluate its function and contribution to the regional air quality network. Any inappropriate monitoring station due to changes in local situation that lead to non-compliance with the SOP siting criteria shall be eliminated.

Review the Need for Expanded Data Analysis

3.1.9 Once uniform criteria for siting, sampling probe height, and use of valid monitoring equipment had been adhered to, the data are comparable from various stations within the network system. Therefore, the role of ambient air quality data is expected to increase in importance in the future as an input to major air policy decisions and other air quality related research studies as identified in latter part of the Table 2-1.

3.1.10 The data shall be stored in a compatible media of the aerometric information reporting system (AIRS) in centralised database system in Hong Kong and Guangzhou. There shall be regular review by the monitoring management committee on the application and needs of these collected air quality data for air quality studies. The major objective of AIRS is to provide an interactive, user-oriented data management system which will easily facilitate the collection, validation, storage, retrieval, analysis, and summarisation of all air data.

3.1.11 Statistical techniques of time series analysis and multivariate analysis shall then be developed and applied for determining regional-wide trends and broad regional changes of pollutants. The application of air quality data could then extend to solve unique problems involved in comparing and evaluating the air quality trends in the region and in evaluating the impacts of model performance on design of control measures.

*Figure 3-1 A Preliminary Implementation Plan of the Regional Air Quality Monitoring Network*

| Task Name | Year 1 | | | | | | | | | | | | Year 2 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mth 1 | Mth 2 | Mth 3 | Mth 4 | Mth 5 | Mth 6 | Mth 7 | Mth 8 | Mth 9 | Mth 10 | Mth 11 | Mth 12 | Mth 1 | Mth 2 | Mth 3 | Mth 4 |
| **Network Planning** | | | | | | | | | | | | | | | | |
| Evaluation of existing monitoring set up | | | | | | | | | | | | | | | | |
| Comparison analysis of the monitoring network | | | | | | | | | | | | | | | | |
| Design of the additional station and the network | | | | | | | | | | | | | | | | |
| Confirmation of preliminary design of the monitoring network | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| **Tender Process** | | | | | | | | | | | | | | | | |
| Confirmation of the network design | | | | | | | | | | | | | | | | |
| Invitation for tender | | | | | | | | | | | | | | | | |
| Tendering process | | | | | | | | | | | | | | | | |
| Award of the tender | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| **Operation Phase** | | | | | | | | | | | | | | | | |
| Design, built & commissioning the monitoring network | | | | | | | | | | | | | | | | |
| Commencement of the network operation | | | | | | | | | | | | | | | | |