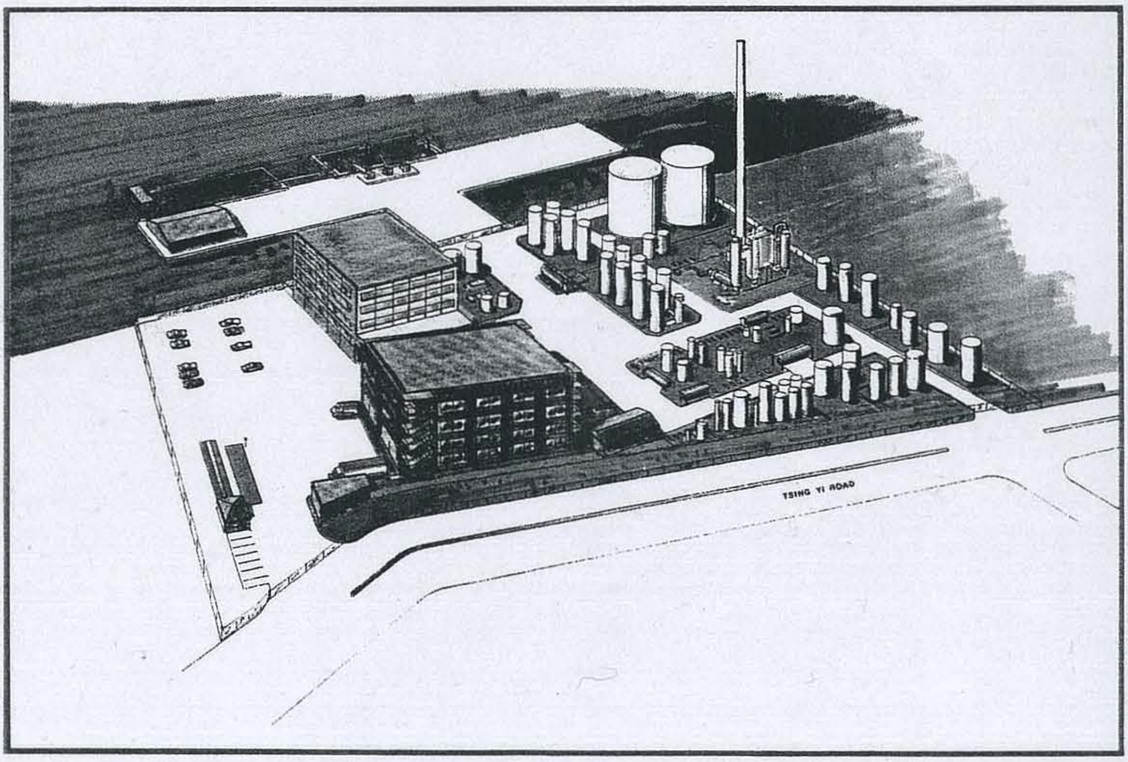
HONG KONG CHEMICAL WASTE TREATMENT FACILITIES

ENVIRONMENTAL IMPACT ASSESSMENT



Enviropace Limited

CHEMICAL WASTE TREATMENT FACILITIES

<u>ENVIRONMENTAL IMPACT ASSESSMENT</u>

FINAL REPORT

Prepared for:

Environmental Protection Department

Government of Hong Kong

Prepared by:

Waste Management International, Inc.

Dames & Moore

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EXECUTIVE SUMMARY

1.0 Background

The Hong Kong Government recently published a Waste Disposal Plan which highlights the magnitude of the problems associated with managing the collection and disposal of nearly 88,000 tonnes of wastes generated in Hong Kong every day. A small percentage of the total volume of wastes produced contains toxic or hazardous compounds. These wastes arise as by-products of various industrial manufacturing and maritime processes. Many wastes are produced by small factories operating in multi-storey industrial buildings. Factory owners generally do not have the space, waste management experience or financial incentive to treat their chemical wastes. The common practice is to discharge wastes into sewers and surface water drains, and coastal and harbour waters. This practice poses serious danger to public health as well as damage to sewage treatment plants and the environment.

The Government has reacted to the problem of chemical waste disposal by announcing plans to introduce comprehensive regulatory controls on the storage, treatment, transport and disposal of these wastes. The Government has also implemented a Waste Disposal Ordinance with provisions for licensing of waste collection and disposal services. To enable the chemical waste disposal strategy to be implemented and to enable industry to comply with the legislative controls of the Waste Disposal Ordinance, the Government clearly needs to establish appropriate chemical waste treatment/disposal facilities.

A Tender was issued to a number of international consortia to present bids for the design, construction and operation of a Government-owned Chemical Waste Treatment Facility (CWTF), to be located on Tsing Yi Island, Hong Kong. A contract was subsequently awarded to Enviropace Ltd, a subsidiary of Waste Management International Inc. (70%), China International Trust and Investment Corporation Hong Kong (Holdings) Ltd. (20%), and Kin Ching Besser Ltd (10%).

The Contract issued by the Government stipulated that an Environmental Impact Assessment and Hazard Assessment (EIA/HA) be completed as part of the design phase of the CWTF in Hong Kong. The purpose of this EIA/HA is to update earlier, planning phase EIA/HA reports on the CWTF, in order to address specific aspects of Enviropace's conceptual design that may differ from the design assumptions in the previous reports. The EIA/HA will be followed by an

Emergency Response Plan, as part of the CWTF operations manuals, to be prepared when the detail engineering is completed.

The previous environmental and hazard reports concluded that the proposed Tsing Yi Island site was suitable for the project and that the CWTF was likely to result in minimal adverse impact on the local environment, whilst the provision of the CWTF would result in considerable environmental benefits to Hong Kong as a whole.

2.0 Chemical Waste Programme in Hong Kong

The Waste Disposal Plan (EPD, 1989) classifies about 0.3% (or 280 tonnes per day) of the wastes from the 20,000 industrial and commercial establishments in Hong Kong as chemical wastes with toxic and hazardous characteristics. Whilst this is a small volume relative to the total wastes in Hong Kong, the chemicals are such that this group of wastes requires special consideration.

The chemical wastes arise as by-products of various industrial processes employed by many of Hong Kong's export-oriented manufacturers. This is particularly the case for the electronic and metal product industries and metal finishing activities. Non-manufacturing industries also produce chemical wastes, mainly as residues from the storage of materials and from damaged or unwanted products. Another major source of chemical waste arises from the shipping industry. Under the International Convention for the Prevention of Pollution from Ships (or the MARPOL Convention), ships are required to install equipment to contain chemical wastes including oily substances that would otherwise be discharged directly to the sea. These wastes must be off-loaded and disposed of in an environmentally acceptable manner.

Present waste disposal practices as described above pose serious environmental, engineering and public health risks and led the Government to examine a range of chemical waste disposal options. The Government concluded that the preferred strategy would involve a combination of recovery and re-use; chemical detoxification; physical, chemical and biological treatment; thermal destruction; stabilization of the residues of these processes; and disposal of these innocuous residues in a landfill.

These processes comprise the Chemical Waste Treatment Facilities that the Government contracted Enviropace to implement. The CWTF will offer major environmental and socio-economic benefits to the local community and the surrounding environment.

3.0 Site Description

The CWTF site is located on the south-east side of Tsing Yi Island, at the southern most part of Rambler Channel and northwest of Hong Kong Island and Victoria Harbour. The site was chosen as the best location for the CWTF following a detailed site selection study. The site was chosen for the following reasons:

- o it was near the heart of marine transport activities;
- o it had reasonably good access to the major industrial zones;
- o it had good access to land and maritime transportation;
- o the site had already been formed and would be available immediately; and
- o the site was located sufficiently far away from residential areas.

The site is bounded to the southwest by vacant land which is reserved for future infrastructure projects. The vacant land separates the site from the China Resources Oil Depot. To the north is the Outboard Marine Asia Limited facility and Rambler Channel, and to the northwest along Tsing Yi Road are Tien Chu Ve-Tsin Chemicals and Dow Chemicals (HK) Ltd. The old Cattle Quarantine Station Jetty is part of the site and is expected to be renovated to receive bulk wastes from barges and other vessels.

The northeastern sector of Tsing Yi Island is largely residential with almost all the residents living in high-rise tower blocks. These two residential estates are more than 1 km from the CWTF site, viz: Mayfair Gardens and Cheung Ching Estate. The total residential population of Tsing Yi Island is about 190,000. Many of the residents commute to Hong Kong for work.

A number of proposed developments have been suggested for Tsing Yi Island. The most significant include a Technical Institute and the Container Terminal 9 (CT9)/Southeast Tsing Yi (SETY) project, which would involve relocation of several major industries, reclamation of 140 ha of sea and the development of a major Container Terminal. The CT9 project is potentially significant to the CWTF because it could adversely affect marine access to the site, the safety associated with handling MARPOL waste, and the design of the seawater cooling system.

4.0 Description of the Project

The CWTF will be an integrated facility capable of handling virtually any type of chemical waste. Processes to be installed at the plant include:

- o high temperature incineration of organic wastes, coupled with energy recovery;
- o separation of oils from water and biological treatment of organically contaminated wastewaters;
- o physical-chemical treatment of inorganic aqueous wastes, including oxidation/reduction reactions, neutralisation of acids and alkalis and precipitation of toxic metals;
- o special and final treatment of various wastewaters by evaporation and catalytic oxidation, coupled with water recovery;
- o recovery of metal and possibly etchant materials from the waste by-products of electronics industries; and
- o stabilisation of sludges and CWTF process residues containing toxic constituents that might otherwise leach in a landfill environment. The residues include wastewater treatment sludge filter cake and incinerator bottom and fly ash.

The Government requires that the CWTF be able to treat a wide range of wastes, although not all can be known at this time. Because of the possibility of receiving wastes in addition to those included in the Contract categories, the CWTF has been designed for flexibility and adaptability in both storage and treatment. Therefore, three of the CWTF processes have greater versatility than their conventional alternatives: rotary kiln incineration, stabilisation, and the PO*WW*ER aqueous treatment process. The rotary kiln can accept most organics, including solids and containers that are not anticipated. PO*WW*ER can treat a very broad range of chemical characteristics simultaneously and still remove contaminants to very low levels. Stabilisation can immobilise toxic metal substances in waste sludges and residues of the other processes by mixing the residues with appropriate reagents, so that all solid materials leaving the CWTF are innocuous. The flexibility in each of these systems will allow the CWTF to handle the range of waste streams required by the Government.

The following chart presents a summary of the quantities of wastes that the CWTF has been designed to receive.

Approximate Quantities of Chemical
Wastes to be Treated at the CWTF

Wastes and Treatment Process	Approximate Quantities (tpa)
Organic Wastes for Incineration	14,650
Inorganic Wastes for Physical/Chemical Treatment	69,500
Aqueous Organic Wastes for Biological and Special Treatment	13,650
Total	97,800

The facility will produce cleaned gases that will be discharged through the incinerator stack, treated liquid effluent that will be discharged to the foul sewer and stabilised solid materials that will be disposed of in landfills.

A comprehensive environmental management and monitoring programme will be implemented at the CWTF to ensure that the potential environmental impacts are minimised. All wastes received at the CWTF will be logged and where appropriate, sampled, to allow tracking through the plant and to ensure delivery to the correct storage and processing unit. Air emissions from the incinerator, liquid effluents to the four sewer, and groundwater at the site will all be monitored. All sampling and analyses will be carried out according to U.S. EPA methods. Information from the monitoring programme will be available to the Government and assessed to ensure that the environmental management procedures are maintained. A preventive maintenance programme and an emergency response plan will be implemented throughout the CWTF.

Enviropace will implement a system of containerisation, collection and laboratory testing for the wastes throughout Hong Kong that will be treated at the CWTF. Containers will be installed at the sites where wastes are generated, and periodically collected and replaced.

Enviropace will also provide equipment and trained personnel for emergency response to chemical accidents throughout Hong Kong.

5.0 Environmental Impact Assessment

The CWTF at Tsing Yi Island has already been the subject of environmental and hazard assessments (ERL 1987). The major conclusions of the assessments were as follows:

- the location of the CWTF is appropriate under the planning strategy for Tsing Yi Island;
- the CWTF will provide a much needed facility for the safe treatment and disposal of the increasing quantities of chemical waste being generated in Hong Kong;
- the CWTF will reduce present risks to public health and safety, and prevent future deterioration in water quality from wastes by reducing present improper disposal practices;
- there are no significant effects on amenity for Tsing Yi residents; and
- approximately 70-100 jobs will be generated by the CWTF once it is operational. (In fact the eventual number of jobs to be generated by the CWTF is now estimated at 375.)

The present EIA/HA has not, therefore, treated in detail all of the issues that were studied previously. The main purpose of the EIA/HA is to address those aspects of the Enviropace conceptual design that may differ from the general plan for the CWTF that was assessed before.

The focus of the EIA/HA has been on a series of key issues which were the subject of a Report prepared after the Enviropace design was accepted by the Government. The Key Issues Report (Appendix A) identified air quality, traffic and visual impacts as the main environmental issues requiring further consideration, together with risks and hazards. Other issues such as solid and liquid waste disposal, noise and socio-economics are discussed in the present environmental assessment, but because of the reduced potential for environmental impact, the approach has been to reconfirm, where appropriate, the results presented by ERL (1987).

The following is a summary of the potential environmental impacts associated with the CWTF:

Air

Air emissions from the CWTF incinerator were identified as the most important of the Key Issues to be studied in detail in the EIA/HA. Computer modelling of the dispersion of pollutants was carried out to determine the concentrations of pollutants at the locations of all possible receptors in the surrounding environment of the CWTF site.

The model assumed that the incinerator would continuously emit pollutants at the maximum rate allowed by the Contract. In practice, however, emissions will be much lower than this most of the time. Also the model predicts the highest pollutant levels that would occur under worst case meteorologic conditions. In reality, however, wind directions and atmospheric stability conditions are always changing. Therefore, pollutants at any particular location will, on most occasions, not be as concentrated as those assumed in the assessment.

Assuming these worst case operating and meteorological conditions, incinerator emissions predicted will be well within the Hong Kong air quality objectives and maximum individual cancer risk standards. Also, a review of the limited air quality data that are available indicates that the cumulative impact of the CWTF on the existing ambient air quality is likely to be negligible.

Monitoring will include an assessment of both incinerator stack emissions and ambient air quality. Key parameters at the incinerator stack will be monitored continuously to ensure proper combustion. Ambient air quality will be measured every six months at three locations.

The CWTF incinerator will be operated with an automatic emergency interlock and shutdown system. This system will ensure an orderly transition to safe conditions during a process upset or mechanical equipment malfunction. In the event of a serious incinerator upset, all waste feed will automatically stop. Even in a complete power loss to the CWTF, the incinerator functions will only decay very slowly while auxiliary power is restored to the system.

Dust generated during construction will potentially cause a short-term, localised, nuisance, but the overall environmental impact will be negligible. The potential for dust during operation is very low. The plant has been designed so that raw materials and incinerator ash are handled in an enclosed environment. Specific procedures have been devised to ensure that the impact from handling these materials will be negligible. No ongoing monitoring program is envisaged.

Five sources of fugitive emissions were identified but none was considered likely to lead to any significant impact. Product storage and handling facilities have been designed so that fugitive emissions will be vented to either a gas scrubber, a carbon absorption system, the incinerator, or an auxiliary boiler. The design features of the CWTF and the very low potential for impact means that no specific management or monitoring programme is planned.

<u>Water</u>

Effluent from the CWTF treatment process will meet very strict limits on pollutant concentrations. This water will be discharged to the foul sewer, in accordance with the Contract. The multiple processes for treating liquids at CWTF, both conventional and special, produce a high degree of confidence that the broad range of wastes can be safely managed.

A comprehensive management and monitoring programme will be implemented. Continuous automatic monitoring of pH, temperature and flow rate will be provided in order to give immediate warning of any significant change in the composition of the effluent. A range of physical and chemical parameters will be monitored each shift.

Other potential sources of water pollutants are: accidental spillages, water run-off from the plant site or contaminated groundwater. The CWTF design and operations include safeguards for all of these.

The highest probability for a spill would be from a pipe connection at the MARPOL wastes jetty. The current design provides for safety checks and valves which greatly reduce the likelihood of such an event. If a spill were to occur, volumes would be small and the area affected would be minimised with the deployment of booms and skimmers. The potential impact arising from a collision could be more significant, depending on the volume and nature of the waste and the location of the spill.

The entire surface of the CWTF is sealed. Storage and process areas are bunded and protected with secondary containment. Rainwater runoff will temporarily be contained here, and effluent discharged from the CWTF operations will first be evaluated and then treated if necessary before it is released.

The Emergency Response Plan will detail the procedures to be observed in the event of a spill. Further, the CWTF plans to implement a groundwater monitoring programme for early detection of possible contamination caused by CWTF activities. To determine site conditions prior to CWTF operations, five boreholes with wells will be installed and samples of soil and groundwater will be extracted and analysed. If the results indicate significant contamination, it is recommended that EPD initiate a detailed environmental audit. EPD may also consider installing other wells offsite to determine groundwater flows in the area.

It is concluded that the CWTF has planned to take important steps to minimize the impact its facility will have on any groundwater or sea water.

<u>Land</u>

All wastes and process residues at the CWTF will be detoxified, chemically stabilised and physically immobilized so that the materials are environmentally benign. The stabilised materials will undergo sampling and analysis. Only then will they be sent off-site for final disposal in a landfill. This will more than comply with all the regulations governing the CWTF residuals. There is little impact these wastes could have on the environment.

Human or Social

TRAFFIC:
The volume of construction traffic is insignificant in terms of general traffic conditions; therefore, it poses only minimal environmental impact as queuing might occur on the main road. Likewise, the impact of waste collection traffic flows are unlikely to be very significant. Installation of signal controls will not be necessary for traffic to ingress and egress the site.

The traffic study identified some potential issues which the CWTF and EPD may want to consider. Rather than the few CWTF vehicles posing a problem for others, it was found that the general traffic conditions in many areas of Hong Kong may prove detrimental to CWTF collection operations. The present scheduling arrangements for collection vehicles necessitate operations during peak rush hour traffic. This will cause delays, reduce the efficiency of collections and possibly present an increased risk in the event of traffic accidents, for purposes of environmental control and emergency response.

NOISE:
Noise associated with construction or operations is unlikely to have any significant impact on residential areas on Tsing Yi. All activities are designed to meet the noise control ordinance.

VISUAL:
The CWTF will be visible from the harbour and from Hong Kong Island, but will not be a prominent visual feature. An appropriate colour scheme will be chosen to mitigate the visual impact of the facilities.

SOCIO-ECONOMICS:
The socio-economic impact of this facility can only be viewed as positive. A cleaner environment, employment generation and the possibility of attracting increased foreign investment

in manufacturing, storage and shipping are all important social benefits which the CWTF is expected to provide.

6.0 Conclusions

The management of waste represents one of the most pressing environmental problems confronting the Hong Kong community. The EIA/HA concludes that there are significant environmental benefits associated with the CWTF. Toxic and hazardous materials that are presently discharged directly into sewers, open drains and coastal or harbour waters will be detoxified, destroyed or otherwise treated, and then stabilised for disposal. The Government has established strict pollution control regulations that apply to all these activities.

The processes and management proposed by Enviropace, and the environmentally protective mitigation measures that are built into the CWTF design, are among the most advanced in the world. The potential environmental impacts associated with the construction and operation of the CWTF can be managed without causing any long term, detrimental effect on the environment.

CHEMICAL WASTE TREATMENT FACILITIES

ENVIRONMENTAL IMPACT ASSESSMENT

FINAL REPORT

1.0 INTRODUCTION

1.1 BACKGROUND

The Hong Kong Government recently published a Waste Disposal Plan which describes existing and proposed arrangements for the collection and disposal of all wastes falling within the ambit of the Government's Waste Disposal Ordinance. The Plan also provides details of existing and proposed waste disposal sites and disposal methods (Environmental Protection Department, 1989).

The Waste Disposal Plan highlights the magnitude of the problems associated with managing the collection and disposal of nearly 88,000 tonnes of wastes generated in Hong Kong every day.

A small percentage of the total volume of wastes produced contains toxic or hazardous compounds. Many of these wastes, estimated at about 280 tonnes per day in 1988, arise as by-products of various industrial processes and most are presently disposed of via direct discharge to sewers and surface water drains. This practice poses serious danger to public health as well as damage to sewage treatment plants and the environment.

The Government has reacted to the problem of chemical waste disposal by announcing plans to introduce comprehensive regulatory controls on the storage, transportation, treatment and disposal of these wastes. This action will require the development of a centralised treatment facility and a secure landfill for the disposal of residual material.

A Tender was issued to a number of international consortia to present bids for the design, construction and operation of a Government-owned Chemical Waste Treatment Facilities (CWTF), to be located on Tsing Yi Island, Hong Kong. A contract was subsequently awarded to Enviropace Ltd, a consortium comprising Pacific Waste Management Ltd. (70%) (a wholly owned subsidiary of Waste Management International); China International Trust and Investment Corporation (20%) (through its wholly-owned subsidiary Belvienna Ltd); and Kin Ching Besser Ltd. (10%).

The turnkey construction contractor for the CWTF is Bechtel Environmental Inc. and the civil contractor for the project is Gammon Construction Ltd. The incinerator system is being provided by Widmer & Ernst, owned by ASEA Brown Boveri.

Two other contractors provide advice to both Enviropace and the Environmental Protection Department (EPD). Johnson Controls International Inc., is developing and installing the CWTF computer system which will provide the EPD with the means to monitor toxic and hazardous chemical waste disposal in Hong Kong, and Dames & Moore International has the responsibility for compiling the Environmental Impact Assessment and the Hazard Assessment (EIA/HA) for the CWTF.

1.2 AIMS AND APPROACH

The Contract issued by the Government stipulated that an EIA/HA be completed as part of the proposal to establish a chemical waste treatment facility in Hong Kong. This document has been prepared in response to this requirement.

The aim of the EIA/HA is to provide information on the facilities in relation to the nature and extent of environmental and hazardous impacts. This information will contribute to decisions on:

- the conditions for the design, phasing and development of the proposed project; and
- the acceptability of any adverse environmental consequences that are likely to arise from the construction and operation of the CWTF.

The assessment will also lead to the development of an environmental management and monitoring programme which will ensure that any adverse environmental impacts will be anticipated and minimised, and an Emergency Response Plan.

The approach adopted for the preparation of the EIA/HA acknowledges that the proposed CWTF has already been the subject of a preliminary environmental review and hazards assessment (ERL, 1987). The ERL environmental review concluded that the proposed Tsing Yi Island site was suitable in environmental planning terms and that the CWTF was likely to result in minimal adverse impact on the local environment, whilst the provision of the CWTF would result in considerable environmental benefits to Hong Kong as a whole. The Facility will likely result in preventing further deterioration of water quality in the surrounding sea of the Territories, improving marine life, reducing and adverse health effect due to improper waste disposal, etc.

The ERL review was also significant because it described a number of key environmental issues that have since been given detailed consideration during the tendering and pre-design phases of the project.

The approach adopted for this study has therefore been to build on the information presented in previous reviews, and to highlight the environmental consequences of various design developments that have occurred in response to earlier environmental assessments and through the tender process.

1.3 SCOPE OF THE STUDY

The scope of the EIA as defined in the Contract is to:

- describe the facilities and the requirements for their development;
- identify and describe the elements of the community and the environment likely to be affected;
- identify and evaluate the net impacts expected to arise during the construction and operation phases;
- identify methods and measures which may be necessary to mitigate these impacts and reduce them to acceptable levels; and
- recommend any further ongoing monitoring requirements necessary to mitigate these impacts and reduce them to acceptable levels.

The key areas to be addressed in the HA are:

- fire hazard in the bulk organic liquids tank areas, including transfer from road tankers and drums;

- consequences of incinerator upset, scrubber failure and loss of main electric power; and
- hazard from accidental mixing of incompatible inorganic wastes in bulk storage and in treatment plants.

In these cases, process and instrumentation diagrams, operating procedures and layout drawings will be reviewed to enable discussion of the degree of risk and means by which acceptable levels of hazard will be achieved.

The Contract also requires the preparation of an integrated on-site Emergency Response Plan. The scope of the Emergency Response Plan covers the main potentially hazardous situations such as spillages of chemical wastes, fire and the uncontrolled release of toxic or asphyxiating gases. The Plan also provides details of the roles of CWTF site personnel and of key government emergency services.

The Emergency Response Plan will be prepared and submitted independently of the EIA/HA.

1.4 STRUCTURE OF REPORT

The EIA/HA has been prepared as two volumes; Volume 1 contains the EIA and Volume 2 the HA.

The structure of each volume is described as follows:

Volume 1, EIA

Section 2.0 describes the issues associated with disposing of chemical wastes in the context of the Government's Waste Disposal Plan for Hong Kong. Section 3.0 describes the geographical setting of the Tsing Yi Island site, adjacent land uses, transportation access, and its location with respect to regional planning issues. Section 4.0 presents a description of the proposed development, the administrative arrangements that will be implemented to operate the CWTF, the operating philosophy and the overall time schedule of the project. The environmental impacts arising from construction and operation of the CWTF are then described in Section 5.0. Each major environmental issue is discussed in terms of sources of impact, impact assessment and impact management/monitoring. Section 6.0 presents the conclusions of the EIA.

Volume 2, HA

Volume 2 has been prepared by Technica Ltd and comprises the following sections:

- Section 2.0, Methodology and Evaluation Criteria;
- Section 3.0, Description of Facilities;
- Section 4.0, Background Data;
- Section 5.0, Hazard Identification;
- Section 6.0, Consequence Analysis;
- Section 7.0, Frequency Analysis;
- Section 8.0, Risk Results;
- Section 9.0, Review and Assessment of Proposed Operating and Storage Procedures; and
- Section 10.0, Conclusions and Recommendations.

2.0 CHEMICAL WASTE TREATMENT IN HONG KONG

2.1 INTRODUCTION

The Waste Disposal Plan (EPD, 1989) estimates that the 20,000 industrial and commercial establishments operating in Hong Kong generates nearly 88,000 tonnes of wastes each day. About 75% of this waste is dredged and excavation material whilst the remainder consists of:

- household wastes;
- street wastes;
- marine collected wastes;
- commercial wastes;
- industrial wastes;
- construction wastes;
- chemical wastes;
- clinical wastes;
- radioactive wastes;
- pulverised fuel ash and furnace bottom ash; and
- "difficult" wastes, which is a collective term used describe sewage sludge, water works sludge, sewage treatment works screenings and grit, excremental waste, livestock waste, condemned goods, animal carcasses and abattoir waste.

About 0.3% (or 280 tonnes per day) of all wastes produced in Hong Kong in 1988 were classified as chemical wastes and whilst this is only a small volume to dispose of, the toxic and hazardous characteristics of the chemicals are such that this group of wastes requires special consideration.

2.2 ORIGIN OF CHEMICAL WASTES

The chemical wastes arise as by-products of various industrial processes employed by many of Hong Kong's export-oriented manufacturers. This is particularly the case for the electronic and metal product industries and metal finishing activities. Non-manufacturing industries also produce chemical wastes, mainly as residues from the storage of materials and from damaged or unwanted products.

Another major source of chemical waste arises from the shipping industry. Under the International Convention for the Prevention of Pollution from Ships (or the MARPOL Convention), ships are required to install equipment to contain chemical wastes including oily substances that would otherwise be discharged directly to the sea. These wastes must be off-loaded and disposed of in an environmentally acceptable manner.

2.3 COMPOSITION OF CHEMICAL WASTES AND PREDICTED VOLUMES

The Waste Disposal Plan presents a breakdown of the different chemical wastes produced in Hong Kong in 1989, viz.

o	alkalis	36.1%
o	acids	19.9%
o	oily wastes	17.3%
o	aqueous wastes	16.0%
o	MARPOL wastes	5.2%
o	solvents	2.9%
o	others	2.6%

Table 1 presents more detailed information on chemical wastes generated in Hong Kong, together with an indication of the projected increases anticipated up to 1997. These data indicate that acid and alkali wastes will continue to make up more than fifty percent of the chemical waste generated in Hong Kong, with significant increases expected in the generation of spent etchant solutions and solvents. These projections reflect the trend towards the higher technology industries such as the manufacture of printed circuit boards for the electronics industry.

TABLE 1

CHEMICAL WASTE GENERATION IN HONG KONG 1992-1997
(tonnes per annum)

Waste		*1992*	*1997*	*% Increase 1992-1997*
Acid		22,000	25,000	13.6
Alkali		42,000	50,000	19.0
Copper containing waste	- Acid and alkaline spent PCB[1] etchant	19,000	25,000	31.6
	- Copper waste solution from other factories	150	160	6.7
Zinc containing waste solution		13	14	7.7
Nickel containing waste solution		140	160	14.3
Other metal salts containing waste solution		1,300	1,400	7.7
Cyanide containing solution		130	160	23.1
Non-chromium bearing oxidising agents		11	12	9.1
Chromium bearing oxidising agents		59	68	15.3
Halogenated solvents		1,700	2,000	17.6
Non-Halogenated solvents		1,800	2,100	16.7
Phenols and derivatives		2.2	2.4	9.1
Polymerisation precursor and production waste		42	44	4.8
Mineral oil		5,700	5,900	3.5
Fuel oil		51	53	3.9
Oil/water mixtures		13,000	13,000	0
Pharmaceutical products		1	1	0
Mixed organic compounds		140	150	7.1
Mixed inorganic compounds		74	78	5.4
Miscellaneous chemical waste		32	35	9.4
Interceptor & treatment plant sludge		42	44	4.8
Tank cleaning sludge		1,000	1,000	0
Tar, asphalt, bitumen and pitch		140	150	7.1
Tannery waste		400	400	0
Printing waste		93	94	1.1
Dyestuff wastes		59	52	-11.9
Plating bath sludges		11	12	9.1
Paint wastes		700	750	7.1
Waste catalysts		4	4	0
TOTAL		110,000	130,000	18.2

Notes:
(1) PCB stands for Printed Circuit Board.
(2) All figures rounded up 2 significant figure.
(3) No projections have been made for MARPOL arisings due to the very wide range of possibilities.

Source: EPD (1989).

2.4 EFFECTS OF CURRENT CHEMICAL WASTE DISPOSAL PRACTICES

Most wastes are produced by small factories operating in multi-storey industrial buildings. Factory owners generally do not have the space, waste management experience or financial incentive to treat their chemical wastes and consequently the common practice is to discharge waste effluent directly into sewers and surface water drains. The environmental, engineering and public health consequences of this practice have been described by ERL (1987) as:

- o chemical wastes discharged into sewers and drains can damage the structure of the sewage system and the sewage treatment or disposal facility, and can expose workers to risk of injury or even death;
- o chemical wastes delivered to municipal waste facilities can cause damage to the equipment and facilities, and may place the operators at risk of injury or death;
- o indiscriminant disposal of chemical wastes can result in the discharge of highly polluting material into water. In the case of environmentally persistent materials this can lead to toxic metal accumulation in sediments and shellfish, or bioaccumulation;
- o discharge of chemical wastes to secondary sewage treatment works can disrupt the biological processes, thereby significantly reducing the quality of final effluent; and
- o discharge of chemical wastes to primary sewage treatment works can result in a seriously high concentration of toxic materials in the sludge, making environmentally acceptable sludge disposal very difficult.

2.5 CHEMICAL WASTE DISPOSAL OPTIONS

The Waste Disposal Plan acknowledged that, because of the wide variety of chemical wastes generated in Hong Kong, a single disposal method would not be acceptable or feasible for all situations. The Plan reviewed a range of options including:

- o dumping at sea (contained);
- o dumping at sea (uncontained);
- o disposal to containment site on land;
- o co-disposal at ordinary landfill;

- o recovery and re-use;
- o chemical treatment; and
- o high temperature incineration.

Ocean disposal, whether contained or uncontained, was considered to be environmentally unacceptable.

Disposal to a containment site on land would require isolating the waste from the environment by liners and an impervious cover to avoid contamination of the surrounding environment. The Plan noted that this essentially represents a method of waste storage and little degradation of the waste could take place. Furthermore, the site would require continuous monitoring, maintenance and supervision, and the site would essentially be precluded from any future use once filled and closed.

The option of co-disposal was regarded as feasible, but with many attendant disadvantages. There is limited scope for promoting adequate detoxification via natural physical, chemical and biological processes, problems associated with isolating incompatible chemical groups, and potential contamination of the larger volume and area of non-hazardous waste with hazardous substances. All these problems make control of the chemical wastes more difficult.

The Plan concluded that the remaining options of recovery and re-use, chemical treatment and high temperature incineration are all feasible, especially if integrated into a dedicated facility. The Plan therefore proposed the establishment of a chemical waste treatment facility incorporating a combination of treatment methods. After treatment at the facility, the residual material would be chemically stabilised to avoid the leaching and migration of hazardous constituents following disposal at landfills. The design for the CWTF is based on the quantities of wastes shown in Table 2.

TABLE 2

DESIGN BASIS WASTE ARISING
(tonnes per annum)

Waste		*Volume*
Acid		20,000
Alkali		35,000
Copper containing waste	- Acid and alkaline spent PCB etchant	12,500
	- Copper waste solution from other factories	140
Zinc containing waste solution		13
Nickel containing waste solution		120
Other metal salts containing waste solution		1,200
Cyanide containing solution		100
Non-chromium bearing oxidising agents		10
Chromium bearing oxidising agents		55
Halogenated solvents		1,300
Non-Halogenated solvents		1,500
Phenols and derivatives		2
Polymerisation precursor and production waste		40
Mineral oil		5,600
Fuel oil		50
Oil/water mixtures		12,000
Pharmaceutical products		1
Mixed organic compounds		130
Mixed inorganic compounds		70
Miscellaneous chemical waste		30
Interceptor & treatment plant sludge		40
Tank cleaning sludge		1,000
Tar, asphalt, bitumen and pitch		140
Tannery waste		400
Printing waste		90
Dyestuff wastes		70
Plating bath sludges		10
Paint wastes		640
Waste catalysts		4
Marpol Annex I		5,000
Marpol Annex II		500
TOTAL		97,755

Source: Contract Document

2.6 LEGISLATIVE CONTROL

The Government of Hong Kong has adopted a wide range of legislative initiatives to deal with the problem of chemical waste disposal. The main principles behind these initiatives have been described by ERL (1987) as follows:

- o waste producers have a duty to take all reasonable steps, having regard to the hazards presented by their wastes, to ensure that wastes are properly managed and disposed of without undue harm to the environment;
- o the collection and disposal of chemical wastes must be carried out by competent and experienced contractors who are licensed to provide such services; and
- o the Waste Disposal Authority must monitor the safe progress of chemical wastes from their generation to the treatment or disposal facility.

Provisions to implement these principles were embodied in the Waste Disposal Ordinance (Cap. 354), enacted in 1980 as the general enabling ordinance for waste management. The most significant of these provisions are:

- o Section 10.0, which provides for the licensing of collection of certain types of wastes;
- o Section 16.0, which provides for the licensing of waste treatment and disposal facilities; and
- o Section 17.0, which requires the producers of prescribed wastes to notify the Waste Disposal Authority and subsequently to dispose of the wastes as directed by the Authority.

The licensing provisions described above have certain deficiencies which will have to be amended by changes to existing legislation. These have been described in the Waste Disposal Plan and are as follows:

- o improving the legal definition of wastes;
- o reclassifying and defining various classes of wastes to facilitate the division of responsibilities between various government departments and the municipal councils for the purpose of legislative control;

- o defining "disposal" to ensure all parts of the waste management chain beyond "collection", i.e. reception, treatment and interim storage as well as final disposal, are controlled;
- o improving the existing licensing provisions with respect to the collection and disposal of waste;
- o extending the licensing controls to cover all government disposal operations;
- o imposing greater responsibility on waste producers to assume duty of care for classes of waste; and
- o imposing stricter control on the import and export of waste.

2.7 CONCLUSIONS

The disposal of waste represents one of the most pressing environmental problems confronting the Hong Kong community. A significant element of this problem relates to a range of toxic and hazardous materials generally referred to as chemical wastes.

The Government of Hong Kong has examined a range of chemical waste disposal options and has concluded that the preferred strategy involves a combination of recovery and re-use, chemical treatment, high temperature incineration and disposal of residual material in a landfill.

The Government has also implemented a Waste Disposal Ordinance with provisions for licensing of waste collection and disposal services. Therefore, to enable the preferred chemical waste disposal strategy to be implemented and to enable industry to comply with the legislative controls of the Waste Disposal Ordinance, the Government clearly needs to support the establishment of appropriate chemical waste treatment/disposal facilities. This need is the basis of the present proposal to establish the Chemical Waste Treatment Facilities at Tsing Yi Island.

3.0 SITE DESCRIPTION

3.1 INTRODUCTION

A site selection study was undertaken throughout the Territories to identify potentially suitable locations for a chemical waste treatment facility. According to the site selection criteria described by ERL (1987), the site should:

- have marine access;
- be reasonably formed and self-contained;
- be available by 1987 to allow early commissioning of the facility;
- be reasonably centrally located relative to the industrial areas of Kwun Tong and Tsuen Wan to facilitate the collection of waste; and
- be outside urban areas and Tolo Harbour, Deep Bay and Port Shelter, given the severe environmental constraints associated with these areas.

Potential sites selected for more detailed evaluation were:

- Tuen Mun Area 47;
- Tai Lam Bay;
- Brothers Point;
- Tsing Yi Area 25; and
- Tsing Yi Area 14.

Tsing Yi Area 25 was favoured for the following reasons:

- it was near the heart of marine transport activities;
- it had reasonably good access to the major industrial zones;
- it had good access to land and maritime transportation;
- the site had already been formed and would be available immediately; (in view of the urgent need for the facilities, this fact was considered very important); and
- the site was located sufficiently far away from residential areas.

The other identified areas were rejected on the grounds that they did not meet one or more of the site selection criteria.

The outcome of this process was to nominate Tsing Yi Area 25 as the CWTF site subject to confirmation following environmental and hazard impact assessments.

The following sections describe the geography of Tsing Yi Island and the main physical characteristics of the proposed CWTF site. The description is largely based on information presented by ERL (1987).

3.2 BIOPHYSICAL SETTING

The location of the proposed CWTF site is shown in Figure 1. The site is on the southeast side of Tsing Yi Island, at the southernmost part of the Rambler Channel and northwest of Hong Kong Island and Victoria Harbour.

To the west of Tsing Yi is the West Tsing Yi Channel. Tidal currents in this region are swift with flows of 1.5m/sec. having been reported near the northwest corner of Tsing Yi. The sea bed near the site generally falls away steeply from the coastline.

The topography of the island is generally very rugged with the terrain rising steeply from sea level to heights ranging between 210m to 335m. The slopes at the northern end of the island are well weathered and have a fair cover of topsoil which supports mainly grassland and scrub. The southern end of the island is steep, rocky and barren. There is a prominent ridgeline striking NW-SE across the island. Such topography does not support agriculture and negligible cropping occurs on the island.

The geological composition of sub-surface strata is characterised by Cheung Chau granite in the northeast and southwest with a concentration of coarse tuffs in the western and northwestern sectors. There are a large number of NE-SW oriented feldspar-porphyry dykes in the western half of the island.

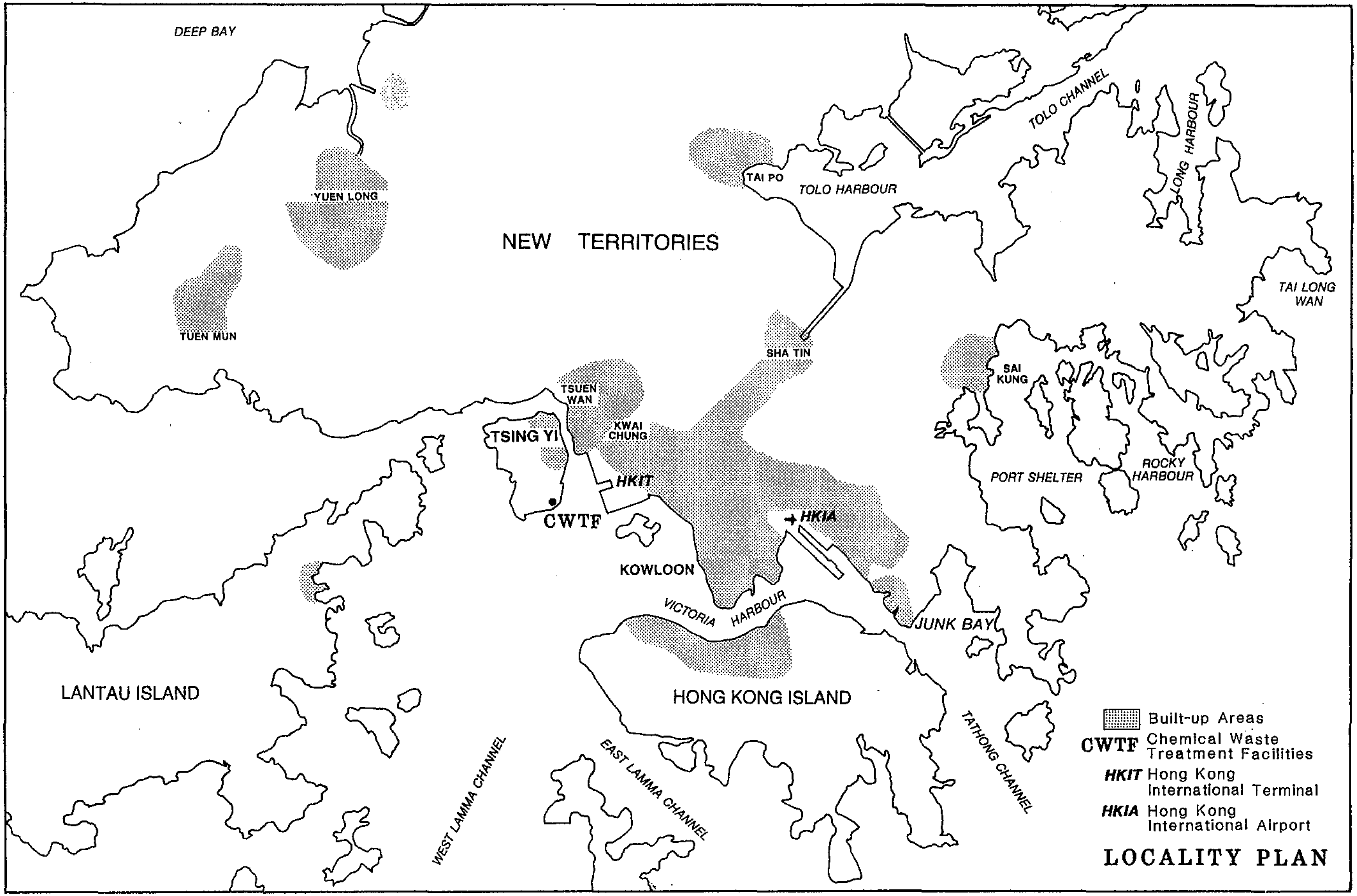


FIGURE 1
DAMES & MOORE

The site for the proposed CWTF is located on the shoreline about 3m above sea level. The site consists of a vacant area of about 2ha that has been reclaimed from the sea using material derived from the construction of Tsing Yi Road, located immediately to the north. The depth of fill material ranges from zero at the landward side to approximately 15m at the seaward side. The fill material consists of fresh granite boulders up to approximately 1m diameter, cobbles, gravels, and concrete debris in a silty sand matrix.

3.3 ADJACENT LAND USE

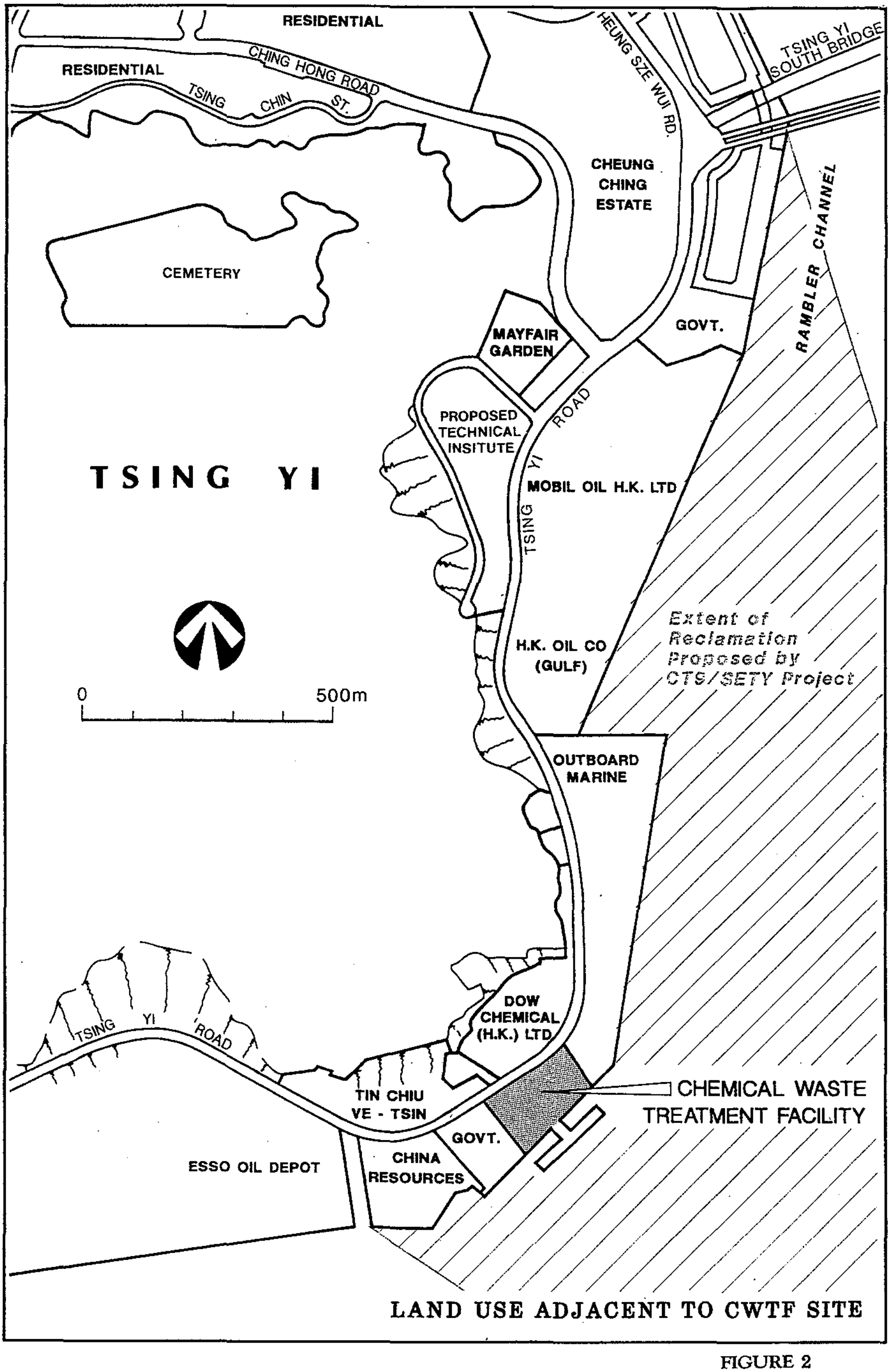
The land uses adjacent to the CWTF site are shown in Figure 2. The site is bounded to the southwest by vacant land which is reserved for future infrastructure projects. The vacant land separates the site from the China Resources Oil Depot. To the north, beyond an 8m wide drainage easement, the site is bounded by Outboard Marine Asia Limited and Rambler Channel, and to the northwest, by Tsing Yi Road, are Tien Chu Ve-Tsin Chemicals and Dow Chemicals (HK) Ltd. The old Cattle Quarantine Station Jetty is part of the site and is expected to be renovated to receive bulk wastes from lighters and other vessels. The extent of these renovations will depend largely on the nature of the reclamation activities proposed as part of the CT9 proposal (see Section 3.4.4), notwithstanding the safety and environmental control requirements for a dedicated jetty facility adjacent to the CWTF.

Other close neighbours to the site include the Peninsula Oil-Fired Power Station and Esso Oil, both of which are located to the southwest. Immediately across the Rambler Channel is the Kwai Chung Municipal Solid Waste Incinerator and Kwai Chung Port Terminal.

The northeastern sector of Tsing Yi Island is largely residential with almost all the residents living in high-rise tower blocks. Two residential estates are reasonably close to the CWTF site:

- Mayfair Gardens: 1.3-1.5km away from site, population ca. 4000; and
- Cheung Ching Estate: 1.5-1.7km away from site, population ca. 25,000.

The total residential population of Tsing Yi Island is about 190,000. Many of the residents commute to Hong Kong for work.



LAND USE ADJACENT TO CWTF SITE

FIGURE 2
DAMES & MOORE

3.4 PROPOSED DEVELOPMENTS

3.4.1 Introduction

A number of developments have been proposed for Tsing Yi Island and have either been approved or are still under review. Whilst it is clearly beyond the scope of this EIA to evaluate the environmental impacts of these proposals, it is useful to consider each in the context of the general development of Tsing Yi.

3.4.2 Industrial Expansion and Relocation

China Resources Ltd, which occupies a site to the west of the CWTF site, proposes to expand its operation. This will necessitate the reclamation of some additional land in the vicinity but will not affect marine access to the CWTF site. The Mobil Oil depot currently located in the northeast of Tsing Yi Island will also be relocated to the south in recognition of the need to accommodate a predominantly residential population in the north.

3.4.3 Technical Institute

A Technical Institute has been proposed for an area located to the south of Mayfair Garden (Figure 2). The Institute, which is due to open in September 1993, will have an initial full-time student population of 3,000, rising to a maximum of 5,000.

3.4.4 Container Terminal 9 (CT9)

A planning and engineering study known as CT9 or SETY is presently examining the feasibility of a major reclamation project for the southeast corner of Tsing Yi Island. The project would involve the relocation of several major industries, reclamation of 140 hectares of sea and the development of a major container terminal.

The proposal has the potential to significantly affect the operation of the CWTF in a number of ways. Firstly, it could affect the marine access to the jetty and the availability of unlimited supplies of water for fire fighting. Secondly, the reclamation process is likely to raise the suspended sediment loads offshore from south east Tsing Yi Island during CT-9 construction, and restrict water circulation after CT-9 construction. Both would adversely affect the operation of the cooling water system at the CWTF. Thirdly, the CWTF requires a dedicated jetty facility for reasons of safety, environmental control, and effective and efficient operations. Any proposal advocating a shared facility could increase the time taken to unload the waste materials, increase the risk of spills and accidents, and most importantly, expose dockside and shipside workers who have not had the appropriate safety and emergency response training, to hazardous chemicals. Finally, CWTF requires a jetty adjacent to its site to avoid double handling of hazardous materials. Loading and unloading activities will increase the relative risks associated with the CWTF.

3.5 REGIONAL TRANSPORTATION

Tsing Yi Island is linked to the Kwai Chung area by two bridges:

- Tsing Yi North Bridge (alternatively known as the Tsing Tsuen Bridge), which is a dual two-lane structure, designed to carry heavy vehicle traffic and serve the rapidly expanding housing developments being established in the north of the Island; and
- Tsing Yi South Bridge, which is a dual one-lane structure connecting Tsing Yi Island to Kwai Chung.

Internal circulation within Tsing Yi Island has also recently been enhanced with the completion of the segment of road between Nam Wan and Fung Shue Wo Road. Further details are provided in Section 5.6.

Various regional transport options have been proposed for Tsing Yi Island either in an attempt to ease traffic congestion on the Island or as part of a larger development programme. Of these, the Route 3 option has the greatest potential to influence activities on Tsing Yi Island. This option comprises a trunk highway traversing the Island and linking the urban areas of Hong Kong Island and Kowloon with the proposed airport on Lantau, the New Territories and China. The proposed CT9 development described above will also have significant implications for regional transportation on Tsing Yi Island. The Tsing Yi South Bridge is to be duplicated to relieve peak-hour congestion and to cater to the expected increases in traffic due to an increase in industrial activity. Other proposed modifications will have a beneficial impact on traffic conditions:

- o reconstruction of the roundabout at the western end of Tsing Yi South Bridge to provide additional slip roads;
- o removal of current turning restrictions which presently limit traffic flow;
- o provision of direct access to CT9 which will limit the need for heavy vehicles serving the proposed development to use existing roadways; and
- o improvements to several junctions on the eastern end of Tsing Yi South Bridge.

3.6 REGIONAL PLANNING ISSUES

Tsing Yi Island was at one time designated as an industrial area and it has seen the development of a number of industrial facilities including oil terminals, container storage areas, chemical factories and a power station. Most of these installations are located at the south of the island. Residential development has also been allowed to occur, principally in the northeast.

The Tsuen Wan Development Office has recognised the incompatibility of the industrial and residential activities and has carried out a review of the future development of Tsing Yi Island with a view to formulating a planning strategy.

The Tsuen Wan Development Office review is concerned principally with:

- o identifying various land uses including transport and other demands of district and territorial significance;
- o identifying various development opportunities and constraints; and
- o formulating medium and long term plans with a view of selecting a strategy, with alternatives, capable of flexible implementation.

It has been found that the general land use pattern of the Island could include the following:

- o residential development and associated uses in the northeastern quadrant;
- o general industrial uses along the eastern coastal area;
- o marine-oriented and port-related uses along the southern and western coastal areas;
- o a strip of port-related uses (boatyards and shipyard) along the central section of the northern coastal area; and
- o the central ridge of the Island being reserved as a Green Belt to separate the major industrial areas from the residential quadrant.

4.0 DESCRIPTION OF PROJECT

4.1 GENERAL DESCRIPTION OF THE CWTF

The CWTF will be an integrated facility capable of handling virtually any type of chemical waste. The major processes to be carried out at the plant will be:

- o high temperature incineration of oil and organic wastes;
- o treatment of organically contaminated wastewater to remove organic constituents for incineration;
- o treatment of effluent and various wastewater, either biologically, or by evaporation and catalytic oxidation;
- o physical-chemical treatment of inorganic aqueous wastes, including neutralisation of acids and alkalis, oxidation/reduction and precipitation of toxic metals; and
- o stabilisation of sludges and solid wastes containing toxic constituents that might leach in a landfill environment. These wastes will include residues generated in the CWTF, such as wastewater treatment sludge filter cake and incinerator bottom and fly ash; and
- o a sequential biological reactor.

Several optional processes might be added to the CWTF at a later date, if they are shown to be economically feasible:

- o solvent distillation, to recycle spent solvents; and
- o oil recovery, to regenerate used lubrication oil.

Other operations will be needed to support these major waste treatment processes. These will include:

- o an analytical laboratory;
- o transportation (trucks and seagoing barge/lighters);
- o waste receiving and container opening and shredding operations;
- o storage;

- o maintenance and shop facilities; and
- o security and administration.

A schematic outline of the CWTF is given on Figure 3.

4.2 DESCRIPTION OF OPERATIONAL UNITS

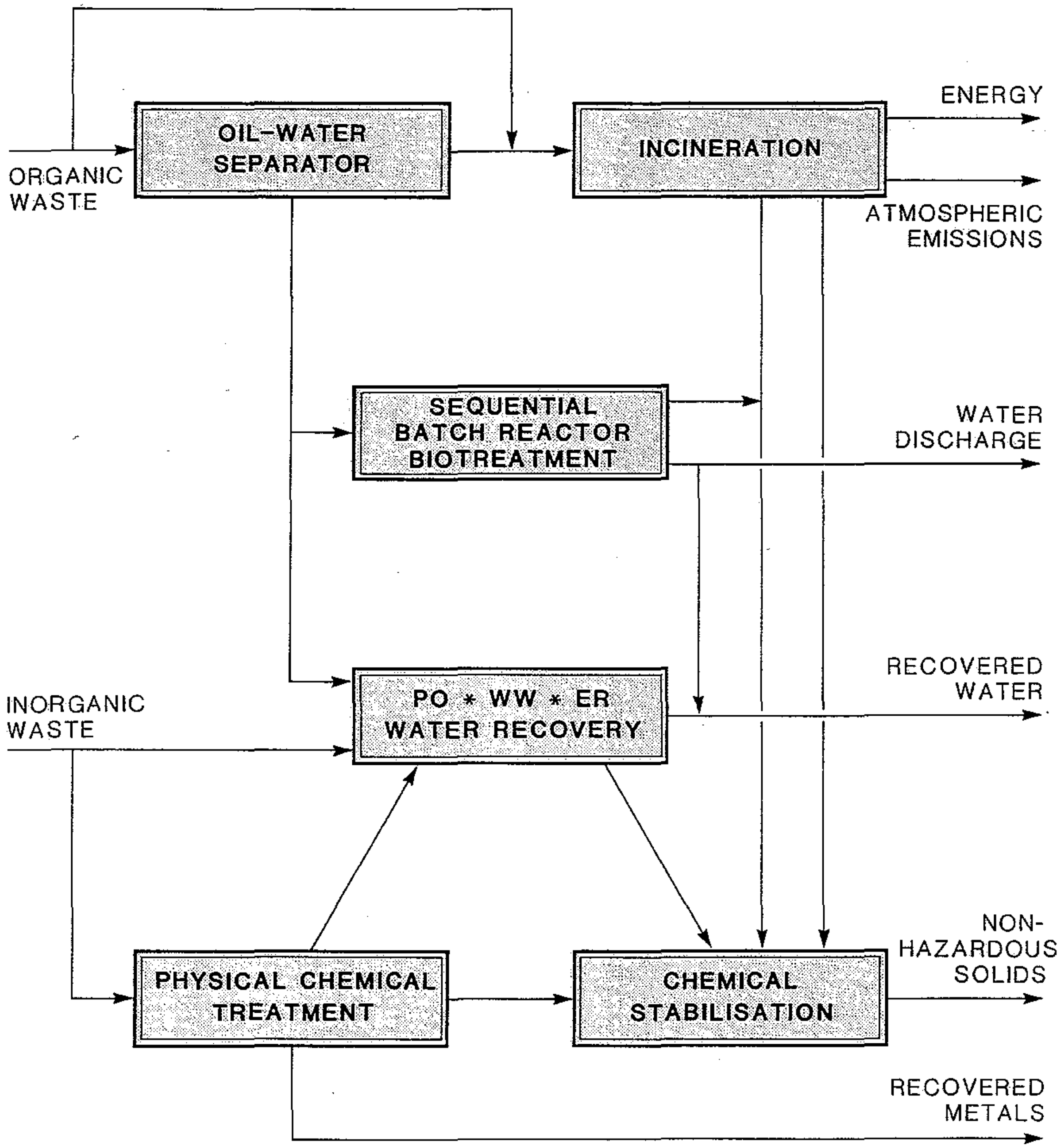
A general layout of the plant is presented on Figure 4. The plant is to be laid out in such a way that compatible areas are combined for reasons of safety and operational efficiency. Waste "streams" will flow from receiving and storage, through processing units, toward solids stabilisation (before final disposal) or liquid effluent treatment (before final discharge). The major operational sections of the CWTF are described below.

4.2.1 Waste Transportation

Nearly all wastes will be moved to the CWTF by road. The only exception will be MARPOL wastes will be carried in CWTF-owned barges, propelled by tugboats.

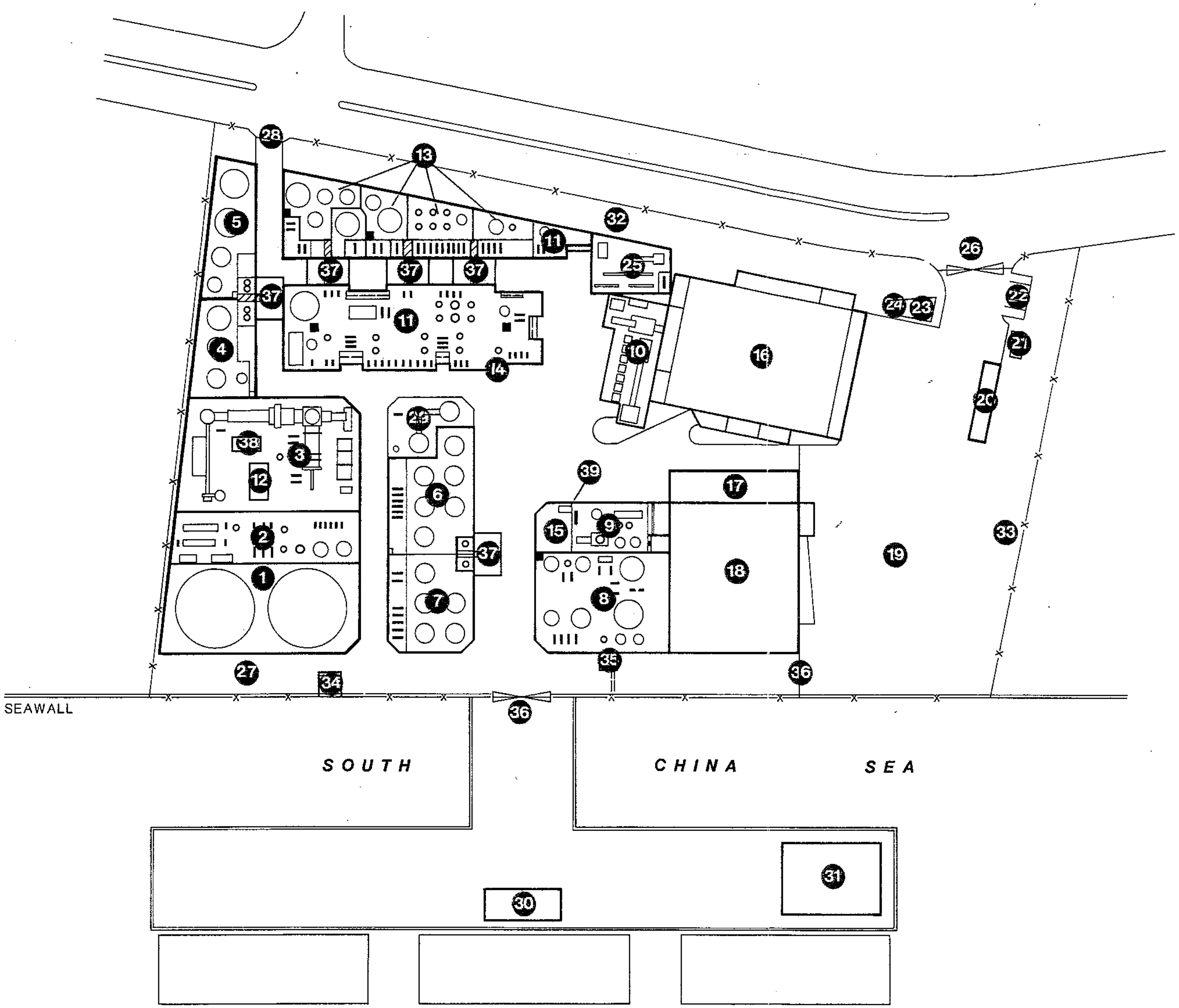
Road tankers will be used to carry bulk shipments of acid, alkali, oil, and organic wastes. Flat-bed trucks with box bodies will be used to carry the expected large volumes of solid, liquid, and sludge wastes in containers. Larger trucks will carry 200-litre drums, while small trucks will bring loads of 20-litre containers from very small industries. A "skip-lugger" truck, with the ability to pick up and put down a large steel container, will be used for transporting stabilized solids to landfills and for any bulk shipments of solids and sludges.

Present plans assume that 800 drums will arrive daily on 27 flat-bed truck loads. Light goods vehicles are expected to deliver some 2,700 20 litre containers in 27 loads each day. Tanker truck loads are expected to total about 15 per day. The jetty facilities should be able to handle up to three vessels at a time, unloading through four separate bulk waste systems. Approximately four to five laden vessels will be unloaded each week.



SCHEMATIC OUTLINE OF THE CHEMICAL WASTE TREATMENT FACILITY

FIGURE 3
DAMES & MOORE



1 MARPOL ANNEX I STORAGE TANKS
2 ORGANIC WASTE BLENDING PRIMARY & SECONDARY OILY WATER SEPARATION
3 INCINERATOR
4 ACID WASTE STORAGE TANKS
5 ALKALI WASTE STORAGE TANKS
6 ORGANIC WASTE STORAGE TANKS
7 BULK OILY WASTE STORAGE SYSTEM
8 FINAL WATER EFFLUENT TREATMENT
9 EVAPORATION UNIT
10 SOLIDS STABILISATION
11 CHEMICAL/PHYSICAL TREATMENT LAYOUT ACID/ALKALI CONTINUOUS TREATMENT SYSTEM
12 INCINERATOR CONTROL BUILDING
13 WASTE/REAGENT STORAGE TANK FARMS
14 CYANIDE/CHROMATE PROCESSING AREA
15 AIR COMPRESSOR AREA
16 PACKED WASTE RECEPTION/STORAGE BUILDING
17 TRUCK WASH/GAS STATION BUILDING
18 ADMINISTRATION/WAREHOUSE BUILDING
19 PARKING AND FUTURE EXPANSION
20 WEIGHBRIDGE
21 GATE HOUSE
22 VISITOR PARKING
23 FIRE WATER PUMP HOUSE
24 SEWER PUMP & LIFT STATION
25 SUBSTATION
26 MAIN GATE ENTRANCE
27 LUGGER BOX STORAGE
28 EMERGENCY GATE
29 UTILITY AREA
30 MARPOL WASTE RECEPTION
31 OIL DISPENSANT/BOOM STORAGE
32 RESERVE FOR ROAD WIDENING/OVERNIGHT TRUCK PARKING
33 RESERVE FOR DRAINAGE/OVERNIGHT TRUCK PARKING
34 SEAWATER INTAKE PUMPING STATION
35 SEAWATER OUTFALL CHAMBER
36 SECURED SECONDARY ACCESS GATES
37 BULK UNLOADING STATIONS
38 AUXILIARY BOILER
39 EVAPORATION UNIT CONTROL ROOM

LAYOUT PLAN OF THE CHEMICAL WASTE TREATMENT FACILITY

FIGURE 4
DAMES & MOORE

4.2.2 Waste Reception and Storage

As noted above, waste is expected to arrive at the CWTF in three major forms:

- o containerised wastes, primarily in 200 litre and 20 litre drums, delivered by trucks;
- o bulk waste delivered by tanker trucks; and
- o MARPOL waste delivered in bulk to the jetty

A four-storey Packaged Waste Reception and Storage Building will receive the drums and containers of wastes. This building and its equipment have been designed to:

- o receive, sample/characterise, and sort wastes into compatible groups for storage and treatment;
- o store up to four day's shipment of containers, segregated into compatible groups;
- o decant packaged wastes for loading into bulk tanks prior to processing;
- o clean decanted containers;
- o store empty containers for reuse; and
- o load empty containers onto vehicles for next day collection

After weighing and sampling of the cargoes, bulk land wastes will be unloaded at five tanker truck unloading stations. The five unloading stations will handle organic and oily wastes, acid and alkali wastes, chelated metal wastes, non-chelated etchants, and miscellaneous chemicals. After wastes have been properly identified, the tanks will be unloaded by pumps into the appropriate bulk storage tanks. Each unloading station will have a sump and curb system to contain spills, and will be roofed to keep rainwater from entering the sumps.

The marine unloading point on the jetty will have four separate pump and hose systems to unload oily wastes, organic wastes, acid wastes, and alkali wastes. To ensure that hoses and pumps are connected to the corresponding tankers, there will be clear identification markings. Cranes mounted on the lighter barges will be used to position the suction hoses. This marine unloading area will also have a system of curbs and sumps to contain spills around the unloading area. Skimmers, chemical dispersants and other containment equipment such as booms and pumps will be stored on the jetty for deployment in the event of a spill into the water.

Bulk storage tanks will be constructed for organic liquid wastes (approximately 300 tonnes), inorganic liquid wastes (approximately 1,000 tonnes), and oil and oily wastewater (approximately 450 tonnes). These tanks will be constructed of appropriate materials for their intended contents; all will have secondary containment in the event of leaks, spills, or tank failure.

MARPOL wastes will be transported by a 1,000 tonne (three compartments) barge. The barge will be making four to five laden trips (eight to ten movements) per week based on the assumption that the average payload would be 40 tonnes in the case of MARPOL Annex I wastes (petroleum based), and 20 tonnes in the case of MARPOL Annex II wastes (noxious liquid bulk substances). The number of trips could increase if the average payload is much lower than anticipated. Furthermore, off loading pumps at the jetty will be designed for a three to six hour pump out period. A dedicated marine access will be required, primarily for reasons of safety but also for operational efficiency and control in the event of an accident.

4.2.3 Analytical Laboratory Facilities

The top floor of the Administration/Warehouse Building will contain a state-of-the-art analytical chemistry laboratory that can support all of the CWTF's needs. The laboratory will include instruments for the complete analysis of all wastes received for treatment, as well as the analysis of environmental samples for monitoring the performance and safety of the facility. Performance of leachate extraction tests will also be a major task of the laboratory. The laboratory is a crucial part of the facility operations since it will help to ensure that the wastes are properly treated. Proper treatment will limit the potential for a mistake which could endanger the workers in the waste processing areas, or endanger public health and/or impair environmental quality.

Major equipment in the laboratory will include instruments such as a: Gas Chromatograph/Mass Spectrometer (GC/MS), Gas Chromatograph with Electron Capture Detector (GC/ECD), Inductively Coupled Argon Plasma Emission Spectrophotometer (ICAP), Atomic Absorption Spectrophotometer (AAS), UV/Visible Spectrophotometer, Bomb Calorimeter, and an Ion Chromatograph (IC).

Additional equipment will include items such as a viscometer, titrator, extractors, and distillation equipment and a wide variety of glassware and reagents.

In order to effectively manage the receipt and processing of waste shipments in a timely manner, it will be necessary to use "fingerprint tests" on incoming waste shipments. These tests are relatively quick and simple and will be performed on samples taken from the containers and trucks to confirm that the overall waste is in fact the type of waste (such as acid, base, solvent, etc.) indicated on the bar-code. Any incorrectly labelled wastes will be identified, held until properly classified and then directed to the appropriate processing plant.

4.2.4 Oil/Water Separation

Oil/water emulsions will be "broken" by processing them through a heat exchanger and an oil/water emulsion treater. Oil-water mixtures in general will undergo a three-stage treatment process. At each stage, the oil will be transferred to an organics storage tank for subsequent incineration. The water will be transferred to the next phase of treatment, as necessary.

Primary treatment will consist of oil/water separation in oily water bulk storage tanks and secondary treatment will involve use of an American Petroleum Institute (API) separator, followed by Dissolved Air Flotation. Tertiary treatment will consist of biological treatment in the Sequencing Batch (activated sludge) Reactor and/or processing in the proprietary PO*WW*ER unit; incineration is a possibility in cases where the other forms of tertiary treatment prove ineffective.

4.2.5 Wastewater Treatment

The wastewater treatment system has three major subsystems: physical-chemical treatment, biological treatment, and evaporation/catalytic oxidation. Used separately or in sequence, this system should be able to treat any type of contaminated water delivered to, or produced in, the CWTF. The by-products of this system will be sludge filter cake and other solids for disposal (with further processing as necessary), effluent for discharge to the foul (sanitary) sewer, certain by-products that must be incinerated, and high quality water for use in the plant.

Physical-chemical treatment is the most varied portion of the wastewater treatment system. It will consist of a segregated storage and feed system for eleven major types of wastewater and the following major treatment processes:

- oxidation of cyanide-containing solutions with sodium hydroxide and chlorine gas, producing nitrogen gas that can be safely vented;
- reduction of chromium-containing solutions from the hexavalent to the trivalent state by reaction with sulphuric acid and sulphur dioxide gas;
- neutralisation-precipitation, in which a variety of inorganic wastewater (including those from the oxidation and reduction processes identified above) are mixed and brought to an approximately neutral pH (lime is added to precipitate heavy metals into low-solubility hydroxide sludges). Output from the neutralisation process will be fed to a clarifier;
- cupric oxide recovery from ammoniacal chloride and cupric chloride etchants by a caustic boil process, producing free ammonia (which will be forced back into solution and converted to an ammonium sulphate fertilizer resource), and cupric oxide (which will be processed for sale, if markets can be developed);
- copper and ferric chloride recovery from ferric chloride etchant by an iron cementation process, producing a concentrated copper-containing powder and a ferric chloride solution; both materials may be saleable if markets can be developed; and
- treatment of chelated metal (ferric chloride, zinc, copper, and nickel) solutions by alkaline precipitation using lime or a variety of other reagents to produce a slurry that is filtered into a cake for stabilisation and disposal.

Biological treatment of oily water, from the Dissolved Air Flotation unit and from truck washing, will use a Sequencing Batch Reactor. "Activated sludge" from previous batches will be mixed with incoming wastewater and aerated; the concentrated microorganisms in the sludge will metabolise organic contaminants in the wastewater, reducing the biochemical oxygen demand. This process will be followed by a sand filter and two activated carbon absorber filters to reduce chemical oxygen demand; the effluent will be discharged to the foul sewer. Excess sludge will be stabilised for disposal.

Treated wastewater from the physical-chemical treatment processes and rinse water from the packaged waste reception/storage building will be treated in the evaporation/catalytic oxidation system. This system has been added because experience has shown that inorganic wastewater, particularly that from metal finishing operations, often contains high concentrations of organics which will not be removed by the physical-chemical treatment step. Though the biological treatment unit could remove much of the organics, typical chemical oxygen demand (COD) levels of about 4,000mg/L can occur in such wastewater, which could not be reduced to the 600mg/L level required by the CWTF's operating standards without further treatment. Also certain inorganic compounds are not precipitated in the hydroxide process described above, but are easily removed by evaporation and oxidation in this process.

This additional treatment requirement will be achieved by using a proprietary process, under the trademark PO*WW*ER, that evaporates inorganic wastewater to produce a concentrated crystal/brine slurry and distilled water. Before the water vapour is condensed, it will be further heated (by fuel oil combustion) in the presence of catalysts that will oxidise any organic materials into carbon dioxide and water.

The distilled water produced by the system will be used throughout the CWTF for container rinsing, boiler feed water makeup, reagent dilution, and filter cake washing. Excess distilled water will be discharged with the biological system effluent to the foul sewer, although there is some possibility of selling it to nearby industries.

The brine slurry will be chemically stabilised (along with sludge filter cake and other solid residues) prior to landfill disposal.

4.2.6 Incineration

Six storage tanks will contain wastes for incineration. Two tanks will have the capacity to contain an estimated one year's generation of MARPOL wastes (organic and inorganic chemicals), while four other tanks will have the capacity to hold an estimated 10 days' deliveries of all other incineration wastes. Four blending tanks, each with a capacity for 1 day's volume of feed to the incinerator, will be used to prepare wastes for destruction.

The waste feed system will constantly circulate the contents of the tank in service by pumping the mix to a point near the burner being used and back into the tank, with only a small portion actually passing into the incinerator. This will prevent clogging in the feed lines. Organic liquids, auxiliary fuel oil, and air will be fed directly into the burners; lean (water-diluted) wastes and sludges will be injected to the incineration chamber via separate "lances." Solids to be incinerated (including steel drums that cannot be reused) will be shredded and fed into the incinerator in combustible containers.

The incinerator's primary combustion chamber will be a rotary kiln, considered to be the state-of-the-art device for versatile hazardous waste incineration. The kiln itself will be a long steel cylinder with a refractory (high-temperature-resistant ceramic) lining, seals at each end, and a pinion gear/girt gear set driven by a variable speed motor. The kiln barrel, which will be slightly inclined, will rotate slowly so that wastes travel down-slope very slowly. This ensures that the wastes have a sufficient residence time in the hot zone of the kiln to ensure complete destruction of organic compounds. For PCBs, the residence time will be a minimum of 2 seconds at 1200°C and for all other wastes, instantaneous destruction occurs at 1095°C. Residence time can be adjusted by varying the speed of rotation.

The system will be operated with an induced draft fan so that there will be a slight negative pressure inside the seals, thereby prohibiting toxic gases from escaping. Sufficient air will be introduced to the kiln to provide complete combustion.

Ash will fall from the lower end of the kiln into a water-filled sump that will quench the ash and keep the system sealed; wet ash will be dragged up an inclined conveyor to begin dewatering the solid incinerator residues.

A secondary combustion chamber (afterburner) will provide two seconds residence time for the combustion gases in an excess air environment at 1,100-1,200°C, with sufficient turbulence to ensure complete combustion. Another burner for auxiliary fuel and easily destroyed waste liquids will be used to preheat this chamber to the design temperature, and to maintain this temperature.

Solid wastes will require shredding before passing to the incinerator. The shredding process will result in the generation of dust and odours, however, the environmental consequences of these emissions will be minimised by using an air lock and a nitrogen blanket system to dispense inert gas, dust or vapours into the incineration unit as make-up air. This process will also have the effect of lowering the concentration of oxygen, thereby reducing the risk of fire. In the event the shredder has to be operated when the incinerator is not on-line, an alternative route of gas or dust disposal will be provided (i.e. auxiliary boiler make-up air or carbon absorption containers).

A water tube heat recovery boiler will be used to cool the combustion gases exiting the secondary combustion chamber to about 400°C. The steam produced by this heat exchanger will be used as needed throughout the CWTF, but mainly in the PO*WW*ER system for evaporating process effluents.

A spray dryer will continuously inject a slurry of water and lime (calcium hydroxide) into the hot gas stream. This process will serve two functions in treating the flue gases exiting the incinerator: the lime will neutralise acid gases, and evaporation of the water will cool the gas stream to approximately 180°C.

A dust collector will remove particulates from the flue gases in bag-shaped fabric filters; this system is often referred to as a "baghouse." A coating will form on the filters, consisting largely of calcium hydroxide (from the spray dryer) and calcium chloride (from neutralised hydrochloric acid gas). This coating will neutralise any acid gases that pass through the spray dryer. Metals that are vaporised in the kiln and other potentially hazardous materials that compound in the system after incineration will be caught in this coating if not washed out in the spray dryer. The filters will be cleaned by pulses from high-pressure air jets. Dust will be removed from the bottom of the baghouse collector for stabilisation and disposal with the other incinerator residues.

A completely self-supporting exhaust stack of reinforced concrete and insulation, with an outside diameter just over 3 metres and an inside diameter of 0.914 metres, will disperse the scrubbed flue gases at a temperature of approximately 175°C. A stack height of 76.3 metres is presently proposed. Visible smoke will not exit the stack, although a condensation mist (steam) will occasionally be visible near the stack depending on the weather.

4.2.7 Stabilisation

Certain solid wastes and most sludge wastes delivered to the CWTF that do not require incineration, must be chemically stabilised prior to land disposal. This process will prevent migration of toxic constituents via dissolution in water (leaching), thereby essentially eliminating the risk of contaminating water resources. All solid residues originating from chemical wastes and reagents processed in the facility will be chemically stabilised prior to leaving the facility for ultimate disposal. The residues to be stabilised will include:

- bottom ash from the incinerator kiln and afterburner;
- fly ash from the incinerator heat recovery boiler;
- fly ash, reacted lime, and excess lime from the incinerator spray dryer;
- dust from the incinerator baghouse dust collector;
- filter cake from acid/alkali neutralisation;
- filter cake from precipitation of heavy metals;
- brine slurry from the evaporation/catalytic oxidation unit; and
- waste activated sludge and filter cake from biological treatment.

A grinder will be provided in this process area should it be necessary to reprocess solidified residues. The stabilisation process itself is relatively simple. Each batch of (generally wet) waste will be analysed and weighed. A calculated and measured amount of the appropriate solidification reagent (often Portland cement) will be added, and mixed intensively in a mechanical mixer. The batch will then be discharged into a transport container, where it will quickly solidify.

Performance of the stabilisation process will be monitored by a leachate extraction test, which simulates, in 24 hours, the long term effects of percolating water contacting wastes in a landfill environment, to determine if toxic constituents can be leached from the materials. The test planned for use in the CWTF is the Extraction Procedure Toxicity Test (often abbreviated as EP Tox Test) developed by the U.S. Environmental Protection Agency (USEPA). Bulk transport containers of stabilised wastes will need to be held in the stabilisation area for one to two days while the tests are being conducted. If wastes "pass" the test, they will be transported to an offsite landfill; as inert solids, they will no longer be considered hazardous wastes. If the wastes do not pass the test they will be reprocessed.

4.2.8 Ancillary Utilities

A variety of facilities will be required to support the CWTF; some are unique to this type of facility while others are rather common in major industrial/chemical plants.

An auxiliary steam boiler will be necessary when the incinerator is not operating, to provide steam for the evaporation/catalytic oxidation system and other steam users. An oil-fired, package water-tube system is planned, rated at approximately 15,000kg/hr of steam at 17.2 bar.

A boiler feedwater system will return condensate from most places where steam is used, collect it in a water tank, and use it (after deaeration) for boiler feedwater makeup, either to the incinerator heat recovery boiler or to the auxiliary boiler.

An integrated hydrated lime storage silo system will be needed as lime is used in a number of places in the CWTF. The lime feed system will continuously make up a 20% lime slurry that will be recirculated to the incinerator scrubber and the neutralisation unit. At each point of use, a metered pump will feed the slurry into the process.

An effluent pump station will be located near the gate. Process effluents and sanitary wastewater will be combined in a below-ground sump. Two $45m^3/h$ submersible pumps (operating and standby) will move this wastewater to the foul (sanitary) sewer via two dedicated force mains (operating and standby).

A compressed air supply system will be needed at the CWTF. Two compressors (operating and standby) will provide utility and instrument air requirements. An instrument air dryer and two air receivers (plant air and instrument air) will be included in this system. A once-through seawater cooling system will be provided for the PO*WW*ER unit condenser and for the dump condenser connected to the incinerator waste heat recovery boiler (needed when the PO*WW*ER unit is not operating). The system includes intake and outfall structures, screens, pumps, stopgates, and a pumphouse.

An emergency power diesel generator will be combined in a building with the electrical substation. The emergency generator is sized at 1000kW, with a power factor of 0.8. It will supply emergency power for security lighting, to critical motors in the incineration system and in other processes where continuous operation is required for safety.

A fire ring and pumphouse have been designed to provide multiple water supply paths to each hydrant, spray system, and building riser. Hydrants will be strategically located so that each potential fire hazard could be reached from at least two hydrants. Dedicated hose cabinets will be installed with hydrants in the waste processing areas. Two firewater pumps - one diesel and one electric - will draw firewater from the sea. Each is sized for 100% of the required firewater supply. The pumps will start automatically with the loss of pressure in the fire ring main. In addition, the packaged waste reception and the administration buildings are equipped with sprinkler systems and roof-top water tanks supplied by fresh-water mains. Tsing Yi Island mains are also available if needed for general firefighting.

4.3 TYPES AND AMOUNTS OF WASTE TO BE TREATED

The Hong Kong Government requires that the CWTF be able to treat a wide range of wastes. Because of the possibility of receiving wastes in addition to those included in the Contract categories, the CWTF has been designed for flexibility and adaptability in both storage and treatment.

As described in Section 4.2, three broad-spectrum, work-horse treatment processes have been included: rotary kiln incineration, stabilisation, and the PO*WW*ER aqueous treatment process. The incinerator can process a wide range of materials, PO*WW*ER can treat virtually anything aqueous, and stabilisation can immobilise toxic substances in the residues of these or other processes. The flexibility in each of these systems will allow the CWTF to handle the range of waste streams required by the Government.

An estimate of the types and amounts of chemical waste, for which the CWTF is designed, has been presented in Table 2 (Section 2.5). Table 3, originally presented in the Contract, indicates the nature and amounts of these wastes which can be disposed of by incineration. The total is estimated as 14,650tpa with 1,170 tonnes of halogenated solvents and polychlorinated biphenyls (less than 10tpa). These data indicate a relatively small volume of solid wastes. The CWTF design provides the flexibility to incinerate small quantities of solid wastes in addition to those listed. For instance, it may be necessary to incinerate hospital waste, spent capacitors containing PCBs, contaminated soils, etc., at some future date.

TABLE 3

ORGANIC MATERIAL TO UNDERGO INCINERATION

Waste Type	*Estimated Annual Generated (tpa)*
Halogenated Solvents	1,170
Non-Halogenated Solvents	1,350
Phenol and Derivatives	2
Polymerisation Precursors and Production Wastes	40
Mineral Oil (oil only, after separation)	4,300
Fuel Oil	50
Oil/Water Mixtures (oil only, after separation)	600
Pharmaceuticals	1
Mixed Organic Compounds	130
Miscellaneous Chemical Waste	15
Interceptor and Treatment Plant Sludges	20
Tank Cleaning Sludge	1,000
Tar, Asphalt, Bitumen and Pitch	140
Printing Waste	90
Dyestuff Waste	70
Paint Waste (assuming 50% of total)	640
Waste Catalysts	4
MARPOL Annex I (oil only, after separation; 95% of total)	4,750
MARPOL Annex II (assuming 50% of total)	250
Polychlorinated Biphenyls	< 10
TOTAL (round)	14,650

Source: Contract Document (1990), Table SB3(b).

Table 4 lists the types and amounts of oil and oily wastewater which are to be treated along with the expected amounts of oil which will need to be incinerated and the water which will need to be treated. The need for a flexible design and adequate storage is evident from the estimate of 5,000tpa for MARPOL waste to be incinerated, which is approximately 32% of the total waste to be incinerated per year.

TABLE 4

OIL/OILY WASTEWATER GENERATION - OIL/WATER SEPARATION

		Estimated Separation Products			
		Oil (incineration)		*H_2O (treatment)*	
Source of Waste	*Tonnes (per annum)*	*%*	*tpa*	*%*	*tpa*
Motor/Vehicle Oil	2,630	95	2,500	5	130
Other Mineral Oil (non MARPOL)	3,000	60	1,800	40	1,200
Oil/Water Mixtures	12,000	5	600	95	11,400
MARPOL Annex 1 (expected)	5,000	95	4,750	5	250
TOTAL	22,630		9,650		12,980

Source: Contract Document (1990), Table SB3(c).

Inorganic wastes to be treated by physical/chemical processes are listed in Table 5 and total about 69,500tpa. Of major interest is the 12,500tpa of spent printed circuit board etchants. These waste require separate processing and may represent a resource recovery opportunity.

The estimated MARPOL wastes include Annex I wastes (5,000tpa) and Annex II wastes (500tpa). The amounts and frequency of these wastes demand flexible design of the storage and incineration capacities.

TABLE 5

INORGANIC MATERIALS - PHYSICAL/CHEMICAL TREATMENT

Waste Type	*Estimated Annual Arising (tpa)*
Acid	20,000
Alkalis	35,000
Copper Waste Solution from Other Factories	140
Zinc Containing Waste Solution	13
Nickel Containing Waste Solution	120
Other Metal Salts Containing Waste Solution	1,200
Cyanide Containing Solution	100
Non-Chromium-bearing Oxidising Agents	10
Chromium-bearing Oxidising Agents	55
Mixed Inorganic Compounds	70
Miscellaneous Chemical Wastes	15
Interceptor and Treatment Plant Sludge	20
Tannery Waste	400
Plating Bath Sludges	10
Spent PCB[(1)] Etchant	
- Ammoniacal	4,900
- Ferric Chloride	6,300
- Cupric Chloride	1,300
TOTAL	69,500

Notes: (1) PCB - printed circuit board.

Source: Contract Document (1990), Table SB3(d).

4.4 ADMINISTRATION AND SUPPORT

The wide variety of operational process units that make up the CWTF will require administrative support, as would any industrial facility of significant size. The CWTF will initially employ about 275 staff and it is expected that this will increase to 375 within five to six years when the full design capacity of the plant is attained. Normal personnel and financial/ accounting office functions will need to be carried out. In fact, the nature of the CWTF requires more support than most industrial plants.

Protection of CWTF workers' safety, and public health will require an environmental control division, which will include an environmental manager, a safety supervisor and a training supervisor. A continuous training programme for all employees will be an important part of the safety effort.

The computer hardware and software will be a major element of the CWTF, with all major operation processes being at least partially computer controlled and monitored. The enormous number of sample analyses will require a major data processing capability for the laboratory alone. In addition, a large and separate portion of the computer system will serve as the Hong Kong Government's data processing system for the enforcement of the laws governing the proper disposal of chemical wastes.

Even though the operator of the CWTF will not collect waste processing fees from the industries generating chemical wastes, the sheer number of these industries will require that CWTF hire personnel responsible for maintaining relations with its clients or users. In addition, the nature of a chemical waste treatment facility requires that someone in its administrative structure perform a public relations function to address the concerns of the public on a full-time basis.

Security is also a major consideration for a treatment facility. The CWTF will be fenced and surveillance cameras will be placed at key locations. A guard force will control traffic entering the site and will provide a 24-hour watch against unauthorised intrusion.

4.5 OPERATING PHILOSOPHY

Enviropace is a partly owned subsidiary of Waste Management, Inc. Through its several hundred operating divisions worldwide, Waste Management has obtained unparalleled experience in the treatment and disposal of over 100,000 types of waste chemicals. The Company was one of the first of any major corporation to formulate an environmental policy. WMI's policy includes and even surpasses the Valdez principles now promoted by many environmental groups.

The fundamental guidelines which will form the basis for the policies and procedures of Enviropace are:

- protection of the public, employees, and the environment;
- total compliance with all health, safety, and environmental regulations; and
- safe, effective, and complete services to customers.

Enviropace's first priority will be the safety of the public and the company's employees, and the protection of the environment.

A comprehensive training program will be instituted and maintained to ensure that all employees work safely, and consistently take all precautions necessary to prevent any adverse impact on the environment. Compliance with Enviropace's health, safety, and environmental guidelines will be achieved through:

- regular training of all employees in the correct performance of their jobs;
- monitoring of all operations by skilled engineering and management staff;
- constant two-way communication between staff and management to recognise superior performance, instill pride and teamwork, and prevent or correct deficiencies; and
- frequent re-evaluation of processes and operating procedures to maximise recycling and resource recovery.

These measures have been found to be highly effective in promoting safe and professional operations throughout Waste Management companies and they will be a key part of Enviropace's operating philosophy.

Virtually all chemical and solid waste facilities operated by companies in the Waste Management family practise an "Open Door" policy. Throughout the world most facilities operated by Waste Management work under the constant presence of environmental regulators. In addition, representatives of regulatory agencies, governmental bodies, civic groups, and news media. from other nations often visit the Company's facilities. An Open Door policy means that, by appointment and accompanied by representatives of the site management, policy makers and ordinary citizens (such as school and scout organisations) may see that a well-run chemical or solid waste facility is a benefit rather than a detriment to the community. Waste Management's Open Door policy has generated public confidence in the Company worldwide and increases public acceptance of its operations. Enviropace will adopt and practise this policy as well.

The goal of Enviropace, its management, and employees will be to provide safe, secure, and prompt service to waste generators, to provide the public with an improved environment, and to aid Government in the monumental task of monitoring and controlling the disposal of the chemical wastes generated in Hong Kong.

4.6 CONSTRUCTION AND COMMISSIONING SCHEDULE

Construction is due to commence at the end of April 1991 and proceed for 17 months (to September 1992). This would be followed by a three month acceptance testing programme. The plant is due for commissioning in January 1993.

5.0 ENVIRONMENTAL IMPACT ASSESSMENT

5.1 INTRODUCTION

The CWTF at Tsing Yi Island has already been the subject of a preliminary environmental review (ERL, 1987). The major conclusions of the review were as follows:

- the location of the CWTF is appropriate under the planning strategy for Tsing Yi Island;
- the CWTF will provide a much needed facility for the safe treatment and disposal of the increasing quantities of chemical waste being generated in Hong Kong. The CWTF will reduce present risks to public health and safety, and prevent future deterioration in water quality from this source by reducing present improper disposal practices;
- there are no significant effects on amenity for Tsing Yi residents; and
- approximately 70-100 jobs will be initiated by the CWTF once it is operational. (In fact, the total number of jobs to be generated by the CWTF is estimated to be 375 when full design capacity is attained).

ERL also highlighted a number of areas that warranted further consideration. These were as follows:

- incinerator stack emissions;
- waste heat utilisation;
- detailed assessment of baseline groundwater conditions and methods to prevent contamination;
- dispersion modelling of effluent discharge to determine the optimum outfall location, which was to include baseline data collection on:
  - ocean current movements off the island of Tsing Yi in the vicinity of the site, and
  - accumulation of heavy metals and persistent organics in sediments and shellfish;
- control of any hydrogen sulphide emission during waste blending; and
- exterior design to enhance the plant's appearance.

Further research and a series of design modifications have been made to the CWTF since the above observations were noted. For example, it is no longer planned to construct a marine outfall to discharge wastewater effluents. Instead, the effluent will be treated to meet stringent water quality criteria before being discharged into a Government foul sewer. This eliminated the need to undertake effluent dispersion modelling and conduct related studies on shellfish and marine sediments. Similarly, there has been further research into the potential for reheating the flue gas to improve dispersion and minimise plume visibility since the ERL recommendations were presented. This recent research has enabled the design team to draw the following conclusions:

- using saturated steam from the boiler will be unlikely to result in any significant increase in the temperature of the flue gas;
- the temperature of the exit flue gases will be considerably above the saturation temperature; hence a condensation plume will be minimised at the stack, and the need for gas re-heating is eliminated; and
- on cold humid days there may be condensation of water vapour, beginning at some distance from the stack. This condition is unavoidable and will occur irrespective of the temperature of gases leaving the stack.

The present EIA has not, therefore, given any further consideration to issues such as those described above. Instead, the main focus of the impact assessment has been on a series of key issues which were the subject of the Key Issues Report prepared as part of the contract requirements by Dames & Moore (Appendix A). In summary, the Report highlighted air quality, traffic and visual impacts as the main environmental issues requiring further consideration, together with risks and hazards. Other issues such as solid and liquid waste disposal, noise and socio-economics are discussed in the present environmental assessment, but because of the reduced potential for environmental impact, the approach has been to reconfirm, where appropriate, the results presented by ERL (1987).

5.2 AIR QUALITY

The Key Issues Report identified sources of air emissions that will occur during the construction and operation of the CWTF. They are:

- o stack emissions from the incinerator; and
- o hydrocarbon and HC-derivative emissions arising from the transfer of organic waste to storage tanks, the storage of organic wastes and incinerator fuel oil, and drum handling and processing.

There will also be dust from site construction and from some operations. Each is discussed in the following sub-sections. Their potential environmental impact is first discussed, and then the environmental management/monitoring measures to control impacts.

5.2.1 Dust

5.2.1.1 Impacts

Dust generated during construction will potentially cause a short-term, localised nuisance, but the overall environmental impact will be negligible. This opinion was supported by ERL (1987) who concluded that dust generated as a result of on-site construction activities would not be a cause for concern because:

- o much of the site has already been piledriven; heavy construction will therefore be minimal and quantities of loose material low;
- o the location is such that few, if any, sensitive receivers are within range of significant dust deposition, i.e. about 250m. The nearest area of residential development is Mayfair Gardens, over 1.3km away. Off-shore winds and the existence of several industrial installations between the treatment plant and Mayfair Gardens will mean that residents will not be affected by dust generated during the construction of the CWTF;
- o the levels of dust anticipated and the distance involved means that Mayfair Gardens will not be measurably affected by on-site production of respirable suspended particles. It is possible that dust deposition on neighbouring industrial facilities may cause a temporary nuisance. It is also possible that, although workers on-site will not generally be continuously exposed to dust sources, some (e.g. bulldozer drivers) may require special measures (e.g. ventilated cabs, dust masks etc.) for protection.

During the operation of the CWTF, a number of design and operations procedures will ensure that dust will have a negligible effect on the environment. The most important procedures relate to the handling of bulk powder reagents and ash from incinerator operations.

Bulk powder reagents used throughout this facility will be received via bulk tanker truck. Some production of dust can occur during the unloading operation. It has been addressed as follows:

o prior to the connection of the tanker unloading hose, the transferring blower is started and the receiving valve is opened. This step is taken to assure that no residue remains in the receiving lines, where residues may cause a spill and potential dusting;
o the tanker unloading line is then hooked to the unloading pipe;
o the tanker unloading valve is then opened, allowing transport of the tanker content into the storage silo;
o this procedure is followed in reverse after the unloading process is completed.

Materials via air cargo are received in a cyclone bag house configuration, then transferred in order to eliminate possible dusting from occurring.

Dust from ash extracted from the incinerator is controlled as follows:

o bottom ash from the kiln is quenched in water;
o fly ash from the boiler, spray dryer and baghouse are extracted in enclosed screw conveyors.

Dust control in the stabilisation area, where ash is delivered, is provided for in the following manner:

o reagents in powder forms, such as cement and cement kiln dust, are loaded from the truck to the silos using a closed pneumatic system. The silos are equipped with dust collectors at the vents. The cement is fed to a closed mixer using a closed screw conveyor.
o the dry scrubber solids and boiler fly ash are dumped into the mixer under a closed hood while using water spray.

5.2.1.2 Management and Monitoring

The greatest potential for dust nuisance will occur during construction activities. Even without any management, the environmental consequences on any sensitive receptors (e.g. residential areas) will be negligible. As discussed above, this is due to a combination of factors such as the nature of the site, the nature of the proposed earthworks and the distance separating the site from sensitive public receptors. As a precaution, however, areas subject to earthworks will be watered down before any activity is allowed to commence. It is considered that this management approach will make it unnecessary to implement an ongoing monitoring programme.

During operations, dust particulates of greatest health concern ($<10\mu$) will be monitored in conjunction with other air pollutants (cf Table 12).

5.2.2 <u>Incinerator Emissions</u>

5.2.2.1 Introduction

The feed to the incinerator is provided in Table 3 and consists of:

- o primarily high heat of combustion waste organics, oil and fuel;
- o a small percentage (< 10%) of halogenated waste; and
- o relatively low quantities of waste solids and moisture.

This waste input will generate steam, carbon dioxide and two environmentally relevant types of stack emissions:

- o volatile and semi-volatile organic compounds present in the original feed and not destroyed in the process of combustion; and
- o gaseous compounds of combustion, including some pollutants

The air quality impact of the CWTF due to these environmentally relevant emissions is assessed by the use of the "worst case indicator pollutant" approach. In consultation with EPD, dioxin was selected as the "worst case indicator pollutant" for the volatile and semi-volatile organic compounds. This is in light of the exceptionally high unit risk factor and the high cancer risk that has been associated with dioxin. For other non-carcinogenic, gaseous compounds of combustion, SO_2 was selected as the worst-case indicator pollutant because of its relatively high toxicity and relatively high emission limit. Pollutant levels for other compounds can be derived using proportionality constants (c.f. Table 10).

Particulate matter will be generated and will mainly include ash and non-combustible solids (e.g. trace metals). Most, if not all, will be scrubbed by the baghouse and therefore not emitted to the atmosphere.

5.2.2.2 Methodology

Air Dispersion Model

The impact of the incinerator emissions has been assessed by conducting detailed air dispersion modelling. The emission characteristics of the incinerator have been modelled for the design pollutant emission rates to produce a set of contours depicting the predicted concentrations for:

- o receptor heights ranging from 0 to 100m above the ground with a interval of 10m between contour sets; and
- o 1-hour, 24-hour and annual averaging periods.

These contours form a reference set of contours from which the impact of other specific pollutants can be determined for any averaging period or receptor height. They were produced using the latest version of the Victorian Environmental Protection Authority dispersion model AUSPLUME (Version 1.6D). AUSPLUME was developed from the USEPA's ISCST model and it generally utilises the best methods available in the international literature. It is often used for:

- o stack height determination;
- o new source assessment;

- o determining the effects of buildings on plume dispersion;
- o monitoring network design;
- o identification of the main contributors to existing air pollution problems; and
- o control strategy evaluation.

The meteorological data used by AUSPLUME generally comprises time series data directly related to the area being studied. This data set would ideally contain 1-hour averages of wind speed, wind direction, air temperature, atmospheric stability class and the atmospheric mixing depth.

Two modifications were made to the AUSPLUME model before it was used to model the emission characteristics of the incinerator. These were performed to allow the concentrations to be predicted at nominated heights above the ground and to include the Briggs urban dispersion curves to account for the high surface roughness associated with Tsing Yi Island.

Model Grid

The AUSPLUME dispersion model has utilised a grid interval of 100m depicted in Figure 5. This figure shows that all of the likely key receptor locations (e.g. Mayfair Gardens; the proposed Technical Institute; and the proposed CT9/SETY development project) are well covered by the model grid.

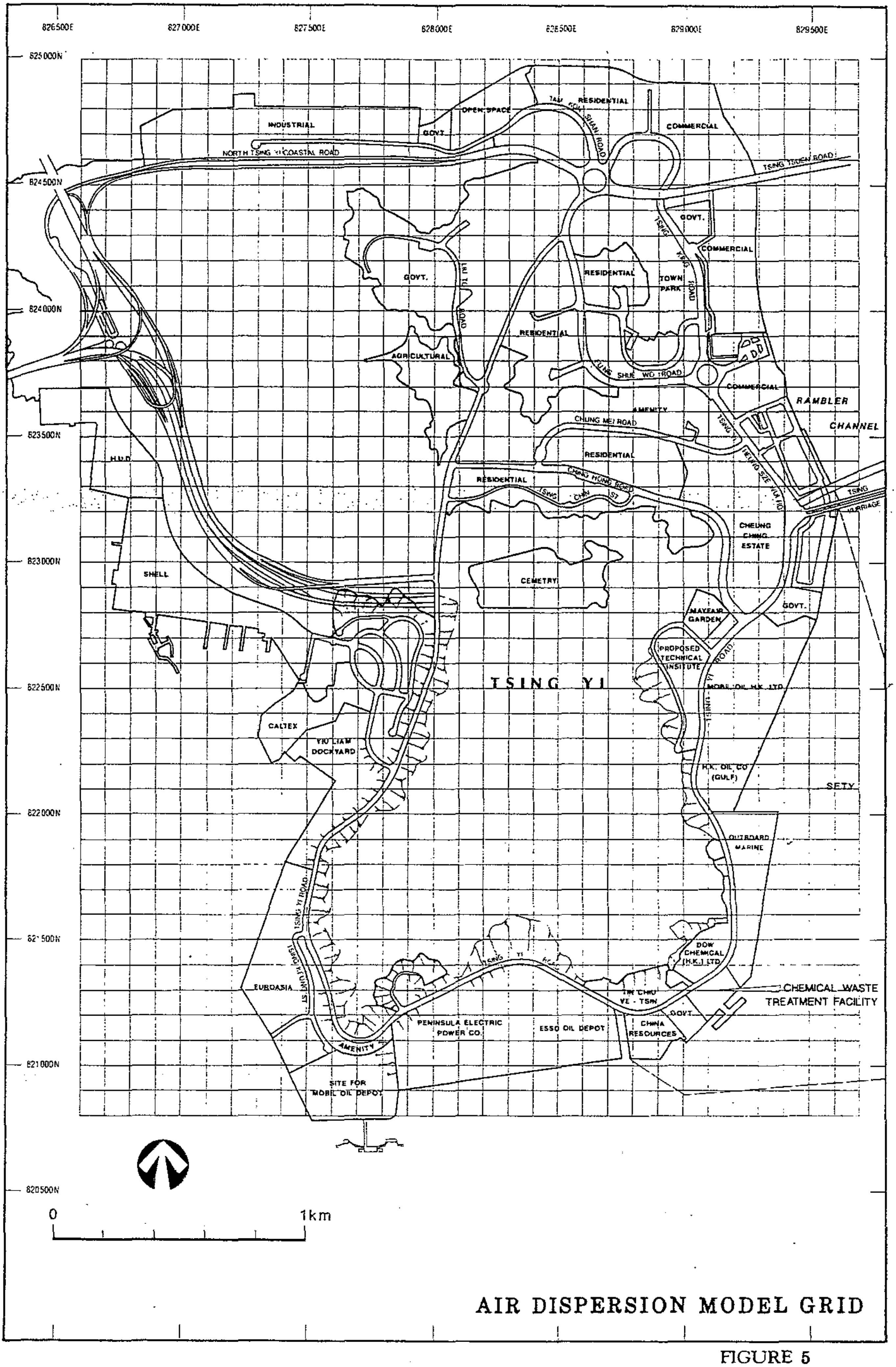
Topographic Influences

The topographic features of Tsing Yi Island have been digitised for each of the model grid points. AUSPLUME utilises the "Egan half-height" approach which modifies the plume height to prevent the plume impacting the ground. The "Egan half-height" method has only been applied when the terrain height is greater than the stack height.

Emissions Information

The CWTF incinerator will discharge its emissions through a 76.3m high stack. A minimum height of 75m has been used in the model, thus adding to the conservative nature of the results. The other emission characteristics, at maximum capacity are as follows:

Stack diameter	-	0.91m



AIR DISPERSION MODEL GRID

FIGURE 5
DAMES & MOORE

Emission Temperature	-	175°C
Emission Volume	-	$14.7m^3/s$ at 175°C

The Contract document for the CWTF specifies a number of emission limits as presented in Table 6. These limits have been utilised in the modelling exercise as they represent the maximum permissible emission rate of pollutants. In reality, previous operating experience indicates that the emission rate of pollutants will be considerably lower than these limits and therefore the model overestimates the effects of the emissions under normal operating conditions. Data from other incineration units operated by Enviropace affiliated companies indicates the following emissions data:

o particulates	22-44 mg/Nm^3
o hydrogen chloride	18-20 mg/Nm^3
o arsenic	.000625 mg/Nm^3
o barium	.0111 mg/Nm^3
o beryllium	.000185 mg/Nm^3
o cadmium	.00308 mg/Nm^3
o mercury	.2111 mg/Nm^3
o lead	.0293 mg/Nm^3

Dioxins and furans have not been measured at any Enviropace affiliated facility with a similar heat release and air pollution control configuration to the Hong Kong facility. Some dioxin and furan measurements have been performed; however, only at waste-to-energy facilities with waste heat boilers and spray dryer-fabric filter air pollution control systems. When the speciated data is "reduced" using the International Toxic Equivalent Factors (ITEF) it is seen that the emissions equivalent to 2,3,7,8 TCDD are in the range of .06-.1 ng/Nm^3.

These data indicate that the pollution control limits given in Table 6 are achievable at least for certain systems and waste feed conditions. The systems and conditions for the Hong Kong CWTF are not identical.

TABLE 6

STACK EMISSION POLLUTION CONTROL LIMITS

Pollutant Parameter	*Pollution Control Limit (mg/m³)*[(1)]
Particulates	75
Chlorine and compounds (as Cl_2)	100
Fluorine and compounds (as HF)	25
Hydrogen sulphide	5
Carbon monoxide	150[(2)]
Acidity (as sulphuric acid)	100
Sulphur dioxide	750
Oxides of nitrogen (as NO_2)	500
Hydrochloric acid	38
Total phosphorus (as P)	7.5
Hydrogen fluoride	7.5
Hydrogen bromide	7.5
Toxic Metals I (including mercury, cadmium, antimony)	3
Toxic Metals II (including lead, copper, arsenic, nickel, chromium and their compounds)	10
Total of Toxic Metals I & II	10
Total hydrocarbons (as C)	35
Dioxins/Furans (as TCDD equivalent)	0.1ng/m³
Smoke/Steam	essentially zero opacity[(3)]

Notes:
(1) Under the reference condition of dry stack gas at standard temperature (0°C), pressure (1 atmosphere) and 12% CO_2.
(2) During fuel fired startups, a limit of 500 mg/m³ of a period of up to 10 minutes duration will be permitted.
(3) zero opacity during startup and normal operations means < 10%.

Source: Contract Document (1990)

Meteorological Data

Three years of meteorological data have been obtained from the Hong Kong International Airport (HKIA) and the Hong Kong International Terminal (HKIT). The meteorological parameters collected at each of the monitoring stations are listed in Table 7.

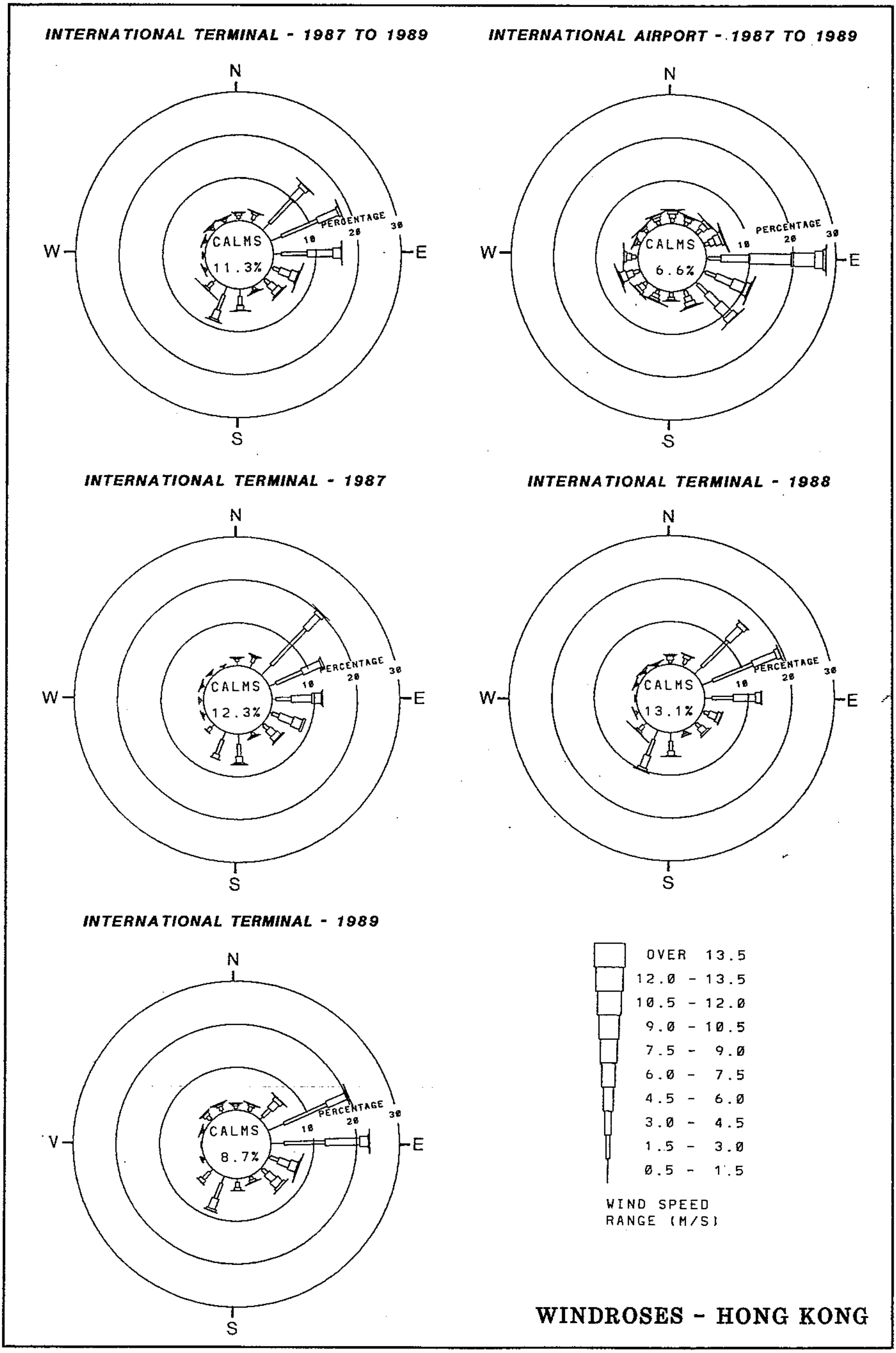
TABLE 7

METEOROLOGICAL PARAMETERS COLLECTED AT THE HONG KONG INTERNATIONAL AIRPORT AND THE HONG KONG INTERNATIONAL TERMINAL

Hong Kong International Airport	*Hong Kong International Terminal*
Wind Speed	Wind Speed
Wind Direction	Wind Direction
Air Temperature	Atmospheric Stability
Atmospheric Stability	
Mixing Depth	

The three year average windroses for the HKIA and HKIT monitoring stations are presented on Figure 6. The windroses indicate that the HKIA station generally experiences stronger winds than the HKIT station. The windroses indicate that northeasterly to southeasterly winds are predominant at both stations, accounting for over 60% of all winds. The HKIT station does, however, experience more winds from the northeast to east-northeast, while the HKIA experiences more winds from the east to southeast. The HKIT station is closer to the site of the CWTF and the data are therefore likely to be more representative of the meteorological conditions on Tsing Yi Island. As a result of this the meteorological data from HKIT were used for the modelling study.

Figure 6 also presents the 1987, 1988 and 1989 annual windroses for the HKIT station. These figures indicate that the annual wind patterns are fairly similar with the major differences being the distributions of northeasterly to easterly winds. The 1988 annual windrose is very similar to the three year average windrose presented on Figure 6 and therefore the meteorological data for 1988 was utilised for this study as this year was considered representative of the three year trend.



WINDROSES - HONG KONG

FIGURE 6
DAMES & MOORE

The frequency occurrence of atmospheric stability classes for the three years 1987-1989 and for 1988 are presented in Table 8. This table shows that the percentage occurrence of stability classes in 1988 is similar to the three year distribution.

TABLE 8

FREQUENCY OCCURRENCE OF ATMOSPHERIC STABILITY CLASSES

Stability Class	*Frequency Occurrence 1987 to 1989 (%)*	*Frequency Occurrence 1988 (%)*
A	6.0	5.9
B	14.4	15.1
C	7.2	6.6
D	31.4	31.1
E	12.2	12.0
F	28.5	29.2

Air Quality Criteria

The basic objective of establishing air quality criteria is to restrict the concentration of pollutants in the ambient air to such levels as will not adversely affect the health, well-being or welfare of the community (NH&MRC, 1986).

Air pollution can be controlled by setting emission criteria for concentrations of pollutants at the source (e.g. the emissions limits contained in Table 6), and/or by specifying ambient air quality standards for groundlevel concentrations of pollutants. Generally, ambient air quality criteria are designed to protect the environment and the emission criteria are intended to ensure that industry incorporates appropriate control technology. Table 9 presents the Hong Kong ambient air quality objectives.

TABLE 9

HONG KONG AIR QUALITY OBJECTIVES

Pollutant	*Ambient Concentration (μg/m³)*		
	1-hour Average	*24-hour Average*	*Annual Average*
Sulphur Dioxide	800	350	80
Particulate Matter		260	80
Nitrogen Dioxide	300	150	80
Carbon Monoxide	30,000		

Source: Environmental Protection Department (1990)

5.2.2.3 Impacts

Air Emissions

The AUSPLUME dispersion model has been utilised to predict the ambient concentrations for 1-hour, 24-hour and annual averages for each of the nominated receptor heights (i.e. 0 to 100m in increments of 10m). The emission characteristics described above, combined with a source strength of 6.72g/s (being the maximum allowable sulphur dioxide emission rate) were utilised for these modelling runs. The predicted concentration contours have been presented in Appendix B and have been used as reference contours. Table 10 presents the factors of proportionality that can be applied to the contours contained in Appendix B. The predicted concentrations for any of the listed pollutants can be determined by simply dividing the existing contour value by the proportionality constant contained in Table 10. Both the predicted maximum 1-hour and 24-hour concentrations represent the maximum concentrations at any grid point at any time.

These results would not occur simultaneously over the modelled area. They are shown as the worst case conditions that could occur at a particular location throughout the year and are thus likely to be conservative estimates.

TABLE 10

PROPORTIONALITY CONSTANTS FOR DETERMINING POLLUTANT CONCENTRATIONS (REFER APPENDIX B)

Pollutant Parameter	*Proportionality Constant*[1]
Particulates	10.0
Chlorine and compounds (as Cl_2)	7.5
Fluorine and compounds (as HF)	30.0
Hydrogen sulphide	150.0
Carbon monoxide	5.0
Acidity (as sulphuric acid)	7.5
Sulphur dioxide	1.0
Oxides of nitrogen (as NO_2)	1.5
Hydrochloric acid	19.7
Total phosphorus (as P)	100.0
Hydrogen fluoride	100.0
Hydrogen bromide	100.0
Toxic Metals I (including Mercury, Cadmium, Antimony)	250.0
Toxic Metals II (including Lead, Copper, Arsenic, Nickel Chromium and their compounds)	75.0
Total of Toxic Metals I and II	75.0
Total Hydrocarbons (as C)	21.4
Dioxins/Furans (as TCDD equivalents)	7.5×10^9
Smoke/Steam	essentially zero opacity[2]

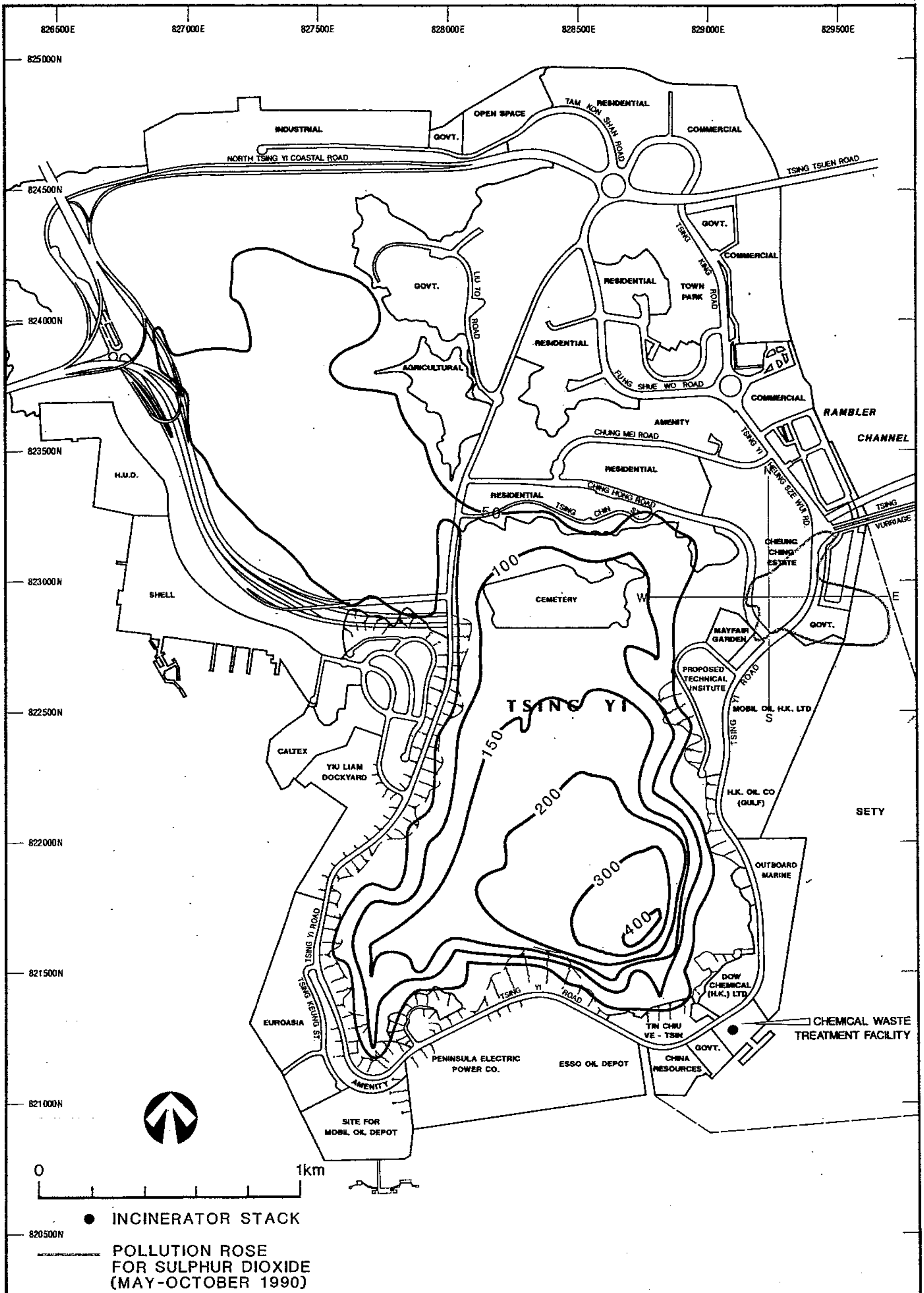
Notes:
(1) The predicted concentrations for any of the listed pollutants can be determined by dividing the existing contour values contained in Appendix B, by the proportionality constant.
(2) zero opacity during startup and normal operations means < 10%.

The modelling results indicate that the maximum 1-hour average groundlevel concentration of SO_2 is 438μg/m^3, which is well within the EPD objective of 800μg/m^3 (Table 9). The results are presented on Figure 7 as contours and show the predicted maximum 1-hour average groundlevel concentration of sulphur dioxide derived from the reference contours contained in Appendix B.

The highest maximum 1-hour concentration of sulphur dioxide is predicted to approach the EPD air quality objective of 800 ug/m^3 at an elevation of 80m above groundlevel and at a location immediately northwest of the CWTF (Figure B9). Furthermore, the model indicates that, at this location, the incinerator plume is approximately 80m above the ground. In theory, therefore, if an 80m high receptor were located at this site, the EPD air quality objectives would not be exceeded. In practice, it is inconceivable that an 80m high receptor would be permitted to locate on the hillside northwest of the CWTF and so it can be concluded that the predicted maximum 1-hour concentrations of sulphur dioxide is unlikely to approach the EPD ambient air quality objective at any groundlevel or elevated receptor, including Mayfair Gardens, the proposed Technical Institute or any other prominent residential area or facility. Similarly, the predicted maximum 24-hour and annual concentrations at all receptor heights are well below the EPD criteria presented in Table 9 for all of the modelled grids.

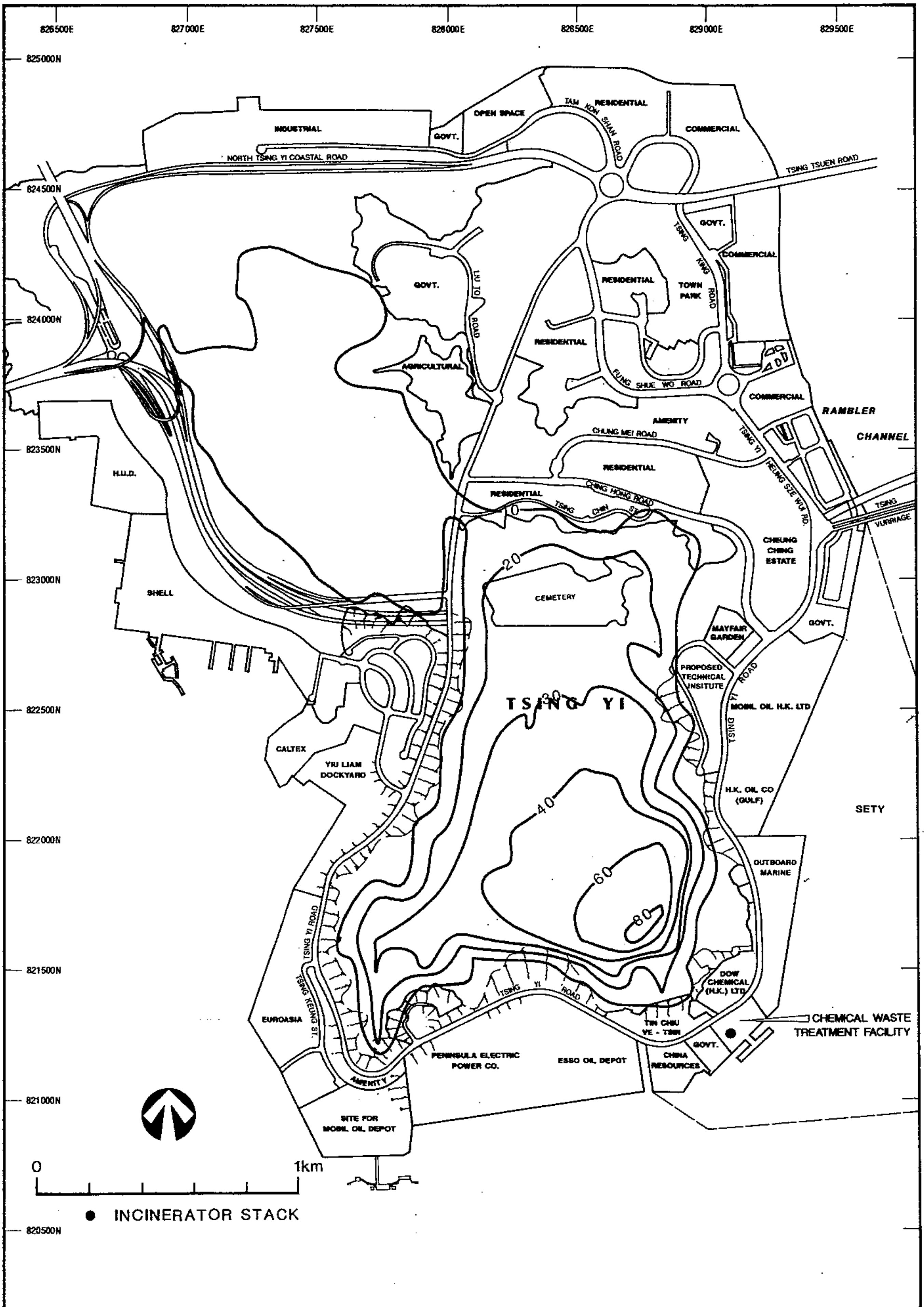
The predicted concentrations for the other criteria pollutants contained in Table 10 can be determined from the plots in Appendix B for any location and elevation under worst case conditions and compared with the EPD air quality objectives. For example, the maximum 1-hour average groundlevel concentration of carbon monoxide has been estimated as 88μg/m^3 (Figure 8). This result is also well below the EPD standard of 30,000μg/m^3.

Since the incinerator does not operate under worst case conditions most of the time, the pollutant levels will generally be much less than any of the levels discussed in this report.



MAXIMUM 1-HOUR AVERAGE GROUNDLEVEL CONCENTRATION OF SULPHUR DIOXIDE IN ug/m^3

FIGURE 7
DAMES & MOORE



MAXIMUM 1-HOUR AVERAGE GROUNDLEVEL CONCENTRATION OF CARBON MONOXIDE IN ug/m^3

FIGURE 8
DAMES & MOORE

TABLE 11

COMPARISON OF PREDICTED CONCENTRATIONS FOR
CRITERIA POLLUTANTS AT MAYFAIR GARDENS AND DOW CHEMICAL

			Maximum Predicted Concentrations (μg/m³)			
			Mayfair Gardens		*Dow Chemical*	
Criteria Pollutant	*Averaging Time*	*AQO*	*Ground level*	*100m*	*Ground level*	*100m*
Sulphur Dioxide	1 hour	800	40	75	40	400
	24 hour	350	8	15	30	50
	Annual	80	0.6	1.5	1.5	4
Nitrogen Dioxide	1 hour	300	27	50	27	270
	24 hour	150	5	10	20	33
	Annual	80	0.4	1.0	1.0	2.7
Carbon Monoxide	1 hour	30,000	8	15	8	80
Particulates	24 hour	260	0.8	1.5	3	5
	Annual	80	0.1	0.2	0.2	0.4

These data have been derived from the contours presented in Appendix B. Generally, all of the predicted concentrations are well within the Hong Kong air quality objectives. The only pollutant that approaches any of the air quality objectives is nitrogen dioxide, and this only occurs at an elevation of 100m above the Dow Chemical site. At Mayfair Gardens, all the criteria pollutants are well within the relevant air quality objectives.

Unit Risk Factors

The USEPA and the California Department of Health Services have determined the Unit Risk Factor (URFs) and Multiple Pathway Adjustment Factor (MPAFs) for dioxins and furans. The URF represents the probability of an individual contracting cancer when exposed to one microgram per cubic metre of an air contaminant over a lifetime of 70 years through the inhalation pathway. If an air contaminant can be absorbed into the body by other mechanisms (such as skin contact) then the MPAFs are applied. This approach is 3 to 5 times more conservative than other accepted approaches. In this case chlorinated dioxins and dibenzofurans are grouped together and expressed as 2,3,7,8 TCDD equivalent (TCDDs are polychlorinated dibenzodioxins). The URF and MPAF for 2,3,7,8 TCDD are 38 and 5.5 respectively. The predicted annual average concentrations for the maximum TCDD equivalent emission rate, combined with the URF and MPAF have been utilised to predict the Maximum Individual Cancer Risk (MICR) as follows:

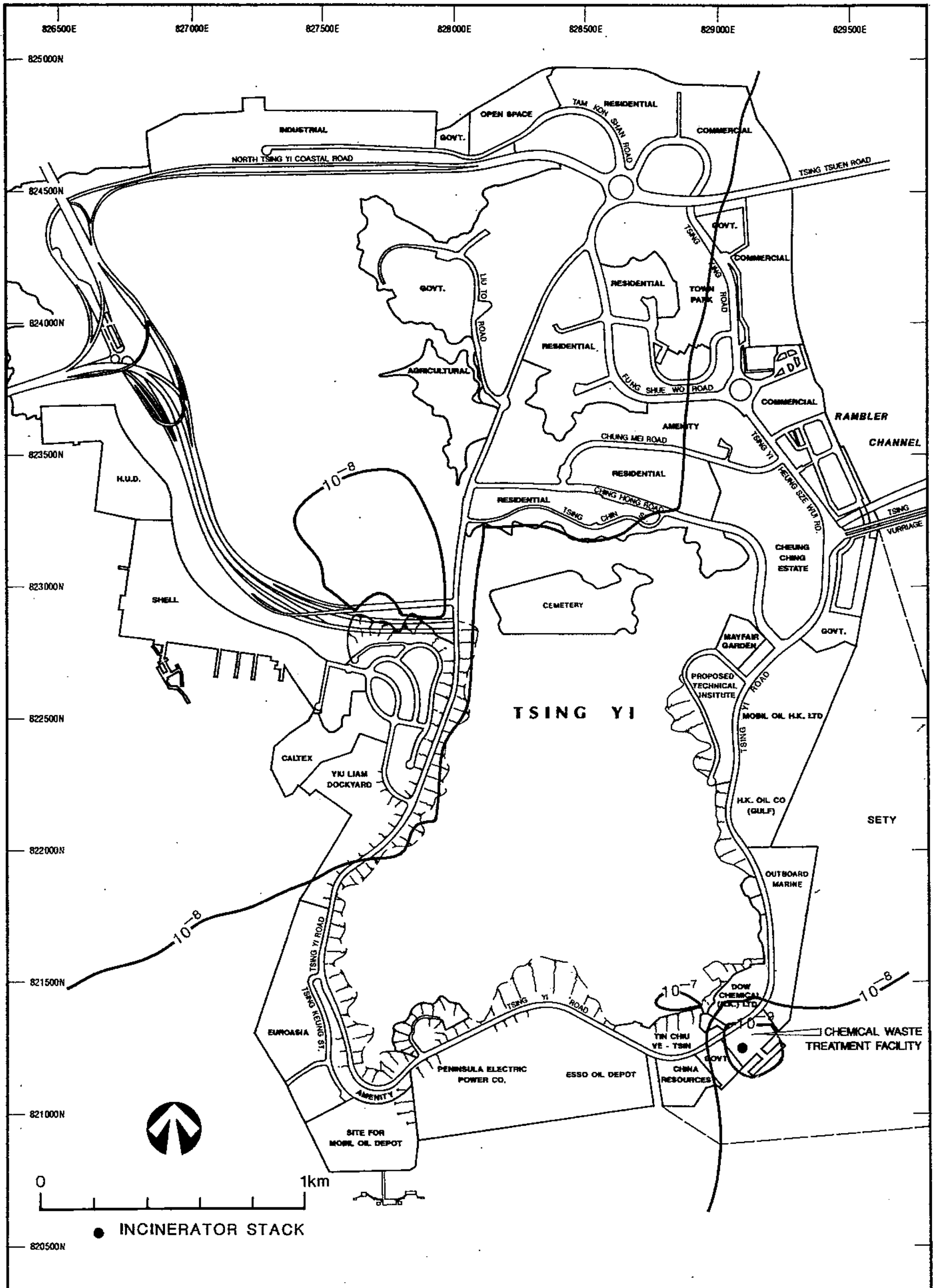
MICR = (Annual average concentration) x URF x MPAF

MICR = 209.0 x (Annual average concentration) for 2,3,7,8 TCDD.

The acceptable MICR set by EPD is 1×10^{-6} (or 1 in a million). The predicted MICRs for receptors at groundlevel and at 100m above the ground are presented on Figures 9 and 10 respectively. Both of these figures clearly show that the goal of 1×10^{-6} is not exceeded. In fact, the largest MICR determined for any receptor at any of the heights considered was 4.06×10^{-7}, or less than half the MICR standard. This value was predicted to occur very close to the CWTF at a receptor height of 100m. For groundlevel concentrations the largest MICR determined for any receptor was 1.28×10^{-7}, or nearly 8 times less than the goal. As can be seen from both figures, the calculated MICR values are largest close to the source, and they decrease rapidly with distance.

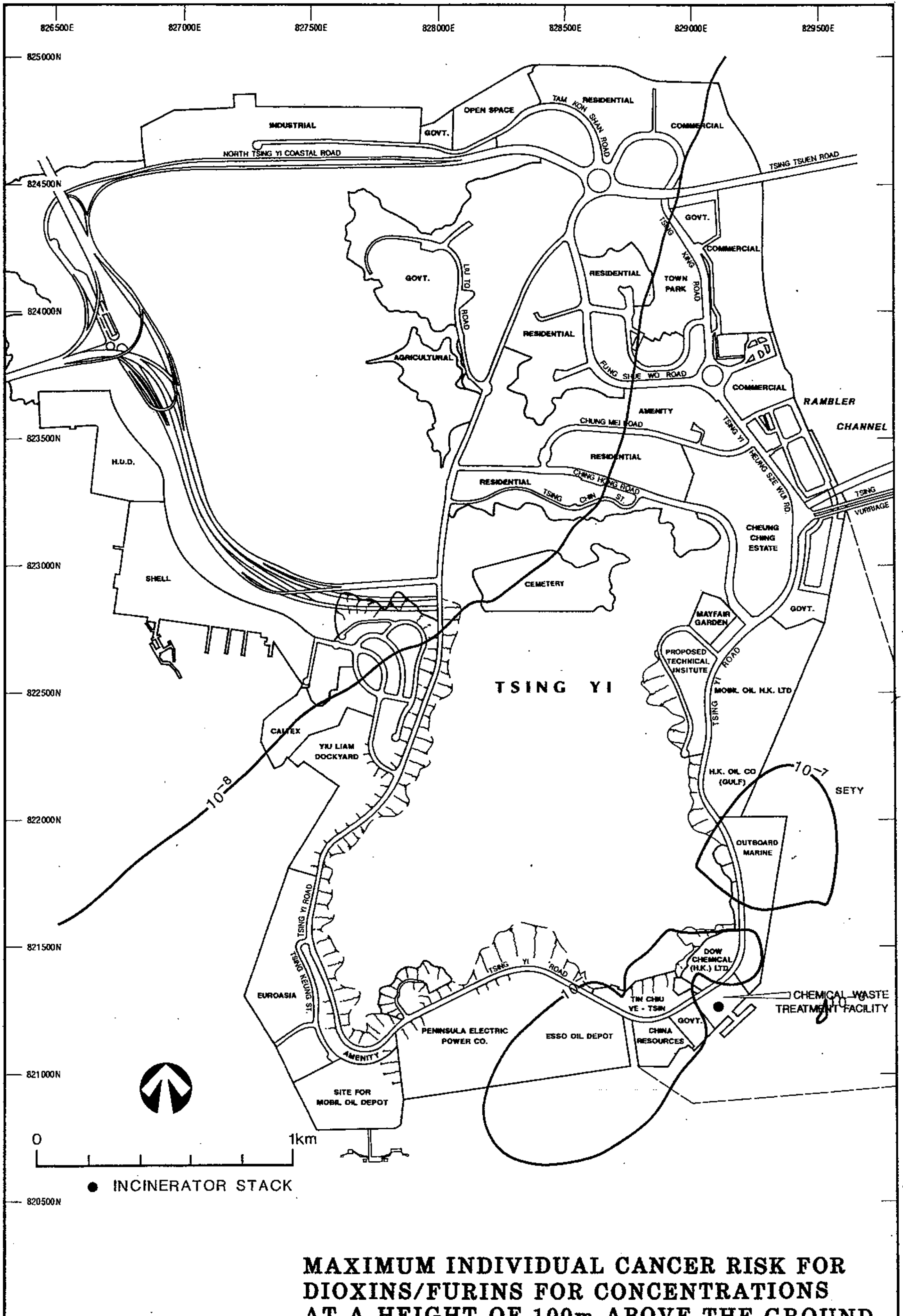
Cumulative Impact

It is difficult to assess the likely cumulative impact of the CWTF emissions on the existing ambient air quality. This is primarily due to the spatial and temporal differences between the different emission sources and conditions under which the plumes may interact directly. Because emissions are monitored so closely at the stack, the CWTF is not expected to prove detrimental to existing ambient air.



MAXIMUM INDIVIDUAL CANCER RISK FOR DIOXINS/FURANS FOR GROUNDLEVEL CONCENTRATIONS

FIGURE 9
DAMES & MOORE



MAXIMUM INDIVIDUAL CANCER RISK FOR DIOXINS/FURINS FOR CONCENTRATIONS AT A HEIGHT OF 100m ABOVE THE GROUND

FIGURE 10
DAMES & MOORE

EPD has recently started monitoring the SO_2 and NO_x concentrations at Ching Yeung House on Tsing Yi Island. Data for six months (May-October 1990) are available. The directional probability, called a pollution rose, is shown in the small green plot on Figure 7. The pollution rose shows that the majority of the existing sulphur dioxide originates from the area located to the southeast through to the northeast of the monitoring station, whereas very low concentrations of sulphur dioxide originate from the direction of the CWTF site. The same trends can be expected for other pollutants. The predicted annual average groundlevel concentration contours (Figure B23, Appendix B) indicate that the CWTF is likely to result in an atmosphere of less than 1$\mu g/m^3$ of sulphur dioxide in residential areas. This is compared to an existing level that is at least a factor of 10 and quite possibly a factor of 100 greater. Considerable improvements in ambient air quality at Tsing Yi Island could be achieved if existing polluters were required to achieve low emission levels and to meet the same stack design criteria as the CWTF. Due to the limited data available for ambient air quality, and the complexity of air pollution sources, it can only be concluded that the cumulative impact of the CWTF emissions on the existing air quality in the residential areas will be very small, and possibly not even quantifiable.

Conclusions

The dispersion modelling exercise has indicated that, for the pollutants considered, the CWTF emissions will not exceed ambient air quality objectives when released from a 75m stack. The predicted concentrations of dioxins and furans are also well within acceptable levels. Since the Unit Risk Factors for all other pollutants are much lower than the Unit Risk Factors for dioxins and furans, and since the dispersion characteristics for all pollutants are similar, compliance with the dioxin/furan criteria implies that the concentrations of other non-criterion pollutants are also acceptable. A brief qualitative analysis of limited air quality data has indicated that the cumulative impact of the CWTF emissions on the existing ambient air quality is likely to be minimal.

5.2.2.4 Management and Monitoring

A comprehensive management and monitoring programme will be implemented to ensure that the operational performance of the plant conforms to the specifications presented in the Contract, and to ensure that the potential environmental impacts described in Section 5.2.2.3 are minimised.

Management

The incineration system is designed to process diverse types of wastes. In order to ensure that all feed materials are compatible with this process, several steps will be taken. All packaged materials (i.e. printing wastes) will be packaged by CWTF personnel who will log the contents of each package and assign an appropriate number to each package. This numbering not only provides for the tracking of each package throughout the plant until proper disposal has been achieved, but also ensures that the materials are properly processed. The same applies for the bulk liquids pumped into the incinerator feed lines. Prior to usage of the feed tank (i.e. sludge, liquid, lean water) all tanks will be sampled to verify that the contents are as recorded, and to prevent incompatibility.

Maintenance of the incineration processing unit will be provided on a continuous basis. Interlocks will be checked on a regular basis, bearings will be lubricated and chains oiled. A detailed preventative maintenance programme will be established for this unit, detailing all of the requirements needed for a safe and efficient operation.

The interlock systems are designed to protect the environment, keep the incinerator functioning and to shut off waste feeds during unplanned upsets. These are described in detail in Appendix C. In the event of a serious incinerator upset, all waste feed (solids and liquids) will automatically stop. A total loss of power would be the most serious failure that could affect the safe operation of the incinerator. However, due to the mass of the refractory and metal within the incineration system and waste heat boiler, the internal temperatures will not decrease at any significant rate. Even in a controlled, intentional cooling down of an incineration system, it normally takes at least one day before the exit gas temperatures from the secondary combustion chamber decrease to below 540°C. In addition to this heat capacity factor, with a mean stack temperature of 175°C the natural draft flow through a 76.3m stack will approximate $6m^3/s$ upon shutdown. Therefore the destruction efficiency of the incinerator will decay very slowly enabling wastes introduced just prior to shut-off to continue combusting while the auxiliary power units gradually restore power to the system components.

The removal of the pollutants from the combusted gases also changes slowly as the volume of combusted gases falls off rapidly. There is a pressurised emergency water supply for the spray dryer, and the fabric filter is a passive system that functions regardless of upsets as long as there is water to control the gas temperature. For example, once residual HCl vapours reach the fabric filter they begin to react with the unreacted lime on the filter bags and are removed from the gas stream.

The emissions of dioxins will be controlled by both the emergency water supply, which maintains the temperature within the needed control range, and by residual reactive coatings on the fabric filters. The emergency water supply is sufficient for 15 minutes, which exceeds the time needed to combust remaining wastes as well as the time to restore emergency power. Also, carbon that may be needed for dioxin control can be injected without electric power. The residual carbon built up on the baghouse filters will continue to function as well.

Monitoring

The monitoring programme will include an assessment of ambient air quality and incinerator stack emissions. The ambient air quality will be measured at the following locations:

- o northeast corner of the CWTF site boundary;
- o Outboard Marine Ltd (one site); and
- o Mayfair Gardens (one site).

The ambient air quality will be measured every six months, with one of the tests being conducted under southwesterly winds, and the other under east-northeasterly winds.

All of the sampling and analysis will be performed according to USEPA methods. The parameters to be monitored, the length of each sampling procedure, and the specified USEPA methods to be employed are summarised in Table 12. Alternative methods which are equivalent to the USEPA methods may be substituted for the methods contained in Table 12.

TABLE 12

AMBIENT AIR SAMPLING PROGRAMME

Parameter	*USEPA Sampling Method*	*Sample Duration (hrs)*	*Analytical Method*
Respirable Particulates	RFPS-1087-06	24	
Total Hydrocarbons	TO-12	24	PDFID or OVA
Polychlorinated biphenyls	TO-4	24	GC/ECD
Dioxins	TO-9	24	HRGC/HRMS
Sulphur Dioxide	EQS-0775-002	24	Pararosaniline
Nitrogen Oxides	EQM-1277-026	24	Sodium Arsenite

Baseline samples will be taken prior to and during start up. The second sampling period will occur during the initial operation of the incinerator and subsequent samples will be taken at six-monthly intervals.

In addition to ambient air quality monitoring, a programme for monitoring the incinerator stack gas composition will be implemented. The components and frequency of testing are presented in Table 13.

TABLE 13

INCINERATOR STACK MONITORING PROGRAM

Sample	*Parameter*	*Frequency*
Stack Gas Components	Particulates	Once/week
	Chlorine and compounds (as Cl_2)	Once/week
	Fluorine and compounds (as HF)	Once/week[(1)]
	Hydrogen sulphide	Once/week
	Carbon monoxide	Continuous[(2)]
	Acidity (as Sulphuric acid)	Twice/week on start-up Once/week on normal operation
	Sulphur dioxide	Twice/day on start-up Once/day on normal operation
	Oxides of nitrogen (as NO_2)	Same as SO_2
	Hydrogen chloride	Same as SO_2
	Hydrogen fluoride	Once/month
	Hydrogen bromide	Once/month
	Total phosphorus (as P)	Once/month
	Toxic Metals I (including mercury, cadmium, antimony and their compounds)	Once/week
	Toxic Metals II (including lead, copper, arsenic, nickel, chromium and their compounds)	Once/week
	Total hydrocarbons	Continuous
	Dioxins/Furans PCDD and PCDF	Once/month
	Smoke/Steam	Continuous

Notes: (1) Once/day if burning F compounds specifically.
(2) Linked to CO_2 measurement to calculate combustion efficiency.

Source: Contract Document (1990), Table SD12(a), and Pending Addenda.

Stack gas analyses will be accomplished using in situ or extractive systems. As the failure of the flue gas analysis system dictates shutdown of the waste feed system, these analysers will be installed as dual, redundant systems, each sending an independent analog signal which will be used in the monitoring and/or control loop. Both output signals will be continuously monitored and compared. A sustained significant difference between the two signals will result in an alarm which will alert the operator to the potential failure of one of the analysers.

Stack gas velocity is an indication of the gas residence time in the secondary combustion chamber, which is critical to the complete thermal destruction of waste materials; therefore, stack gas velocity will be measured with dual, redundant thermal dispersion velocity transmitters. As in the other application of critical redundant measurements, both signals will be continuously monitored and compared. A sustained significant deviation will cause an alarm to alert the operator of the possible malfunction of one of the transmitters. Temperature will also be monitored continuously at both the primary and secondary chambers.

Finally, the CWTF will be operated with an automatic emergency interlock and shutdown system. This system will ensure an orderly transition to safe conditions during a process upset or mechanical equipment malfunction which could cause unsafe operating conditions or major equipment damage. Further details of this system are provided in Appendix C.

5.2.3 Fugitive Emissions

5.2.3.1 Impacts

The potential for significant environmental impacts arising from fugitive emissions is minimal. ERL (1987) has considered the potential consequence from fugitive emissions and their assessment, together with additional comments to reflect the Enviropace design, are reproduced below.

Storage of Organic Wastes

The fugitive emissions created by filling the storage tanks, and ambient condition changes within the storage tanks, will create a vapour emission source. Depending on the storage tank contents, vapours will be transported into either a gas scrubber or directly into the incinerator unit. Whenever the incinerator is not in operation, the vent gas will be directed either into the auxiliary boiler or into a carbon absorption system prior to discharge into the atmosphere. The installation of this system is to ensure tight process controls of the emitted vapours.

Breathing losses and groundlevel hydrocarbon concentration are expected to be minimal for the following reasons:

- o it is anticipated that tonnages of volatile organic wastes handled by the plant will be small; and
- o complying with APC Regulations, the incinerator will burn No. 2 fuel oil, which is a heavy oil with a minimal volatile fraction.

Road Tanker/Storage Tank Transfer

Hydrocarbon emissions will occur during transfer of organic wastes from road tankers to storage tanks because wastes pumped into storage tanks will displace any volatiles above the stored liquid. This is unlikely to constitute a problem because:

- o hydrocarbon releases will be small; and
- o any potential problem emissions could be controlled by fitting vapour return lines.

All transfers occurring during tanker filling operations will be guarded in accordance with the storage tank filling process and will be treated in the same manner as for breathing losses described above.

Drum Handling and Processing

Hydrocarbon emissions will be produced when the drums containing volatile organic wastes are opened for treatment. These emissions will be vented to the incinerator or to activated carbon canisters and, therefore, very little, if any, vapour accumulation is expected in the processing area.

Hydrogen Sulphide Emissions During Blending

It is possible that hydrogen sulphide emissions will occur during the blending of certain wastes for incineration, e.g. sulphur-containing wastes with organic acids. This has the potential to cause transient odour nuisance. The environmental consequences of this impact are unlikely to be significant because the storage tank will be sealed to the atmosphere and any vapour will be discharged to either the incineration unit or a carbon absorption device.

Incinerator Shredding Operation

Dust and emissions created during the shredding operation will be contained within the shredder system. This system will be equipped with a nitrogen blanket system which will dispense inert gas. This will have the effect of reducing the concentrations of oxygen and hence preventing explosions, as well as forcing dust or vapours into the incinerator unit. The shredder may occasionally be operated when the incinerator unit is not on-line in which case an alternate route of gas or dust disposal will be provided (e.g. directed to the auxiliary boiler or carbon absorption canisters).

5.2.3.2 Management and Monitoring

Standard operating procedures will ensure that the predicted impacts arising from most of the identified sources of fugitive emissions will be negligible. No specific environmental management or monitoring programme is therefore envisaged. There is the potential for the build-up of hydrocarbons in the drum handling and processing area and therefore the central section of the handling area roof will be raised and louvres will be installed at regular intervals around the building to promote circulation and ventilation. Tanks with volatile organics will be vented to the incinerator. If the incinerator is not operating (e.g. during phased start-up), venting can be channelled through activated carbon beds.

5.3 LIQUID EFFLUENT DISCHARGES

5.3.1 Introduction

There are four potential sources of effluent discharges that could arise from the CWTF. They can be summarised as follows:

- o treated effluent discharges;
- o spills from on-site operations and the transference of MARPOL wastes at the jetty;
- o run-off from the plant site; and
- o contaminated groundwater discharge.

The potential impacts that could result from these discharges are discussed in the following sections together with appropriate management and monitoring procedures.

There is also a question of whether there will be any thermal effects from the use of sea water for cooling at the CWTF. At this point there are no regulations governing water temperature at CWTF. However, the facility designs take into account a balance between the amount and quality of water used for cooling, the temperature rise of the cooling water, and the effects these have on the water source and receiving water body so that unstable conditions do not occur. If the Technical Memorandum on water quality is applied to CWTF in the future, then specific temperature limitations will be considered as they may effect the design of the cooling system.

5.3.2 Treated Effluent Discharges

5.3.2 1 Impacts

The Contract outlined the broad aspects of the waste collection and treatment systems required by the Hong Kong Government and provided a list of specific wastes and expected volumes. The Government, through the EPD, has correctly noted that waste types and quantities change as business conditions change, as regulations become effective, and as alternatives for waste treatment increase. Enviropace, through its parent company, has experienced these changes and the facility has been designed for flexibility and adaptability in both storage and treatment. The Contract for the CWTF specifically allows for this flexibility.

Because of this uncertainty, it is not possible to accurately predict the physical and chemical composition of the treated wastewater effluent requiring off-site disposal. The Contract specifies the maximum allowable concentrations of pollutants in the treated effluent discharged from the CWTF and these are presented in Table 14.

Enviropace's previous experience indicates that a conventional plant design might not meet all performance criteria for all wastes as specified in the Contract (Table 15). Therefore, a Sequencing Batch Reactor and the PO*WW*ER evaporative system was included in the design of the CWTF. These additional treatment processes will enable compliance; therefore, the discharge of the treated wastes will not lead to any unacceptable environmental impacts. Similarly, since the quality of the water which is discharged from the CWTF is likely to be higher than that in the foul sewer (particularly in terms of BOD, COD, faecal coliforms and heavy metals derived from storm-water run-off), the effluent discharge is unlikely to cause any engineering problems within the sewerage system.

TABLE 14

EFFLUENT DISCHARGE POLLUTION CONTROL LIMITS:
COMPARISON OF CONTRACT DOCUMENT AND TECHNICAL MEMORANDUM
(Figures shown are mg/L unless otherwise stated)

Parameter	*Contract Document*	*Technical Memorandum*[1]
pH	6-10	6-10
Temperature (°C)	43	43
Total Suspended Solids	100	900
Settleable Solids	N/A	100
COD	600	2,200
Grease and Oil	20	50
Toxic Metals		
(a) Cadmium	0.1	0.1
(b) Mercury	0.05	0.1
(c) Total Chromium	1.0	2.0
(d) Copper	2.0	4.0
(e) Zinc	2.0	4.0
(f) Ni, Ag individually	2.0	3.0
(g) Mn, Sn individually	5.0	2.0
(h) As, Pb individually	2.0	2.0
(i) Ba, B individually	5.0	6.0
Total Toxic Metals	10.0	8.0
Iron	10.0	25.0
Cyanide	0.1	2.0
Sulphate	2,000	1,000
Sulphide (S)	10.0	10.0
Phenols	0.5	1.0
Total Residual Chlorine	1.0	N/A
Total Nitrogen	100.0	200.0
Total Phosphorus	10.0	50.0
Polychlorinated Biphenyls	3.0	N/A
Surfactants	15.0	50.0

Note:(1) Based on a maximum effluent discharge rate of 167.5m^3/day. This flow rate represents a throughput equivalent to 100% of the design capacity.

Source: Contract Document (1990);
Technical Memorandum: Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters. (to WPCO 1990)

TABLE 15

COMPARISON OF CWM[1] LIQUID EFFLUENT TREATMENT PERFORMANCE WITH SELECTED CONTRACT LIMITS

Parameter	*Contract Limits (mg/L)*	*CWM Experience (mg/L)*
Cd	0.1	< 0.28
Cr (T)	1.0	< 0.40-0.53
Cu	2.0	< 0.40-0.77
Fe	10.0	1.96-85.0
Ni	2.0	< 0.40-0.65
Pb	2.0	< 0.04-0.05
Zn	2.0	0.15-5.02
Phenol	0.5	0.06-3.30

Note: (1) CWM: Chemical Waste Management, Inc., a subsidiary of Waste Management Inc.

The Government has recently adopted a range of effluent discharge pollution control limits as specified in the Technical Memorandum to the Water Pollution Control Ordinance (CAP. 358, 5.21) and these are provided in Table 14. These limits apply to the general industry in Hong Kong and in the case of manganese, tin, total toxic metals and sulphate, the limits are stricter than the limits specified for the CWTF in the Contract Document (Table 14). The CWTF may well meet all of the limits nominated in the Technical Memorandum, however, this will largely depend on the characteristics of the wastes requiring treatment.

5.3.2.2 Management and Monitoring

Because of the nature of the facility and uncertainty of the wastes to be treated, a comprehensive environmental management and monitoring programme for final effluent will be implemented. This programme is specified in the Contract and is summarized in Table 16.

TABLE 16

MONITORING PROGRAMME FOR TREATED EFFLUENT

Parameter	*Frequency*
pH	Continuous
Flow rate	Continuous
Temperature	Continuous
Suspended solids	Each Shift[(1)]
Cyanide (CN^-)	Each Shift[(1)]
Metals (Ag, As, Ba, Cd, Cr, Cu, Hg, Pb, Ni, Zn, B, Mn, Fe, Sn)	Each Shift[(1)]
Total Nitrogen (Kjeldahl)	Each Shift[(1)]
Sulphide ($S^{=}$)	Each Shift[(1)]
Sulphate (SO_4)	Each Shift[(1)]
Total Residual Chlorine	Each Shift[(1)]
Phenol	Each Shift[(1)]
Grease and Oil	Each Shift[(1)]
Phosphate	Each Shift[(1)]
Detergents	Each Shift[(1)]
COD (Cr)	Each Shift[(1)]
Polychlorinated biphenyls	Weekly

Notes: (1) The final effluent is sampled automatically each hour and a composite sample is prepared from these hourly samples.

Source: Contract Document (1990), Table SD12(b) and Pending Addenda.

Monitoring will be undertaken on all potentially contaminated liquids leaving the site, including:

- o treatment process effluent discharge to foul sewer;
- o surface runoff from bunded areas; and
- o groundwater discharge from beneath the site.

Each of these discharges will be monitored by regular sampling at or near the site boundary. Groundwater will be sampled by means of bores while surface runoff and discharge to the foul sewer will be monitored by automatic samplers or regular hand sampling (Sections 5.3.4, 5.3.5). Continuous automatic monitoring of pH, temperature and flow rate will be provided in order to give immediate warning of any significant change in the composition of the effluent. Monitoring will occur prior to mixing with sanitary water at the pump station for the foul sewer.

The effluent testing programme assumes that discharges will be produced each day of the year since the Sequential Batch Reactor and PO*WW*ER are continuous processes. Although both will experience shut-down periods it has been assumed that one or the other will be discharging at all times.

The monitoring programme will require comprehensive back-up from the on-site laboratory. Table 17 summarizes the types of instruments that will be used as part of the monitoring programme.

TABLE 17

EXAMPLES OF LABORATORY EQUIPMENT

Equipment Category	*Units Required*
Gas Chromatograph/High Resolution Mass Spectrometer	1
Gas Chromatograph/Mass Spectrometer	1
Inductively Coupled Argon Plasma	2
Graphite Furnace/Atomic Absorption	1
Cold Vapour/Atomic Absorption	1
Ion Chromatograph	1
Total Organic Halogens	1
Total Organic Carbon	1
Analyser, O_2, H_2, N_2, S, C	8
Gas Chromatograph/Electron Capture Detector	2
Ultra-violet/Visible Spectrophotometer	5
Bomb Calorimeter	2
Shaker	24
Distillation/Extraction/Filter/Incubator	25
Digester/Combustor/Wet-oxidator	8
Viscometer	1
Titrator	14

The proposed monitoring programme has been designed to ensure compliance with Government pollution limits and efficient overall plant performance. As stated elsewhere, many of the environmental control limits are very low. Indeed, many are at or below normal detectability limits and are below normal quantification limits (which usually are roughly ten times the detectability limit). In some cases sensitivity can be improved (i.e. detectability and quantification limits lowered). For metals, this can be achieved by concentrating a large volume of liquid sample (e.g. a 10:1 concentration) which will give a 10-fold increase in sensitivity of the test. However, some sampling methods give only low volumes of liquid (i.e. 30mL or so). To reach the control limits specified in Table 14 and quantify the concentration of metals, it would probably require extracting a minimum of one litre of liquid per hourly sample. Enviropace has assumed, based on experience, that only normal volumes of samples will be collected and that the non-detection of a species will be taken as *prima facie* evidence that the environmental control limits have been achieved.

5.3.3 Spills Occurring On-site and at the MARPOL Jetty

5.3.3.1 Impacts

On-site

On-site spills may occur during the handling of waste containers in the reception area, from road tankers during transferring operations, and in the storage tank areas.

Based on the precautionary measures planned, the likelihood of a spillage occurring on-site is considered low. Spills occurring in the bunded processing area will be contained by the structure containment walls, collected in the sump pit and transferred into the storage tank for treatment within the CWTF. As an additional precaution, all areas designated for routine waste handling will be underlain by an impermeable liner to prevent soil and groundwater contamination in the event of a spill.

MARPOL

The volume of MARPOL wastes generated within Hong Kong has been estimated at 5000tpa for Annex I wastes (petroleum-based) and 500tpa for Annex II wastes (noxious liquid bulk substances). These wastes will be transported to the CWTF via the following routes:

- o directly from ships within the Hong Kong harbour area using a CWTF vessel;
- o small local vessels; and
- o company-owned transportation vehicles and third party road vehicles that have previously collected the wastes from local vessels at other land berths. These wastes will be in both packaged and bulk form.

The collection of these wastes by sea will be performed by means of a multiple tank disposal barge with a carrying capacity of approximately 1,000 tonnes. This vessel will be specially designed for the proper handling and collection of MARPOL annex I and II wastes at sea. Enviropace will perform this service by means of the company-owned barge towed by a subcontracted tug boat service.

Assuming an average payload of 40 tonnes in the case of Annex I wastes and 20 tonnes in the case of Annex II wastes, the vessel will be making three or four laden trips per week. Up to three maximum sized barges will be able to unload at the MARPOL jetty at any one time.

In order to comply with the MARPOL Regulations, and to avoid undue delays to ships containing these wastes, ocean-collection services will be designed with sufficient flexibility so as to be ready to react to emergency calls and to waste surge situations.

There is the potential for three kinds of spillages:

- upon disconnecting the pipeline from the manifold to the jetty;
- rupture of the flexible pipe; and
- collision between the barge and another vessel or the jetty.

Of the three possibilities, the highest potential for a spill would occur as the pipeline is disconnected from the manifold to the jetty. Several design procedures will largely eliminate the prospects of a spill. Once the valve is closed, nitrogen gas will be introduced into the tank to blow any remaining materials into and through the line. Therefore, when decoupling occurs, the lines will be clear of any residual oil. As an extra precaution, a sump will be installed under the manifold to contain any spillage, drips or residue that may inadvertently flow from the line.

Rupture of the flexible pipe linking the barge with the storage tank has a low probability of occurrence, since stringent supervision and maintenance will be provided. In the unlikely event of a spillage the Emergency Response Plan would be activated. This Plan will make provisions for deploying booms to contain the spread of the spillage and skimmers to recover the wastes. The recovered waste would then be processed at the CWTF.

A more unlikely cause of a spillage might be a collision between a laden MARPOL barge and the jetty or another vessel. As noted above, the maximum carrying capacity of the MARPOL barge is 1,000 tonnes. This is many times larger than the average payload which will approximate 40 tonnes for Annex I wastes and 20 tonnes for Annex II wastes. The additional design capacity has been requested in the Contracts to deal with waste surge situations that may require a vastly increased storage capability. In practical terms, however, it can be assumed that if an accident involving a MARPOL barge were to occur, the maximum likely spillage would be 20-40 tonnes.

The environmental effects of a spillage of this size would largely depend upon the chemical nature of the waste and the location of the incident. The light fractions of the Annex I petroleum wastes would quickly evaporate and photo-oxidise, whilst the heavier fractions could cause localised damage to the environment if not quickly contained. Most of the damage would be of a physical nature (e.g. fouling of shipping and near-by coastal facilities): however, if the spill were to impact the shoreline, some impact on sediment chemistry and marine biota could be expected. Given the generally small volumes that would be involved, it is unlikely that the long term environmental impact of a single incident would be significant. Again, this would depend on the location of the incident. In the event of an accident, the Emergency Response Plan would ensure that containment booms, skimmers and dispersants were quickly deployed where appropriate, in order to minimize the effects of a spill. Skimmers are often used in preference to dispersants: however, the latter will be available for use under special circumstances, as defined in the Plan. Any recovered oil will be processed at the CWTF.

5.3.3.2 Management and Monitoring

The Emergency Response Plan will be a normal part of the plant operation manuals and will ensure that, in the event of an accident, the detrimental effects can be minimised. As was the case for on-site spills, an ongoing management and monitoring programme is not envisaged, partly because any such incident has a low probability of occurrence and would only occur as an isolated event, and partly because there would be little benefit in periodically collecting baseline water quality data for any post-spill comparison. This is because the affects of an isolated spill on water quality could only be observable over the short-term and would have little to no long-term environmental implications on water quality. If the CWTF jetty were located in shallow water, it would be desirable to periodically sample the marine sediments since frequent spills could lead to an accumulation of pollutants in the benthos. But again, low probability of such an event, together with the depth of water offshore from the facility, eliminate the effectiveness of an ongoing monitoring programme. Since the coastal wastes have been polluted by multiple sources for such a long time, it would not be possible to deduce that a measurement of contamination actually derived from an identifiable source.

As described above, the potentially more environmentally damaging event would involve a spillage at the MARPOL jetty since containment and clean-up is more difficult on water than on land. However, it is worth noting that, in a general environmental sense, the proposal to collect and treat the MARPOL waste offers considerable benefits over the traditional practice of direct discharge to the sea. The operating procedures have been designed to minimise the risk of spillage but such a risk can not be completely eliminated. Enviropace has adopted a rigorous management policy to minimise the risk of an accident and to ensure that a comprehensive contingency plan and education programme is prepared and constantly updated.

It is also envisaged that Enviropace, in conjunction with EPD and Port Authorities, will develop a MARPOL Waste Disposal and Tracking System to track waste from the ship (recorded in the Oil Record Book and Cargo Record Book) to the CWTF, for the proper disposal of the waste. The Hong Kong Government will enforce this system.

The procedures for handling MARPOL wastes will be similar to those for other containerised wastes with the exception of the pre-acceptance sampling procedure. Instead, samples will be taken and analysed upon arrival at the site. Treatment will be based upon this sample and waste will be transferred to the proper storage tanks. Advance bar coding will not be possible as Enviropace is not contracted to provide containers for MARPOL wastes.

Both the Enviropace vessel and the CWTF will be fitted with standard discharge connections according to MARPOL convention regulations. All safety and emergency equipment, as specified in the Contract, will be fitted. Vessels carrying MARPOL wastes will also comply with the requirements of the Dangerous Goods Ordinance, CAP 295.

5.3.4 Site Runoff

5.3.4.1 Impacts

Some of the facilities at the site will be roofed to enable the waste treatment operations to proceed uninterrupted by wet weather. This includes the waste handling areas.

Bulk tank areas will not be covered but they will be bunded to prevent direct runoff into the sea. Run-off from the reception areas will be collected via a sump/reception tank. There will be short-term storage capacity for runoff from both of these areas, so that water can be tested for contamination. After potentially contaminated surfaces have been washed clean, direct discharge to the sea will be allowed.

In addition, it is planned to temporarily contain runoff from process and storage areas until analyzed and deemed non-contaminated.

Contaminated runoff will be returned for onsite treatment whereas runoff which is judged to be non-contaminated (i.e. below environmental effluent control limits) will be discharged directly into the sea, after passing through a collection facility (e.g. sump) that will catch physical objects such as floatable substances, solids larger than 10mm, refuse, etc.

The overall effect of these runoff control measures will be to ensure that runoff from the site poses no significant environmental hazard.

5.3.4.2 Management and Monitoring

Because site run-off is unlikely to lead to any significant impacts, the management and monitoring will essentially involve an observation and drainage maintenance programme, detailed in the CWTF engineering design. This programme will include provision for on-site sampling and analysis for contamination. The principal objective will be to ensure that the bunds and collection facilities described above are operating during wet weather and are capable of impounding large volumes of runoff that could result during a fire fighting emergency.

5.3.5 On-site Soil and Groundwater

5.3.5.1 Impacts

A description of the physical nature of the site has been given in Section 3.2. It is clear from this description and available geotechnical bore logs that the sub-surface soils are permeable and highly variable in composition. This variability is to be expected given that the site is comprised of heterogeneous fill transported to the site during the construction of Tsing Yi Road.

The potential for soil and groundwater contamination to occur as a result of the operation of the CWTF has been recognised and taken into account during the preliminary design stages of the Contract Offer. All areas within the site used for chemical storage or handling will be bunded and underlain by an impermeable lining.

Seepage beyond impermeable liners is always a theoretical possibility and could lead to soil and groundwater contamination. The significance of this impact would depend upon the chemical nature of the material, the size of the spill/leakage, the frequency of occurrence, and the permeability of the subsurface.

Infrequent small spills would be contained and cleaned up before the likelihood of significant impact. A number of small spills over a long period of time could potentially result in a more significant impact if they were not cleaned up each time. If necessary, any contaminated soil could be remediated before the effects of chronic pollution were allowed to take place. Large spills occurring on-site would most likely be isolated events and would generally be contained and rapidly cleaned up. Since leakage could, in principle, result in groundwater contamination, the groundwater will be monitored using the procedures described in Section 5.3.5.2.

In order to monitor all possible effects, it would be necessary to determine the amount of soil and groundwater contamination which has resulted from activities occurring outside the CWTF site. Adjacent industries are:

- o Dow Chemical Plant, which manufactures polystyrene;
- o TCVT Chemical Plant, which produces monosodium glutamate;

- o CRC Oil Terminal, which is used for the storage of LPG and petroleum products; and
- o Esso Petroleum Products Terminal, which stores petroleum products.

The principal type of contaminants that could have migrated from these areas to underlie the CWTF site are hydrocarbon products. If present in significant quantifies, some chemicals would represent a potential risk to the construction workers and site personnel.

5.3.5.2 Management and Monitoring

An Emergency Response Plan will be prepared to deal with on-site and MARPOL spills. The Plan will ensure that there is a rapid response to any accident, both from the point of view of worker safety and in order to minimise the effects of seepage to the groundwater or contamination of the marine environment.

Five groundwater monitoring bores will be installed around the site. These bores will be initially used to extract soil and groundwater samples to determine baseline conditions. Subsequently, they will form part of an ongoing monitoring programme.

The bores will be constructed in conformance with the American Society of Testing Methods (ASTM). Two inch threaded PVC pipe will be used and drilling rods and equipment will be steam cleaned between boreholes to ensure that no cross-contamination occurs. Each bore will be logged, as will in-situ permeability tests. Dedicated sampling equipment will be used such as the QED Well Wizard PVC bladder pump. This will provide the most representative samples from groundwater and will eliminate cross-contamination between boreholes using bailers or non-dedicated pumps. In-line filters will also be used when sampling for metals and inorganics.

The parameters recommended for soil and groundwater monitoring, and the analytical sampling and analysis methods are presented in Table 18. Volatile organic compounds (VOCs) which include chlorinated solvents and indicators of residual chlorine (i.e. chloroform, bromoform, etc.) will be monitored as will other non-chlorinated solvents which may provide an indication of contamination originating from adjacent sites. The other parameters that will be monitored include metals, polychlorinated biphenyls, cyanide, phenol and grease and oil. Five soil samples will also be analysed for the same parameters. The groundwater will be sampled quarterly.

Dames and Moore recommends that EPD establish two additional boreholes and wells upgradient from the site boundary. This recommendation is based on the premise that the groundwater might follow the general topography and discharge towards the ocean. The boreholes should be located to provide data on potential impacts from adjacent commercial and industrial facilities and the rates of groundwater flow.

TABLE 18

SOIL AND GROUNDWATER MONITORING PROGRAMME

Parameter	*Sampling Method*	*Analytical Method (USEPA Reference)*
Volatile Organic Compounds[1]	Bladder Pump	8240 - GC/MS Purge and Trap
Metals: Ag, As, Ba, Cd, Cr, Cu, Pb, Pb, Ni, Zn, B, Mn, Fe, Sn	Bladder Pump with in-line filtration	200.7/6010 ICP
Mercury (Hg)		245.2/7471 Cold vapour AA/ICP-Hydride
Cyanide (total)	Bladder Pump	335.3
PCB	Bladder Pump	8080 - GC/ECD
Phenol (Total)	Bladder Pump	420.2/9066
Oil and Grease	Bladder Pump	413.2

Notes: (1) Includes both chlorinated solvents and constituents of chlorine residual.

The baseline soil and groundwater programme will be implemented before the commencement of excavations. It is intended to be an investigative study and not a detailed environmental audit. If significant contamination is found EPD may consider initiating an audit comprising the following elements:

- review of adjacent land uses to identify contaminants which may have been transported to the site by groundwater movements;
- drilling and sampling six to eight boreholes around the perimeter of the site to obtain soil and groundwater samples for subsequent laboratory chemical analysis;

- o installation of three permanent groundwater monitoring bores;
- o laboratory analysis of groundwater and soil samples in order to establish background data and assess existing contaminant levels;
- o evaluation of contaminant levels, if any, in terms of available acceptance criteria and, as appropriate, potential health hazards; and
- o reporting of the results of the field and laboratory investigations, and the results of the contamination assessment, to the EPD.

The potential contaminants, and corresponding sampling and laboratory testing requirements are described in Appendix D.

If EPD considers that more detailed studies are warranted, then the field and laboratory work should be undertaken in accordance with a "Health and Safety Plan" and specific operating procedures.

The Health and Safety Plan should be prepared for the fieldwork and set out details of the health and safety requirements and procedures including details of the following aspects:

- o material safety data sheets on potential contaminants;
- o levels of protective clothing required;
- o designation of work areas;
- o decontamination procedures; and
- o emergency procedures.

The general standard operation procedure requires a methodical approach and rigorous Quality Assurance/Quality Control. Details of recommended specifications are presented in Appendix D.

The timing implications for the successful completion of the Health and Safety Plan and Environmental Audit, if required, should be considered in terms of the overall timing of the project, particularly since both exercises should be completed before the commencement of excavation.

5.4 SOLID WASTE DISPOSAL

5.4.1 Impacts

The following solid residues and maximum quantities will be processed by the CWTF:

- incinerator bottom ash (4,000tpa);
- filter cake, metal treatment (3000tpa);
- biotreatment sludge (100tpa);
- PO*WW*ER brines (6,000tpa);
- filter cake, neutralization (6,000tpa); and
- spray dryer solids/fly ash (6,000tpa).

The residues originating from the different plant processes described above will be chemically stabilised within the CWTF (Figure 3) prior to laboratory testing, shipment and disposal.

The laboratory testing is required in order to determine whether the specifications given in the Government Waste Disposal Ordinance CAP 345 and the pollution control limits (Table 19) are met. It is only after the compliance is confirmed, that approval to transport and dispose will be given.

TABLE 19

STABILIZED RESIDUES POLLUTION CONTROL LIMITS

(Figures shown are upper limits unless specified otherwise)

	Pollutant Parameters	*Pollution Control Limit*
(A)	For all stabilized residues*	
	pH	8-10.5
	Toxic Metals:Cd	0.5ppm
	Hg	0.1ppm
	Cr (total)	10ppm
	Total Cu, Ni, Pb, Zn	25ppm
	Fe	20ppm
	Sulphide (S")[1]	10ppm
	Ammoniacal Nitrogen [1]	10ppm
	Cyanide (CN)[1]	5ppm
	C.O.D. (Cr)[1]	1000ppm
	Total Organic Carbon[2]	1ppb
(B)	The stabilized incineration residue itself	
	Total unburnt hydrocarbon (i.e. volatile organic content)	0.5% by weight
	Total organo chlorine	10ppm
	Total chloro phenols	2ppm
	Polychlorinated biphenyls	1ppm
	TCDD equivalent (ITEF method)	1ppb

Note: * These limits apply to the leachate from the residues produced in the USEPA Extraction Procedure Toxicity Test.

1 For Stabilized Chemical Treatment Residues

2 For Stabilized Incinerator Residues

Solid residues produced by the CWTF will not consistently meet the off-site pollution control limits without further treatment. One reason for this is that, in Enviropace's experience, conventional waste processing equipment can, paradoxically, produce higher quality results if non-optimal operational procedures are adopted. The filtration process is one example. Conventionally, filters are run to dewater the solids to the maximum possible extent, giving a solid-appearing filter cake and a liquid filtrate. However, for effective stabilisation, it may be better to leave a substantial portion of the liquid with the solid because a slurry stabilises more quickly and completely than a compacted solid. The PO*WW*ER process operates satisfactorily on aqueous streams containing high concentrations of suspended solids. Clean separation of solids and liquids prior to PO*WW*ER treatment or stabilisation is not necessary and may be even more costly.

The further treatment process advocated by Enviropace would involve stabilisation using a cement/ash mixture or one of a number of chemical reagents depending upon the chemistry of the residue. Following stabilisation, a solid is formed which is environmentally benign and safe for disposal.

The environmental effects of this disposal method are therefore minimised. Furthermore, the quantities of waste produced (about 150 tonnes per day) will not greatly affect the disposal capacity of the planned disposal sites.

5.4.2 Management and Monitoring

The management and monitoring of the solid wastes produced by the CWTF will involve a sampling and analysis procedure performed on stabilisation process residue.

Incinerator ash, filter cakes, and filtrates will require additional treatment to meet the criteria of the Government's pollution control limits (Table 19). Although the treatment steps were not specified in the Contract, the Tender Offer includes the PO*WW*ER system and stabilisation. Thus, the effluent discharge (which must meet Government specifications) will be a combination of the Sequential Batch Reactor effluent and the distillate from PO*WW*ER that is not consumed on-site for other purposes. Similarly, the solid residues will consist of stabilised incinerator residues, which must meet the requirements of Table 19, and stabilised chemical treatment residues. Table 20 outlines these testing and sampling plans.

5.5 NOISE

5.5.1 Impacts

Noise impact is best considered in terms of construction and operation activities. Construction activities will generate an increase in traffic along the Tsing Yi Road and of this, about 50% of the construction vehicles will consist of heavy vehicles delivering materials and plant components to the site. It is predicted that the effect of this traffic on the noise environment will be insignificant because of the general heavy vehicle activity currently occurring along Tsing Yi Road and the roundabouts located north of the site (Section 5.6.5).

On-site construction activity will be controlled by the Noise Control Ordinance CAP 400 and the associated limits (Table 21). If excessively noisy construction activity is necessary, the contractors will attempt to schedule the activity during working hours, when background noise levels are highest. If it is necessary to carry out construction work during night time, weekends or on public holidays, the contractor will request a permit as required under the Noise Control Ordinance.

The Noise Control Ordinance will also apply to noise levels generated during the operation of the plant and consequently, all plant items will be designed to conform to the limits contained therein. The major source of noise during operation is expected to be from the induced draft fan of the incinerator. However, proper fan motor design or housing, and the large stack height and diameter, will reduce this noise to levels within those defined in the Ordinance. Isolated activities may cause short-term noise emissions that will require careful attention. For example, it is expected that the crusher will be noisy when crushing hard aggregates such as slag, refractory brick or large metallic objects contained in the bottom ash. However, on average, the crusher will only operate 30-45 minutes a day and it will therefore be possible to schedule these potentially noisy activities to a time during the day when background noise levels are high and when least inconvenient to potentially sensitive receptors.

TABLE 20

ANNUAL WASTE STREAM SAMPLES (ENVIRONMENTAL)

Parameter/Type	*Incinerator Stack*	*Groundwater*	*Water Effluent*	*Stabilised Incinerator Residue*	*Stabilised Treatment Residue*
Sampling Events	50	20	1,095	716	1,522
Fingerprint (REC)	N/A	N/A	N/A	N/A	N/A
MAIN LABORATORY					
Fingerprint (PRE)	N/A	N/A	N/A	N/A	N/A
pH				716	1,522
Acid/Alkali					
Cyanide		20	1,095		1,522
Res. Chromium			1,095		1,522
Oil Content					
Oxygen					
Hydrogen					
Nitrogen					
Sulphur					
Carbon					
PCBs		20	50	716	
Suspended Solids			1,095		
Hg	50	20	1,095	716	1,522
As	50	20	1,095		
Cd,Cr,Cu,Ni,Zn,Pb,Sb,Sn	50	40	2,190	716	1,522
Fe			1,095	716	1,522
Total N (Kjeldahl)			1,095		
Ammonia as N					1,522
Sulphide			1,095		1,522
Sulphate			1,095		
BOD					
COD			1,095		1,522
Total Organic Carbon			1,095	716	
Res. Chlorine			1,095		
Phenols		20	1,095		
Grease and Oil		20	1,095		
Phosphate			1,095		
Detergents			1,095		
Total Organic Content				716	
Total Organic Chlorine				716	
Total Chloro Phenols				716	
TCDD/PCDD/PCDF	12			716	
Particulates	50				
Chloro Compounds as Cl	50				
Fluoro Compounds as HF	50				
H_2S	50				
Acid as H_2SO_4	50				
SO_2	350				
HF	12				
HCl	350				
HBr	12				
Total Phosphorus	12				
Total NO_x as NO_2	350				
USEPA E.P. Tox Test				716	1,522

These observations, together with the findings of the ERL preliminary environmental review (ERL, 1987), suggest that noise from the CWTF is unlikely to cause any concern to the nearest residential developments of Mayfair Garden and Cheung Ching Estate, or to the proposed Technical Institute.

5.5.2 Management and Monitoring

Noise levels will be monitored in accordance with the specifications of the Noise Control Ordinance, as detailed in Table 21. Operations have been designed specifically to meet these requirements.

TABLE 21

NOISE POLLUTION CONTROL LIMITS

Pollutant Parameter	*Pollution Control Limit*	*Reference Source and Comments*
Operational Noise	The Corrected Noise Levels (CNL)* for the operations on the CWTF at the nearest Noise Sensitive Receiver (NSR)* shall not exceed either the Acceptable Noise Level (ANL)* or the prevailing background (L_{90})* without the contribution from the CWTF itself, whichever is the lower. The definitions of the terms marked "*" shall be determined according to the "Technical Memorandum for the Assessment of Noise from places other than Construction Sites, Domestic Premises or Public Places" and general acoustic principles.	Noise Control Ordinance (CAP 400), Technical Memorandum for the assessment of noise from places other than construction sites, domestic premises or public places (March, 1987).

Source: Contract Document (1990), Table SC34(a).

5.6 ROAD TRAFFIC

5.6.1 Introduction

A traffic study on the effects of transportation of chemical wastes associated with the CWTF site was carried out by Wilbur Smith & Associates. The objectives of the study were:

- to estimate future traffic volumes and conditions that would occur through natural growth (without the development of the CWTF site);
- to estimate site traffic generated during the construction and operational phases of the project;
- to assess the impact of the facility on traffic patterns at Tsing Yi North Bridge (Tsing Tsuen Bridge) and Tsing Yi South Bridge; and
- to provide recommendations for management of traffic (where necessary) based on the findings of the study.

The following sections summarise the methodology, results and recommendations of the study.

5.6.2 Designated Chemical Waste Transport Routes

Chemical wastes will be transported to the CWTF site by road from numerous locations in the Territory and treated waste will be trucked to a landfill site in Junk Bay (Tsueng Kwan O). Figures 1 and 2 show the general locality plan of the site. Due to the potentially dangerous nature of the cargo, routes for the transport of chemical waste through the Territory were outlined in the Contract. These designated routes are devised to avoid travel through all tunnels. The option of transporting non-MARPOL wastes by sea has been discounted due to loading/unloading safety and spill control concerns.

Upon leaving the site, all empty waste transport vehicles will travel north on Tsing Yi Road and then proceed east on the Tsing Yi South Bridge. Traffic management plans dictate that waste transport vehicles proceed south on Route 2 for distribution to Kowloon, Hong Kong Island, Tai Po and Junk Bay.

Recent improvements to the road network system serving Tsing Yi Island include the four-lane Tsing Yi North Bridge linking the island to Tsuen Wan. Internal circulation within Tsing Yi Island has also been refined by the completion of the section of Tsing Yi Road between Nam Wan and Fung Shue Wo Road in northeast Tsing Yi. These improvements offer additional vehicular capacity and provide alternatives to the designated routes for non-waste vehicles.

5.6.3 Future Development of Southeast Tsing Yi

Future development of southeast Tsing Yi potentially includes plans for numerous road facilities and improvements, including:

- reclamation of land from the Rambler Channel for a container terminal and associated infrastructure, including the construction of another bridge alongside the existing Tsing Yi South Bridge;
- reconstruction of the roundabout at the western end of the Tsing Yi South Bridge and provision of slip roads for major traffic movements;
- removal of the current restrictions on turning at the roundabout; and
- improvements to several junctions at the eastern end of the bridge.

It is anticipated that these improvements would improve traffic conditions in the area. However, the timing for these proposals is the mid-1990s, later than the estimated timing for construction and commissioning of the CWTF site. As a result, estimates of 1992 road conditions are based on relatively small adjustments to existing conditions. The estimates presented below therefore represent a worst case, temporary situation that will prevail until improvements are completed.

5.6.4 Existing Road Network

In the vicinity of the CWTF site, Tsing Yi Road has a 16m cross section carriageway with two lanes in each direction and a 2m median reserve with a barrier. The curb lanes in both directions are generally occupied throughout the day by goods vehicles which are either parked or queuing to enter nearby facilities.

Existing traffic control regulations are as follows:

- o southbound movements through the roundabout are banned. Vehicles travelling south of Tsing Yi Heung Sze Wui Road must turn left onto the Tsing Yi South Bridge eastbound;
- o turning onto the Tsing Yi South Bridge by northbound traffic on Tsing Yi Road is restricted between 7.00am and 7.00pm, Monday to Saturday. Permission to turn is restricted to buses, minibuses, emergency vehicles and vehicles with special permits. Other vehicles must proceed north on Tsing Yi Heung Sze Wui Road and use the roundabout at Fung Shue Wo Road to reverse direction; and
- o turning by westbound vehicles on the bridge to the north on Tsing Yi Heung Sze Wui Road is similarly restricted.

5.6.5 <u>Survey of Existing Traffic</u>

A traffic survey was conducted on Tuesday, 18 December 1990 to sample existing traffic volumes and confirm peak hours for road traffic. It was not possible to conduct a detailed traffic analysis for this EIA, however a comprehensive study is presently being conducted as part of the CT9 investigation. Preliminary results from this detailed study have been used to assist in the interpretation of the data generated during the recent survey described above.

Two locations were surveyed:

- o Tsing Yi Road adjacent to the site; and
- o Tsing Yi South Bridge, including the western end of the Tsing Yi Road roundabout.

The bridge, which is a critical link for traffic from the facility, is already experiencing traffic congestion during peak hours.

The survey showed that peak hours were as follows:

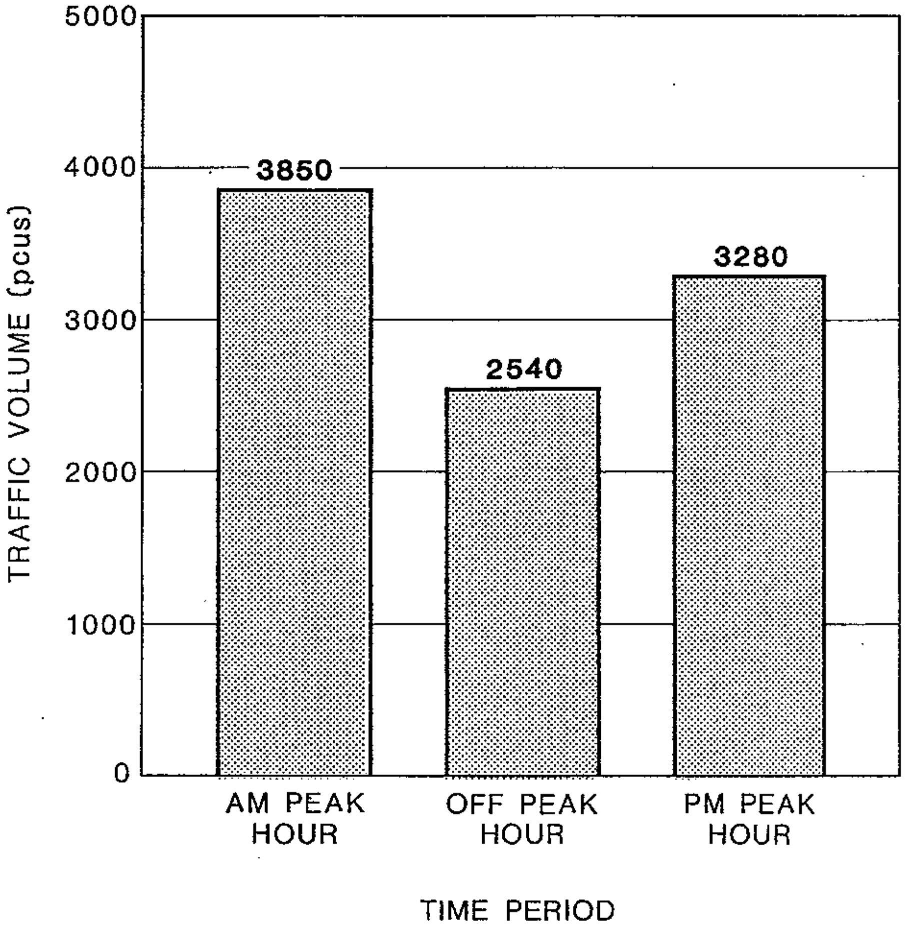
o	Tsing Yi Road	7.45-8.45am	2.45-3.45pm
o	Tsing Yi South Bridge	7.30-8.30am	4.15-5.15pm

Peak hour traffic volumes and distribution by vehicle type are summarised in Table 22. Traffic volumes are presented in passenger car units, a standardised parameter used in traffic engineering capacity calculations. Vehicles are converted to passenger car units by applying factors which represent their physical impact on the available road capacity.

The morning peak is the busiest period of the day as shown in Table 22 and illustrated on Figure 11. The off-peak hour flow (the highest observed one hour during the off-peak period) occurred between 11.45am and 12.45pm. Goods vehicles are the largest component of traffic at the site. It should be noted that data collected in short-period traffic studies such as this type are subject to variability of up to 30%. The trends would, however, remain the same and for the purpose of this report, such variation is considered acceptable.

No traffic problems were observed on Tsing Yi Road during the hours surveyed. Traffic volumes observed were accommodated by the single available lane (the curb lane being occupied by parked vehicles and vehicles queuing to enter nearby facilities).

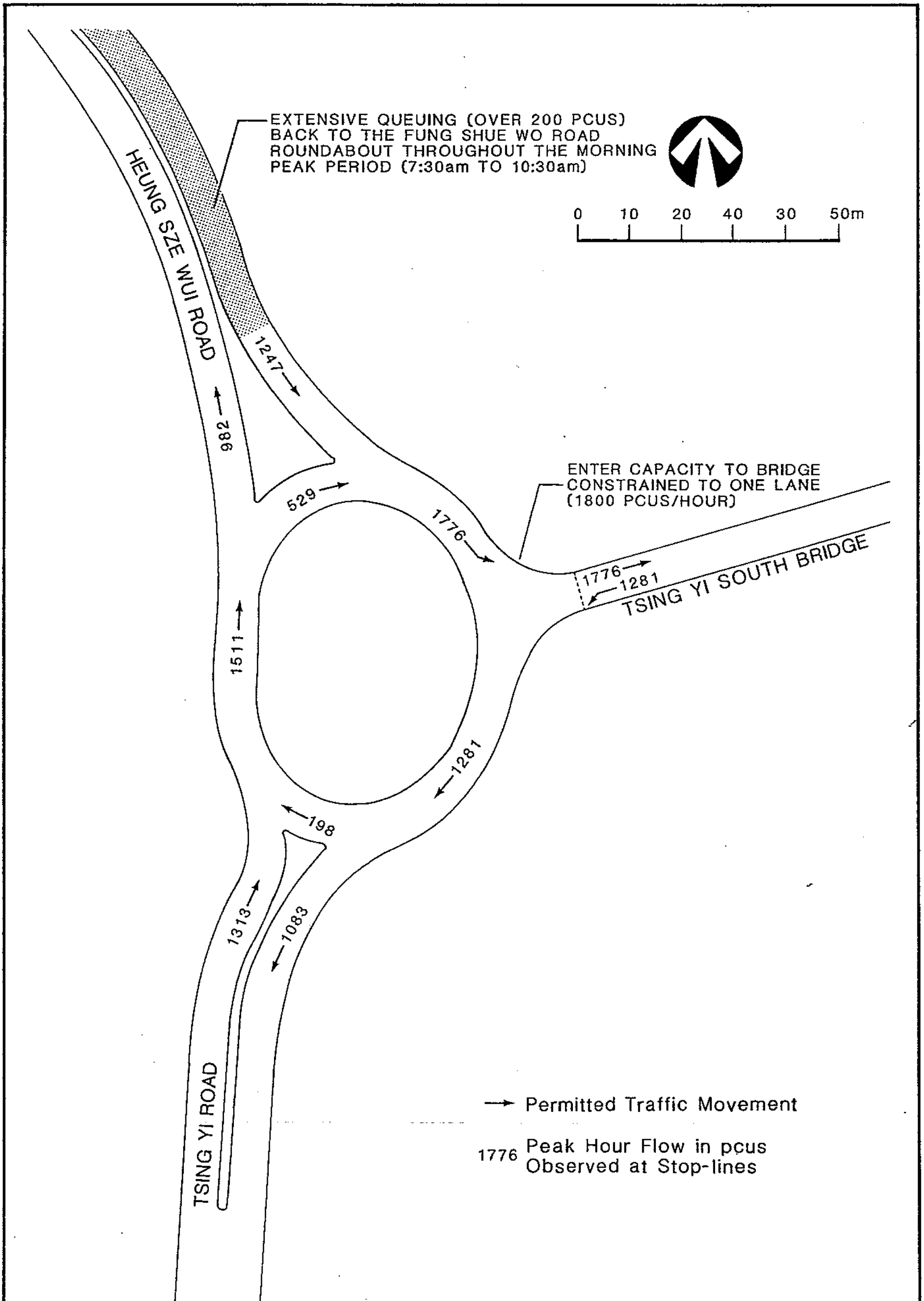
Substantial queues of vehicles were observed on the southbound approach to the roundabout on Tsing Yi Heung Sze Wui Road. Figure 12 illustrates the morning peak flows and the area where extensive queuing was observed. This was primarily caused by congestion at the Kwai Tsing Road/Tsuen Wan Road roundabout on the eastern side of the bridge which forced eastbound traffic to queue on the Tsing Yi South Bridge. The queue extended for the entire length of the bridge and delayed southbound traffic on the Heung Sze Wui Road arm of the roundabout. A secondary constraint occurs as a result of dual carriageway traffic southbound on Heung Sze Wui Road merging into the single eastbound carriageway on Tsing Yi South Bridge.



SOURCE: WSA TRAFFIC SURVEY, DECEMBER 18, 1990

PEAK HOUR TRAFFIC THROUGH TSING YI SOUTH BRIDGE ROUNDABOUT

FIGURE 11
DAMES & MOORE



1990 MORNING PEAK TRAFFIC FLOWS
TSING YI SOUTH BRIDGE ROUNDABOUT

FIGURE 12
DAMES & MOORE

pcus
passenger car units ?

TABLE 22

LOCAL TRAFFIC FLOWS
(Two Way Peak Hour Traffic and Distribution by Vehicle Type)

Location	*Peak*	*Car/Taxi/Van*	*PLB[1]*	*Light Goods Vehicle*	*Heavy Goods Vehicle[2]*	*Bus/Coach*	*Total Vehicles*	*Total pcus*	*% Heavy Vehicles[3]*
Tsing Yi Road (at the site)	am	124	48	77	129	35	413	758	39.7
	pm	82	17	101	116	4	320	586	37.5
Tsing Yi South Bridge (roundabout)	am	1,076	115	338	408	327	2,264	3,841	32.5
	pm	948	104	312	401	209	1,974	3,280	30.9

PERCENTAGE DISTRIBUTION BY VEHICLE TYPE

Location	*Peak*	*Car/Taxi/Van*	*PLB*	*Light Goods Vehicle*	*Heavy Goods Vehicle[1]*	*Bus/Coach*	*Total Vehicles*
Tsing Yi Road (at the site)	am	30.0	11.6	18.7	31.2	8.5	100.0
	pm	25.6	5.9	31.6	26.2	1.3	100.0
Tsing Yi South Bridge	am	47.6	5.1	14.9	18.0	14.9	100.0
(roundabout)							
	pm	48.0	5.3	15.8	20.3	10.6	100.0

<u>Notes</u>:
(1) Public Light Bus.
(2) Vehicles with four or more axles, including container trucks.
(3) Includes heavy goods vehicles and buses/coaches.

These conditions combined to create an observed average delay for southbound vehicles on Tsing Yi Heung Sze Wui Road queuing to enter the roundabout of at least 5.3 minutes per vehicle during the morning peak hour. The range of average delay per vehicle during the 7.30-10.30am time period on the survey data is illustrated on Figure 13. No queues or delays were observed at the other approaches to the roundabout in the morning peak.

Queuing was not observed to be a problem during the afternoon or off-peak periods. Queues forming at Tsing Yi Heung Sze Wui Road in the afternoon peak hour were slight, amounting to an average delay per vehicle of 0.09 minutes. These queues were a result of traffic merging into one carriageway at the entrance to the Tsing Yi South Bridge or temporary reductions in traffic speed due to heavy goods vehicles negotiating the turn onto the Bridge from the roundabout.

The existing queues and delays observed at the roundabout were extensive and, by general traffic engineering standards, unacceptable. It should be understood that the delays result from congestion elsewhere in the corridor and that improvements to the key junctions are proposed as part of the SETY development (Section 5.6.3). It might be worthwhile to consider night-time and Sunday collection for the CWTF to avoid traffic delays and thus higher probability of collision.

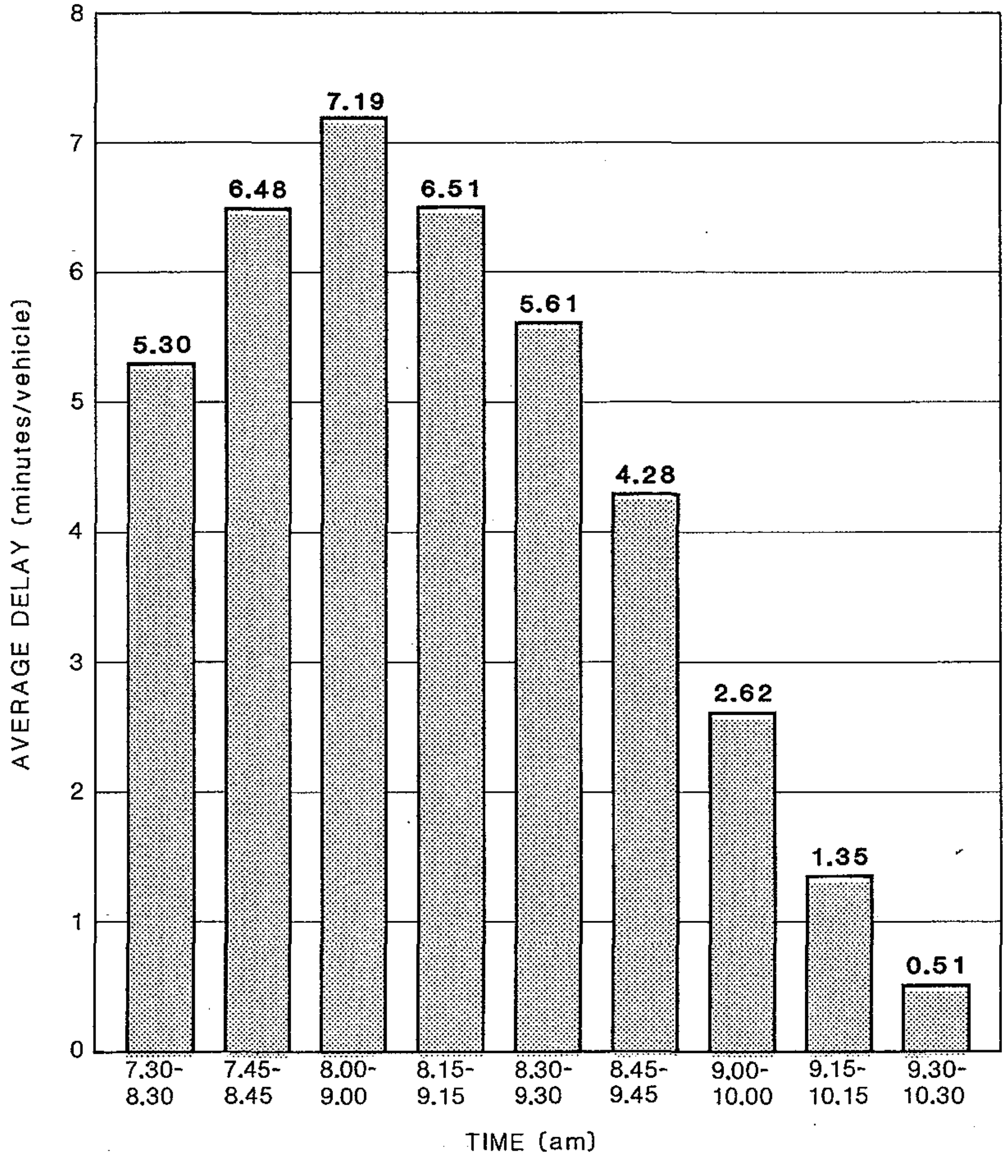
5.6.6 Estimation of Construction Traffic

Gammon Construction, which is responsible for civil and foundation project design, has provided estimates of the number of daily construction vehicles entering and exiting the site during the busiest period of construction activity. These estimates are based on past experience of similar projects and are as follows:

- Car/Van - 15
- Light Truck - 15
- Heavy Truck - 35

Heavy trucks are defined to include concrete mixers and transport/container trailers. For purposes of analysing the impacts of construction traffic, the following assumptions have been made:

- the majority of site construction traffic is most likely to occur during the morning and afternoon peak hours;



SOURCE: WSA TRAFFIC SURVEY

AVERAGE DELAY AT ENTRY TO TSING YI SOUTH BRIDGE ROUNDABOUT AT TSING YI HEUNG SZE WUI ROAD

FIGURE 13
DAMES & MOORE

- o all the cars/vans will enter/exit the site during peak hours;
- o approximately 40-45% of light and heavy trucks will enter/exit the site during peak hours. Construction vehicles are assumed to lie idle overnight at contractor sites remote from the facility; and
- o the predominant construction traffic flow during the morning peak period will be south on Tsing Yi Road to the site, with a much smaller flow turning right (north) onto Tsing Yi Road from the site. These flows will be approximately reversed during the afternoon peak period. Little traffic is expected to approach or leave the site along Tsing Yi Road South.

The number of construction vehicle trips predicted for the morning and afternoon peak hours at the Tsing Yi South Bridge roundabout is shown in Table 23.

TABLE 23

PEAK HOUR TRIP GENERATION DURING CONSTRUCTION PERIOD

Vehicle Type	*Morning Peak*		*Afternoon Peak*	
	Outbound	*Inbound*	*Outbound*	*Inbound*
Car/Van	2	13	13	2
Light Truck	1	3	3	1
Heavy Truck	0	7	7	0
Total	**3**	**23**	**23**	**3**

Source: Gammon Construction

5.6.7 Estimation of Operation Traffic

Due to the potentially dangerous nature of the cargo, operations traffic will travel along designated routes outlined in the Contract as discussed in Section 5.6.2.

The number of vehicles travelling to and from the site following commissioning is dependent upon several factors including the phased expansion of the CWTF and the outcome of a number of projects proposed for Southeast Tsing Yi Island (Section 5.6.3). It is anticipated that a fleet of approximately

60 vehicles will accommodate daily waste collection and transport requirements. The fleet vehicle types and approximate numbers are as follows:

o	Bulk Liquid Tanker	-	5
o	Flat Bed Truck	-	27
o	Light Goods Vehicle	-	27
o	Skip Lugger Vehicle	-	2

The operation plan for these transport vehicles assumes that the bulk liquid tankers and skip luggers will each make three trips in and out of the site per day. The flat bed trucks and light goods vehicles will leave the site in the morning to service their scheduled collection points before returning with full loads later in the day. The design and operations of the CWTF was based on collection services restricted to the hours of 7.00am and 7.00pm, 300 days per year.

For purposes of analysis of future site traffic, the following assumptions apply:

- the major generation of site traffic is most likely to occur within the first hour of daily operation (7.00 to 8.00am);
- approximately 50% of the service fleet will not exit the site before 7.30am; and
- seasonal variations in operations and related traffic will not be significant.

The number of vehicle trips generated by the site during the morning peak hour at the Tsing Yi South Bridge roundabout is shown in Table 24. The afternoon peak-hour trip generation estimates are also displayed for comparative purposes. For the purposes of traffic analysis, it was assumed that the flat bed and light goods vehicles which had exited the site in the morning peak hour will return to the facility during the afternoon peak hour. However, the tankers and skip luggers are expected to exit the facility during the afternoon peak hour for a third collection trip each day. The site-generated traffic during the peak hour is limited mainly to service vehicles and visitor trips.

TABLE 24

PEAK HOUR TRIP GENERATION DURING OPERATION PERIOD

	Morning Peak		*Afternoon Peak*	
Vehicle Type	*Outbound*	*Inbound*	*Outbound*	*Inbound*
CWTF Fleet				
Bulk Liquid Tanker	3	0	3	0
Flat Bed	15	0	0	15
Light Goods Vehicle	15	0	0	15
Skip Lugger	2	0	2	0
SUBTOTAL	35	0	5	30
Other				
Car/Taxi	0	10	7	3
TOTAL	**35**	**10**	**12**	**33**

5.6.8 Impact on Road Network

5.6.8.1 Methodology

The assessment of potential impacts on the principal roads on eastern Tsing Yi Island, as well as the Tsing Yi South Bridge assumes that no major highway improvements will be completed within the study area by the end of 1992. The methodology for analysis of future traffic volumes on the Tsing Yi Road involves summing the projected site traffic (Sections 5.6.6 and 5.6.7) with the predicted background traffic and identifying 1992 volumes at principal locations within the study area. For the Tsing Yi South Bridge roundabout, the projected traffic flows were analysed according to the U.K. Transport and Road Research Laboratory's computer program ARCADY2 which is recognised as the standard method for roundabouts. Existing traffic volumes have been assumed to increase by an average rate of 7% per year accounting for a 3% annual growth in background traffic and an approximate 4% annual traffic growth resulting from new development in the study area.

5.6.8.2 Construction Impacts

In order to determine potential impacts resulting from site construction traffic, estimated construction traffic has been added to predicted 1992 background traffic. The resulting 1992 volumes during the construction phase of the site are identified at principal locations, as well as the percentage of heavy vehicles in the traffic stream (Table 25). The projected site traffic characteristics during the construction period are depicted on Figure 14.

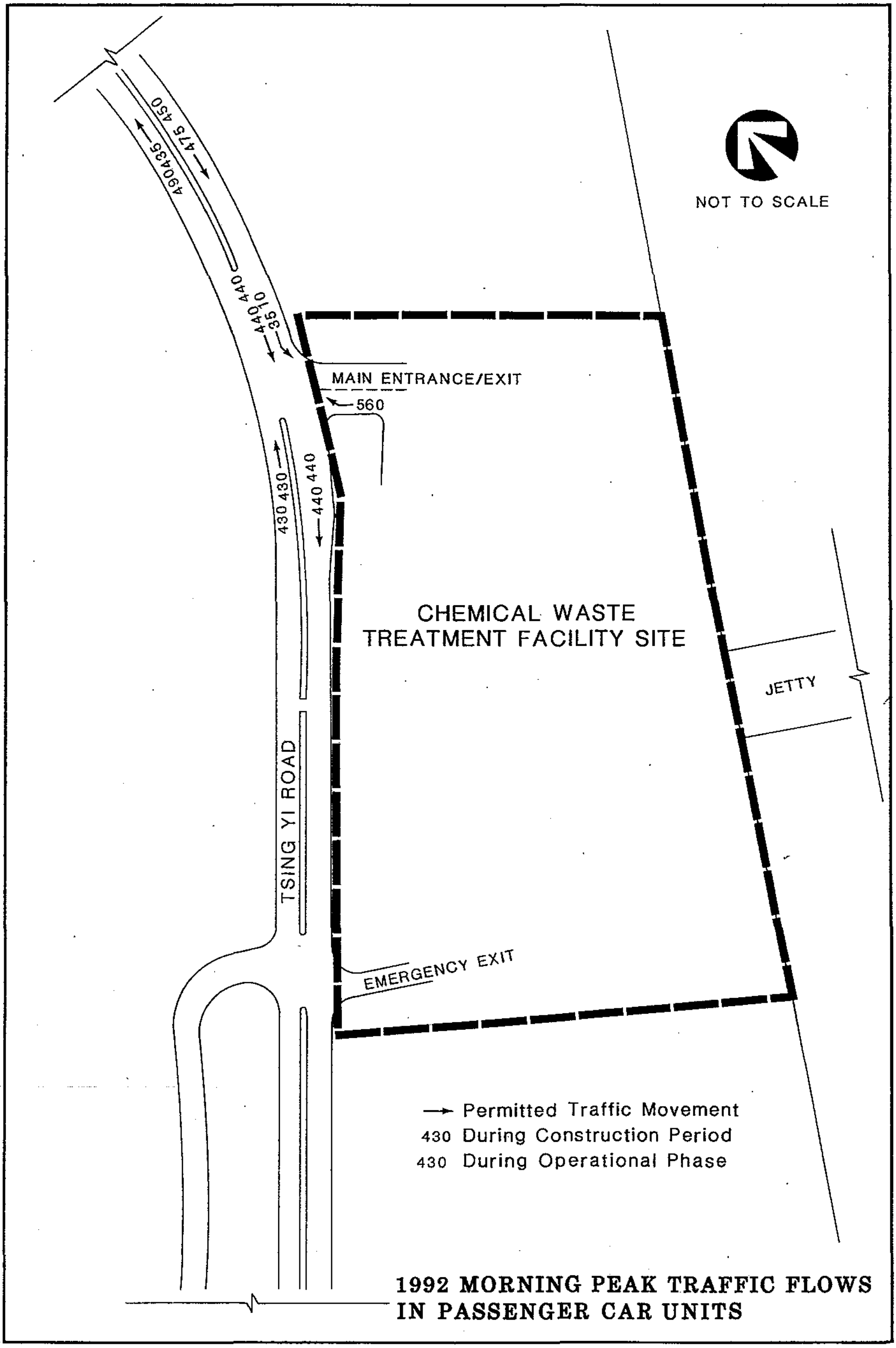
TABLE 25

1992 PEAK HOUR TOTAL VEHICLES AT SELECTED LOCATIONS
AND PERCENTAGE OF HEAVY VEHICLES DURING CONSTRUCTION PERIOD

	Tsing Yi Heung Sze Wui Road North of Roundabout	*Tsing Yi Bridge East of Roundabout*	*Tsing Yi Road South of Roundabout*	*Tsing Yi Road North of Site*
Morning Peak Hour	7.30-8.30am	7.30-8.30am	7.30-8.30am	7.30-8.45am
Total Vehicles	1,750	1,900	1,650	500
% Heavy Vehicles	40	43	42	54
Afternoon Peak Hour	4.15-5.15pm	4.15-5.15pm	4.15-5.15pm	2.45-3.45pm
Total Vehicles	1,625	1,550	1,325	400
% Heavy Vehicles	41	42	42	61

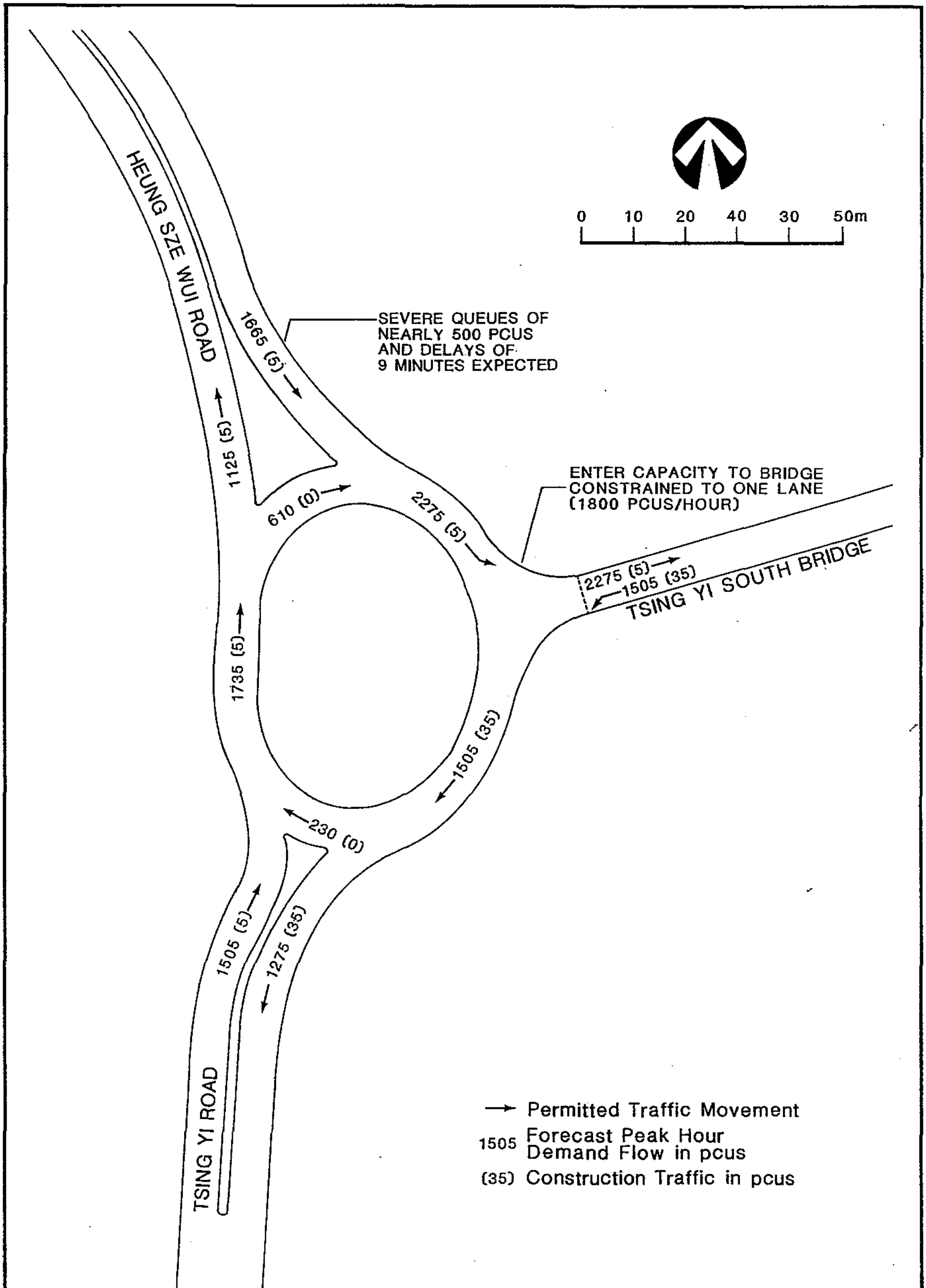
Notes: (1) Number of vehicles rounded to nearest 25.
(2) Vehicle numbers represent two-way totals.
(3) Heavy vehicles consist of bus, coach and goods vehicles over 1.5 tonnes gross vehicle weight.

The analysis of 1992 morning peak traffic flows through the Tsing Yi South Bridge roundabout (Figure 15) indicate a potential additional delay to vehicles travelling eastbound on Tsing Yi South Bridge. Projected volumes on Tsing Yi Heung Sze Wui Road southbound suggest an average delay of approximately nine minutes per vehicle during the morning peak hour. However, this delay is primarily caused by factors external to the roundabout and almost all the vehicles in the queue are non-construction vehicles. The predominant flow of construction vehicles in the morning peak will be westbound on the bridge to Tsing Yi South Bridge. This movement through the roundabout is not expected to encounter any delay.



1992 MORNING PEAK TRAFFIC FLOWS IN PASSENGER CAR UNITS

FIGURE 14
DAMES & MOORE



1992 MORNING PEAK TRAFFIC DEMAND FLOWS
TSING YI SOUTH BRIDGE ROUNDABOUT
DURING CONSTRUCTION PERIOD

FIGURE 15
DAMES & MOORE

The analysis of traffic conditions assumes that all construction vehicles would travel across the Tsing Yi South Bridge. As construction vehicles will not necessarily need to follow prescribed routes, the less congested Tsing Yi North Bridge may be a viable alternative.

5.6.8.3 Operation Impacts

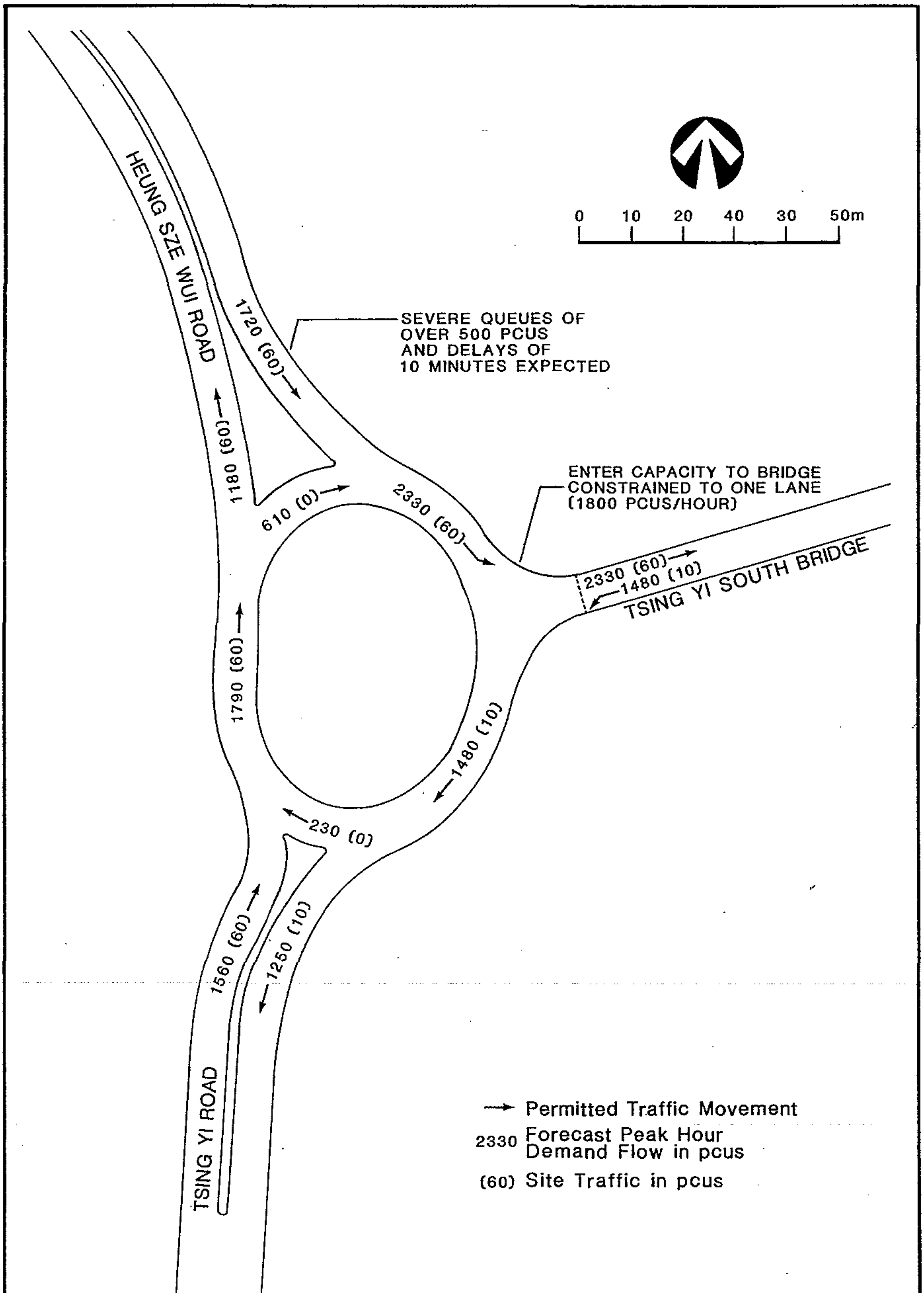
An analysis of predicted 1992 morning peak traffic flows on Tsing Yi Road, Tsing Yi Road junction and the proposed main entrance/exit of the CWTF indicates that operational traffic is not expected to experience significant difficulties and that installation of signal control will not be necessary for traffic to ingress and egress the site. The projected site traffic characteristics are depicted on Figure 14.

The analysis of the Tsing Yi South Bridge Roundabout is more complex because delays are caused by factors external to the roundabout itself, i.e. the queue of eastbound vehicles on the bridge resulting from congestion at junctions on the east side. As noted in Section 5.6.3, improvements to these junctions are proposed as part of the development of south east Tsing Yi.

Assuming no new road improvements in this area by 1992, the analysis of 1992 morning peak traffic flows through the Tsing Yi South Bridge roundabout indicates a potential additional delay to vehicles travelling eastbound on Tsing Yi South Bridge. Projected volumes suggest a delay of 9.3 minutes per vehicle during the morning peak hour. This figure represents an approximate additional delay of four minutes over 1990 conditions. This relatively large increase in delay for a modest increase in volume is typical of queuing situations. The Tsing Yi South Bridge will also operate at a volume/capacity ratio exceeding 1.0. For the purpose of comparison, the average delays to be expected at the roundabout during the morning peak if traffic were free flowing on the bridge are:

- o Existing Traffic - 0.2 minutes/vehicle
- o 1992 Background Traffic - 0.9 minutes/vehicle
- o 1992 Total Traffic (including site traffic) - 1.5 minutes/vehicle

The 1992 morning peak traffic flows for the Tsing Yi South Bridge roundabout are displayed on Figure 16.



1992 MORNING PEAK TRAFFIC DEMAND FLOWS TSING YI SOUTH BRIDGE ROUNDABOUT DURING OPERATIONAL PHASE

FIGURE 16
DAMES & MOORE

At the industrial areas where waste generators are concentrated, Enviropace has observed that each additional vehicle can substantially aggravate an already difficult traffic situation in which long delays are experienced in pick up and delivery. If CWTF could arrange collection at night, there would be improvement not only in traffic but also safety and emergency response in the event of accidents and spills.

5.6.9 Management and Monitoring

The anticipated peak hour traffic generated by the chemical waste treatment facility can be adequately accommodated by Tsing Yi Road in the vicinity of the site without special improvements, provided that the access arrangements do not cause queuing on the main road. It should be emphasised that the additional traffic generated by the CWTF will contribute only a small fraction to the total number of vehicles that are projected for 1992.

Projected 1992 traffic at the Tsing Yi South Bridge (including traffic generated by the CWTF) is expected to result in increased delays, however, the following points are particularly relevant:

- the site is a small component of a large redevelopment plan presently under study, which will include major improvements to the bridge and roundabout;
- the delays are partially attributable to congestion at the eastern end of the bridge, to which committed improvements are pending; and
- the contribution of vehicles generated as a result of the construction and operation of the CWTF is a minor component of the total projected vehicles for Tsing Yi Road and the Tsing Yi South Bridge roundabout.

The collection vehicles that are able to leave the site shortly after 7.00am will have the best chance of avoiding the morning peak congestion conditions at the Tsing Yi South Bridge and roundabout. The work shifts of 7.00am to 3.00pm and 3.00pm to 11.00pm should enable some employees to time their arrival and departure periods to avoid peak traffic which occurs at 7:30 am. However, shifts would need to commence at about 6:30 am if the entire collection fleet were to avoid significant delays.

It is feasible that even greater changes could be made to the proposed day time collection schedule. For instance, if collections were made during night time, the impact of the collection vehicles on existing traffic would be reduced even further from the already low levels. The overall efficiency and safety of the operation would also improve dramatically because the time required for collection vehicles to travel to and from the waste generation sites would be substantially reduced. Night also improves the time for emergency vehicles to respond to accidents and spills, to secure the area, and to perform the necessary remediation work.

Whilst such a scheme is theoretically feasible, the industries responsible for generating the wastes would have to undergo some operational changes, such as rescheduling some shipping and receiving personnel. It seems that a number of generators already do this, most likely to avoid daytime congestion. These and many other practical constraints would require time and effort to overcome, but the advantages could be significant.

As discussed in Section 5.6.8.3, it is considered that installation of signal control will not be necessary for traffic to ingress and egress the site. A stop sign for traffic exiting the site should be adequate to allow vehicles to enter the main traffic stream. It would not be necessary to ban right hand turns into the site. Adequate measures should be taken at the gate house area on-site to prevent incoming vehicles from queuing back into the Tsing Yi Road junction. Examples of such measures could include streamlining admission procedures at the gate house and locating the gate house in such a way as to provide off-road queuing space for several vehicles.

The Tsing Yi North Bridge has a greater capacity than the Tsing Yi South Bridge and provides a viable alternative to the Tsing Yi South Bridge for construction and waste collection vehicles not required to use designated routes.

It is proposed that a traffic management plan would be prepared and that monitoring of vehicle traffic would occur following commencement of construction activities and during the operations phase of the CWTF project. This plan would be reassessed if and when the CT9 proposal is implemented. Also, if it appears that traffic generated by the CWTF has an unacceptable impact on the traffic flow at Tsing Yi Road and Tsing Yi South Bridge roundabout, mitigation measures such as rescheduling the collection times as described above will be implemented.

5.7 VISUAL EFFECTS

5.7.1 Impacts

The main elements that will contribute to the overall appearance and hence to the visual impact of the CWTF will be the treatment plant, administration and storage buildings, and the 76.3m incinerator stack. On occasions, as described in Section 5.1, there may be condensation of water vapour at some distance above the top of the stack, and this will be visible at a distance.

5.7.1.1 Visibility from the Harbour and Hong Kong Island

The CWTF will be located on the coastline and, clearly, the upper part of the major buildings and the majority of the incinerator stack will be visible from the harbour and from northwestern parts of Hong Kong Island. From these vantage points, it is concluded that the visual impact of the facility will not be significant for three reasons:

- the site is backed to the north by a prominent ridgeline which is in excess of 300m high. The ridge is essentially devoid of vegetation and provides a sympathetic backdrop to the proposed facility. Neither the plant buildings nor the incinerator stack will break the skyline from southern vantage points;
- the plant facilities will generally not exceed four stories. Many of the facilities will be covered and will assist in creating an uncluttered appearance;
- the plant site is over 5km from the northwest shoreline of Hong Kong Island and, given the backdrop described above and the general industrial setting, the facility will have a subdued visual appearance from the populated areas of the Island.

5.7.1.2 Visibility from Nearby Residential Areas

The nearest residential areas to the CWTF site are located at Mayfair Gardens and Cheung Ching Estate. ERL (1987) has described the view from these locations as follows:

- o looking southwest from the roofs of these buildings it is possible to see clearly the:
  - Mobil Oil Depot
  - a piece of vacant reclaimed land
  - buildings and the container storage area of Tai Tung Industry Ltd
  - buildings and container storage area of Outdoor Marine Asia Ltd; and
- o beyond the toe of the ridge, which is about 50m high, it is just possible to see a small chimney stack belonging to Dow Chemicals and the tops of some of their storage silos.

The main plant facilities of the CWTF will not be visible, although the top portion of the incinerator stack will appear above the ridgeline.

Emissions from the stack will be largely invisible except for some steam, depending on the weather conditions as explained below. An incinerator malfunction may result in the emission of partially combusted material or partially cleaned gas (i.e. some visible smoke). Such an event would be of very limited duration because a malfunction of this nature would result in an automatic shut down of input feed within seconds.

Emissions of steam at some distance above the top of the stack will be visible during cool, humid conditions. This situation is unavoidable.

The overall conclusion is that the visual impact of the CWTF will be minimal. A Landscape Plan will be prepared and implemented to improve the overall aesthetics of the site and to minimise the visual impact of the CWTF. This plan is discussed in the following section.

5.7.2 Management and Monitoring

Although the visual impact of the CWTF will be low, a landscaping concept has been prepared. This concept will form the basis of a Landscape Plan. The major features of the Plan are given below.

5.7.2.1 Landscape Concept

The Landscape Concept involves a colour co-ordination scheme for the physical structures that will be erected.

Key areas such as site entry points, the administration centre and visitor's car park will be enhanced through the use of appropriate signage and lighting. An appropriate design and colour scheme for the buildings will improve the distant visual identity of the area. There will be special paved areas for vehicular and pedestrian circulation. The site will surrounded by a fence for security. There will be perimeter lighting at night. A colour scheme will complement the natural landscape. A suggested colour range would include third order colours for the buildings, complemented by primary colours where appropriate.

The scheme would recognise a colour range that relates to the sea environment, and a colour sense that relates to the surrounding natural Tsing Yi Hill slopes.

A preliminary colour range is suggested below:

o	building mass	-	sea colours
o	visible roof space	-	sea colours
o	guardhouse structure	-	land colours
o	tank farm - foreground	-	land colours
o	tank farm - background	-	sea colours
o	chimney stack	-	sea colours
o	jetty structures	-	sea/land colours

This concept will be discussed with the contractor during the design phases of the project.

5.8 SOCIO-ECONOMIC EFFECTS

ERL (1987) identified three key socio-economic issues associated with the project:

- o the socio-economic effects on Hong Kong as a whole, particularly in terms of the disposal of chemical wastes;

- the socio-economic effects for the residents of Hong Kong, particularly employment; and
- the suitability of the CWTF in terms of the planning philosophy of Tsing Yi Island.

At present there is no facility in Hong Kong capable of treating chemical wastes. Hazardous and toxic compounds are discharged into sewers and open surface water drains, posing a serious public health risk, a significant environmental problem and jeopardising the operation of conventional water treatment facilities.

The proposed CWTF will lead to improved water quality and reduced public health risk. Industry will have the means of disposing of their wastes in an environmentally responsible manner, as well as conforming with new licensing requirements. Additionally, the facility may serve to attract foreign investment due to Hong Kong's ability to manage hazardous wastes in an environmentally safe manner. The CWTF will also enable Hong Kong to comply with its obligations to the international community under the MARPOL Convention.

The CWTF will initially employ about 275 staff. As the capacity expands to full design over five to six years, the staff will increase to about 375. Many of these will be specialists. There will be a need for about 100 field operators and 80 drivers. The CWTF thus provides employment opportunities for the local Tsing Yi Island community.

The site for the CWTF is located on industrial land and conforms with the overall planning strategy for Tsing Yi Island (see Section 3.4).

It is concluded that the CWTF will offer several significant benefits to both the local community and the general Hong Kong community. There do not appear to be any significant adverse impacts and consequently, no specific management and monitoring programme has been recommended.

6.0 CONCLUSIONS

The disposal of waste represents one of the most pressing environmental problems confronting the Hong Kong community. A significant element of this problem relates to a range of toxic and hazardous materials generally referred to as chemical wastes. At present, most of these wastes are discharged directly into sewers and surface water drains and also enters the coastal waters. This results in significant environmental, engineering and public health problems.

The Government of Hong Kong has examined a range of chemical waste disposal options and has concluded that the preferred strategy would involve a combination of recovery and re-use, detoxification, chemical and physical treatment, thermal destruction and disposal of stabilised innocuous residual material in a landfill.

The proposed Chemical Waste Treatment Facilities will reduce present risks to public health and safety, prevent future deterioration in water quality, and in general result in significant environmental benefits to Hong Kong.

The present EIA/HA was commissioned to provide a more detailed assessment of the environmental issues identified in the Key Issues Report, developed after the Government accepted the Enviropace design for CWTF. Particular attention in this EIA has been given to the changes in plant design that have occurred during the tender process and the related environmental consequences.

Air Quality

Three sources of impacts were identified: dust, stack emissions from the incinerator and fugitive hydrocarbon emissions. Of these, stack emissions had the potential to be the most significant. A number of modelling exercises were undertaken and it was concluded that none of the pollutants likely to be emitted from the CWTF incinerator would exceed the Hong Kong ambient air quality objectives if the emission rates met or approached the Contract requirements. Dust and fugitive emissions were also addressed and it was concluded that they would not cause any significant impact.

Specifically, worst case operating and meteorological conditions indicate that the maximum 1-hour average groundlevel concentration of SO_2 is 438 $\mu g/m^3$, which is well within the EPD objective of 800 $\mu g/m^3$. The highest maximum 1-hour concentration of sulphur dioxide is predicted to approach the EPD air quality objective of 800 $\mu g/m^3$ at an elevation of 80m above groundlevel and at a location immediately north west of the CWTF. In theory, therefore, if there were a person at this position above ground, the EPD air quality objectives would not be exceeded. Of course, for most of the time, the incinerator will not be operating under worst case conditions.

The model was also used to predict the maximum concentrations for a number of other criteria pollutants both at Mayfair Gardens and Dow Chemicals, and at other points in the area. Generally, all the predicted concentrations are well within the Hong Kong air quality objectives. The only pollutant that approaches any of the air quality objectives is nitrogen dioxide, and this only occurs at an elevation of 100m above the Dow Chemical site. At Mayfair Gardens, all of the criteria pollutants are well within the relevant air quality objectives.

Maximum Individual Cancer Risks (MICR) were predicted for groundlevel and elevated (100m) receptors. The largest MICR determined at any position was 4.06×10^{-7} or less than half the MICR standard. For groundlevel concentrations, the largest MICR determined for any receptor was 1.28×10^{-7}, or about a factor of ten less than the standard.

Limited ambient air quality data obtained from EPD for a site located about 1.5km north of the CWTF site indicated the majority of the existing sulphur dioxide originates from the area located to the southeast through to the northeast of the monitoring station. The predicted annual average concentration indicates that the CWTF incinerator is likely to result in an atmosphere of less than 1$\mu g/m^3$ of sulphur dioxide in residential areas. This is compared to an existing level that is at least a factor of 10 and quite possibly a factor of 100 higher. Considerable improvements in the ambient air quality at Tsing Yi Island could be achieved if other sources of pollutants were required to achieved low emission levels similar to those required of the CWTF. Overall, it is concluded that the cumulative impact of the CWTF incinerator on the existing air quality in the residential area will be very small, and possibly not even quantifiable.

Liquid Effluent Discharges

Four potential sources of liquid effluent discharges were identified as having the potential to impact the environment. They were: treated effluent from the CWTF, accidental spillages of chemicals or MARPOL wastes, run-off from the plant site and discharge of contaminated groundwater.

One of the operating principles of the CWTF is that it has the adaptability and flexibility to store and treat a wide range of chemical wastes. This requirement is due to the uncertainty in the nature of the waste to be received at the CWTF and the likelihood of receiving difficult wastes not specifically included in the contract categories. As a consequence, it is not possible to accurately specify the physical and chemical make-up of the treated effluent discharge. However, Enviropace is committed to meet the pollution control limits set in the Contract, and as a corollary, it is concluded that there will not be any unacceptable environmental impacts resulting from the disposal of treated effluent.

Accidental spillages could lead to contamination of soil and groundwater. Over a period of time, this contamination could migrate to the sea. All areas of the CWTF where spills could occur will be protected with bunds and drainage controls. It was concluded that the probability of a major incident occurring was very low and that small isolated incidents could be managed without leading to any long term environmental damage. Similarly, runoff from the plant site will be contained and will be managed so that any environmental impact would be negligible.

The highest potential for a spillage of MARPOL waste would occur as the pipeline is disconnected from the manifold to the jetty. Several design features and management procedures will largely eliminate the prospect of a spill occurring in this way; however, a contingency plan will be incorporated in the Emergency Response Plan to minimise the area affected by a spill and hence its impact on the marine environment.

Another unlikely cause of a spillage might be a collision between a laden MARPOL barge and the jetty or another vessel. The environmental effects of such a spillage would largely depend upon the chemical nature of the waste and the location of the incident. The light fractions of Annex 1 wastes would quickly evaporate and photo-oxidise, whilst the heavier fractions could cause localized damage to the environment if not quickly contained. Most of the damage would be physical; however, if the spill were to impact the shoreline, some impact on sediment chemistry and marine biota could be expected.

Since the CWTF site is in an industrial area and on the coast, and has permeable fill soils, there is the possibility of prior site contamination. The CWTF has been designed and management techniques developed to reduce the magnitude of any further impact and ensure that there will be little possibility of any long term environmental risk. A groundwater monitoring programme will be implemented to initially determine the baseline condition of the site. Should the baseline study identify existing contamination, a series of more detailed investigations is recommended. The recommended programme would be additional to the field programme specified in the Contract which is intended to be an investigative study not a detailed audit. The timing of the recommended study should be considered in terms of the overall project schedule.

Solid Waste Disposal

All the solid wastes produced at the CWTF will conform with Government pollution control limits and present little threat to the environment. Stringent QA/QC procedures will be implemented to ensure that all treatment residues leaving the site are detoxified, chemically stabilised, physically immobilized and suitable for safe, long-term disposal.

Noise

The environmental effects of noise associated with construction and operation activities are unlikely to cause a nuisance to any residential areas. Similarly, noise associated with traffic serving the site is likely to be insignificant. Sound levels generated at the CWTF will comply with the regulations.

Traffic

A detailed traffic study was undertaken to determine the likely effects of the project on traffic flows and existing road networks. The study concluded that the traffic generated by the project will have an insignificant effect on the existing traffic flows. Of greater potential concern is the delays that the existing traffic may have on the efficiency of the waste collection operations.

Projected 1992 traffic at the Tsing Yi South Bridge indicates that increased delays will occur. The existing delays are partially attributable to congestion at the eastern end of the bridge, to which committed improvements are pending. Also, the general area is presently the focus of a large redevelopment plan which will include major improvements to the bridge and roundabout.

It is recommended that consideration be given to rescheduling the commencement of the early morning shift prior to 7:00 am. This would allow sufficient time for the waste collection fleet to leave Tsing Yi Island before the peak traffic flows begin to congest the South Bridge. This usually occurs at 7:30 am. Even greater changes to the collection schedule appear feasible and warrant further consideration. Night and Sunday collection would be considerably more efficient and protective of public safety, if it could be arranged with the waste generators.

Visual

The visual impact of the CWTF will not be significant. The CWTF will be visible from the harbour and Hong Kong Island but the backdrop to the site, the small scale of most of the structures, and the distances involved mean that it will not be a prominent visual feature. Emissions from the incinerator stack will generally be invisible except during periods of cool humid weather when steam will form.

Socio-economics

The overall socio-economic effect to the local Tsing Yi Island community and the general Hong Kong public will be positive. The project will ultimately provide employment for 375 people.

The major socio-economic benefit is that the CWTF will provide a facility for the safe treatment and disposal of a variety of toxic and hazardous chemicals. These chemicals are presently disposed of indiscriminantly, posing a risk to public health and safety and resulting in significant environmental damage.

Furthermore, industries concerned about the environment will tend to make future investments in Hong Kong if there is an adequate infrastructure for waste management. The CWTF project provides both the facilities and the collection system components of this needed infrastructure to make foreign investment more attractive.

7.0 REFERENCES

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ERL (Asia) Ltd (1987). Development of Chemical Waste Treatment Facilities; Key Issues Report 2, Environmental Review.

NH&MRC (1986). National Guidelines for Control of Emission of Air Pollutants from New Stationary Sources. Recommended Methods for Monitoring Air Pollutants in the Environment. National Health and Medical Research Council.

Technica Ltd (1988). Tsing Yi Island Risk Re-assessment.

APPENDIX A

APPENDIX A

TSING YI CHEMICAL WASTE TREATMENT FACILITIES
ENVIRONMENTAL IMPACT ASSESSMENT
KEY ISSUES

I.0 INTRODUCTION

The Environmental Protection Department (EPD) of the Hong Kong Government has awarded a contract to a consortium led by Waste Management International for construction and operation of the Chemical Waste Treatment Facilities (CWTF) on Tsing Yi Island, Hong Kong.

The facility, which will receive organic and inorganic wastes from throughout Hong Kong, will include a high temperature incinerator as well as equipment for chemical treatment and solvent recovery.

An initial Environmental Assessment has already been carried out for the EPD by ERL (Asia) Limited. Two risk assessments, one by ERL and one by Technica, have also been carried out.

This position paper addresses the key environmental issues associated with the proposed facility based on a review of these documents.

2.0 KEY ISSUES

2.1 AIR QUALITY

The major issue to be address in the EIA relates to potential atmospheric emissions. These include stack emissions under normal operating conditions, emissions during possible up-set conditions and possible gaseous emissions from waste blending.

There is a lack of ambient air quality data for Tsing Yi Island. Such data are necessary as a baseline against which the results of compliance testing and on-going monitoring can be compared following construction of the CWTF.

The following parameters were proposed and subsequently revised through discussions with EPD:

Parameter

- o Respirable suspended particulates
- o Sulphur dioxide
- o Nitrogen dioxide
- o Total chloride
- o Total hydrocarbons
- o Dioxins & PCB's

These sampling operations will be undertaken at three separate locations on Tsing Yi Island on two occasions to represent different but common meteorological conditions.

The initial Assessment Report has shown that, with emissions within the limits specified by the EPD, there will be no unacceptable impact on air quality. Accordingly, the only additional air quality impact evaluations will result from the detailed risk assessment. These will address:

- o the consequences of incinerator up-set such as by loss of power or failure of the control system.
- o possible emissions from accidental mixing of incompatible wastes.

Such hypothetical incidents will be assessed qualitatively. They will also be considered in the Risk Assessment.

2.2 MARINE WATER QUALITY

The key marine environmental issue relates to the potential affects of accidental spillage of chemical wastes. The original CWTF concept includes a marine outfall pipeline for the discharge of treated liquid effluent. An assessment of the impacts of this effluent on the marine environment would have required dispersion plume modelling, using data collected from current meters and temperature and salinity probes that would have been required to be deployed close to the proposed discharge location. These oceanographic data would have been used to predict the size, shape and dispersion of the effluent plume. The final CWTF contract required discharge to the foul sewer and therefore, through discussions with EPD, it was agreed that the offshore dispersion modelling component of the original scope was no longer required. Furthermore, it was agreed that it was not with the scope of the CWTF EIA/HA to study the Government's future plans for sewerage treatment systems.

2.3 TRAFFIC

The traffic study will assess the impact of the projects on traffic conditions both during construction and during operations. Should these studies indicate particular problems caused by project traffic, remedial measure will be identified.

The facility is designed to receive MARPOL wastes. These wastes will be collected from the ships by barges and delivered to the site. Other land-based wastes will be collected by liquid tanker trucks, flat-bed trucks and light good vehicles. The EIA will therefore also consider the potential effects of accidental spillage resulting from either land or sea transport modes.

2.4 RISK ASSESSMENT

The detailed risk assessment will focus on:

- Fire risks
- Consequences of an incinerator up-set
- Consequences of accidental mixing of incompatible wastes
- Consequences of accidental spills
- Societal risk (other than employees)

Following out of the risk assessment, Emergency Response Plans will be formulated for each potentially hazardous scenario. The plans will include:

- Detection and warning systems
- Availability, type and location of remediation equipment
- Designation of responsible personnel, authority level and reporting requirements
- Personnel training procedures
- Shut down procedure
- Excavation procedure for site workforce
- Post-emergency cleanup.

As part of the ERP, contingency plans will be developed for off-site incidents such as transportation accidents, typhoons and incidents at nearby facilities.

The EPD has determined that the ERP should be prepared as a part of the plant operations, after the detailed engineering of CWTF is completed, and not as a part of the EIA/HA.

2.5 OTHER ISSUES

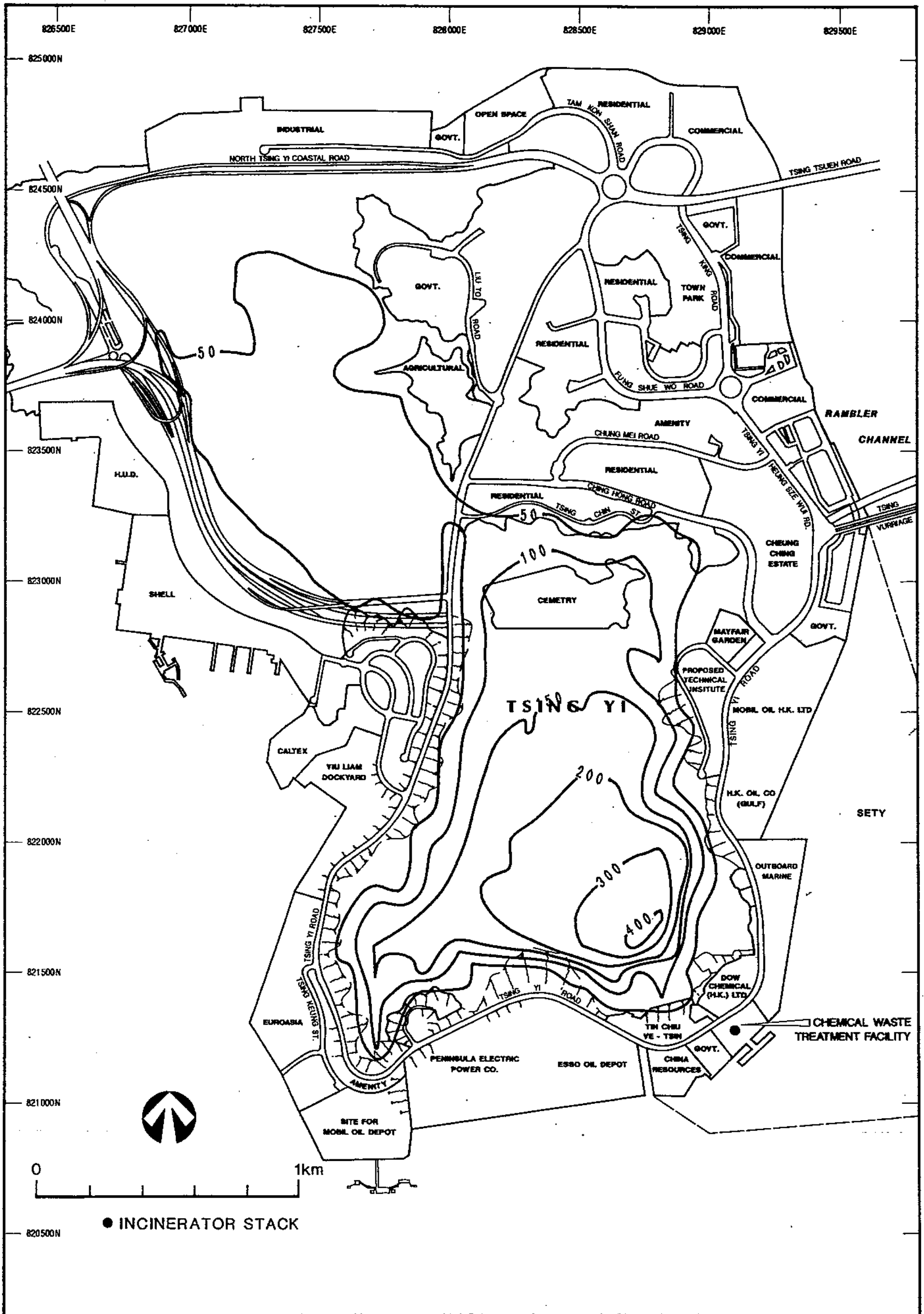
Although not identified as "Key Issues" there are several other issues which warrant further assessment. These include:

- o Soil and groundwater contamination. A programme of sampling and testing is proposed to test for existing contamination of the site. In addition, considerable attention will be provided in the EIA to the safeguards to be incorporated in the design to minimise the risk of groundwater contamination.

- o Visual impact. An assessment will be made of the visual impact of the facility. In addition a landscape masterplan will be prepared to enhance the visual appearance of the facility.

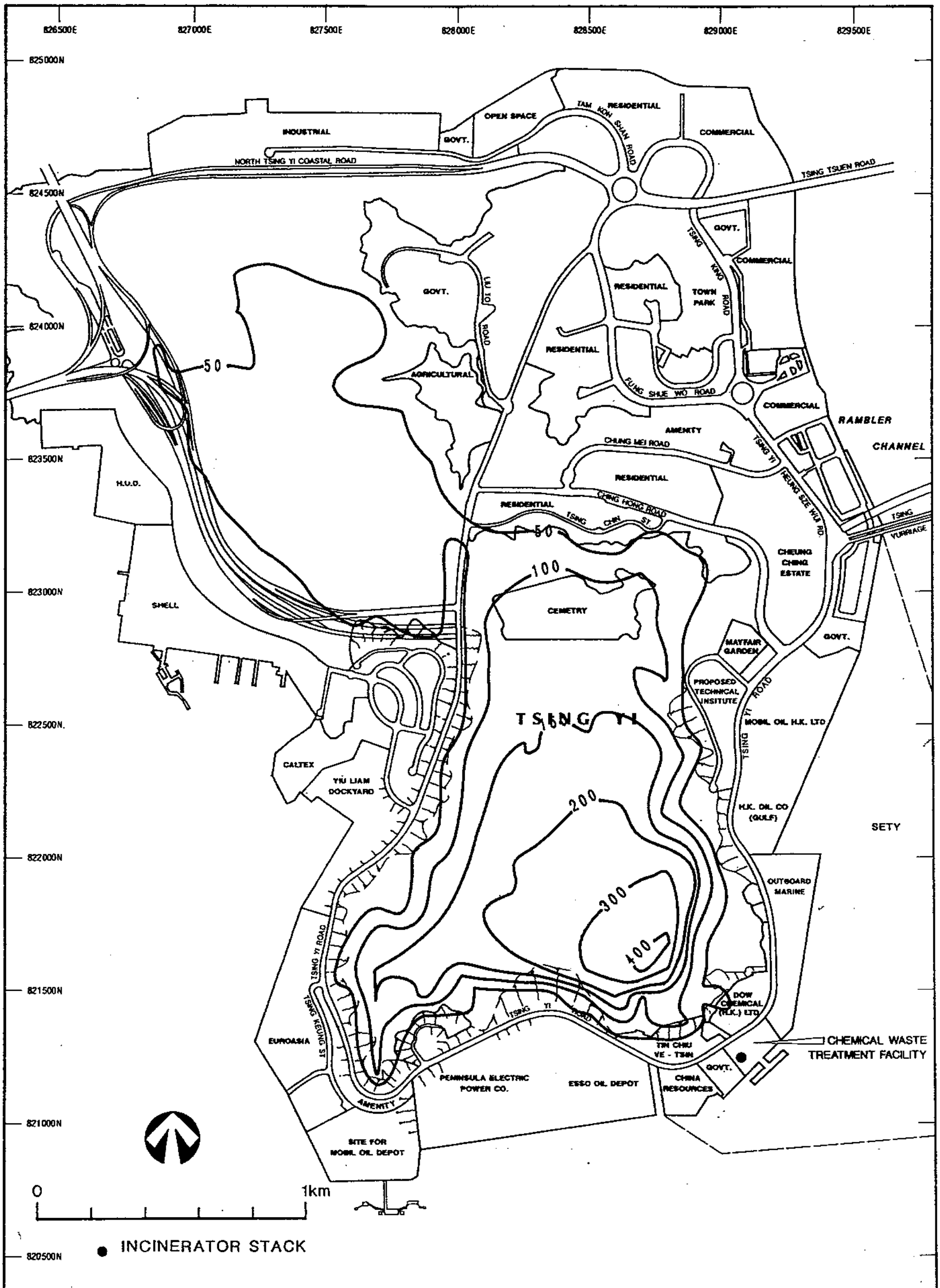
- o Marine impacts. Treated effluent from the facility will now be discharged to a sewer pipeline, not directly into the sea. Therefore, the marine water quality should not be directly affected by the CWTF. The emphasis of the EIA will therefore focus on defining management procedures designed to prevent occasional spills or contaminated surface runoff to the marine environment. Consideration will also be given to the possibility of the discharge of contaminated groundwater into the marine environment, and of the pollution of groundwater by coastal waters.

APPENDIX B



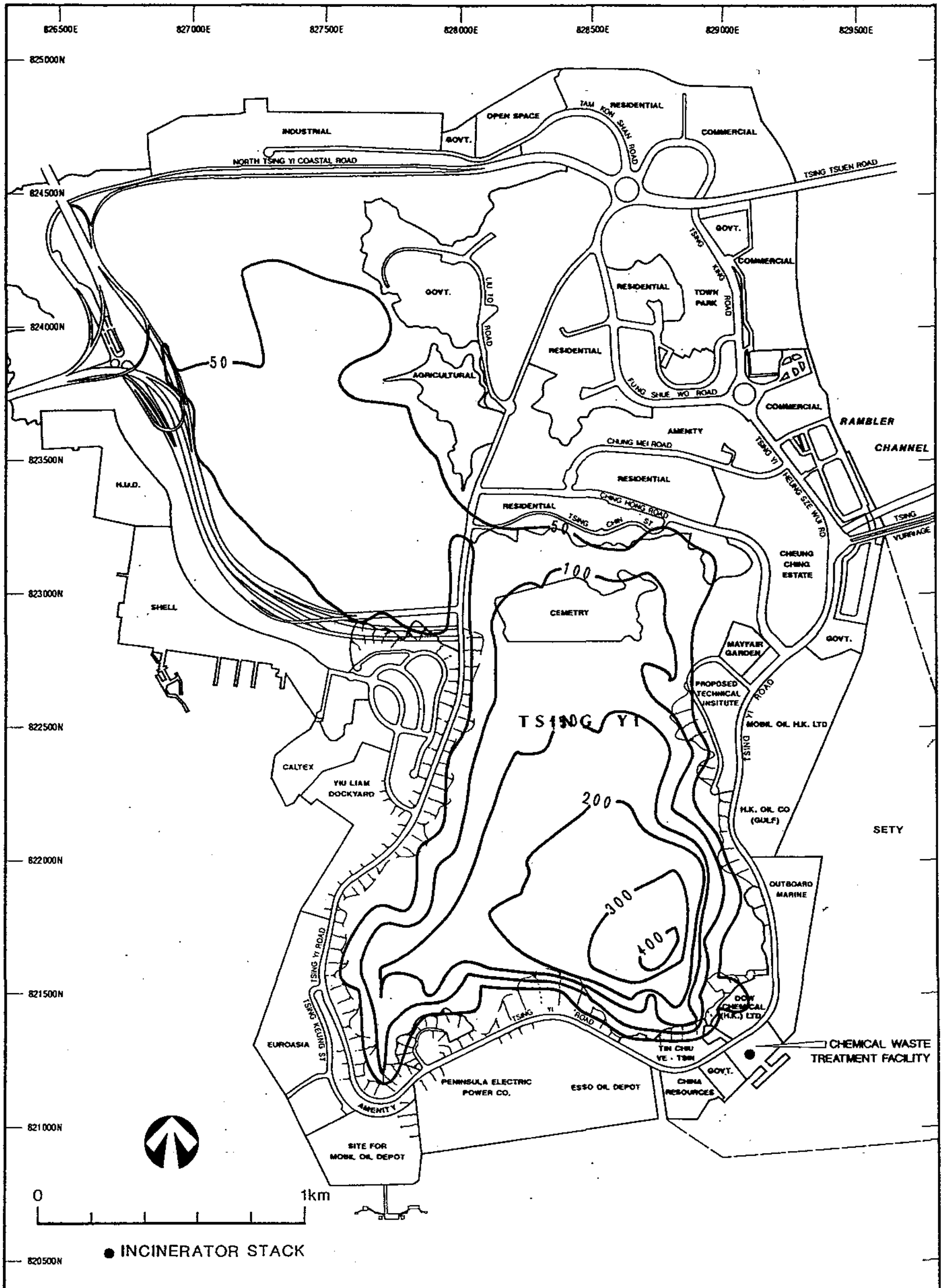
PREDICTED 1-HOUR AVERAGE GROUNDLEVEL CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m³

FIGURE B1
DAMES & MOORE



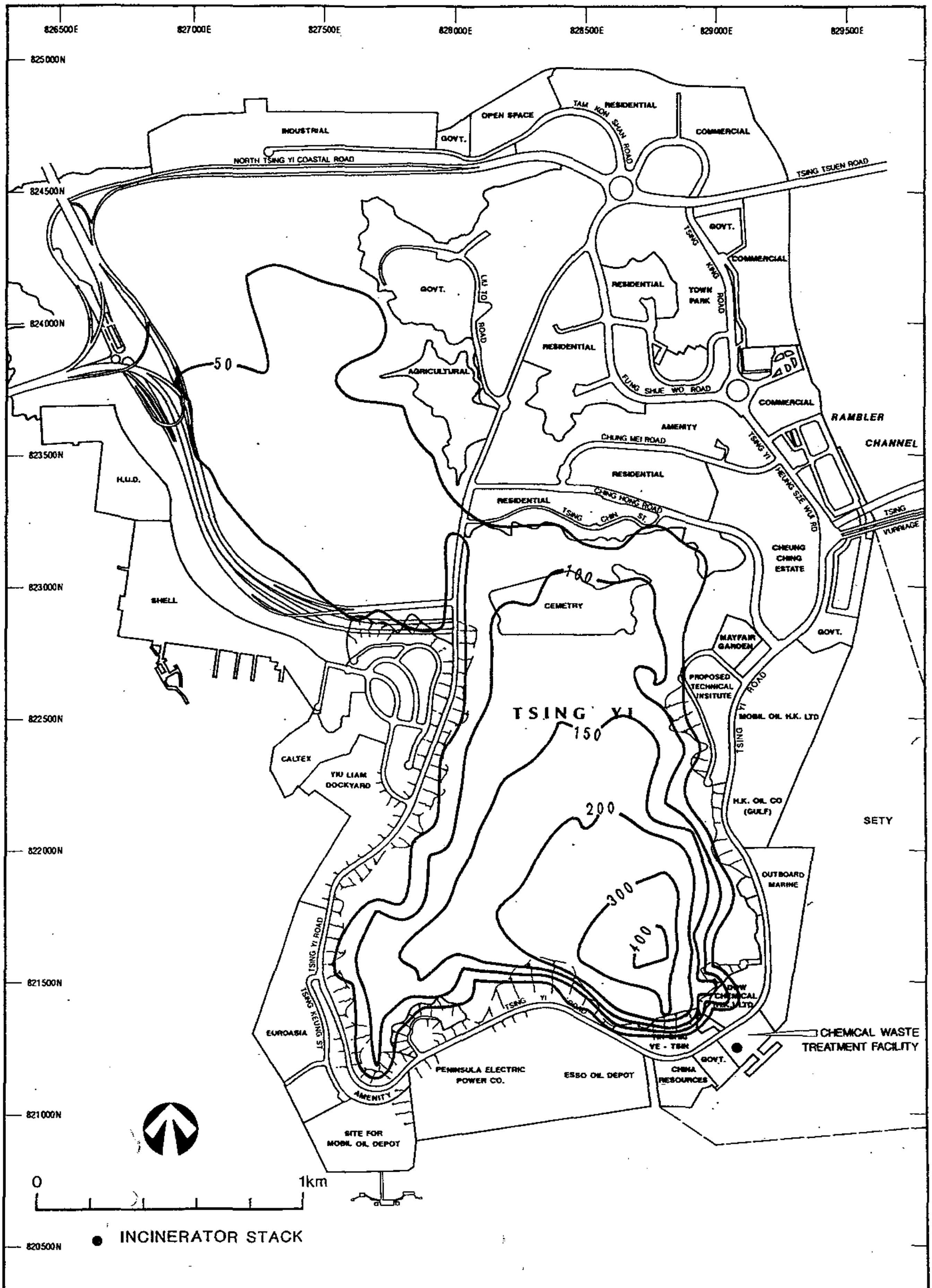
PREDICTED 1-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m³ FOR A RECEPTOR HEIGHT OF 10m

FIGURE B2
DAMES & MOORE



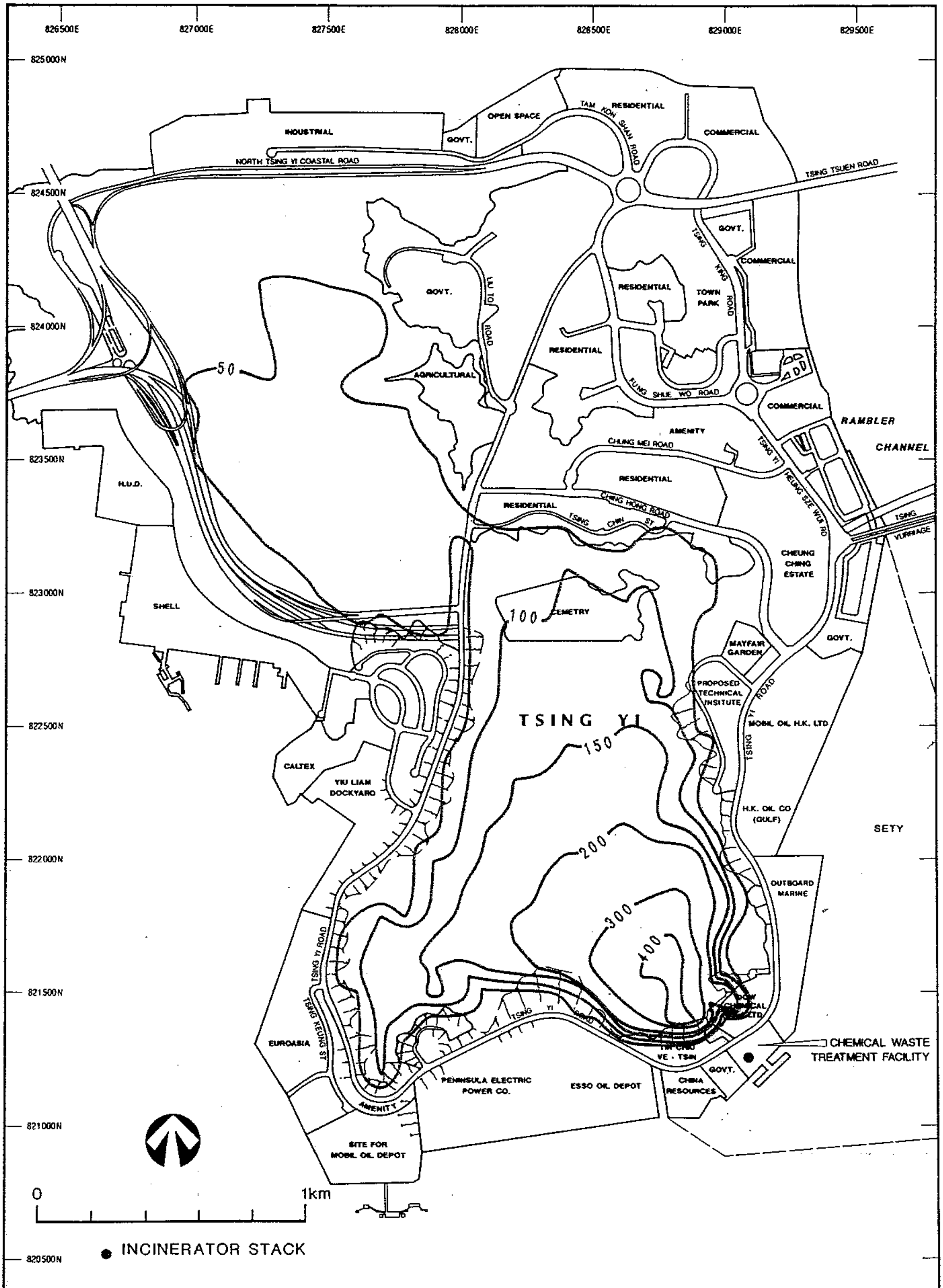
PREDICTED 1-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 20m

FIGURE B3
DAMES & MOORE



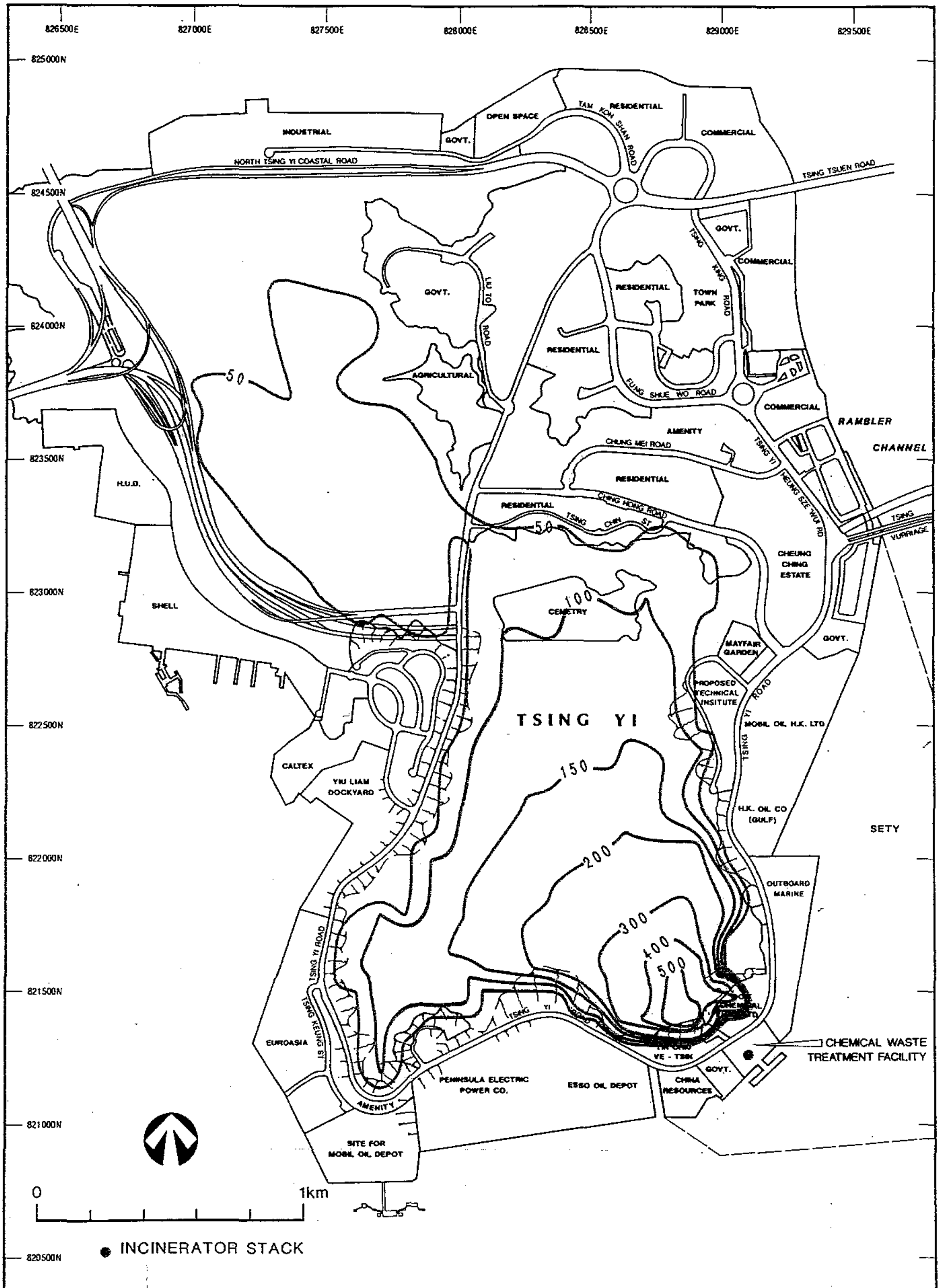
PREDICTED 1-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 30m

FIGURE B4
DAMES & MOORE



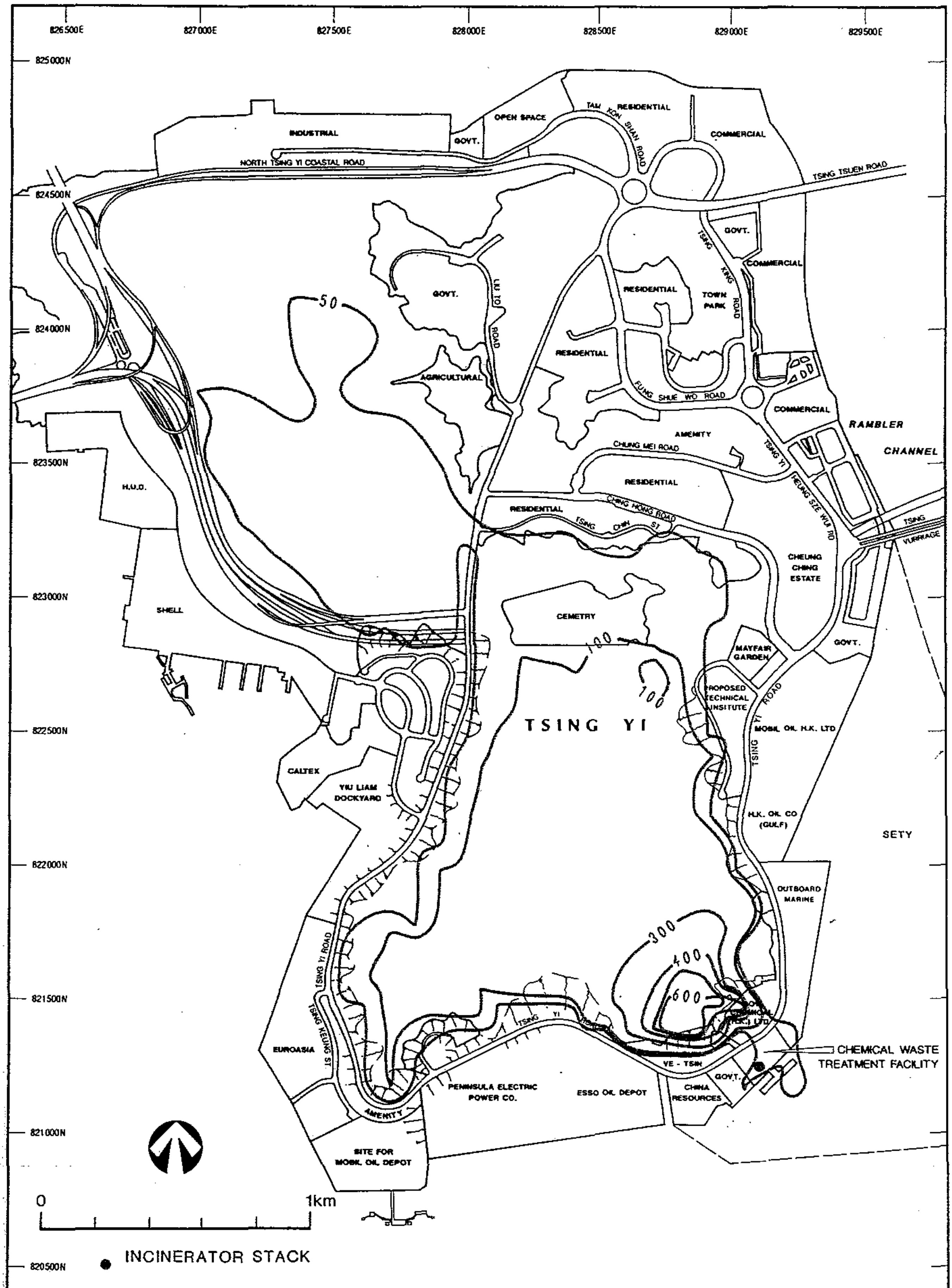
PREDICTED 1-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 40m

FIGURE B5
DAMES & MOORE



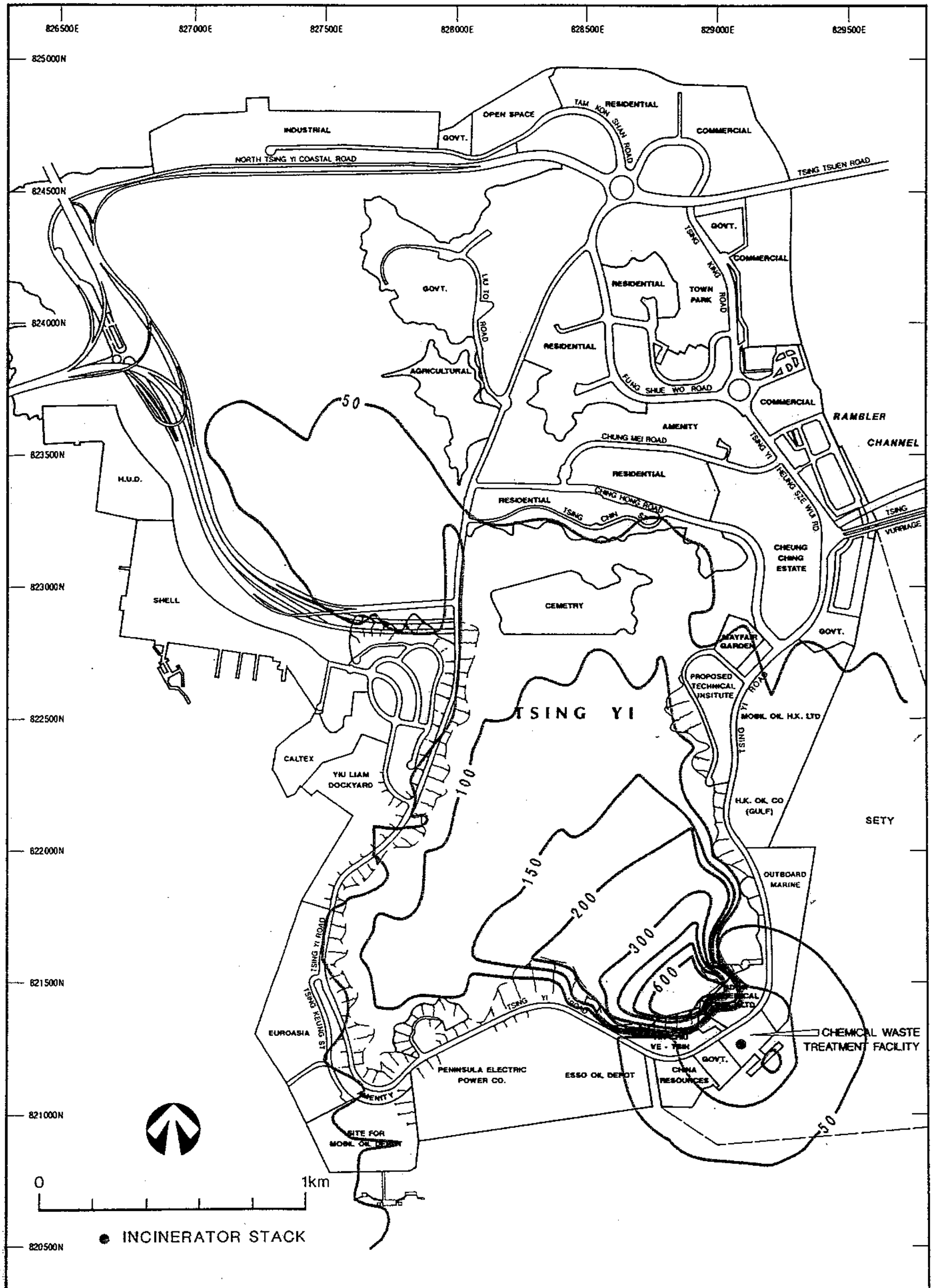
PREDICTED 1-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 50m

FIGURE B6
DAMES & MOORE



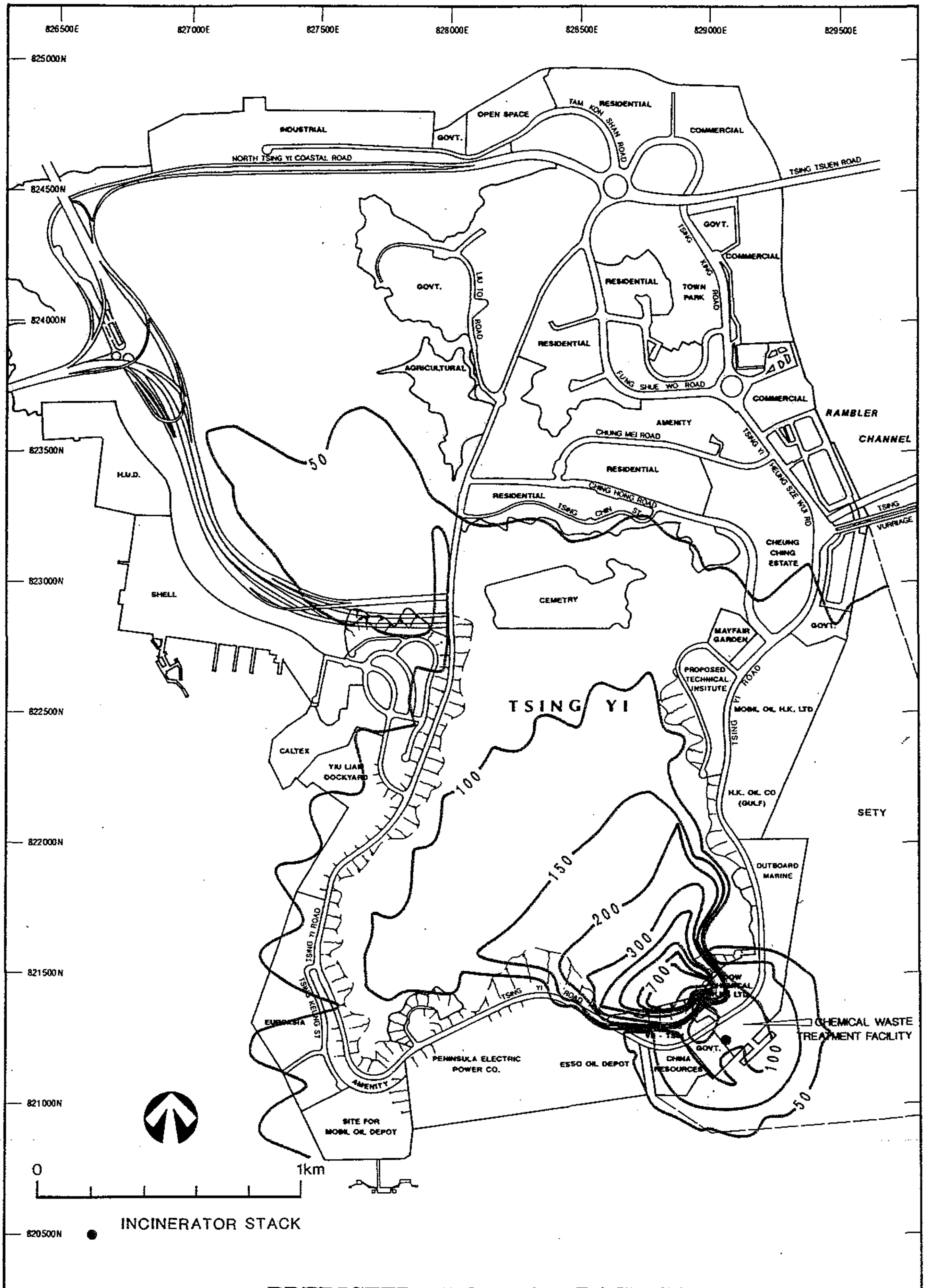
PREDICTED 1-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 60m

FIGURE B7
DAMES & MOORE



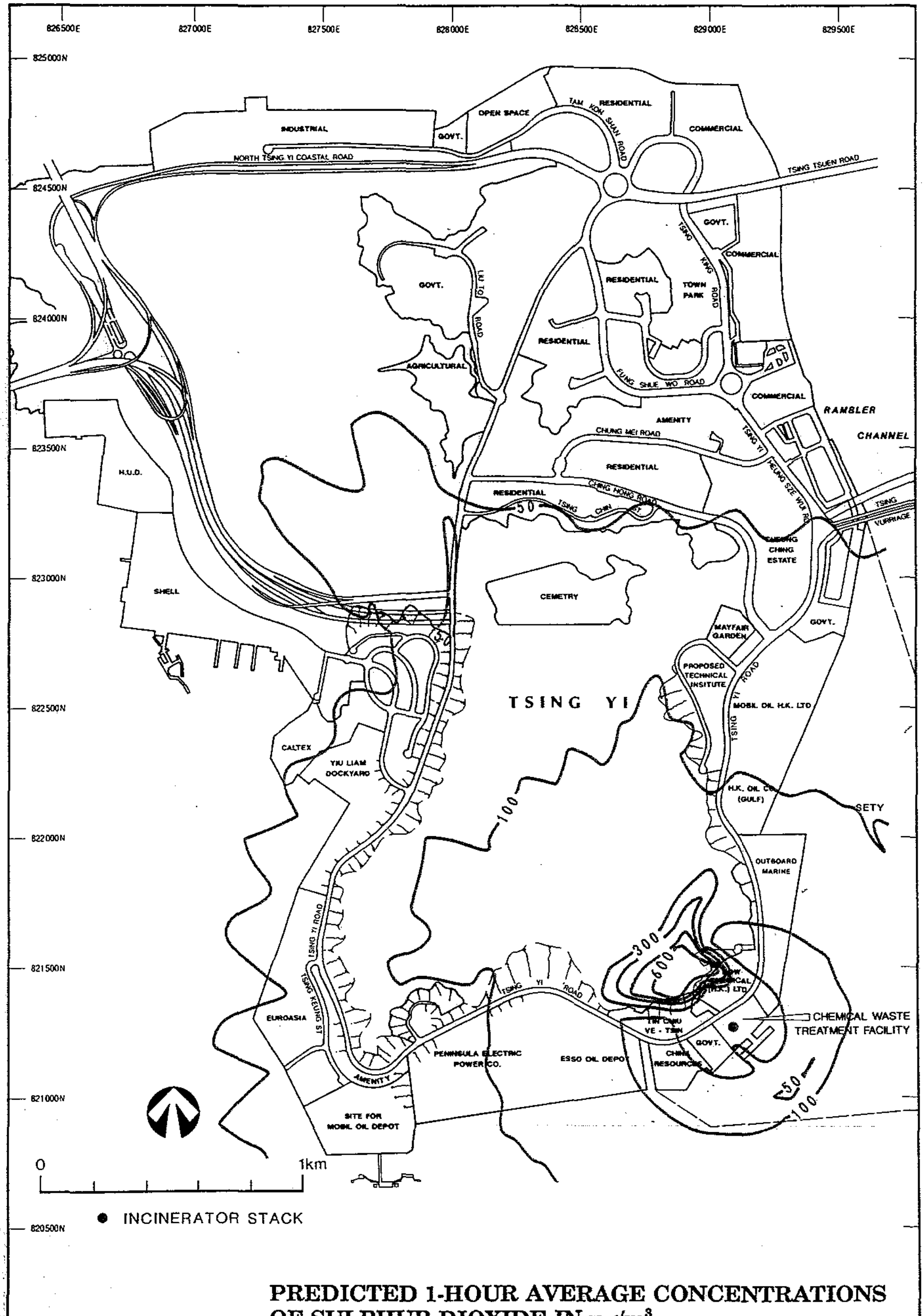
PREDICTED 1-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 70m

FIGURE B8
DAMES & MOORE



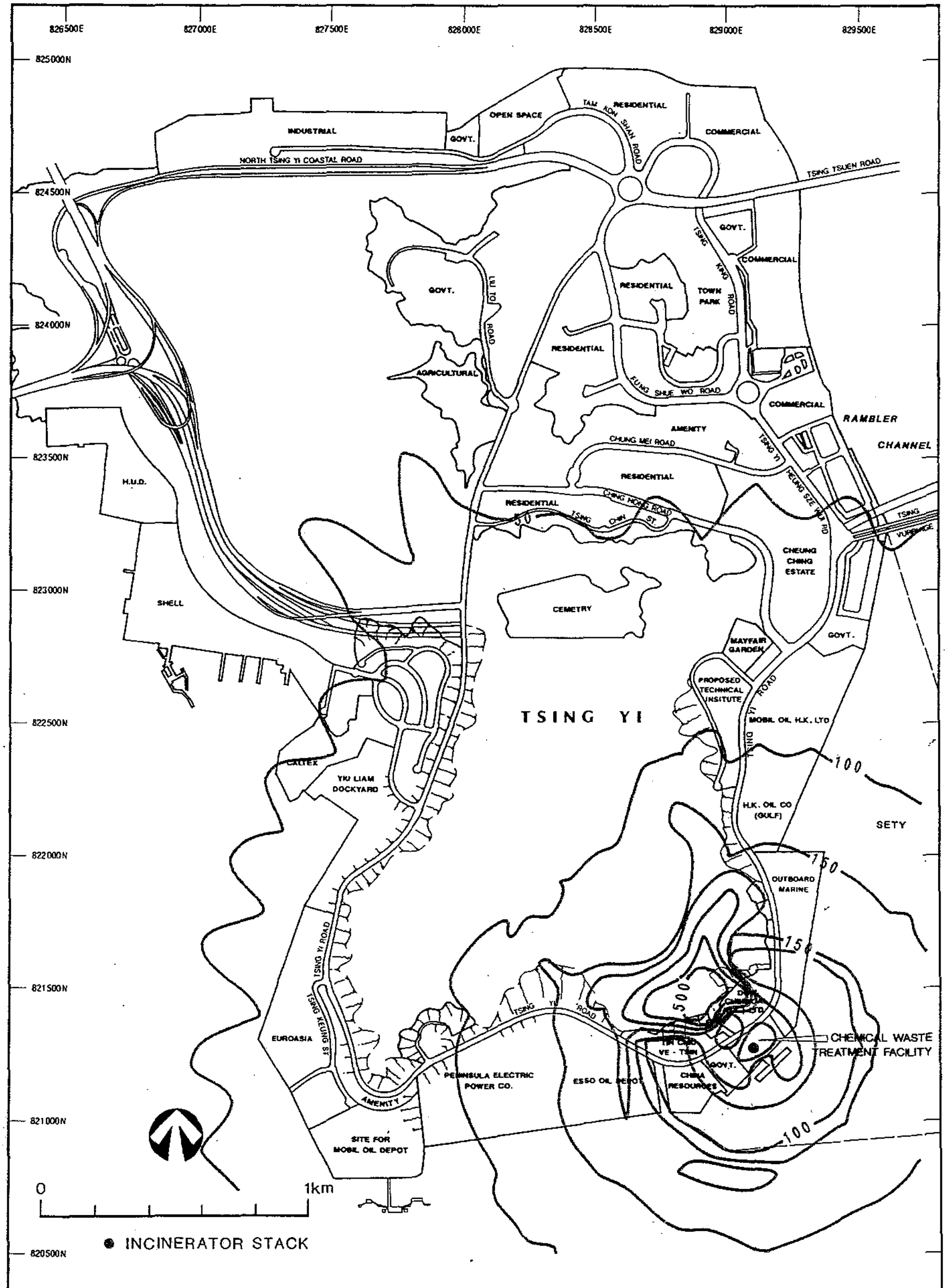
PREDICTED 1-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m³ FOR A RECEPTOR HEIGHT OF 80m

FIGURE B9
DAMES & MOORE



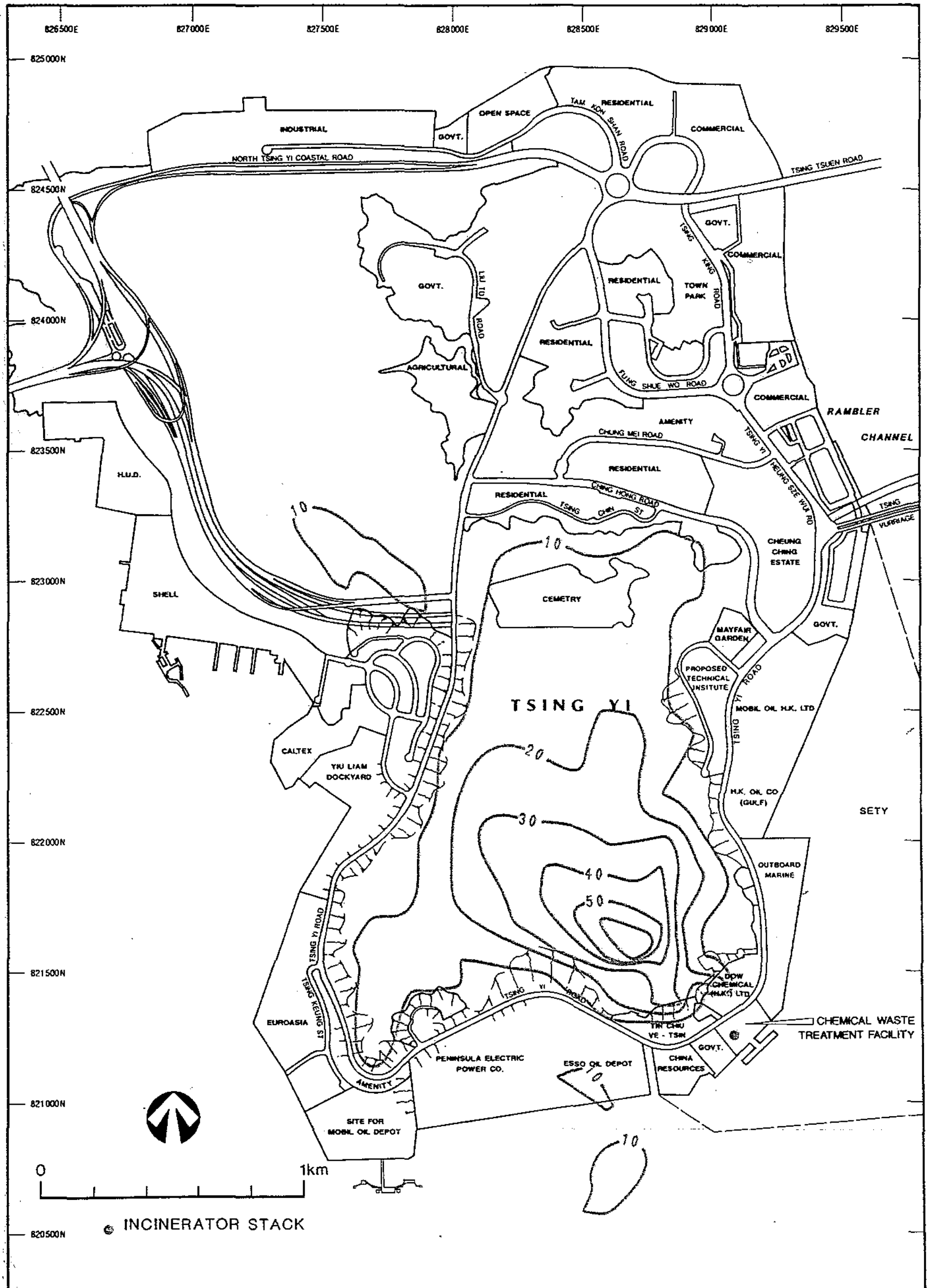
PREDICTED 1-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m³ FOR A RECEPTOR HEIGHT OF 90m

FIGURE B10
DAMES & MOORE



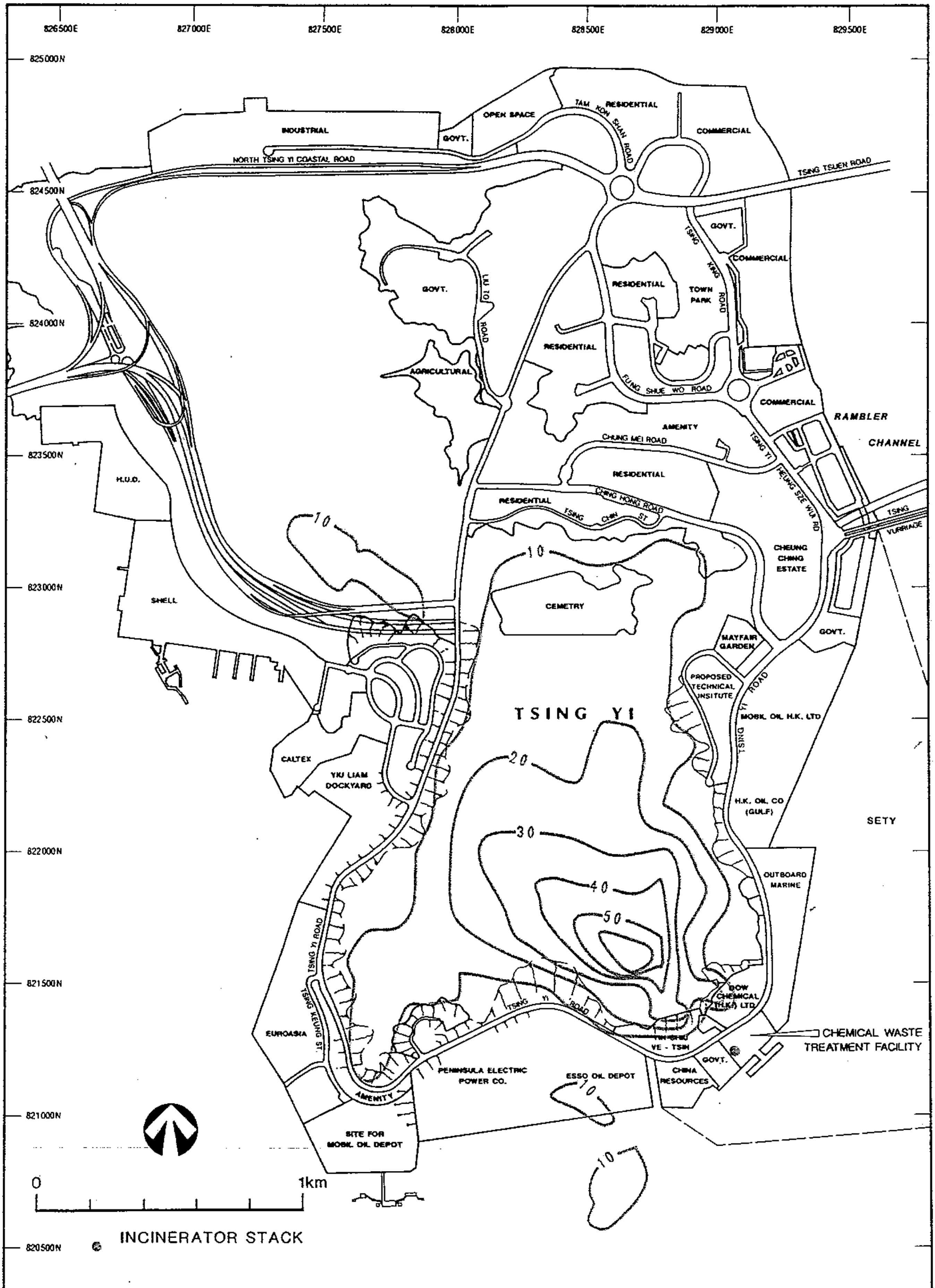
PREDICTED 1-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m³ FOR A RECEPTOR HEIGHT OF 100m

FIGURE B11
DAMES & MOORE



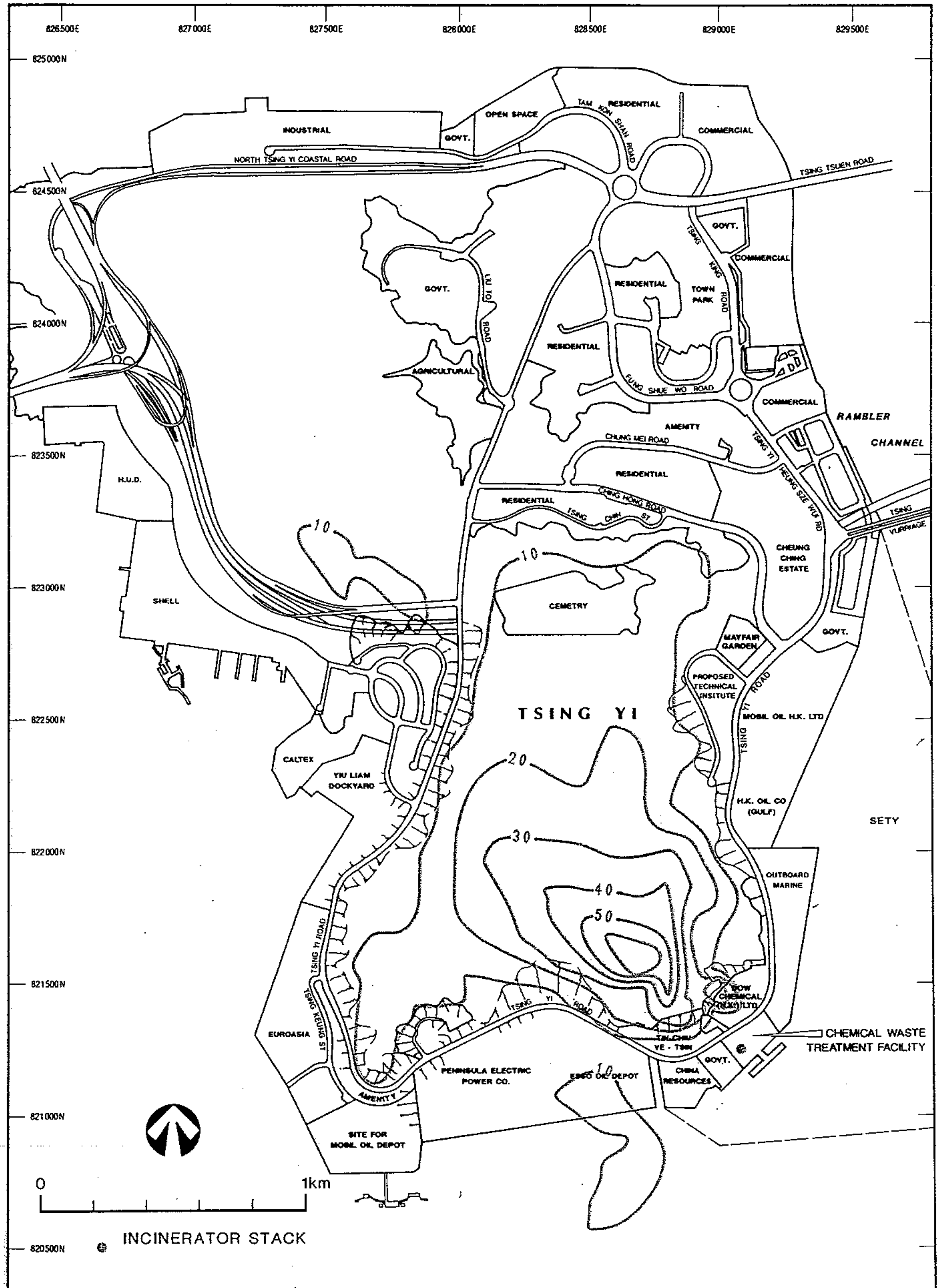
PREDICTED 24-HOUR AVERAGE GROUNDLEVEL CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m³

FIGURE B12
DAMES & MOORE



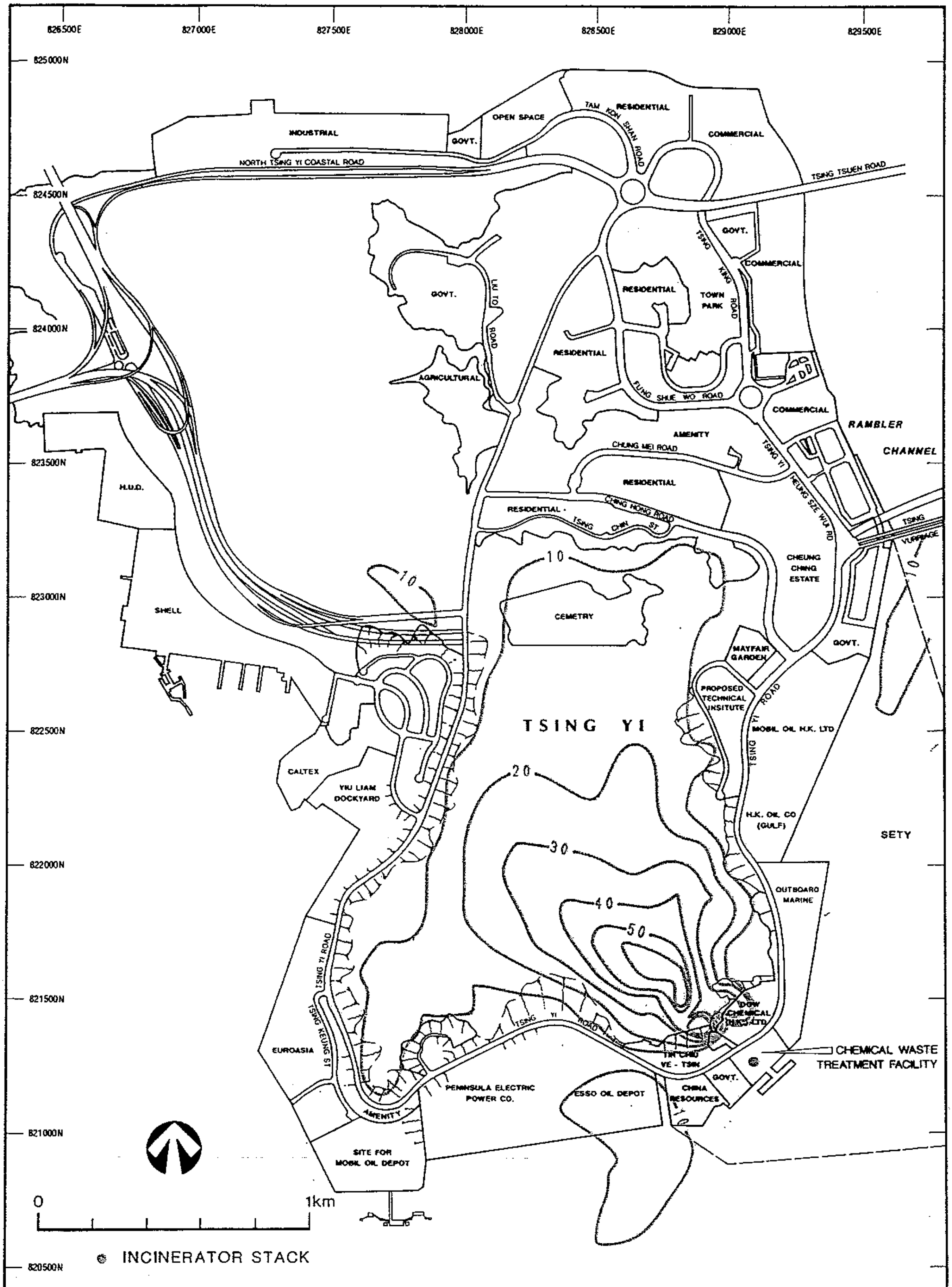
PREDICTED 24-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 10m

FIGURE B13
DAMES & MOORE



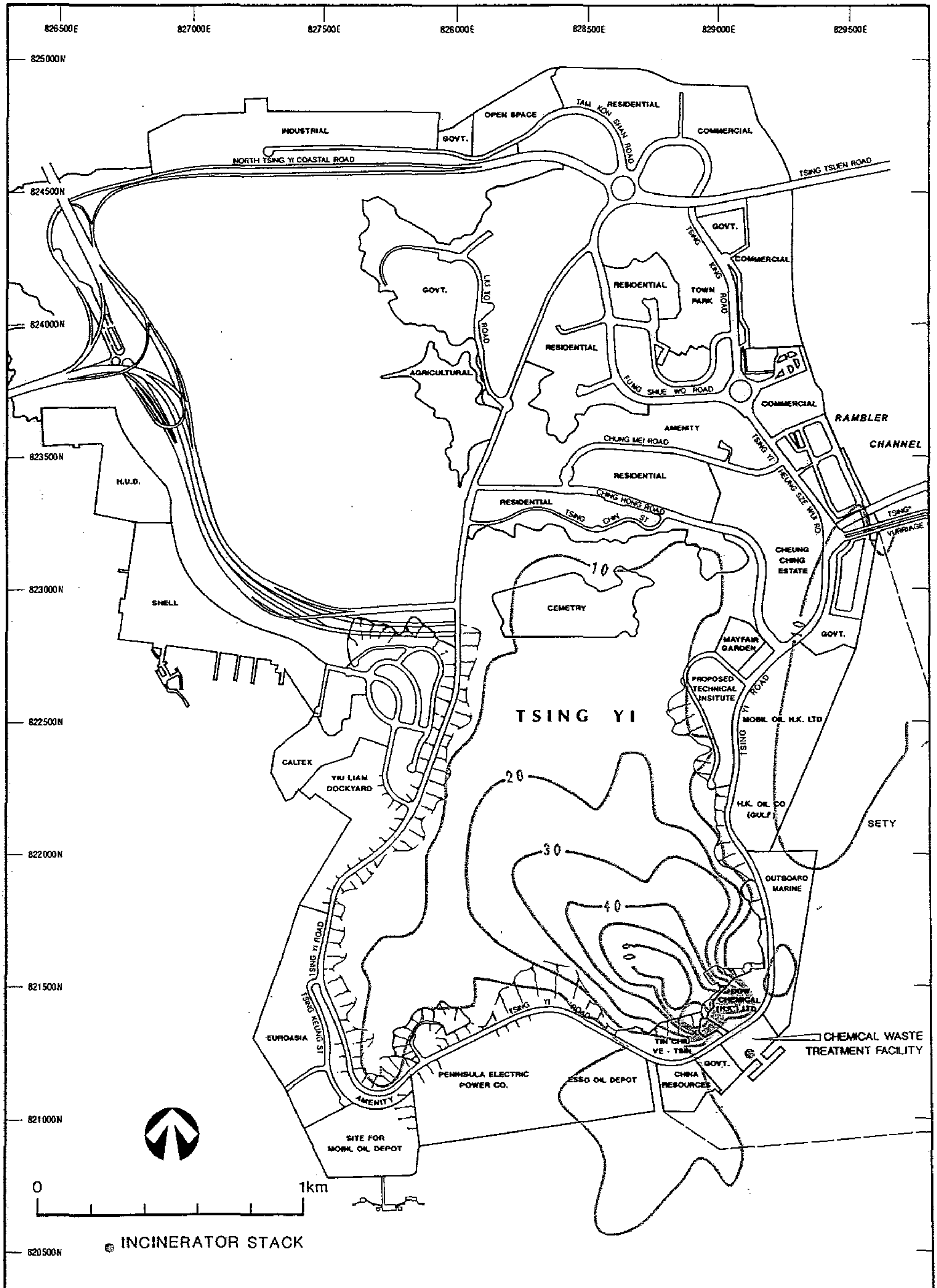
PREDICTED 24-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 20m

FIGURE B14
DAMES & MOORE



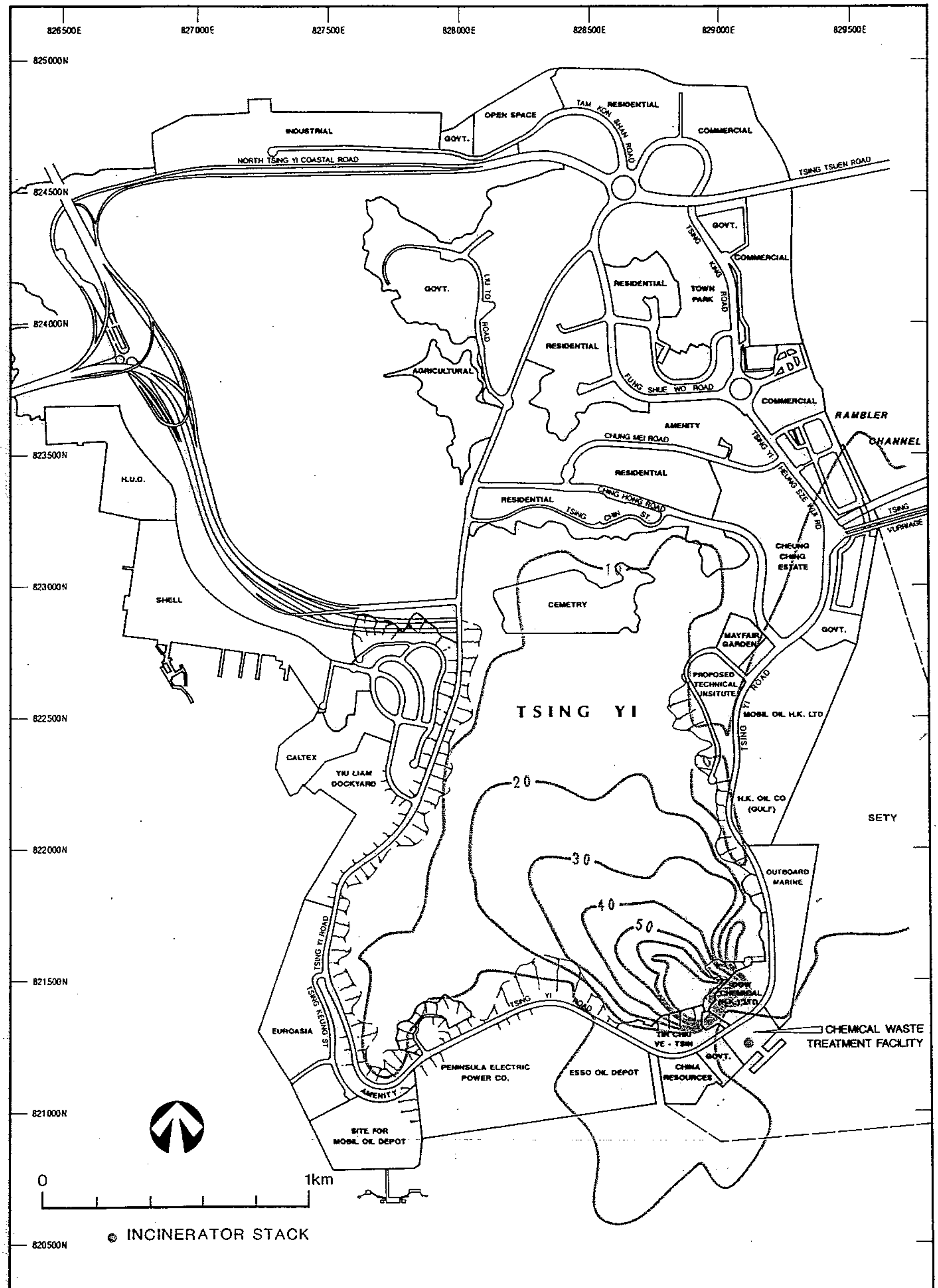
PREDICTED 24-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 30m

FIGURE B15
DAMES & MOORE



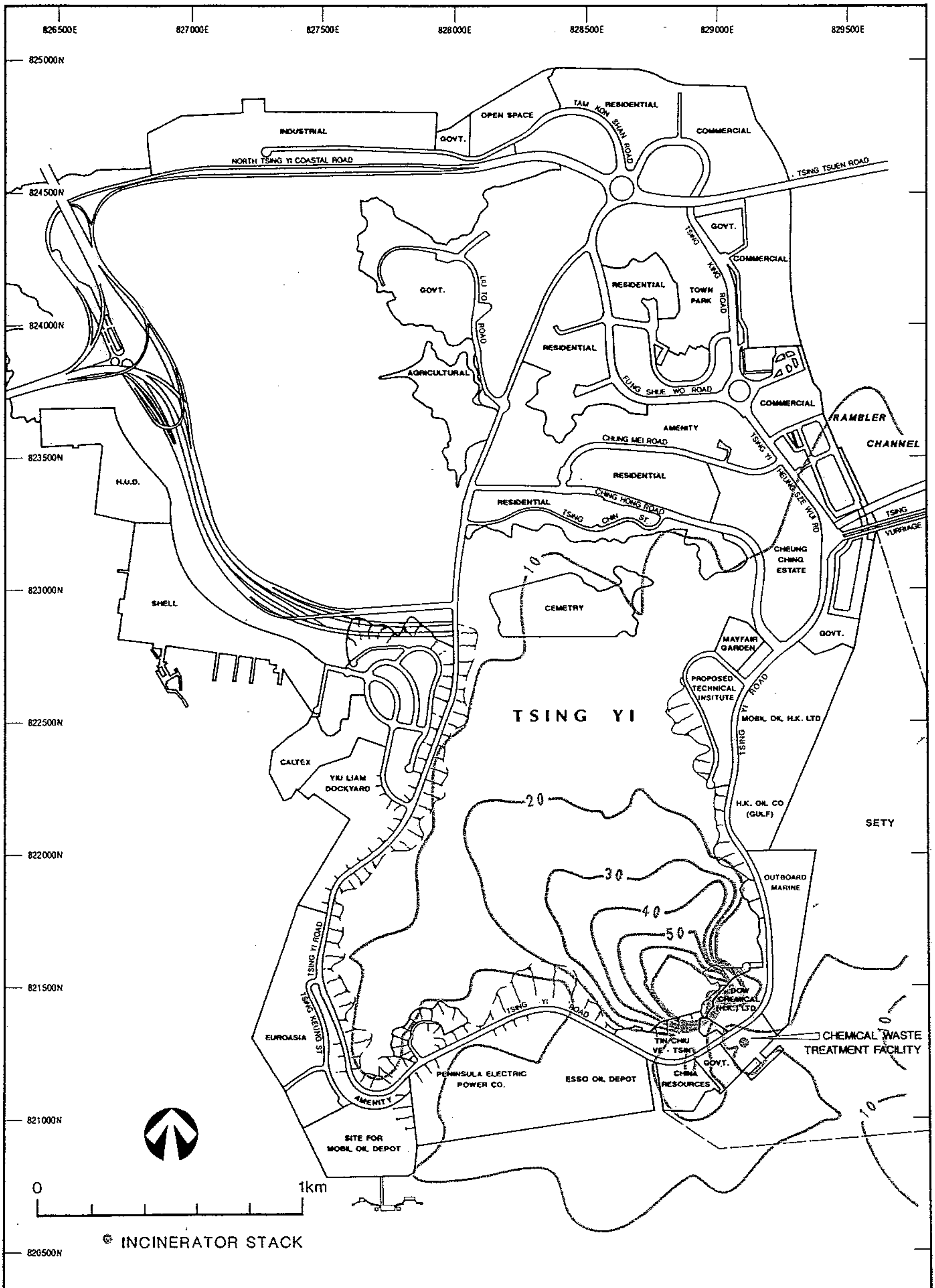
PREDICTED 24-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 40m

FIGURE B16
DAMES & MOORE



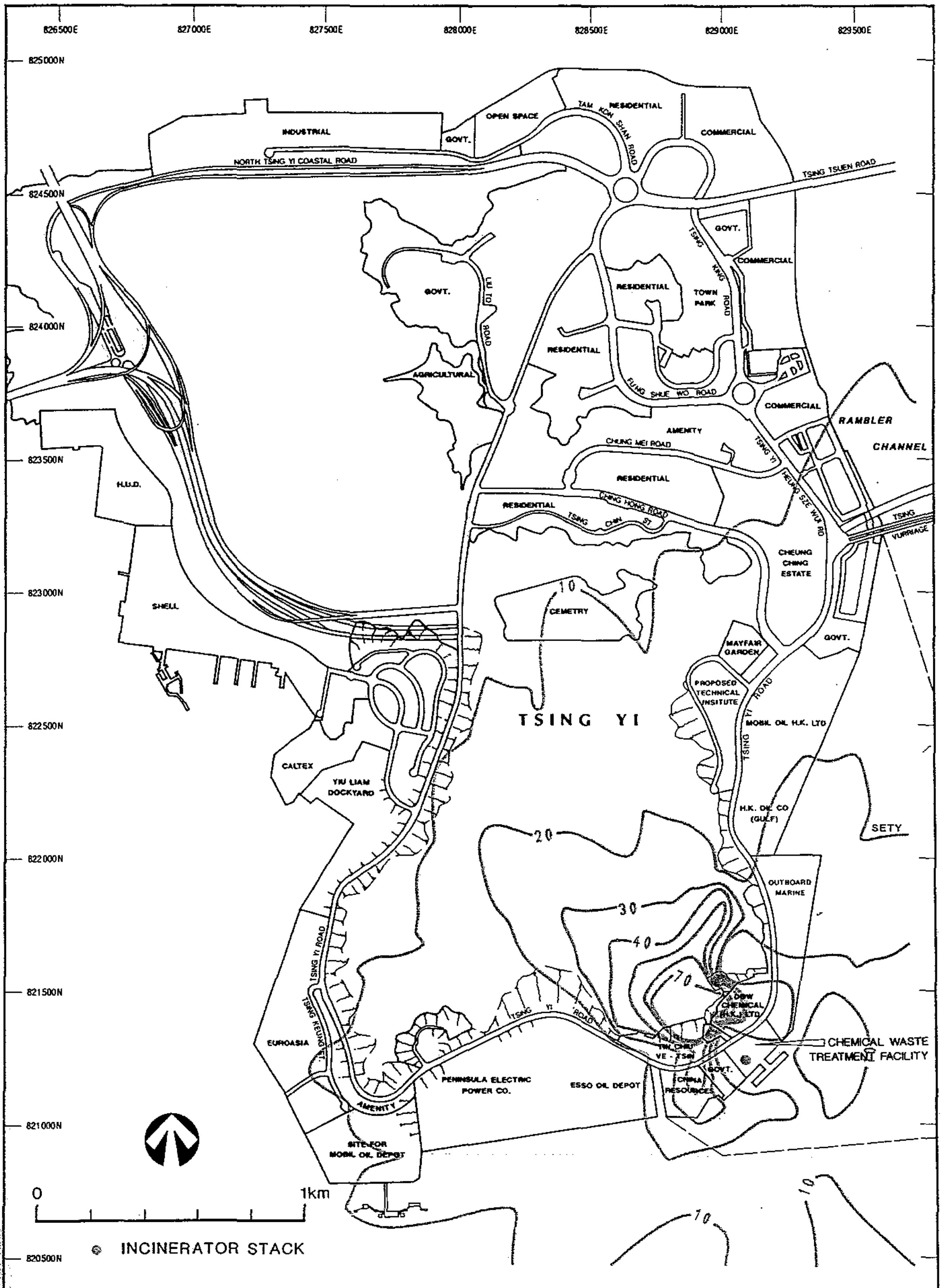
PREDICTED 24-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m³ FOR A RECEPTOR HEIGHT OF 50m

FIGURE B17
DAMES & MOORE



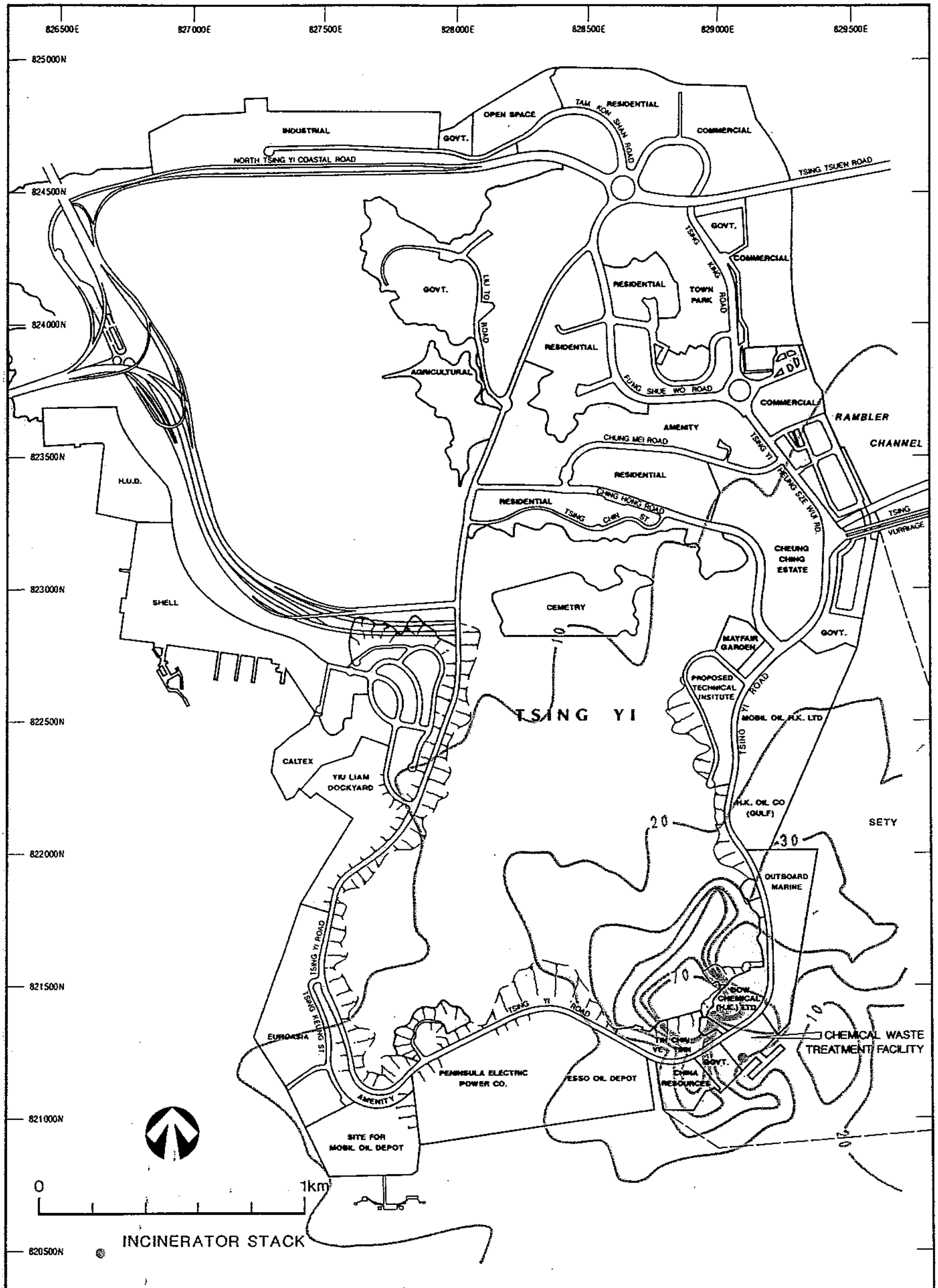
PREDICTED 24-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 60m

FIGURE B18
DAMES & MOORE



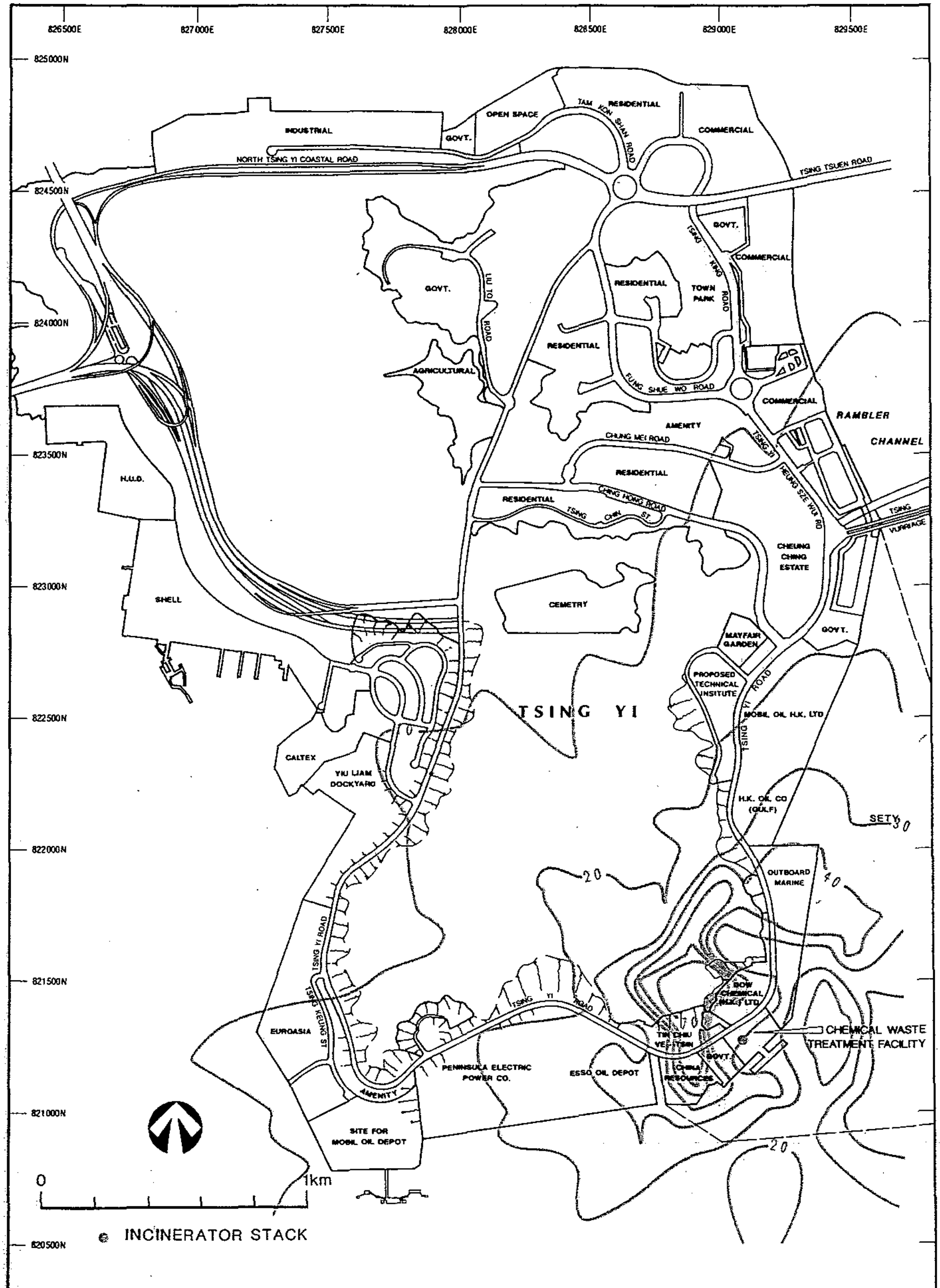
PREDICTED 24-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 70m

FIGURE B19
DAMES & MOORE



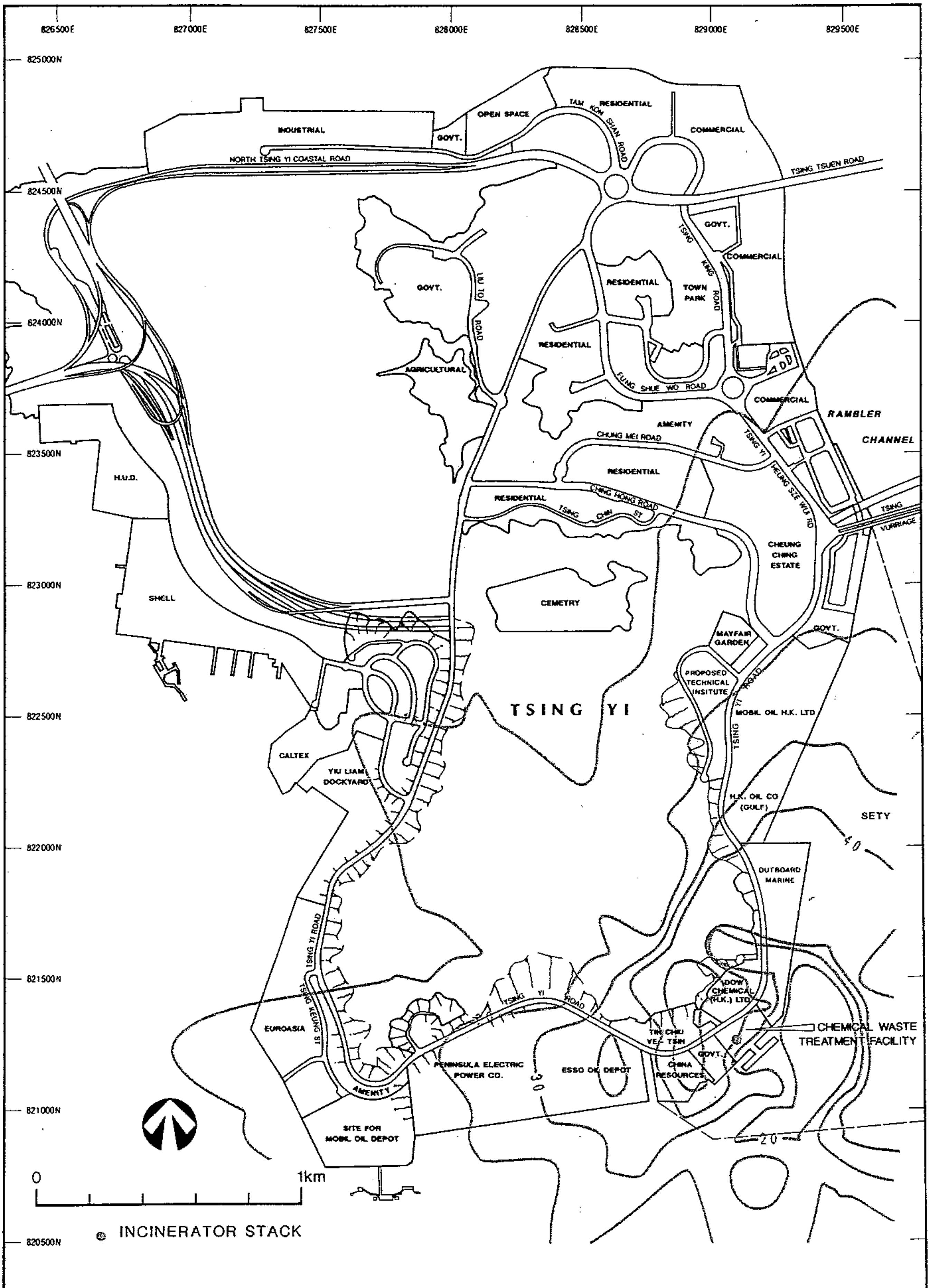
PREDICTED 24-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 80m

FIGURE B20
DAMES & MOORE



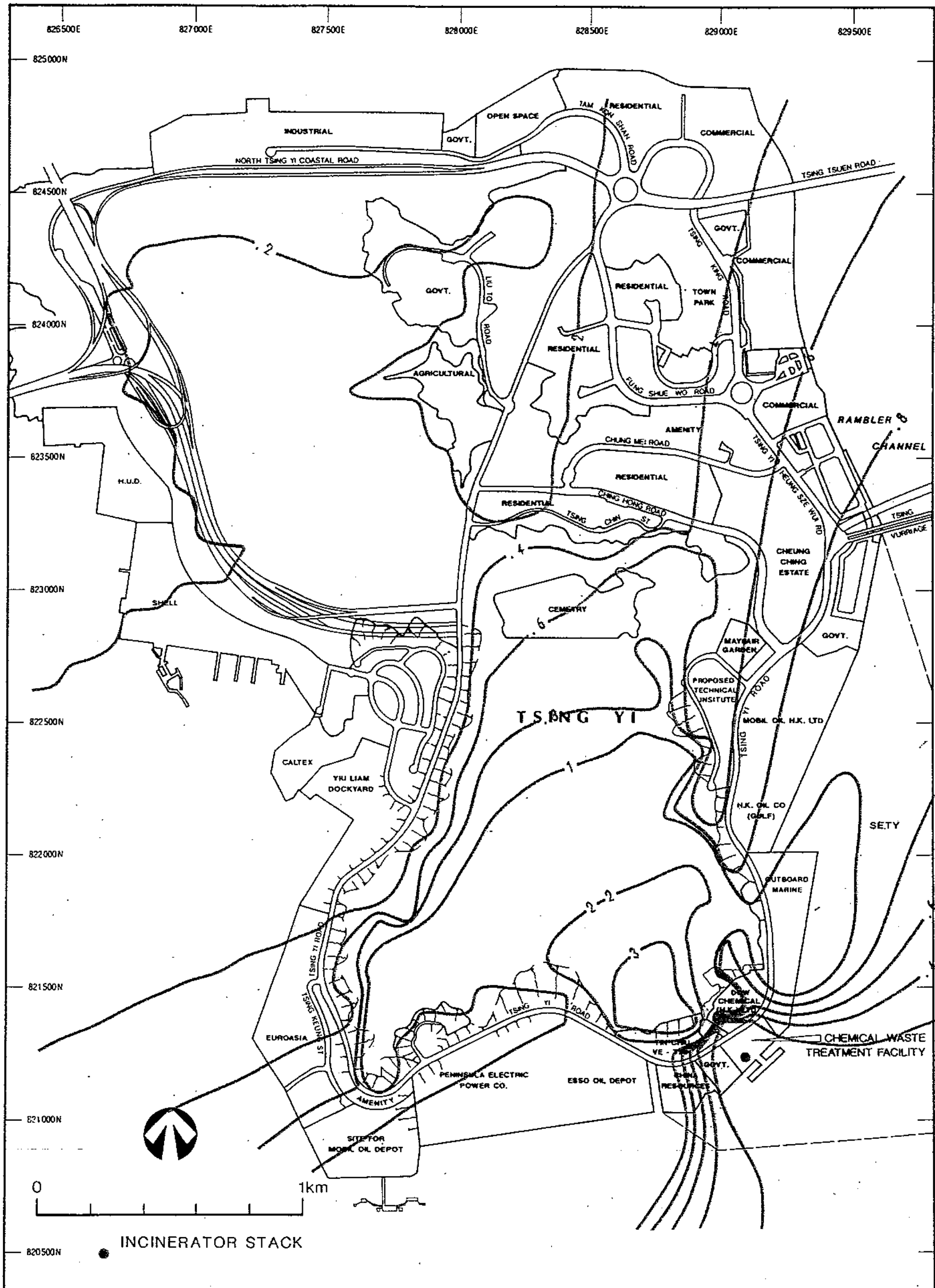
PREDICTED 24-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m³ FOR A RECEPTOR HEIGHT OF 90m

FIGURE B21
DAMES & MOORE



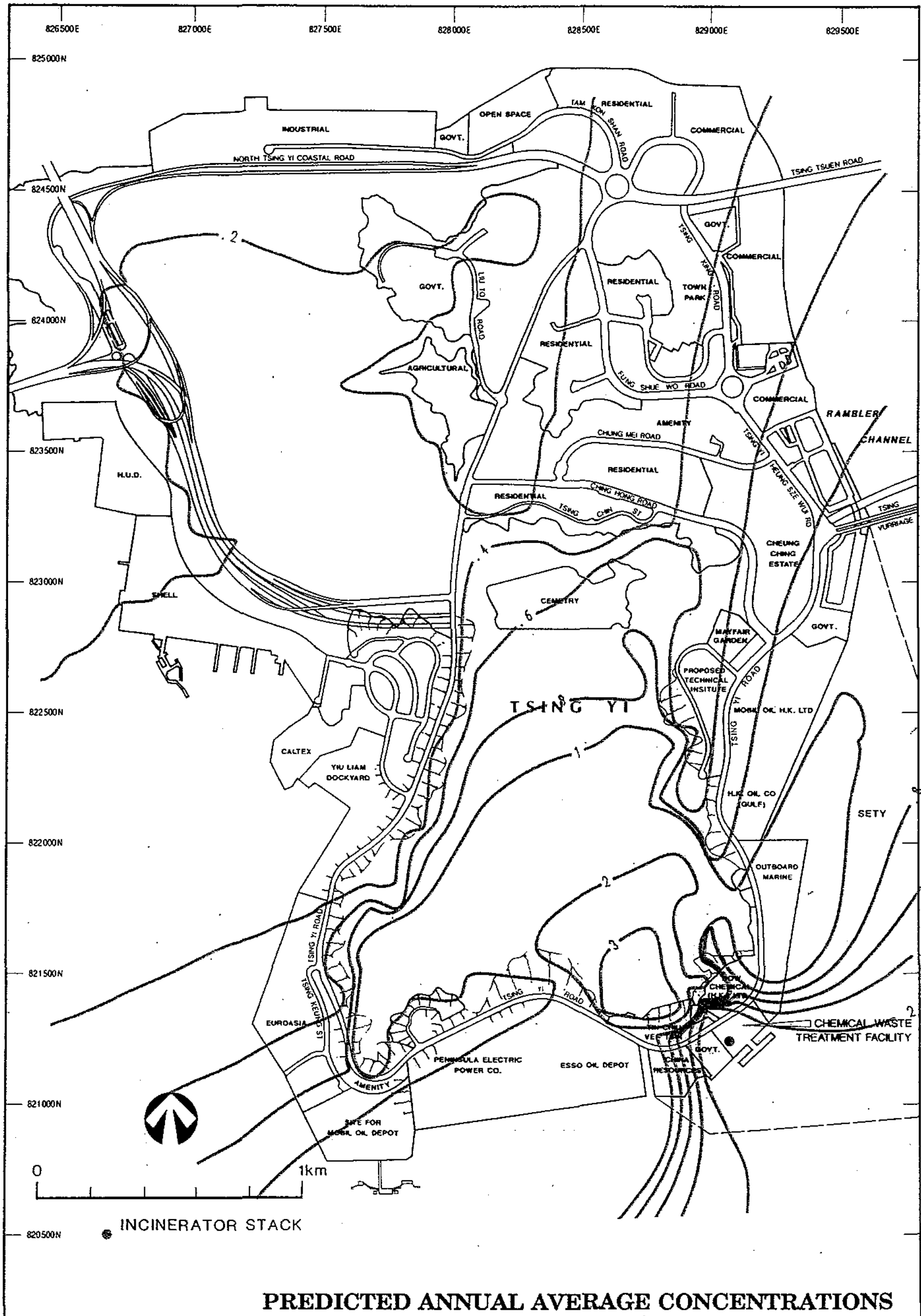
PREDICTED 24-HOUR AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 100m

FIGURE B22
DAMES & MOORE



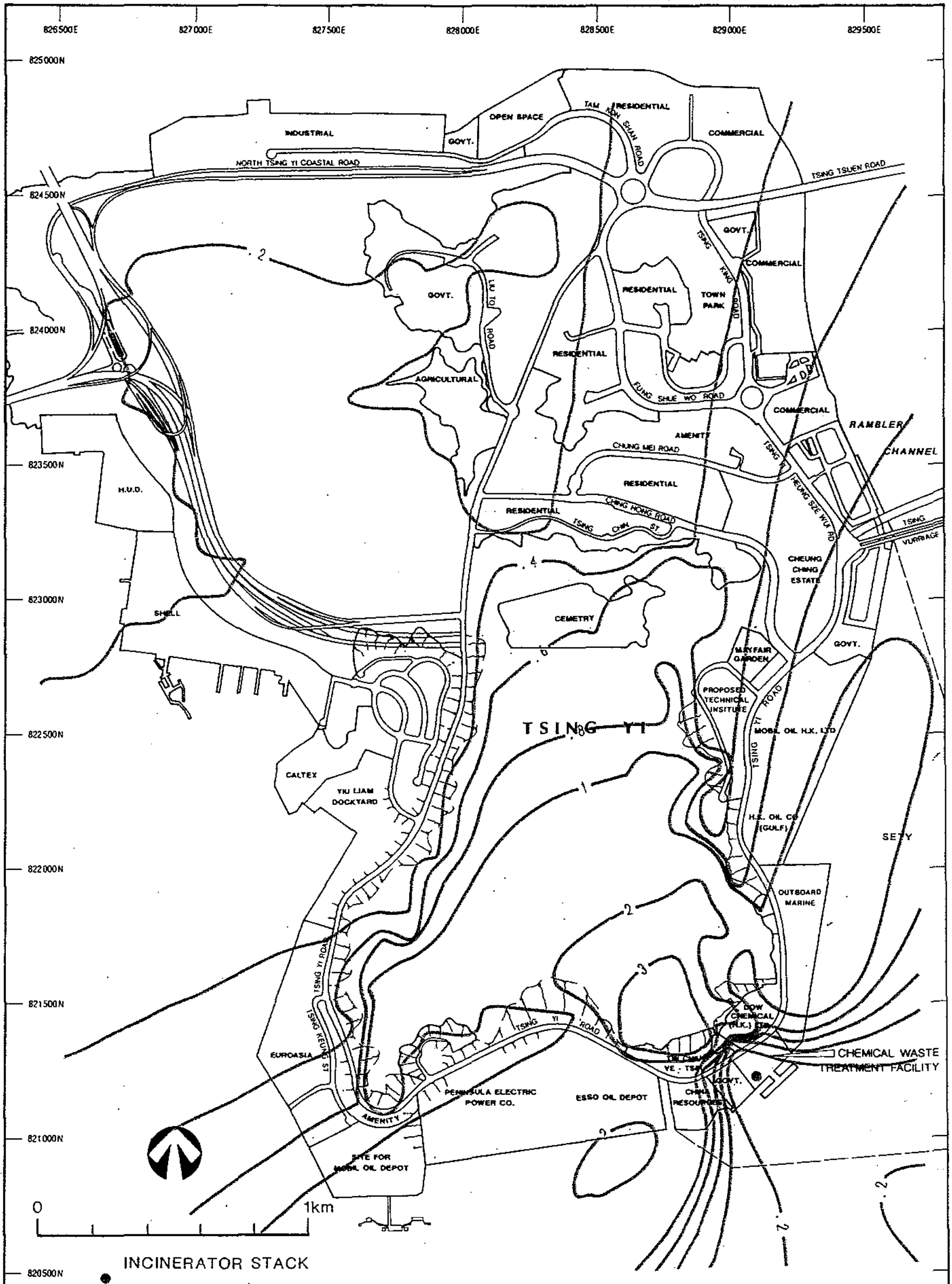
PREDICTED ANNUAL AVERAGE GROUNDLEVEL CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3

FIGURE B23
DAMES & MOORE



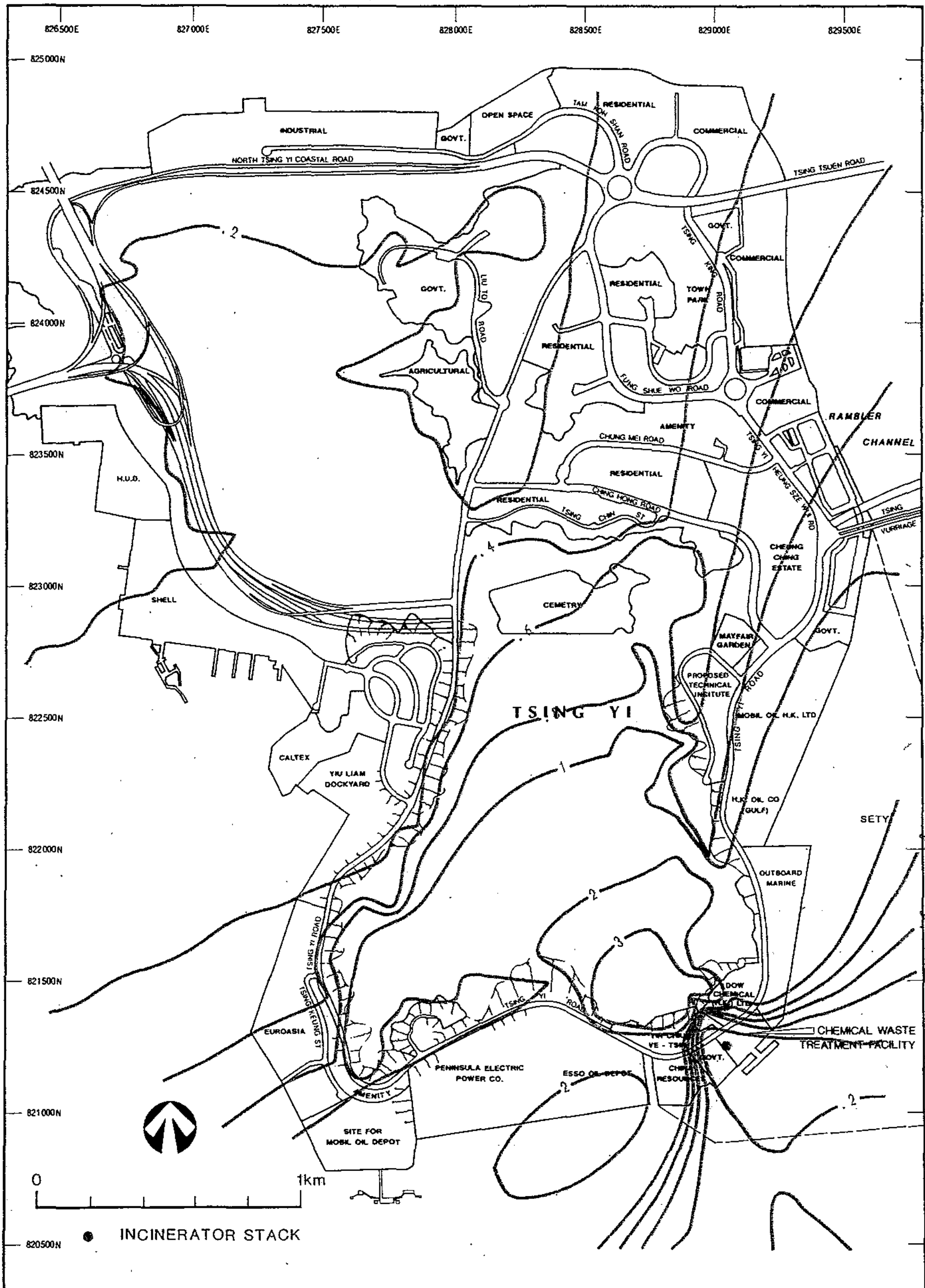
PREDICTED ANNUAL AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m³ FOR A RECEPTOR HEIGHT OF 10m

FIGURE B24
DAMES & MOORE



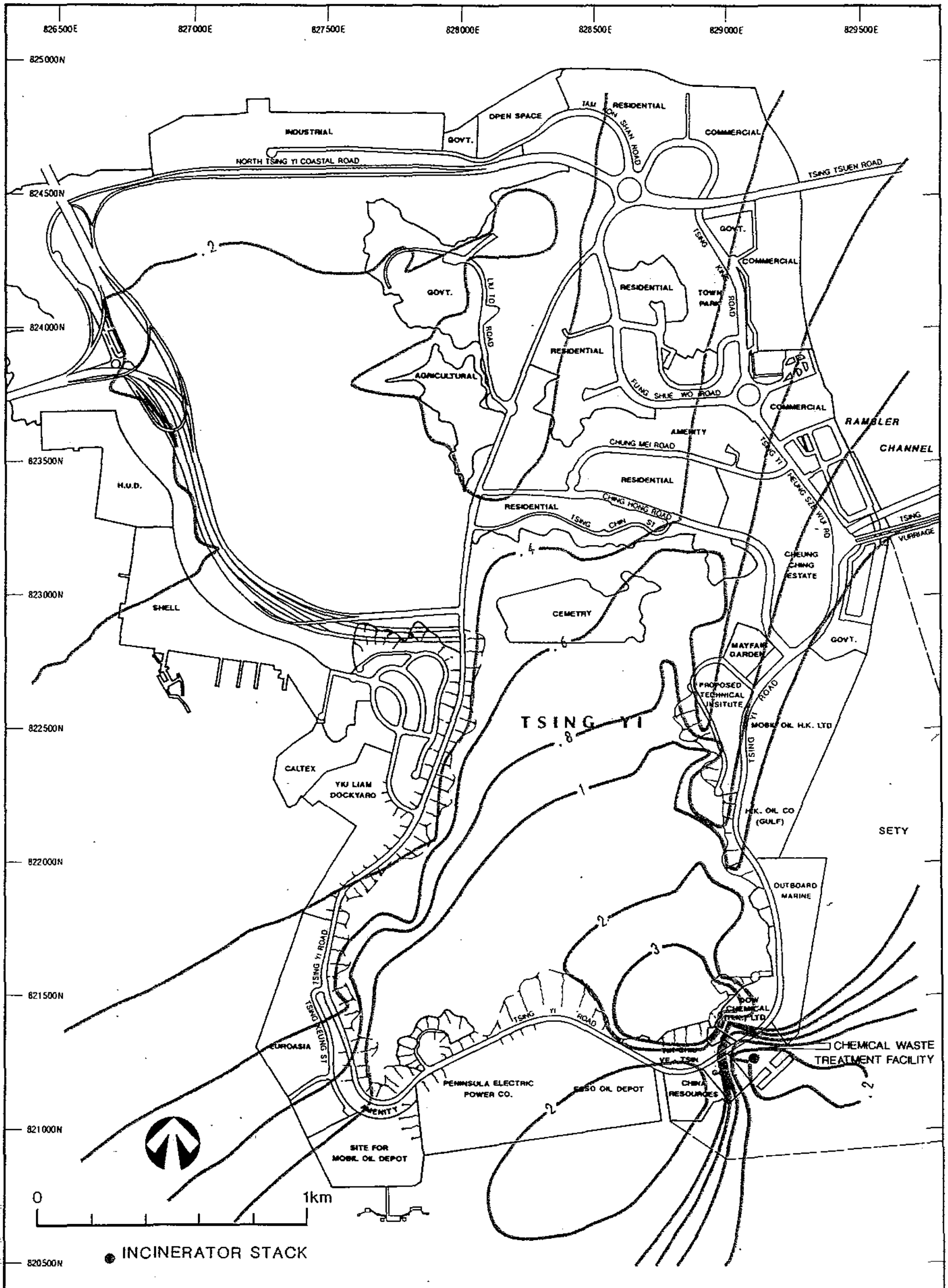
PREDICTED ANNUAL AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 20m

FIGURE B25
DAMES & MOORE



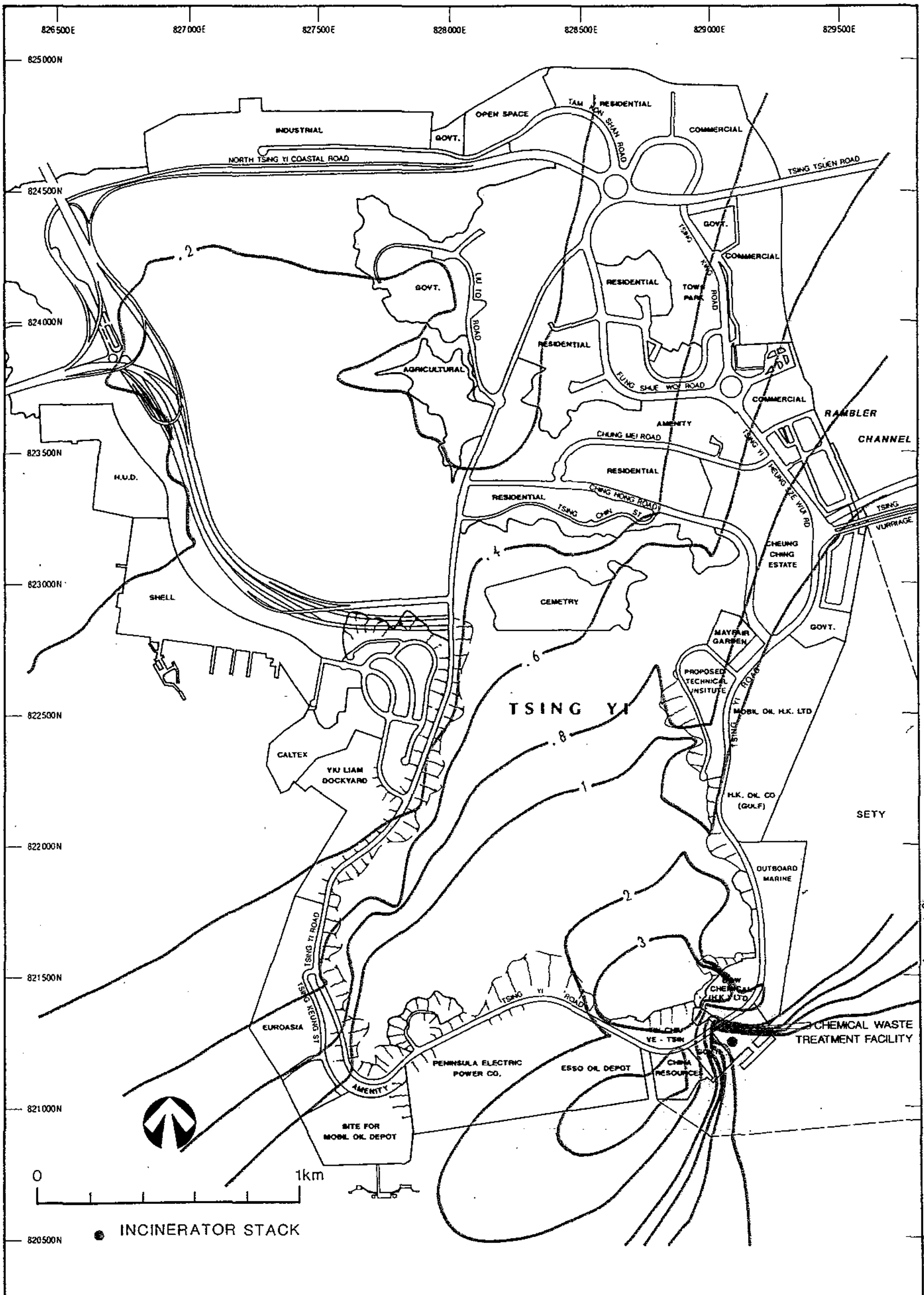
PREDICTED ANNUAL AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 30m

FIGURE B26
DAMES & MOORE



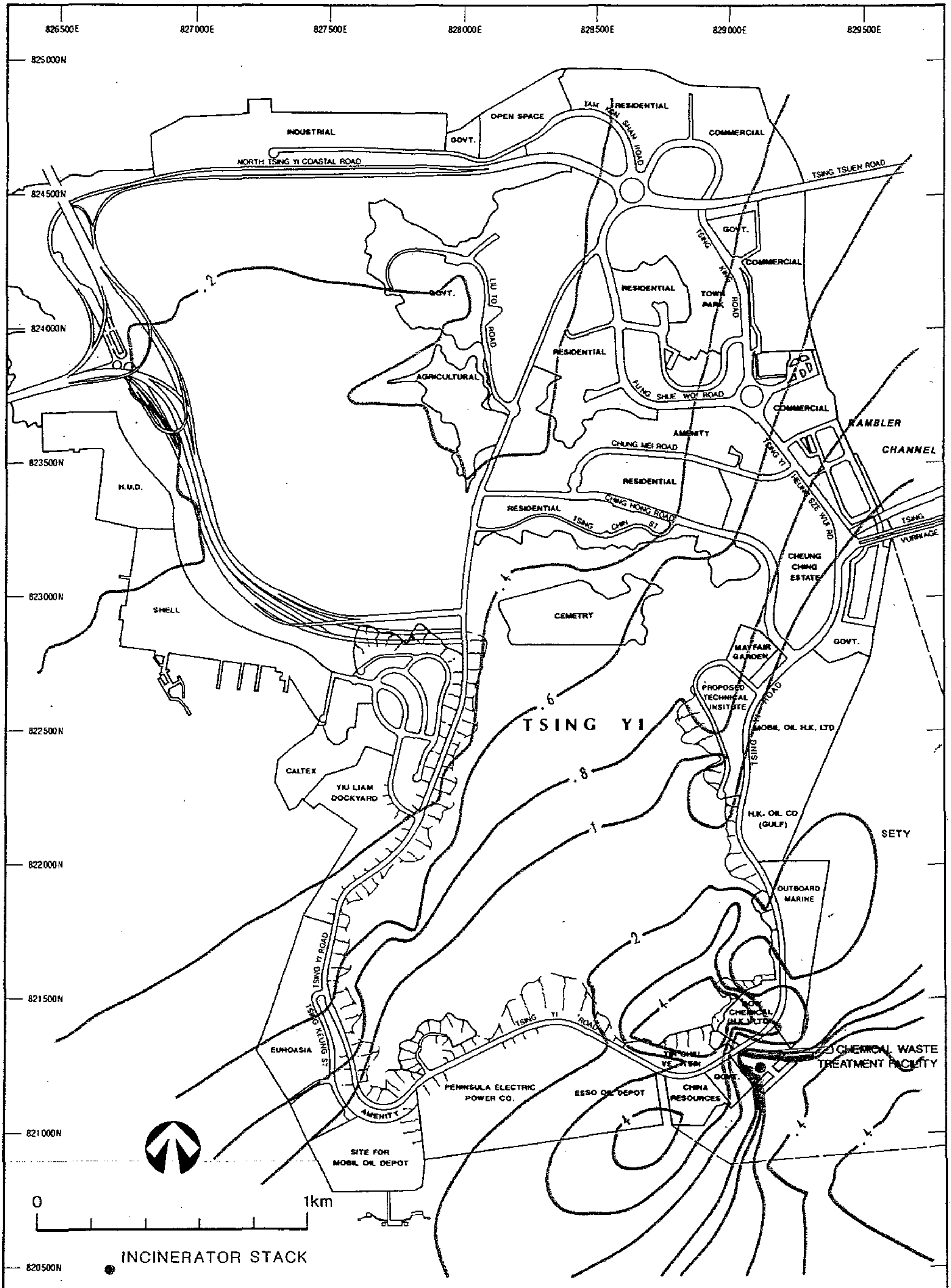
PREDICTED ANNUAL AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 40m

FIGURE B27
DAMES & MOORE



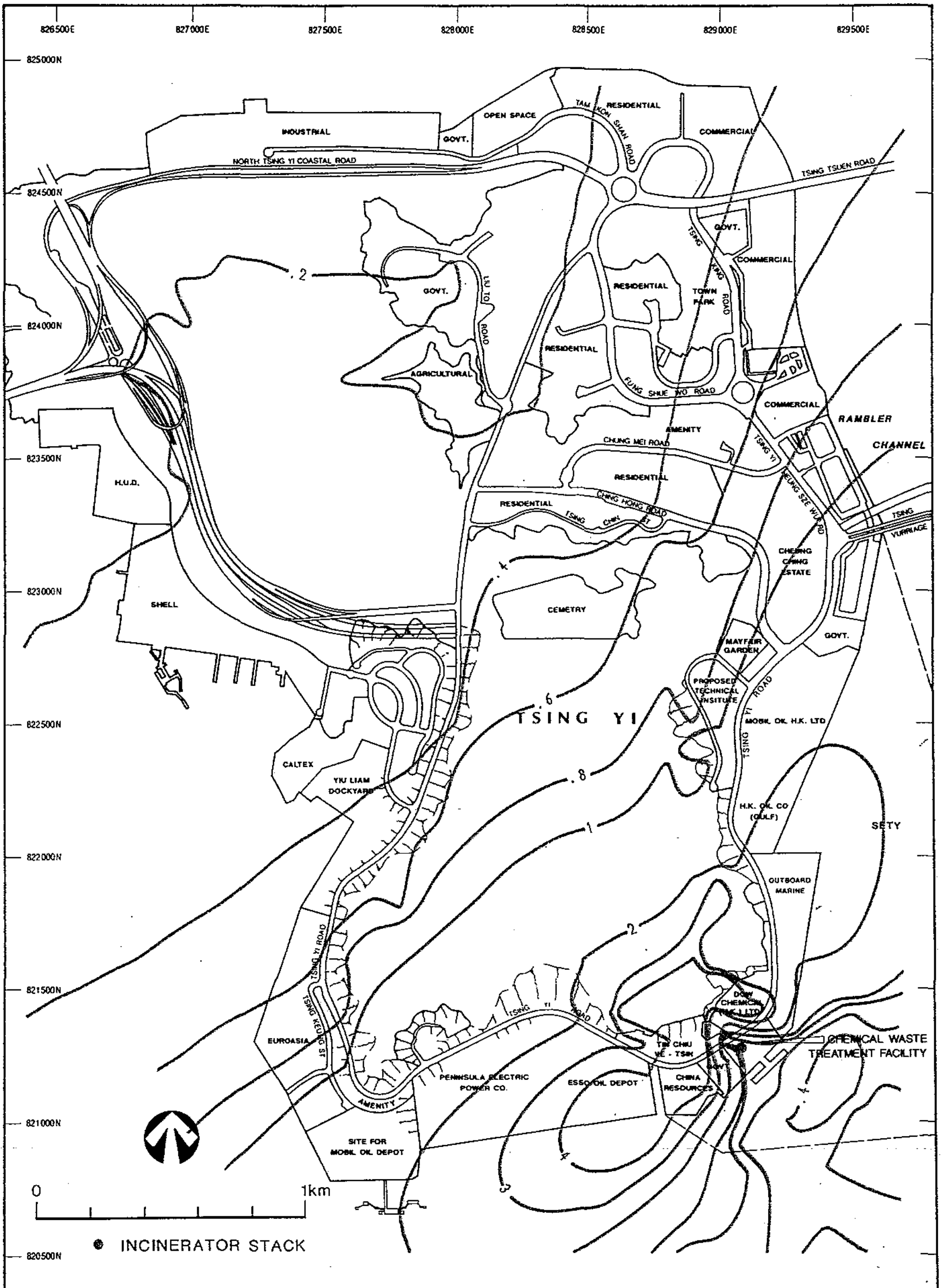
PREDICTED ANNUAL AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 50m

FIGURE B28
DAMES & MOORE



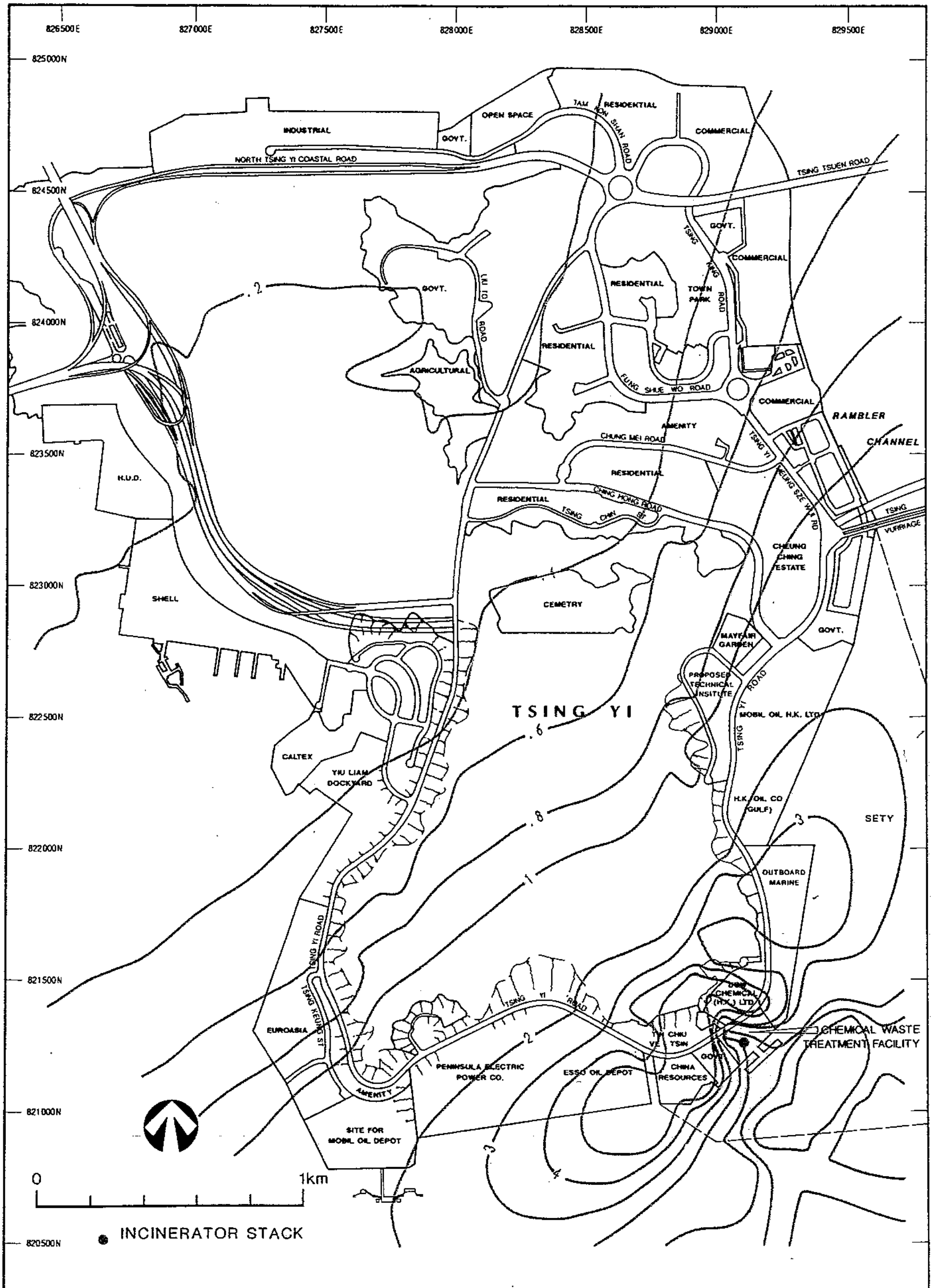
PREDICTED ANNUAL AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m³ FOR A RECEPTOR HEIGHT OF 60m

FIGURE B29
DAMES & MOORE



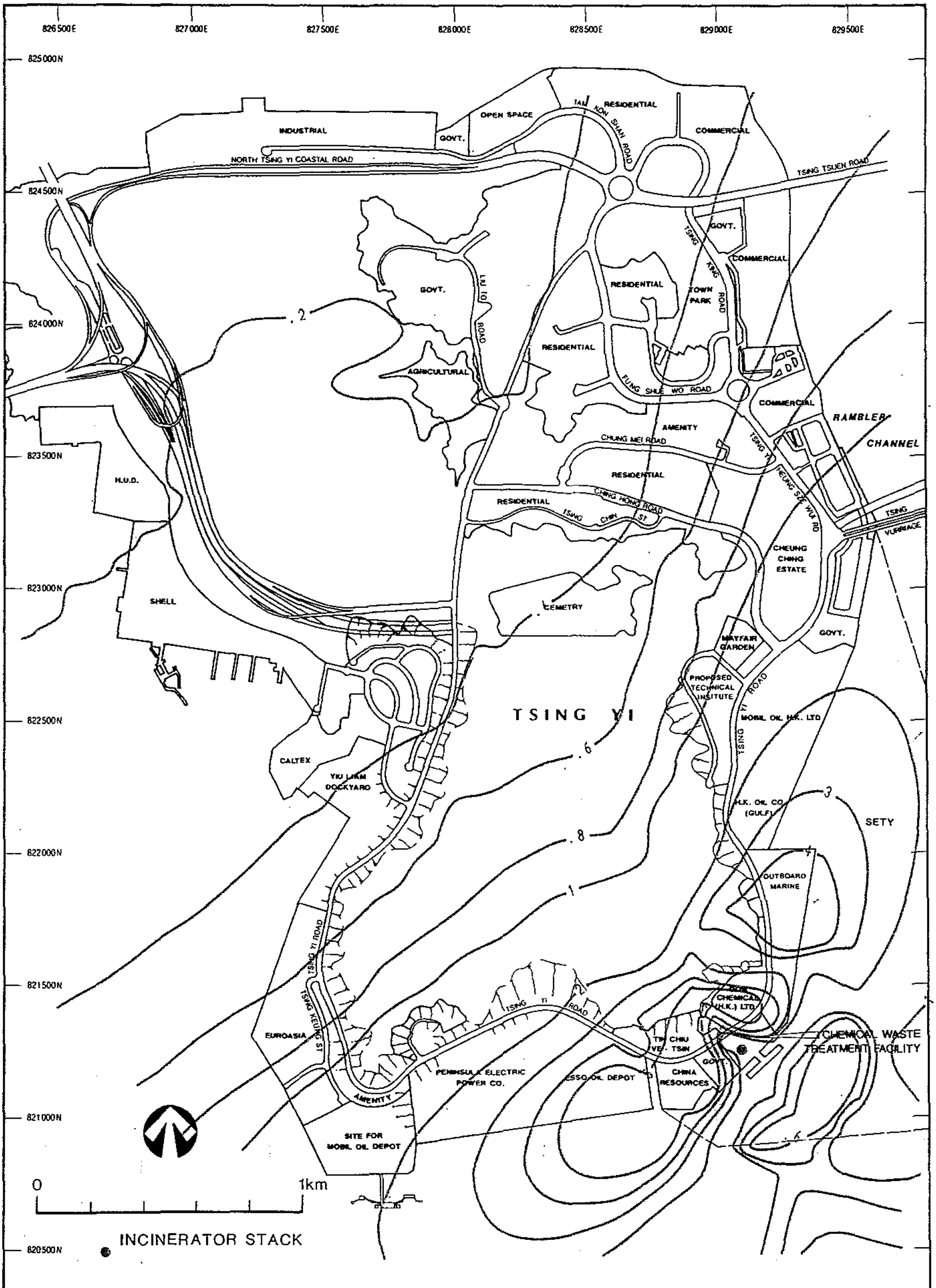
PREDICTED ANNUAL AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 70m

FIGURE B30
DAMES & MOORE



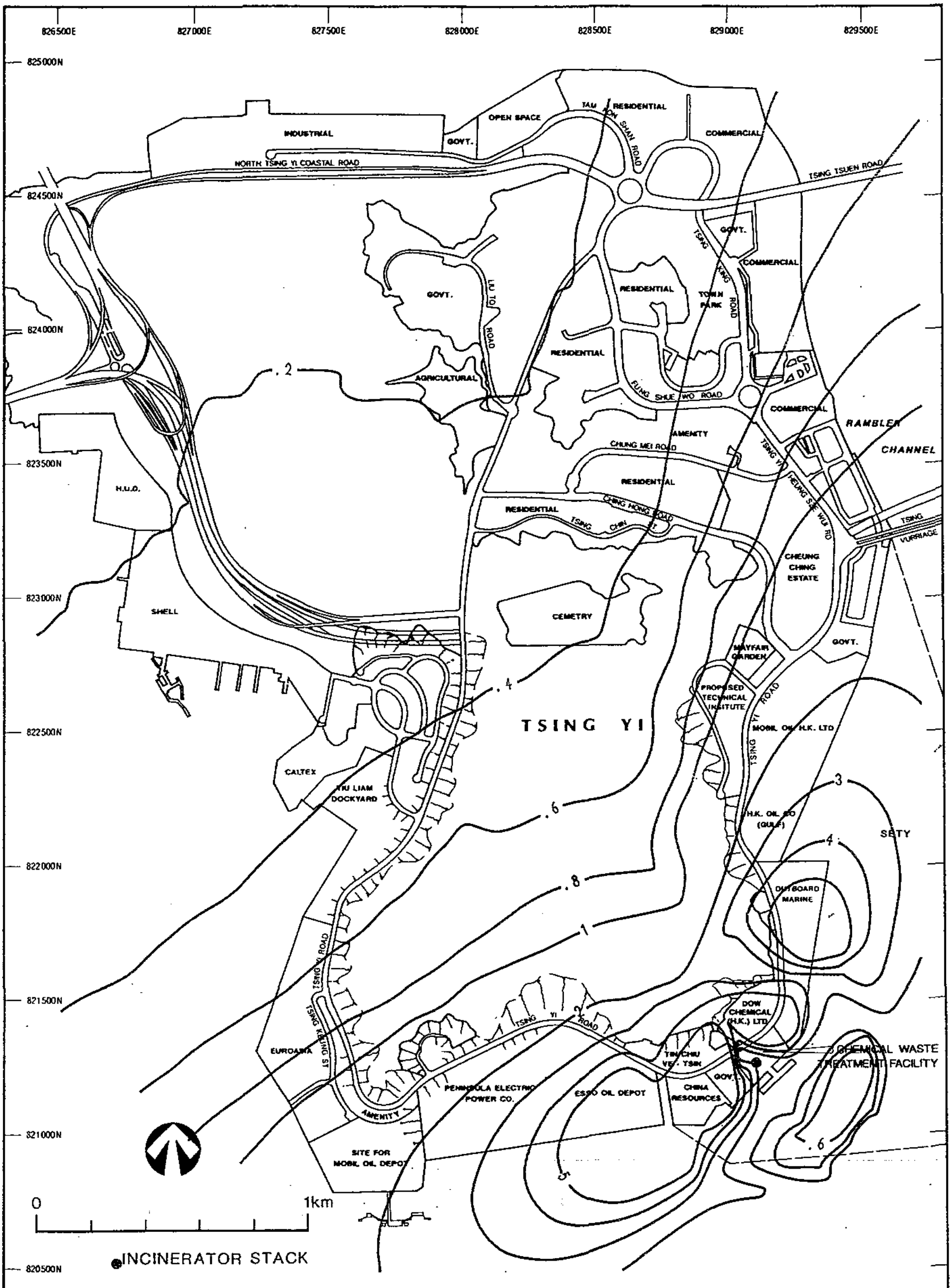
PREDICTED ANNUAL AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 80m

FIGURE B31
DAMES & MOORE



PREDICTED ANNUAL AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m^3 FOR A RECEPTOR HEIGHT OF 90m

FIGURE B32
DAMES & MOORE



PREDICTED ANNUAL AVERAGE CONCENTRATIONS OF SULPHUR DIOXIDE IN ug/m³ FOR A RECEPTOR HEIGHT OF 100m

FIGURE B33
DAMES & MOORE

APPENDIX C

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APPENDIX C

EMERGENCY SHUTDOWN CONTROL SYSTEM

The incineration system will be equipped with six ESCS (emergency shutdown control systems) which activate emergency shutdown procedures for the incinerator when any one of the following emergency situations occur:

(1) primary and secondary system electrical power outage;
(2) primary failure of the ID fan driver;
(3) failure of primary and secondary excessive baghouse inlet temperature;
(4) loss of boiler water supply;
(5) spray dryer failure; and
(6) loss of water supply.

The following discussions elaborate the emergency shutdown procedures required by the ESCS:

<u>Primary and Secondary System Electrical Power Outage</u>

If there is a loss of primary electric power, the ESCS will automatically activate the following sequences:

- o an alarm is activated and the emergency generator is started;
- o the emergency power is applied to the ID fan;
- o all waste feed systems are shut down; and
- o critical systems are restarted.

The incineration system continues to operate within controlled temperature limits until the waste in the kiln has been combusted. After that time, the incineration system may be safely shut down until the primary electrical power supply has been restored.

If primary and secondary power sources have both failed, the ID fan will be shut off. The operator's response will be to ascertain and repair the cause of the problem and report the incident.

<u>Primary Failure of the ID Fan Driver</u>

If the primary ID fan driver fails, the ESCS will automatically activate the following responses:

- o all waste feeds will be shut off;
- o all combustion air fans will be shut off;
- o an alarm will be activated; and

- o once normal operating conditions have been established, the operator may reinstate waste feeds.

The ID fan will be shut off and the fan damper opened. The operator's response will be to ascertain and repair the cause of the problem and report the incident.

Failure of Primary and Secondary Excessive Baghouse Inlet Temperature

If the primary excessive temperature exceeds 260°C for the baghouse inlet gases, the ESCS will activate the following responses:

- o an alarm will be activated and the emergency water supply system will activate; and
- o all waste feeds will be shut off.

The incineration system continues to operate within controlled temperature limits until the waste in the kiln has been combusted. After that time, if repairs are required to the process water system, the incineration system will safely be shutdown.

The emergency water system will add sufficient additional water to the spray dryer to lower the baghouse inlet temperature to safe levels until the system is restored to normal operation. The emergency water supply will continue until the high temperature condition no longer exists or until the emergency water supply has been exhausted. The emergency water tank will hold a minimum of a 15 minute emergency water supply.

If secondary excessive temperature exceeds 274°C for the baghouse inlet gases, the following additional steps will be taken:

- o the ID fan will be shut off and the fan damper opened; and
- o the combustion air blowers will be shut off.

The operator's response will be to ascertain and repair the cause of the problem and report the incident.

Loss of Boiler Water Supply

If the feedwater supply to the waste heat boiler stops, the ESCS will activate the following responses:

- o all waste feeds will be shut off;
- o an alarm will be activated, and the backup boiler feedwater pump started up

The operator's response will be to ascertain and repair the cause of the problem and report the incident.

Spray Dryer Failure

If there is a loss of water and lime slurry flow, or compressed air flow to the spray dryer, the ESCS will activate the following responses:

- o all waste feeds will be shut off;
- o an alarm will be activated and the emergency water supply system will activate; and
- o depending upon the reason for the spray dryer failure the operator will activate the backup lime slurry or water pumps, or the alternate air compressor.

The operator's response will be to then ascertain and repair the cause of the problem and report the incident.

Loss of Water Supply

If there is a loss of all water supply to the incineration system, the ESCS will activate the following responses:

- o all waste feeds will be shut off;
- o an alarm will be activated and the ID fan will be shut off, and the fan damper opened;
- o all combustion air blowers will be shut off;
- o depending upon the reason for the loss of water supply either the emergency generator will be started up or the backup water supply pumps will be activated.

The operator's response will be to then ascertain and repair the cause of the problem and to report the incident.

APPENDIX D

APPENDIX D

RECOMMENDED OPERATING PROCEDURES FOR SOIL AND GROUNDWATER CONTAMINATION ASSESSMENT

1.0 INTRODUCTION

The following description outlines a recommended programme of work to determine the environmental condition of the CWTF site. The programme recommends a detailed investigation and would be additional to the investigative survey specified in the Contract. Elements of the investigative survey and the recommended study could proceed in parallel. This issue was discussed between the EPD and Enviropace on several occasions during the EIA/HA process.

2.0 SELECTION OF SAMPLING LOCATIONS

General operating procedures are presented for field operations. Detailed procedures should need to be developed prior to undertaking the fieldwork.

Sampling locations should be selected on the basis of locations of sources of potential contaminations, expected direction of groundwater movement and site geometry. The following site investigation borehole layout has been developed on the information available to date:

- one in each of the corners of the site; and
- two on the landward (northern) site boundary (i.e. upgradient)

Since it is expected that the contaminants would be transported by groundwater, sampling should be concentrated on groundwater sampling.

The locations of each bore and the surface elevations at each location should be located by survey using an appropriate local grid reference system and datum.

3.0 SAMPLING AND INVESTIGATION

3.1.1 Equipment

A drill rig equipped with hollow flight augers, and split spoon SPT sampler is recommended. Water depth measuring equipment, sampling containers and borelog sheets are also required.

3.1.2 Sampling Procedure

One soil sample is recommended for each location. The sample should be placed in a correctly cleaned jar and preserved and shipped as described below. A minimum of 100 grams of soil is recommended for analysis.

The sample must be immediately transferred to a sampling jar, the jar sealed and then stored in a cooled esky. Sample Record and Chain of Custody forms are also to be filled out.

3.1.3 Sampling Intervals

There are no specific sampling depths set for soil samples, but it is recommended that one sample should be collected in each borehole at approximately 0.5m above the watertable. However, the presence of visual contamination will determine and control the sample depth.

3.2 GROUNDWATER LEVEL MEASUREMENTS

Groundwater levels should be routinely measured in all investigation boreholes and any other existing bores on site. Groundwater levels should be measured prior to any water sampling. Depths to groundwater should be referenced to the existing ground surface. The date and time of all groundwater level measurements should be recorded.

3.3 GROUNDWATER SAMPLING

Groundwater sampling should be undertaken from each of the contamination assessment boreholes and each of the monitoring wells.

3.6 SAMPLE HANDLING

3.6.1 Soil Sample

All containers used for the collection of samples must be cleaned using detergent, water rinsed, and solvent washed as appropriate prior to use. Soil samples of a minimum of 100 grams must be stored in a glass jar, with teflon wrapped around the screw thread and fitted with a cap. Unfilled pockets within the jar must be minimised and exposure to the air should be minimised to prevent loss of volatiles.

3.6.2 Water Samples

All containers used for the collection of samples must be cleaned using detergent, water rinsed, and solvent washed as appropriate prior to use. Water samples of a minimum of 500 mls must be stored in a glass jar, with telfon wrapped around the screw thread and fitted with a cap. Care must be taken to completely fill the jar and exposure to the air should be minimised to prevent loss of volatiles.

3.6.3 Storage

Upon completion of sample collection, all samples must be placed in an cooled esky for temporary storage and transportation to the laboratory. Samples should be forwarded to the laboratory for analysis as soon as possible.

3.6.4 Shipment of Samples

Samples must be placed in a cooled esky for preservation during shipment to the laboratory. All shipment containers are to be sealed and clearly addressed to the selected laboratory representative.

A Chain of Custody form must accompany each shipment of samples to the laboratory.

3.7 LABORATORY TESTING

Laboratory testing must be carried out on samples of soil and groundwater collected during the assessment. Both soil and groundwater should be tested for the following analytes using the detection limits listed:

ANALYTE	DETECTION LIMIT WATER (μg/L)	DETECTION LIMIT SOIL (mg/kg)
Benzene	1.0	0.1
Toluene	1.0	1.0
Xylene	1.0	1.0
Ethyl Benzene	1.0	1.0
Styrene Monomer	1.0	1.0
Total Petroleum Hydrocarbons	1000	10
C6-C9	200	10
C10-C15	200	10
>C15	200	50

The analytical procedures to be followed by the testing laboratory would be set out in a separate document titled "Analytical Protocols." This document would also specify laboratory quality control/quality assurance procedures.

3.4.2 Bore Construction

It is currently envisaged that the wells should be constructed using cable tool drilling techniques. The bores would be large enough to permit the installation of 80mm diameter Cass 9, PVC casing slotted over the appropriate depth interval. In the annulus between the borehole wall and casing a 25mm wide gravel pack should be installed comprising 1.6mm to 3.2mm sand fine gravel.

The slots in the casing should be 1mm wide. In the watertable monitoring bores they should extend from approximately 1m above the maximum water level to the base of the pipe at approximately 2m below the lowest water level. In the deeper monitoring bores the bottom 2m should be slotted.

The PVC should be fitted with both top and bottom end caps. Lengths of PVC pipe must be joined either by the use of dowels or threaded joints. The use of solvent glue is not permitted.

Each bore should be fitted with a lockable protector casing, a lockable man-hole cover or other vandal resistant device, as appropriate. The steel casing or other device should be set in concrete which should be at least 1.2m in diameter and set at least 0.8m below the surface. The concrete must seal the top of the gravel pack to prevent flow of liquids into the bore. The slots in gravel pack to prevent flow of liquids into the bore. The slots in the PVC casing should be at least 1m below the base of the concrete.

3.5 DECONTAMINATION PROCEDURES

All sampling equipment must be decontaminated between sampling points and drilling equipment must be decontaminated prior to drilling each hole. The following equipment will be required:

- o portable high pressure steam cleaning unit;
- o fresh water;
- o detergent;
- o solvent solution; and
- o items such as buckets, brushes and disposable towels.

Decontamination of equipment must be undertaken away from sampling locations to prevent contamination of samples.

For sampling in the contamination assessment boreholes, slotted PVC pipe with a minimum nominal diameter of 50mm should be inserted in the hole to at least 2m below the water table. The pipe should be slotted so that the slots extend from at least 0.3m above the watertable to at least 1.0m below the water table. An end cap should be fitted to the lower end and the pipe should be wrapped in filter sock to prevent migration of fires into the pipe.

The sampling should be collected with either a bailer (stainless steel or teflon) or a submersible sampling pump.

Prior to any purging and/or sampling a bailer sample of the top water surface should be collected to check for the presence of floating product.

Prior to collection of a groundwater sample the well should be thoroughly purged. The minimum purging should be the removal of three monitoring well volumes.

If there is any chance that materials used in the drilling and sampling well installation have changed the water quality then purging beyond the minimum must be allowed for. In these instances electrical conductivity, pH, Eh, temperature and dissolved oxygen should be monitored regularly during the purging process and purging continued until all of the above parameters have stabilised.

3.4.1 Location

At least three permanent groundwater monitoring bores should be installed on the site. The locations of these bores need to be selected with due consideration of the following aspects:

- physical restrictions, both during construction and layout of facilities; and
- optimal locations based results of the assessment of existing contamination.

Depending on the contaminants which may originate from the permanent facility, it may be necessary to have a nest of two bores at each location. One would be used for sampling at the watertable, the other for sampling groundwater at the base of the fill.