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FUNDAMENTALS OF AREAWIDE ENVIRONMENTAL QUALITY MANAGEMENT, AEQM and THE BIEN HOA, DONG NAI VIET NAM EXAMPLE

DG/VIE/95/053

VIET NAM

Report*

* This document has not been edited.

V.99-88667

The preparation of this report was coordinated by Ralph A. Luken the Cleaner Production and Environmental Management Branch, Industrial Sectors and Environment Division. It is based on the work of Harold J. Day, Chief Technical Advisor, Walter M. Grayman, International Expert-Water Resources, Theodore R. Siegler, International Expert-Environmental Expert Environmental Economics and Solid Waste Management and Blair T. Bower, International Expert-Environmental Expert Environmental Economics and Engineering.

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EXECUTIVE SUMMARY

Introduction

This report has been written to supplement the final report for the United Nations Development Program, Project VIE/95/053, Industrial Pollution Reduction in Dong Nai, dated August 10, 1998. The purpose of this report is to outline the analysis and planning steps of Areawide Environmental Quality Management (AEQM) and illustrate the application of an AEQM analysis to the environmental problems facing the City of Bien Hoa, Dong Nai Province, Viet Nam.

Project VIE/95/053 was originally focused just on industrial pollution reduction in the Bien Hoa region of Dong Nai Province. After the project work groups had been identified, the national and international consultants hired and the work begun, the values of, and need for, a more comprehensive and regional environmental analysis was recognized. AEQM concepts were introduced at that point. The value of the AEQM approach became even clearer toward the end of the project when it became apparent that attention to industrial pollution alone was not likely to provide significant improvements in environmental quality, and that a regional approach that encompassed more than the original study area boundaries was essential.

AEQM is the continuous management of discharges to the environment, making the most efficient use of the limited resources available to a region to provide the highest level of environmental quality. AEQM begins with quantification of waste discharges to land, air and water by type of activity (e.g., residential, commercial, transportation, industrial, agricultural). Then, an assessment of the impact of these waste discharges (including pollution loadings from upwind or upstream areas) on environmental quality is made, both currently, and at some selected future time. Current and potential future environmental quality can then be compared with alternative environmental quality objectives that decision makers in the region believe can or should be met.

Physical measures are then identified which can be used to reduce waste discharges and/or improve the assimilative capacity of the environment. These include structural measures (e.g., waste water treatment plants, changes in industrial production processes) and non-structural measures (e.g., effluent charges, pollution prevention programs, discharge limitations). For each physical measure applied to each type of activity, implementation incentives and unit cost estimates are developed. Based on the ease of implementation, and the estimated cost, physical measures are combined into AEQM strategies. The combined reductions in waste discharges estimated for each AEQM strategy are then modeled to determine the potential impact on future environmental quality, and a preferred AEQM strategy selected for implementation.

Summary of Conclusions

Based on water and air quality sampling and analysis carried out as part of the VIE/95/053 project, and the subsequent AEQM analysis, the following conclusions are summarized:

- The Industrial Pollution Prevention Project which preceded this AEQM analysis clearly identified the potential for significant reductions in pollution from industrial activities in the study area. Estimates were made by industrial pollution consultants that a fifty percent reduction in water, air and solid waste discharges could be accomplished through pollution prevention and process technology changes. However, as illustrated by the subsequent AEQM analysis, requiring industry to invest in pollution prevention and control methods will not be sufficient to improve environmental quality in the Bien Hoa area. Instead, it will be necessary to combine investments in industrial pollution control, with investments in pollution prevention and treatment from commercial, transportation, agricultural and domestic sources. In addition, there will be a need to coordinate the efforts of Dong Nai Department of Science Technology and Environment (DOSTE) with those of surrounding provinces, especially Ho Chi Minh City (HCMC) associated with air quality, and provinces up-stream from Dong Nai Province for water quality.

- A majority of the urban population in the Bien Hoa area currently lives with air quality that does not meet Viet Nam or World Health Organization air quality standards. Even with significant reductions in industrial air emissions, air quality will continue to deteriorate due to domestic and transportation activities and to the impact of poor air quality from the HCMC area.

- The Dong Nai River adjacent to Bien Hoa is classified as Standard A due to drinking water intakes for HCMC located immediately downstream of Bien Hoa. Currently, approximately 40 percent of the dissolved oxygen measurements in the Dong Nai River are below Standard A and 90 percent of the water quality samples exceed the BOD standard. This appears to be due primarily to upstream, unidentified BOD contributions. Attention only to industrial waste water discharges will not be sufficient to significantly improve Dong Nai River water quality in the Bien Hoa area. Attention must also be paid to upstream land use and pollution loadings.

- Continued discharge of domestic, commercial and industrial effluents from the Bien Hoa area will result in portions of Song Cai becoming anaerobic within ten to fifteen years unless steps are taken to reduce waste water discharges. The largest source of waste water discharges to Song Cai appears to be domestic activities.

- Currently, only approximately 23,000 tonnes of the estimated 90,000 tonnes of solid wastes generated in the Bien Hoa area are collected and landfilled. The remainder are indiscriminately dumped and burned. An additional 5,700 tonnes of industrial hazardous wastes are currently dumped on-site or indiscriminately dumped or burned. If population and economic growth continues as projected, this will increase to 245,00 tonnes of solid and hazardous wastes indiscriminately dumped or burned by the year 2010 unless significant investments are made in collection equipment and landfill disposal.

Recommendations

Based on the AEQM analysis the following management and implementation strategy is recommended for consideration by the Dong Nai Peoples Committee (DNPC).

Inform Policy Makers, Technical Leaders and Citizens

This AEQM analysis contains important information about current and projected water, air and solid waste discharges and their impacts on environmental quality. There is a need for Dong Nai DOSTE to make this information available to the DNPC, technical leaders and citizens so that a consensus can begin to be developed to increase investments in environmental quality in the study area.

Begin Implementation of Low Cost Pollution Prevention Programs and Increase Air and Water Quality Monitoring

Industrial Pollution Prevention Program

Many industrial pollution prevention and process technology changes were judged to be low cost measures, with some offering efficiency improvements that would actually reduce production costs. However, industries in the Bien Hoa area will not implement those changes without the development of incentives for them to do so. These incentives could include both financial incentives such as grants and low interest loans, as well as the adoption, monitoring and enforcement of discharge standards.

Air and Water Quality Monitoring

This AEQM analysis presents important information about current environmental quality based on the initial water and air quality monitoring which Dong Nai DOSTE has carried out over the past several years. There is a need to substantially increase monitoring activities to: (1) confirm or modify the initial results; (2) begin to establish trends with respect to ambient environmental quality; and (3) to answer questions raised by the initial monitoring and subsequent modeling of the data. DOSTE's budget should be increased sufficiently to assure that on-going collection and analysis of samples can be accomplished, and expanded to address the import and export of water and air pollutants.

Begin Investments in Improving Environmental Quality

Based on the AEQM analysis of three management strategies, it is recommended that the DNPC and DOSTE implement Strategy Two, which is a combination of low and medium unit cost measures to improve future environmental quality in the study area. Important implementation issues include:

Water

- Based on current data on Dong Nai River water quality it appears that upstream sources of pollution are significant. In addition to the increased upstream sampling recommended above, it is necessary to begin to address agricultural and aquacultural sources of pollution.

- The key to improving water quality, especially in the Cai branch of the Dong Nai River will be the development of an interceptor to collect surface and shallow ground water flow, and discharges from the existing storm water collection system.

Air

- Based on the initial sampling data and the historical growth in motor vehicles, there is a need to develop a transportation plan to divert traffic from the urban areas, and to separate motor vehicle and train traffic. Prohibiting 2 cycle engines should be considered. And, DOSTE should begin to work with the Ministry of Science Technology and the Environment (MOSTE) and other appropriate agencies concerning the potential to eliminate leaded gasoline.

- The industrial waste audits and pollution prevention programs can be used to identify industries most appropriate for fuel substitution and/or the addition of air pollution control equipment.

Solid and Hazardous Wastes

- It is critical that DOSTE either obtain hazardous waste definitions from MOSTE or develop definitions for Dong Nai Province. Once these definitions have been developed it will be necessary to require each industrial plant to inventory their hazardous wastes. DOSTE and Sonadezi, the industrial park management entity, should continue to work to construct a lined hazardous waste landfill. Once this landfill is constructed DOSTE should require that all hazardous wastes be delivered to this landfill and enforce this regulation.

- A bio-hazardous waste incinerator or autoclave should be constructed, with a requirement that all bio-hazardous wastes be delivered to this bio-hazardous treatment facility.

- The Bien Hoa Peoples Committee should consider requiring that all urban households participate in, and pay for, collection of domestic solid wastes. Fees should be charged to each household to pay for Bien Hoa Urban Environment Services Company to expand its fleet of trucks and laborers to service the Bien Hoa urban area.

Coordinate With Other Provinces

Upstream water pollution, and the impact of air pollution from HCMC requires that the DNPC and Dong Nai DOSTE begin to form strong working relationships with surrounding provinces to address the many forms of inter-regional air and water pollution. One key measure would be to develop an AEQM analysis for the Southern Economic Focal Zone. The results will assist both Bien Hoa and HCMC in improving environmental quality.

While outside the purview of this study, there has been an on-going exchange of AEQM information between this study area and the Northern Economic Focal Zone. Rapid growth is expected in the Northern Economic Focal Zone and both areas would benefit from the application of a similar AEQM analysis to this area. Many of the lessons learned as part of this AEQM analysis would prove useful in the north, and the Bien Hoa area would also benefit from improvements in AEQM analysis that could be carried out during a second study in the north.

Fundamentals

of

Areawide Environmental Quality Management, AEQM

and

The Bien Hoa, Dong Nai Example

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PREFACE

This report has been written to supplement a section of the final report for the United Nations Development Program, UNDP, Project VIE/95/053, Industrial Pollution Reduction in Dong Nai, dated August 10, 1998. The title of the section is, Annex E, Preliminary Report on Areawide Environmental Quality Management, AEQM, Analysis. Some important conclusions were tentative since they were based upon a minimum of data, for example, attention to industrial pollution reduction in Dong Nai alone would neither be environmentally wise nor cost effective. Other parts of the report contained important information related to this report. In particular, recommendation number 11 presented in Section 1 is important as guidance in organizing this supplemental activity. It is repeated here:

"11) An extension of the present project is recommended to complete the AEQM analysis reported in preliminary form in Annex E and used as part of the Strategy for Pollution Control in Dong Nai presented in Section 3, Output 2.3. Important additions to the completed work include:

a) Revisions to the river water quality model based upon new knowledge of upstream pollution loadings. The revisions would be based upon the recent water quality sampling work done by the Environmental Protection Center in the upper basin and upon future additional sampling. Knowledge gained by the Study Fellows in North America on sample analysis and on river water quality modeling would be useful in this effort. The revised model will be needed to estimate the river water quality associated with different levels of beneficial uses and investments in technologic changes selected in scenarios for the 2010 period.

b) Expanded cost estimates associated with different technologic changes such as plant specific initiatives and/or combined municipal/industrial waste water treatment collection and treatment systems.

c) Expanded efforts to estimate the characteristics and amount of industrial hazardous wastes in the AEQM study area. This work is needed to design adequate treatment and disposal facilities for hazardous wastes.

d) Estimates of types and quantities/concentrations of specific hazardous industrial pollutants to aid in further estimation of significance of industrial discharges and emissions to ground, water and air."

The following work elements have been added since the report was written.

e) Assess the benefits of the proposed improvements in water and air quality.

f) Assess the effectiveness of land use planning and permitting in environmental quality management.

SECTION I
INTRODUCTION

Environmental quality problems exist in all countries, because human activities generate wastes which require disposal to the land, air and water.

Waste discharges increase with the process of urbanization and industrialization. At the same time, the capacity of the environment to assimilate increased discharges is often reduced due to filling of wetlands, paving, construction of buildings, and increased exploitation of natural resources.

Deteriorating environmental quality places strains on the ecosystem, reduces the quality of life for the human population, and contributes to increasing costs associated with water supply, industrial production and health care.

Ultimately, the deteriorating environment requires that governmental and economic institutions make decisions about maintaining or improving environmental quality. Governmental leaders are often required to make decisions about investments in improving environmental quality without knowing the full range of options available to them and what it will cost to achieve these improvements.

Decisions to invest in new facilities or programs to improve environmental quality are therefore often based on national (or even international) environmental quality standards which may or may not be achievable at a reasonable cost within the region. These decisions are also often based on the assumption that there will be a need to construct capital intensive, central waste treatment facilities that require substantial investments of public resources for construction and operation.

These investments in central waste treatment facilities must compete with demands for other essential public services, such as schools, roads, and health care facilities. In many cases, a more careful analysis of alternatives available to improve environmental quality would show that: (1) national environmental standards may not be achievable at a reasonable cost; and/or, (2) attention to pollution prevention, institutional changes, low cost decentralized technologies, and investments in production efficiency would be less costly, freeing up resources for other public and private investments.

What is needed is a framework, or methodology, for analyzing environmental quality management options that decision makers can use in deciding where and when to make investments that will yield the greatest environmental benefits at the lowest cost. This framework, sometimes called Areawide Environmental Quality Management (AEQM), exists and has been used as the basis for analyzing environmental quality management in Dong Nai Province, Viet Nam.

Section II of this document outlines the general AEQM framework, first, in a conceptual manner, and second, in sufficient detail for use operationally in conducting an actual study. Section III of this document is the example of an AEQM study made for the Bien Hoa, Dong Nai area.

SECTION II
FRAMEWORK OF AEQM

The AEQM framework may be described in relatively simple terms, but the actual process is more complex. Two separate flow charts have been prepared to aid in understanding the framework. Figure II-1 illustrates the fundamental steps. Figure II-2 provides a more detailed illustration of the operational details described in this document.

As discussed below, and illustrated by the Bien Hoa example in Section III, AEQM is not just about analysis. Instead, AEQM is about the continuous management of discharges to the environment in a changing world without perfect data and with limited resources to spend on all of societies needs, including a reasonable level of environmental quality.

AEQM FUNDAMENTALS

Figure II-1 illustrates the AEQM fundamentals arranged in a circular shape to emphasize the continuous nature of the AEQM approach. The analysis and planning segment begins with a description of the existing situation, and of the trends which resulted in the existing situation, in a carefully selected study area that contains the primary environmental quality problems to be addressed.

The study area should be small enough to make the study practical, and large enough to provide useful results that will assist policy makers to make wise management decisions. Imports and exports of pollutants to/from the study area must also be considered. The description of the existing situation should include: current environmental quality, institutions, levels of activity in various economic sectors, population, and land use.

Next, a time into the future, typically 10 or 15 years, is chosen. Social, political, economic, and technologic variables likely to impact on the planning agency mission and to impact directly on environmental quality in the future must then be selected. Important variables include, but are not limited to, future changes in population and economic activity, changes in per capita disposable income, changes in technology, gov rnment expenditures, the active or passive nature of government, and the role of citizens and non-governmental organizations, (NGOs) in attempting to influence population and economic growth, land use, and future environmental quality.

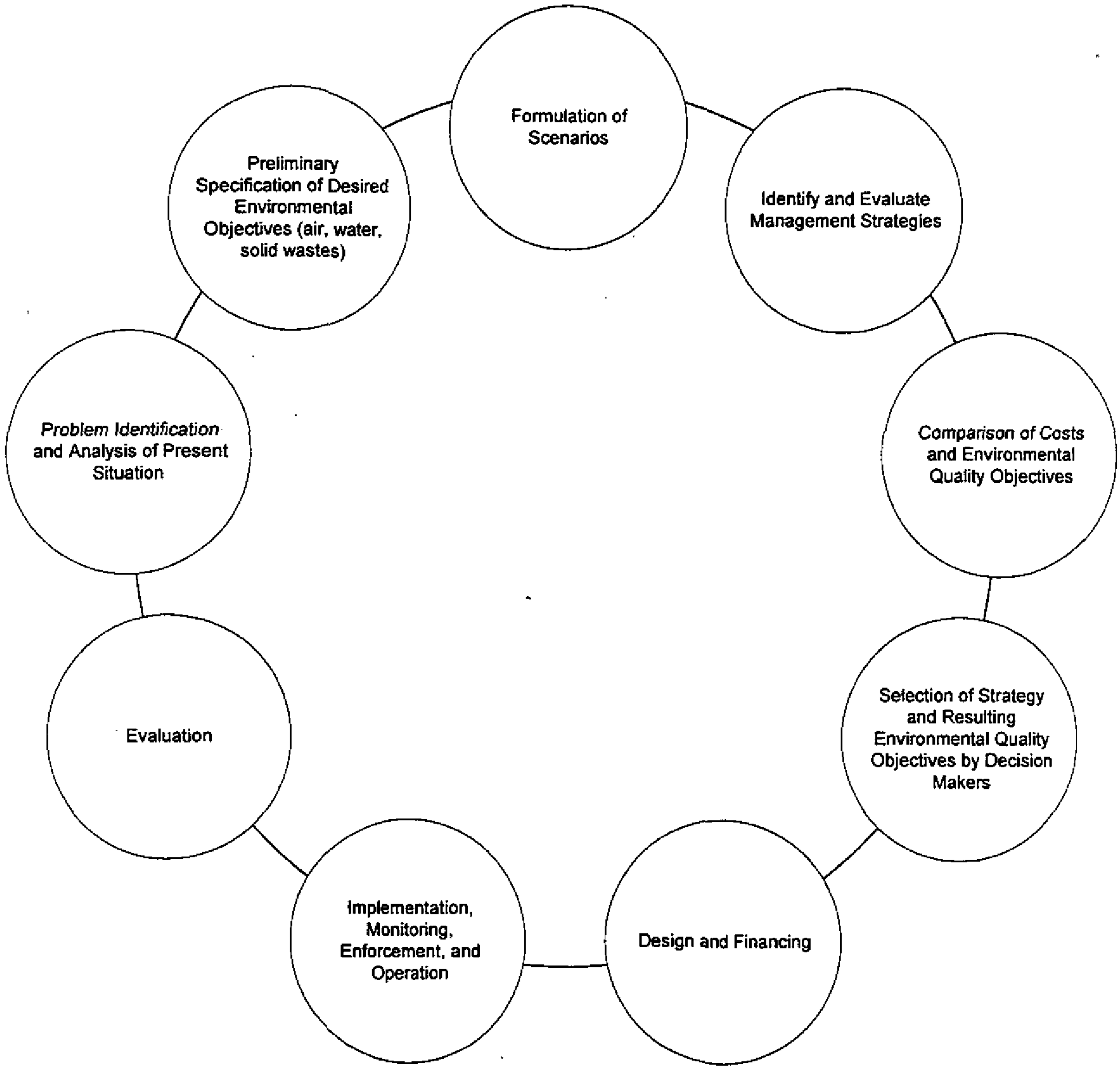
Because of the uncertainties associated with the future, it is useful to make more than one set of assumptions about the future, and examine the impact on environmental quality associated with these different sets of assumptions. Each of these sets of assumptions about the social, political and economic and technologic variables is defined as an alternative future scenario.

The next step is to identify levels of environmental quality that the government hopes to achieve and the hydrologic and meteorologic conditions judged to place the greatest stress on the environment.

Then, estimate air, water and solid waste generation and disposition at the future time period selected associated with the most plausible scenario, and compare these projections with present conditions, and with the selected environmental quality objectives.

If the desired environmental quality can not currently be met, or be achieved in the future with increasing population and economic growth, then identify the lowest unit cost measures to reduce environmental discharges. Combine these measures, and implementation incentives into alternative strategies that are potentially feasible, given available resources, and political and institutional limitations. Present these potential strategies and associated public and private sector costs and implementation issues to the decision makers. Measures selected by the decision makers under the preferred strategy can then be implemented and the results evaluated.

Figure II - 1: Simplified Illustration of the AEQM Approach



CONDUCTING AN ACTUAL AEQM STUDY

Figure II-2 illustrates the most important operational details of the AEQM process. The operational details have been organized in an 11 step process consistent with the description presented in this Section II.

Each step is described initially in outline form. Later, more details for each step are presented.

AN OUTLINE OF THE OPERATIONAL DETAILS FOR CONDUCTING AN ACTUAL AEQM STUDY

Analysis and Planning Segment

- **Step One - Problem Identification and Analysis of Present Situation:** Describe the present conditions and set up the analysis, including the study area and identification of areas outside impacting on the study area, time period, and criteria for evaluating strategies.

- **Step Two - Environmental Objectives:** Choose several levels of desired future environmental quality (environmental objectives), and the hydrologic and meteorologic conditions judged to place the greatest stress on the environment.

- **Step Three - Formulate Plausible Alternative Scenarios:** Formulate future scenarios and their impact on future population and economic activity, based on best judgements about the complex social, political, economic and technological changes that will impact on the mission of the environmental planning and implementing agencies. Review these possible scenarios with decision makers and the public, and choose two or three future scenarios to evaluate, and the time frame of the analysis.

- **Step Four - Project Future Air, Water and Solid Waste Generation and Discharge to the Environment:** This Step consists of two parts. First, changes in per person and per employee (unit) waste generation over the time frame of the analysis must be estimated. Then, these changes in unit generation must be multiplied by the changes in population and economic activity defined in each Scenario in Step 3 to estimate total air, water, and solid waste discharges to the environment for each of the selected Scenarios.

- **Step Five - Estimate the Impact on Future Environmental Quality In the Absence of Any AEQM Strategy For The Most Plausible Scenario:** Using available air and water quality models and the existing solid waste management system, project changes in environmental quality at the selected future time period for the most plausible scenario. Compare this with the levels of environmental quality objectives established in Step 2.

- **Step Six- Develop a List of Potential Measures That Could Be Taken To Reduce Air, Water and Solid Waste Discharges and Improve Environmental Quality:** There are many measures available to reduce and treat air, water and solid wastes, and to modify the environment to improve its ability to assimilate the wastes disposed to it. It is important to list the full set of measures that might be available, as well as different levels of each measure (e.g., primary, secondary, tertiary waste water treatment) and then develop a shorter list of those measures that may be feasible given social, and political conditions.

- **Step Seven - Estimate Costs and Reductions in Environmental Discharges For Selected Measures, Combine Measures to Develop AEQM Strategies:** Develop rough cost estimates for each of the short listed measures in Step 6, and estimate the level of reduction in air, water, or solid waste discharges associated with each measure. Starting with the lowest unit cost measures, combine measures to create one or more AEQM strategies which appear to provide sufficient reduction in environmental discharges to meet the environmental quality objectives.

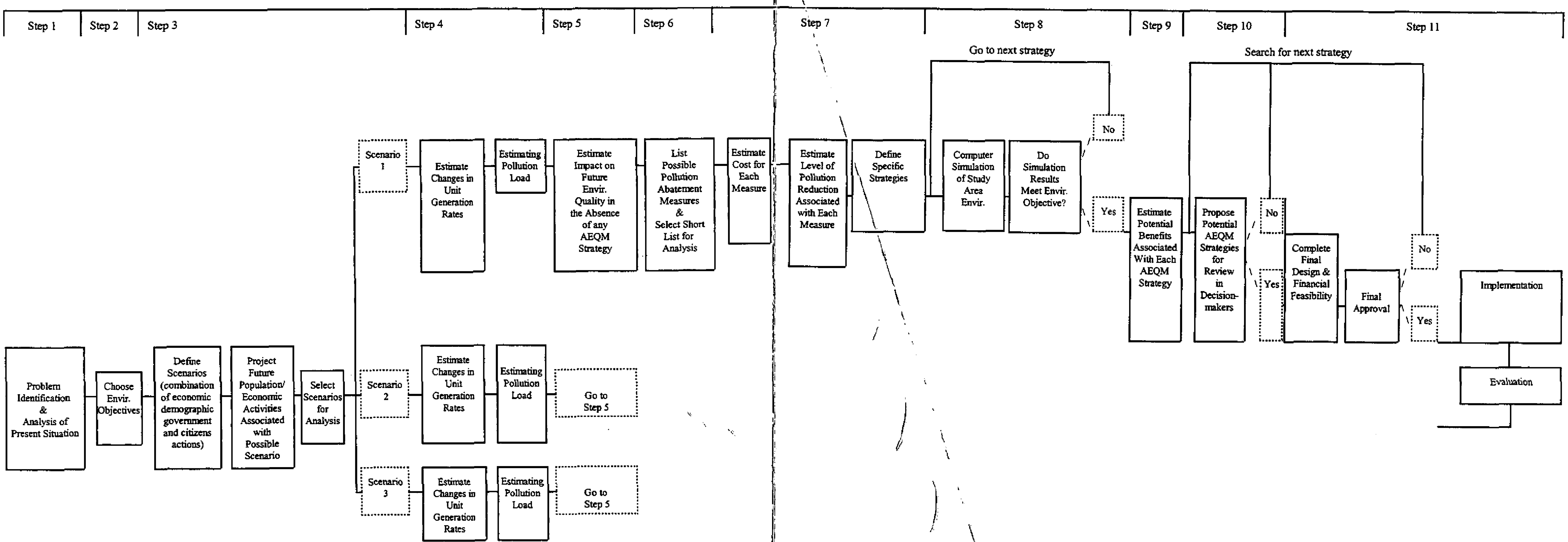
- **Step Eight - Using Available Water and Air Quality Models and Solid Waste Management Objectives, Estimate Future Environmental Quality Associated With the Selected AEQM Strategies:** Future environmental quality associated with the air, water, and solid waste reduction and treatment measures specified for each AEQM Strategy defined in Step 7 can be estimated for each selected future scenario and compared with the environmental quality objectives specified in Step 2.

- **Step Nine -Estimate the Potential Benefits Associated With Each AEQM Strategy:** Too often decisions about an AEQM strategy are based solely on the costs of the strategy. Therefore, it is important to attempt to list, and quantify if possible, the benefits associated with improvements in environmental quality associated with each AEQM strategy.

- **Step Ten -Propose Potential AEQM Strategies to the Decision Makers:** Review the AEQM strategies selected in Step 7, and the projected environmental quality estimated in Step 8 with the decision makers. Include a full discussion of the implementation issues associated with each strategy. Seek a decision of a potentially preferred strategy and level of environmental quality.

- **Step Eleven - Complete Final Design and Financial Feasibility for the Selected Strategy:** Often, the cost of the selected strategy will increase with final design of the proposed measures. Therefore, it will be necessary to go back to the decision makers to review and seek final approval to go forward, or to modify or change the strategy, before beginning implementation.

Figure II - 2: An Operational Flowchart for Conducting an AEQM Study



Implementation and Evaluation

Implementation begins with final approval from the decision makers of a preferred AEQM Strategy. It is important to remember that implementation is a long term process, often taking between five and ten years to fully achieve, with many modifications to the strategy over this time period. Implementation, including the continued provision of adequate funding, monitoring of effectiveness, enforcement of discharge restrictions, and measurement of environmental quality, is the key to the success of an AEQM strategy. Therefore, implementation requires substantial long term commitment by all of the institutions identified in the strategy.

During implementation, conditions will continue to change resulting in the need to reevaluate the AEQM strategy, making modifications as necessary. This is the continuous nature of AEQM.

OPERATIONAL DETAILS FOR CONDUCTING THE ANALYSIS AND PLANNING SEGMENT OF AN ACTUAL AEQM STUDY

Following is a detailed discussion of the operational steps associated with the AEQM analysis. It may be useful to continue to refer to Figure II-2 during the review of the operational steps.

Step One: Problem Identification and Analysis of Present Situation

1a) Summarize information relating to current environmental quality, including information on land use, economic activity, and historical changes in population, economic activity, technology and environmental quality.

1b) Select the study area and the future point in time for the analysis, typically 10, 15, or 20 years.

1c) Determine present land use activities within the study area, and land use activities in external areas affecting the study area.

1d) List and describe those institutions with responsibility for managing environmental quality and environmental discharges within the study area and external to the study area, and the interrelationships among these institutions.

1e) Group the activities within the study area for purposes of estimating generation and discharge of waste materials. A suggested grouping is:

- residential
- commercial/institutional
- transport, including gas stations and repair shops
- industrial
- agricultural

1f) Estimate current levels of activity for each group and for major dischargers and non-point sources, such as an industrial park, a large electricity generating station, or run-off from urban streets. Suggested data include:

- population, number of households, location and density of housing, household income and characteristics;
- number, type and location of commercial and institutional activities, and employment or other measure of level of activity;
- number and types of vehicles, transportation routes, and vehicle miles traveled per year;
- number, type and location (by Standard Industrial Classification) of industrial activities, and some measure of the level of activity such as employment, output, or raw material input; and,
- agricultural and forest production by type, such as fish farming, rice and coffee.

1g) Estimate current generation of wastes and discharges to air, water and land by activity. These data could be organized as:

- liquid waste measurements such as biochemical oxygen demand (BOD), total suspended solids (TSS), chemical oxygen demand (COD), and toxics (PCB, Pb, Hg);
- gaseous waste measurements such as total suspended particulates (TSP), nitrogen oxides (NOX), carbon dioxide (CO_2), and lead (Pb); and,
- solid waste measurements such as residential wastes (paper, plastics, organics), industrial solid and hazardous wastes, hospital wastes (biohazardous) and transportation wastes (oil, engine coolants and tires).

In each case, it will be necessary to first estimate unit generation (such as kilograms BOD/ household/year, tonnes of air and solid waste emissions per employee/year) and then estimate total generation based on total population and employment.

1h) Determine the area outside of the study area boundary that exports pollutants to the study area and estimate imports and exports of environmental discharges, including:

- upstream and downstream watershed
- upwind and downwind airshed
- import/export of hazardous and solid wastes

1i) Estimate current impacts of discharges from within and outside of the study area on study area environmental quality. For example:

- water quality models may be used to estimate the impact on dissolved oxygen (DO), of BOD discharges from the activities listed above;
- air quality models may be used to estimate the air quality associated with imports and with study area discharges of TSP, NOX, and other gaseous pollutants; and,
- nature and collection and disposal of solid and hazardous wastes may be used to determine the potential impacts of indiscriminate dumping of solid wastes or the improper disposal of hazardous industrial wastes or biohazardous wastes.

1j) List and describe the criteria expected to be used in evaluating management strategies. Criteria may include costs, distribution of costs and benefits, social and political feasibility, time frame for implementation, and time after implementation before measurable improvements in environmental quality occur.

Step Two: Choose Potential Environmental Quality Objectives

For some environmental quality indicators there will be national or international standards imposed on the study area. For example:

- Surface water DO standards;
- Drinking water standards for organic chemicals and toxic metals;
- Air quality standards for TSP, VOC, and other gaseous pollutants; and,
- Requirements for the proper management of biohazardous wastes.

National and international standards may be used as a starting point. However, it may become apparent during the analysis that achieving these standards over the analysis period is unlikely due to the limited financial and human resources available in the study area and the existing level of environmental quality. In such a case, it will be necessary to analyze what levels of environmental quality could be achieved with available resources. This is a key component of AEQM.

In other cases, there may be no standards available. For example, organized collection of solid wastes from households may not be required by national standards, although it would probably be desirable to reduce litter, illicit dumping, and disease. In this case, solid waste management objectives must be specified for the analysis. Alternatively, international standards may require double lined landfills while realistically, simply consolidating all of the wastes in an appropriate location with frequent covering may be a significant improvement over current conditions.

Once potential environmental quality objectives have been selected, it is necessary to evaluate hydrologic and meteorologic conditions that affect environmental quality during the year, and select the set of conditions which are likely to represent the most stress to environmental quality. For example, in many cases low flow in streams and rivers associated with the dry season reduces dilution, typically resulting in lower surface water quality. However there may be cases where urban runoff during the rainy season, or spring runoff has a greater impact on water quality. Similarly, stagnant air may produce lower air quality in some circumstances, while prevailing winds from major upwind sources may contribute to lower air quality in other cases.

Step Three: Formulate Plausible Alternative Scenarios, Select One or More for Analysis

An analysis of future environmental quality requires that the planning agency conducting the analysis confront the uncertainty associated with future social, political, economic, and technologic changes which impact both on the mission of the agency and on future environmental quality. Because of the uncertainties associated with these variables, a single view of the future is inherently inaccurate, and AEQM strategies based on one forecast of the future will often be misdirected.

Strategic analysis and planning is designed to assist the planning agency in developing a proactive rather than reactive position concerning future environmental quality. To do so, it is necessary for the planning agency to systematically anticipate and assess the range of plausible alternative futures in which strategies and plans will be implemented. Scenarios provide a means for testing potential strategies across of range of future conditions.

Scenarios are not predictions about the future. Each scenario is a combination of internally consistent and plausible forecasts about likely changes in key variables over the time period of the analysis. These key variables are initially identified by the planning agency, and then reviewed by decisions makers with public input. Key variables may include, but are not limited to changes in: population and economic activity; per capita income; government expenditures on the planning agency and/or future environmental quality; actions or inaction of government; significant technologic changes; and, the role of citizens and NGOs in attempting to influence government policy, especially toward the environment.

Because there is uncertainty about each of these variables, it is necessary to initially create multiple scenarios, and then narrow the list of scenarios to a manageable number for analysis. Judgements must be made about the probability of each selected scenario being a likely forecast of future conditions. The scenario judged to be the most plausible can then be selected for analysis in the absence of an AEQM strategy. Additional scenarios can be selected as necessary to evaluate the effectiveness of AEQM strategies under changing assumptions about the future.

Multiple scenarios help clarify how various strategies will work under different conditions. This makes planning and management more flexible by helping to identify the threats and opportunities associated with alternative futures. More specifically, consideration of multiple, or alternative scenarios:

- make assumptions about the future explicit, helping ensure that these assumptions are thorough and consistent;
- force consideration of alternative futures in place of reliance on a single forecast, so that future changes are less likely to surprise decision makers, or render management strategies ineffective;
- help identify major threats and opportunities for which management strategies should be formulated, so risks can be contained and crisis avoided;
- provide a way to test the viability of management strategies when confronted with changing future conditions; and,
- help identify the key variables in the future which have the greatest to impact on environmental quality.

The final key step in developing and selecting alternative future scenarios is to make sure that decision makers and citizens are actively involved in the development and selection of scenarios for analysis. This helps ensure future acceptance and support for management strategies shaped by the selection of appropriate future scenarios

Step Four: Project Future Air, Water and Solid Waste Discharges to the Environment

1a) It is not reasonable to assume that there will be no changes in unit (per person, per employee) generation of environmental discharges over time. For example, increasing per capita income will increase consumption and therefore per capita generation of solid wastes. In many countries bicycles are being replaced by motorized vehicles, increasing environmental discharges even in the absence of growing population. In other countries, older more polluting vehicles are being replaced with newer, more efficient and less polluting vehicles. Similarly, old industries close down, or change the way they produce goods, and new industries start up that discharge different levels and mixes of environmental discharges.

Therefore, it is necessary to make some rough predictions about how unit generation of air, water, and solid wastes is likely to change over the planning period, even in the absence of an AEQM strategy prior, to applying the population and economic projections developed in Step 3.

1b) Once changes in per capita and per employee generation have been made, then it is possible to multiply these generation coefficients by the projected changes in population and economic activity assumed for the most plausible scenario to estimate discharges of air, water, and solid wastes to the environment.

Step Five: Estimate the Impact on Environmental Quality in the Absence of Any AEQM Strategy For the Most Plausible Scenario

Air, water, and solid waste discharge projections developed in Step 4 must be translated into estimates of future environmental quality in the absence of an AEQM strategy. Air and water quality models are used to predict what future levels of environmental quality are likely to be given the air, water, and solid waste discharges for the chosen scenario.

These projected levels of environmental quality can be compared against the environmental quality objectives described in Step 2. To the extent that the environmental quality objectives are not likely to be met without an AEQM strategy, it will be necessary to evaluate measures which could be taken to reduce discharges to meet the environmental quality objectives. AEQM strategies, based on combinations of these measures, can then be defined.

Step Six: List Potential Measures that Could Be Applied to Activities and Groups of Activities to Reduce Air, Water, and Solid Waste Discharges and Improve Environmental Quality

Reducing waste discharges can be accomplished in many ways. Some of them involve the construction of facilities, such as waste water treatment plants, or construction of new solid waste landfills. These can be called structural measures. Others involve changes in public policies, imposition of waste discharge fees, changes in the behavior of the population, or other activities where construction of facilities may or may not occur. These can be referred to as non-structural measures. Each measure has a potential pollution reduction level associated with it. Most measures will have costs associated with them. However, some measures may save money, such as increasing efficiency at a particular factory and therefore reducing waste discharges.

Usually, non-structural measures are less costly then structural measures. Too often they are ignored in favor of more expensive structural measures. This is a key reason for conducting an AEQM analysis.

Examples of possible structural and non-structural measures are:

- reducing waste generation at the source
- increased production efficiency through such measures as in-plant process changes (e.g., waste fiber recovery at a paper mill), or switching to less toxic production process at an electronics factory
- removal of lead or sulphur from fuels to reduce lead and SO_2 emissions from vehicles and power plants
- in-plant waste treatment, such as individual waste water treatment or air emission controls on a smoke stack
- combined treatment of wastes from groups of similar activities such as group household septic systems, industrial park treatment plants, and waste oil storage tanks for automotive garages
- metropolitan centralized treatment systems, especially for waste water and solid/hazardous wastes

For each physical measure, either structural or non-structural, incentives are necessary to convince individuals, commercial, and industrial activities to adopt these physical measures. These can be called implementation incentives. Specification of the implementation incentives associated with each physical measures is a key component of an AEQM analysis. For example, a pollution prevention audit does not, by itself reduce pollution. Instead, a pollution prevention audit provides information concerning changes in production processes and/or installation of treatment equipment (physical measures) which could lead to reductions in waste discharges. It is implementation incentives which provide reasons to adopt these changes in production processes or invest in waste treatment equipment.

Examples of implementation incentives include:

- increased charges for inputs, such as water or electricity
- charges for waste discharges
- technical assistance with improvements in production efficiency
- subsidies for the cost of treatment equipment, including low interest loans and/or grants
- adoption, monitoring and enforcement of regulations restricting waste discharges
- requirements that all waste water generators hook up to a waste water treatment system and pay a fee for use of the system

Once a list of physical measures (both structural and non-structural) and associated implementation incentives have been developed, then physical measures and associated implementation incentives can be combined into alternative strategies for analysis.

Typically, because of the importance of costs on feasibility, the operational way to proceed with the analysis is to develop rough unit cost data ($/kg of waste discharge reduced) for each specified measure. The lowest unit cost measures can then be combined to create potential AEQM strategies.

Other factors that might be considered in selecting measures for analysis include:

- administrative considerations, including simplicity, flexibility, and potential for illegal activities
- timing considerations, including the number of years it will realistically take to implement various measures, and the additional number of years it will take to obtain improvements in environmental quality
- political considerations, including: priority in relation to other environmental, social, and economic problems; impact on intergovernmental relations; acceptability to the public; and, legal difficulties
- resource use effects, including net energy use, land and water requirements

Step Seven: Estimate Costs and Reductions in Environmental Discharges For Each Selected Measure, Combine Measures to Develop AEQM Strategies

Structural and non-structural measures can be broadly grouped into three categories:

1) Reducing waste generation, including changing: production inputs; the production process; or, individual consumption habits.
2) Modifying or treating wastes that are generated including: air pollution control equipment; waste water control equipment; waste water treatment plants; and, solid and hazardous waste disposal facilities.
3) Modifying the environment to reduce the impacts of waste discharges, including: planting trees to improve air quality; restoring stream banks to reduce run-off; and, aeration of surface waters.

Figure II-3 roughly illustrates a cost/waste reduction curve associated with various pollution control measures applied to an industrial plant, starting with improving efficiency which actually saves the plant money and ending with an expensive waste water treatment facility treating the combined discharges from the plant.

Figure II-4 illustrates the impact on environmental quality (in this case measured as levels of dissolved oxygen in surface water in the river adjacent to the plant) associated with these increasing cost measures for the industrial plant.

Once the costs and associated reduction in air, water, or solid waste discharges have been estimated for each measure, it is possible to choose the least cost combination of measures yielding the greatest reductions in air, water, and solid waste discharges to develop proposed AEQM strategies.

Note that <u>you must</u> identify the implementation issues associated with each measure used in these calculations since there are different requirements for them to be put in place. For example:

- while pollution prevention activities may be low cost, they require access to commercial and industrial plants, and specialists who must first be trained and then adequately paid to carry out their work
- monitoring and enforcement of individual discharge limitations must be carried out by staff who are trained and adequately paid, reducing the risk of bribery to avoid enforcement
- in plant modifications must be designed, financed, and carried out - often the costs of design and financing are significant
- centralized treatment facilities must be sited, designed, financed, built, operated efficiently, and monitored

All of these implementation issues and the associated costs must be included in the cost analysis.

Step Eight: Using Air and Water Quality Models, Estimate the Impact on Future Environmental Quality Associated With the Potential AEQM Strategies Developed in Step 7.

Reductions in environmental discharges for each potential AEQM strategy must be modeled to determine whether they are sufficient to meet the environmental quality objectives specified in Step 2. If they are not, then either: the proposed AEQM strategy must be modified; a new AEQM strategy selected; and/or environmental quality objectives re-evaluated in light of the costs associated with achieving the objectives.

Figure II-3 Cost/Waste Reduction Curve

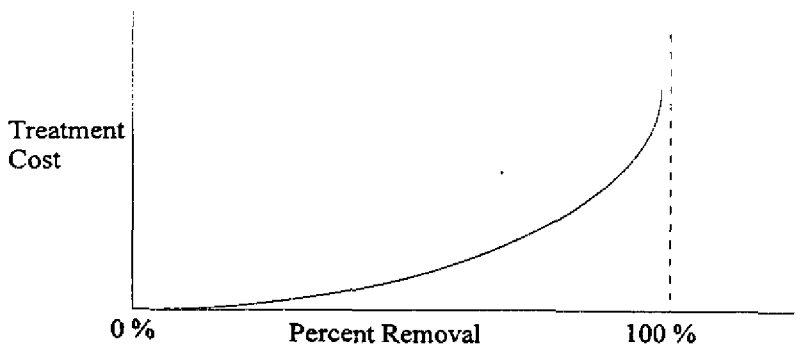
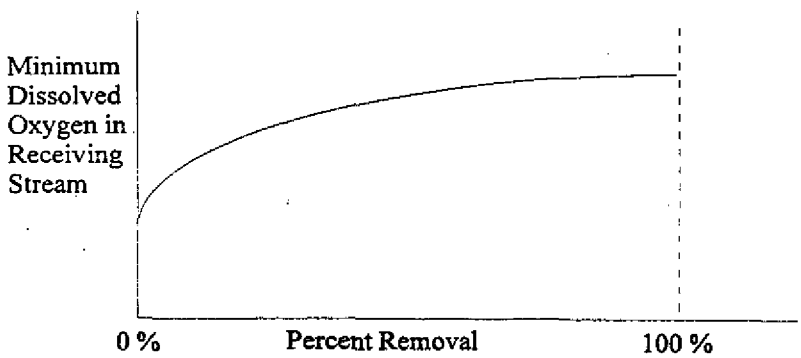


Figure II-4 Impact on Environmental Quality



Step Nine: List, and Where Possible, Quantify the Expected Health and Ecosystem Benefits Associated With Each AEQM Strategy

Often selection of an AEQM strategy is made based on the costs and implementation difficulties associated with each strategy. However, it is also important to list the health and ecosystem benefits associated with each strategy. If data are available, it may also be possible to quantify some of the benefits, in terms of:

- extended lifetimes and reduced infant mortality associated with cleaner air
- increased productivity and higher intelligence associated with reducing lead levels
- increased recreational opportunities associated with cleaner water
- a more complex and healthy ecosystem
- improved esthetics associated with the removal of litter and solid wastes
- reduced industrial production costs associated with cleaner water and healthier employees
- lower water treatment costs associated with reduction in discharge of hazardous wastes to the groundwater
- reduced costs associated with not having to purchase bottled water
- increased food production associated with healthy fish populations

Step Ten: Propose Alternative AEQM Strategies and Associated Levels of Environmental Quality to Decision Makers

Once the costs, implementation issues, and associated levels of environmental quality have been estimated for each selected AEQM strategy, these strategies can be presented to the decision makers. It is important to clearly describe the implementation issues associated with the strategy as part of the recommendations.

After a preferred AEQM strategy has been selected by the decision makers, then final design and financial feasibility can be undertaken.

Step Eleven: Complete Final Design and Cost Estimates For the Selected Strategy

Many times, cost estimates increase as the final design of the structural and non-structural measures in AEQM strategies are developed. Therefore, it is necessary to complete the final design of facilities and an implementation strategy, and then submit the information on total costs to policy makers for final approval. The final design includes such activities as:

- siting and permitting proposed facilities
- final design of the facilities based upon site specific information
- making specific arrangements for financing and repaying long-term debt and for on-going funding of annual operation and maintenance
- development of operational manuals and procedures
- specification of responsibilities for implementation, monitoring, assessment of fees, and enforcement
- specification of inter-institutional responsibilities

- final design of non-structural programs, including staffing and resources required, by institution
- development of regulations and enforcement provisions
- development of an ambient environmental monitoring system

Implementation and Evaluation

Implementation of the chosen strategy involves a full range of activities, including:

- Raising necessary capital for construction of facilities and on-going funds for operation and maintenance expenses
- Construction of structural measures, such as waste water treatment plants, agricultural buffer strips, solid waste landfills, rerouting of roads, and laying of sewer lines
- Recruiting and training of competent environmental agency staff for analysis, monitoring, and enforcement
- Development of adequate laboratory capacity and training of individuals to properly collect and maintain custody of samples
- Design of user fees and charges to finance the management including incentives to reduce waste generation
- On-going pollution prevention analysis and recommendations
- Coordination of institutional responsibilities for various programs such as agriculture, solid waste, water supply, public works, and transportation

During implementation there will be a need to evaluate the effectiveness of programs as conditions change in the future. At some point in time it will be necessary to begin the AEQM planning and analysis steps again. Evaluation will include:

- Have incentives lead to the desired activities occurring?
- Have the measures lead to desired environmental quality?
- Have technologic changes occurred which should be incorporated into the AEQM strategy?
- Have institutional changes occurred which affect the capacity to carry out the strategy?
- Have demands for environmental quality changed?

SECTION III
BIEN HOA, DONG NAI PROVINCE
AN EXAMPLE OF AEQM APPLIED IN VIET NAM

INTRODUCTION

The previous section (Section II) of this report provided a general description of the AEQM process. This section describes an application of the analysis and planning segment of AEQM to the Bien Hoa area of Dong Nai Province in Viet Nam. This section has been organized following the framework outlined in Section II so that potential users of the AEQM approach can understand more clearly how the analysis and planning steps described in Section II were actually used in this example. The general character of the problem, what physical and economic data were needed and how it was collected, the analytical methods and procedures that were followed in performing the AEQM analysis, and the results and conclusions of the study are all described. Although the details of each application of AEQM would be expected to vary from project to project, this example should provide the reader with a general understanding of how the AEQM framework can be translated into actual use.

The example described here is based upon information from a project sponsored by the Government of the Socialist Republic of Viet Nam, the United Nations Development Program (UNDP), and the Peoples Committee of Dong Nai Province, who also served as executing agency. The project was implemented by the Department of Science, Technology and the Environment (DOSTE), Dong Nai Province and the United Nations Industrial Development Organization (UNIDO). It is designated as Project VIE/95/053, and is titled "Industrial Pollution Reduction in Dong Nai". The focus of the project was the area around the principal city in the province, Bien Hoa. Started in 1996, the project formally ended in 1998 but was extended into 1999 to expand the results and to prepare this report.

PROJECT SCOPE AND EVOLUTION

Project VIE/95/053 was originally focused just on industrial pollution reduction in the Bien Hoa region of Dong Nai Province, with work activities and international consultants addressing subjects including: waste auditing and pollution prevention, legal and regulatory efforts, air quality, water resources, water quality laboratory and economics and incentives. A major part of the project was directed toward building the capacity of the local environmental regulatory agency, Dong Nai DOSTE, to meet its expanding responsibilities.

After the project work groups had been identified, the national and international consultants hired and the work begun, the values of, and need for, a more comprehensive and regional environmental plan was recognized. Areawide Environmental Quality Management (AEQM) concepts were introduced at that point. *The value of the AEQM approach became even clearer toward the end of the project when it became apparent that: (1) attention to industrial pollution alone was not likely to provide significant improvements in environmental quality; and, (2) a regional approach that encompassed more than the original study area boundaries was essential.*

In applying the AEQM approach, the following analysis and planning steps were taken.

1. Problem Identification and Analysis of Present Situation
2. Identify Environmental Objectives
3. Formulate Possible Scenarios
4. Project Future Air, Water, and Solid Waste Generation and Discharge to the Environment for the Dominant Scenario
5. Estimate Impact on Environmental Quality in Absence of AEQM
6. Develop List of Structural and Non-Structural Measures to Reduce Discharges to the Environment
7. Define Potential AEQM Strategies for Improving Environmental Quality
8. Evaluate Effects of AEQM Strategies on Environmental Objectives
9. Estimate Potential Benefits Associated with AEQM Strategies
10. Propose Potential AEQM Strategies and Their Impacts to Decision Makers

Completion of the eleventh step, Final Design and Financial Feasibility, will be the responsibility of Dong Nai DOSTE.

Application of the AEQM analysis to the Bien Hoa study area is described below.

STEP ONE: PROBLEM DEFINITION AND ANALYSIS OF PRESENT SITUATION

1a) Summarize information relating to current environmental quality, including information on land use, economic activity and historical changes in population and economic activities.

Information about the region was obtained from a number of sources, including the original VIE/95/053 Project Document, reports by project work groups, and many other sources.

Dong Nai Province encompasses a major developing area immediately east and northeast of Ho Chi Minh City. The land area of Dong Nai Province is 5800 square kilometers. Bien Hoa, the primary city in the Province is a rapidly industrializing city of approximately a half million people. The Dong Nai River, which is the major water resource and the western boundary of the Province, serves many purposes including navigation, fisheries and a water supply for both the Province and Ho Chi Minh City. Extensive industrial and residential development is underway and is projected to increase in the coming decade.

Hydrology

The Dong Nai River system (figure III-1) is one of the three largest systems in Viet Nam (Mekong, Red, Dong Nai) and covers approximately 36,000 square kilometers in the southern part of Viet Nam. The river system is composed of the mainstem Dong Nai River and three major tributaries: La Nga, Be, and Saigon Rivers. The Dong Nai and La Nga Rivers combine upstream of the major Tri An Reservoir. Immediately downstream of Tri An, the Be, and Dong Nai Rivers combine. The Dong Nai river then flows through Bien Hoa, finally combining with the Saigon River before reaching the South China Sea. A tributary loop in the Dong Nai River called the Cai River in Bien Hoa is important because of its location in the center of Bien Hoa

City and the magnitude of industrial and domestic inflows entering the river at that point. Tidal effects can be observed in the Dong Nai River almost up to the confluence with the Be River and elevated salinity is found as far upstream as Bien Hoa. There are several hydraulic interconnections between the Saigon River and the Dong Nai mainstem in the 30 kilometer reach of the Dong Nai River upstream of its confluence with the Saigon River. Due to these interconnections and the tidal effects, the flow patterns in this stretch of the river are very complex.

Starting at the confluence of the Dong Nai River and the Saigon River and ending at Tri An Reservoir, a river kilometer index was developed by measuring the stream distance in kilometers along the Dong Nai River. The resulting schematic representation of the Dong Nai River (Figure III-2) shows the location of major features such as Bien Hoa City, and water intakes.

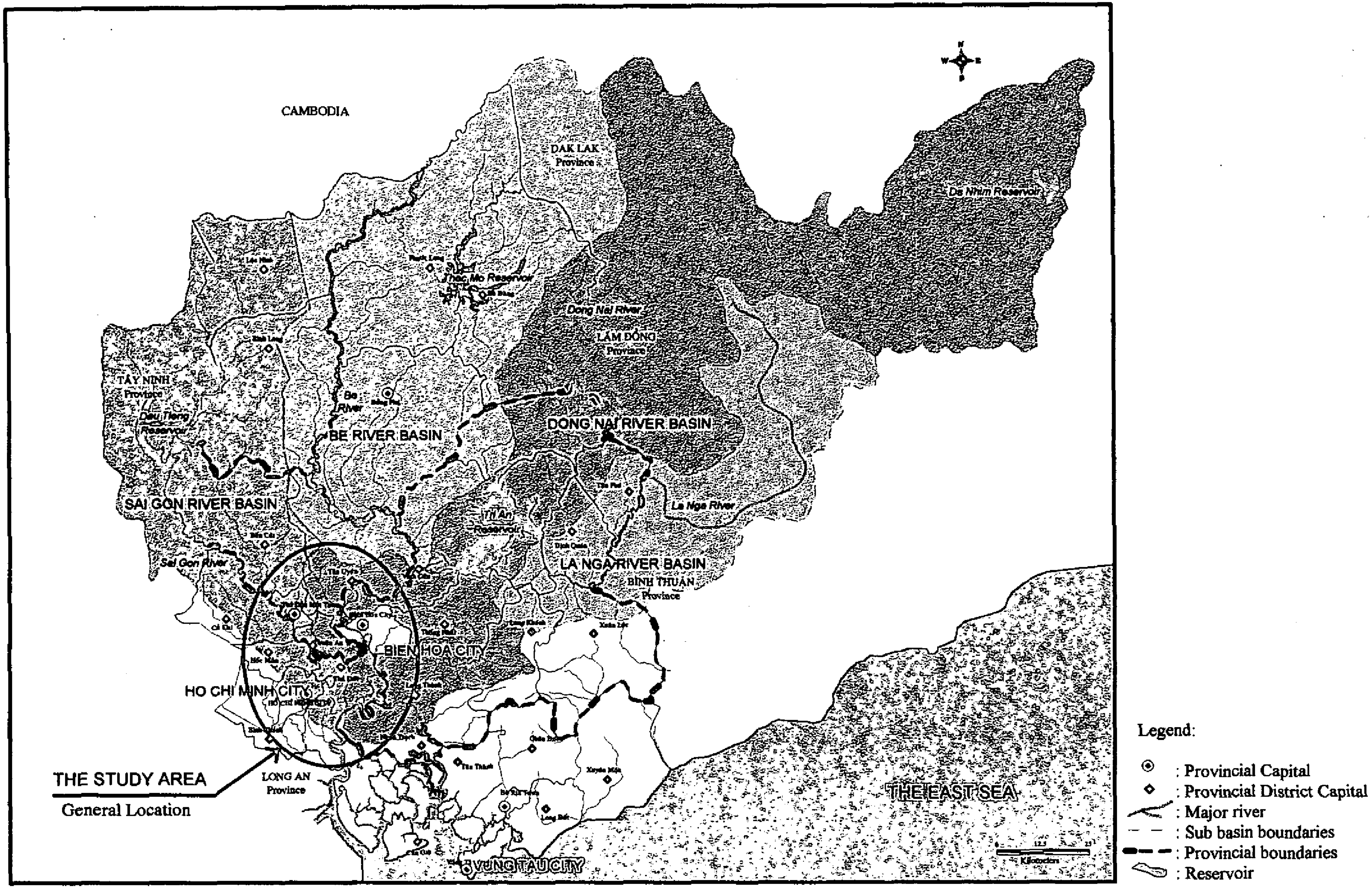


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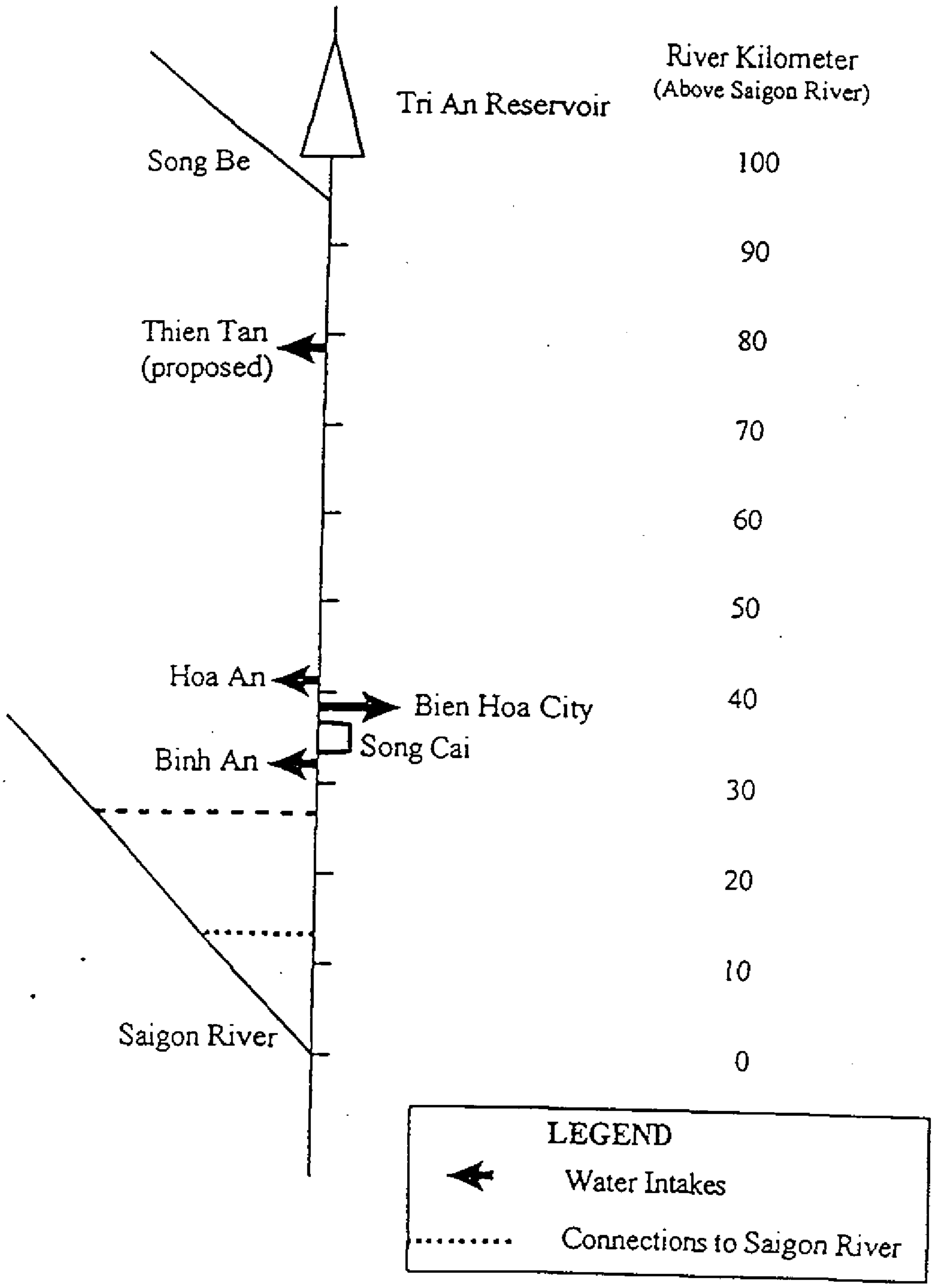
FIGURE III-1 Đồng Nai River Basin - General Information

Figure III - 2: Schematic representation of Dong Nai River with River Kilometer System



Meteorology

Precipitation varies significantly over the Dong Nai Basin and between the wet and dry seasons of the year. Average precipitation over the basin is approximately 2000 mm/year. The wet season extends from approximately May through October with the dry season covering the remainder of the year. During the dry season, average stream flow in the Dong Nai River (near Bien Hoa) is approximately 450 cubic meters per second. During the wet season this average increases to 1350 cubic meters per second. Average monthly flow and precipitation values are presented in Table III-1 for various locations in the vicinity of the study area.

Table III-1: Average Monthly Hydrologic and Meteorologic Characteristics in the Dong Nai River Region

Month	Air Temperature Bien Hoa City (°C)	Precipitation HCMC (mm)	Flow Tri An (m3/sec)	Flow Song Be (m3/sec)	Calculated Flow Dong Nai River (m3/sec)
JAN	27.8	13	236	139	375
FEB	26.9	4	225	208	433
MAR	27.8	11	246	202	448
APR	28.9	50	255	233	488
MAY	28.3	211	281	293	574
JUN	27.9	310	358	351	709
JUL	26.8	296	545	485	1031
AUG	27.2	271	835	606	1440
SEP	27.2	331	1180	767	1947
OCT	27.2	271	1068	881	1949
NOV	27.1	117	556	488	1044
DEC	27.1	48	249	184	433
Average	27.5	1932	503	403	906

Because of the proximity of Ho Chi Minh City to Dong Nai Province, wind direction has a significant influence on air pollution in the region. Figures III-3 and III-4 display the distribution of wind direction and speed in Ho Chi Minh City for the dry season and the wet season. These "wind roses" indicate that the predominant wind direction during the dry season is from the southeast, while the predominant wind direction is from the southwest during the wet season. Thus, during the wet season, air pollution from Ho Chi Minh City impacts on air quality in Bien Hoa City and Dong Nai Province.

Figure III - 3: Wind Rose - Ho Chi Minh (Nov-May 1995)

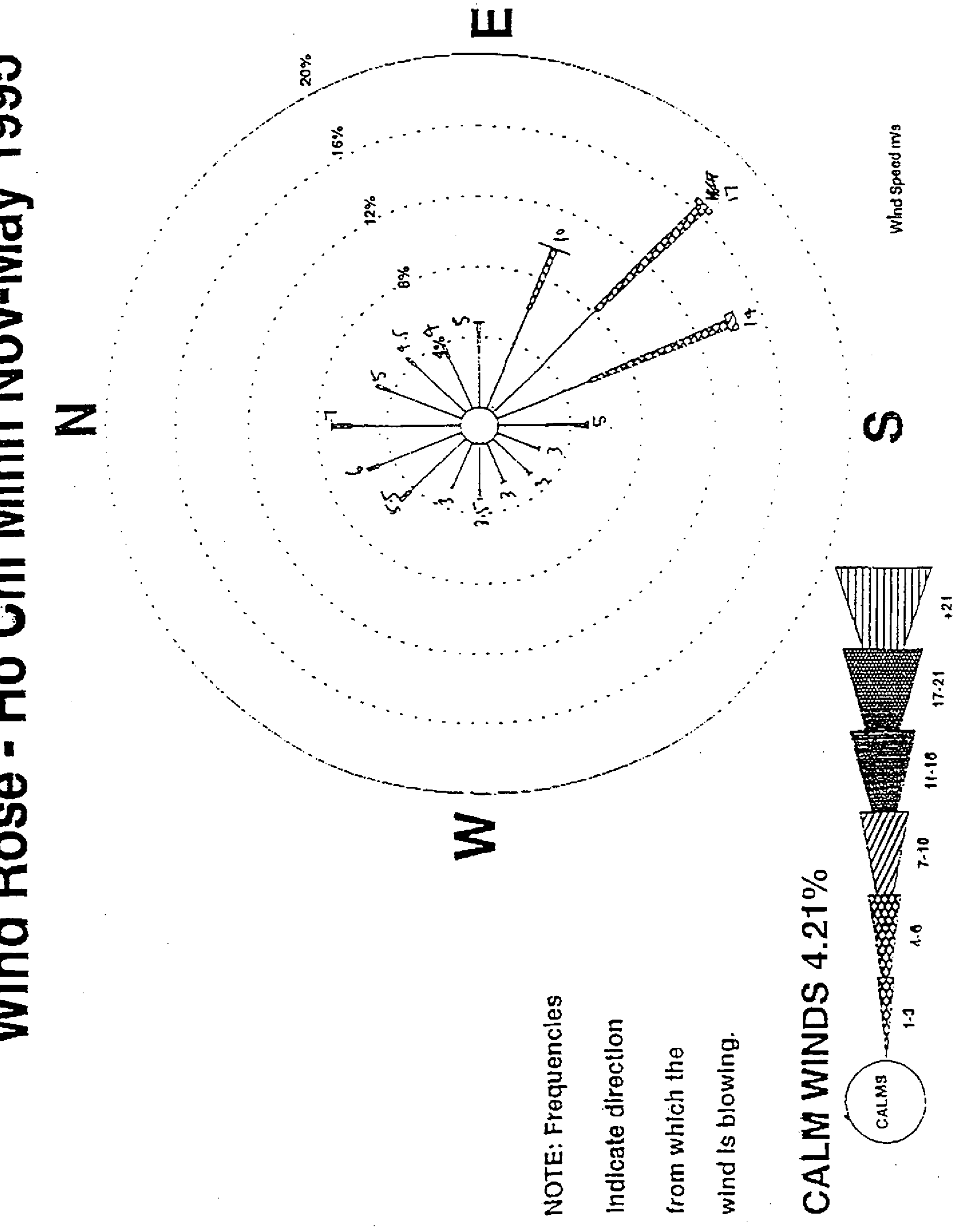
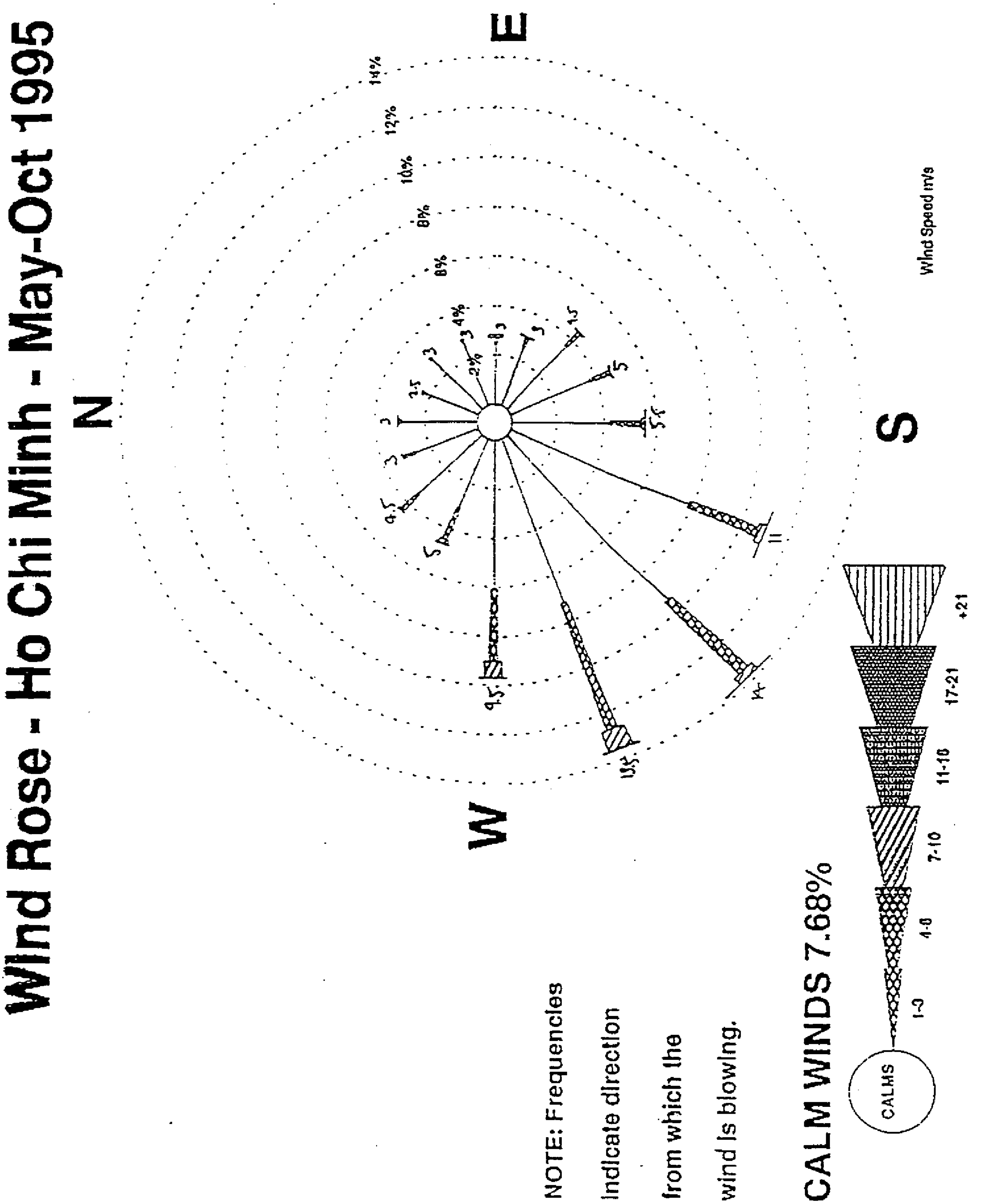


Figure III - 4: Wind Rose - Ho Chi Minh (May - Oct 1995)



Infrastructure

Bien Hoa City is partially served by a wastewater and storm water collection system. Individual houses and commercial/institutional buildings may be served by septic tanks or holding tanks. Effluent from these facilities travel via the combined sewer system, overland flow or through the shallow groundwater to the surface stream system. These streams then discharge to the Dong Nai River or to the Cai River without treatment. Waste water effluent from industrial plants is discharged to drainage ditches and surface streams, in most cases without treatment.

There are several existing and future intakes for drinking water in the Bien Hoa area. The main intake for Ho Chi Minh City is located at the Hoa An Bridge (KM 41) while the intake for Bien Hoa is located between the Hoa An Bridge and the Cai River (KM 39). Another intake for Ho Chi Minh City is under construction downstream of the Cai River (KM 36) and one is proposed upstream at Thien Tan (KM 78).

There are no air pollution control devices installed at major industrial sources of air pollution. Solid wastes are disposed of at the unmanaged Trang Dai landfill or disposed indiscriminately.

Economic and Demographic Features

Dong Nai Province currently has one of the highest industrial growth rates in the country. The province is part of the Southern Economic Focus Zone (SEFZ) which is comprised of Ho Chi Minh City and the provinces of Dong Nai, Binh Doung, Binh Phouc, and Ba Ria-Vung Tau. The core of the SEFZ is Ho Chi Minh City, a major commercial, educational, and political center in southern Viet Nam, and the cities of Bien Hoa, Thu Dau Mot and Vung Tau. In recent years, the SEFZ has been the fastest growing region in Viet Nam with a very high development rate in both the industrial and commercial sectors. More than half of the total industrial production of the country comes from this economic focus zone.

With the implementation of political, institutional, and economic reform since the early 1980's, the economic structure of Dong Nai Province has been changing. In the year 1990, agricultural production was the largest sector, contributing 50 % of the Gross Domestic Product (GDP), while industry and services contributed 20 % and 30 % of the GDP, respectively. [Source: Master Plan for Dong Nai Province, 1996]. Industrial production has now surpassed agriculture, forestry and fishery and become the most important sector in the province. Between 1990 and 1995, the annual GDP growth rate for Dong Nai's industrial sector was 15.5%. The industrial growth rate increased to 30% in 1996, but slowed in 1997 and 1998. During the first half of 1998 it declined to 16%. Within this sector, foreign capital, with more than US$ 4 billion, provided the highest growth rate. Foreign direct investment during 1998 was approximately 26% less than the same period in 1997.

The provincial per capita level of GDP has also grown and is projected to be much higher in the years ahead. The Dong Nai per capita GDP was US$ 257 in 1995 and is projected to be US$ 1700 by 2010.

A summary of the economic activity for Dong Nai Province during recent years is presented in Table III-2.

Table III-2: Summary of Dong Nai Gross Domestic Product in 1995, 1996 and 1997 (in 1994 billions of VND)

	1995	1996	1997
ECONOMIC SECTOR			
Agriculture, Forestry, Fishery	**1810**	**1920**	**2000**
Agriculture	1760	1880	1960
Forestry	20	10	20
Fishery	30	30	30
Industry and Construction	**2320**	**3050**	**3720**
Industry	2180	2880	3510
Construction	10	170	210
Services	**1650**	**1800**	**1980**
OWNERSHIP TYPE			
Domestic	**5020**	**5750**	**6320**
State (central)	1420	1630	1800
State (local)	670	830	890
Cooperatives	10	30	30
Private	150	280	320
Individual (households)	2710	2920	3210
Other	60	70	80
Foreign	**750**	**1020**	**1370**
TOTAL	**5780**	**6760**	**7690**

The 1996 urban and rural population of the region is shown in Table III-3, for the Southern Economic Focus Zone, Dong Nai Province and Bien Hoa City.

Table III-3: Population of the Region (1996, 1000's)

Area	Urban population	Rural population	Total population
Southern Economic Focus Zone	4,493	3,800	8,293
Dong Nai Province	557	1,412	1,969
Bien Hoa City	435	0	435

Institutional Features

Institutional features of importance in understanding the present environmental situation and in developing potential AEQM strategies have been divided into two segments: legal foundation and agency implementation.

Legal Foundation

The 1993 Law on Environmental Protection clearly defined the legal responsibilities for environmental protection and management. Highlights of the law follow:

- Article 1. "Environmental protection as stipulated in this law includes activities aimed at preserving a healthy, clean and beautiful environment, improving the environment, ensuring ecological balance, preventing and overcoming adverse impacts of man and nature on the environment, making a rational and economical exploitation and utilization of natural resources."

- Article 4. "The State shall be responsible for organizing the implementation of education, training, scientific and technological research activities and the dissemination of scientific and legal knowledge on environmental protection."

- Article 8. "The Government and the People's Committees at all levels shall be responsible for organizing the implementation of the environmental legislation."

- Article 38.
  - " The Ministry of Science, Technology and the Environment shall be responsible to the Government for exercising the function of State management of environmental protection."

  - "The People's Committees of provinces and cities directly under the Central Government shall exercise their State management function for environmental protection at the local level.

- "The Services of Science, Technology and Environment shall be responsible to the People's Committees of provinces and cities directly under the Central Government, for environmental protection in their localities."

The legal foundation represents a significant challenge to successful implementation of an AEQM strategy. Because of the wide range of government agencies with legal authority over different aspects of environmental management, success depends upon an understanding of the AEQM approach by the leaders of agencies at the national, regional, provincial and local levels, and a strong commitment to communication and integration among them.

Agency Implementation

The primary agencies responsible for implementation of an AEQM strategy are listed in Table III-4. Coordination between the Dong Nai Provincial Agencies listed has begun and some progress has been made in expanding the staff in recent years. The table contains a listing of the total number of employees, those responsible for environmental activities and the 1998 budget devoted to environmental management activities for the listed agencies.

Table III-4: Summary of Budget and Staffing for Dong Nai Provincial Agencies with Environmental Management Responsibilities, Totals and Environment Only

Dong Nai Agency	Role	Budget for Env. Activities (Millions VND)	Employees (1998)	
		1998 Envir.	Total	Envir.
People's Committee	Policy Overview		85	10
Construction	Urban Sewerage	467400	41	6
Agri & Rural Dev	Ground Water	964	63	15
Ind. Zone Auth.	Ind. Park Air, Water & Solid W.	500	37	4
Planning & Inv.	Budget & Finance	5040	54	5
Sci., Tech. & Environment	Monitoring & enforcement	7000	60	60
Sonadezi	Industrial Park Management	50000	368	15
BienHoaUrbanEnv. Service Company	Solid Waste Collection/Disposal	14453	264	174

Primary environmental management responsibilities of each of the Provincial Agencies listed above are summarized in Step 1d below.

Historical Perspective

A further understanding of factors impacting on environmental quality of the region can be developed through a historical perspective.

- The area now known as Industrial Park Bien Hoa I is the site of the first industrial development in the region. It began to be built during the late 1950's soon after the end of World War II. Development was primarily of heavy industry, largely unregulated. Industrial waste water was, and with few exceptions, continues today to be discharged directly to the river without treatment. There are no regulatory limitations on the discharge of air emissions, or the disposition of solid and hazardous wastes. This type of development continued during the war years that followed, after reunification in 1975 and until the early 1990's. Major industrial plants constructed in or adjacent to Bien Hoa I include: COGIDO Paper; Bien Hoa Sugar; Tan Mai Paper; Dong Nai Garment; VICASA Steel; and Dong Nai Battery.

- The population of Bien Hoa City has been growing very rapidly during the past decade, primarily due to rural immigration by people seeking the higher incomes offered by factory employment. The 1985 population was 200,000; today it is approximately 480,000. While a majority of the population is supplied with potable water, there is no waste water collection or treatment system, and it is estimated that less then 25 percent of the households participate in solid waste collection services.

- There have also been significant changes in transportation during the past ten years. Motor bike registrations increased in Vietnam (no data are available for Bien Hoa) by 400 percent during the period 1990 - 1993. In 1998 there were 91,000 motorcycles and 11,800 cars and trucks registered in Bien Hoa, and it appears that the number of motor vehicles continues to grow faster then the population.

- Even as the number of people employed in agriculture has fallen, agricultural land use in the region has intensified with increased use of fertilizers, and pesticides to obtain higher crop yields. More soil erosion is part of the result of these activities. A significant increase in the river load of suspended solids and nutrients has also occurred. Limited field measurements were made during past years but some informal oral history from people living along the Dong Nai River shore confirm the growth of eutrophication, in the form of floating algae, from higher concentrations of upstream nutrient sources during the past decade.

- Fish farms developing during the past five years on the surface of the Tri An Reservoir have also contributed to excess nutrients in the Dong Nai River downstream.

- During 1998, there were two separate water quality field surveys conducted of the Be River and Dong Nai River upstream of the Tri An Reservoir. The results tend to show that significant non point pollution comes from both major drainage basins upstream. No significant point sources have been identified to date.

1b) Select the study area and the time period for analysis

Figure III-5 illustrates the approximate boundaries of the study area selected for analysis of water and solid waste management. The study area includes the 1400 square kilometer region of the Dong Nai River water shed surrounding Bien Hoa, the primary population center in Dong Nai Province. Figure III-6 illustrates the larger study area selected for analysis of air pollution. The larger study area is necessary to incorporate the potentially significant impacts of Ho Chi Minh City on air quality around Bien Hoa City.

The time period selected for the analysis was 15 years, 1995-2010. This time frame was considered to be short enough for practical policy making projections and long enough to reflect the amount of time necessary to implement comprehensive AEQM strategy. The project began in 1996, so the 1995 period was the logical one for access to recent land use, population, industry and other local data.

1c) Determine the present land use activities within the study area.

Information on present land use conditions was obtained from a number of different sources. Most of them were reports, including many tables and maps, by local agencies. These reports were identified and obtained by the DOSTE staff and by the National Consultants (NC's) participating in the project.

1d) List and describe those institutions with responsibility for managing environmental quality and environmental discharges within the study area and the interrelationships among these institutions.

The provincial law on environmental protection was approved by the People's Committee of Dong Nai late in the summer of 1998. It was patterned after the national law. In the provincial law, the responsibilities for environmental quality management were distributed among several different departments:

- Policy review and approval-People's Committee of Dong Nai
- Urban domestic waste water collection and treatment-Department of Construction
- Ground water quantity and quality-Department of Agriculture and Rural Development
- Industrial park air, water, and solid wastes-Industrial Zone Authority
- Budget and fund distribution-Department of Planning and Investment
- Monitoring and enforcement-Department of Science, Technology, and the Environment

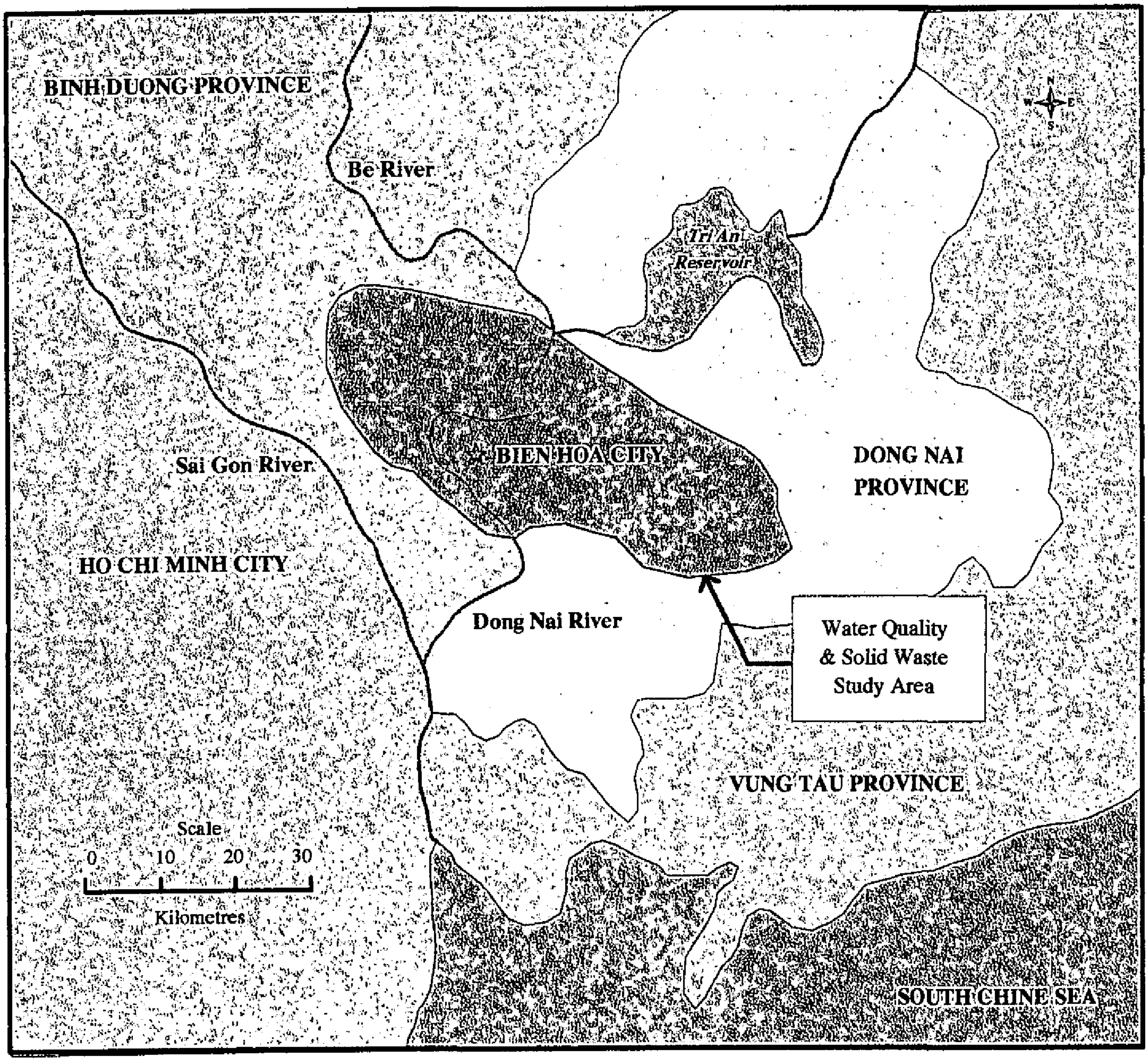
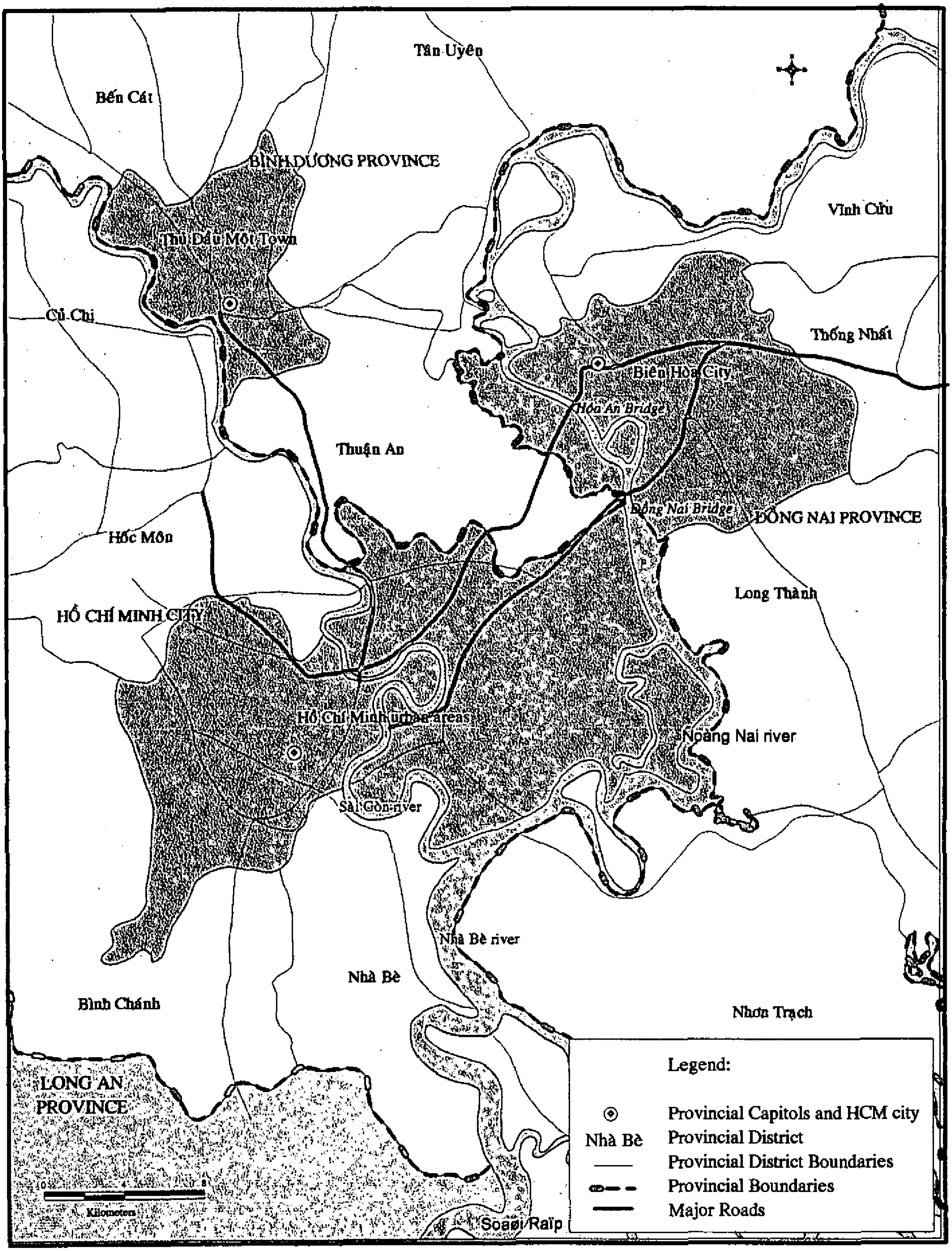


FIGURE III-5 STUDY AREA; WATER QUALITY AND SOLID WASTE

FIGURE III-6
STUDY AREA; AIR QUALITY
(HO CHI MINH CITY - BIEN HOA CITY - THU DAU MOT TOWN)



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Other important implementing agencies include:

- SONADEZI - manager of the major industrial parks, including solid, hazardous, and liquid waste collection and treatment
- Bien Hoa Urban Environmental Services Company (BHUESC) - responsible for collection and disposal of residential, commercial and institutional solid wastes

Agencies responsible for environmental management in Ho Chi Minh City will also have a significant impact on environmental quality, especially with respect to air quality.

1e) ***Group the activities within the study area by category and geographic sub-areas for purposes of estimating the generation and discharge of waste materials.***

The activities were grouped into the following categories:

- industrial
- domestic
- agricultural
- transportation
- commercial/institutional

The geographic sub-areas that were selected differed for each of the types of activities (water, air, solid waste) as follows:

Water

The majority of water use and demand is met by the surface water system. Therefore, emphasis was placed on the surface water system. Limited data are available on groundwater. It is not considered to be a major water resource in this area at this time, although it may be significantly impacted by many of the activities in the study area. In addition, if groundwater is already significantly polluted, it may be impacting surface water quality during recharge.

The study area, bounded upstream by the confluence of the Be and Dong Nai Rivers just downstream of the Tri An Reservoir and downstream by the confluence of the Buong and Dong Nai Rivers, was divided into five sub basins to provide more clarity of land use and surface water pollution sources (Figure III-7). They are:

- Dong Nai River mainstem upstream of the Hoa An bridge
- Dong Nai River mainstem downstream of the Hoa An bridge
- Cai River, a Dong Nai branch flowing around Cu Lao Pho Island in the center of Bien Hoa
- Ba Lua stream, a tributary
- Buong and Quong Rivers, tributaries

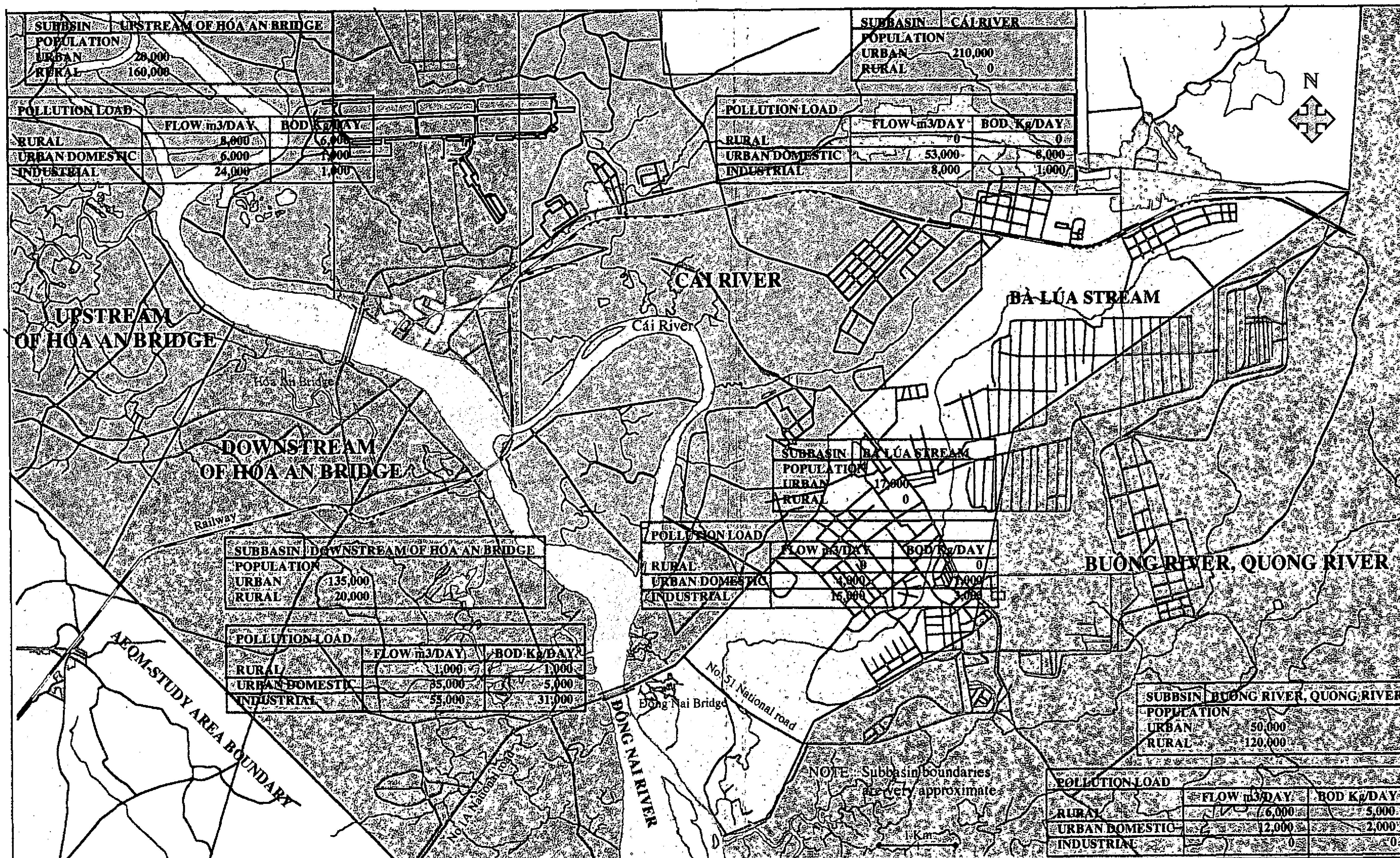


FIGURE III-7 SUBBASINS FOR WATER QUALITY STUDY AREA DRY SEASON - PRESENT POLLUTION LOADS

Two of the sub basins, Dong Nai River mainstem upstream of the Hoa An Bridge and the Buong and Quong Rivers contain large areas of rural land. The other three sub basins are located in the Bien Hoa urban area. The five sub-basins are shown in Figure III-7.

Air

Air data were developed for Southern Economic Focal Zone, as well as for the sub areas of Dong Nai Province and Bien Hoa (the approximate location of the study area).

Solid Waste

Solid waste generation rates were developed for each of the major groups of activities for the water quality study area, and were not sub-divided into sub-areas.

1f) *Estimate current levels of activity according to the chosen groups and for major dischargers.*

Industrial Activity

Table III-5 summarizes current (1997) industrial activity in the study area.

Table III-5: Summary of Industrial Activity in the Bien Hoa Study Area (1)

Industrial Park	Number of Industries	Number of Employees
Amata	5	600
Bien Hoa 1	55	17,200
Bien Hoa 2	60	23,400
Loteco	6	100
Pou Chen	1	8,000
Total	**127**	**49,300**

(1) Source: Dong Nai Industrial Development Authority, 1997, number of employees rounded to nearest 100.

Domestic

Population distribution in the study area for 1997, divided according to the five water quality sub basins, is presented in Table III-6.

Table III-6: 1997 Study Area Population Distribution by Water Quality Sub Basins

Sub Area	Population (1000's)	
	Rural	Urban
Dong Nai River Mainstem Upstream of Hoa An Bridge	160	20
Dong Nai River Mainstem Downstream of Hoa An Bridge	20	135
Cai River Branch		210
Ba Lua Tributary		17
Buong & Quong Tributaries	120	50
Totals	300	435

Agriculture

Agricultural areas planted in Dong Nai Province in 1997 are provided in Table III-7 by major crop categories.

Table III-7: Agricultural areas in Dong Nai Province (1997)

Agricultural Categories	Hectares (1000's)
Major perennial crops (tea, coffee, rubber, paper, coconut, cashews)	101
Fruit crops	15
Other perennial crops	1
Annual food crops (rice, maize, sweet potato, cassava)	151
Vegetable and beans	25
Annual industrial crops (soybean, ground nuts, sesame, sugar cane, tobacco, cotton, melon)	40
Feed crops	2
Other annual crops	1
TOTAL	**335**

Transportation

There are currently (1998) 91,000 motorcycles and 11,800 cars and trucks registered in Bien Hoa study area.

Commercial/Institutional

Limited data were collected on commercial activities. In most cases water, air, and solid waste generation for these activities are included in the estimates of domestic generation.

Because of the importance to solid waste management, data were collected for hospitals, as a sub-set of institutions. The study area contains four hospitals, containing a total of 1150 beds.

1g) ***Estimate the current generation of wastes and discharges to air, water and land by activity, where discharges are defined to include liquid, gaseous and solid materials.***

1h) ***Determine the area outside of the study area boundary that exports pollutants to the study area and quantify the imports and exports of environmental discharges.***

Parts 1g and 1h were combined for this project because the readily available information was combined.

Water

Estimates of current water quality based on BOD loads were made for the five sub basins. The results are shown in Table III-8 and Figure III-7. These estimates were based on limited field data. The available data were used in conjunction with generalized relationships for Viet Nam to develop the generation rates used in the study. The following data sources were used in the process:

- 1997 population census data for Bien Hoa,
- the number of factories, the number of employees, type of product produced and the land area covered,
- a general coefficient for BOD generation and delivery to the stream per person per day (39 grams/person/day), and
- a 1995 survey report of the pollution discharges from the factories located in industrial park Bien Hoa I.

It should be noted here that the availability of data on which to conduct an AEQM analysis often requires use of data from various time periods around the base year due to the nature of data collection activities by different agencies and for different purposes.

Table III-8: Present (1998) Study Area Surface Water Flows and BOD Loads Estimated by Sub Basins

Category	Wet Season		Dry Season	
	Flow (1000 m^3/day)	BOD (1000 kg/day)	Flow (1000 m^3/day)	BOD (1000 kg/day)
Dong Nai River Upstream of Hoa An Bridge				
Rural	1080	9	8	6
Urban	11	1	6	1
Industrial	24	1	24	1
Dong Nai River Downstream of Hoa An Bridge				
Rural	136	1	1	1
Urban	68	8	34	5
Industrial	49	31	49	31
Cai River Branch of Dong Nai River				
Rural	0	0	0	0
Urban	105	12	53	8
Industrial	8	1	8	1
Ba Lua Stream Tributary Of Dong Nai River				
Rural	0	0	0	0
Urban	8	1	4	1
Industrial	25	4	25	4
Buong & Quong Rivers, Dong Nai River Tributaries				
Rural	872	7	6	5
Urban	25	3	13	2
Industrial	0	0	0	0

Air

Air emission data were developed for the Southern Economic Focal Zone, Dong Nai Province and Bien Hoa. Data are based primarily on rough generation coefficients applied to major sources, plus limited air quality sampling conducted as part of this project. A summary of this information is presented in Table III-9.

Table III-9: Present (1998) Population and Air Pollution Emissions for the Southern Economic Focus Zone , Dong Nai Province, and Bien Hoa (Approximate Study Area)

Area & Emission Type	Pollutants (1000 kg/day)					Population (1000's)	
	Total Suspended Part,TSP	Carbon Monoxide CO	Volatile Organic s VOC	Sulphur Dioxide, SO2	Nitrogn Oxides, NOX	Urban	Rural
Industrial							
Southern Econ Foc Zone	29			340	25	-	-
Dong Nai Province	19			230	17	-	-
Bien Hoa	8			135	5	-	-
Domestic (Rural &Urban)							
Southern Econ Foc Zone	1			3	2	4700	3600
Dong Nai Province	0.2			0.6	0.4	580	1400
Bien Hoa	0.006			0.1	0.1	460	0
Transportation							
Southern Econ Foc. Zone							
Dong Nai Province							
Bien Hoa	0.5	90	48	0.6	2.2	-	-

Solid Waste

No data on solid waste generation were available at the beginning of the project. Therefore, contracts were let for an international solid and hazardous waste consultant (IC), and with the Environmental Protection Center in Ho Chi Minh City to develop information on solid and hazardous waste generation and disposition.

Household Generation and Composition

The Science, Technology and Environment Board (STEB) of Bien Hoa City conducted a survey of solid waste generation and composition in Bien Hoa during January and February, 1997 and 1998. Based on the STEB study, it is estimated that per capita generation of residential waste is 0.27 kg/day. Average composition is reported in Table III-10.

Table III-10: Composition of Household Waste, Bien Hoa City, 1997-1998

Material	Percent by Weight
Food	64 - 69
Paper	4.5 - 6.0
Nylon Bags	5.5 - 7.0
Plastic	1.0 - 3.5
Textiles	2.0 - 3.0
Rubber	2.0 - 4.5
Leaves and branches	7.5 - 14.5
Glass	1.5 - 2.5
Metal	1.0 - 3.5
Inerts (ash and dirt)	5.0 - 12.0

Table III-10 illustrates that on average 77 percent of the household waste is food and yard wastes. With the addition of paper, approximately 82 percent of household generation is organic, and therefore potentially compostable. Another 9 percent is inert ash and dirt. Only approximately 13 percent of household generation is potentially recyclable, including paper. Much of this potentially recyclable material is currently collected for recycling, either by scavengers operating on the streets, or by scavengers at the landfill.

Commercial Generation and Composition

The STEB did not analyze commercial generation. Therefore it was necessary to make some rough estimates based on data reported in the literature. According to the World Bank Technical Paper, Managing Urban Environmental Quality in Asia, Kingsley, G.T, et al, 1994, "household generation" which includes commercial wastes, ranges from 0.4 to 0.7 kg/capita/day. Given the low generation rate reported by STEB for Bien Hoa, it is reasonable to assume that commercial waste would not add more then 1 kg/capita/day, after scavenging at the commercial activities.

Therefore, for estimation purposes, it is assumed that residential/commercial generation rates can be estimated using 0.37 kg/person/day for net generation, after source separation and recycling/reuse. The current population of Bien Hoa City is reported to be 436,650. This yields 59,000 tonnes of waste per year, or approximately 160 tonnes per day (7 days per week).

Recycling

No data are available on the amount of material recycled. However, based on the composition of the waste stream (see above), it assumed that approximately 10 percent of the residential and commercial waste stream (exclusive of automotive wastes as discussed below) are collected for recycling from the residential and commercial waste stream by scavengers on the street and at the landfill.

Collection

According to the EPC report, BHUESC collects waste in only 15 of the 26 wards/communes in Bien Hoa. And, even in these wards the EPC estimates that only 26 percent of the households are served, with the remainder either bringing their waste to a collection transfer location or disposing in illicit dumps or in the small stream beds. When the wards/communes without service from BHUESC are included, EPC estimates that only 13 percent of the households are served by a formal collection system.

Beginning in 1996, the People's Committee of Dong Nai Province and DOSTE authorized BHUESC to begin collection of domestic type wastes, and some industrial wastes from industries in the Bien Hoa area. Two crane vehicles are utilized to collect waste from 67 industries, four hospitals, and 10 commercial sites.

Disposal

The Trảng Dai landfill is located on a 15 ha site approximately 10 km from the center of the City. There have been no hydrogeologic investigations of the site. The site is unlined and waste is not covered. Approximately 50 scavengers work picking through material at the landfill.

Theoretically, industrial wastes are disposed of in separate cells from residential and commercial wastes. Much of the industrial waste is disposed indiscriminately with the residential and commercial waste. Hospital wastes are also disposed in the same location (see below).

On-Site and Indiscriminate Disposal

In all areas of the study area not served by BHUESC, all non-recyclable wastes are disposed of on-site, or in adjacent vacant areas. Indiscriminate dumping of solid wastes in the stream beds throughout Bien Hoa is a significant problem, contributing significantly to degradation of these streams.

Hospital Bio-hazardous Wastes

Tours of the two largest hospitals in Bien Hoa City were conducted. In both cases the hospitals attempt to follow regulations implemented in 1996 requiring them to maintain three waste bins with red, yellow, and blue plastic bags respectively. Sharps and surgical wastes are placed in the red bins, bandages, and other similar materials in the yellow bin, and domestic wastes in the blue bins.

Based on our tours of the two hospitals, it appears that the nursing staffs are careful about following the regulations. However, implementation of the system breaks down after this for the following reasons:

- It is difficult and expensive to obtain the required three colors of bags. For this reason, most of the bins either had one color plastic bag or no bag.

- As a consequence, the employees responsible for collecting and emptying the bags make mistakes, placing potentially bio-hazardous waste in the domestic waste bins. The waste from these bins are then brought to the BHUESC landfill where scavengers are potentially exposed to this bio-hazardous waste.

- Neither hospital has adequate on-site disposal facilities for the bio-hazardous wastes which are kept separate. The Children's hospital (350 beds) simply open burns and buries this waste on-site. The Dong Nai Provincial hospital has a small brick oven behind the hospital where these wastes are burned. This oven has no grates, forced air supply, secondary combustion chamber, or pollution control equipment. Instead, waste is thrown onto the ash pile, covered with some used oil, and ignited.

In conclusion, the hospital waste system fails for lack of adequate funding, equipment, and training of the maintenance staff, to implement the modern system of bio-hazardous waste management which the nursing staffs have implemented. The result is that scavengers are exposed to bio-hazardous wastes at the landfill, and the incomplete combustion contributes to localized sources of air pollution.

Hospital Waste Generation

Based on data from the two hospitals, and assuming that there are 1150 beds at the four hospitals in the study area, it is estimated that a total of 1050 tonnes of "domestic" waste and 210 tonnes of bio-hazardous wastes were generated in 1998 in the study area.

Transportation Activities

In addition to the obvious air emission issues, motor bike, automobile, bus, and truck use generates waste oils, cooling fluids, old batteries, and tires which must be disposed of. These wastes can have significant impacts on ground and surface water quality if improperly managed. In addition, the underground fuel storage tanks used to store and distribute gasoline and diesel fuels will eventually develop leaks, releasing fuel oil, and gasoline into the environment unless a regular monitoring and replacement program is in place.

Waste Oil Generation Rates

Based on some rough assumptions about waste oil generation per vehicle, and discussions with garages in the study area, it is estimated that approximately 20,000 liters of waste oil are currently dumped on the ground or into drains.

No attempt has been made to estimate the number of batteries and tires disposed of each year, but as illustrated by the rough calculations above for waste oil, improper disposal of batteries and tires may also be a significant concern in the study area.

Industrial Wastes

Three approaches were taken to develop information on the quantity and composition of industrial waste generation. First, data were collected on employment and on products produced by each industrial activity in each park. A search of the literature was made for per employee waste generation and composition coefficients, by industry type to apply to these employment data.

Second, data from SONADEZI on recent per plant waste collections was compiled and compared with employment data at these plants.

Third, the EPC conducted site visits to 106 industrial plants to obtain information on solid and hazardous waste generation, recycle, and disposition. Data collected from the site visits, combined with the estimates based on the literature search and SONADEZI information, were used to develop estimated solid and hazardous waste generation and disposition in the study area (Table III-11 and III-12).

Table III-11: Summary of Industrial Solid Waste Generation, Bien Hoa Study Area (1998)

Location	Total Industrial Wastes (tonnes/day)	Recovered for Recycling (tonnes/day)	On-Site Disposal or Storage (tonnes/day)	Private Collection & Disposal (tonnes/day)	Collected by BHUESC for Disposal (tonnes/day)
Bien Hoa 1	68.3	16.2	45.2	1.0	6.9
Bien Hoa 2	30.5	7.6	1.2	0.2	21.5
Amata	0.2				0.2
Loteco	0.1				0.1
Other	1.2	0.8	0.2	0.2	
Total	**100.3**	**24.6**	**46.6**	**1.4**	**28.7**

Table III-12: Estimated Industrial Hazardous Waste Generation, Bien Hoa, 1997

INDUSTRY	TOTAL # OF FIRMS	EMPLOYEES	1000s EMPLOYEES	ESTIMATED WASTE GENERATION (TONNES/YEAR)								
				Acids	Alkalis	Inorganic Wastes	Reactive Wastes	Resins and Paints	Organic Solvents	Oily Waste	Contaminated Containers	Organic Chemicals
Food	13	3035	3.0	0.9	303.5	6.1	0.0	0.0	6.1	30.4	6.1	0.6
Tobacco	1	340	0.3	0.1	34.0	0.7	0.0	0.0	0.7	3.4	0.7	0.7
Textiles	3	703	0.7	0.7	1.0	2.4	0.0	6.0	1.6	26.9	0.9	0.1
Apparel	14	26754	26.8	26.8	37.5	91.0	0.0	230.1	61.5	1022.0	34.8	2.7
Lumber	7	1853	1.9	0.2	2.6	7.4	0.0	37.1	3.7	18.5	3.7	0.2
Furniture	1	294	0.3	0.0	0.4	1.2	0.0	5.9	0.6	2.9	0.6	0.0
Paper	3	1558	1.6	1.6	9.3	15.6	6.2	31.2	7.8	15.6	3.1	0.3
Printing	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chemicals	12	1485	1.5	74.5	297.9	59.5	11.9	29.8	10.4	119.1	29.8	3.0
Petroleum	1	254	0.3	12.8	51.0	10.2	2.0	5.1	1.8	20.4	5.1	0.5
Plastics	9	1345	1.3	6.9	67.5	108.0	0.0	13.5	0.1	13.5	1.3	0.0
Leather	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stone/Clay/Glass	7	1637	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Primary Metals	0	60	0.1	24.1	6.0	2.4	0.1	0.0	0.1	3.6	0.1	0.0
Fabricated Metals	7	633	0.6	31.7	31.7	5.1	1.3	12.7	3.2	19.0	1.9	0.0
Machinery	9	2189	2.2	218.9	43.8	17.5	0.0	43.8	2.2	65.7	21.9	0.2
Elec. Equip	18	5403	5.4	540.3	108.1	43.2	0.0	108.1	5.4	162.1	54.0	0.5
Transportation Equip.	5	1871	1.9	186.9	18.7	11.2	3.7	18.7	5.6	112.1	3.7	0.0
Measure/Photo	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous	11	2106	2.1	105.3	63.2	12.6	4.2	210.6	12.6	63.2	63.2	0.4
Total	121	51520	52	1232	1076	394	29	752	123	1698	231	9

Waste Water Treatment Plant, and Industrial Waste Sludge

There are current plans to construct three waste water treatment plants (WWTP) to serve AMATA, LOTECO, and Bien Hoa 2. There are no plans to construct a WWTP serving Bien Hoa 1. Each of these WWTPs is supposed to be an activated sludge plant. Based on some very rough flow data, it is estimated that sludge generation would be about 3000 kg/day of dry sludge. This is equivalent to 2.5 tonnes per day of wet sludge (at 20 percent solids) or approximately 900 tonnes per year. It is likely, given the number of industries that would be discharging to these treatment facilities, that this sludge will not be acceptable for land application, and will have to be landfilled.

In addition, there are industries, especially in Bien Hoa 1, who discharge liquid wastes into lagoons, where settling occurs. Eventually, these lagoons must be dredged. Currently, this dredged material is hauled to the Trang Dai landfill area for disposal. No data are available on the quantities or composition of this material, including whether any of this material is hazardous.

Import and Export of Solid and Hazardous Wastes

No data are available on import or export of solid and hazardous wastes to/from the study area. There does not appear to be significant import or export of wastes, other then the export of recyclable materials to HCMC.

1i) *List and Describe the Institutions with Responsibility for Managing Environmental Discharges that are Imported to the Study Area. Describe the Linkages to Institutions within the Study Area*

A formal list of institutions was not prepared. However, it includes several ministries in the central government such as the Ministry for Planning and Investment and the Ministry of Science, Technology, and the Environment. It would also include the People's Committee and the Department of Science, Technology, and the Environment for each of the surrounding provinces, including Binh Duong, Binh Phuoc, Lam Dong, Long An, Tay Ninh, Ninh Thuan, and Baria-Vung Tau. Various parts of the Ho Chi Minh City government, especially the People's Committee and the Department of Science, Technology, and the Environment would also be included. The formal and informal linkages among these agencies are unknown.

1j) *Estimate Current Impacts of Discharges from Within and Outside of the Study Area on the Ambient Environmental Quality of the Study Area*

Water

Limited data are available on current water quality of the area.

Twice monthly measurements of dissolved oxygen (D.O.) and biological oxygen demand (BOD) have been taken at the Hoa An water intake for many years by the Environmental Protection Center (EPC) in Ho Chi Minh City. These data were used to plot the histograms shown in Figures III-8 and III-9. These parameters are dependent upon a wide range of biological and chemical constituents and thus serve as general indicators of the health of the river with the exception of toxic materials such as heavy metals and synthetic organics. These data indicate a long term average for D.O. of 6 mg/L and 8.5 mg/L for BOD. Provincial and national standards for rivers that serve as sources for drinking water require D.O. of at least 6 mg/L and BOD less than 5 mg/L. Examination of the distribution of D.O. and BOD measurements indicate that approximately 40% of the D.O. measurements at Hoa An are below that standard and that 90% of the BOD measurements exceed the standard.

Figure III - 8: Distribution of D.O. Measurements at Hoa An Water Intake

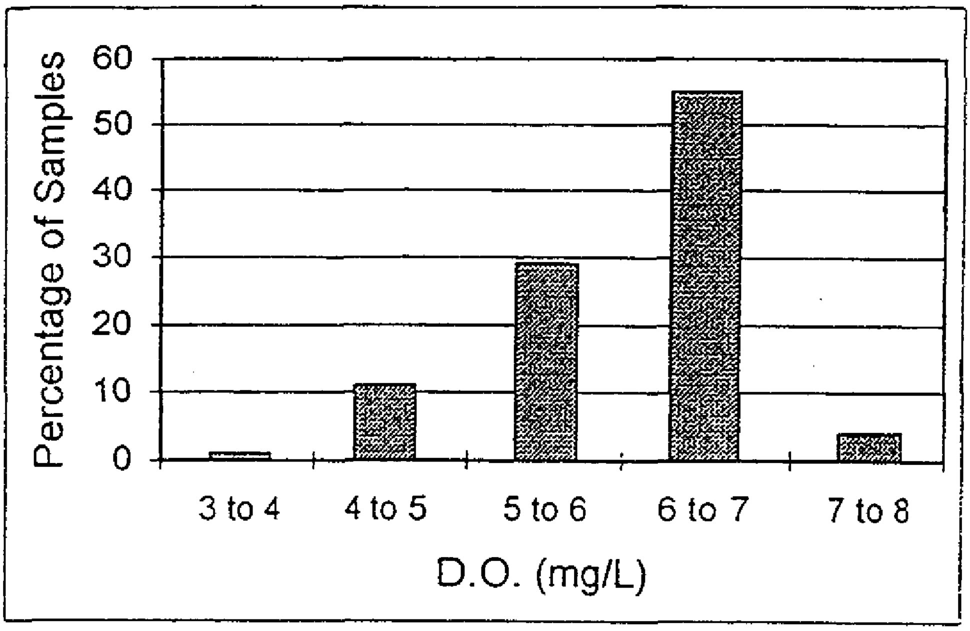
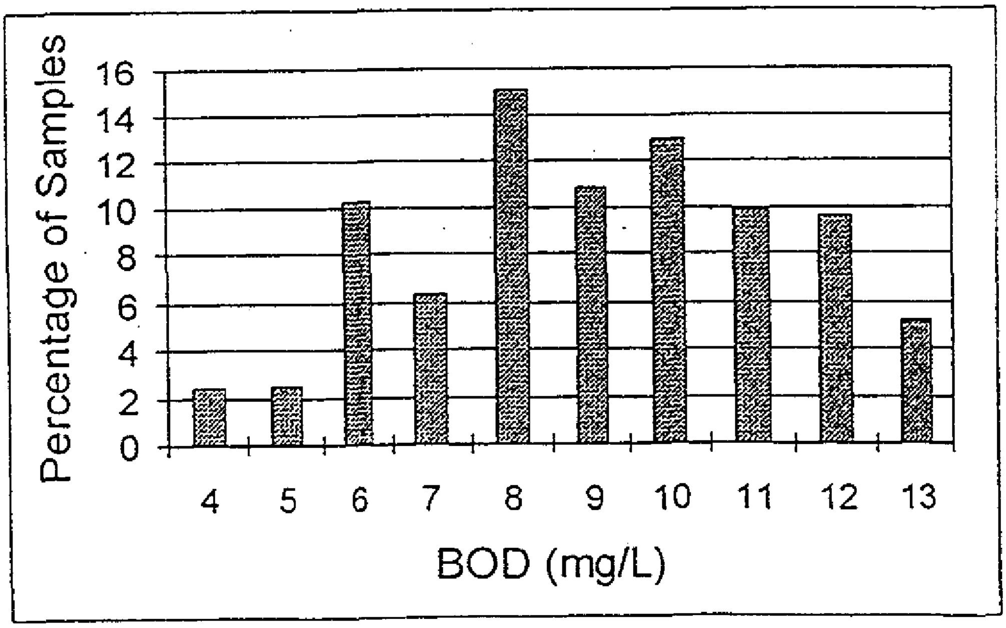


Figure III - 9: Distribution of BOD Measurements at Hoa An Water Intake



No other systematic water quality data were available. The following conclusions were reached based on water quality data that had been collected from various special purpose studies and from computer simulations of the river.

- Water quality measurements that are in excess of the river standards have been observed for ammonia, nitrites, total suspended solids, and coliforms.

- Significant localized areas of pollution have been observed on the Cai River and the Dong Nai River in the vicinity of industrial and municipal outfalls.

- Depressed levels of dissolved oxygen are likely in both the Cai River and in the Dong Nai River downstream of Bien Hoa.

- Water quality is worst during the ebb tide when local discharges are "trapped" in the Bien Hoa area.

Air

Tables III-13(a) and (b) summarize sample data for Bien Hoa in 1996 for suspended particulate matter (SPM), sulphur dioxide (SO2), nitrogen oxides (NO_2), total hydrocarbons (THC) and lead (Pb). The national standard for SPM is 0.3 mg/m^3. Twenty of the 24 sample locations exceeded the SPM standard in January, and all of the sample locations exceeded the SPM standard at the end of the dry season in May. For SO_2 (standard, 0.5 mg/m^3), all but two sampling locations are below the standard in May, but all 24 sampling locations exceed the standard in January.

The impact of various air discharges, both particulate and gaseous, have been estimated using ambient air quality sampling data in 1996 for various locations in Bien Hoa City, and a computer simulation model of the larger study area.

Table III-13(a): Ambient Air Data in Bien Hoa City (January, 1996)

Sampling site	Noise dBA	SPM mg/m^3	SO_2 mg/m^3	NO_2 mg/m^3	THC mg/m^3	Pb 10^{-4} mg/m^3
1. Hoa An cross road	58-84	4.10	0.17	0.018	0.71	1
2. Don Bridge cross road		0.73	0.21	0.029	0.74	<1
3. Near to Pou Chen factory	50-77	0.81	0.18	0.029	0.41	
4. Near to water intake station	68-84	0.41	0.29	0.023	0.68	1.1
5. Buu Long tourism zone	38-74	0.27	0.22	0.026	0.21	<1
6. Hoa An cross road to Buu Long tourism zone	52-84	0.38	0.18	0.027	0.28	
7. Near to DOSTE of Dong Nai province		0.31	0.21	0.024	0.74	1.2
8. Tan Van Island	38-64	0.36	0.21	0.028	0.27	
9. Near to Bien Hoa water supply plant	48-74	0.29	0.21	0.024	0.51	1.1
10. Road of August Evolution and National Road No 1.		0.24	0.19	0.027	0.71	1.1
11.Dong Khoi road-National Road No1	52-76	1.70	0.21	0.021	0.31	1.1
12. Road No - Dong Khoi Road	48-74	0.32	0.21	0.037	1.20	1
13. National Road No5- Road No5.		0.31	0.22	0.030	0.68	0.12
14. San Mau Cross Road		0.32	0.25	0.017	0.22	1
15. Cross road to Tan Mai Paper Mill	62-84	0.29	0.28	0.034	0.90	1.2
16. Tam Hiep cross road	62-83	0.77	0.23	0.028	0.91	1.6
17. Cross road near to Sharpen stone plant.		0.31	0.48	0.061	0.87	1.2
18. Cross road near to Dong Nai Tobacco factory		0.32	0.37	0.047	0.80	1.6
19. Vung Tau Cross Road	65-87	0.92	0.47	0.002	1.70	1.7
20. Near to COGIDO	38-67	1.90	0.52	0.077	0.67	1.2
21. Road No3- Road No 8.	38-67	0.37	0.52	0.059	0.70	1
22. Road No9- Road No 5	38-70	0.41	0.38	0.034	0.87	
23. Carbide calcium plant -VICACO- Road No 7.		0.77	0.42	0.051	0.77	1.4
24. Gate of VICASA plant	47-84	0.71	0.57	0.077	0.81	1.7

Table III-13(b): Ambient Air Data in Bien Hoa City (May, 1996)

Sampling site	Noise dBA	SPM mg/m^3	SO_2 mg/m^3	NO_2 mg/m^3	THC mg/m^3	Pb 10^{-4} mg/m^3
1. Hoa An cross road	65-75	1.28	0.083	0.031	0.90	$<10^{-4}$
2. Don Bridge cross road	66-83	0.92	0.092	0.024	0.93	$<10^{-4}$
3. Near to Pou Chen factory	-	-	-	-	-	-
4. Near to water intake station	71-82	1.15	0.070	0.030	0.75	$<10^{-4}$
5. Buu Long tourism zone	62-75	1.40	0.094	0.026	0.95	$<10^{-4}$
6. Hoa An cross road to Buu Long tourism zone.	69-84	1.30	0.085	0.022	0.84	$<10^{-4}$
7. Near to DOSTE of Dong Nai province	75-86	0.90	0.075	0.029	0.77	$<10^{-4}$
8. Tan Van Island	69-84	0.07	0.072	0.022	0.65	$<10^{-4}$
9. Near to Bien Hoa water supply plant	62-79	0.74	0.086	0.028	0.85	$<10^{-4}$
10. Road of August Evolution and National Road No 1.	65-82	0.85	0.069	0.027	0.70	$<10^{-4}$
11.Dong Khoi road-National Road No1	70-85	0.92	0.095	0.020	1.00	$<10^{-4}$
12. Road No - Dong Khoi Road	68-85	0.76	0.087	0.030	0.92	$<10^{-4}$
13. National Road No5- Road No5.	63-87	1.60	0.083	0.028	0.75	$<10^{-4}$
14. San Mau Cross Road	74-85	1.60	0.092	0.020	0.95	$<10^{-4}$
15. Cross road to Tan Mai Paper Mill	68-76	1.23	0.113	0.024	1.10	$<10^{-4}$
16. Tam Hiep cross road	72-87	1.10	0.083	0.024	0.86	$<10^{-4}$
17. Cross road near to Sharpen stone plant.	67-85	0.72	0.095	0.025	0.92	$<10^{-4}$
18. Cross road near to Dong Nai Tobacco factory	65-78	0.89	0.105	0.033	1.02	$<10^{-4}$
19. Vung Tau Cross Road	75-88	0.77	0.080	0.028	0.87	$<10^{-4}$
20. Near to COGIDO	74-85	0.95	0.092	0.023	0.97	$<10^{-4}$
21. Road No3- Road No 8.	65-78	1.20	0.112	0.027	0.83	$<10^{-4}$
22. Road No9- Road No 5	67-82	0.83	0.074	0.018	0.72	$<10^{-4}$
23. Carbide calcium plant -ViCACO- Road No 7.	62-78	0.75	0.078	0.027	0.79	$<10^{-4}$
24. Gate of VICASA plant		0.85	0.125	0.032	0.91	2.10^{-4}

To augment the limited field data, computer simulations were made for the Southern Economic Focal Zone (SEFZ) for SPM and SO_2. These computer simulations are based on rough emission coefficients based on 1998 population, land use, and economic data. The computer model used in the simulation is called ISC3 and was developed and is routinely used by the United States Environmental Protection Agency. The model uses estimates of emissions to the air and combines this with meteorological information (wind direction, wind speed, etc.) to predict the resulting air quality concentrations in the region being modeled.

Figures III-10 and III-11 illustrate estimated current 1998 lines of constant concentration (isolines) and compare these with current standards. Figures III-10 and III-11 should be used with caution. They are not based on actual measurements and have not been correlated with actual measurements. They also do not account for changes during the year. The primary value of these Figures is that the impact of future changes in emissions and associated changes in air quality can be predicted for future scenarios.

FIGURE III-10
Modeled Ambient Concentration of Suspended Particulate Matter, SPM, in the Sourthern Economic Focal Zone, SEFZ, for Present Condition (Ho Chi Minh City - Bien Hoa City - Thu Dau Mot Town)

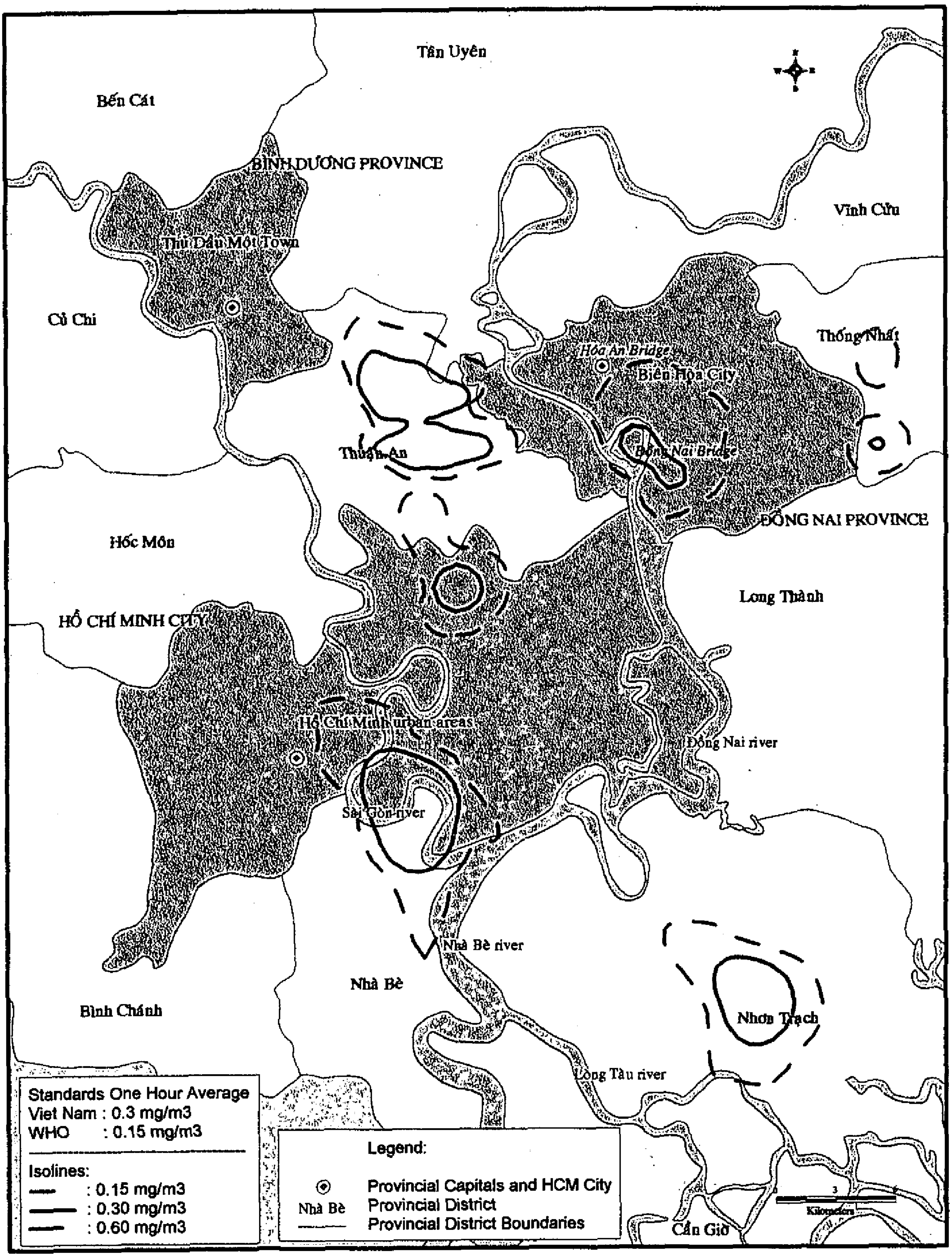
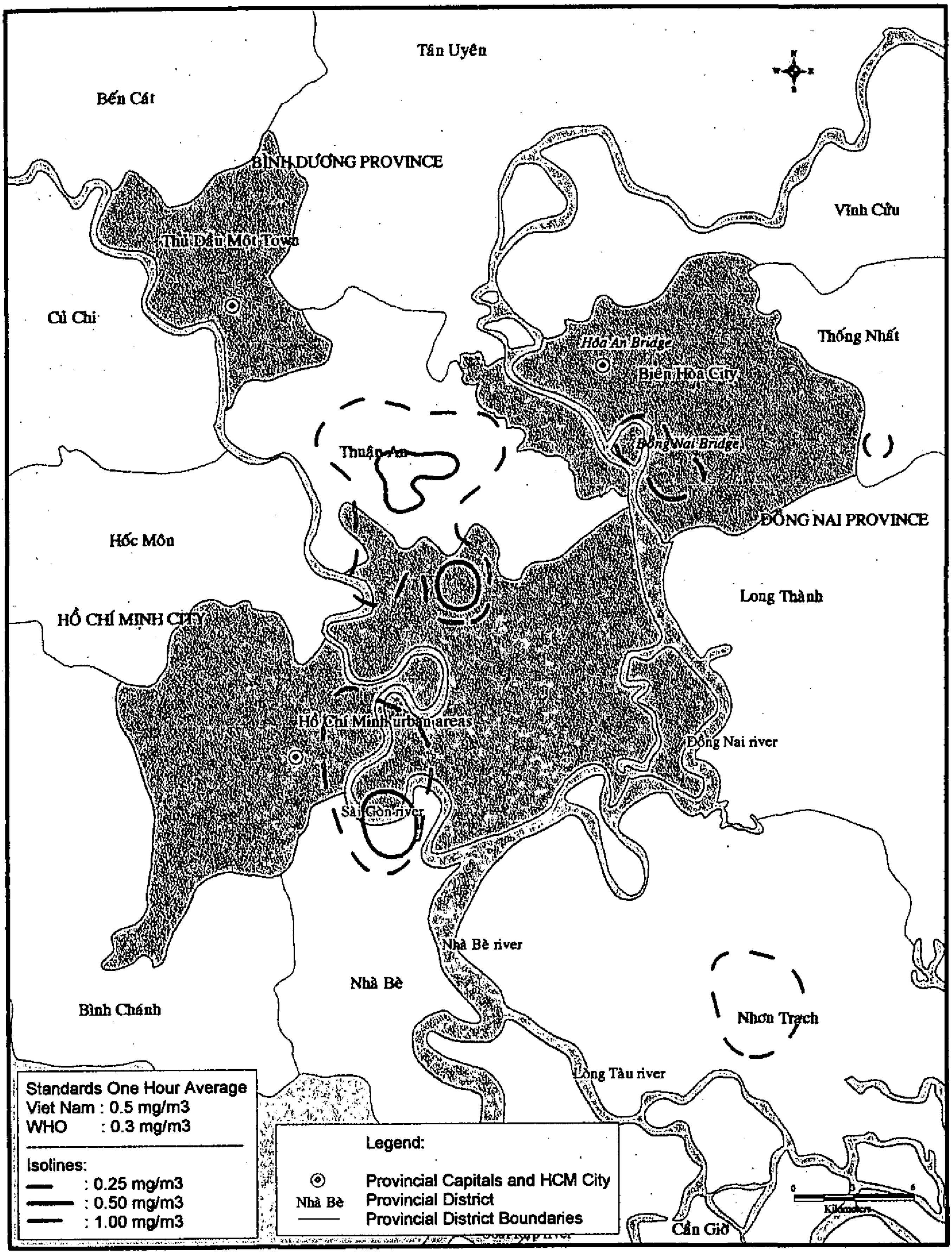


FIGURE III-11
Modeled Ambient Concentration of Sulphur Dioxide, SO2, in the Southern Economic Focal Zone, SEFZ, for Present Condition (Ho Chi Minh City - Bien Hoa City - Thu Dau Mot Town)



Solid and Hazardous Wastes

Impacts on ambient environmental quality associated with the current disposition of solid and hazardous wastes are discussed below:

Indiscriminate Disposal of Domestic Wastes

It is estimated that less then 25 percent of domestic and commercial wastes are collected by BHUESC and disposed of at the landfill. The remaining wastes are indiscriminately dumped or burned in the study area contributing to the following environmental problems.

- Much of the waste is dumped in wetlands or in creeks, contributing to water pollution.

- The indiscriminate disposal contributes to large amounts of litter outside of the area serviced by street sweepers and BHUESC collection crews. This significantly degrades the esthetic value of the environment, as well as impacts on the ecology.

- Piles of waste are scavenged by humans and animals increasing the risks of spread of infectious diseases. This problem is made worse by the lack of an adequate bio-hazardous waste management program, which means that potentially infectious medical wastes are included in the wastes being scavenged.

Trang Dai Landfill

Leachate generation from the Trang Dai landfill site was estimated to be 75,000 cubic meters per year. Initial sampling of leachate concentrations conducted by EPC indicate that ground water does not yet appear to be impacted. This may be the result of one or more of the following factors:

- the clay soils may be acting to attenuate leachate concentrations;
- significant ground water flow may be adequately diluting the existing leachate; and,
- the five sampling points may not be correctly placed because no data are available on direction of flow of ground water under the site.

The issue of ground water flow may be important, because the EPC believes the flow is north which would discharge upstream of the HCMC drinking water intake. However, because the landfill is located approximately 3 km from the river, on clay soils, with significant ground water flow, it is not likely that the landfill is a significant contributor to surface water contamination at this time.

Methane concentrations appear to be elevated based on EPC data. This could pose a threat to building located near the landfill.

Transportation Wastes

It is estimated that approximately 20,000 liters of waste oil are discharged to ground water and surface water each year in the study area. This has significant implications for surface and ground water contamination, although the impact has not been quantified.

Waste coolants are also dumped directly into storm sewers or the ground, increasing ground and surface water contamination.

Industrial Wastes

There are no secure disposal facilities for the estimated 5,700 tonnes of hazardous wastes generated by industries in 1998 in the study area. This poses a substantial threat to ground water.

On-site disposal of waste in Bien Hoa I is also a problem. For example, it is estimated that the Dong Nai Tile and Construction Material Company disposes of approximately 10,000 tonnes per year of wet sludge containing asbestos. This material is pushed in piles and allowed to dry. Once dry, the friable fibers are susceptible to wind erosion contributing to potential health problems for households located adjacent to the industrial park.

Finally, there is significant (unquantifiable) illicit disposal of industrial wastes off-site by small firms and individuals who collect industrial wastes for recycling. For example, barrels containing hazardous wastes from one industry are collected for recycling. The industry does not know what happens to any residues left in the barrels after they are collected.

In summary, the lack of controls on the collection, recycling and disposal of industrial wastes leads to widespread indiscriminate disposal, with potential for significant impacts to the environment and potentially to public health.

1k) *List and Describe the Criteria Expected to be Used in Evaluating Management Strategies*

In addition to total capital and O&M cost and financial feasibility, the following criteria will be used to evaluate potential AEQM management strategies.

- Administrative simplicity and flexibility
- Staffing and training requirements
- The amount of time it would take to implement the measures comprising the strategy
- Impact on inter-governmental relations
- Distribution of benefits and costs
- Consistency with existing legal authority
- Social acceptability
- Political acceptability

STEP TWO: CHOOSE POTENTIAL ENVIRONMENTAL QUALITY OBJECTIVES

Water

Provincial surface water quality standards were initially used as potential environmental quality objectives. Rivers are classified according to two sets of standards. Category A rivers are considered acceptable for use as a source of drinking water. Category B rivers are appropriate for uses that are consistent with lower water quality. Standards are defined for 39 different parameters. For planning studies, the most commonly used parameters are dissolved oxygen (D.O.) and biological oxygen demand (BOD). These parameters are dependent upon a wide range of biological and chemical constituents and thus serve as general indicators of the health of the river. Standard A has a minimum level of dissolved oxygen at 6.0 mg/L and a maximum level of BOD (5-day BOD at 20°C) of 5 mg/l. Standard B has a minimum level of dissolved oxygen of 3.0 mg/L and a maximum BOD of 25 mg/L. Presently, Standard A has been established for the Dong Nai River reach from the confluence with the Be River downstream to the Dong Nai Bridge (KM 35), while Standard B applies to the river below Dong Nai Bridge. Standard A was required in order to support the current water intake at Hoa An (KM 41), the Binh An water intake that is under construction (KM 35) and the proposed intake at Thien Tan (KM 78).

For the analysis, low flow conditions during the dry season were identified as the likely critical case. Though loadings increase during the wet season due to run off and non-point sources, the higher dilution during the wet season generally resulted in lower concentrations of pollutants in the river. A stream flow value of 400 cubic meters per second, which corresponds to the average flow in the river during December - February dry season below the confluence of the Be and Dong Nai Rivers, was selected.

Air

The present air quality standards for Vietnam are shown in Table III-14 for different averaging periods.

Table III-14: Vietnam and World Health Organization (WHO) Air Quality Standards (mg/m^3)

Parameter	1-hour averaging Viet Nam	1-hour WHO standard	8-hour averaging Viet Nam	24-hour averaging Viet Nam
Carbon monoxide (CO)	40		10	5
Nitrous oxide (NO2)	0.4		-	0.1
Sulphur dioxide (SO2)	0.5	0.3	-	0.3
Lead (particulate)	-		-	0.005
Ozone (O3)	0.2		-	0.06
Suspended particulate matter (SPM)	0.3	0.15	-	0.2

The standard corresponding to the one-hour averaging time was selected for use in the study. For comparison purposes, the more stringent corresponding air quality standards issued by the World Health Organization (WHO) for selected parameters for the same one-hour averaging time are also shown.

Meteorologic conditions associated with the dry season were selected for use in the assessment.

Solid Wastes

Unlike many of the impacts from air and water discharges, which can be directly linked to quantifiable environmental quality objectives, solid and hazardous waste discharges contribute either indirectly to environmental quality, or impact environmental quality in less quantifiable ways. For example, reducing litter may have significant esthetic and ecological benefits, but those benefits are not readily quantifiable.

Currently, there are no government definitions of environmental quality objectives for solid waste. Therefore, the following objectives were based upon professional judgement:

- Low levels of toxins in ground water
- Low enough levels of toxins in surface waters so that sediments do not contain levels of heavy metals or persistent toxins that endanger fish populations or public health
- Reduced health risks from infectious diseases
- Improved wetlands quality
- Improved esthetics

Improved solid and hazardous waste management will also impact on specific environmental quality objectives defined for air and water above. Specifically,

- Increased DO levels in ground and surface waters
- Improved air quality through reductions in TSP and VOC's

STEP THREE: FORMULATE POSSIBLE SCENARIOS

3a) *Determine Key Variables*

Key variables identified for the study area were:

- Population and economic growth within the study area
- Economic growth in south-east Asia
- Citizen and NGO involvement in environmental quality and land use decisions
- The extent of government intervention in land use decisions, promotion of economic growth, and protection of environmental quality

3b) *Define Scenarios*

Scenarios were defined in terms of: (1) population and economic growth; (2) level of government intervention; and (3) degree of NGO and citizen participation. For each variable, two levels were identified resulting in a possibility of eight possible scenarios. They were:

- growth rate (high and low growth rates for rural and urban sectors and for economic development)
- the degree to which government specificies where industrial and population activities locate (minimum and maximum)
- NGO and citizen participation (high and low)

Annual growth rates chosen are presented in Table 15.

Table III-15: Annual Growth Rates, Percent

	Low	High
Economic (industry)	2	15
Population (urban)	2	8
Population (rural)	-2	0

The full set of possible scenarios with these defined conditions are presented in Table III-16.

Table III-16: Set of Possible Scenarios Given the Three Variables Specified

Scenario No.	Growth	Government Intervention	Public Participation
1	High	Max	High
2	High	Min	Low
3	High	Max	Low
4	High	Min	High
5	Low	Max	High
6	Low	Min	Low
7	Low	Max	Low
8	Low	Min	High

3c) Select One or More Scenarios for Analysis

Based on discussions with the Peoples Committee and the Industrial Zone Authority, continued high economic growth will continue to be a high priority for Viet Nam and the local Peoples Committee. Therefore, Scenario 2 was selected as the most plausible scenario. Scenario 2 is based on high economic growth and resulting high population growth as people move to the study area for the employment opportunities. Further, it was assumed that the Peoples Committee would actively promote economic growth but remain relatively passive in directing the associated growth and controlling environmental discharges. Because of the continued need for employment, it was also assumed that citizens and NGOs would initially remain relatively passive concerning the impact of growth on the environment. Over time, if environmental quality continued to decline, citizens and NGOs would become more actively involved in pushing for environmental protection. However, as has been reported to be the case in Dong Nai Province to date, citizen protests would have limited affect on environmental quality during the next ten years.

Assumptions about government and citizen actions were confirmed based on discussions with Dong Nai DOSTE staff, national consultants and citizens and media personnel active in the study area.

During the course of the project, economic conditions in the rest of Asia deteriorated, impacting on the high growth rates experienced in the study area over the past ten years. Therefore, Scenario 6 was selected as an alternate scenario for analysis. Scenario 6 is based on significantly lower economic and population growth, and the assumption that the government would attempt to maintain economic growth by lowering environmental standards for foreign joint ventures and continuing to remain passive concerning environmental discharges from state owned enterprises. While Scenario 2 was selected as the most plausible by DOSTE staff and the Peoples Committee, Scenario 6 also appears to be a plausible scenario given current economic conditions in south-east Asia. Therefore, Scenario 6 was chosen as an alternative scenario for analysis. Scenario 6 is also useful to illustrate the impact on environmental quality associated with lower growth.

3d) Make Population and Economic Growth Projections

Projections were made using present information and the various growth rates listed above in Section 3a. The information is summarized in Tables III-17 and III-18. The economic growth projections were based upon the number of factories, the land they occupied and the number of employees in place during the present period.

Table III-17: Projected Population Year 2010 (in 1000's of people)

Sub Basins	Present Population		2010 Population			
	Urban	Rural	Urban-Low	Urban-High	Rural-Low	Rural-High
Dong Nai Mainstem Upstream of Hoa An Bridge	20	160	29	60	124	160
Dong Nai Mainstem Downstream of Hoa An	135	20	180	370	15	20
SongCai	210	0	270	570	0	0
BaLuaTributary	17	0	22	45	0	0
Buong/Quong Tributaries	50	120	65	140	92	120

Table III-18: Industrial (Economic) Growth Projections, 2010 Period

Sub Basins	Present		2010 with low growth		2010 with high growth	
	# of Factories	Land area (hectares)	# of Factories	Land area (hectares)	# of Factories	Land area (hectares)
Dong Nai Mainstem Upstream of Hoa An Bridge	1	20	1	20	1	20
Dong Nai Mainstem Downstream of Hoa An	83	524	83	524	1008	2635
Song Cai	1	10	1	10	1	10
BaLuaTributary	72	191	155	386	155	386
BuongQuong Tributaries	0	0	0	0	0	0

STEP FOUR: PROJECT FUTURE AIR, WATER, AND SOLID WASTE DISCHARGES TO THE ENVIRONMENT FOR THE MOST PLAUSIBLE SCENARIO

As discussed in Step Three the dominant scenario is assumed to be high growth with minimum government intervention in managing population or industrial location and low levels of NGO and citizen participation.

Projecting future water, air, and solid waste discharges for the dominant scenario is a two step process. First, changes in unit generation must be projected over time. Then, the increase in population and economic activity can be applied to these changes in unit generation to estimate total discharges.

4a) Changes in Unit Generation Coefficients

Water

It was assumed that there would be a 15% increase in the per capita domestic waste water generation by the year 2010. This reflects an increase in water use that is common with increased income associated with economic growth. The result is an increase of per capita waste water generation of BOD from 39 grams/person/day to 45 grams/person/day. Total waste water generation by category was not tabulated, but the impacts on surface water quality are projected in Step Five below.

Air

Air emissions by activity were not estimated for the year 2010. Instead rough estimates based on land use changes and industrial growth were made, with no assumptions made about changes in unit generation of air pollutants. However, as discussed below, per capita ownership of motorcycles and automobiles is assumed to increase over the planning period. In addition, it is assumed that the mix of industrial activities will change to be more reflective of the mix of industrial activities located in Bien Hoa 2 industrial park, as opposed to the type of heavy industry located in Bien Hoa 1.

Solid Wastes

Industrial

Projections of solid and hazardous waste generation per employee have been based on the current mix of industries in the newer industrial park, Bien Hoa 2. This appears to be more representative of future growth than projections based on the current mix of industries in the study area, including the older Bien Hoa 1. This results in lower per employee solid waste generation and higher per employee hazardous waste generation.

Domestic

Increasing incomes and consumption are assumed to lead to increasing per capita waste generation. Current per capita waste generation estimated to be at the low end of "household generation" as reported in Managing Urban Environmental Quality in Asia, Kingsley, G.T, et al, 1994, World Bank. Therefore, it is assumed that per capita waste generation will increase to 0.55 kg/capita by the end of the study period, which is the midpoint of the range reported by Kingsley, et al.

Agricultural

It is likely that agricultural production will become more intensive per hectare cultivated to feed the growing urban population. This would result in increasing pesticide per ha. However, based on a report from the NC, Environmental Economics, there has been a concerted effort by Provincial crop protection specialists to implement integrated pest management practices. IPM is reported to have reduced pesticide use on rice crops by 50 percent. IMP in this case more broadly includes improved fertilizer use and better management of run-off.

Therefore, for purposes of this analysis, it has been assumed that the increase in the intensive nature of agriculture will be balanced by the increased use of IPM. However, given the apparent large pollution loading in the Dong Nai River upstream of Bien Hoa, this assumption needs further examination.

Transportation

It is reasonable to assume that, for solid waste and hazardous waste generation, per vehicle generation rates will remain constant over the study period, with increasing total generation resulting from the increasing per capita ownership of motor vehicles.

Commercial and Institutional

Commercial and institutional waste generation coefficients are included in the Domestic estimates above. There will be changes in composition, with increasing levels of plastics and other packaging and reduced levels of organics.

4b) Project Future Discharges

Water and Air

Because of the large number of individual sources, and the multiple points of discharge, projections of year 2010 discharges for water and air were done as part of the modeling effort under Step Five, below, and are not reported separately here.

Solid Wastes

Table III-19 presents projected future solid waste generation from domestic and industrial activities for the study area.

Table III-19: Projected Solid Waste Generation, Most Plausible and Alternate Scenarios

Projections	**Domestic Wastes (1000's tonnes/2010)**	**Industrial Wastes (1000's tonnes/2010)**	**Hazardous Wastes (1000's tonnes/2010)**
Scenario 6, Alternate	76	37	7
Scenario 2, Most Plausible	220	165	30

As illustrated by Table III-19, high population and economic growth rates under the most plausible scenario result in solid and hazardous wastes becoming a significant disposal burden by the year 2010.

Transportation

Based on the projected growth in transportation activities, it is estimated that waste oil discharges to the environment will increase from and estimated 20,000 liters annually in 1995 to 85,000 liters under high projections and 36,000 liters under low projections.

STEP FIVE: ESTIMATE THE IMPACT ON ENVIRONMENTAL QUALITY IN THE ABSENCE OF AN AEQM STRATEGY FOR THE MOST PLAUSIBLE SCENARIO

Water

The future impact of BOD discharges, from both point and non-point sources, from within and from upstream, in the absence of a AEQM management strategy has been estimated using a combination of a computer simulation model (QUAL2E) and informal assessment. Tables III-20 and III-21 present projected BOD loads for 2010 for both the dominant and alternate scenarios.

QUAL2E is a widely used riverine water quality model distributed by the U.S. Environmental Protection Agency. The model is a steady-state, one-dimensional model that may be used to simulate a variety of parameters including all or part of the D.O.-BOD-nitrogen-phosphorous cycle. Rivers are represented by a branching network composed of a series of reaches. Reaches are delineated based on common hydraulic conditions and confluences with tributaries.

In applying QUAL2E to any river, assumptions and approximations are necessary. For the Dong Nai River, major approximations include the one-dimensional analysis, flow and velocity averaged over a tidal cycle, and elimination of loops in the river (i.e., when the river splits into two channels that later come together). However, it is felt that these approximations do not seriously limit the applicability of the model to the Dong Nai River.

The Dong Nai River is represented in the model from 5 kilometers above the Hoa An Bridge downstream to a point 11 kilometers above the confluence with the Saigon River. Five reaches represent the mainstem of the river and one reach represents the industrial channel loop in the Bien Hoa area. The most downstream reach, extending from the study area downstream boundary (kilometer 28) to kilometer 11, is considered to be very approximate representation and is included only to provide a general understanding of the potential impact of loadings in the Bien Hoa area on the lower stretches of the river. The industrial channel loop (Cai River) is represented as a withdrawal from the main channel and a separate tributary to the mainstem.

The study area includes the contributing drainage area to the Dong Nai River downstream of the confluence of the Be and Dong Rivers. However, little information is available for the stretch of the river from the confluence to a point slightly upstream of Bien Hoa City. Therefore, for modeling purposes, the upstream boundary was set at Kilometer 46 which is 5 kilometers upstream of the Hoa An Bridge. There are significant field data available to help define the water quality at this point. The impact of discharges above this upstream boundary which includes discharges both in the formal study area and upstream of the study area are therefore based on 1998 water quality sampling at the upstream end of the modeled reaches. For current conditions, the water quality at that point was defined as 6 mg/L of dissolved oxygen and 6 mg/L of BOD.

Table III-20: Year 2010 BOD Discharges to Surface Waters by Sub Basins in Study Area Based on the Most Plausible Scenario

Category	Wet Season		Dry Season	
	Flow (1000 m^3/day)	BOD (1000 kg/day)	Flow (1000 m^3/day)	BOD (1000 kg/day)
Dong Nai River Upstream of Hoa An Bridge				
Rural	1080	9	8	6
Urban	30	4	15	3
Industrial	148	6	148	6
Dong Nai River Downstream of Hoa An Bridge				
Rural	136	1	1	1
Urban	186	22	93	17
Industrial	49	31	49	31
Cai River Branch of Dong Nai River				
Rural	0	0	0	0
Urban	287	33	143	22
Industrial	49	4	49	4
Ba Lua Stream Tributary Of Dong Nai River				
Rural	0	0	0	0
Urban	23	3	11	2
Industrial	130	21	130	21
Buong & Quong Rivers, Dong Nai River Tributaries				
Rural	872	7	6	5
Urban	68	8	34b	6
Industrial	0	0	0	0

Table III-21: Year 2010 BOD Discharges to Surface Waters by Sub basins in Study Area Based on the Alternate Scenario

Category	Wet Season		Dry Season	
	Flow (1000 m³/day)	BOD (1000 kg/day)	Flow (1000 m³/day)	BOD (1000 kg/day)
Dong Nai River Upstream of Hoa An Bridge				
Rural	1080	7	6	5
Urban	14	1	7	3
Industrial	31	6	31	1
Dong Nai River Downstream of Hoa An Bridge				
Rural	136	1	1	1
Urban	214	25	44	17
Industrial	49	31	49	31
Cai River Branch of Dong Nai River				
Rural	0	0	0	0
Urban	105	16	68	11
Industrial	10	1	10	1
Ba Lua Stream Tributary Of Dong Nai River				
Rural	0	0	0	0
Urban	11	1	5	1
Industrial	35	6	35	6
Buong & Quong Rivers, Dong Nai River Tributaries				
Rural	867	5	5	4
Urban	32	4	16	3
Industrial	0	0	0	0

The results of the simulation based on the dominant scenario are shown for D.O. and BOD for the Dong Nai River mainstem (Figure III-12) and for the Cai branch of the Dong Nai River (Figure III-13). For comparison purposes, the simulated conditions based on present loadings are also shown. The following conclusions can be reached based on these simulations . and further assessment of the future loadings on the water quality of the receiving waters.

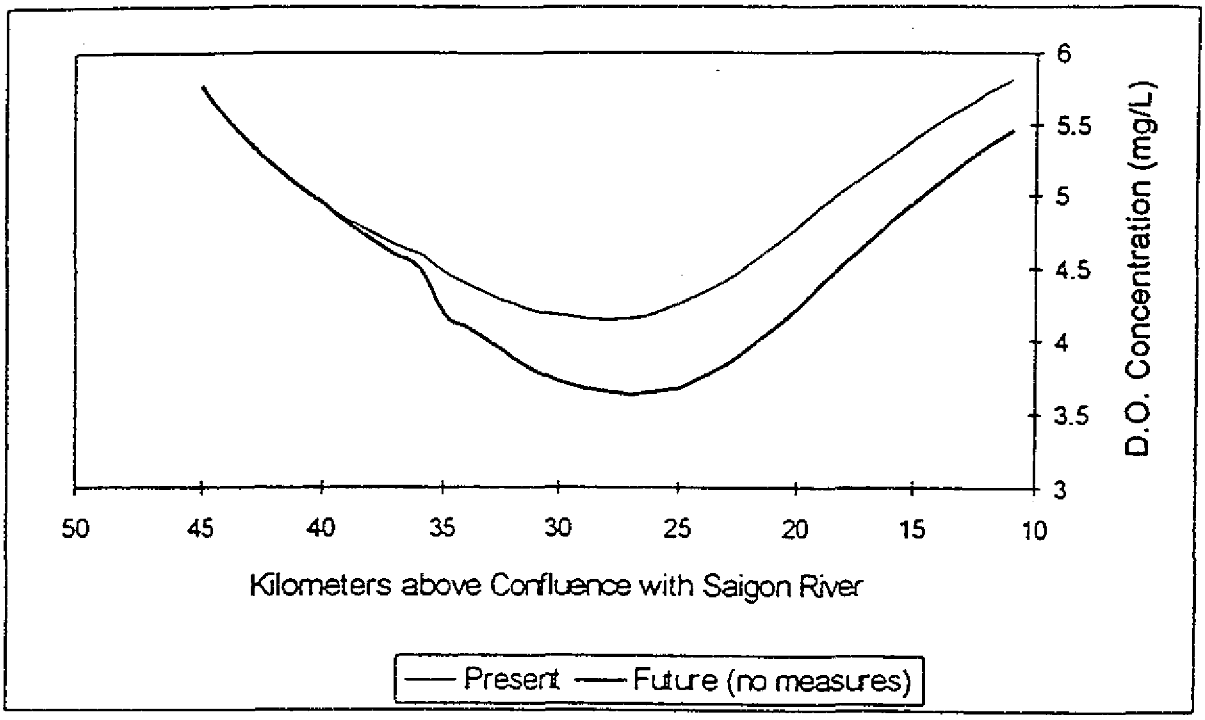
- Under the dominant scenario, the minimum dissolved oxygen level in the Dong Nai River will drop by approximately 0.5 mg/L in the future. This minimum D.O. point is expected to be approximately 5 kilometers downstream of the downstream confluence of the Dong Nai River and the Cai River. BOD levels in the Dong Nai River downstream of the Cai River are expected to increase by approximately 1.5 mg/L. Based on these values, it is likely that the river standards (Standard A) would seldom be met in the river between Hoa An Bridge and the Dong Nai Bridge.

- With diminished fresh water inflow caused by the proposed exports of water from the Dong Nai River above Bien Hoa, the potential for the poorer water quality affecting the water intakes at Hoa An due to tidal action is quite likely.

- In the Cai River, D.O. levels are predicted to drop by approximately 1.5 mg/L while BOD levels are predicted to rise by over 3 mg/L. This would mean that the Cai River would generally not meet the Standard B and that periods of extremely low D.O. could be expected.

- Significantly increased loading will result in much worse localized water quality problems in both the Cai and the Dong Nai Rivers in the vicinity of Bien Hoa. Complaints of visible contamination and bad odors, especially during low tidal conditions, in the area near the shoreline would be expected to increase very significantly. Likewise, higher levels of harmful bacteria along the shoreline are inevitable due to the much increased untreated domestic waste.

Figure III - 12: Modeled D.O. and BOD Profiles for the Dong Nai River for Present and Future Conditions Under the Most Plausible Scenario (with no AEQM measures)



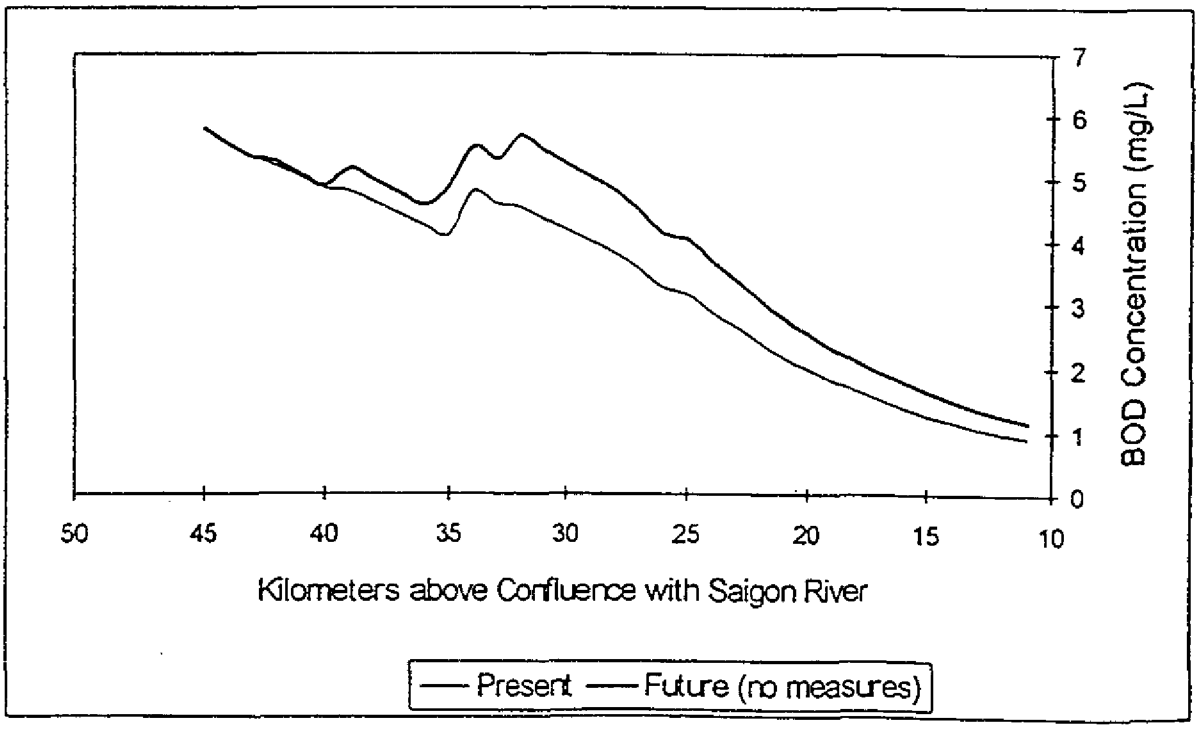
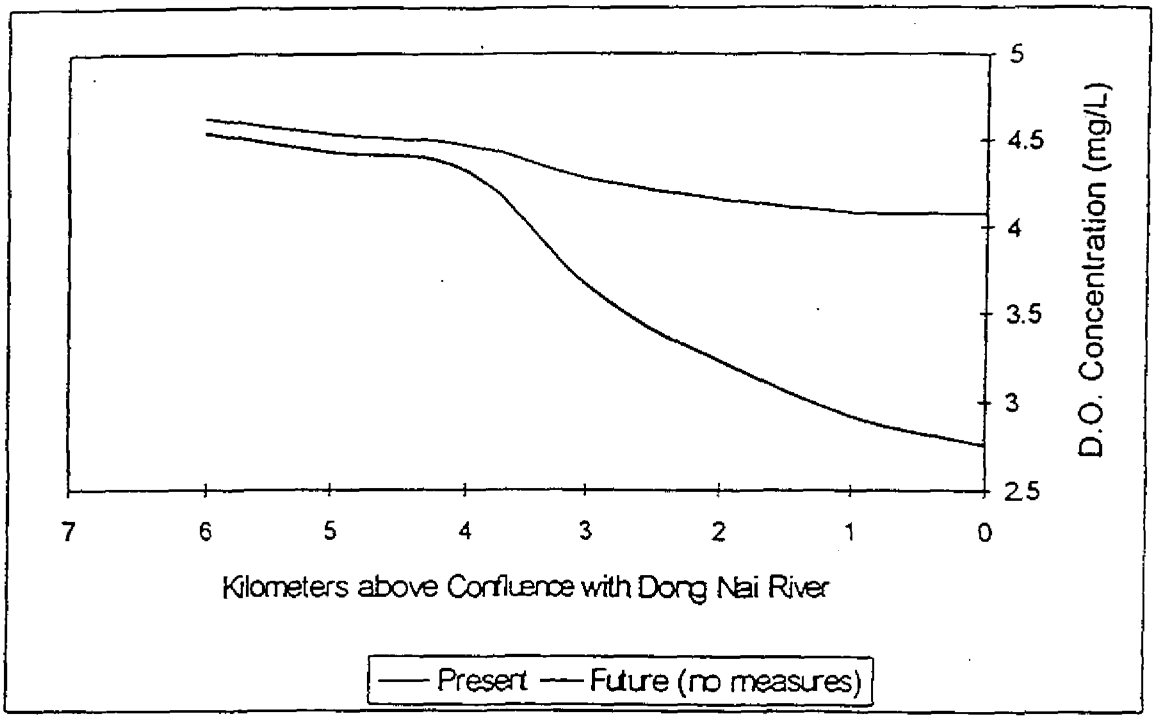
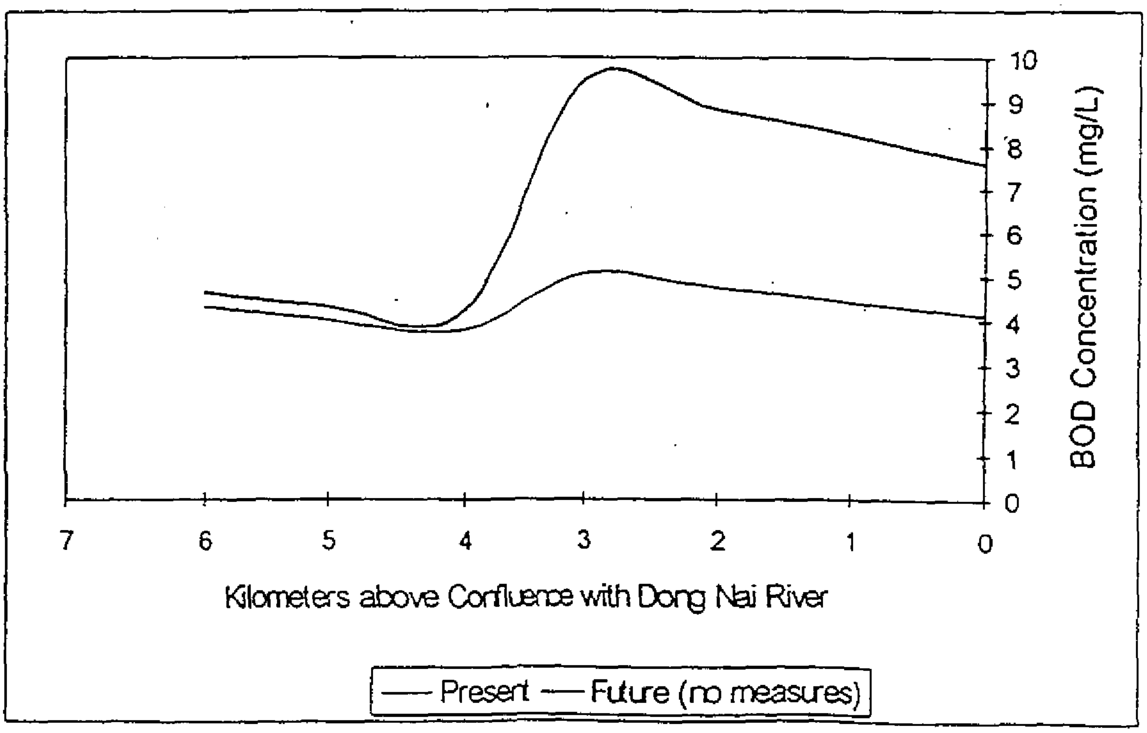


Figure III - 13: Modeled D.O. and BOD Profiles for the Song Cai for Present and Future Conditions Under the Most Plausible Scenario (with no AEQM measures)





Air

Air quality projections for SO_2 and SPM in the Southern Economic Focal Zone (SEFZ) for the year 2010 assuming no AEQM strategy were made for both the most plausible scenario and the alternate scenario. Figures III-14 and III-15 illustrate projected ground level concentrations for SPM and SO_2 for the most plausible scenario. Figures III-16 and III-17 illustrate the same information for the alternate scenario.

It is important to note that the projected air quality for the 2010 period is based on extremely rough air emission estimates based on land use projections, not on estimates by activity.

A comparison of estimated current levels of SPM compared to projected SPM levels under the dominant and alternate scenarios reveals a significant increase in SPM in many parts of the SEFZ. While no areas are identified with concentrations at or above the level of 0.6 g/m^3 for the present period, a number of small areas emerge in the alternate scenario projection and a large area, mostly in the Ho Chi Minh City (HCMC) region emerges in the dominant scenario. All of the SEFZ in the metropolitan HCMC region, including Bien Hoa, Thu Dan Mot and the surrounding areas are at or above levels of 0.15 mg/m^3, the standard set by the World Health Organization. The atmosphere above all of the densely populated areas is more polluted, with levels at or above 0.30 mg/m^3, the standard set by the Government of Viet Nam.

A similar comparative review of the data for SO_2 shows the same trend, although not as serious. Once again, the projected growth in air pollution shows most of the densely populated urban areas with SO_2 concentrations at or above the standards set by the Government of Viet Nam, 0.5 mg/m^3 for the 2010 period under the dominant scenario.

Clearly some remedial actions to reduce both SPM and SO_2 air pollution will be needed before the 2010 period. Expanded monitoring of emissions at many locations in the SEFZ will be needed to provide the data for more accurate simulation of the ambient concentrations.

FIGURE III-14
Modeled Ambient Concentration fo Suspended Particulate Matter, SPM, in the Southern Economic Focal Zone, SEFZ,
***for the 2010 Period* (high growth: 15% per year) No AEQM Measures**
(Ho Chi Minh City - Bien Hoa City - Thu Dau Mot Town)

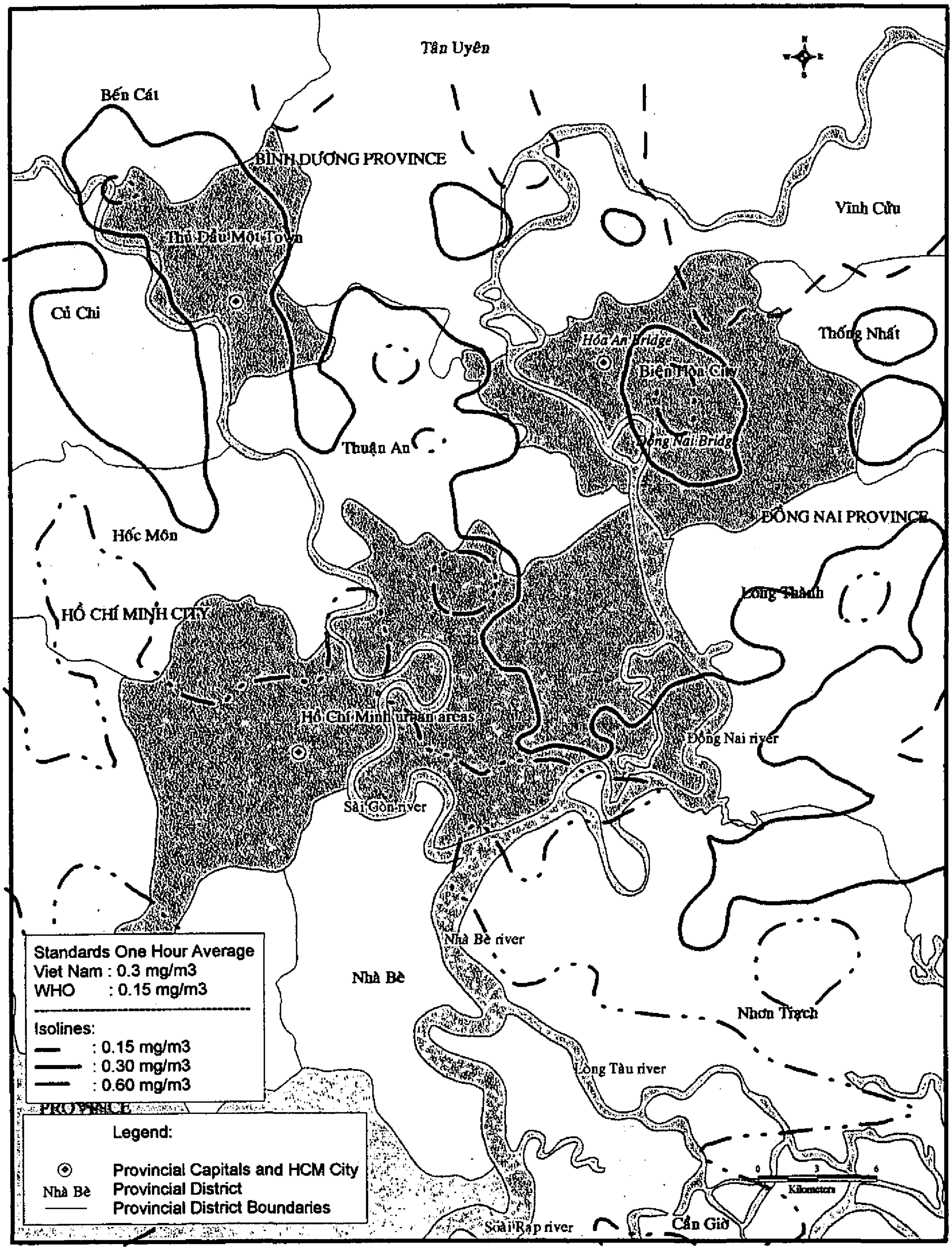


FIGURE III-15
Modeled Ambient Concentration of Sulphur Dioxide, SO2,
in the Southern Economic Focal Zone, SEFZ,
in the 2010 Period (high growth: 15% per year) No AEQM Measures
(Ho Chi Minh City - Bien Hoa City - Thu Dau Mot Town)

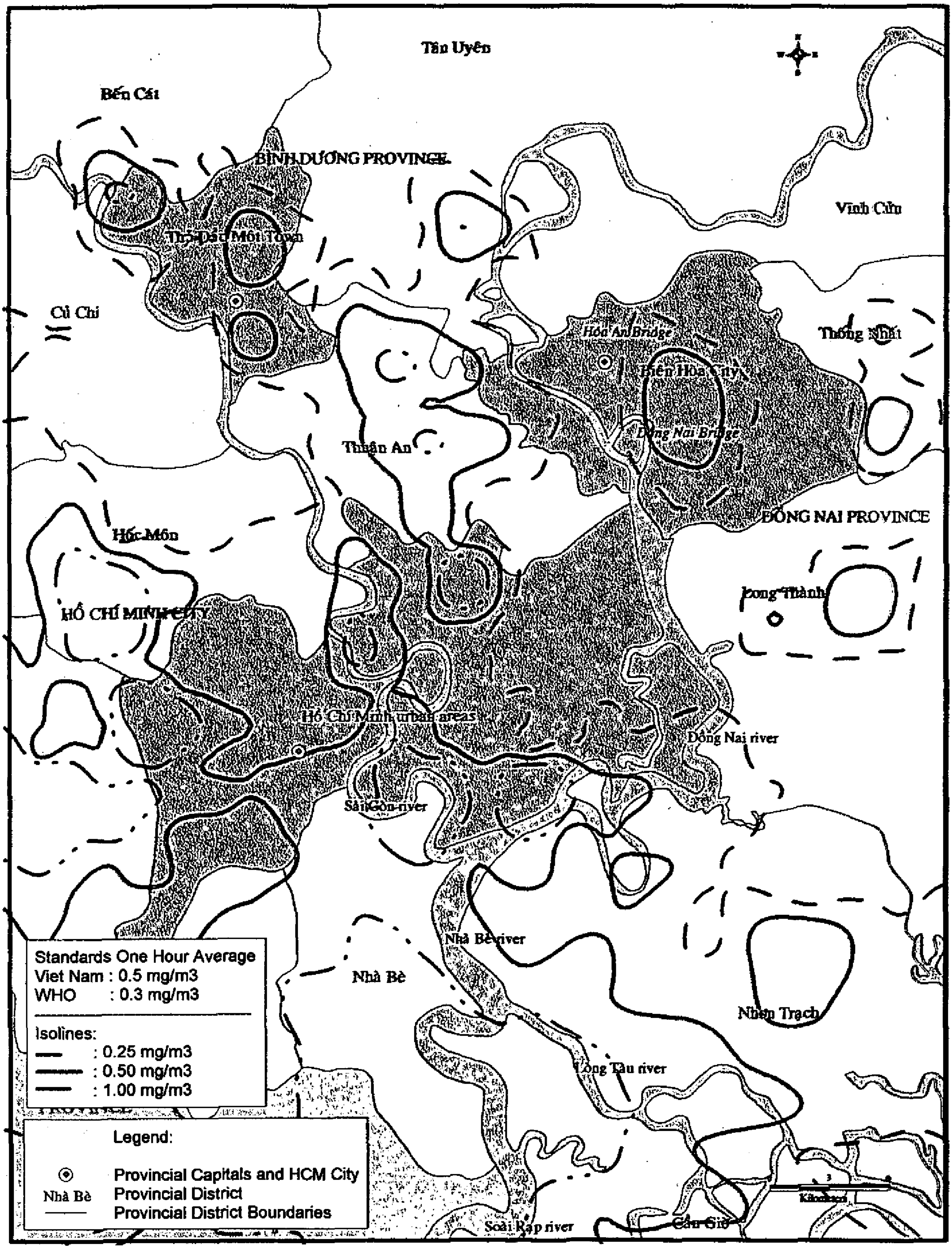


FIGURE III-16
Modeled Ambient Concentration of Suspended Particulate Matter, SPM, in the Southern Economic Focal Zone, SEFZ, for the 2010 Period (low growth: 2% per year) No AEQM Measures (Ho Chi Minh City - Bien Hoa City - Thu Dau Mot Town)

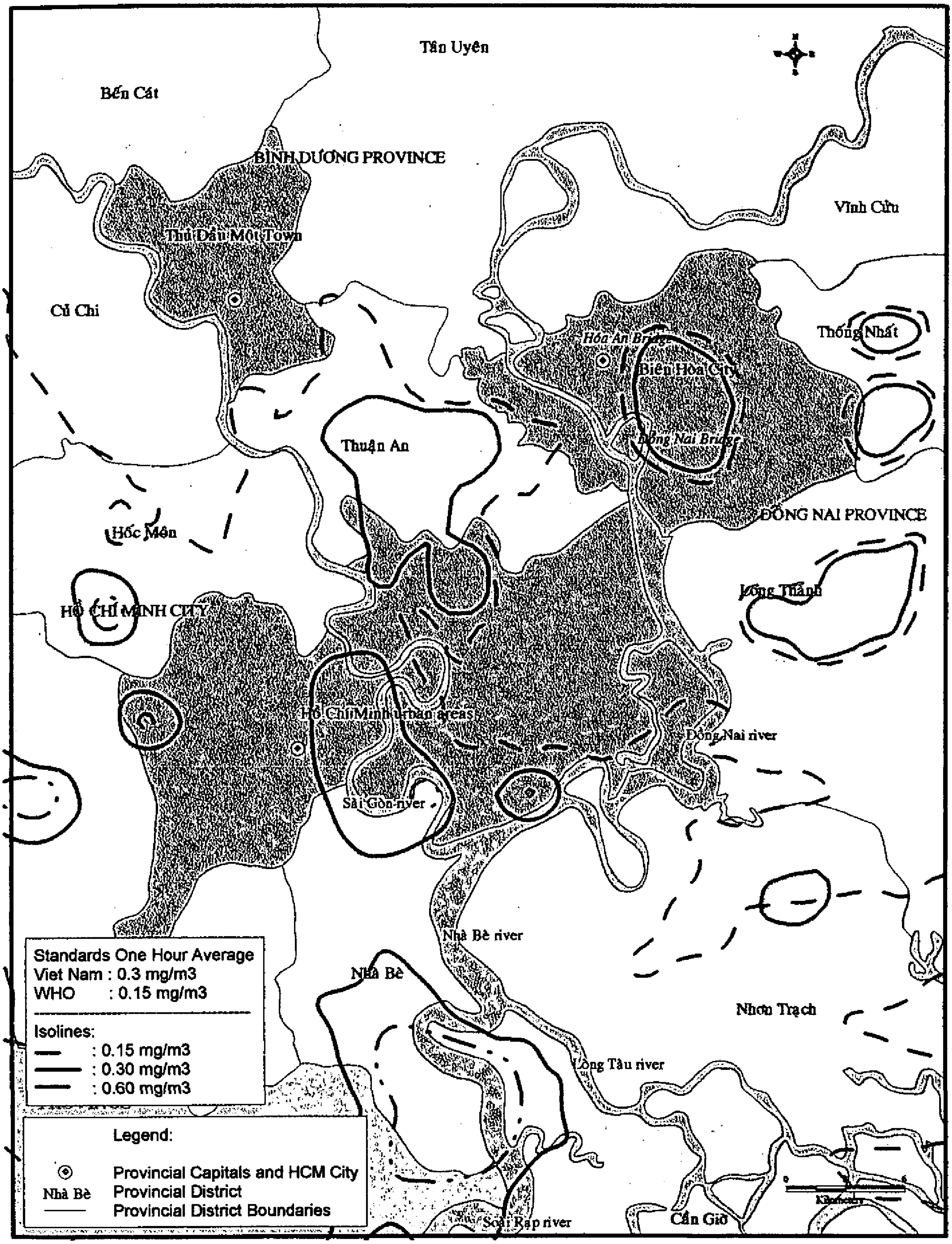
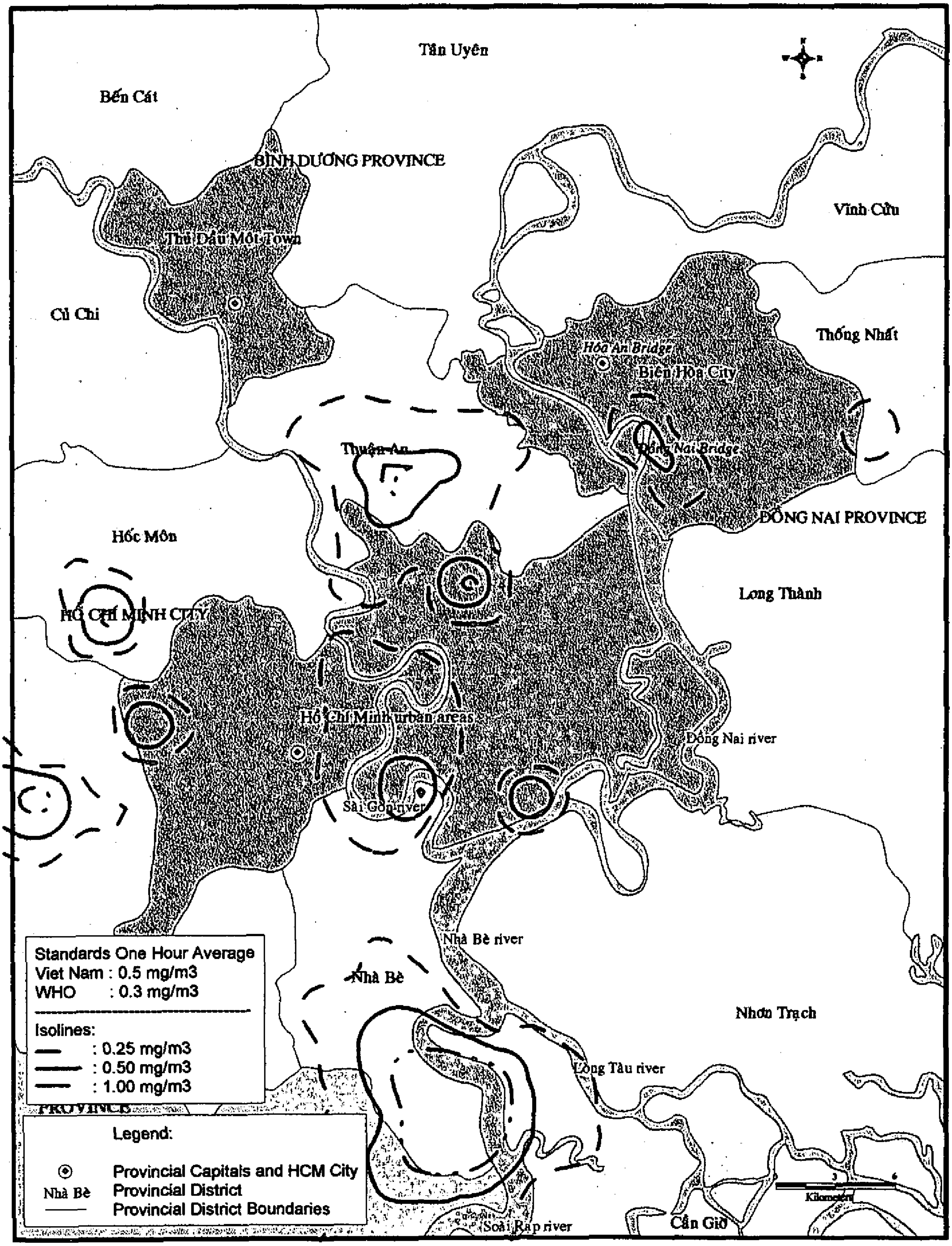


FIGURE III-17
Modeled Ambient Concentration of Sulphur Dioxide, SO2,
in the Southern Economic Focal Zone, SEFZ,
for the 2010 Period (low growth: 2% per year) No AEQM Measures
(Ho Chi Minh City - Bien Hoa City - Thu Dau Mot Town)



Solid Waste

Table III-22 compares estimated current (1998) disposition of solid and hazardous wastes with projected future year 2010 disposition under the most plausible and alternate scenarios.

As illustrated by Table III-20, under the most plausible scenario, approximately 165,000 tonnes of solid waste will be burned and indiscriminately dumped in the year 2010. An additional 80,000 tonnes of industrial, non-hazardous wastes will be dumped on site. Burning, indiscriminate dumping, and on-site disposal will contribute to increased air and water pollution, and will significantly degrade the esthetic beauty and ecological systems of the study area. In addition, the improper disposal of approximately 500 tonnes of bio-hazardous wastes, 30,000 tonnes of hazardous wastes, and 85,000 liters of waste oil will create additional health impacts, and further threaten ground water quality.

The impacts are significantly less severe under the alternate scenario. However, they are still approximately 50 percent greater then under current conditions.

In addition to the impacts of indiscriminate dumping and burning, leachate and methane gas generation will increase significantly at the Trang Dai landfill. Based on current estimates of 75,000 cubic meters of leachate discharged from the landfill, it is estimated that approximately 225,000 cubic meters of leachate will be discharged to ground water by the year 2010 under the dominant scenario.

It should be noted that hazardous waste management may be improved even in the absence of an AEQM strategy by the government over the next twelve years. Sonadezi is proposing to construct a lined landfill for hazardous wastes by the year 2000. If Sonadezi is successful, this lined landfill will provide a more environmentally sound disposal facility for some portion of the hazardous wastes generated by industrial activity in the study are over the next ten years. This will improve environmental quality compared to the above projections.

However, in the absence of an implementation strategy to assure that hazardous wastes are actually delivered to the facility, it is difficult to estimate what percent of the hazardous wastes will actually be disposed in this new site. Specifically, in the absence of national hazardous waste rules which define and/or list wastes subject to hazardous waste rules, combined with enforcement of hazardous waste inventory requirements, and licensing of industrial waste collectors, it will be very difficult to convince many of the industrial plants to pay to utilize the site.

Finally, Table III-22 above illustrates that substantial investments in new collection vehicles by BHUESC will be required <u>just to maintain</u> the current level of collection of approximately 25 percent of the solid wastes generated in the study area. Specifically, BHUESC currently utilizes 10 trucks to collect an estimated 23,000 tonnes of domestic and industrial solid wastes. This is equivalent to 2,300 tonnes per truck.

Under the most plausible scenario, it would be necessary for BHUESC to collect an estimated 55,000 tonnes per year in the year 2010 just to continue collecting approximately 25 percent of the solid wastes projected to be generated in the study area in the year 2010. This would require the purchase of an additional two trucks each year over the next twelve years, over and above replacement of existing trucks as they become too old. Each added truck would require additional labor, fuel, and maintenance. This can be compared with BHUESC's current difficulties in replacing worn out trucks, or purchasing even one more truck per year in an effort to expand the amount of Bien Hoa City serviced by BHUESC.

Table III-22: Current (1998) and Projected Future Solid and Hazardous Waste Generation and Disposition, (2010) in the Absence of an AEQM Strategy, Most Plausible and Alternate Scenarios

Waste Type	Total Tonnes	Collected for Recycle/Disposal	Scavenged/Burned /Indiscriminate Dumping	On-Site Disposal
Current (c1998)				
Domestic and Commercial	59,000	15,000	44,000	
Bio-Hazardous	200		100	100
Industrial				
Solid	30,800	8,300	7,900	14,600
Hazardous	5,700		3,100	2,600
Transport (Waste Oil in liters)	50,000	30,000	20,000	
Most Plausible Scenario				
Domestic and Commercial	220,000	55,000	165,000	
Bio-Hazardous	500		250	250
Industrial				
Solid	165,000	44,000	43,000	78,000
Hazardous	30,000		16,000	14,000
Transport (Waste Oil in liters)	210,000	125,000	85,000	
Alternate Scenario				
Domestic and Commercial	76,000	19,000	57,000	
Bio-Hazardous	300		150	150
Industrial				
Solid	37,00	10,000	10,000	17,000
Hazardous	7,000		3,700	3,300
Transport (Waste Oil in liters)	83,000	50,000	33,000	

STEP SIX: LIST POTENTIAL MEASURES THAT COULD BE TAKEN TO REDUCE AIR, WATER, AND SOLID WASTE DISCHARGES AND IMPROVE ENVIRONMENTAL QUALITY

A list of possible physical measures and implementation incentives was developed for reducing pollution in the air, water and solid waste discharges in the study area, and are listed in Tables III-23 through III-25.

Table III-23: Air Pollution Abatement Measures

Sector	Physical Measures	Implementation Incentives
Industrial	▸ Change stack height and diameter to dilute (only), not reduce emissions ▸ Modify manufacturing processes by installing more efficient production units ▸ Substitute cleaner fuels for dirty fuels ▸ Install air pollution control facilities for dust (particulates) Settling Chambers Cyclones Bag filters Electronic precipitators Wet scrubbers ▸ Install air pollution control facilities for gases	▸ Institute emission charges ▸ Adopt, monitor, and enforce emission standards ▸ Provide low interest rate loans for installation of air pollution control devices ▸ Provide grants for installation of air pollution control devices ▸ Provide pollution prevention technical assistance
Transportation	▸ Raise engine exhaust pipe to roof of vehicle ▸ Install exhaust catalytic converters to reduce NOX and CO ▸ Install exhaust adsorption tubes to reduce VOC ▸ Construct road/street overpass at railroad crossing ▸ Substitute leaded with lead-free gasoline ▸ Substitute diesel oil with cleaner fuel such as LPG, alcohol and gasoline ▸ Reduce the number of motor vehicles on the roads by higher quality public transportation	▸ Increase gasoline and diesel fuel prices ▸ Subsidize the cost of public transportation ▸ Ban sale of new 2 cycle engines ▸ Buy back existing motorcycles with 2 cycle engines ▸ Increase motor vehicle taxes and use funds to construct new by-pass roads ▸ Adopt, monitor and enforce vehicle emission standards ▸ Begin annual vehicle emission tests
Domestic	▸ Raise kitchen exhaust pipe 3 to 5 meters above the roof ▸ Substitute dirty fuels such as coal, wood and kerosene with clean fuels such as LPG, alcohol and electricity	▸ Subsidize replacement of dirt fuel stoves for clean fuel stoves ▸ Ban use of coal and wood for cooking in urban areas ▸ Monitor and enforce ban on dirty fuel use ▸ Develop educational program on health impacts of burning dirty fuels

Table III-24: Water Pollution Abatement Measures

Sector	Physical Measures	Implementation Incentives
Industrial	▸ Plant process modification ▸ Holding tanks, periodic pumping and disposal at an approved site ▸ Industrial park sewer collection system and interceptor to a stream/river ▸ Industrial park sewer collection and waste water treatment system with primary level treatment only ▸ Industrial park sewer collection and waste water treatment system with primary and secondary level treatment ▸ Regional sewer collection system connected to a single downstream treatment plant. (An example is the four industrial parks in the Suoi Ba Lua *drainage basin)*	▸ Provide low cost plant process waste auditing ▸ Provide technical assistance in plant process modifications ▸ Adopt and enforce effluent charges ▸ Adopt, monitor and enforce effluent standards ▸ Require connection to sewer collection systems ▸ Increase charge for water use ▸ Require location of industrial plants in existing industrial parks
Municipal	▸ Domestic and commercial waste water collection and interceptor system for wet and dry seasons. No treatment plant ▸ Domestic and commercial waste water collection and treatment system for wet and dry seasons with secondary level treatment plant ▸ Metropolitan regional waste water collection and treatment system for wet and dry seasons with secondary level treatment plant (municipal and *industrial combined)* ▸ Interceptor pipe for diversion of surface drainage and all outfall effluent into Song Cai to downstream of the Dong Nai and Song Cai confluence ▸ Wet season storm water runoff diversion and settling ponds	▸ Increase per household water charges ▸ Develop educational program on water conservation ▸ Organize co-operative septic tank systems ▸ Require connection to sewer collection system ▸ Adopt and enforce regulations concerning location of new housing adjacent to sewer lines
Rural	▸ Wet season storm water diversions and treatment ponds ▸ Plant vegetative buffer strips ▸ Implement Integrated Pest Management Plans	▸ Develop IPM Plans ▸ Land use planning - crop rotation ▸ Develop agricultural technical assistance programs

Table III-25: Solid Waste Pollution Abatement Measures

Sector	Physical Measures	Implementation Incentives
Industrial, Non-Hazardous	▸ Recycling of separated wastes at designated processing facility ▸ Collection, transport, disposal at Trang Dai landfill ▸ Collection, transport, disposal at lined landfill cell at Trang Dai ▸ Collection, transport, disposal at new lined landfill	▸ Restrict collection of solid wastes to designated collectors ▸ Prohibit on-site disposal, and require disposal in designated sites only ▸ Provide waste audits to all facilities ▸ Assist with development of waste reduction plans, by plant ▸ Develop a solid waste management plan by industrial park ▸ Require that collection and disposal be charged full cost/tonne ▸ Begin waste management inspections to ensure compliance with rules
Industrial, Hazardous	▸ Collection, transport, and disposal to separate clay lined landfill ▸ Collection, transport and disposal to double plastic lined landfill ▸ Treatment of compatible wastes prior to lined landfill disposal ▸ Incineration with lined landfill disposal of ash residues	▸ Prepare list of hazardous wastes, require all plants to inventory ▸ Require each plant to prepare hazardous waste minimization plan ▸ Require manifesting of all listed hazardous wastes ▸ Restrict collection of hazardous wastes to licensed collectors ▸ Restrict recycling of hazardous containing wastes to licensed facilities ▸ Prepare industrial park hazardous waste management plan ▸ Recruit and train hazardous waste specialists at DOSTE and SONADEZI ▸ Begin inspections to assure hazardous waste rules compliance ▸ Inventory non-industrial park hazardous waste generators

Table III-25 cont.

Domestic	▸ Increase collection of wastes to majority of households ▸ Disposal in unlined, unmanaged site ▸ Disposal in unlined, managed site with daily cover in wet season ▸ Anaerobic or aerobic composting of organic wastes ▸ Disposal in lined landfill with daily cover and leachate collection/treatment ▸ Begin separate collection of recyclable wastes ▸ Construct and operate recycling processing plant	▸ Develop educational program on liter/proper management of wastes ▸ Develop waste reduction educational program ▸ Provide BHUESC with sufficient resources to begin area-wide collection ▸ Mandate that all households pay a collection fee to BHUESC ▸ Organize informal scavengers to improve recycling and scavenger health ▸ Develop illicit disposal regulations, monitor, and enforce ▸ Determine ground water flow direction at Trang Dai landfill ▸ Begin ground water monitoring program at Trang Dai landfill ▸ Begin methane monitoring program surrounding landfill ▸ Restrict open burning of wastes
Transportation	▸ Begin fuel tank replacement program to double walled tanks ▸ Establish waste oil collection tanks throughout study area ▸ Establish waste coolant collection tanks throughout study area	▸ Develop education program on proper management of vehicle wastes ▸ Monitor, and if necessary, organize waste tire collections
Commercial / Institutional	▸ Construct central bio-hazardous treatment plant ▸ Replace open transfer points with collection trucks or transfer containers ▸ Construct recycling processing plant	▸ Organize bio-hazardous waste management program ▸ Monitor and enforce bio-hazardous waste management rules ▸ Require organized collection of wastes ▸ Require all commercial activities to pay full cost of collection and disposal
Agriculture	▸ Recycle by plowing at time of field preparation ▸ Open field burning and ash disposal by plowing at time of field preparation	▸ Provide agricultural technical assistance ▸ Ban use of certain pesticides ▸ Restrict times of year for fertilizer application

STEP SEVEN: ESTIMATE COSTS AND REDUCTIONS IN ENVIRONMENTAL DISCHARGES FOR EACH SELECTED MEASURE, COMBINE MEASURES TO DEVELOP AN AEQM STRATEGY

The measures listed in Step Six were evaluated by International and National Consultants and Dong Nai DOSTE staff using experience and professional judgement. Then, those considered most feasible in the Bien Hoa study area were grouped in three separate categories, based on rough estimates about whether they were low, medium or high unit cost measures. These three groups were used as the basis for defining three different strategies. The first strategy consisted of only these measures considered to be low unit cost. The second strategy consisted of the low unit cost measures combined with those in the medium unit cost group. The third strategy consisted of all possible measures for the Bien Hoa study area.

It should be emphasized that the cost and pollution reduction estimates presented in Tables III-24 through III-26 are very approximate. They are based largely on professional judgement and should be used as a starting point only. Detailed feasibility level estimates of actual unit costs were not carried out as part of this project, but would be the next logical step.

Strategy One: Low unit cost measures

Table III-26 presents a list of low unit cost measures. Each measure is described in terms of: The type of activity it would be applied to; estimated capital and annual O & M costs (1998 US dollars); potential reduction in environmental discharges; the environmental media that would be impacted; and the lead implementation agency.

Table III-26: Low Unit Cost Measures

Activity	Measure	Capital Cost Million (US$)	O & M Cost 1000 (US$/ year)	Environmental Impact	Media	Lead Agency
Industrial	Pollution prevention auditing	1.2	50	20% pollution reduction	AWS	SONA
	Combustion Efficiency Impr.	0.1	20	5% pollution reduction	A	DOSTE
	Low sulphur fuel (20% switch)	0	1000	10% pollution reduction	A	DOSTE
	Recycle process water	3.8	50	10% pollution reduction	W	SONA
	Material recovery	2.5	50	10% pollution reduction	WS	SONA
	Regulate solid waste hauling	0	5	10% pollution reduction	S	DOSTE
	Regulate/inventory haz-waste	0.05	20	10% pollution reduction	WS	SONA
Domestic	Substitute clean fuels for dirty	0.1	5	15% pollution reduction	AS	DOSTE
	Reduce open waste burning	0.05	20	5% pollution reduction	AS	DOSTE
	Reduce Litter	0.05	20	2% pollution reduction	WS	DOSTE
	Leak detection	0.1	25	Public health	W	DOC
	50% solid waste collection	0.4	50	20% pollution reduction	AWS	BHUES
	Landfill monitoring	0.05	7	5% pollution reduction	AW	DOSTE
	Waste oil education campaign	0.05	10	10% pollution reduction	W	DOSTE
	Red bag collection Bio-haz	0	50	15% pollution reduction	S	BHUES
Agriculture	Farm practices education	0.1	50	10% pollution reduction	AW	DOA
	Improve aquiculture efficiency	0	25	20% pollution reduction	W	DOA
Transportation	No new 2-cycle engines	0	10	20% pollution reduction	A	DOT

(1) Media: Air (A), Water (W), Solid Waste (S)

(2) Lead Agencies: SONA, Sonadezi; DOSTE, Dong Nai DOSTE; DOC, Department of Construction; BHUES, Bien Hoa Urban Environmental Service Company; DOA, Department of Agriculture; DOT, Department of Transportation

(3) The pollution reduction estimates for each activity are not additive

Strategy Two: A Combination of the low and the medium unit cost measures

The additional measures listed here are estimated to have a moderately higher unit cost than those presented above in strategy one. If strategy one does not abate the air, water, and solid waste pollution enough to meet the environmental objective chosen in Step Two, these added measures should be considered.

Table III-27: Medium Unit Cost Measures

Activity	Measure	Capital Cost Million (US$)	O & M Cost 1000 (US$/year)	Environmental Impact	Media	Lead Agency
Industrial	Add electrostatic precipitators	3	50	10% pollution reduction	AS	SONA
	Haz-waste manifest system	0	20	10% pollution reduction	WS	SONA
	Clay lined haz-waste site	0.5	10	10% pollution reduction	WS	SONA
	Small-med enterprise program	0.5	20	20% pollution reduction	AWS	DOSTE
Domestic	Ceiling kitchen exhaust pipes	1	20	10% pollution reduction	A	DOSTE
	Dong Nai/Song Cai Interceptor	20	20	50% pollution reduction	W	DOSTE, DOC
	75% solid waste collection	0.7	80	50% pollution reduction	AWS	BHUES
	Containerized transfer points	0.5	30	5% pollution reduction	S	BHUES
	Mandatory collection fee	0.1	20	10% pollution reduction	S	BHUES
	Wet season daily landfill cover	0.1	30	5% pollution reduction	WS	BHUES
	Bio-hazardous autoclave	0.05	10	5% pollution reduction	S	DOSTE, BHUES
	Waste oil collection tanks	0.1	20	5% pollution reduction	WS	DOSTE
	Gasoline tank monitoring	0.05	20	5% pollution reduction	WS	DOSTE
Agriculture	Enforcement of no open burn	0.1	20	10% pollution reduction	A	DOSTE, DOA
	Shoreline improvements	5	20	20% pollution reduction	W	DOSTE, DOA
	Monitor agric. nutrient loading	0.05	10	5% pollution reduction	WS	DOSTE, DOA
	Incentives for int. pest manage.	0	10	5% pollution reduction	WS	DOSTE, DOA
	Manure management program	0.05	10	10% pollution reduction	WS	DOSTE, DOA
Transportation	Subsidized 2-cycle replacement	1.0	10	30% pollution reduction	A	DOT
	New propane fueled buses	1.0	20	10% pollution reduction	A	DOT

Strategy Three: A Combination of the Low, Medium and High Unit Cost Measures

The measures listed here are judged to have a higher unit cost for pollution abatement than those listed previously. When combined with those given in Strategies One and Two, the complete list of measures available for Strategy Three is defined.

Table III-28: High Unit Cost Measures

Activity	Measure	Capital Cost Million (US$)	O & M Cost 1000 (US$/year)	Environmental Impact	Media	Lead Agency
Industrial	Plant modernization Raise stack heights Install scrubbers/bag houses Connect Bien Hoa I to sewers Hazardous waste treatment	100 1 3 3 0.5	1000 0 50 20 50	25% pollution reduction 10% concentration reduction 10% pollution reduction 10% pollution reduction 10% pollution reduction	AWS A AS W WS	SONA SONA SONA SONA SONA
Domestic	Regional wastewater treatment 90% solid waste collection All season daily landfill cover Enforcement of no open burn Enforcement of anti-litter laws Fuel tank replacement program	200 1 0.1 0.05 0.05 0.05	1000 100 50 10 10 50	90% pollution reduction 80% pollution reduction 30% pollution reduction 10% pollution reduction 10% pollution reduction 10% pollution reduction	W AWS AWS A WS W	DOSTE, DOC BHUES BHUES DOSTE DOSTE DOSTE
Agriculture						
Transportation	Construct railroad overpasses Eliminate leaded gas	1 0	5 20	10% pollution reduction 20% pollution reduction	A A	DOSTE, DOC DOT

Implementation Issues Associated With Each Strategy

While Tables III-26, III-27, and III-28 contain the key words and related information about each measure selected, some additional comments are presented as an aid to understanding how they could be implemented. These comments have been organized according to each strategy, the media effected, and the activity in which the measure is classified.

Strategy One: Low Cost Measures

Air

Industrial

- Provide pollution prevention auditing assistance to industrial plants. A review of all manufacturing processes can be expected to identify a variety of actions to reduce the SPM, SO_2, and other emissions in the industrial sector. Some of the in plant process changes may be expected to reduce while others will increase costs. Trained specialists will be needed to provide this service.

- Provide low cost loans and grants to induce industrial plants to adopt pollution abatement measures identified by the waste audits.

- Improve the efficiency of combustion units through more careful and more frequent maintenance.

- Adopt, monitor and enforce emission standards.

- Require that industrial plants substitute low sulphur fuel, coal and oil, for high sulphur content sources, or provide an economic incentive to switch to cleaner burning fuels by taxing dirty fuels.

Domestic

- Provide funding for households to substitute clean fuels for dirty fuels. Propane gas should be used instead of charcoal, wood, kerosene, or coal for food preparation and various small commercial enterprises. The cost of propane could be subsidized initially to convince households to switch fuels.

- Adopt, monitor and enforce bans on open burning of wastes in urban areas.

Agriculture

- Provide technical assistance to farmers to reduce burning of crop residues, minimize pesticide applications, and adopt no-till agriculture.

Transportation

- The development and enforcement of a policy replacing the existing two-cycle with four-cycle engines over an extended period would be an effective way to reduce air pollution from all of the motor-bikes. Two-cycle engines are four times more polluting per km driven than four-cycle engines. New two-cycle engines could be banned and low interest loans for replacement on two-cycle with four-cycle engines instituted.

Water

Industrial

- Provide pollution prevention auditing. This measure, if combined with low interest loans or grants to adopt identified measures and enforcement of water discharge standards, could be very effective in reducing the volume and strength of water pollution generated. This is especially the case for processes that are major pollution sources in the Study Area, especially the paper mills and the sugar refinery. One added benefit would be the reduction of fresh process water needed due to the increased volume available for recycling.

- Regulate/Inventory hazardous waste. Water pollution from unregulated disposal of liquid and solid hazardous wastes could be reduced by developing regulations requiring the inventory and reporting of hazardous wastes and restrictions on disposal to permitted facilities. Enforcement of these regulations would be required by DOSTE.

Domestic

- The reduction of litter, especially when it reaches the stream tributaries, would reduce water pollution. This is particularly true in the urban area where the tributaries are open sewers and where they receive litter from many sources. Development of a public education program concerning proper litter disposal and expansion of municipal collection would help reduce litter.

- Landfill monitoring would provide a more rapid warming of possible surface and groundwater pollution caused by either leachate or surface run-off.

- Waste oil from the many engine repair businesses throughout the urban are is often spilled upon the ground where it seeps into the ground water. It also can be dumped into the surface water. A public education program would help shop owners and society in general to understand the pollution impact of these actions and stop them.

Agriculture

- Water polluted with excess pesticides can be reduced through an educational program and technical assistance.

- The rapidly growing aquiculture industry on Tri An Reservoir may be creating pollution problems from nutrient enrichment of the reservoir water. The Dong Nai River water down stream may be degraded from the same source, excess aquiculture, and the human population living on the reservoir to raise the fish. A combination of monitoring, regulation, and education may be effective in gaining more knowledge of the pollution and finding an effective way to abate it.

Solid Waste

Domestic

- Implement an educational campaign designed to convince residents to reduce littering and to begin to utilize an organized collection system for household wastes.

- Increase BHUESC funding so that they can increase organized collection from an estimated 25 percent of the domestic and commercial wastes to 50 percent.

- Continue to dispose of collected wastes in the Trang Dai landfill, with no changes in management practices.

- Begin ground water and methane gas monitoring program at the Trang Dai landfill site.

- Provide sufficient funding and education at the hospitals so that the majority of bio-hazardous wastes are placed in red bags for collection by BHUESC and disposal in separate area of the Trang Dai landfill.

Industrial

- Provide inexpensive waste auditing services to any industrial plant requesting the service.

- Require that only BHUESC or Sonadezi collect industrial wastes in the industrial parks.

- Require that all private firms collecting industrial material be licensed, and that an inspection of their business by DOSTE be part of the licensing process.

- Include solid and hazardous wastes in any cleaner production programs implemented in the study area.

- Either adopt MOSTE's hazardous waste regulations, or develop DOSTE hazardous waste regulations that include a list of hazardous materials. Assign DOSTE staff to conduct periodic inspections of industrial plants to determine if inventories are being properly kept.

- Require that all industrial plants provide DOSTE or Sonadezi with estimated quantities of wastes listed as hazardous materials.

Strategy Two: Medium Cost Measures

Water

The following measures are added to the list of low cost measures for the medium cost AEQM strategy for solid and hazardous wastes.

The major regional structural option for water pollution reduction is construction of an interceptor along the Dong Nai River and Cai River in Bien Hoa City and an outfall to discharge untreated waste into the Dong Nai River. The proposed interceptor is approximately 21 kilometers long extending from 3 kilometers upstream of the Hoa An Bridge to approximately 6 kilometers downstream of the Dong Nai Bridge. All major municipal and industrial discharges would be connected to the interceptor via the existing drainage system and shallow ground water flow. Some degree of industrial pre-treatment of waste would be desirable prior to discharge to the interceptor.

Under dry weather and moderate wet weather conditions, all flow would be conveyed to the downstream end of the interceptor. Under more severe wet weather events, overflow of some of the combined stormwater, domestic and industrial waste would be necessary at points along the river. An outfall pipe and diffuser would be constructed at the downstream end of the interceptor in order to evenly discharge the waste along the full width of the river. This would eliminate local points of high pollution such as are currently found near the outfalls to the Song Cai and Dong Nai River.

Solid Waste

Domestic

- Increase collection so that 75 percent of the wastes in the study area are collected.
- Place containers at each existing transfer point for collection and hauling of wastes.
- Require that all households and commercial activities in areas serviced by BHUESC pay a fee for collection.
- Provide daily cover during the rainy season at the Trang Dai landfill.
- Construct a single bio-hazardous waste autoclave for disinfection of all red bag bio-hazardous hospital wastes.
- Provide waste oil collection tanks at centralized locations throughout the study area.
- Require that all gasoline and fuel oil sellers begin weekly measurement of tanks and report leaks to DOSTE..

Industrial

- Require that all non-hazardous industrial solid wastes be disposed of at the Trang Dai landfill.
- Begin a hazardous waste manifest system requiring that all industries generating listed hazardous wastes track the disposal of this waste.
- Construct and begin operation of a clay lined landfill with individual cells for compatible wastes for disposal of hazardous wastes, and any waste water treatment plant sludges that are tested as hazardous wastes.

Strategy Three: High Cost Measures

The following measures would be added to the low and medium cost measures listed above to create the high cost strategy for management of solid and hazardous wastes.

Water

- A regional waste water treatment plant at the downstream end of the interceptor is part of the high cost strategy. The treatment plant would receive flow from the interceptor and, after treatment, would discharge to the outfall pipe. The interceptor-outfall could operate either with or without the treatment plant. A phased approach could be adopted, involving initial construction of the interceptor and outfall, followed at a later time by the construction of the waste water treatment plant if it is deemed necessary.

Solid Waste

- Increase collection services to 90 percent of the study area.
- Begin daily covering at centralized facility (either within the study area, or in an interregional facility) with disposal of the treated wastes in a landfill with a plastic liner, leach detection system, and underlying clay base.

STEP EIGHT: USING AIR AND WATER QUALITY MODELS, ESTIMATE THE IMPACT ON FUTURE ENVIRONMENTAL QUALITY ASSOCIATED WITH THE AEQM STRATEGY DEVELOPED IN STEP 7.

Water

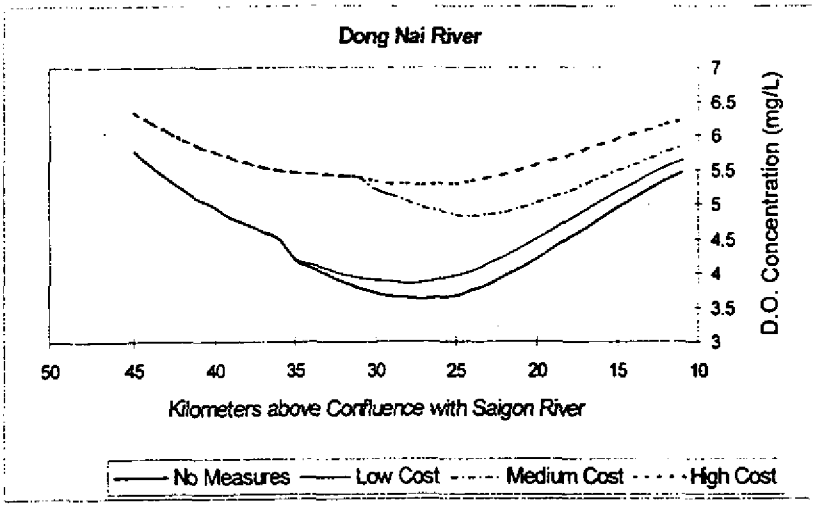
The measures developed under Step 7 were combined into low cost, medium cost and high cost strategies for reducing water pollution. The effects of each of these strategies on the environment were evaluated through a combination of the application of the QUAL2E model and through a qualitative assessment of the localized impacts on the receiving waters. The resulting dissolved oxygen profiles for the Dong Nai mainstem and Cai River are presented in Figure III-18.

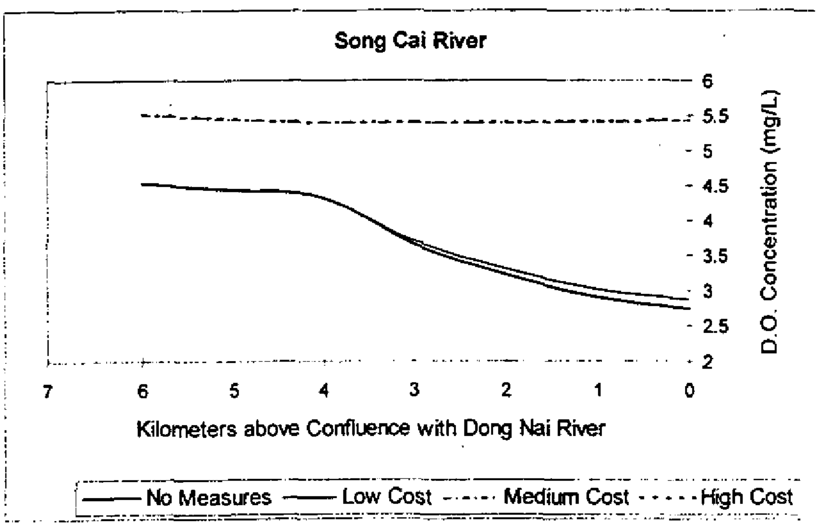
The measures associated with each strategy and the quantitative environmental consequences as determined with QUAL2E are summarized in Table III-29. The present water quality situation as simulated by QUAL2E is also shown for comparison purposes.

Table III-29: Summary of Water Quality Impacts (2010) of Alternative Strategies For the Most Plausible Scenario

Time Period And Strategy	Minimum D.O (mg/L) in Song Cai	D.O. (mg/L) at Dong Nai Bridge (KM35)	Minimum D.O. (mg/L) in Dong Nai River	Maximum BOD (mg/L) in Dong Nai River	Maximum BOD (mg/L) in Song Cai
Present	4.1	4.4	4.1	5.8	5.1
Future:					
No AEQM Strategy	2.8	4.1	3.6	5.8	9.5
Low Cost - AEQM Strategy	2.9	4.1	3.9	5.8	9.1
Medium Cost - AEQM Strategy	5.4	5.4	4.9	3.9	2.8
High Cost - AEQM Strategy	5.4	5.4	5.3	3.9	2.8

Figure III - 18: Modeled D.O. Profiles for the Dong Nai and Cai Rivers for the Low, Medium and High Cost Strategies Under the Most Plausible Scenario





The simulations show that there is a significant improvement in water quality associated with the medium cost strategy in both the Cai and the Dong Nai Rivers. This strategy also virtually eliminates the localized river pollution problems near to the discharge points in the immediate Bien Hoa area. The addition of the treatment plant in the high cost strategy results in some further improvement in the water quality of the Dong Nai River but this improvement is relatively limited and does not directly impact the immediate Bien Hoa area.

Based on the above assessment, the following conclusions and recommendations were reached:

- Standard A for dissolved oxygen (6 mg/L) and BOD (5 mg/L) cannot be dependably reached in the Dong Nai River at Hoa An at the present time due to the upstream BOD contributions. Based on bi-monthly sampling data at Hoa An, the average D.O. concentration is 6 mg/L and the average BOD is 8.5 mg/L. Figures III-8 and III-9 contain histograms of historical concentrations for D.O. and BOD respectively at Hoa An. As illustrated, in approximately 40% of the measurements the D.O. is below the standard while in approximately 90% of the samples, the BOD standard is exceeded. A more realistic and reasonable goal for D.O. is 5 mg/L and for BOD is 8 mg/L. These levels are not generally considered to be a significant impairment for treated drinking water sources and is common in many developed countries. Slight improvements in treatment of the drinking water would mitigate any negative impacts of this level of water quality. Modification of the Standard A (for rivers used as drinking water intake) and instigation of upstream controls to improve the water quality in the river entering Bien Hoa are recommended.

- The proposed interceptor would move the existing and increased waste loads from the Bien Hoa area to a point downstream of the highly developed area and the water intakes. It would greatly reduce the existing pockets of contaminated water in the vicinity of domestic and industrial outfalls. Construction of an outfall and diffuser would spread the loadings across the width of the river eliminating small areas of high levels of pollution in the vicinity of the outfall.

- A wastewater treatment plant at the downstream end of the proposed interceptor would further improve the water quality downstream of Bien Hoa. However, due to the relatively high cost of such a facility and the minimal impacts on the water quality of the developed and developing portions of Bien Hoa, construction of such a facility does not appear to be a high priority in the short term.

Air

The impact of the measure related to air quality in each of the three strategies described in Step Seven has been estimated by assuming that a reduction in emissions would occur throughout the Southern Economic Focal Zone, SEFZ. The reductions are presented in Table III-30.

Table III-30: Assumed Impact of AEQM Strategies On Air Quality in the Southern Economic Focal Zone, SEFZ, Year 2010

Strategy	Reduction in Emissions Suspended Particulate Matter, (SPM)	Sulphur Dioxide, (SO_2)
One	20%	20%
Two	40%	40%
Three	60%	60%

These emission reductions were used as input to the air quality model to predict ambient concentration of SPM and SO_2 in the SEFZ for the year 2010 for the dominant and alternate scenarios. These data were combined with a geographic information system, GIS, data set to produce the maps presented in the following pages. Figures III-19 and III-20 are the results for a 20% reduction, SPM and SO_2. Figures III-21, III-22, III-23, and III-24 are the results for a 40% and a 60% reduction, respectively.

Keeping in mind the limitations in the data used to make these predictions, that is the approximate nature in estimating the emissions through an indirect approach, some comments on the expected impact of each strategy may be made. Comparing Figures III-14 and III-15 with Figures III-19 and III-20 provides insight on the impact of a 20% reduction. The air quality improvement is very modest. The isolines in Figure III-19 enclose less land than in Figure III-14 showing some improvement in SPM but the change is modest. The same minimal improvement is apparent for the SO_2 from comparing Figures III-15 and III-20. Most of the SEFZ continues to have higher concentrations of SPM than the WHO standard and large urban area especially in Ho Chi Minh City, have concentrations that are higher than the Viet Nam standard.

Using the same approach for the 40% and 60% reduction, that is, comparing Figures III-14 and III-16 with III-21 and III-22 for the 40% reduction and III-14 and III-16 with III-23 and III-24 for the 60% reduction, more substantial improvements in the ambient air quality became apparent. The SEFZ continues to have concentrations greater than the WHO standard, but the area of elevated concentrations is reduced considerably with a 40% drop in emissions, (Figures III-21 and III-22), and even more with the 60% drop, (Figures III-23 and III-24).

These very subjective evaluations suggest that an AEQM strategy that results in only a 20% reduction in the expected emissions for the most plausible scenario will not be sufficient to achieve Viet Nam standards. However, under the alternate scenario, this reduction would have a significant impact.

FIGURE III-19

Modeled Ambient Concentration of Suspended Particulate Matter, SPM, in the Southern Economic Focal Zone, SEFZ, for the 2010 Period Based upon a High (15%) Annual Growth Rate and AEQM Measures Providing a 20% Reduction in Emissions (Ho Chi Minh City - Bien Hoa City - Thu Dau Mot Town)

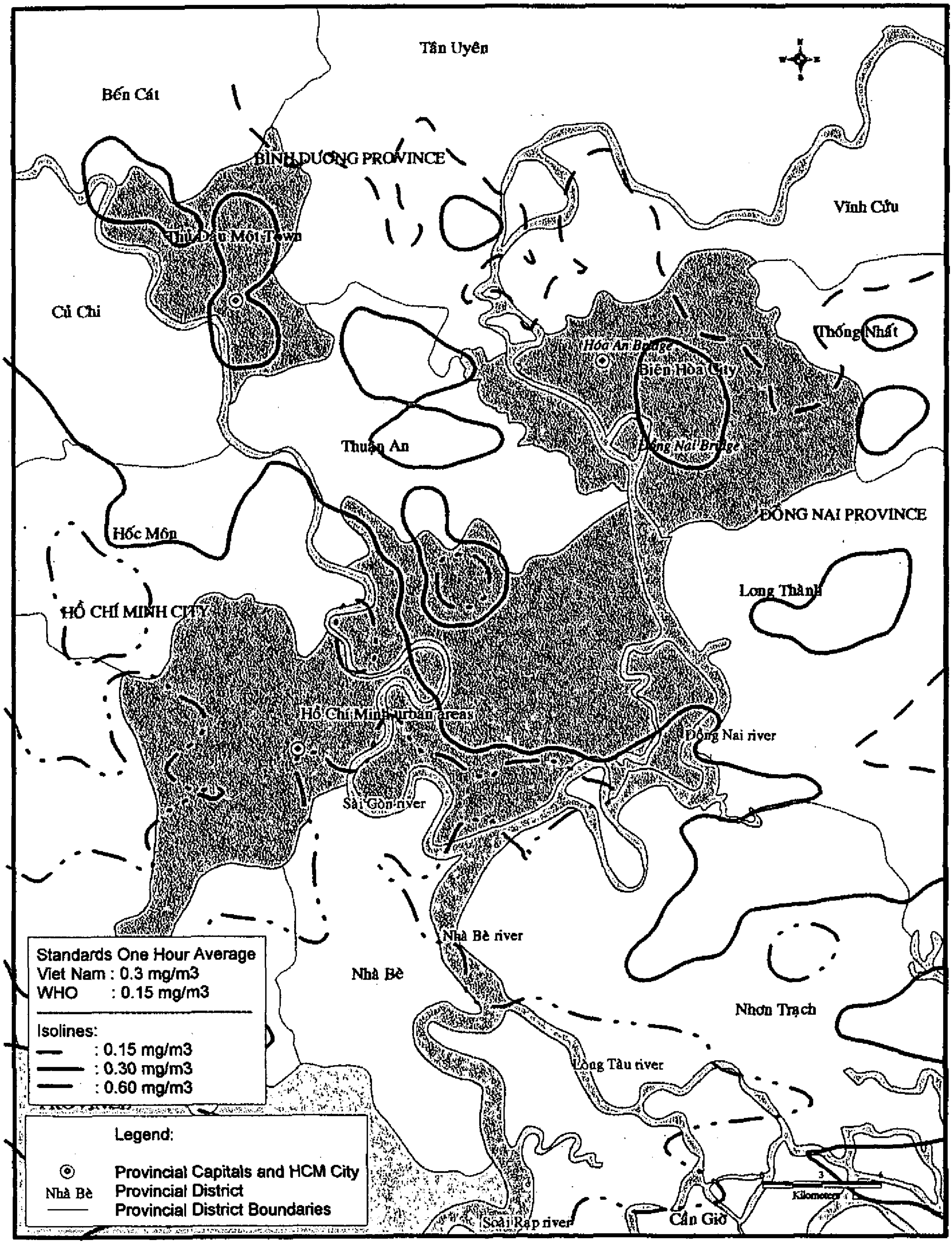


FIGURE III-20

Modeled Ambient Concentration of Sulphur Dioxide, SO2, in the Southern Economic Focal Zone, SEFZ, for the 2010 Period Based upon a High (15%) Annual Growth Rate and AEQM Measures Providing a 20% Reduction in Emissions

(Ho Chi Minh City - Bien Hoa City - Thu Dau Mot Town)

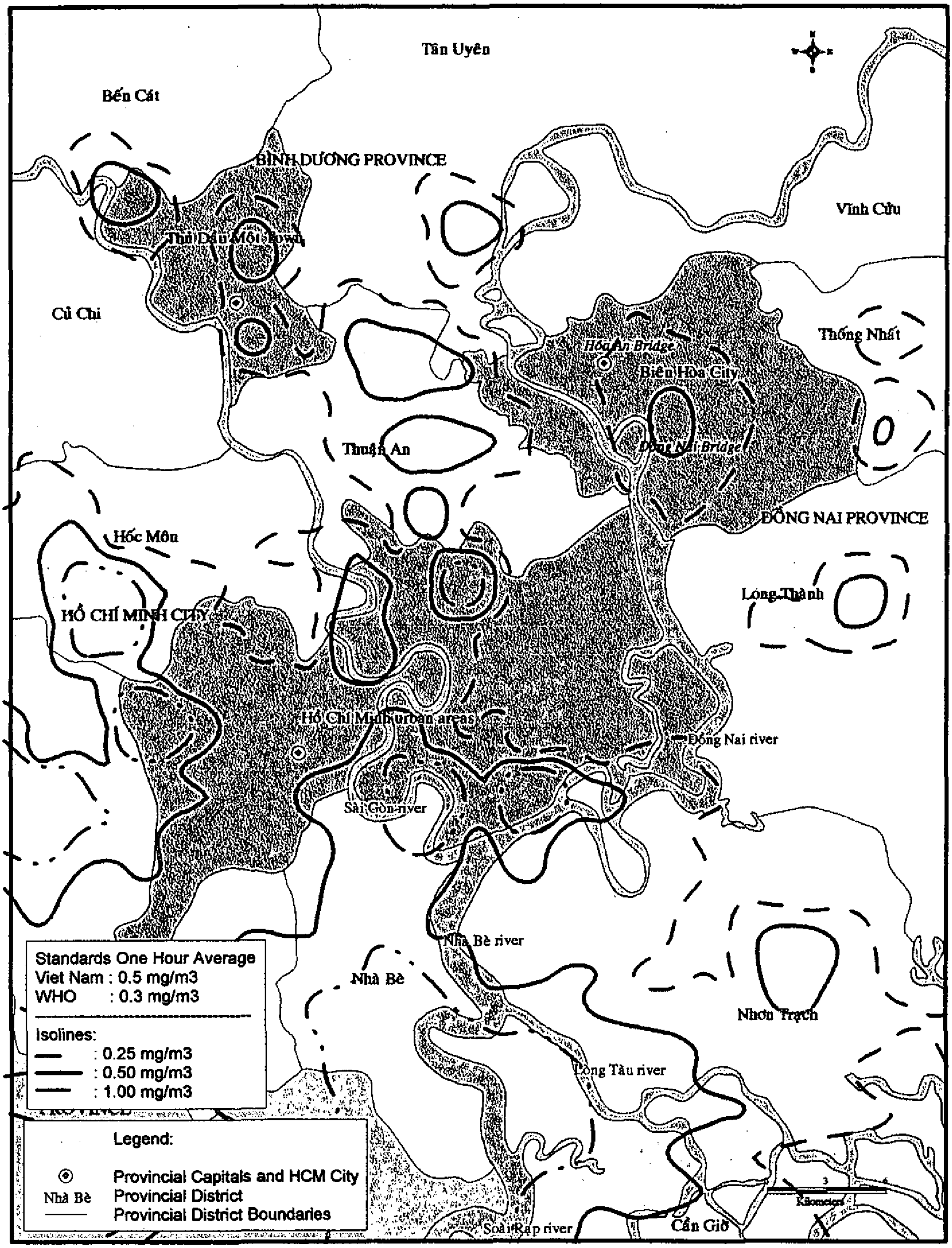


FIGURE III-21

Modeled Ambient Concentration of Suspended Particulate Matter, SPM, in the Southern Economic Focal Zone, SEFZ, for the 2010 Period Based upon a High (15%) Annual Growth Rate and AEQM Measures Providing a 40% Reduction in Emissions

(Ho Chi Minh City - Bien Hoa City - Thu Dau Mot Town)

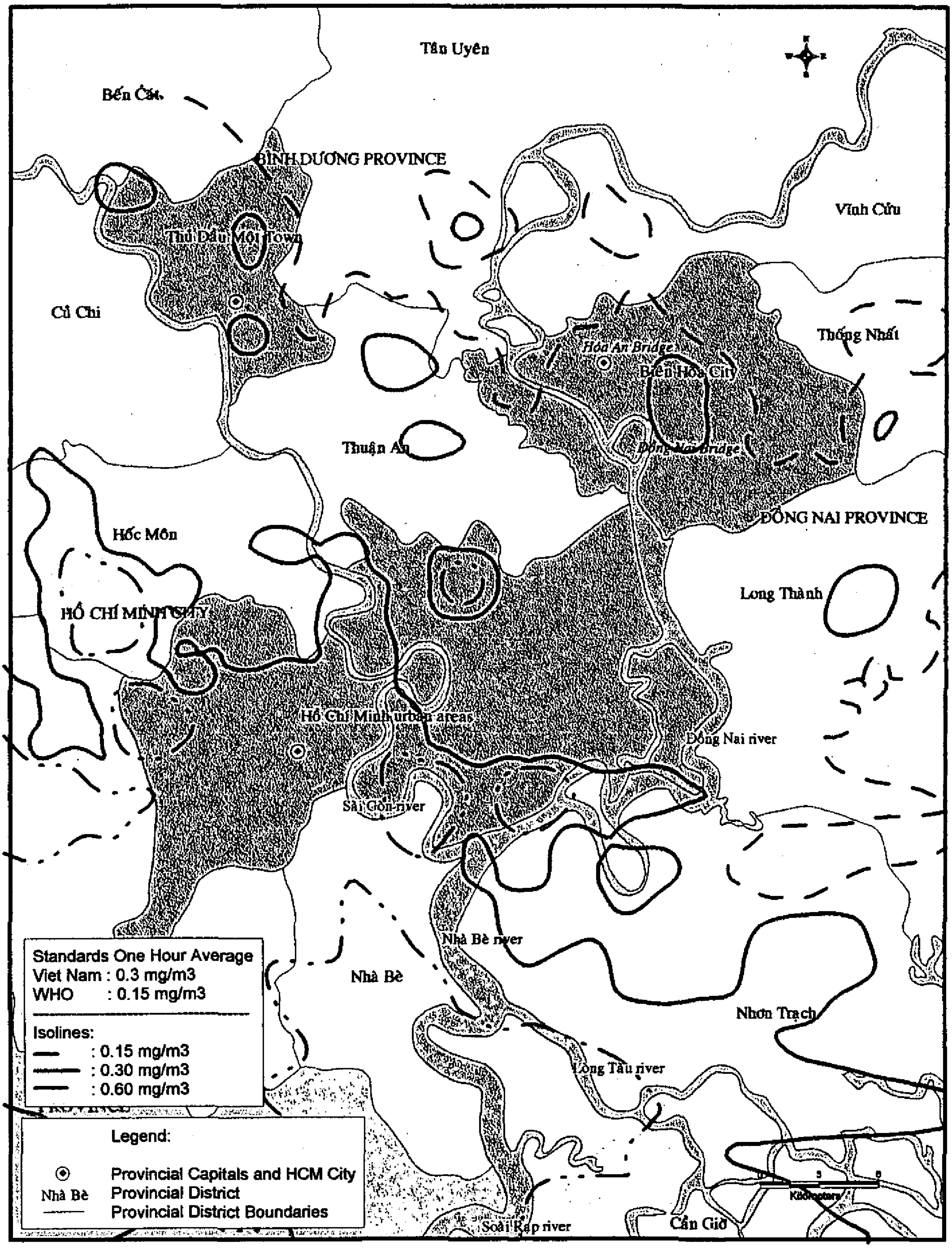


FIGURE III-22
Modeled Ambient Concentration of Sulphur Dioxide, SO2, in the Southern Economic Focal Zone, SEFZ, for the 2010 Period Based upon a High (15%) Annual Growth Rate and AEQM Measures Providing a 40% Reduction in Emissions
(Ho Chi Minh City - Bien Hoa City - Thu Dau Mot Town)

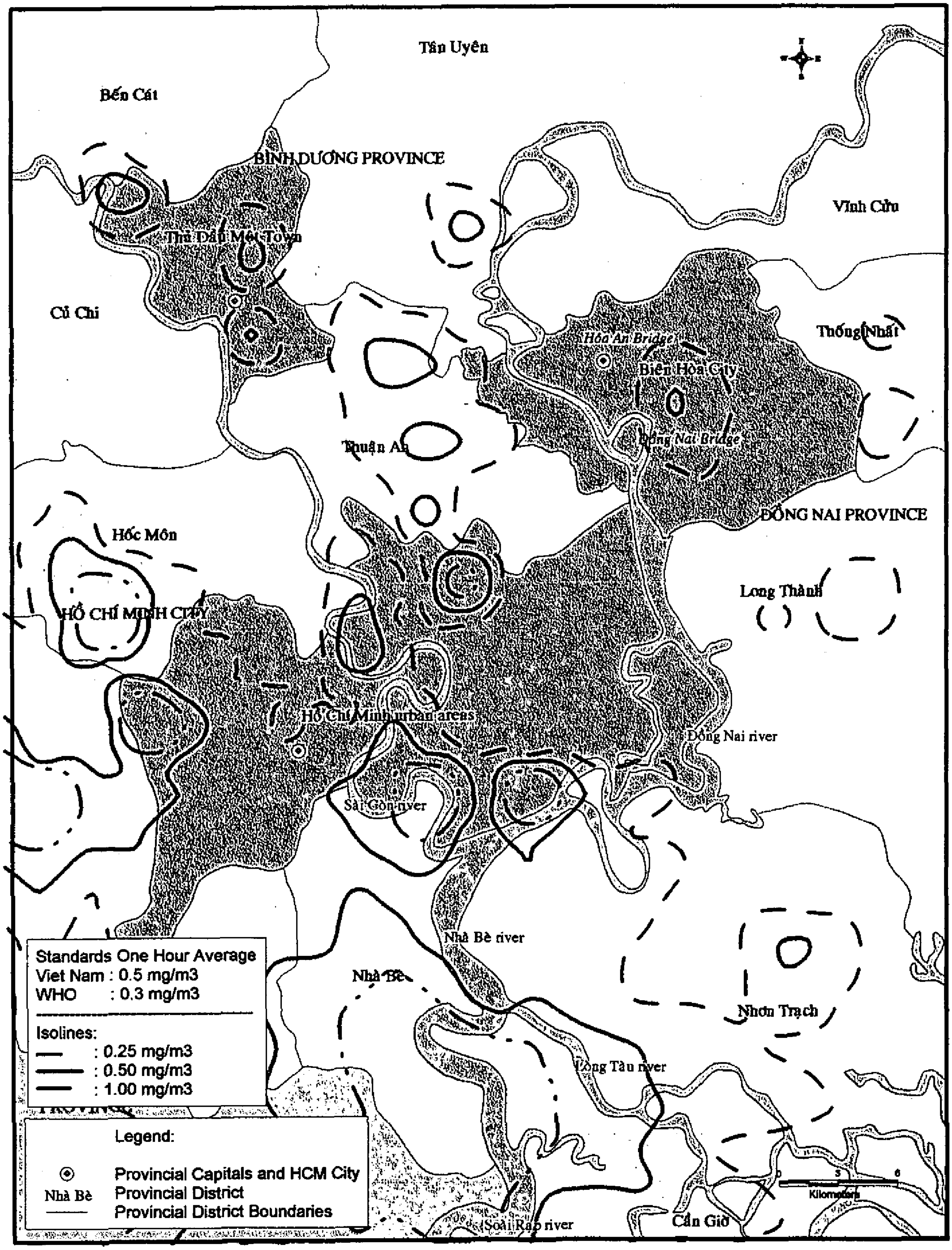


FIGURE III-23

Modeled Ambient Concentration of Suspended Particulate Matter, SPM, in the Southern Economic Focal Zone, SEFZ, for the 2010 Period Based upon a High (15%) Annual Growth Rate and AEQM Measures Providing a 60% Reduction in Emissions

(Ho Chi Minh City - Bien Hoa City - Thu Dau Mot Town)

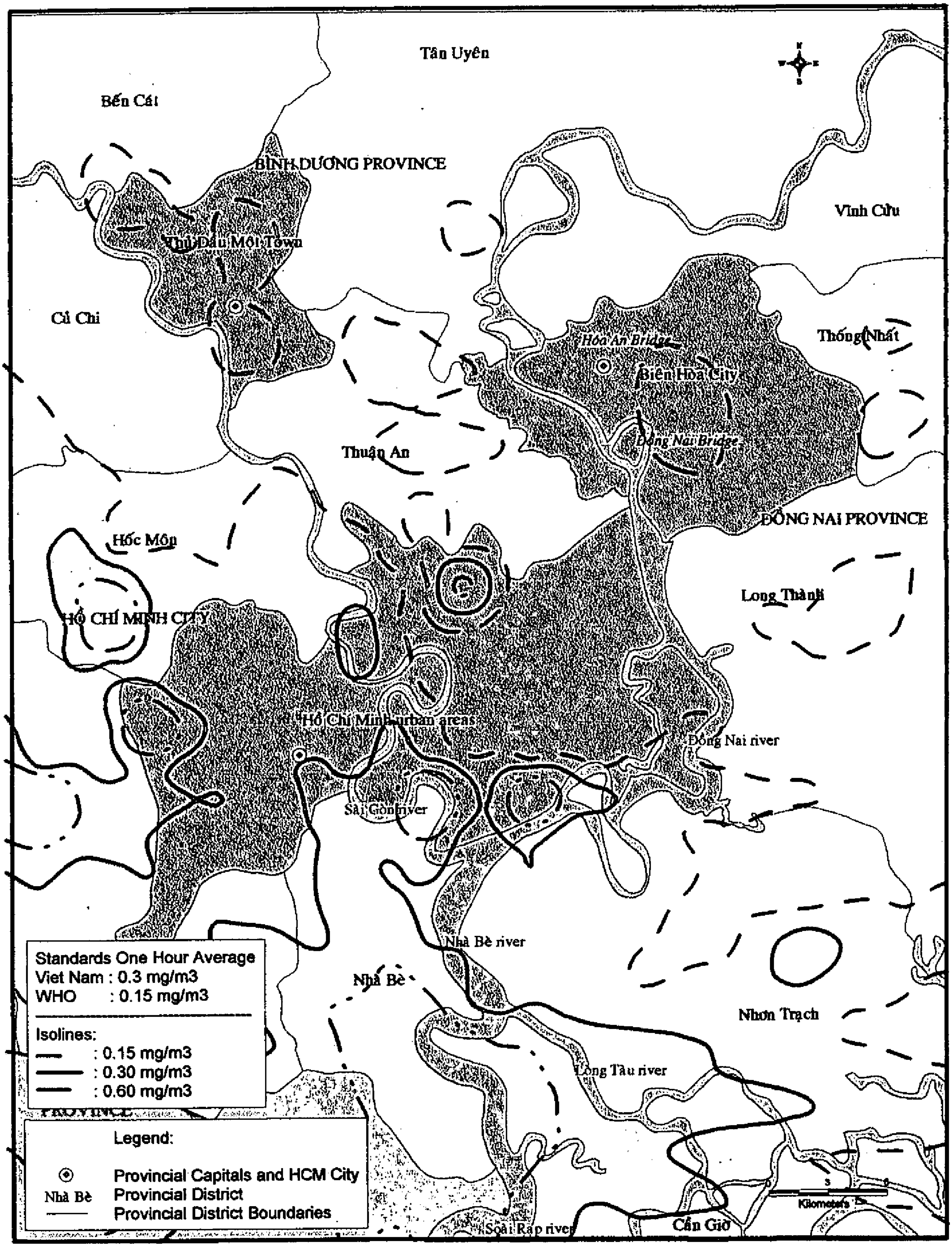
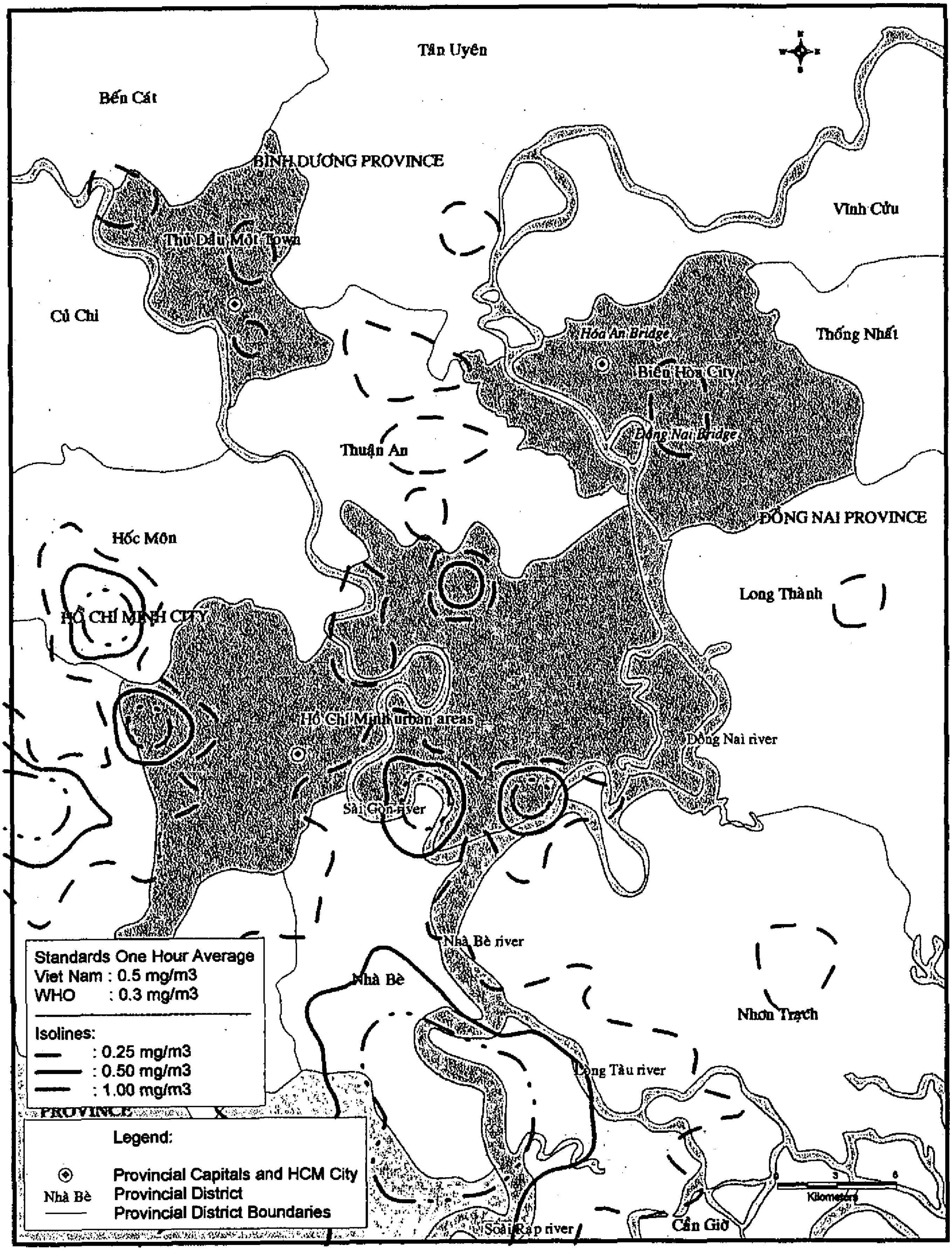


FIGURE III-24

Modeled Ambient Concentration of Sulphur Dioxide, SO2, in the Southern Economic Focal Zone, SEFZ, for the 2010 Period Based upon a High (15%) Annual Growth Rate and AEQM Measures Providing a 60% Reduction in Emissions

(Ho Chi Minh City - Bien Hoa City - Thu Dau Mot Town)



Solid and Hazardous Wastes

As discussed in Step 3, in most cases there are not objective environmental quality objectives associated with improved management on solid and hazardous wastes. Instead, there are defined management practices that have been demonstrated to reduce the risks to environmental quality associated with improper management. Based on experience elsewhere, the listed measures in the low, medium and high cost management strategies defined in Step 7 are estimated to have the following positive impacts on overall environmental quality in the study area by the year 2010.

Environmental Quality Impacts of Low Cost Strategy on the Dominant Scenario

- Eliminate burning and indiscriminate disposal of 50,000 tonnes of wastes.
- Eliminate the discharge of 20,000 liters of waste oil to ground and surface waters.
- Reduce health risks from scavenging of wastes by 50 percent.
- Reduce industrial waste generation by 25 percent, or approximately 40,000 tonnes per year by the year 2010 for the high growth scenario.
- Reduce indiscriminate disposal of industrial wastes by an additional 20,000 tonnes per year.
- Reduce hazardous waste generation by approximately 20 percent, or 6000 tonnes.

Environmental Quality Associated With Medium Cost Strategy

- Eliminate burning and indiscriminate disposal of 125,000 tonnes of waste .
- Reduce discharge of leachate to ground water by an estimated 110,000 cubic meters per year.
- Reduce health risks of bio-hazardous wastes by 90 percent.
- Reduce by 90 percent, or 27,000 tonnes per year, the improper disposal of hazardous wastes and therefore the threat to ground and surface waters, and to public health.

Environmental Quality Associated With High Cost Strategy

- Eliminate burning and indiscriminate disposal of 150,000 tonnes per year of waste.
- Reduce leachate discharges to ground water by an estimated 180,000 cubic meters per year.

- Eliminate risks of leachate contamination of ground water from hazardous waste disposal.

STEP NINE: LIST, AND WHERE POSSIBLE QUANTIFY THE EXPECTED HEALTH AND ECOSYSTEM BENEFITS ASSOCIATED WITH EACH AEQM STRATEGY

Because of the approximate nature of the analysis presented in Steps Seven and Eight, no attempt has been made to quantify the expected health and ecosystem benefits associated with improvements to environmental quality resulting from each AEQM strategy. Instead, a list of potential benefits has been compiled to illustrate the types of benefits which could accrue from expenditure of funds to reduce water, air and solid waste discharges over the next 15 years. However, it should be noted that according to the US EPA, benefits to the United States associated with implementation of clean air legislation alone over the past twenty years have exceeded costs by forty times, with total costs of approximately 0.5 trillion US dollars and total benefits of approximately 20 trillion US dollars (US EPA, The Benefits and Costs of the Clean Air Act, 1970 to 1990, October, 1997)

Water

- Reduced drinking water treatment costs
- Reduced industrial plant water treatment costs
- Increased fish yields and increased income to fishermen
- Reduced contamination of fish by toxic chemicals, with corresponding reductions in health problems associated with eating the fish
- Increased recreational opportunities
- Improved river esthetics, with increased values to households along the river
- Increased flood protection

Air

- Increased life spans
- Reductions in chronic bronchitis
- Reductions in asthma attacks
- Reductions in coronary disease
- Reductions in hospital admittance and hospital stays
- Reductions in days of work lost due to illness and increased worker productivity
- Increased intelligence in children
- Improved esthetics
- Increased agricultural yields and income
- Improved ecological conditions
- Reductions in maintenance costs of buildings and equipment

Solid and Hazardous Wastes

- Increased esthetics and cleaner neighborhoods
- Reduced transmission of infectious diseases
- Improved ecological conditions
- Improved wetlands quality
- Improved surface and ground water quality
- Reduced flooding
- Reduced water treatment costs

STEP TEN: PROPOSE POTENTIAL AEQM STRATEGIES TO THE DECISION MAKERS

Introduction

As illustrated in Step Eight, there will be significant declines in environmental quality over the next fifteen years under the most plausible scenario. Major impacts by the year 2010 include:

- Potential anaerobic conditions in portions of the Cai River at certain times of the year
- Significant reductions in water quality in the Dong Nai River with no portions of the river within the study area meeting the current designated Standard A
- The majority of the urban population living with air quality that does not meet Viet Nam or World Health air quality standards
- Approximately 245,000 tonnes per year of domestic and industrial wastes burned, and indiscriminately dumped in rivers and streams, on vacant land, and on-site.

The most plausible scenario assumes that the Dong Nai Peoples Committee (DNPC) will continue to promote high rates of economic growth during the next ten years, and will devote only limited resources to protecting environmental quality. It further assumes that while citizens will increasingly protest the decline in environmental quality, citizens and the DNPC will be primarily concerned about employment and increasing incomes.

Reducing economic and population growth, as illustrated by the alternate scenario, will significantly reduce the decline in environmental quality. This scenario may occur if economic conditions in south-east Asia continue to decline as they have over the past several years resulting in slower growth in the study area. Or, the DNPC could choose to reduce growth in the study area to reduce the impacts on environmental quality. However, even with slower growth, environmental quality will continue to decline associated with the increased level of industrial, commercial and domestic activity which has occurred in the study area over the past ten years.

Over the past two years Dong Nai DOSTE, with assistance from national and international consultants, has begun to document the current level of environmental quality in the study area. As part of this AEQM analysis, an initial attempt has also been made to project future levels of environmental quality, both in the absence of any management strategy, and under low, medium, and high cost management strategies. Based on current environmental quality and projected declines in future quality, especially for the dominant scenario of continued high economic and population growth, it is clear that the DNPC must consider taking a more active role in environmental protection and increasing its investment in environmental protection.

This AEQM analysis has shown that simply requiring industry to invest in pollution prevention and control methods will not be sufficient to improve environmental quality in the study area. Instead, it will be necessary to combine investments in industrial pollution control, with investments in pollution prevention and treatment from commercial, transportation, agricultural and domestic sources. In addition, there will be a need to coordinate the efforts of Dong Nai DOSTE with those of surrounding provinces, especially HCMC associated with air quality, and provinces up-stream from Dong Nai Province for water quality.

Recommendations

Based on the AEQM analysis the following management and implementation strategy is recommended for consideration by DNPC. The strategy consists of four steps.

Step One: Inform Policy Makers, Technical Leaders and Citizens

This AEQM analysis contains important information about current and projected water, air and solid waste discharges and their impacts on environmental quality. There is a need for Dong Nai DOSTE to make this information available to the DNPC, technical leaders and citizens so that a consensus can begin to be developed to increase investments in environmental quality in the study area.

One approach would be to create a Dong Nai Province Environmental Quality Management Committee responsible for steering implementation of an AEQM strategy. A sample organizational structure is proposed below. One of the key purposes of creating this management committee would be to inform citizens about current environmental quality, strengthening their ability to promote improvements in inspections and enforcement of pollution prevention and treatment. This could be a significant benefit to Dong Nai DOSTE's efforts to reduce pollution.

Proposed Dong Nai Province Environmental Quality Management Committee

Executive Committee

Chair- People's Committee Member
Other Members- Involved Provincial Agencies,
To be selected

Technical Advisory Committee
Chair- A person from DOSTE
Other Members- National Consultants
from VIE/95/053 project,
DOSTE Staff from VIE/95/053 proj.,

Public Advisory Committee
Chair- To be selected
Other Members- Local Media,
Local Commune Leaders,
Others to be selected

Research Institutes, Universities,
Local industries, Sonadezi
Others to be selected

The purpose of the committee would be to assist the Dong Nai People's Committee, DNPC, to develop and implement an environmental quality management plan based upon this AEQM report. Activities of the committee would include sponsoring and organizing an information program to inform all segments of the community about the AEQM approach, the general conclusions and the specific measures described in this report. A combination of public information programs and technical briefings is suggested. The public could be informed using the radio, newspaper, television and local meetings. The technical briefings could be provided for interested industry, government, university and other technical people.

Step Two: Begin Implementation of Low Cost Pollution Prevention Programs and Increase Air and Water Quality Monitoring

Industrial Pollution Prevention Program

The Industrial Pollution Prevention Project which preceded this AEQM analysis clearly identified the potential for significant reductions in pollution from, especially, industrial activities in the study area associated with waste audits and pollution prevention activities. Estimates were made by industrial pollution consultants that a fifty percent reduction in water, air and solid waste discharges could be accomplished through pollution prevention and process technology changes. Many of these activities were judged to be low cost measures, with some offering efficiency improvements that would actually reduce production costs.

The key to implementing this waste auditing and pollution prevention approach is creation of the technical and financial expertise which can be made available to the industries. Based on discussions with Dong Nai DOSTE and with the industrial park management entity, Sonadezi, it appears that Sonadezi should take the lead in establishing this waste auditing expertise. This is because: (1) Sonadezi already has relationships with most of the large industries in the industrial parks; (2) is currently involved in providing industrial infrastructure, such as roads, power and waste water collection and (in the future) treatment; and, (3) is not a regulatory agency such as Dong Nai DOSTE so that it will have easier access to information necessary to conduct detailed waste audits and pollution prevention analyses.

Air and Water Quality Monitoring

This AEQM analysis presents important information about current environmental quality based on the initial water and air quality monitoring which Dong Nai DOSTE has carried out over the past several years. Water and air quality models developed based on these monitoring data have been used to make initial judgements about current environmental quality and to make projections about future environmental quality. Many of the proposed management strategies are based on the results of this modeling.

There is a need to substantially increase monitoring activities to: (1) confirm or modify the initial results; (2) begin to establish trends with respect to ambient environmental quality; and (3) to answer questions raised by the initial monitoring and subsequent modeling of the data. DOSTE staff have gained valuable training, both in Viet Nam and through study tours to the United States and Canada, associated with proper collection and analysis of sampling data. DOSTE's budget should be increased sufficiently to assure that on-going collection and analysis of samples can be accomplished, and expanded to address the import and export of water and air pollutants. Specifically, there is a need to begin to identify the apparent large pollution loadings upstream of the study area in the Dong Nai river. There is also a need to expand the air quality sampling network to more clearly define current ambient air quality, and begin to identify sources of significant air pollution in the region.

The importance of this monitoring effort can not be overemphasized because the results will directly impact on the DNPC and DOSTE's decisions concerning future investments in pollution control and treatment. However, the lack of additional sampling data should not be viewed as a reason to delay beginning to implement the many investments that are necessary over the next ten years. These investments are summarized below. In most cases, the feasibility level analysis necessary to determine actual costs and viability can be carried out simultaneous with the expanded monitoring program. The monitoring data can then be used along with the detailed feasibility level analysis to make decisions on actual implementation.

Step Three: Investments in Improving Environmental Quality

Based on the AEQM analysis, it is recommended that the DNPC and DOSTE implement Strategy Two, which is a combination of low and medium unit cost measures to improve future environmental quality in the study area. Tables III-26 and III-27 provide a complete list of the proposed measures and estimated costs. Important implementation issues are summarized below:

Water

- Based on current data on Dong Nai River water quality it appears that upstream sources of pollution are significant. In addition to the increased upstream sampling recommended above it is necessary to begin to address agricultural and aquacultural sources of pollution.

- The key to improving water quality, especially in the Cai branch of the Dong Nai River will be the development of an interceptor to collect surface and shallow ground water flow, and discharges from the existing storm water collection system. There are a number of key steps which need to be taken now in order to determine the feasibility of such an interceptor. These include surveys of the topography (if not already available) along the proposed interceptor line; preliminary alignment of the interceptor; assessment of the amount and nature of the property which would be affected by the interceptor construction; preliminary sizing of the interceptor; and, an initial analysis of the cost and financing options for construction and maintenance.

Air

- Based on the initial sampling data and the historical growth in motor vehicles, there is a need to develop a transportation plan to divert traffic from the urban areas, and to separate motor vehicle and train traffic. Prohibiting 2 cycle engines should be considered. And, DOSTE should begin to work with MOSTE and other appropriate agencies concerning the potential to eliminate leaded gasoline.

- The industrial waste audits and pollution prevention programs can be used to identify industries most appropriate for fuel substitution and/or the addition of air pollution control equipment.

Solid and Hazardous Wastes

- It is critical that DOSTE either obtain hazardous waste definitions from MOSTE or develop definitions for Dong Nai Province. Once these definitions have been developed it will be necessary to require each industrial plant to inventory their hazardous wastes and provide DOSTE with an annual report on the generation and disposition of hazardous wastes. DOSTE and Sonadezi should continue to work to construct a lined hazardous waste landfill. Once this landfill is constructed DOSTE should require that all hazardous wastes be delivered to this landfill and enforce this regulation. Collection of industrial wastes should be restricted to licensed haulers with a requirement that the disposal of all hazardous wastes be documented and provided to DOSTE with license subject to annual renewal.

- A bio-hazardous waste incinerator or autoclave should be constructed by BHUESC. DOSTE should require that all bio-hazardous wastes be delivered to the bio-hazardous treatment facility.

- The Bien Hoa Peoples Committee should consider requiring that all households participate in, and pay for, collection of domestic solid wastes. Fees should be charged to each household to pay for BHUESC to expand its fleet of trucks and laborers to service the Bien Hoa urban area

Step Four: Coordination With Other Provinces

Upstream water pollution, and the impact of air pollution from HCMC requires that DNPC and Dong Nai DOSTE begin to form strong working relationships with surrounding provinces to address the many forms of inter-regional air and water pollution. One key measure would be to develop an AEQM analysis for the Southern Economic Focal Zone. This continues to be the fastest growing region in Viet Nam. It is also the site of an on-going UNDP/UNIDO project. And, the results will assist both Bien Hoa and HCMC in improving environmental quality.

While outside the purview of this study, there has been an on-going exchange of AEQM information between this study area and the Northern Economic Focal Zone. Rapid growth is expected in the Northern Economic Focal Zone and both areas would benefit from the application of a similar AEQM analysis to this area. Many of the lessons learned as part of this AEQM analysis would prove useful in the north, and the Bien Hoa area would also benefit from improvements in AEQM analysis that could be carried out during a second study in the north.