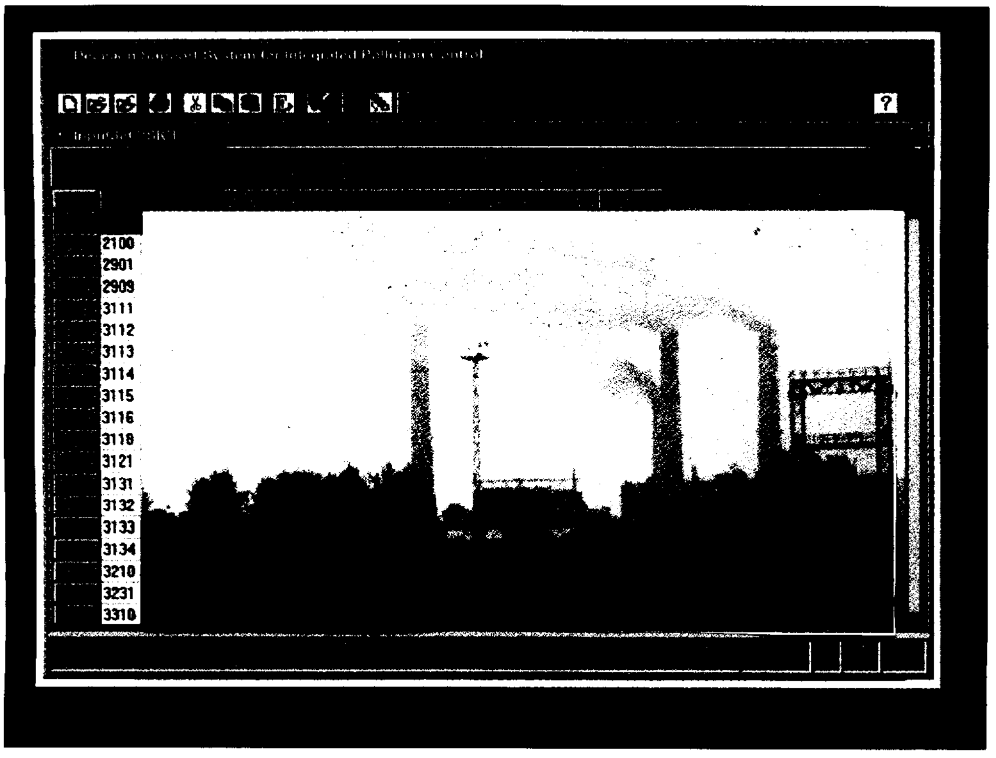
The World Bank

21650
December 1999

Decision Support System for Integrated Pollution Control

Software for Education and Analysis in Pollution Management



Iona Sebastian
Kseniya Lvovsky
Henk de Koning

World Bank

Decision Support System for Integrated Pollution Control

Software for Education and Analysis in Pollution Management

User Guide

The World Bank
Washington, D.C.

The International Bank for Reconstruction
and Development/THE WORLD BANK
1818 H Street, N.W.
Washington, D.C. 20433, U.S.A.

Manufactured in the United States of America
First printing December 1999

Cover photo by Curt Carnemark, the World Bank.

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Abstract

Developing a cost-effective pollution control strategy for urban areas and for other areas with large numbers of varied pollution sources is a complex task that often requires the application of special methodologies. The task is frequently complicated by lack of information about emissions from the various sources, the effects of the emissions on ambient quality, and mitigation alternatives.

This volume illustrates how, by applying standard emissions factors, simple dispersion models, and cost functions, analysts can arrive at reasonable estimates even when field data are inadequate. The method outlined is based on the Decision Support System for Integrated Pollution Control (DSS/IPC), a software program developed by the World Bank in collaboration with the World Health Organization (WHO) and the Pan American Health Organization (PAHO). The reliance on a logical analytical strategy and on readily available default information is, however, broadly applicable to environmental management and pollution assessment in general. Such a procedure can help identify cost-efficient control measures, including good housekeeping and waste prevention methods that can contribute to plant efficiency as well as to pollution reduction. By providing information about pollution problems and alternative abatement measures, it can foster participation and consensus building.

The analytical approach and the DSS/IPC system will be of interest to staffs of environmental agencies and international development organizations, environmental engineers, economists, and policy analysts. The DSS/IPC software is available on the World Bank Website, http://www.worldbank.org/pollutionmanagement.

Acknowledgments

The Decision Support System for Integrated Pollution Control is the product of a joint effort by the World Bank, the World Health Organization (WHO), the Pan American Health Organization (PAHO), Tebodin Consultants and Engineers, and the Dutch Institute for Health and Environment (RIVM). The software automates the framework for pollution load inventory and environmental assessment in a given area, as described in WHO, "Management and Control of the Environment" (WHO/PEP/89.1). Tebodin Consultants and Engineers developed and incorporated into this framework the module for calculation and analysis of pollution control costs.

The development of the system was initiated and managed by Iona Sebastian (World Bank), with co-management by Henk de Koning (WHO/PAHO) and Kseniya Lvovsky (World Bank). Kseniya Lvovsky managed the development of the latest stage of the product.

This guide draws on the work and contributions of the following team:

- Tebodin Consultants and Engineers (Netherlands): Frank van Woerden, Daren Luscombe, and Ron Venegas Carbonell
- The Dutch Institute for Health and Environment: J. Linders and J. Klein-Wolterink
- BSO/Origin (Netherlands): Max Blaauwbroek and Floris Zwarteveen
- The World Bank: Sanjeev Aggrawal, David Hanrahan, and Chuck Marshall (consultant).

The software was developed and built by BSO/Origin under a contract with the World Bank and WHO/PAHO. Modifications to and upgrades of the software were implemented by MadWolf Technologies, L.L.C.

During the testing and evaluating of the software, valuable comments were received from Richard Ackermann, Anthony Gorman, and Gordon Hughes.

The project was financed by the government of the Netherlands with contributions from PAHO, the World Bank, and the government of Norway.

Overview of the DSS/IPC

The DSS/IPC system is a software package for personal computers that was developed by the World Bank in collaboration with the World Health Organization (WHO) and the Pan American Health Organization (PAHO) to analyze alternative pollution control strategies and policies. It builds on a WHO method for estimating pollution loads in a study area, such as a metropolitan area or water basin, by applying standard emissions factors to data on economic activity, by industry or sector. The load estimates are then used to compute annual average concentrations of pollutants in an area or water body and the outcomes of selected pollution controls. The DSS/IPC extends this approach, allowing users to calculate the costs of controls and outline a cost-effective abatement strategy.

The DSS/IPC system comprises a set of extensive databases and a number of computation modules. The computation modules enable a user to estimate:

- Air, water, and solid waste emissions, on the basis of an inventory of economic activities for a given location
- Ambient concentrations of air and water pollutants, by using simple (screening) dispersion models with minimum meteorological and hydrological data
- Total costs of control options, by using standardized engineering-type cost functions
- Long-run marginal cost schedules for achieving a certain level of emissions reduction (or decline in ambient concentration) for a chosen pollutant.

The DSS/IPC software contains the following databases, compiled by medium of discharge—air, water, and solid and hazardous wastes:

- Pollution-intensive technological processes across all sectors of economic activity, including mining, manufacturing industries, energy, transport, and the municipal sector, grouped according to the UN International Standard Industrial Classification (ISIC) at the four-digit level
- The principal control options available for each process, including good housekeeping and waste prevention programs
- Emissions factors associated with these processes and with process-control options
- Normalized unit costs for control technologies
- Health guidelines for air and water pollutants, where applicable.

The editing and calibration features of the software allow the user to adjust the default data to local conditions when actual information is available.

Uses of the DSS/IPC System

The DSS/IPC system can be used by Bank staff, environmental agencies, pollution engineers, economists, and policy analysts as:

- An educational tool in pollution economics and management
- A reference database for pollution management
- A screening and data management tool
- An analytical tool.

An educational tool

The DSS/IPC identifies key issues and cause-effect links in pollution management. It demonstrates how various factors that can be influenced by sectoral and environmental policies affect pollution loads and ambient quality. These factors include the scale, composition, and density of economic activities in a study area; the geographic location of industrial estates; the controls adopted; and low-cost waste prevention and good housekeeping programs. The system permits the user to analyze pollution control policies and technological options by looking at the policies' potential impact on ambient concentrations of priority pollutants – those most closely linked to health and environmental damage – at different sources in an area or watershed. It promotes public participation and consensus building by informing stakeholders about the key pollution problems, major pollution sources, and principal mitigation measures in the area. It creates a framework for negotiating tradeoffs and for agreeing on targets and necessary interventions.

A reference database for pollution management

The system can be used in a variety of activities in research or project preparation and analysis. The DSS/IPC database and manual, which are incorporated into the software, provide information on toxic pollutants, emissions factors, dispersion models, technological processes, control options, and unit costs and contain formulas that can be independently applied in other models or studies or can serve as a reference.

A screening and data management tool

The DSS/IPC system helps users assess the pollution situation in the area and identify major pollution sources even when monitored data on emissions and ambient concentrations are not available. It can be used to highlight deficiencies in the existing system of data collection for pollution management; organize in a systematic way the process of gathering relevant information; continuously update and process this information; and present it swiftly in a convenient format as a table, chart, or map. The DSS/IPC database covers nearly 150 industrial processes and other polluting activities and 30 air and water pollutants, as well as solid wastes. Some information does have to be provided by the user: an inventory of industries in a given area, including data on key inputs, outputs, or both, in physical units (for those products whose processing or manufacturing is most directly linked to medium-specific pollution), and information on the types of existing controls.

An analytical tool

The DSS/IPC system is designed to help develop a cost-effective pollution control strategy across various pollution sources for a given area and identify priority investments in specific industries and in the municipal sector. The software permits an analysis that (a) highlights variations in marginal costs of abatement across industries and other sources and (b) defines the control levels and associated investments needed in various industries to achieve a desired pollution abatement target at least cost for the area as a whole. In particular, the system estimates the amount of pollution reduction that can be achieved without costly investments, just by improving management, operation, and maintenance. The software can also be used to support the selection of alternative locations for new industries, industrial zones, urban development, and expanded municipal services. For each proposed location, it can estimate the potential effects on the level of pollution and the costs of complying with environmental regulations.

Water pollution control. The DSS/IPC system is designed to support integrated wastewater management and can be applied at both municipal and watershed levels. It permits estimation of the total loads of major water pollutants discharged in a watershed (or portions of a watershed) and their relative impact on ambient quality; the shares in these loads of different pollution sources, including municipal sewage; and the total and marginal costs of alternative levels of wastewater treatment. (See the case study of Colombo in Box 1.) The results produced by the DSS/IPC can help in deciding whether or where to use more sophisticated water quality models and which wastewater treatment options at specific sources merit further consideration and analysis.

Air pollution control. The DSS/IPC can provide support for an integrated approach to airshed management in a given location. The system enables the user to generate an inventory of atmospheric emissions from all significant sources in an urban area,

Box 1. Analyzing Wastewater Treatment Options in Colombo, Sri Lanka

The Colombo Metropolitan Area (CMA) is a rapidly growing urban and industrial center that contains a quarter of Sri Lanka's total population and accounts for over 70 percent of its industrial activity. Water quality has been deteriorating over the past decades in all water systems in the area; Beira Lake and Lunawa Lagoon are now devoid of aquatic life. Of particular concern for environmental authorities is water quality in Kelani Ganga. This river, the main waterway of the CMA and a major source of water for the capital, receives wastewater from some of the most densely populated areas and a considerable number of industries. The IPC analysis estimated the pollutants that are discharged in significant quantities and have the greatest effect on water quality, including biological oxygen demand (measured over five days—BOD_5), chemical oxygen demand (COD), suspended solids, phosphorus, and nitrogen. The analysis revealed that—contrary to perceptions that industry is the main contributor to the deterioration in the biological and bacteriological indicators of water quality—the largest part of organic pollutants comes from households and the municipal sector (75 percent for COD and over 90 percent for BOD_5). This proportion is likely to remain the same in the future, given continuous urbanization, if measures to collect and control municipal discharges are not taken. Without improvements in sanitation, even the most advanced treatment of all industrial discharges may not improve water quality in the Kelani; it can, at most, remove only about one-fifth of the total load of BOD_5 going into the water (see Figure A). The analysis of treatment options demonstrated a great variation in the marginal costs of BOD_5 abatement for different industries and measures and for the industrial and municipal sectors (see Figure B). An important point is that the largest portion of both industrial and municipal loads of BOD_5 can be treated at relatively low marginal and total costs. The assessment identified a cost-effective combination of municipal effluent treatment and low-cost abatement options for industry (good housekeeping and primary treatment). Expansion of the residential sewerage network and treatment of sewage should be priorities for the municipal sector. (Low-cost options, including extension of sewers into the ocean, must be also considered in defining the most appropriate treatment level.)

Figure A. Water pollution in the Kelani River, dry season, under two control options

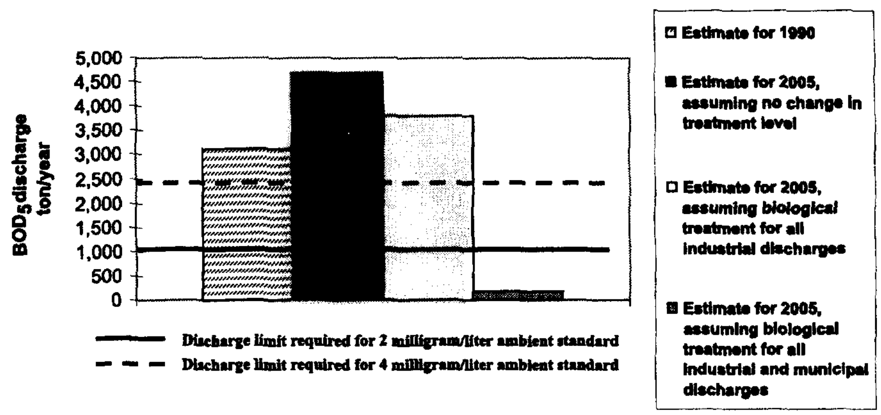
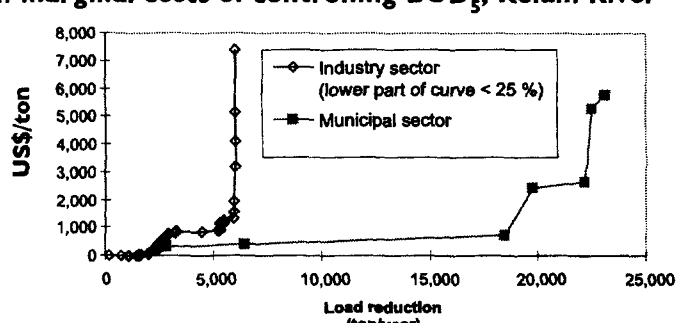


Figure B. Long-run marginal costs of controlling BOD_5, Kelani River



Note: The lower part of the curve is less than 25 percent.

including industries, power and heating plants, commercial and household boilers, municipal incinerators, and motor vehicles, and to identify pollution "hot spots" and "worst offenders" that may require the use of more advanced and refined airshed models. (One such model, for analyzing the impact of a small number of dominant or typical point sources of air emissions, is incorporated in the DSS/IPC software.) In general, the analysis of pollution control strategies and policies in the DSS/IPC is aimed at large industries and power plants, where control technologies can be installed at reasonable cost.

The software can be used to predict ambient pollution concentrations on the basis of selected control strategies for emissions sources. It permits users to propose least-cost programs of control options across industries for each prespecified level of improvement in ambient quality. The user can also compare associated abatement costs with the estimated benefits of lowering ambient concentrations for pollutants that have recognized health effects and well-established dose-response functions. (See Box 2.)

The DSS/IPC system reveals the limitations of pollution control policies targeted at large industrial sources air pollution problems and highlights the significance and relative impact of other, small pollution sources that are typically dispersed and difficult to control. (See Box 3.) Emissions of dust and sulfur dioxide (SO_2) from nonindustrial sources (small boilers and stoves, trucks, open burning of municipal waste, and so on) are considerable in most cities in the developing world and often determine ambient quality, especially in residential areas. This fact has important implications for selection of pollution control policies and targeting of specific sectors or sources.

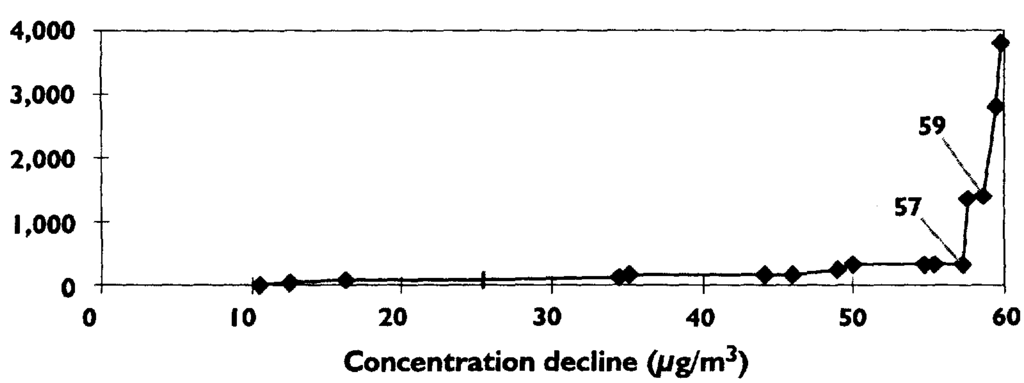
Analysis of pollution control policies. The DSS/IPC system can be used as the first step in:

Box 2. Costs and Benefits of Controlling Industrial Emissions of Particulates in Rio de Janeiro

The most severe air pollution problem in the Rio de Janeiro Metropolitan Area (RJMA) is in an airshed that covers an area of about 700 square kilometers (including downtown Rio) with a population of about 6.6 million. Concentrations of total suspended particulates (TSP) in the airshed have been increasing steadily since 1990 and stood at 125 micrograms per cubic meter (µg/m3) in 1994.

An analysis using the DSS/IPC looked at TSP emissions from industries and from such nonindustrial sources as transport and waste burning. The system was then used to calculate the costs of control measures that could be adopted by industrial sources and the expected effect of these measures on emissions and concentrations of TSP. The analysis showed that most of the TSP can be removed at a relatively low marginal cost (see Figure). After a reduction of 57 $\mu g/m^3$ is achieved, at a total annual cost of US$7.4 million, marginal costs start increasing sharply. Still, estimates of health benefits from the decline in TSP levels show a maximum net benefit of US$135 million a year for removing 59 $\mu g/m^3$, at a cost of US$9.3 million a year. The results suggest that a very high economic payoff may be obtained from tightening control of industrial emissions of particulates.

Marginal costs of controlling ambient concentration of particulates, Rio de Janeiro



Box 3. Assessing the Relative Effect on Ambient Quality of Air Emissions from Different Sources

Using a simplified air dispersion model recommended and tested by WHO, the DSS/IPC system links emissions from each category of sources to variations in annual average concentrations of the corresponding pollutants. The analysis quantitatively shows that, in addition to the volume of emissions, the height of emissions sources greatly affects the level of ambient concentrations. Table 3 demonstrates the significant differences in the impact of a unit of SO_2 emissions from three categories of sources, grouped by height: low level (space heating and traffic); medium level (most industrial processes); and high level (electric utilities). Low-level sources turn out to have the largest effect. Thus, the design and evaluation of pollution control policies should take into account the reality that a substantial reduction in emissions from utilities and industries may have little impact on ambient quality and exposure in an urban area if the policy is not accompanied by specific measures to tackle emissions from low-level sources.

Change in annual average concentration of sulfur dioxide per 1,000-ton change in emissions ($\mu g/m^3$)

	Area (square kilometers)		
Source level	*500*	*1,000*	*1,500*
Low	3.25	2.16	1.71
Medium	0.20	0.14	0.12
High	0.06	0.05	0.05

Note: Meteorological assumptions on yearly probabilities of atmospheric stability and wind speed combinations are as follows:

- Unstable conditions with wind speed: moderate, 10 percent; high, 20 percent
- Neutral conditions with wind speed: very low, 20 percent; low, 20 percent; moderate, 10 percent; high, 10 percent
- Stable conditions with very low wind speed, 10 percent.

- Estimating the costs of attaining proposed emissions or ambient standards in an area
- Estimating the impact on ambient quality of proposed emissions standards or technological standards
- Allocating cost-effective emissions standards across pollution sources
- Estimating, with the use of long-run marginal cost schedules, emissions charge rates that will provide incentives to meet environmental targets for the area or watershed.

Limitations

In applying the DSS/IPC system to the analysis of the situations described above, it is important to remember that the system is a tool for rapid, rough assessment. It can give only an indication of where problems are likely to occur, the relative significance of different pollution sources, and the order of magnitude of the costs and effects associated with alternative pollution control strategies. Its main advantage is in helping to create a comprehensive picture of the pollution problems in an area and to focus further analysis on specific priorities.

Implementation

The DSS/IPC system runs under Windows 3.1x and has convenient export-import links with Microsoft Excel and other data-processing programs. The database is maintained in Access but can be manipulated directly through the DSS/IPC software. The minimum PC hardware requirements are a 486 processor with 12 megabytes (Mb) internal memory and a 250-Mb hard disk.

To start a study, the user defines an area or several areas according to which all subsequent information will be processed and presented. The minimum data for each area to be used by the system comprise output or input for major industries (at the four-digit ISIC level), basic information on municipal services and traffic, and existing levels of pollution controls. If the analysis includes water pollution, rivers and lakes that receive discharges from the area(s) should be defined as well.

From this information, the DSS/IPC can estimate air, water, and solid waste pollution loads, using default emissions coefficients. The estimates can be refined with further knowledge of local emissions factors and control technologies, which can be used to calibrate default values. On the basis of the calculated loads, simple air and water dispersion models offer estimates of pollutant concentrations when basic geographic data are provided.

The system contains two air dispersion models and five water models that can be selectively run by a user in any combination. For air, a very simple area model calculates the annual average concentration of a pollutant, for emissions from all sources identified in the area. A more complex point-source model generates the maximum hourly ground-level concentration of a pollutant (with the corresponding downwind distance) that is attributed to a particular source of emissions such as a power plant. Water models enable a user to calculate annual or seasonal mean concentrations of conservative substances (those whose properties do not change) in a river or lake, the critical phosphorus load for a lake in relation to the estimated load, and the dissolved oxygen deficit, as well as decaying levels of coliform in a river downstream from the discharge point.

After ambient concentrations for air or water pollutants are estimated and priority pollutants are defined, the system can generate total and marginal costs for different levels of controls on selected pollutants. These costs are based on standardized functions and a set of default parameters, which can be refined by using locally specific economic data.

The DSS/IPC database covers nearly 150 industrial processes and other polluting activities and 30 air and water pollutants, as well as solid wastes.

The DSS/IPC has been used in project preparation and economic sector work undertaken by World Bank staff in Algeria, Brazil (state of Rio de Janeiro), Mexico, Morocco, Saudi Arabia, Sri Lanka, and Syria. In Sri Lanka, the DSS/IPC was also used to analyze water pollution control options in the Kelani River basin as part of a technical assistance project sponsored by the U.S. Agency for International Development (USAID), as described in Box 1. The DSS/IPC database and selected computation modules were also employed in environmental studies for China and the East Asian region.

Chapter 1

Fundamentals of the DSS/IPC

Structure of the database

The DSS/IPC database contains files with separate information about air pollution, water pollution, and solid wastes. All data files are related to one of these three environmental modes. They contain information on:

- Economic activities and processes, by ISIC code at the four-digit classification level
- Pollutants and health guidelines
- Emissions factors, by process and by relevant pollutant
- Reduction measures for polluting processes
- Reduction factors by pollutant and by reduction measure for polluting processes
- Cost formulas for controlled processes and reduction measures, for the air and water modes only.

These files are described in greater detail in the sections that follow.

Economic activities

The database contains a file of economic activities at the four-digit ISIC level, showing ISIC codes for those activities that have significant environmental impact (typically, up to 90 percent of emissions and wastewater discharges generated in an urban area).

Polluting processes

The database contains three separate files on polluting processes: for air, for water, and for processes that generate significant amounts of solid waste. The selection criteria for the incorporation of processes into the database are as follows:

- The environmental impact of the process has to be relevant.
- The available information from experience and in the literature has to be generally applicable.

The processes data file contains the following fields:

1. **Environmental mode (air, A; water, W; or solid wastes, S)**
2. **ISIC code**
3. **Process ID**
4. **Process description**
5. **Process unit**
6. **Volume of air or water (in cubic meters) per process unit**
7. **Number of production hours per year**
8. **Cost ID**
9. **Memo field**

Fields 1, 2, and 3. Valid processes are uniquely identified in the computer by the combination of the three environmental mode codes, A, W, or S; the four-digit ISIC code; and the Process ID. The Process ID is either a four-letter code or a four-character code that has as the first character "&" followed by three letters. Each ISIC code can be assigned one, several, or no processes in each of the three environmental modes. However, at least one process in one environmental mode is assigned to each ISIC code given in the ISIC file.

For example:

3710 Iron and steel basic industries

A 3710 AAUA	**Gray iron foundries**
S 3710 &BUA	**Iron and steel mill waste**
W3710 &BUA	**Electric arc process**
W3710 CAUA	**Galvanizing**

The Process ID sometimes contains a one-letter or two-letter code. In this case, it refers not to an actual process but to the entire category of processes with four-character Process IDs, each of which begins with the same letter or letters.

For example:

4101	**Power, light, and heat**
A 4101 A	**Utility boilers**
A 4101 AAUA	**Natural gas**
A 4101 ABUA	**Residual fuel oil**
A 4101 ACUA	**Hard coal**
A 4101 ADUA	**Lignite**

The first two characters of the Process ID also represent a process group, which is further described in the section on calculating long-run marginal costs. Processes with four-character Process IDs represent the highest level of detail in the DSS/IPC. Only for these processes are fields 5, 6, 7, and 8 filled in. These fields contain interactive information; that is, they are uniquely linked to all the emissions factors and the associated pollutants.

Process IDs that have "&" as the first character typically represent general processes. Four-letter codes are usually assigned to specific processes, but there are exceptions to this rule, as when a distinction between a general process and a specific process is not quite clear, or when coding a large number of general processes under one ISIC technically requires the use of four letters. Power, light, and heat, ISIC 4101, is one example; another is grain mill products.

3116	**Grain mill products**
A 3116 &AUA	**General milling and roasting**
A 3116 AAUA	**Wheat milling**

The general Process IDs have been formulated using one of three techniques as appropriate:

- The sum of activities that make up the complete process has been taken. For example, the components of cotton processing (ISIC 3210)—yarn sizing, kiersing, bleaching, dyeing, and printing—are assigned a single general Process ID for discharges to water.
- Where a process includes a number of different or obscure activities, those most commonly used have been selected for the general Process ID data. For example, the most commonly used processes are selected for 3710, Iron and steel basic industries (see example above.)
- Where a process includes a number of different activities that are all commonly used, those activities have been grouped by category. Average emissions factors across those factors or processes representative for a category have been calculated and assigned to general Process IDs (for example, 4101, Power, light, and heat).

The database primarily contains general processes. Specific processes are added only if they are easily identified and have significantly different emissions factors, as in the example of ISIC 3116, above. It should be emphasized that the general Process IDs provide only a rough indication of wastes generated and released to air and water. Great care should be taken in the interpretation and use of the results to ensure that the general Process IDs provide information that is both relevant and pertinent to the activities actually carried out in the area being modeled.

All processes have either the letter "U" or the letter "X" in the third position of the four-letter Process ID. Those designated U are base processes with no control or prevention measures and with no cost function attached. Those designated X are cleaner alternatives to base processes and are linked to cost functions through the Cost ID displayed in field 8 (see below). These processes are also called controlled processes. Process files contain only those cleaner alternatives to base processes (i.e., controlled processes) that can be achieved by modifying process inputs or core technologies, through such means as waste prevention programs and good housekeeping measures (WPP/HG). They do not include end-of-pipe controls, which are stored in a separate data file, Reduction Measures (see below).

For example:

A 3310 AAUA	**Wood painting: oil base**
A 3310 AAXA	**Wood painting: oil base—WPP/GH**
A 3310 AAXB	**Wood painting: water soluble**

Field 4. The Process Description field is filled in for every row of the data file.

Field 5. Every process with a four-character Process ID has a field for the production unit describing the unit of measurement of the annual production linked to that process (for example, head/year for livestock raising; tons of product per year for the chemical industry).

Fields 6 and 7. For all the processes in the air and water modes with a four-character Process ID and identified cost functions, default values have been filled in for the volume of air or water that is emitted or discharged per unit of production and for the number of production hours per year. These values are used only in the Cost Calculation module. In the absence of actual information, the following default values are used in the system:

Volume 0.99 cubic meters/unit of production

Production hours 8,000 hours/year.

Field 8. Cost ID connects the system pollution control technologies or actions with the corresponding type of cost formula. The cost formulas are given in the Cost Calculation section.

Field 9. The memo fields contain specified information about each process and appear in the system as footnotes. New footnotes can be added to the system by the user, and existing footnotes can be deleted.

Pollutants

For each of the three modes (A, W, and S) a data file recording the environmentally significant pollutants has been prepared. The pollutants data files contain the following fields:

1. **Environmental mode code (A, W, or S)**
2. **Pollutant ID**
3. **Pollutant description**
4. **Pollutant stability class**
5. **Long-term environmental health guidelines for air and water pollutants**
6. **Short-term environmental health guidelines relevant for air pollutants**

Field 4. The air pollutants are classified into three stability classes:

1. **Stable pollutants (retention time > 3 hours)**
2. **Nonstable pollutants (0.5 to 3 hours)**
3. **Unstable pollutants (< 0.5 hour).**

The water pollutants are also classified into three stability classes:

1. **Stable pollutants (retention time > 5 days)**
2. **Nonstable pollutants (0.5 to 5 days)**
3. **Unstable pollutants (< 0.5 day).**

The computer program disregards unstable pollutants (class 3) when calculating long-term average ambient concentrations. Pollutants provided in the default data file are assigned stability class 1 or 2. Pollutants can be excluded from concentration calculations by changing their stability to class 3. The user can force an evaluation by changing the stability class to 1 or 2 manually.

Fields 5 and 6. Long-term and short-term environmental health guidelines are limit values for annual and hourly ambient concentrations of air and water pollutants. These values are used in the system to identify those pollutants whose ambient levels may cause health hazards in a given area (see Health Guidelines). The limit values can be changed by the user to reflect national ambient quality standards or community health risk preferences; alternative uses of the media, such as use of river water for drinking, for irrigation, or for livestock feeding; or environmental criteria other than health for the identification of pollution problems. Note that not all air and water pollutants have default limit values in the DSS/IPC system.

Emissions factors

For each of the three environmental modes, the database contains a data file with emissions factors. The emissions factor data file contains the following fields:

1. **Environmental mode code (A, W, or S)**
2. **ISIC code**
3. **Process ID**
4. **Pollutant ID**
5. **Emissions factor**
6. **Footnote field.**

Field 3. Emissions factors can be linked only to four-character process IDs (♦♦U♦ or ♦♦X♦, where ♦ indicates a character). Every process at the four-character Process ID level must have at least one emissions factor.

Field 5. An emissions factor is the amount of a pollutant that is emitted per unit of production. The unit of measurement used is kilograms per unit of production. A process is most often associated with more than one emissions factor/pollutant-ID.

Field 6. The information presented in this field is included in the system as "footnotes." All memo fields/footnotes contain information that is important for a user in evaluating whether the particular emissions factor should be modified to reflect local conditions. In a number of cases, the memo fields/footnotes contain formulas that have to be applied by a user for manual calculation of emissions factors.

Reduction measures

The database contains a data file with reduction measures for the air and water modes only.

A reduction measure is a mitigating control on a polluting process. It is different from applying a cleaner process. A cleaner (controlled) process (with four-character Process ID ♦♦X♦) replaces a base (uncontrolled) process (♦♦U♦) with new, mostly lower, emission factors . Attached to a cleaner process is a cost formula for calculating the additional costs it requires by comparison with the base process. The cleaner processes, together with the base processes, are part of the same data file. A reduction measure, found in a separate data file, can be applied to all the processes with four-character Process IDs (♦♦U♦s, as well as ♦♦X♦s). Reduction measures typically represent end-of-pipe technologies such as wastewater treatment systems or fabric filters for controlling dust emissions.[1] Reduction measures are also referred to as *control measures.*

The reduction measure data file contains the following fields:

1. **Environmental mode code (A or W)**
2. **Cost ID**
3. **Reduction ID**
4. **Reduction measure**
5. **ISIC code**
6. **Process title**

Field 2. Cost ID refers to a data file with cost formulas; see Cost Formulas.

Field 3. Reduction ID is a one-letter code that is unique for every reduction measure within a specific process group (processes with identical first two characters within the same ISIC and the same environmental mode); within a process category (processes with identical first characters within the same ISIC and the same environmental mode); or within an ISIC group (all processes within the same ISIC and the same environmental mode).

Field 4. This field describes the reduction measure.

Field 6. The process title usually consists of a two-character code but can also consist of a one-character code or may be absent. One- or two-character process titles mean that the measure is applicable to all the processes within the concerned ISIC group in which the Process IDs have the same first or first two characters. The absence of a process title means that the reduction measure is applicable for all the processes with four-character Process IDs within the given ISIC group.

Reduction factors

Reduction measures are associated with reduction factors that represent the share of air emissions or water effluents discharged into the environment after the measure is applied. The value 0 means total removal of the concerned pollutant from the waste stream, while the value 1 stands for no reduction at all. Because the reduction measures provided by the system are generic, the corresponding reduction factors give only a rough indication of the level of control for the pollutants affected by the measures.

The reduction factor data file contains the following fields:

1. **Environmental mode code (A or W)**
2. **ISIC code**
3. **Process title**
4. **Reduction ID**
5. **Pollutant ID**
6. **Reduction factor**

Fields 5 and 6. Every relevant air or water pollutant (pollutant ID) is linked to the reduction measure through one reduction factor. More than one pollutant ID and reduction factor can be attached to a reduction measure.

Cost parameters

Data files with cost formulas are provided for the air and water modes. The cost formulas apply to both controlled processes and reduction measures. Although the cost calculations provide only estimates of potential relative costs, every effort was made to incorporate all the relevant process parameters, such as wastewater or waste air volume per hour, the number of sources to which the control has to be applied, and annual production hours. Local economic conditions, such as labor and energy costs, are incorporated into the cost calculations and can be varied by a user to reflect regional or temporal characteristics.

The cost data files contain the following fields:

1. **Environmental mode code (A or W)**
2. **Cost ID**
3. **Control technology description**
4. **I/V-flag (investment/capital costs or operating/variable costs)**
5. **F/P-flag (indicating whether the cost calculation formula is based on flow rate of**

the water discharged or the air emitted, or on the level of production)

6. Cost unit (refers to the labor, energy, or material component; default values appear in the table below)

7. Ratio R (for data-fitting purposes)

8. Parameter A (for data-fitting purposes)

9. Parameter B (for datafitting purposes)

10. Parameter C (for data-fitting purposes)

11. Parameter D (for data-fitting purposes)

12. Pollutant ID

13. Parameter E (for data-fitting purposes)

14. Depreciation period (in years).

One general cost format per source is used, as follows:

$$Cost_i[I, V] = UNIT * R * \{A + B * ([F, P]/N)^C + D * ([F, P]/N) * T + E * POL * [F, P]/N\}.$$

Overall, in the individual cost formulas, the UNITS given below are used (kWh, kilowatt-hour; Nm^3, normal cubic meter; m^2, square meter; kg, kilogram):

In the general formula, *A* is a fixed cost parameter. The term $B * ([F, P]/N)^C$ is used to data-fit (with *B* and *C*) the costs that vary with the capacity of the process (the *P* format) or the process waste volume (the *F* format). The term $D * ([F, P]/N) * T$ is applicable for *F*-type formulas in which *D* stands for the cost per cubic meter of waste. The term $E * POL * [F, P]/N$ is relevant for *P*-type formulas in which *E* stands for the cost per kilogram of pollutant and *POL* is the emission factor of the concerned pollutant.

N in the general formula stands for the number of polluting sources for the process. Since many cost formulas are not linear in relation to the capacity of the process, the number of sources is an important parameter for taking into account the effect of economies of scale. *N* has a default value of 1.

The following guidelines for estimating the number of sources apply:

1. In general, the number of sources is one per production unit. Production units can be

Number	*UNIT*	*Description*	*Unit of measurement*	*Default (1990 U.S. data)*
1	GU	General overall cost ratio	—	1
2	LU	Labor ratio (local labor cost/1990 U.S. labor cost)	—	1
3	MU	Material ratio (local material cost/1990 U.S. material cost)	—	1
4	EU	Energy ratio (local energy cost/1990 U.S. energy cost)	—	1
5	HR	Cost of 1 hour skilled labor	US$/hour	20
6	EE	Cost of 1 kWh electricity	US$/kWh	0.05
7	EG	Cost of 1 Nm^3 natural gas	US$/$Nm^3$	0.15
8	MB	Cost of 1 m^2 bag filter	US$/$m^2$	75
9	MK	Cost of 1 m^3 catalyst	US$/$m^3$	20,000
10	MD	Cost of disposing of 1 kg hazardous waste	US$/kg	0.25
11	MW	Cost of 1 m^3 cooling water	US$/$m^3$	0.0002
12	MT	Cost of treating 1 m^3 wastewater	US$/$m^3$	0.02
13	MX	Cost of 1 kg perchloroethene	US$/kg	1
14	EO	Cost of 1 liter gasoline	US$	0.4
15	ED	Cost of 1 liter diesel	US$	0.4
16	MC	Cost of 1 kg active coal	US$/kg	4

process installations, fuel-burning installations, waste incinerators, hotels, restaurants, hospitals, and farms or stables. As a rule, the number of sources is the number of installations that would be necessary to control a polluting process.

2. **For air emissions caused by transport, *N* is equal to the number of vehicles for which a measure will be taken.**
3. **In ISIC 9200 (municipal services), population size is used in the calculation of the water discharges, but for the cost calculations the number of sources is the number of sewage treatment plants to be built. The default value for *N* is 1.**

One cost ID can include several formulas for investment costs and for operating costs. For example, there are separate formulas for energy costs, labor costs, and operating costs, all under the same cost ID.

Values of the parameters in the cost functions can be changed to identify the costs of new technologies and measures available for controlling discharges and emissions.

Calculations

Load inventories

The main model steps are:

1. **Inventory of polluting sources, their production levels, and the levels of adopted controls**
2. **Calculation of pollution loads by multiplying the levels of production by the corresponding emissions factors and by the corresponding reduction factors if a control technology (reduction measure) is adopted.**

Emissions factors are average values that take into account the type of process used in the particular industry; the input or other technological characteristics that are relevant for emissions levels (e.g. type of fuel used; and the presence or absence of waste prevention programs.

The default database contains default emissions factors for all relevant pollutants for each polluting process, as well as default reduction factors for each reduction measure and the affected pollutants. All these factors can be adjusted by a user on the basis of local data, if available. The production levels have to be provided by a user in the **Inputdef[Production]** window. Footnotes are important for the use of that window. A user can also define in that window the number of sources, which are later used in the cost calculations.

New factors can be added for processes not included in the database. For each new process or activity introduced into a specific study, the user must provide all the relevant linked information concerning pollutants and their health guidelines (if additional to the default list), emissions factors, reduction measures and factors, and control costs.

(Emission load by pollutant) = (production level) × (emission factor for this process and pollutant) × (reduction factor for this pollutant and adopted control technology, if any).

Load calculations are initiated by choosing the **Window | Calculate | Load...** option from the menu.

Ambient air and water concentrations: dispersion models

Dispersion models are applied to estimate concentrations of the specific pollutants in air and in water. The system includes seven simple models:[2]

Air

1. Area
2. Point source

Water

1. River conservative
2. River BOD
3. River coliform count
4. Lake conservative
5. Lake phosphorus

Area

Model equations

The emissions-concentrations relationships for low-, medium-, and high-level sources are as follows. The change in ambient concentrations C (measured in micrograms per cubic meter, $\mu g/m^3$) per unit emission from source *h* (where emissions are measured in metric tons and *h* can be high, medium, or low) is:

$$\Delta C = D^h / 10000 \qquad (1)$$

where the dispersion coefficients D^h for low-level sources are given by:

$$D^h = \sum_{km} F_{km} \cdot e^{\left(\alpha^h_{km} + \beta^h_{km} \ln(R)\right)} \qquad (2)$$

and those for medium- or high-level sources are given by:

$$D^h = \sum_{km} F_{km} \cdot e^{\left(\alpha^h_{km} + \beta^h_{km} \ln(R) + \gamma^h_{km} (\ln(R))^2\right)} \qquad (3)$$

where R is the effective radius of the area computed by the formula:

$$R = \sqrt{A/\pi} \tag{4}$$

and A is the area in square kilometers (the area need not be circular). The frequency parameters F_{km} refer to the contents of Table 1.1. The parameters α^h_{km}, β^h_{km}, and γ^h_{km} are taken from Tables 1.2, 1.3, and 1.4, respectively.

Input

User defined

Area size

Area emission density factor (spatial average concentration ratio)

Area frequency factors (should be stored per area)

Constants/calculated values

Coefficients based on atmospheric stability and wind speed

Table 1.1 Area Frequency Factors F_{km}

	Wind speed (m)			
Atmospheric stability (k)	*Very low (< 2 m/s)*	*Low (2-5 m/s)*	*Moderate (5-7.5 m/s)*	*High (> 7.5 m/s)*
Unstable	F11	F12	F13	F14
Neutral	F21	F22	F23	F24
Stable	F31	F32	F33	—

Note: The sum of all frequency factors per area must be 1.000.

Table 1.2 Coefficients α^h_{km} for the Area Dispersion Model

Frequency	*Source level*		
factor	*Low*	*Medium*	*High*
F11	6.391	2.604	1.171
F12	6.075	3.219	1.034
F13	5.925	3.352	0.600
F14	5.800	3.128	0.647
F21	7.778	1.044	–30.801
F22	6.843	2.668	–13.820
F23	6.245	2.995	–9.381
F24	5.893	2.886	–6.275
F31	7.398	–0.743	–18.380
F32	7.256	0.864	–44.510
F33	6.976	0.0	0.0

Table 1.3 Coefficients β^h_{km} for the Area Dispersion Model

Frequency	*Source level*		
factor	*Low*	*Medium*	*High*
F11	–1.492	–0.419	0.885
F12	–1.724	–0.827	0.427
F13	–1.712	–1.082	0.327
F14	–1.682	–1.138	0.251
F21	–1.592	0.493	19.537
F22	–1.600	–0.305	7.981
F23	–1.619	–0.630	6.243
F24	–1.624	–0.804	4.250
F31	–0.872	1.217	3.978
F32	–1.241	0.635	20.894
F33	–1.433	0.0	0.0

Table 1.4 Coefficients γ^h_{km} for the Area Dispersion Model

Frequency	*Source level*	
factor	*Medium*	*High*
F11	-0.111	-0.284
F12	-0.053	-0.230
F13	-0.007	-0.216
F14	0.0	-0.232
F21	-0.228	-3.117
F22	-0.134	-1.226
F23	-0.094	-1.124
F24	-0.070	-0.821
F31	-0.279	0.0
F32	-0.230	-2.654
F33	0.0	0.0

Calculated load per area, process, and pollutant combination

Output

All of the results below are calculated for the area under consideration.

Intermediate results

- Annual load per pollutant for low-level sources
- Annual load per pollutant for medium-level sources
- Annual load per pollutant for high-level sources
- Annual average concentration per pollutant for low-level sources
- Annual average concentration per pollutant for medium-level sources
- Annual average concentration per pollutant for high-level sources.

Results

- Total annual average concentration per pollutant
- Approximate local maximum concentration per pollutant.

Point source

Model equations

In the DSS/IPC system, a simple gaussian dispersion model is employed to assess the maximum ground-level impact from point sources. This model should be used for large sources outside urban areas, as well as for selected ones within urban areas in cases where such sources are expected to contribute to high local air pollution concentrations.

For each pollutant j, the model determines ground-level concentrations ${}^{j}C_{USx}$ for various wind speeds U at 10 m above the ground and different sets of feasible atmospheric (Pasquill) stability classes S and distances x according to the formula:

$$ {}^{j}C_{USx} = 10^{9} \cdot Q_j \frac{e^{-\frac{1}{2}\left(\frac{H_{eff}}{Rho_Z(x)}\right)^2}}{\pi \cdot U_s \cdot Rho_Z(x) \cdot Rho_Y(x)} \quad (1) $$

where Q_j is pollutant j load per point source and U_s is wind speed at stack height H calculated as $U_s = U(H/10)^p$, where p is determined by atmospheric stability class, as follows:

Atmospheric stability class S					
A	B	C	D	E	F
0.10	0.10	0.16	0.16	0.30	0.30

H_{eff} is effective stack height derived from the formula:

$$ H_{eff} = H_d + \frac{21.425}{U_s}\left(2.45 \cdot V_s \cdot D^2 \frac{T_s - T_a}{T_s}\right)^{0.75} \quad (2) $$

where

$$ \left(2.45 \cdot V_s \cdot D^2 \frac{T_s - T_a}{T_s}\right) < 55 $$

or from

$$ H_{eff} = H_d + \frac{38.71}{U_s}\left(2.45 \cdot V_s \cdot D^2 \frac{T_s - T_a}{T_s}\right)^{0.6} \quad (3) $$

where

$$ \left(2.45 \cdot V_s \cdot D^2 \frac{T_s - T_a}{T_s}\right) \geq 55 + $$

V_s is exit gas velocity; D is stack internal diameter; H_d = H where V_s/U_s ³ 1.5 or, where $V_s / U_s < 1.5$,

$$ H_d = H + 2 \cdot D \cdot \left(\frac{V_s}{U_s} - 1.5\right) $$

T_s is exit gas temperature; and T_a is ambient temperature.

In equation (1), functions $Rho_Z(x)$ and $Rho_Y(x)$ are determined by the following parameters:

Area roughness	Z_0
Atmospheric stability classes	S
Effective stack height	H_{eff}

Where $H_{eff} < 10$ (case 1) or $H_{eff} > 100$ (case 3), functions Rho are calculated as:

$$ {}^{1,3}Rho_Y(x) = 1.431 \cdot a \cdot x^b \quad (4) $$

$$ {}^{1,3}Rho_Z(x) = 10 \cdot Zo^{0.53(x^{-0.22})} \cdot c \cdot x^d \quad (5) $$

where coefficients a, b, c, and d depend on atmospheric stability class, as shown in Tables 1.5 and 1.6.

Where 10 £ H_{eff} £ 100 (case 2), functions Rho are calculated by interpolation of cases 1 and 3:

$$ {}^{2}Rho_Y(x) = {}^{1}Rho_Y(x) + \frac{H_{eff} - 10}{100 - 10}\left({}^{3}Rho_Y(x) - {}^{1}Rho_Y(x)\right) \quad (6) $$

$$ {}_{0}{}^{2}Rho_Z(x) = {}^{1}Rho_Z(x) + \frac{H_{eff} - 10}{100 - 10}\left({}^{3}Rho_Z(x) - {}^{1}Rho_Z(x)\right) \quad (7) $$

For every pollutant j, the model calculates ground-level concentrations ${}^{j}C_{USx}$ for the following set of distances x (in meters):

Table 1.6 Coefficients for Formulas (4) and (5) for $H_{eff} < 10$

Atmospheric stability class	*a*	*b*	*c*	*d*
A	0.527	0.865	0.28	0.90
B	0.371	0.866	0.23	0.85
C	0.209	0.897	0.22	0.80
D	0.128	0.905	0.20	0.75
E	0.098	0.902	0.15	0.73
F	0.065	0.902	0.12	0.67

Table 1.7 Coefficients for Formulas (4) and (5) for $H_{eff} > 100$

Atmospheric stability class	*a*	*b*	*c*	*d*
A	0.40	0.91	0.41	0.91
B	0.40	0.91	0.41	0.91
C	0.36	0.86	0.33	0.86
D	0.32	0.78	0.22	0.78
E	0.31	0.71	0.06	0.71
F	0.31	0.71	0.06	0.71

100, 150, 200, 300, 400, 500, 750, 1,000, 1,250, 1,500, 2,000, 3,000, 4,000, 5,000, 7,500, 10,000, 15,000, 20,000

and for the following possible combinations of wind speeds and atmospheric stability conditions (marked •):

	Wind speed (m/s)				
Atmospheric stability class	*1*	*2*	*3*	*5*	*10*
A	•	•			
B	•	•	•		
C		•	•	•	
D			•	•	•
E		•			
F		•			

The resulting values for ${}^{j}C_{USx}$ are compared. The highest value indicates both the most adverse situation and its conditions (distance from the source *x*, wind speed *U*, and atmospheric stability class *S*).

Input

User defined

Area roughness
Point source characteristics
Physical stack height
Stack internal diameter
Exit gas velocity or exit gas volume
Exit gas temperature (in degrees Kelvin)
Ambient temperature (in degrees Kelvin)
Pollutant load per point source (in kg/s)
Selected wind speed/stability class combinations

Constants/calculated values

Set of distances
Set of possible wind speed/stability class combinations

Output

All the results below are calculated for each point source.

Intermediate results

None

Results

Approximate local maximum concentration per pollutant
The wind speed, stability class, and distance at which the maximum occurs

General notes on water models

The discharge load of a substance into a body of water is calculated as the sum of the contributing loads from the areas discharging into that body of water.

Areas can discharge varying proportions of their generated pollution loads into various bodies of water. Within an area some industries might discharge into one body of water and other industries into other bodies of water. The user must identify these percentages and specify them in the Load Contribution to Water Bodies window.

For both lake and river conservative models, only substances assigned pollutant class 1 or 2 are used.

River conservative

Model equations

For each pollutant *j* assigned stability class 1 or 2, the model first calculates the discharge load B_j (in grams per second) from the calculated substance load L_j (in tons per year)

$$B_j = \frac{L_j \cdot 10^6}{365 \cdot 24 \cdot 3600} \qquad (1)$$

and then calculates the concentration of conservative pollutant *j* after discharge C_j (in milligrams per liter):

$$C_j = C_{j0} + \frac{B_j}{Q}, \qquad (2)$$

where C_{j0} is the initial concentration of the pollutant j (in milligrams per liter) and Q is the river average flow rate (in cubic meters per second).

Input

User defined

River flow rate

Initial concentration of each pollutant in the water body

Calculated by area or industry

Calculated load for pollutants in all areas

Output

Intermediate results

Discharge load of a substance into the river

Results

The concentration of the conservative substance (pollutant j)

River BOD

Model equations

The model calculates D_c (the critical DO deficit after the discharge point) by the formula:

$$D_c = \frac{K_r}{K_2} \cdot L_a \cdot e^{-\left(\frac{K_r}{V} \cdot X_m\right)} \quad (1)$$

where K_r is the BOD removal rate constant (per day) at temperature T (in degrees Celsius):

$$K_r = 0.23 \cdot e^{0.046(T-20)} \quad (2)$$

K_2 is the reaeration constant (per day) at temperature T (in degrees Celsius):

$$K_2 = 5 \cdot \frac{V^{0.67}}{H^{1.85}} \cdot e^{0.024(T-20)} \quad (3)$$

H is the river depth (in meters), and V is the water velocity in meters per second, determined as

$$V = \frac{Q}{B \cdot H} \quad (4)$$

where B is the river width (in meters) and Q is river average flow rate (in cubic meters per second).

The value L_a used in equation (2) is the concentration of BOD_5 right after the discharge point, calculated as:

$$L_a = \frac{1}{\left(1 - e^{-0.23 \cdot t_o \cdot e^{(T_o - 20)}}\right)\left(1 + 0.02(T_o - 20)\right)} \left(L_o + \frac{L_q}{Q}\right) \quad (5)$$

where L_0 is river background BOD concentration in milligrams per liter (concentration just before the discharge point, determined by BOD analysis); T_0 is temperature for background BOD analysis (in degrees Celsius); t_0 is number of days for background BOD analysis; and L_q is river BOD load (in grams per second, g/sec). Finally, X_m is the distance from the discharge point where critical oxygen deficit occurs:

$$X_m = \frac{V}{K_2 - K_r} \ln\left(\frac{K_2}{K_r} - \frac{K_2 \cdot (K_2 - K_r)}{K_r^2} \cdot \frac{D_a}{L_a}\right) \quad (6)$$

where D_a is the initial DO deficit ($D_a = C_s - C_a$); C_a is river initial oxygen concentration (in milligrams per liter, mg/l); and C_s is oxygen saturation concentration at temperature T (in mg/l):

$$C_s = 9.1 \cdot e^{-0.023 \cdot (T-20)} \quad (7)$$

Input

User defined

River depth

River width

River volume/average flow rate

River initial oxygen concentration

Water temperature (in degrees Celsius)

Number of days (for BOD analysis)

Temperature (for BOD analysis)

River BOD background concentration (for t_o, T_o)

River BOD load in Y/S (optional)

Constants/calculated values

Oxygen saturation concentration value based on temperature

River BOD load in Y/S (optional)

Output

Intermediate results

None

Results

Critical DO deficit (D_c)

River coliform count

Model equation

Using the number of days since discharge, the water temperature, the coliform die-off rate, and the initial number of coliforms per 100 milliliters (ml), the model calculates the coliform count N (per 100 ml):

$$N = N_i \cdot e^{-\left(K_{b20} \cdot 1.075^{T-20}\right)t} \qquad (1)$$

where N_i is the initial number of coliforms per 100 ml; K_{b20} is coliform die-off rate constant per day at 20° Celsius; T is actual temperature (in degrees Celsius); and t is time since discharge (in days)

Input

User defined

River coliform die-off rate constant at 20° Celsius
Time since last discharge (in days)
Water temperature (in degrees Celsius)
Initial number of coliforms per 100 ml

Constants/calculated values

None

Output

Intermediate results

None

Results

Coliform count

Lake conservative

Model equations

For each pollutant j assigned stability class 1 or 2, the model calculates concentration of the conservative substance in the lake C_{jl} (in milligrams per liter) from the material-balance equation:

$$C_{jl} = C_{ji} \cdot \left(1 + \frac{Q_e}{Q_i - Q_e}\right) \qquad (1)$$

where Q_i is total inflow of water volume (in cubic meters per year); Q_e is water volume lost by evaporation (in cubic meters per year), and C_{ji} is background (inflow) concentration of the pollutant j in the lake (in milligrams per liter).

The value for C_{ji} is determined by the total load of the pollutant B_j (in tons per year) and total inflow volume:

$$C_{ji} = 10^9 \cdot \frac{B_j}{Q_i} \qquad (2)$$

Input

User defined

Lake annual inflow rate
Lake evaporation volume

Calculated by area/industry

Calculated load for pollutants in all areas

Output

All results below are calculated for the lake under consideration.

Intermediate results

Discharge load of a substance into the lake

Results

Concentration of the conservative substance (pollutant j)

Lake phosphorus (pollutant = PX)

Model equations

The model first calculates the critical phosphorus load L_c (in milligrams P per m^2 a year) above which eutrophication conditions begin to develop:

$$L_c = 10 \cdot \frac{Q_i}{A} \cdot \left(1 + \sqrt{Z \cdot \frac{A}{Q_i}}\right) \qquad (1)$$

where Q_i is annual inflow rate (in cubic meters per year), A is lake area (in square meters), and Z is lake mean depth (in meters).

The model then determines the maximum annual discharge of phosphorus B (in tons per year):

$$B = \frac{L_c}{10^9 \cdot A}. \qquad (2)$$

In the output window, the user can compare this maximum annual value with actual PX discharge load, calculated according to percentages of load contribution to water bodies.

Input

User defined

Lake area
Lake mean depth
Lake annual inflow rate

Output

Intermediate results

Critical phosphorus load for the lake

Results

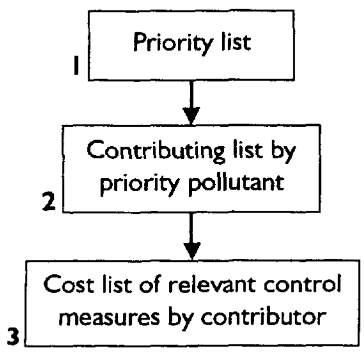
Maximum annual discharge load of phosphorus above which eutrophic conditions may begin to develop

Cost analysis

Choosing priorities for pollution control

The cost analysis function must be started from the menu bar with the **Window | CostAnalysis/What-if...** option. The cost analysis is done according to media type (water or air). It leads a user through the following steps:

1. Priority list



Ambient concentrations of pollutants are listed and compared with the accepted health guidelines when the latter are available (see Health Guidelines, below). The percentage above the limit value is calculated, together with the critical load and excess load for the pollutants surpassing these values.

Critical pollution load is defined here as the threshold load beyond which additional pollution load leads to the adopted ambient quality standards/limit values being exceeded.

Annual excess pollution load is defined here as the pollution load discharged in excess of the critical pollution load.

A user can concentrate the cost analysis on the pollutants whose loads exceed the critical loads. Since not all pollutants have established limit values, the system will not estimate critical and excess loads for all of them, and it is up to the user's judgment to choose a final list of priority pollutants, drawing on environmental epidemiologic and toxicological studies.

The selection of pollutants for further analysis of control options is made by clicking on the check box in the first column next to the targeted pollutant. With the Next button shown at the bottom of the cost window, a user can continue the cost analysis by identifying industries, areas, and contributing processes.

2. Contributing list

All contributing processes are shown per pollutant. Within the media type Air, a process is identified by area, ISIC, process title, and process description. Within media type Water, a process is identified by water body, area, ISIC, process title, and process description. Industries or processes contributing to the ambient levels of selected priority pollutants are identified and prioritized according to their relative contributions, expressed as a percentage. It should be stressed that at this stage of the analysis, the system shows contributions of different processes to the ambient concentrations of selected pollutants, not just to the emissions levels as was done earlier, at the stage of load calculations.

3. Cost list

A list of selected processes and their cleaner alternatives, comprising both control measures and controlled processes, is shown to enable the cost-effectiveness analysis of all pollution abatement options. The cost is calculated and presented for each controlled process or control measure. The cost list contains such fields as area description and ID, water body description and ID (for water pollutants), pollutant description and ID, industry description and ID, and process description and ID. It also has fields for displaying remaining pollution loads; pollution loads that can be removed by each reduction measure or controlled process linked to the base process; the annualized total cost of controls; the cost of pollution control per unit of pollution removed; and the long-run marginal costs.

LRMC graph

The LRMC-Across processes button shown at the bottom of the window can be used to open a new window that shows a graph and a corresponding schedule of the long-run marginal costs within a selected process group or across all analyzed processes.

WHAT-IF analysis

With the check boxes in the first column, a cleaner alternative process can be selected. The Re-analyze button shown at the bottom of the window can be used to run the load and model calculations for the alternative production processes or controls proposed. As a result, a new priority list is generated, and the cost analysis can be restarted. The column "Old ID" will always show the originally active Process ID at the start of the analysis.

The Back button will return to the second step of the cost analysis.

Cost calculation

One general cost format per polluting source is used:

$$Cost_j[I, V] = UNIT * R * \{A + B * ([F, P]/N)^C + D * ([F, P]/N) * T + E * POL * [F, P]/N\}.$$

The general format can be used for investment/capital (I) costs, as well as operating/variable costs (V). An I/V flag in front of the formula in the data file signifies which of the two is appropriate.

The general format can be used for costs that are dependent on the volume of wastewater or waste air (F), as well as for costs that depend on the volume of production (P). An F/P flag in front of the formula in the data file signifies which cost type is appropriate. When the formula uses P, the annual production level of the specific process (in units of production per year) is taken by the costs model as the value for P. When the model needs to calculate costs on the basis of F (m^3/hr), F is calculated from:

$$F = V * P/T$$

where F is hourly waste volume (m^3/hr); V is waste volume per unit of production (m^3/unit); P is annual production (units of production/yr); and T is annual production hours (hr/yr).

Default values for V and T are included in the database. They can be changed by a user in the Inputdef [Process] window.

The following guidelines for estimating N, the number of sources, apply:

1. **In general, the number of sources is one per production unit. Production units can be process installations, fuel-burning installations, waste incinerators, hotels, restaurants, or hospitals. As a rule, the number of sources is the number of installations that would be necessary to control a polluting process.**
2. **Intensive farming (ISIC 1110) has different definitions for *N* for air and water:**

   ***N* (water) = number of stables or chicken farms**

   ***N* (air) = number of animals.**

   Example: for a chicken farm producing 120 chickens per year, with 30 days being the average life of a chicken, the average number of chicken sources is 10 for air and 1 for water.
3. **For air emissions caused by transport, *N* is equal to the number of vehicles.**
4. **In ISIC 9200 (municipal services), the population served by sewers is used in calculating water discharges, but for the cost calculations the number of sources is the number of sewage treatment plants to be built. The default value of N is 1.**

All costs functions are standardized for 1990 U.S. conditions.

A control cost consists of cost type/cost unit combinations for which constants are defined.

The format UNIT is a specific parameter for which costs have to be taken into account. UNITs are described in detail in the cost formulas. A UNIT can be a cost ratio (such as LU, EU, or MU for labor, energy, or material costs ratios) or an amount of money (U.S. dollars) for a good that is consumed. The user can modify the UNIT costs and ratios that apply to the whole study in the Study[Info] drop-down window. If ratios differ by area within the study, these can be specified in the Inputdef[Area] window. Local costs should be compared with 1990 U.S. costs. In situations where many materials and equipment have to be imported, values for the general cost ratio, GU, and MU will be higher than 1.0.

The general cost ratio, GU, is used when specific information is not available for material, labor, and energy costs. A study-specific GU is determined relative to the overall 1990 U.S. cost indexes. A working cost index formulation applicable to GU is 0.4 * MU + 0.4 * LU + 0.2 * EU.

When costs for pollution control are calculated, the model adds up all the investment-related costs $Cost_i(I)$ to estimate the total investment costs INV_{tot} per source of polluting process, and it adds up all the variable costs $Cost_i(V)$ to calculate the total variable costs VAR_{tot} per source of polluting process.

Total annual costs per Process ID are calculated as:

$$ANNUAL_{tot} = N \cdot \{ANNUITY(INV_{tot}, RATE, DEPREC) + VAR_{tot}\}$$

where *RATE* is the local interest rate and *DEPREC* is the depreciation time in years.

$$\text{ANNUITY} = \text{INV}_{tot} \cdot \left\{ \frac{\text{RATE}}{1-(1+\text{RATE})^{-\text{DEPREC}}} \right\}$$

The costs of pollution control are calculated and presented in the cost list as total costs and cost per ton of individual pollutant removed. Control costs are calculated for each process. They affect one, several, or all pollutants associated with the process. This is reflected only in the column "Pollution removed." The same control cost appears for each pollutant removed. Control costs are not additive for different pollutants. If the quantities removed differ for various pollutants, the differences are reflected in the cost per ton of pollutant removed. A control cost might appear uneconomical if considered on the basis of tons of one type of pollution removed, but it may be highly effective if one considers the entire range of pollution affected by the proposed measure.

Good housekeeping and waste prevention programs may have beneficial economic effects on the productivity of the industry beyond their effects on pollution reduction.

All these effects have to be considered by the analyst outside the DSS/IPC system, using the results of the computerized analysis as the starting point for an educated interpretation of the options available to policymakers.

Long-run marginal cost (LRMC) calculation

Processes are identified by a four-character Process ID, built as follows:

A	**Process title**
AA	**Process subtitle**
AAUA	**Base (uncontrolled) process**
AAXA	**Cleaner (controlled) process**

Reduction measures are associated with both base and cleaner processes. All available combinations of processes and reduction measures for controlling the same pollutant(s) are alternatives that constitute a process group. Within a process group, the combination of a process and a reduction measure actually applied in a study area is called the existing process; any other combination of a process with a reduction measure is an alternative process.

The algorithm for calculating long-run marginal costs for controlling a selected pollutant in one area or water body is as follows:

Step 1

Within each process group, sort all processes in ascending order of pollution load removed.

Step 2

Within each process group, identify the existing process. Exclude from further calculations all alternative processes with smaller or equal load reduction relative to the existing process. If among the remaining alternative processes are some with equal load reduction, exclude those with greater total annual costs. If the costs are equal as well, leave the first of those processes. All further steps apply only to the remaining alternative processes.

Step 3

Within each process group, execute the following calculations for each alternative process from a subset of those processes that are left after completing steps 1 and 2 (starting with the next process after the existing process in the subset):

- Subtract the total costs for the previous process-reduction measure combination from the total costs for the current process-reduction measure combination and enter the result as *change in costs.*
- Subtract the pollution load removed for the previous process-reduction measure combination from the pollution load removed for the current process-reduction measure combination and enter the result as *change in pollution removed.*
- Divide the change in costs by the change in pollution removed to calculate the marginal costs for each alternative process (i.e., for each process-reduction measure combination other than the existing process).

Note: The above procedure for calculating change in costs for a process group is based on the assumption that a set of alternative processes allows for a multistage development of pollution abatement facilities though subsequent upgrading of existing facilities with a corresponding adjustment (decrease) in the costs of superior controls. Although the assumption is generally valid for *alternative* control measures provided in the DSS/IPC system, exceptions are possible in the context of specific studies. For example, the assumption (and thus the algorithm) does not apply when the existing process incorporates a control measure for a specific air pollutant (e.g., nitrogen oxides) and a user analyzes control options for another air pollutant (e.g., total suspended particulates or sulfur dioxide) that are not alternatives to the existing process. It is the user's responsibility to check whether the assumption is justified in a specific case. If it is not, the LRMC calculations should be reviewed outside the system. (This note is relevant when the existing process is controlled or incorporates a control measure.)

Step 4

If, within a process group, an alternative process exists that has higher marginal costs than the next alternative process (in ascending order of pollution load removed), the first process should be discarded, and the change in costs, change in pollution load removed, and marginal costs should be recalculated as in step 3 for each remaining alternative process.

Note: A negative value of marginal costs for an alternative process after a zero value for a process/reduction measure combination will remove the latter, in line with the algorithm.

This iteration procedure continues until only those alternative processes are left for which, in ascending order of pollution load removed, the marginal costs are also in ascending order.

When the above procedure has been completed, the resulting process-reduction measure combinations are the efficient solutions for which the long-run marginal costs are calculated. These efficient solutions represent viable alternatives to the existing process.

Note: The alternative processes that were discarded in the foregoing steps will not have a value in the "Long-run marginal costs" column. Rather, the text "discarded option" will be shown. The existing process will not have a value for LRMC, either; the text "existing process" will be shown in the LRMC column.

Step 5

Sort all efficient solutions (process-reduction measure combinations), identified above, across all ISICs/process groups by LRMC in ascending order. These are the efficient alternatives for the existing processes selected in the contributing list (also called "efficient processes").

Note: For the Air mode, all efficient alternatives (process-reduction measure combinations) for controlling a pollutant within each area are presented. For the Water mode, all efficient alternatives (process-reduction measure combinations) for controlling a pollutant within each water body are presented.

Along the cost-efficient processes sorted in ascending order of LRMC, calculate the values of accumulated costs and accumulated pollution load removed by adding change in costs and change in pollution removed in the current row to the (accumulated) values in the previous row. In each row, the corresponding accumulated values represent the total annual costs and the abated pollution load for a set of efficient processes comprising processes between the first row and the current row.

Note: This set of efficient processes indicates a program of pollution abatement measures that will achieve the given level of pollution reduction at least cost across industries or pollution sources in the area or watershed. (If this set includes several alternative processes from one process group, the superior process should be adopted.)

The results of this step are shown in a graph (LRMC-Across processes) for a given pollutant across all ISICs and process groups:

x-axis: accumulated pollution removed (tons/year)
y-axis: long-run marginal costs (US$/ton)

Below the graph, a grid is shown that contains the information in the graph in tabular form. The tables contains the rows from the costs list in Cost analysis, with the efficient processes shown in the graph sorted in the ascending order of LRMC. The table contains the columns as shown in the Cost analysis costs list, as well as columns for accumulated total costs and accumulated pollution load removed.

Evaluation of pollutants in the DSS/IPC

Health guidelines for air and water pollutants

The estimated ambient concentrations of air and water pollutants generated by the DSS/IPC models are compared with some target values that can be stored in the data file Pollutants. A number of default values that are provided by the DSS/IPC for air and water pollutants are largely based on WHO health guidelines. In a few cases where WHO limit values are not available, values originating from national and international institutions are given. For air pollutants, annual and hourly limit values can be provided; for water pollutants, only annual limit values can be provided. Drinking water requirements are used in establishing limit values for water pollutants. All limit values serve as a reference and can be changed by a user for a particular study to reflect local ambient quality standards or a different use of water. Not all pollutants are assigned default limit values in the DSS/IPC. Table 1.8 presents the limit values contained in the DSS/IPC, with their sources.

Hazardous wastes

Material generated by society is defined as waste if no proper use can be identified or if the material has a zero or negative value. Most solid waste streams should not be particularly hazardous. Still, all waste streams need a proper destination, and some waste streams require special attention because of potential contamination with hazardous substances. The nature and the concentration of the hazardous components determine whether the total waste stream has to be identified as hazardous. Hazardous waste is a risk to health and the environment, and exposure of the population through water, food, and air has to be prevented.

For many processes, it is difficult to establish accurate emission factors for hazardous components in the waste streams in order to determine whether the total waste is hazardous. For example, the rejects of metal ore mines will most likely contain heavy metals. However, in many cases the concentrations of these metals are low enough that the material can be regarded as nonhazardous. Therefore, the choice was made to categorize the waste streams in the emissions factor table according to a limited number of more or less general waste types and to give, in the title of the process or sometimes in footnotes, specific information about the components in the waste that might require identification of the waste as hazardous.

As a tool for identifying identification of potential hazardous wastes, a comprehensive list of activities likely to create hazardous waste is provided in Annex B. The list was published in 1991 as an addition to the Hazardous Waste Act of the Netherlands.

Table 1.8 Default limit values in the DSS/IPC

	Annual	*Hourly*	*Source*
Air pollutants (μg/m^3)			
Ammonia	180	2,700	RIVM
Carbon monoxide	3,300	30,000	WHO
Fluoride (hydrogen fluoride)	20		RIVM
Hydrogen sulfide	150		WHO
Lead	1		WHO
Nitrogen oxides	150	400	WHO
Particulates, total	75		WHO (average of 60–90)
Particulates < 10	50		WHO (average of 40–60)
Sulfur dioxide	50	350	WHO
Water pollutants (mg/l)			
Cyanide	0.07		WHO
Phenols	5.25		RIVM based on CEC/SCF

Note: RIVM, Dutch Institute for Health and Environment; WHO, World Health Organization. The derivation of these values is explained in Annex A.

Notes

1. An exception is "low-NOx burner" for ISIC 4101, which is currently modeled as a reduction measure.
2. The air point source model is taken from Committee for Prevention of Disasters, The Netherlands,

"Methods for the Calculation of Physical Effects" (1992). The river BOD model is from Huisman, "Water, Contamination and Self-Purification" (Technical University of Delft, The Netherlands, 1973). All the other models are taken from World Health Organization, "Management and Control of the Environment," WHO/PEP/89.1 (1989).

Chapter 2

How to Operate the IPS System

Control flow diagram of the system

The DSS/IPC was developed to assist environ-mental managers in making decisions on pol-lution control in their communities. The decisions made using this system are based on consensus among groups in the community that hold different views. DSS/IPC is a tool for organizing technical information and an accepted methodology for selection of pollution control interventions. For situations in which monitoring data do not exist or are too costly to obtain, the DSS/IPC includes an extensive database on which a preliminary analysis of the local situation can be performed.

The system is based on the assumption that tasks within the system are strictly separated. That is, the input of all data is done within the input definition (Inputdef) functions. Within these functions, the user can enter data in spreadsheet form. Although the user can add and change data, with each new study a default database is created that contains the definition of industrial processes according to ISIC number, the pollutants and their stability class, and the generalized values for emissions factors. These emissions factors associate specific technologies used in all sectors of economic activity with emissions of pollutants in each medium. On the basis of the analysis of the area under study, a user enters area, river, and lake characteristics; meteorological conditions (for air dispersion modeling); and the production values for industrial processes in each specified area. Additional information, such as point source characteristics and data on monitored loads and concentrations, is optional and can be used to refine the outcomes of the calculations on availability.

The control flow within the system is illustrated by Figure 2.1, page 20.

After all the study-specific data have been defined, the pollutant loads or area pollution inventory can be evaluated. Load calculation implies the multiplication of the production values by the appropriate emissions factors. The load calculations are used to estimate ambient concentrations in the dispersion models.

The pollutant concentration values are compared with health guidelines to identify (a) any hazards to human health in a particular area and (b) industry- and location-specific least-cost solutions for reaching acceptable ambient quality. Since concentration values can be traced to the originating industrial processes, the cost analysis allows identification of the contribution of the specific processes to ambient levels of pollution, as well as alternative control measures and the corresponding investments.

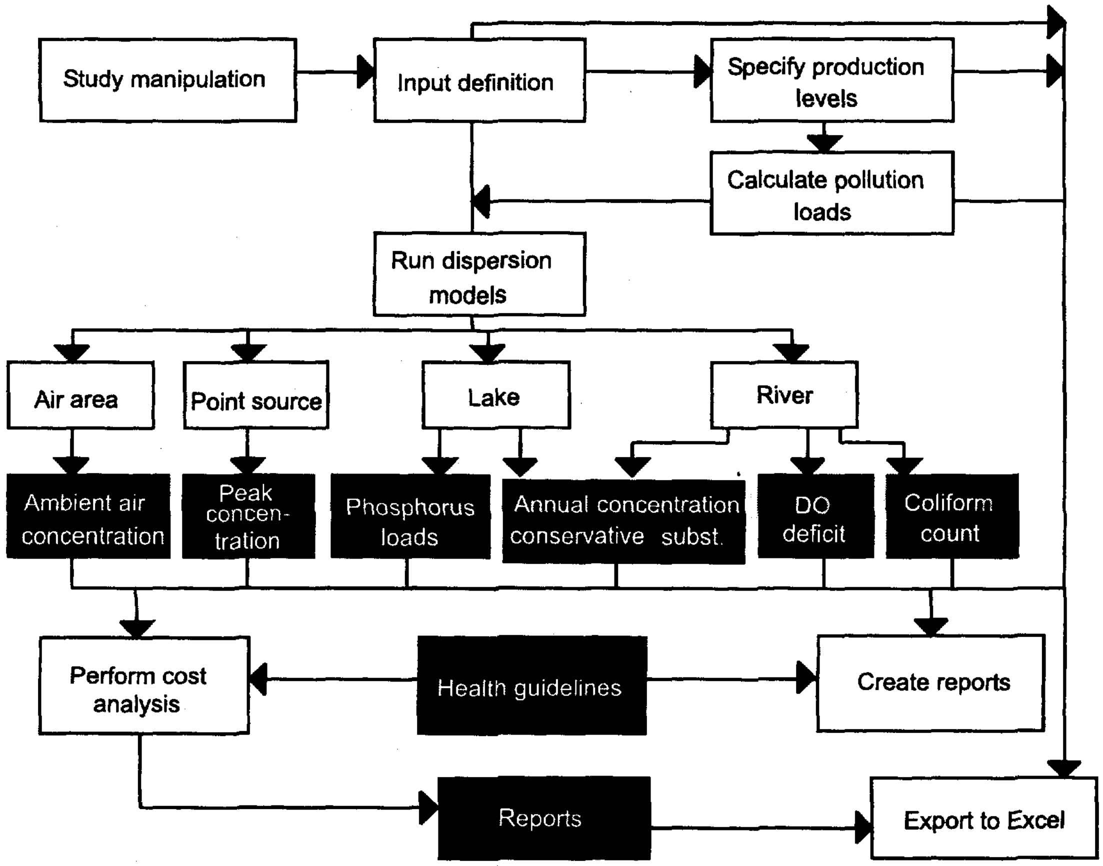
Within the system, all of the captured information can be printed and exported to Microsoft Excel or other programs for further analysis.

DSS/IPC desktop

Multiple document interface (MDI)

The DSS/IPC system is designed as Microsoft Windows 3.x-based software. It uses Multiple Document Interface (MDI), which allows the user to perform multiple tasks within a single application.

Figure 2.1 Control flow in the DSS/IPC system



The DSS/IPC desktop corresponds to a study. When the software is started, the main window with menu bar, toolbar and status bar appears. Within this window, also called the container window, multiple smaller windows (MDI-child windows) can be open at the same time (see Figure 2.2). There is always one active window. (When no MDI-child windows are open, the container window itself is an active window.) The toolbar and the message and status bar, as well as available commands in the menu bar, correspond to the active window.

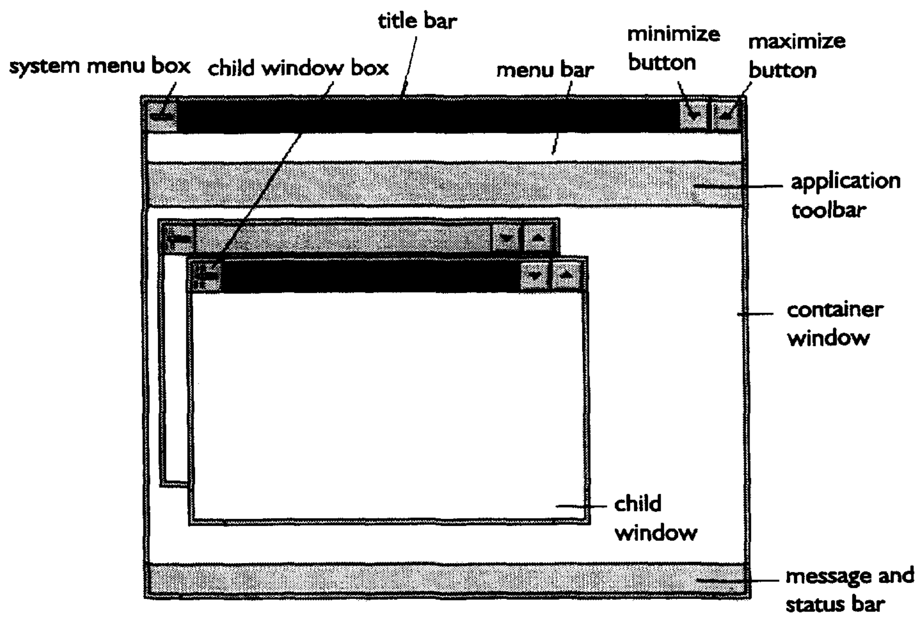
An MDI-child window represents one of the active tasks the user is working on. The window may be maximized to take up the whole container window, resized to the necessary scale, or minimized as an icon at the bottom of the container window.

Window elements and their description

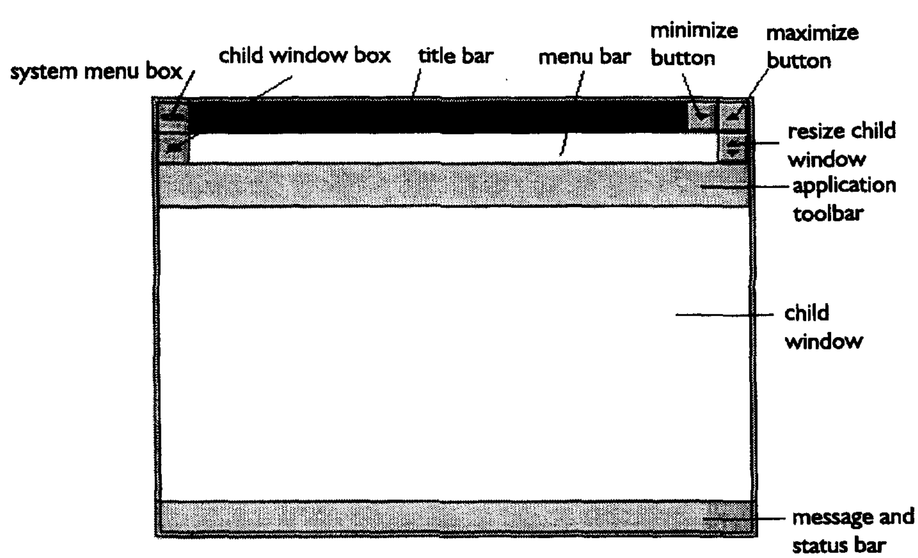
- **System menu box**
  A double click closes the application; a single click makes the standard system menu for the window pop up.
- **Child window box**
  A double click closes the MDI-child window; a single click makes the standard MDI-child menu pop up.
- **Title bar**
  The title bar contains the title of the application (or, in case of an MDI-child window, the title of the window). Click the title bar and keep the left mouse button down to drag the container window to another location (or to drag the MDI-child window to another location within the container window).
- **Menu bar**
  The menu bar contains all the top menu choices of the system.
- **Minimize button**
  The Minimize button reduces the application or an MDI-child window to an icon.
- **Maximize button**
  The Maximize button enlarges an iconed application to full-screen size or enlarges an MDI-child window to the full size of the container window.

Figure 2.2 Window layout

DSS/IPC desktop with several MDI-child windows (active window is on top)



DSS/IPC desktop with maximized active MDI-child window



- **Resize child window**
  The Resize child window button resizes the MDI-child window to its original size before it was maximized.
- **Application toolbar**
  The Application toolbar contains all application buttons. It can be used for quick access to a number of frequently used functions that are accessible through the menu bar. The toolbar contains buttons representing the functions that are available at the current state. If a button is grayed out, its function is not available to the active window; if it is displayed in black or color, its function is available to the current active window. The toolbar can be displayed or hidden, using the Toolbar option from the Options menu.

- **Container window**
  The container window is the area in which MDI-child windows can be displayed.
- **Message and status bar**
  The message and status bar contains all informational, prompt, and error messages. In addition, the name of the current study is displayed, along with the status of the Numlock, Capslock, and Insert/Overstrike keys.

Windows basic techniques

It is assumed that DSS/IPC users have basic knowledge of Windows 3.x operations and techniques. Some information on windows, menus, the keyboard, and other information about Microsoft Windows can be found in the Help file of the Program Manager. The section on Keyboard options is especially useful in operating Windows.

Menu basics

A menu can be opened by clicking on the menu icon and selecting the desired item from the drop-down menu. A more efficient procedure is to click a menu option, keep the left mouse button down, and walk through all the available menu options. When the left mouse button is released, the option on which it is positioned will be activated.

As an alternative to the mouse, shortcuts can be used from the keyboard. Use the Alt key together with the underlined character in the desired menu option to select that option.

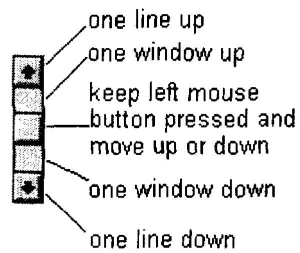
Sometimes arrows or dots are displayed in addition to the menu option text. These symbols have the following meanings:

Arrow	**A submenu will follow when this option is selected.**
Three dots	**A dialogue introducing additional options will follow when this option is selected.**

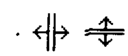
Spreadsheet operations

In the DSS/IPC, most information is presented to the user in the spreadsheet format. The following are some of the spreadsheet characteristics and features used in DSS/IPC windows.

- *Scroll bars* are displayed to the right of the spreadsheet if the spreadsheet contains more rows than can be displayed on the screen. The rows of the spreadsheet can be scrolled as illustrated:



- *Fixed columns* are found in the spreadsheets used with the Window Inputdef functions. These columns (usually two) contain the identification of a row. When the spreadsheet is scrolled horizontally, the fixed columns remain in position so that the user can see how the information in the other columns relates to the rows.
- *Resizing width and height* allows the width of each column and the height of each row to be resized as the user prefers. When the mouse pointer is moved across the border between two rows or columns, the shape of the mouse pointer changes as follows:



When the mouse pointer appears as above, press the left mouse button, keep it down, and move the mouse either vertically to change the height of a row or horizontally to change the width of a column. When the left mouse button is released, the height or width will retain the new size.
Row and column selection allows the user to select a complete row, by clicking in the gray cell at the far left of the row, or to select a complete column, by clicking in the gray cell at the very top of the column (the column header). The complete row or column will be highlighted.

Dynamic and static input tables

In the DSS/IPC, data input can be done by the user only in the spreadsheets within Inputdef windows. There are two types of these spreadsheets: dynamic and static tables.

A *dynamic input table* is a spreadsheet with a variable number of rows. Rows can be deleted from the spreadsheet, and new rows can be added at the bottom of the spreadsheet. This kind of table is used because the number of entries in the table is not known in advance. The tables contain information that is later used for building up static input tables. (Some input tables contain default data that can be amended by the user.)

A *static input table* is a spreadsheet with a fixed number of rows. It is used for filling in values for a predefined structure of data. On the basis of user selection in the drop-down list box(es) at the top of the window, rows in such table are filled with the data from dynamic tables.

Dialogue box operations

Within the DSS/IPC dialogue boxes, it is sometimes necessary to use the following features:

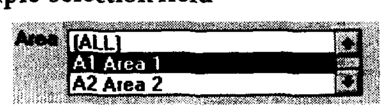
- **Check box**

A check box within the DSS/IPC system has two possible values: it is either checked (with a cross) or empty. The user can toggle the value of the check box by clicking either the box or the associated text string.

- **Spin button**

A spin button is always related to an input field. The user can specify an integer value in the text field but can also use the spin button to increase or decrease the current value from the text field.

- **Multiple-selection field**



A multiple-selection field contains a list of entries that can be selected separately to yield a list of applicable values. Clicking an entry from the list selects it as the only applicable value. When an entry is clicked while holding down the Ctrl key, that entry is added to the list of applicable values. When entries are clicked while holding down the Shift key, all entries on the list between the two clicked-on entries will be added to the list of applicable values.

- **Drop-down list box**

A drop-down list box is a special type of input field in which a selection can be made from a fixed set of values. There are three ways to select a value:

1. **Type the first character of the desired value. If more than one value exists with the same first character, enter additional characters until the desired value is shown in the field.**
2. **Use the up arrow, down arrow, page up, and page down keys to scroll through the list values.**
3. **Use the button on the right of the field to open the list with all available values; then select the desired one by clicking it with the mouse.**

DSS/IPC menu commands

This section describes DSS/IPC functions that are available from the application menu bar and the respective submenus. Six top-level choices are available directly from the menu bar: File, Selected, Edit, Options, Window, and Help. Selecting any of these items drops down a menu with several functions or submenus. For the purpose of description below, such functions and submenus are divided into logical groups, which often, but not always, correspond to separators (horizontal dividing lines in the menus).

File functions

Functions available through the **File** option are logically grouped as follows:

- Study Handling functions
- Print functions
- Export/Import functions
- Calibrate functions

Study Handling Functions

The Study Handling functions must be started from the menu bar by selecting the **File** option. The Study Handling functions are New, Open, Close, Copy, Info, and Remove. Each function is discussed below.

The highest abstraction level within the system is that of the study. Within a regional study in one or several areas, data can be stored, updated, deleted, analyzed, and reported. Because of this level of abstraction, special functions are offered for handling studies, as follows.

New

 This button closes the current study (if one is open) and starts a completely new study.

The New function may be started from the menu bar with the option **File | New** or from the toolbar with the Study New button.

A dialogue box Study [New] appears in which a new study name and the other general study attributes are entered. (Entering this information is mandatory.)

Validation consists of a check to determine whether the study already exists. Confirmation (by pressing OK) instructs the system to place a copy of the default database in the new study database and to open the new study database. If a study is open before this action begins, that study will be closed automatically. If a study is open and the action is canceled, the original study remains open.

Open

 This button opens an existing study. A drop-down list box is presented in which a user must choose from all existing studies.

The Open function may be started from the menu bar with the option **File | Open** or from the toolbar with the Study Open button.

A dialogue box Study [Open] appears from which an existing study can be selected. With the exception of the study name, all general study attributes can be modified.

Confirmation (pressing OK) opens the selected study database. If a study is open before the action begins, that study will be closed automatically. If a study is open and the action is canceled, the original study remains open.

Close

 This button closes the current study, i.e., the most recently opened study that resides on the user's desktop.

The Close function may be started from the menu bar with the option **File | Close** or from the tool bar with the Study Close button. This function closes the desktop and all its windows.

User verification is asked for each window where changes have been made. Confirmation (pressing the OK button) saves the changes. Canceling Save Changes for a window will cancel the Study [Close] action. Quitting the application will result in the same user verification dialogue if windows are being edited.

Copy

The Copy function must be started from the menu bar with the option **File | Copy**. A dialogue box **Study [Copy]**, identical to **Study [New]**, will appear where the current study name and the other general attributes are shown. New attributes should be entered in these fields. Confirmation (pressing the OK button) instructs the system to make a copy of the current study database in a new study database and to open the new study database.

Info

The Info function must be started from the menu bar with the option **File | Info**. A dialogue box appears in which the study-related attributes can be modified. Confirmation results in the model-related study attributes being saved to the study database.

The **File | Info** option can be activated only when an existing study is already open.

The cost parameters in this dialogue are the values used in calculating costs within the study. For certain parameters, it is possible to enter a specific value for each area in the **Inputdef [Area]** window. When no value is specified for that parameter in **Inputdef [Area]**, the value specified in this dialogue is used.

Remove

The Remove function must be started from the menu bar with the option **File | Remove**. A dialogue box **Study [Remove]** appears in which confirmation is asked for removal of the active study. Confirmation results in the removal of all associated data from the hard disk. After confirmation, the removed material cannot be recovered.

The **File | Remove** action can be activated only when an existing study is already open.

Print functions

PRINT

This button causes the contents of the active window to be printed. Before printing starts, the user is asked to specify some printer characteristics.

The Print function can be started by using the Print button or through the menu bar by choosing **File | Print**. The Print option allows selection of the target printer and other printer-related choices. When OK is selected, the contents of the active window will be printed. When an MDI-child window is open, the user is able to print the contents of the window.

PRINTER SETUP...

The Printer Setup... function must be started from the menu bar with the **File | Printer Setup...** option. This option displays a Microsoft Windows dialogue for configuring the active printer, with options such as portrait or landscape page orientation and selection of the default printer.

Because of the width of most MDI-child windows, it is generally best to print in landscape orientation.

Export/Import functions

Import

The Import functions must be started by selecting the **File | Import** option from the menu bar. The **File | Import** option leads to a submenu with four possible choices: Production, MonitoredLoad, MonitoredConc, and Study.

Each Import function leads to a common **File [Open]** dialogue in which an import file name must be chosen. The default import directory and extension are taken from the preferences (see Preferences function). The following Import functions with their dialogue window titles are found in the DSS/IPC system.

PRODUCTION...

Activated by selecting the **File | Import | Production...** option. Production values specified in an ASCII file are checked for consistency and are read into the database of the current study. Exact file formats are specified in the DSS/IPC file formats.

MONITOREDLOAD...

Activated by selecting the **File | Import | MonitoredLoad...** option. Monitored load values specified in an ASCII file are checked for consistency and are read into the database of the current study. Exact file formats are specified in DSS/IPC file formats.

MONITOREDCONC...

Activated by selecting the **File | Import | MonitoredConc...** option. Monitored concentration values specified in an ASCII file are checked for consistency and are read into the database of the current study. Exact file formats are specified in DSS/IPC file formats.

STUDY...

Activated by selecting the **File | Import | Study...** option. The Study function must be used to import a previously exported study, either on the same PC or on another PC, into the current system. This function also opens the study so that the user can work with it. See also **File | Open** function.

Note: If a study was not previously exported through the DSS/IPC export function (see below) but was saved as an [study_name].mdb file, the following procedure will restore the study in the DSS/IPC: (a) keep the [study_name].mdb file in a drive/directory different from DSS/IPC; (b) open a new study in the DSS/IPC with the same name; and (c) overwrite a newly created [study_name].mdb file in the DSS/IPC directory with the stored study file.

Note: The import files for Production, MonitoredLoad, and MonitoredConc must be in ASCII format. When creating these files with software such as Microsoft Excel, use Save As ASCII Text when saving the file.

Warning: The import process for Production, MonitoredLoad, and MonitoredConc will import correct entries and will reject incorrect entries. Reimporting a corrected import file will result in messages that the previously correct entries already exist. A possible bypass is to export the complete study before using one of these import functions. If incorrect, the study can be removed and reimported in the initial state.

Export

The Export functions must be started by selecting the **File | Export** option from the menu bar. A submenu appears with three possible choices: to GIS, current Study, and Window to Excel. The Window to Excel can also be started from the toolbar with the Export button. Each choice is discussed below.

To GIS...

Selecting the **File | Export | to GIS...** option leads to a **File [Save]** dialogue in which four file names, as well as the export directory, extension, and drive, can be specified. The default export directory and extension are taken from the preferences (see Preferences function). **File | Export | to GIS...** will export the following data files: areas, production per area, load per area, and concentrations per area.

Current Study

Selecting **File | Export | current Study** leads to a common File [Save] dialogue, entitled Study Export, in which an export file name can be chosen. The default extension of the export file is .IPC.

Note: Exporting a current study will export user-defined data as entered in the input definition functions: Area, Production, MonitoredLoad, Lake, River, Load Contribution to Water Bodies, WaterInitialConc, PointSource, and SourceData. User modifications to other data – for instance, emissions factors or reduction factors – are exported optionally.

Note: Extensive changes to the default database, such as deleting or replacing processes and reduction measures, *cannot* be exported. To preserve such changes, the user has to copy the entire database (mdb) file for this study, [study_name].mdb, from the DSS/IPC directory to another drive or directory. To copy the file onto a floppy disk, a compression utility such as PKZIP may be needed.

Window to Excel...

 This button exports the contents of the active window to a file that can be read by Excel.

This function must be started by selecting the **File | Export | Window to Excel...** option from the menu bar or from the toolbar with the Export button.

The contents of each active window can be exported to Microsoft Excel. This results in a common File [Save] dialogue, entitled Export to Excel, in which an export file name can be chosen. The default export directory and extension are taken from the preferences (see Preferences function).

Calibrate functions

Calibrate functions must be started from the menu bar with the option **File | Calibrate.** They are applicable to emissions factors (to adjust the results of load inventory) and to density factors (to adjust the results of the areawide air dispersion model).

Emfactor

The calibration of emissions factors must be started from the menu bar with the option **File | Calibrate | Emfactor.** The emissions factors for all relevant pollutant/process combinations with monitored load will be newly calculated with the following formula:

New emission factor = monitored load / process production value

For a controlled process with a reduction measure, the new emissions factor will also be divided by the corresponding reduction factor.

Densfactor

The calibration of density factors must be started from the menu bar with the option **File | Calibrate | Densfactor.** The area density factors of all relevant area/pollutant combinations with observed concentration will be newly calculated using the following formula:

$$\frac{\sum_{pol=0}^{n}\left(\frac{\text{observed concentration}_{pol}}{\text{calculated concentration}_{pol}}\right)}{n}$$

in which n is the number of pollutants for which observed concentration values are available.

Selected functions

Add

The Add function must be started from the menu bar with the **Selected | Add** option. The Add function is used in Inputdef windows only.

When the Add function is used in dynamic Inputdef windows, it moves the cursor to the bottom row, in which new data can be entered. If the cursor was already in the last row and the user enters any data into this row, the function adds the current row to the database.

In static Inputdef windows, the Add function always results in the data being entered in the database and is equivalent to the **Update** function.

Update

The Update function is used in Inputdef windows only. The Update function must be started from the menu bar with the **Selected | Update** option.

This function updates the current row of the database. By default, the system causes an update of each row in an Inputdef window as soon as the cursor is moved to another row in that same window.

Delete

This button removes the selected row from the database. User confirmation is requested first. If no row is selected, an error will occur.

The Delete function is used in dynamic Inputdef windows only. The Delete function can be started from the menu bar with the **Selected / Delete** option or with the Delete/Clear button from the toolbar. This function removes the selected row from the database. An error message appears if no row is selected. The system will not permit selection and deletion of more than one row in a single operation.

Clear

This button clears user-entered data from the selected row. If no row is selected, an error will occur.

The Clear function is used in static Inputdef windows only. The Clear function can be started from the menu bar with the **Selected | Clear** option or with the Delete/Clear button from the toolbar. This function clears the input data from the selected row. An error message appears if no row is selected. The system will not permit selection and clearing of data from more than one row in a single operation.

Sort

This button sorts the contents of the active window based on the selected column. If no column is selected, an error will occur.

The Sort function is used in Inputdef windows only. The Sort function may be started from the menu bar with the **Selected | Sort** option or by using the Sort button on the toolbar. The Sort function causes the current data set to be sorted using the selected column. It is possible to select more than one column, but only the left column will be used for sorting.

Scaling

This button starts the scaling dialogue when the active window is a concentration model window. Calculated concentration values can be adjusted by adding a value or by multiplying by a factor.

The Scaling function, used to change a set of calculated concentration values, operates on the Model [ ] windows only. The Scaling function may be started from the menu bar with the **Selected | Scaling** option or by using the Scaling button from the toolbar. When the Scaling menu option is selected, a Scaling dialogue box appears with a detailed description of the desired scaling process. When the OK button is pressed, all the concentration values in the Model [ ] window are changed according to the user's specification. The specified value is either added to or multiplied by all the contained concentration values.

InsertLine

This button makes a copy of the current line from the production window and inserts it right after the current line.

The InsertLine function can be activated only when the Inputdef [Production] or Inputdef [MonitoredLoad] window is active. The InsertLine function may be started from the menu bar with the **Selected | InsertLine** option or by using the Insert line button from the toolbar. The function is used to insert a copy of the selected line within the static input table. This is necessary when a certain process has production values for more than one reduction measure associated with that process. A copy of the selected row is inserted in the static input table.

Edit functions

Cut

This button cuts the selected text and copies it to the clipboard.

The Cut function may be started with the Cut button from the toolbar or with the **Edit | Cut** option from the menu. This function deletes the selected text from its original place and copies it to the clipboard.

COPY

 This button copies the selected text to the clipboard.

The Copy function may be started with the Copy button from the toolbar or with the **Edit | Copy** option from the menu. This function copies the selected text to the clipboard but does not delete it from its original location.

PASTE

 This button inserts the text from the clipboard at the current cursor position.

The Paste function may be started with the Paste button from the toolbar or with the **Edit | Paste** option from the menu. This function pastes the clipboard text at the current cursor position.

Options functions

PREFERENCES....

The function must be started from the menu bar with the **Options | Preferences...** option. It is used to tailor the system to the user's own preferences. The following options can be set:

- **Import file extension.** In the Import [ ] dialogue for importing files, the default extension for import files will be set to the user's specified extension. The default value is ASC.
- **Export file extension.** In the Export to or Study Export dialogues for exporting files, the default extension for export files will be set to the user's specified extension. The default value is ASC.
- **Import-export directory.** In the dialogues for importing and exporting files, the default directory for looking for files will be set to the user's specified directory. The default value is C:\ .
- **Ask on update.** When a row is changed in the Inputdef functions and the cursor is moved to another row, the user is asked whether the current row should be updated in the database. Confirmation can slow the process when large amounts of data are being inputted. When the Ask on update option is set to *No,* the confirmation question does not appear if the user leaves the row.
- **Show toolbar.** When this option is set to *Yes,* the system displays the toolbar with buttons at the top of the screen. To save space on the screen, it can be set to *No,* and the toolbar will not be displayed.

DEFAULTS...

The Defaults... function must be started from the menu bar with the **Options | Defaults...** option.

The Defaults... function is used to specify default values for a number of confirmation drop-down list boxes in the system. This option is particularly convenient when, for example, the user is inputting data for one area. Normally, the user has to select this area each time a drop-down list box appears in an MDI-child window. If the default for area is set in the Defaults window, however, the system automatically inserts the specified default value in the drop-down list box.

Defaults can be specified for the following entities within the system: area, media type, ISIC, river, and lake.

The Clear defaults button will clear all selected values. To clear just one value, click the corresponding label to the left of the default drop-down box.

TOOLBAR

The Toolbar function must be started from the menu bar with the **Options | Toolbar** option. The toolbar in the DSS/IPC includes the following buttons: Delete/Clear, Copy, Cut, Export (to Excel), Help, Insert line, Paste, Print, and Sort.

With this option, the toolbar can be toggled on or off; when off, it is not visible at the top of the container window, but all functions are still accessible from the menu.

Window functions

The Window functions are intended to work on separate MDI-child windows. They are grouped into functions that arrange MDI-child windows on the desktop, open new windows, and open a numbered Window List. The Window List choices allow the user to select any of the open windows, making it visible on top of the others and active. Each newly opened MDI-child window is added to the Window List as it is created.

1. **Window Arrangement functions.** Functions in this group are used to rearrange and organize the user's desktop.
2. **Show Window functions.** When a user selects any function from this group, a corresponding new MDI-child window opens. (If the window was already open, this command makes it active.) The group has several subgroups, with Inputdef functions being the most numerous.

Inputdef. All Inputdef functions are designed similarly, since their main purpose is to enable the user to enter data into the system. Each Inputdef [ ] window has zero to four drop-down list boxes in the header of the MDI-child window. In each drop-down list box, the user must make a selection. If all selections are made, or if there is no drop-down list box, the spreadsheet will be opened and filled with the contents of a database table. The user can add, change, and delete rows of data. In a dynamic input table, rows can be added at the end of the spreadsheet. In a static input table, the user has to fill in the open spaces to add values to the database. Rows can be updated in the database table by changing row values; by moving to another row; or by using the Update function. With any of these actions, the current row will be updated in the database with the new values. Rows can be deleted by selecting a row and activating the Delete function, either from the toolbar or from the menu.

When an Inputdef [ ] window is opened and the spreadsheet is filled with data, several first columns (usually two) remain on the screen when the spreadsheet is scrolled horizontally.

Calculate. Functions in this group include Load and Model options. These options lead to a dialogue box in which the user has to specify which load or models need to be calculated or displayed. When the dialogue box is closed with the OK button, calculation proceeds, and the results are presented in a spreadsheet format. (For further details, see the description of the Load and Model functions.)

CostAnalysis/WhatIf... This subgroup contains only one function. The function brings up a dialogue box that ties to several specific windows. (For further details, see the description of this function, below.)

Report. The Report subgroup contains three options: Production, Pollution Load Inventory, and Ambient Concentration. All three options lead to a dialogue box in which the user can specify what information has to be shown in the report. The OK button presents the report in a new MDI-child window. The contents of the window can be printed using the Print button at the top of the Report [ ] window.

3. **Window List.** This group's contents are determined by the number and titles of all open DSS/IPC windows.

Window Arrangement functions

Tile Horizontal

This function must be started from the menu bar with the **Window | Tile Horizontal** option. It tiles all open windows horizontally, leaving space for icons at the bottom of the container window.

Tile Vertical

This function must be started from the menu bar with the **Window | Tile Vertical** option. It tiles all open windows vertically, leaving space for icons at the bottom of the container window.

Cascade

This function must be started from the menu bar with the **Window | Cascade** option. It cascades all open windows.

Arrange Icons

This function must be started from the menu bar with the **Window | Arrange Icons** option. It arranges all icons on one line within the container window.

Show Window functions

Inputdef functions

The Inputdef functions are used to view, input, update, and delete data. As with any window, Inputdef [ ] windows can be used to export data to Microsoft Excel. The following are the available Inputdef functions:

- ISIC
- Process
- Pollutant/HealthGuidelines
- Emfactor
- Footnote
- ReductionMeasure
- ReductionFactor
- ControlCost
- Area
- Production
- MonitoredLoad
- Lake
- River

- Load Contribution to WaterBodies
- WaterInitialConc
- PointSource
- SourceData
- MonitoredConc

The first group of Inputdef functions (from ISIC through ControlCost) enables the user to view and modify the default data set that is distributed with the DSS/IPC system.

The second group of Inputdef functions (from Area through MonitoredConc) enables the user to enter study-specific data.

Only the user-defined data entered in this last group of Inputdef functions will be exported when exporting a study.

ISIC

The International Standard Industrial Classification (ISIC) is a standard four-digit code that is unique for every industry. The ISIC function must be started from the menu bar with the **Window | Inputdef | ISIC** option. An MDI-child window is shown with a three-column dynamic input table. The key field is *ISIC*.

The DSS/IPC system contains default definitions of ISIC based on 1986 UN values.

Industry Description is a field of 72 characters.

Src Level, source level of emissions into the air, can have three possible values: low (L), medium (M), or high (H). These values can be selected from a drop-down list. When the Src level field is active, a push-button is shown next to the field. The drop-down list will be shown when this push-button is clicked. The Src level values represent the stack height of the industries concerned. The following values are used in the classification:

Identification	*Full value*	*Criterion*
L	Low	< 20 meters
M	Medium	20–100 meters
H	High	> 100 meters

Note: User modification in this Inputdef function is optional for an exported study when using the **File | Export | current Study** option.

Process

The Process function must be started from the menu bar with the **Window | Inputdef | Process** option. An MDI-child window is shown with a dynamic input table. The key field is *Process ID*.

The DSS/IPC system contains default data for the prevailing technological processes included in the list of industries in the default database. The processes, which are unique for each ISIC and media type, are stored within a hierarchy of process titles and actual industrial processes. The process titles can be identified by a one- or two-character code.

Processes can be added, changed, or deleted after a media type and ISIC have been selected from the drop-down list box in the MDI-child window. If selected, all the corresponding processes are entered on the spreadsheet.

The *Process ID* is a one-, two- or four-character code. When the Process ID is a one- or two-character code, it is actually a process title. Only when a Process ID contains four characters is it regarded as an actual process. This means that such a process can contain an emissions factor associated with each relevant pollutant and that the process can have production or monitored load values. The third character in the code indicates the type of process, as follows:

U = base (uncontrolled)
X = cleaner (controlled)

When the user introduces a new process as part of the new study, the system checks to make sure that the Process ID is unique.

Process Description is a descriptive field of 60 characters.

Src Level contains a choice list with three possible values: low (L), medium (M), or high (H); see also the **Window | Inputdef | ISIC** option. If an Src level value is specified for a process, it will override the default value corresponding to the ISIC in the database.

Unit specifies the units of production in which the output of each process is measured. It is a text field of maximum 50 characters.

Volume (m^3/unit of production) specifies the emissions and effluents associated with the particular technological process, expressed in cubic meters per unit of production. This is a very important parameter in the reconstruction of cost functions for the economic evaluation of alternative pollution controls.

Annual Operation (hours/year) specifies the number of operating hours per year characteristic of the industrial process. This parameter is also used in the construction of cost functions.

Cost ID specifies the corresponding Cost function (see the ControlCost function).

The *Footnote* list reveals whether there are footnotes associated with modifiers of the emissions factors for a process. When this field is not empty, double-clicking it will pop up a window with the relevant footnote text. (For more information, see Polluting Processes, page XX.)

Note: User modification in this Inputdef function is optional for an exported study when using the **File | Export | current Study** option.

Pollutant/HealthGuidelines

The Pollutant/HealthGuidelines function must be started from the menu bar with the **Window | Inputdef | Pollutant/HealthGuidelines** option. An MDI-child window is shown with a dynamic input table. The key field is *Pollutant ID*.

The DSS/IPC system contains default values for pollutants and health guidelines that are included every time a new study is started. Pollutants are unique within media type. Pollutants can be added, changed, or deleted after a media type is selected from the drop-down list box at the top of the MDI-child window. If selected, the spreadsheet is filled with all corresponding pollutants.

Pollutant ID is a 10-character text field. It must contain a unique identification.

Pollutant Description is a 40-character descriptive field.

Stability Class contains an integer specifying the class of the pollutant. Within media type air, the values stand for:

Class	*Explanation*
1	Stable
2	Nonstable
3	Unstable

Within media type water, the values stand for:

Class	*Explanation*
1	Conservative
2	Intermediate
3	Nonconservative

Ann.Avg.Guideline (?g/m^3) specifies the annual average health guideline in micrograms per cubic meter for air and milligrams per liter for water. (For solid waste, this field is irrelevant.)

Hrly.Avg.Guideline (?g/m^3) specifies the hourly peak health guideline in micrograms per cubic meter for air. (For solid waste, this field is irrelevant.)

Short-Term Local Max.Conc. (mg/l) specifies the short-term local maximum concentration health guideline in milligrams per liter for water.

Health guidelines can be added or changed within the Inputdef [Pollutant/HealthGuidelines] window. However, the user can delete health guidelines only by removing the entire pollutant/health guidelines row from the database. To do that, the user must first delete the emissions factors for this pollutant (see Emfactor, below). For more information on the default health guidelines, see Pollutants and Health Guidelines in chapter 1 of this guide.

Note: User modification of this Inputdef function is optional for an exported study when using the **File | Export | current Study** option.

Emfactor

The Emfactor function must be started from the menu bar with the **Window | Inputdef | Emfactor** option. An MDI-child window is shown with a static input table.

The DSS/IPC system contains default values for emissions factors. They are included in the study each time a new study is started. Emissions factors are unique within the combination of media type, ISIC, process, and pollutant.

Emissions factors can be added, changed, or cleared from the table whenever the three drop-down list boxes at the top of the MDI-child window are specified. Process can be specified only if an ISIC is chosen. In that case, the process drop-down list box is filled with all processes within the selected ISIC. From the process list, only actual processes with a four-character code can be selected. The other entries are for reference purposes only.

Emissions factor is a factor that is related to a process-pollutant combination. The multiplication of this factor by the production value of a process gives the pollutant load.

Pollutant ID is a unique 10-character code. It cannot be changed.

Pollutant Description is a descriptive field of 40 characters. It cannot be changed.

Em.Fact.(kg/unit of production) contains the emissions factor value.

The *Footnote* list associates the relevant footnotes with the emissions factor. Double-clicking this option will make a window containing the relevant footnote text pop up.

For more information, see Emissions Factors in chapter 1 of this guide.

Note: User modification of this Inputdef function is optional for an exported study when using the **File | Export | current Study** option.

Footnote

The Footnote function must be started from the menu bar with the **Window | Inputdef | Footnote** option. An MDI-child window is shown with a dynamic input table. The key field is *Footnote ID*.

The DSS/IPC system contains default footnote texts for processes and emissions factors. They are included in the study each time a new study is started. Pollutants are unique within media type.

Footnotes are used to store an explanation for process or emissions factors. The Footnote ID must be specified along with the process or emissions factor in order to link to the footnote.

Footnote ID is a unique integer value.

Footnote Description is a field that contains footnote text with a maximum of 768 characters.

For more information, see the footnotes for the health guidelines for water and air pollutants.

Note: User modification of this Inputdef function is optional for an exported study when using the **File | Export | current Study** option.

ReductionMeasure

The ReductionMeasure function must be started from the menu bar with the **Window | Inputdef | ReductionMeasure** option. An MDI-child window is shown with a dynamic input table. The key fields are *ISIC, Process,* and *Reduction ID*. The combination of these fields is unique within the media type.

The DSS/IPC system contains default values for reduction measures. They are included in the study each time a new study is started. Reduction measures are unique within media type.

Reduction measures represent industrywide actions directed specifically toward reduction of waste and pollution. They include good housekeeping measures that concern handling and maintenance of plant and equipment. (For more information, see Reduction Measures in chapter 1 of this guide.)

The value in the *ISIC* field must be an existing ISIC code and should be selected from the drop-down list.

Process must be an existing process title of one or two characters within the selected ISIC.

Reduction ID is a one-character code specifying the reduction measure.

Reduction Measure is a descriptive field of 40 characters.

Cost ID specifies the corresponding Cost function (see the ControlCost function).

Note: User modification of this Inputdef function is optional for an exported study when using the **File | Export | current Study** option.

ReductionFactor

The ReductionFactor function must be started from the menu bar with the **Window | Inputdef | ReductionFactor** option. An MDI-child window is shown with a static input table.

The DSS/IPC system contains default values for reduction factors. They are included in the study each time a new study is started. Reduction factors are unique within media type and reduction measure.

Reduction factors can be added, changed, or cleared after a media type and a reduction measure have been selected. The reduction measure drop-down list box is filled with the corresponding values when the media type is selected.

Pollutant ID is a unique 10-character code and cannot be changed.

Pollutant Description is a descriptive field of 40 characters and cannot be changed.

Reduction Factor stores the reduction factor value that is later multiplied by the emissions factor if the corresponding reduction measure is applied to the process.

Note: User modification of this Inputdef function is optional for an exported study when using the **File | Export | current Study** option.

ControlCost

The ControlCost function must be started from the menu bar with the **Window | Inputdef | ControlCost** option. An MDI-child window is shown with a dynamic input table. The key fields are *Cost ID, Cost Type,* and *Cost Unit.* This combination must be unique within media type.

Cost ID is an integer that identifies the specific Cost Function to be selected by the system. For more details, see Cost Parameters in chapter 1 of this guide.

Cost Type contains either **I** for Investment Cost component or **V** for Variable Cost component. When adding a new row to the table, the user can select this value from a drop-down list.

Cost Unit stands for pollution control cost unit. (For a complete list, see Cost Parameters in chapter 1 of this guide.)

Cost Description is a text field of 40 characters.

The fields *R, A, B, C, D,* and *E* contain constant floating-point values that are used in the general control cost formula.

Pollutant ID is the identification of the relevant pollutant for which control costs are calculated. The emissions factor of this pollutant is used in the control cost formula.

Deprec.Period (years) contains a floating-point value that specifies the depreciation period.

F/P flag contains either **F** to indicate that the cost calculation formula is based on the flow rate of the water discharged or air emitted or **P** to indicate that it is based on the level of production. (For more details, see Cost Parameters in chapter 1 of this guide.) This value can be selected from a drop-down list.

Ref. is a descriptive field of 40 characters that directs the user to reference information on the values.

Ref.Year is a four-character field that specifies the year of reference.

Note: User modification in this Inputdef function is optional for an exported study when using the **File | Export | current Study** option.

Area

The Area function must be started from the menu bar with the **Window | Inputdef | Area** option. An MDI-child window is shown with a dynamic input table. The key field is *Area ID,* which must be unique within a study.

Areas are specified to divide the region in the study into smaller subareas. An area is an independent zone in which loads, concentrations, and costs are considered separately. A region in the study can be subdivided into areas to take into account differentiated wind or geographic conditions; political subdivisions for which disaggregated production data are available; subareas within a critical water basin; or two points in time representing various production patterns in the same region or area.

Area ID is a 6-character field that contains the identifying code for an area.

Area Description is a descriptive field of 40 characters.

Population shows the number of people living in the area.

Size (km^2) is the size of the area in square kilometers.

Em.Dens.Factor is a ratio included in the database that can be overridden for any study area to reflect local conditions more accurately. It is used in the areawide air dispersion model to approximate roughly a potentially greater contribution by small sources (e.g., transport; residential or commercial boilers) to the ambient levels of air pollution in high-density downtowns or similar areas, compared with the levels averaged for the entire area. (See Annex C for recommended ratios of local peak pollutant levels to urban averages.) If no density factor is specified, a value of 1.4 will be applied as the default.

Roughness (m) contains a floating-point value to specify the roughness of the given area. It is used only in the point source air dispersion model. (See Annex C for guidance on the appropriate value.) If no value is specified by the user, a value of 1 is used as the default.

Energy Ratio, to be used in the Cost function calculations, is a floating-point value specifying the local energy cost ratio relative to the study default.

Interest Rate (%), used to discount control costs, is a floating-point value specifying the local annual interest rate.

Labor Ratio, used in the variable costs calculation, is a floating-point value specifying the local labor cost ratio relative to the study default labor cost.

Materials Ratio is a floating-point value specifying the local material cost ratio relative to the study default costs of materials.

Labor Costs is a floating-point value specifying the local hourly wage rate, in U.S. dollars.

The frequency factors (*F##*) are area-specific values used in the area dispersion model to calculate ambient concentrations. The factors are decimal fractions from 0 to 1 that specify the frequency of prevailing atmospheric conditions according to the following table.

	Wind speed			
Atmospheric stability	*Very low (< 2 m/s)*	*Low (2–5 m/s)*	*Moderate (5–7.5 m/s)*	*High (> 7.5 m/s)*
Unstable	F11	F12	F13	F14
Neutral	F21	F22	F23	F24
Stable	F31	F32	F33	

The user enters the approximate percentage of time throughout the year that a given combination of wind speed and atmospheric stability prevails. The sum of all frequency factors must be 1.

The wind speed/atmospheric stability combination check boxes *A-1* ... *F-2* store information to be used by the PointSource model. They let the user specify the possible combinations of atmospheric stability (stability classes A through F) and wind speed (values from 1 m/s to 10 m/s) for which the model should calculate ground-level concentrations. (For more information, see the description of the PointSource model in chapter 1 of this guide, particularly the table on page XX.) When the user enters a new row (Area ID) in the table, these check boxes appear in their default state—that is, all checked—meaning that the model will calculate concentrations for all possible combinations of wind speed and atmospheric stability. To speed the calculations, the user can remove the check marks on boxes referring to combinations that are irrelevant or unlikely for a particular area.

Production

The Production function must be started from the menu bar with the **Window | Inputdef | Production** option. An MDI-child window is shown with a static input table.

Production values (or levels) must be specified by the user on the basis of the results of the inventory in the study areas. Production values can be specified after selection of the media type, the area, and the ISIC. As a result, all processes within this combination will be shown in a static table for the user to specify the production values for all relevant processes.

Within the drop-down list box for *ISIC* the option (*ALL*) is added to give the user maximum flexibility in the specification of production values. In the case of fertilizers, pesticides, and insecticides, these represent inputs rather than production. The same is true for power generation when fuel input is the relevant measure. In the case of traffic, production values can be expressed either as fuel used or as vehicle-kilometers traveled. All production values can be entered in one MDI-child window.

The following columns are shown:

ISIC is a unique four digit code. It cannot be altered.

Process ID is a unique four-character code. It cannot be altered. If there is a one-or two-character code in this field, the row shows not an actual process but a process category (a subgroup of similar processes within the same ISIC). No data can be entered in such rows.

Process Description is a descriptive field of 60 characters. It cannot be altered.

Footnote list specifies the footnotes associated with some processes. Double-clicking a cell in this column will make a window containing the related footnote text pop up. The column cannot be altered.

Em. contains check marks signaling the existence of a footnote modifying the value of the emissions factors related to that process. If the text of this footnote must be viewed, the Inputdef [Emfactor] window has to be opened to see the corresponding footnotes and their footnote text. The column cannot be altered.

Unit specifies the unit of measurement in which the associated production value must be expressed. The field cannot be altered.

Production, 1000 is a field in which a user can enter a respective production (input or output) level in 1,000 units.

Number of Sources contains an integer specifying the approximate number of individual sources of pollution associated with the given production process in that area. This number is used in the cost analysis to obtain an indication of whether economies of scale are present when a specific control alternative is considered. The default value is 1. (For detailed instructions on the number of sources for ISIC groups, see Cost Calculation in chapter 1 of this guide.)

Reduction Measure allows the user to select a reduction measure for the process from the drop-down list, defined by the data in the Inputdef [Reduction-Measure] window.

MonitoredLoad

The Monitored Load function must be started from the menu bar with the **Window | Inputdef | MonitoredLoad** option. An MDI-child window is shown with a static input table.

Monitored load values can be optionally introduced if data are available in the areas concerned. Load values can be specified after the selection of the media type, the area, the ISIC, and the actual process. As a result, all pollutants within this combination will be shown in a static table so that the user can easily specify the monitored load values for one or several pollutants.

The following columns are shown:

Pollutant ID is a 10-character text field. It cannot be altered.

Pollutant Description is a 40-character descriptive field. It cannot be altered.

Load (tn/year) is a floating-point value specifying the pollutant load.

Reduction Measure allows the user to select a reduction measure for the process from the drop-down list, defined by the data in the Inputdef [Reduction-Measure] window.

Lake

The Lake function must be started from the menu bar with the **Window | Inputdef | Lake** option. An MDI-child window is shown with a dynamic input table. The key field is *Water ID*, which must be unique within a study.

Water ID is the unique identification of the lake. It is a nine-character code.

Water Description is a descriptive field of 40 characters.

Area (m^2) is a value specifying the size of the lake in square meters.

Inflow (m^3/year) is a field specifying annual lake inflow rate in cubic meters per year.

Evaporation (m^3/year) is a value specifying the annual lake evaporation volume in cubic meters per year.

Mean Depth (m) is a field specifying the mean lake depth in meters.

River

The River function must be started from the menu bar with the **Window | Inputdef | River** option. An MDI-child window is shown with a dynamic input table. The key field is *Water ID*, which must be unique within a study.

Water ID is the unique identification of the river. It is a nine-character code.

Water Description is a descriptive field of 40 characters.

BOD load (g/sec) is the BOD load discharged into the stream in grams per second. This value can be either entered manually, if data are available, or calculated by the DSS/IPC with the CalculateLoad function.

BOD Back.Conc. (mg/l) is the BOD background concentration in milligrams per liter, determined by BOD sample analysis or estimated.

BOD Anal.No.Days (days) is the number of days for which the BOD sample analysis took place.

BOD Anal.Temp. (C) is the temperature in degrees Celsius at which the sample analysis took place.

DO level (mg/l) is oxygen saturation of the river in milligrams per liter.

Colif.Count (per 100 ml) is the coliform count per 100 milliliters.

Colif. Die-off Rate is the coliform die-off rate constant per day at 20 degrees Celsius. Values range from 1.0 for large streams to 1.8 for medium-size streams.

Colif. Die-off Time (days) is the number of days since the last discharge.

Mean Depth (m) is the mean depth of the river in meters.

Avg.Flow (m^3/sec) is the average flow rate in cubic meters per second.

Temp. (C) is the mean water temperature in degrees Celsius.

Width (m) is the river width in meters.

Load Contribution to WaterBodies

The Load Contribution to WaterBodies function must be started from the menu bar with the **Window | In-**

putdef | Load Contribution to WaterBodies option. An MDI-child window is shown with a static input table.

Contributing percentages of each area or industry load to any one water body can be specified after the selection of the area and the ISIC. For the ISIC field, it is possible to select all ISICs, or one specific ISIC since in any one area some industries might discharge into different bodies of water.

Double-clicking the table will give a total of all the specified contribution values in the current table on the bottom line. If the total does not equal 100, the user must make corrections.

Water ID is the unique identification of the lake or river as specified in the Inputdef [Lake] or Inputdef [River] window. The field cannot be altered.

Water Description is a descriptive field for the river or lake as specified in the Inputdef [Lake] or Inputdef [River] window. The field cannot be altered.

Water Type is either lake (L) or river (R). The field cannot be altered.

Percent (%) is a number that specifies the percentage of load contribution to water bodies for the area or for the industry within that area. The sum of all percentages must be between 0 and 100. Note that the system does not check the addition.

Emissions to rivers can be calculated per river segment. The total load to the river segment that is farthest downstream can be calculated by adding up all the loads upstream. This can be done separately by adding up the loads of each river segment in a spreadsheet and inputting the loads into the following next segment manually before making the Model Concentration calculations.

WaterInitialConc

The WaterInitialConc function must be started from the menu bar with the **Window | Inputdef | WaterInitialConc** option. An MDI-child window is shown with a static input table. The function is used to specify the initial concentration of pollutants that are observed in the water bodies under consideration.

First, specify the water body with the drop-down list box. Since the media type is always water, Media listbox is inactive and is shown only for consistency.

Pollutant ID is a 10-character text field. It cannot be altered.

Pollutant Description is a 40-character descriptive field. It cannot be altered.

Stability Class contains an integer specifying the class of the pollutant. The values stand for:

Class	*Explanation*
1	Conservative
2	Intermediate
3	Nonconservative

Init.Conc. (mg/l) is the initial concentration in milligrams per liter of the given pollutant within the specified water body.

PointSource

The PointSource function must be started from the menu bar with the **Window | Inputdef | Pointsource** option. An MDI-child window is shown with a dynamic input table. The key field is *PointSource ID*.

Point sources can be added, changed, or deleted after the media type, ISIC, area, and process are selected from the drop-down list boxes at the top of the MDI-child window. If all list boxes contain a value, the spreadsheet is (re)filled with the relevant point sources. Process can be specified only if an ISIC is chosen; the process drop-down list box is filled with all processes within the selected ISIC. From the process list, only actual processes (those with a four-character code) can be selected. The other entries are for reference purposes only.

PointSource ID is a 10-character code. This code should be unique within the selected media type, area, ISIC, and process.

Pointsource Description is a descriptive field of 40 characters.

% of Process is a value specifying the percentage the point source contributes to the total load of the given process.

Annual Operation is the average number of hours a year the point source is in operation.

Stack Height (m) is the stack height of the emitting source in meters.

Internal Diameter (m) is the internal stack diameter of the emitting source in meters.

Exit Gas Volume (m^3/sec) is the exit gas volume in cubic meters per second.

Exit Gas Velocity (m/sec) is the exit gas velocity in meters per second.

Exit Gas Temp. (K) is the exit gas temperature in degrees Kelvin..

Ambient Temp. (K) is the ambient temperature in degrees Kelvin.

Longitude specifies the longitude of the point source. The value is used for exporting point sources to GIS.

Latitude specifies the latitude of the point source. The value is used for exporting point sources to GIS.

Lines of longitude and latitude are measured in degrees, minutes, and seconds, with north, south, east, or west designation. For example: 120°30' 50" W indicates a longitude of 120 degrees, 30 minutes, 50 seconds west of the prime meridian; similarly the measurement 45° 20' 10" N indicates a latitude of 45 degrees, 20 minutes, 10 seconds north of the equator.

The *x*- and *y*-coordinates must be specified in decimal degrees instead of in degrees, minutes, and seconds. Since there are 60 seconds in a minute, 60 minutes in a degree, and 3,600 seconds in a degree, the decimal degrees for a longitude of 120°30' 50" W are [120 + (30 / 60) + (50 / 3600)] = (120 + 0.5 + 0.01) = 120.51 W, or -120.51. Negative signs are used to indicate W or S.

SourceData

The SourceData function must be started from the menu bar with the **Window | Inputdef | SourceData option.** An MDI-child window is shown with a static input table.

This function is used to record observed loads for specific point sources. The recording can be done manually if loads per specific point sources are known, or the load can be calculated when load calculations are made.

Specify the relevant point source with the drop-down list boxes for media, area, and PointSource. The list box for point sources is filled when a choice is made for both media type and area. The list will show all point sources within the selected media type and area.

Pollutant ID is a 10-character text field. It cannot be altered.

Pollutant Description is a 40-character descriptive field. It cannot be altered.

Load (kg/sec) is the actual pollutant load for the specified point source. It must be specified in kilograms per second.

MonitoredConc

The MonitoredConc function must be started from the menu bar with the **Window | Inputdef | MonitoredConc** option. An MDI-child window is shown with a static input table.

This function is used to specify monitored concentration within an area. The specified values are used for the calibration of density factors.

Pollutant ID is a 10-character text field. It cannot be altered.

Pollutant Description is a 40-character descriptive field. It cannot be altered.

Specify the area first with the drop-down list box. The Media listbox is inactive and is shown only for consistency; the media type is always air.

In the four *Station#* (?g/m^3) fields, monitored concentrations can be specified, in micrograms per cubic meter. Each time one of the station values is changed, the average value in the last column is recalculated on the basis of the new inputted value.

The average value can also be inputted to the field *Average* (?g/m^3) itself. It will override the calculated average value with the specified value.

Calculate functions

Calculate functions enable the user to make calculations with the data that were entered into the DSS/IPC database through Inputdef functions. For calculations to be performed properly, the user must enter all the necessary data (see Notes, below). If data are lacking, a warning message appears.

Load...

The pollutant load calculation must be started from the menu bar with the **Window | Calculate | Load...** option. Loads can be calculated by the system, with the results shown in an MDI-child window. First, the Load dialogue box will be presented to a user with the following fields:

- *Area:* a multiple-selection field for specifying one, several, or all areas for which loads need to be calculated.
- *Media:* a multiple-selection field for specifying one, two, or all three media types for which loads need to be calculated.
- *ISIC:* a multiple-selection field for specifying one, several, or all industries for which loads need to be calculated.

- *Pollutant:* a multiple-selection field for specifying one, several, or all pollutants for which loads need to be calculated. When no media type is selected, this list box will remain empty because the set of pollutants is media dependent. When more than one media type is selected, the pollutant list will show the *(ALL)* option only.
- *Calculate:* a check box to specify whether loads need to be calculated. If loads are not calculated, the system will display the results from earlier calculations.
- *Show results:* a check box to specify whether results should be shown.
- *Calculate initial pollutant loads for PointSources:* a check box to specify whether pollutant loads for point sources need to be calculated.
- *Calculate default BOD loads for rivers:* a check box to specify whether BOD loads for rivers need to be calculated. (Newly calculated values replace default values entered by the user in the Inputdef [River] window. The DSS/IPC will display an appropriate warning before proceeding.)

Choosing "OK" results in the calculation of the load if the Calculate box is checked. The status bar contains the message "Load calculation is ongoing. Please wait...". When the calculation is finished, a Load window will be opened containing the load calculation results. It is possible to open more than one Load window at the same time.

The Load window contains totals for each pollutant in the specific area. A relative percentage is given for each process.

Note: The total is not displayed in case a subset [not *(ALL) ISIC*] is selected.

Note: Load calculation requires study areas as well as production data for the areas entered.. The default data for emissions and reduction factors related to processes and reduction measures determine the outcome of the load calculation.

Model...

The model function is used to apply selected dispersion models to the inventory of pollution load data. By taking into account meteorological conditions and the height of the source, the models estimate the potential concentrations of the relevant pollutants in the air and water. Based on the concentration values and on comparisons with criteria standards, a measure of the exposure of the habitat to the most hazardous pollutants can be derived. The calculations must be started from the menu bar with the **Window | Calculate | Model...** option.

Selection of this option results in a Model dialogue box in which a user can specify the selected models and corresponding parameters. The user must be aware that calculated loads are used as inputs for the dispersion models. These calculated loads are the result of the most recent load calculation. If production levels, emissions, or reduction factors are changed without repeating the load calculation routine, the load data will not reflect the most up-to-date situation.

The user will be presented with a dialogue box with the following fields:

- *Model type:* a frame with seven check boxes for specifying which combination of the seven models must be applied. Double-clicking the frame will highlight all current choices. This procedure can be used to select all models.
- *Area:* a multiple-selection field for specifying one, several, or all areas for which loads need to be calculated. This field will be active only when the Area or PointSource model needs to be applied.
- *River:* a multiple-selection field for specifying one, several, or all rivers for which the model is to be applied. This field will be active only when the River conservative, River BOD, or River coliform count model needs to be applied.
- *Lake:* a multiple-selection field for specifying one, several, or all lakes for which the model is to be applied. This field will be active only when the Lake conservative or Lake phosphorus model needs to be applied.
- *Calculate:* a check box for specifying whether the model results need to be calculated. If the models are not calculated the system will show the results from former calculations.
- *Show results:* a check box for specifying whether results should be shown.
  Note: Model calculation requires that load calculation be completed. All models require that specific attributes be entered (the model input parameters). The water conservative models additionally require that load contribution to water bodies be entered as study data.

Model input

Table 2.1 shows, for each of the seven dispersion models, the corresponding Inputdef functions for which the user needs to specify data before the model calculations can begin.

MODEL RESULTS

The results of the computations are individually displayed, with each model in a specific window format:

Model type	*Corresponding window*
Area Model	[Air Area]
PointSource	Model [PointSource]
River conservative, Lake conservative	Model [Water conservative]
River coliform count, River BOD	Model [River coliform/BOD]
Lake phosphorus	Model [Lake phosphorus]

For more information on model calculation, see Ambient Air and Water Concentrations: Dispersion Models in chapter 1 of this guide.

CostAnalysis/What-if...

The Cost Analysis function must be started from the menu bar with the **Window | CostAnalysis/What-if...** option.

Note: Cost analysis requires that the relevant model calculation be completed. The relevant models are the Area model for media type Air Emission, and the Water conservative model for media type Water Effluent. An appropriate warning is shown when the **Window | CostAnalysis/What-if...** option is selected.

Cost analysis can be done according to media type (Water or Air). It will lead a user through the sequence of steps (windows).

1. *Cost Analysis /What-if*
   This empty window appears when the user selects the **Window | CostAnalysis/What-if...** option. It contains only the media drop-down list, in which a user can select either Air Emission or Water Effluent. Immediately after a selection is made in the drop-down list, this window changes into the next one.
2. *Cost Analysis Priority List [ ]*
   This window provides a list of all pollutants and the percentage concentration exceeding the health guidelines. The critical load and the excess load for the pollutant in the specified media are calculated here. The user can select one or more pollutants for further analysis by clicking on the check box in the first column for the desired pollutant.

   Within this window, the pollutant stability class is shown per pollutant.

   By clicking the Next button at the bottom of the window, the user can advance to the next window and continue the cost analysis.
3. *Cost Analysis Contributing List [ ]*
   All contributing processes per pollutant are shown in this window. Within the media type Air, a process is identified by area, ISIC, process title, and process description. Within the media type Water, a process is identified by water body, area, ISIC, process title, and process description. On the basis of production and, for media type Air, the height of the source, the increase in the concentration of a pollutant for each process is calculated. The user may select one or more processes for further analysis by clicking on the check box in the first column for the desired pollutant.

Table 2.1 Model Types and Inputdef Functions

Model type	*Inputdef functions*
Area	Area, Process, *Pollutant/HealthGuidelines, ISIC, Emfactor, ReductionMeasure, ReductionFactor*, Production
PointSource	Area, PointSource, SourceData
River conservative	River, WaterInitialConc, *Process, Pollutant/HealthGuidelines, Emfactor, ReductionMeasure, ReductionFactor*, Load Contribution to WaterBodies, Production
River BOD	River, Load Contribution to WaterBodies, Production
River coliform count	River
Lake conservative	Lake, Load Contribution to WaterBodies, *Process, Pollutant, Emfactor, Reduction Measure, Reduction Factor*, WaterInitialConc, Production
Lake phosphorus	Lake, Load Contribution to Water bodies, Production

Note: The default data Inputdef functions are shown in italics. The user does not have to specify data for these Inputdef functions. They can, however, be changed or added to as relevant for the study at hand.

Note: Process titles are also shown for each contributing process. They cannot be selected for further analysis.

By clicking the Next button at the bottom of the window, the user can go on to the next step of the cost analysis. Clicking the Back button returns the user to the previous step of the cost analysis.

4. *Cost Analysis Cost List [ ]*
   A list of selected industrial processes and their controlled alternatives is shown, allowing the user to compare the effectiveness and costs of alternative, more controlled, processes aimed at reducing the excess loads identified in the priority list. For each process, total costs, average costs, and long-run marginal costs are calculated according to the cost formula built into the system.

   The calculated costs are presented in a list that contains the pollutant, process title category, process description, total cost, process cost per unit of production, and long-run marginal cost per unit of production. (For full details, see the discussion in the sections on Cost Calculation and Long-Run Marginal Costs Calculation in chapter 1 of this guide.)

   By using the check boxes in the first column, an alternative process can be selected instead of the current one.
5. *Graph [Cost Analysis]*
   The "LRMC - Across processes" button displayed at the bottom of the window can be used to open a new Graph [Cost Analysis] window that shows a graph of the long-run marginal costs across all selected processes in the area or watershed. The graph is based on the table shown at the bottom of the window.
6. *WHAT-IF Analysis*
   The Re-analyze button shown at the bottom of the window can be used to run the load and model calculations for alternative processes and reduction measures to be selected and applied. As a result, the user will be returned to a new Cost Analysis Priority List [ ] window with a new priority list, and the process of cost analysis can be started again.

   The Back button returns the user to the previous step of the cost analysis.

Report

The **Report** functions must be started from the menu bar with the **Window | Report** option.

The **Window | Report** option presents a submenu with three possible choices: ***Production, Pollution Load Inventory,*** and ***Ambient Concentration.*** Each choice leads to a dialogue box for a more detailed specification of the data the user wants to see in the report. After all the choices have been specified, an appropriate Report [ ] window is shown.

Every Report [ ] window displays the following buttons on the top line:

- Go to the first page
- Go to the previous page
- Go to the next page
- Go to the last page
- Stop reading report data
- Overview
- Print report

A Report [ ] window displays the following information on the top line:

- *Read:* the number of records actually read
- *Selected:* the number of records that satisfied the selection criteria
- *Total:* the number of records in the database related to the report type
- *%:* Records read as a percentage of the total
- *Page ... of ...:* the number of the current page of the report and the total number of pages in the report

Production...

This function must be started from the menu bar with the **Window | Report | Production...** option. The dialogue box for specifying the contents of the Production report contains the following fields:

- *Area:* a multiple-selection field for specifying one, several, or all areas to be shown in the Production report.
- *Media type:* a multiple-selection field for specifying one, two, or all three media types to be shown in the Production report.
- *ISIC:* a multiple-selection field for specifying one, several, or all ISICs to be shown in the Production report.

After all the selections are made and the user clicks the OK button, the report is generated and is displayed in the Report [Production] window.

Pollution Load Inventory...

This function must be started from the menu bar with the **Window | Report | Pollution Load Inventory...**

option. The dialogue box for specifying the contents of the load report contains the following fields:

- *Area:* a multiple-selection field for specifying one, several, or all areas to be shown in the load report.
- *Media type:* a multiple-selection field for specifying one, two, or all three media types to be shown in the Load report.
- *ISIC:* a multiple-selection field for specifying one, several, or all ISICs to be represented in the Load report.
- *Pollutant:* a multiple-selection field for specifying one, several, or all pollutants to be shown in the Load report. When no media type is selected, this list box will stay empty because the set of pollutants is media dependent. When more than one media type is selected, the pollutant list shows the *ALL* option only.

After all the selections are made and the user clicks the OK button, the report is generated and is displayed in the Report [Pollution Load Inventory] window.

AMBIENT CONCENTRATIONS...

This function must be started from the menu bar with the **Window | Report | Ambient Concentrations...** option. The dialogue box for specifying the contents of the concentration report contains the following fields:

- *Area:* a multiple-selection field for specifying one, several, or all areas to be shown in the concentration report.
- *ISIC:* a multiple-selection field for specifying one, several, or all ISICs to be shown in the concentration report.
- *Pollutant:* a multiple-selection field for specifying one, several, or all pollutants to be shown in the concentration report. The contents of the list depend on the selected model type. For Area or PointSource, the air pollutants are shown in the list. For the WaterBody model type, the water pollutants are shown in the list.
- *Model type*: a radio-type selection option button for specifying which model type must be shown.
- *Show Contributing Processes:* a check box for specifying whether the contributing processes for each pollutant within each area must be shown or whether only concentrations for each pollutant within each area must be given.

Note: Only for model types Air Area, PointSource, or WaterBody are contributing processes given.

After all the selections are made and the user clicks the OK button, the report is generated and is displayed in the Report Concentration [Air Area, PointSource, or Waterbody] window.

Windows list

This group of functions is a numbered list of up to nine titles of open MDI-child windows. The window that is currently active is marked with a check to the left of its number. A user can switch to any window by selecting its title from the list. When more than nine windows are open, an option **More Windows...** appears at the bottom of the list. When the user selects this option, a dialogue box Select Window appears, allowing the user to select any window from the full list.

Help functions

HELP INDEX

[?] This button gives a user access to the on-line help of the DSS/IPC system.

The Help Index function may be started from the menu bar with the **Help | Help Index** option and from the toolbar with the Help button.

This help file will be opened with the contents page.

SEARCH...

The Search function must be started from the menu bar with the **Help | Search...** option.

The help search screen will be opened for the DSS/IPC help file.

USING HELP

The Using Help function must be started from the menu bar with the **Help | Using Help** option.

When this selection is made, Microsoft Windows offers a standard description on how to use the help system.

ABOUT...

The About... function must be started from the menu bar with the **Help | About...** option.

A window is opened with some descriptive information about the DSS/IPC system.

Memory: the amount of free memory that is now available in your computer. This amount can be enlarged by increasing the size of the windows swap file.

Disk: the amount of free disk space on the drive that is currently active.

SystemResources: an indication of how much space is left for opening new windows. This value must not go below plus or minus 4 percent. If it does, it is wise to close some DSS/IPC windows or close some other applications.

Installing and configuring DSS/IPC

Hardware and software requirements

The DSS/IPC system should be run on a personal computer with a Pentium or 486 processor (SX or DX), preferably 33 Mhz. Microsoft Windows 3.1 or later versions should be installed.

Installation

The DSS/IPC system can be installed from a set of diskettes or a single installation file (available on the Internet at www.worldbank.org/pollutionmanagement). If you use an install set, initiate a setup.exe file from the first diskette.

If you have downloaded single installation file IPC-INST.EXE from the Internet or other network, start this file by double-clicking it in Windows File Manager or Windows Explorer.

Follow the instructions given by the Setup program to install the DSS/IPC system. The system will be installed into the directory \IPC on your hard disk C drive, unless otherwise specified.

If a previous version of the DSS/IPC system is present, it is recommended that you first remove that version by removing the directory, using the File Manager.

If other programs are still active, the Setup program might have problems in installing certain components on your system. In this case, messages such as the following will appear:

SETUPKIT.DLL is in Use. Please close all applications, and reattempt setup.

Continue / Cancel / Ignore

You can continue installation by ignoring these messages.

IPC.INI file

The IPC.INI file can be found in the Windows directory. It contains values used to configure the system. The syntax of an INI-file consists of lines with the following syntax:

Variable = value

The DSS/IPC system reads the INI-file and searches for a number of known variables. The following variables, with values, can be found in the IPC.INI file. A short explanation of each is given in the right-hand column below.

Line in INI-file	*Description*
[Preferences]	**Group label**
ImportFileExt = IMP	**Import file extension**
ExportFileExt = ASC	**Export file extension**
IEDirectory = C:\IPC	**Import-export directory**
ShowToolbar = 0	**If the toolbar must be shown, 0 for yes, 1 for no**
AskOnUpdate = 0	**If a user must be asked for confirmation if rows are changed or added, 0 for yes, 1 for no**
[System]	**Group label**
DBPath = C:\IPC	**Full path specification where database files are stored**
FilePath = C:\IPC	**Full path specification where additional files such as *.ico and helpfile are stored**
HelpFile = C:\IPC\IPCHELP.HLP	**Full path specification of the helpfile**
LastOpenDatabase = IPCTEST.MDB	**Name of the last open database (be careful to change this value)**

Decimal points

If decimal points are not shown correctly, the following steps should be taken: from the Program Manager, open the Main Group; open the Control Panel window; select International; and select the following values for the number notation:

- 1000 separation character = ,
- Decimal character = .
- After decimal sign = 6
- Use leading zeros

Specifications

Units of measurement

Unit	*Measurement*
Annual average concentration (air)	?g/m³
Area roughness	m
Area size	km²
Calculated load	ton/year
Coliform count (river)	per 100 ml
Concentration (lake/river)	mg/l
Cost depreciation period	years
Costs	US$
Critical DO deficit (river)	mg/l
Discharge load of substance (lake/river)	ton/year
Distance (point source)	m
Emissions factor	kg/unit of production
Lake annual inflow rate	m³/year
Lake area	m²
Lake calculated load	ton/year
Lake initial concentration	mg/l
Lake evaporation volume	m³/year
Lake mean depth	m
Local energy costs ratio	–
Local labor costs	US$/hour
Local labor costs ratio	–
Local material costs ratio	–
Local maximum concentration (air)	µg/m³
Maximal annual phosphorus discharge (lake)	ton/year
Monitored load	ton/year
Peak concentration (point source)	?g/m³
Point source ambient temperature	degrees Kelvin
Point source annual operation	hours/year
Point source exit gas temperature	degrees Kelvin
Point source exit gas velocity	m/sec
Point source exit gas volume	m³/sec
Point source internal diameter	m
Point source load	kg/sec
Point source stack height	m
Point source *x* coordinate	decimals
Point source *y* coordinate	decimals
Pollutant annual guideline (air)	?g/m³
Pollutant annual guideline (water)	mg/l
Population	people
Process annual operation	hours/year
Process volume	m³/hour
River BOD analysis number of days	days
River BOD analysis temperature	degrees Celsius
River BOD background concentration	mg/l
River BOD load	g/sec
River coliform die-off rate constant at 20°	–
River depth	m
River initial coliform count	per 100 ml
River initial concentration	mg/l
River initial oxygen concentration (DO level)	mg/l
River volume/average flow rate	m³/sec
River water temperature	degrees Celsius
River width	m
River, time since last discharge	days
Stability class (point source)	–
Windspeed (point source)	m/s

Maximum values

Maximum lengths are defined for key fields (see the description of Inputdef functions). No maximums are defined for the number of records within a table, apart from physical constraints such as the size of the hard disk.

Import file formats

Import files contain one or more records separated by a new line character (ASCII value 13). Each record contains fields that are separated by a tab character (ASCII value 9). There is no difference between upper-case and lower-case characters within the ID fields. The layouts on the following pages are valid for the import files:

Production

Media type	One character
	Possible values: A, W, or S
Area ID	Six characters
	Constraint: it must exist in the Area table
ISIC ID	Four characters
	Constraint: it must exist in the ISIC table
Process ID	Exactly four characters
	Constraint: it must exist in the Process table for the specified media type and ISIC
Red. measure ID	One character
	Constraint: it must exist in the Reduction Measure table for the specified process, ISIC, and media type. For media type S, this value is irrelevant.
Production value	Ranges from –2,147,483,648 to 2,147,483,647
Number of sources	Integer value
	Ranges from 1 to 999

Monitored load

Media type	One character
	Possible values: A, W, or S
Area ID	Six characters
	Constraint: it must exist in the Area table
ISIC ID	Four characters
	Constraint: it must exist in the ISIC table
Process ID	Exactly four characters
	Constraint: it must exist in the Process table for the specified media type and ISIC
Red measure ID	One character
	Constraint: it must exist in the Reduction Measure table for the specified process, ISIC, and media type. For media type S, this value is irrelevant.
Pollutant ID	Ten characters
	Constraint: it must exist in the Pollutant table for the specified media type, area ID, ISIC ID, and process ID
MonitoredLoad	Range from -2,147,483,648 to 2,147,483,647

Monitored concentration

Media type	One character Possible values: A, W, or S
Area ID	Six characters Constraint: it must exist in the Area table
ISIC ID	Four characters Constraint: it must exist in the ISIC table
Process ID	Exactly four characters Constraint: it must exist in the Process table for the specified media type and ISIC
Red. measure ID	One character Constraint: it must exist in the Reduction Measure table for the specified process, ISIC, and media type. For media type S, this value is irrelevant.
Pollutant ID	Ten characters Constraint: it must exist in the Pollutant table for the specified media type, area ID, ISIC ID, and process ID
MonitoredConc.	Ranges from -2,147,483,648 to 2,147,483,647

Chapter 3

Self-Training Computer Exercise

Introduction

The purpose of this exercise is to familiarize users with the application of the DSS/IPC and to demonstrate how the outcomes of the analysis can be used in assessing decisions on pollution control targets, policies, and instruments. The exercise will help develop a better understanding of how to translate economic and physical information on an area into DSS/IPC inputs and what kinds of problems and situations can be analyzed with the help of the DSS/IPC. The case study was specially designed for illustrative and training purposes. It describes a hypothetical and simplified situation, which, however, allows the user to examine some typical pollution control problems and tradeoffs in urban areas.

General information on the study area

The Emerald City, population 900,000, covers an area of 100 km^2. It is situated along the Winkie River. Within and near the city, the river has a width of 500 m, an average depth of 5 m, and an average flow of 250m^3/sec. Upstream of the city, water in the river is considered clean. Near the city is Skeezer Lake, with an area of 125,000 m^2 and an average depth of 10 m. Total annual inflow to the lake (precipitation, catchment drainage, and direct discharges) is, on average, 80 million m^3, and annual evaporation is nearly 10 million m^3. Until recently, water in the lake was almost pristine. The annual mean water temperature for both river and lake is 10° Celsius. Atmospheric conditions, in terms of frequencies of atmospheric stability and

Table 3.1 Atmospheric conditions in the study area

Atmospheric stability	*Wind speed (m/s)*	*Frequency factor (0–1)*
Unstable	Very low (2 m/s)	0
	Low (2–5 m/s)	0
	Moderate (5–7.5 m/s)	0.1
	High (> 7.5 m/s)	0.2
Neutral	Very low (2 m/s)	0.1
	Low (2–5 m/s)	0.2
	Moderate (5–7.5 m/s)	0.2
	High (> 7.5 m/s)	0.1
Stable	Very low (2 m/s)	0.1
	Low (2–5 m/s)	0
	Moderate (5–7.5 m/s)	0
		1.0

Note: The frequency factors must add to 1.

wind speed combinations, that greatly affect dispersion patterns of air emissions are given in Table 3.1.

Industries, transport, and services. Major industries include a steel mill that produces 800,000 tons of metal per year at its two facilities; one large cement plant with five emission stacks that processes 10 million tons of clink per year; three textile factories that process, respectively, 330,000 tons of cotton, 120,000 tons of wool, and 150,000 tons of synthetics per year; and two meat-processing plants with an overall capacity of 100,000 tons live weight of animals killed (LWK). A meat plant that began operations two years ago is currently the only industrial facility to discharge wastewater into the lake. (The plant's discharges account for 50 percent of total discharges from the meat industry.) All other industries, as well as two main municipal sewers serving the entire population of the city, discharge into the river. In addition, 30 large industrial and district-heating boilers burn 1.5 million tons of coal per year, and 200,000 tons of coal are used in small boilers and stoves by 100 other industrial and commercial establishments. Road transport in the Emerald City consists of 100,000 gasoline-powered cars (average annual mileage per car, 10,000 km) and 60,000 diesel-powered buses and trucks (average annual mileage per vehicle, 20,000 km).

Prices and wages. The average wage is US$5/hour; energy and material prices are at the world market level. The commercial interest rate is 10 percent.

Pollution control. Currently, pollution controls are few and include only primitive cyclones (removal efficiency, 75 percent) at the cement plant and primary wastewater treatment at the cotton-processing factory. Recently, however, the government has made commitments to pay much greater attention to the quality of the environment and has set ambient quality targets (in terms of annual mean concentrations of key pollutants), including the following:

Air quality. First step: reduce the ambient level of particulates to or below 70 $\mu g/m^3$. Second step: reduce the ambient level of particulates below 50 $\mu g/m^3$.

Water quality. The ambient level of BOD_5 should not exceed 4 mg/l for both river and lake.

Assignments

Users are requested to complete the following assignments for a computer exercise:

- Set up a study for the Emerald City.
- Input the information given above according to the format required by the DSS/IPC software.
- Make all necessary calculations (loads, concentrations, and costs of abatement).
- Export the results into Excel, analyze the results, and answer the questions and problems given below.

Questions and problems

AIR

1. Which pollutants have to be controlled first ("worst pollutants")?
2. Which pollution sources have to be controlled first ("worst polluters")?
3. Identify two sets of pollution control measures at specific point sources that will allow for a least-cost reduction of the annual mean ambient levels of particulates to (a) 70 $\mu g/m^3$ and (b) 50 $\mu g/m^3$. *Tip:* on the basis of DSS/IPC calculations for this study, a 1,000-ton reduction in emissions of total suspended particulates (TSP) emissions from major industries results in a 0.4 $\mu g/m^3$ reduction in the mean ambient level of TSP.
4. How much do these two sets of measures cost? What should be the rate of an emission charge on particulates that would force industries to implement set (a)? set (b)?
5. Which set of measures would you recommend be implemented? Why? What additional measures would have to be considered if the ambient target for particulates were set at 40 $\mu g/m^3$?

WATER

1. Assess and compare water quality in the river and the lake. Where is the current situation worse?
2. Identify and compare major pollution sources for the river and the lake.
3. Identify least-cost sets of pollution abatement measures that will reduce the ambient level of BOD_5 below 4 mg/l (a) in the river; and (b) in the lake. What are the costs?

4. What emissions (effluent) charge on BOD_5 discharges should be used to achieve the desired ambient quality target (e.g., an annual mean concentration of BOD_5 equal to or below 4 mg/l) (a) in the river, (b) in the lake, and (c) in both the river and the lake?
5. Which level charge would you recommend? Why? Is the target level for BOD_5 reasonable, or would you suggest a different approach?

Additional problems

The following are advanced-level problems that require the completion of new rounds of calculations.

Air

Compare the environmental impact (e.g., the impact on ambient levels of particulates and sulfur dioxide, SO_2) of the following measures for 30 large industrial and district heating boilers that operate in the city:

- Installation of cyclones at each boiler
- Use of better-quality coal, with both ash content and sulfur content being half those in the coal initially used
- Use of natural gas instead of coal (assuming that the heating value of coal is 7.2×10^3 Kcal per ton and the heating value of natural gas is 9.34×10^9 Kcal per m^3)
- Replacement of 20 district-heating boilers with one centralized utility with a high stack and a high level of control, while using the same coal.

Water

A new cotton factory to be built in the city will increase the cotton-processing capacity of the local textile industry by 30 percent.

- Where would you recommend that the new factory be located (and its effluents be discharged): on the river or on the lake? (*Note:* to solve this problem, the user will have to create two study areas representing "lake watershed" and "river watershed" and assign each industry to one of these areas, according to the discharges. For example, one meat plant will be in the "lake" area and the other in the "river" area. In this setting, 100 percent of all discharges from all sources in an area will be allocated to the lake or river, respectively.)
- What set of measures will be required to keep the ambient BOD_5 level below 4 mg/l?

Step-by-step instructions: Emerald City pollution analysis

A. Create a new study

1. From menu bar, select **File**, then **New**.
2. When **Study [New]** dialogue box appears, fill empty fields
   a. In the field **Study Name,** enter **Emerald1.**
   b. In the field **Study Description,** enter **Emerald City pollution analysis.**
   c. In the field **Owner,** enter your initials.
   d. Fields **Creation Date** and **Modific.Date** should already show today's date.
3. Click **OK** button and wait while DSS/IPC creates a new study.

B. Change default health guidelines

1. From menu bar, select **Window**, then **Inputdef**, then **Pollutant/HealthGuidelines.**
2. In the drop-down list **Media** within **Pollutant[HealthGuidelines]** window, select **Air Emission.**
3. For the row **TSP** in the spreadsheet, change value in the field **Ann.Avg.Guideline** from **75** to **70.**
4. Click the next row. If DSS/IPC asks for confirmation to update the previous row, click **OK** button.
5. In the drop-down list **Media** within **Pollutant[HealthGuidelines]** window, select **Water Effluent.**
6. For the row **BOD5** in the spreadsheet, in the field **Ann.Avg.Guideline,** enter value **4.**
7. Click the next row. If DSS/IPC asks for confirmation to update the previous row, click **OK** button.

C. Enter information about the area

1. From menu bar, select **Window**, then **Inputdef**, then **Area**.
2. When warning **No data found!** appears, click **OK** button.
3. In **Inputdef [Area]** window, fill empty fields:
   a. In the field **Area ID,** enter any code of 6 characters or less, e.g., **Area1**.
   b. In the field **Area Description,** enter **Emerald City.**
   c. In the fields **Population, Size, Labor Cost,** and **F11–F33,** enter data from General Description above.
   d. In the field **Labor Ratio,** enter **0.25** (since specified labor cost of $5/hr is four times less than the default cost of $20/hr).
   e. All other fields: leave with default values or empty.
4. Click the next row. If DSS/IPC asks for confirmation to insert the previous row, click **OK** button.

D. Enter information about the lake

1. From menu bar, select **Window**, then **Inputdef**, then **Lake**.
2. When warning **No data found!** appears, click **OK** button.
3. In **Inputdef [Lake]** window, fill empty fields:
   a. In the field **Water ID,** enter any code of 6 characters or less, e.g., **Lake**.
   b. In the field **Water Description,** enter **Skeezer Lake**.
   c. In the fields **Area, Inflow, Evaporation,** and **Mean Depth,** enter data from General Information.
4. Click the next row. If DSS/IPC asks for confirmation to insert the previous row, click **OK** button.

E. Enter information about the river

1. From menu bar, select **Window**, then **Inputdef**, then **River**.
2. When warning **No data found!** appears, click **OK** button.
3. In **Inputdef [River]** window, fill empty fields:
   a. In the field **Water ID,** enter any code of 6 characters or less, e.g., **River**.
   b. In the field **Water Description,** enter **Winkie River**.
   c. In the fields **Mean Depth, Avg.Flow, Temp.,** and **Width,** enter data from General Information.
   d. All other fields: leave with default values or empty.
4. Click the next row. If DSS/IPC asks for confirmation to insert the previous row, click **OK** button.

F. Change defaults to speed up data input

1. From menu bar, select **Options**, then **Defaults...**
2. In **Defaults** window, select two first fields:
   a. In the field **Area,** select the code and description you entered for the Emerald City area.
   b. In the field **Media,** enter **Air Emission.**
3. Click **OK** button.

G. Enter production data for industries emitting into the air

1. From menu bar, select **Window**, then **Inputdef**, then **Production.**
2. When information message appears, click **OK** button.
3. In **Inputdef [Production]** window, **Area** and **Media** fields should already show default values.
4. In the field **ISIC**, select **3710**. When DSS/IPC asks for confirmation to fill spreadsheet with selection data, click **OK** button. In the spreadsheet, enter data into the row for **Process ID &BUA**:
   a. **Production** **800**
   b. **Number of sources** **2**
   c. Click the next row. If DSS/IPC asks for confirmation to update the previous row, click **OK** button.

5. Repeat previous steps for the following combinations:

ISIC	*Process ID*	*Production*	*Number of sources*
4101	BFUA	1,500	30
4101	CEUA	200	100
7112	BBUA	1,000	100,000
7112	EBUA	1,200	60,000

6. In the field **ISIC**, select **3692**. When DSS/IPC asks for confirmation to fill spreadsheet with selection data, click **OK** button. In the spreadsheet, enter data into the row for **Process ID &BUA**:
   a. **Production** **10,000**
   b. **Number of Sources** **5**
   c. **Reduction Measure** **PM control moderate (75%)**
   d. If DSS/IPC asks for confirmation to update the row, click **OK** button

H. Change defaults to speed up data input

1. From menu bar, select **Options**, then **Defaults...**
2. In **Defaults** window, select two first fields:
   a. In the field **Area,** select the code and description entered for the Emerald City area.
   b. In the field **Media,** enter **Water Effluent.**
   c. In the field **River,** select the code and description you entered for the Winkie River.
   d. In the field **Lake,** select the code and description you entered for Skeezer Lake.
3. Click **OK** button.

I. Enter production data for industries discharging into the water bodies

1. From menu bar, select **Window**, then **Inputdef**, then **Production.**
2. When information message appears, click **OK** button.
3. In **Inputdef [Production]** window, **Area** and **Media** fields should already show default values.
4. In the field **ISIC**, select **3111**. When DSS/IPC asks for confirmation to fill spreadsheet with selection data, click **OK** button. In the spreadsheet, enter data into the row for **Process ID &AUA**:
   a. **Production** **100**
   b. **Number of Sources** **2**
   c. Click the next row. If DSS/IPC asks for confirmation to update the previous row, click **OK** button.
5. Repeat previous steps for the following combinations:

ISIC	*Process ID*	*Production*	*Number of sources*
3210	&AUA	120	1
3210	&CUA	150	1
3710	&AUA	800	2
9200	ABUA	900	2

6. In the field **ISIC,** select **3210** again (to enter data for cotton factory that include not only production but also reduction measure). When DSS/IPC asks for confirmation to fill spreadsheet with selection data, click **OK** button. In the spreadsheet, enter data into the row for **Process ID &BUA**:
   a. **Production** **330**
   b. **Number of Sources** **1**
   c. **Reduction Measure** **Primary sedimentation**
   d. If DSS/IPC asks for confirmation to update the row, click **OK** button

J. Enter load contributions to water bodies

1. From menu bar, select **Window**, then **Inputdef**, then **Load Contribution to WaterBodies**.
2. In **Inputdef [Load Contribution to WaterBodies]** window, **Area** field should already show default value.
3. In the field **ISIC**, select **3111**. A spreadsheet appears with two rows, one for Skeezer Lake, another for Winkie River. In the far right-hand column, **Percent (%)**, enter distribution of discharges according to General Information.
   a. In the field **Percent (%)**, for Winkie River enter **50.**
   b. Click the previous row. If DSS/IPC asks for confirmation to update the current row, click **OK** button.
   c. In the field **Percent (%)**, for Skeezer Lake enter **50.**
   d. Click the next row. If DSS/IPC asks for confirmation to update the current row, click **OK** button.
4. Repeat steps (a) and (b) above for the following combinations:

ISIC	*Percent (%)*
3210	**100**
3231	**100**
3710	**100**
9200	**100**

Steps (c) and (d) can be skipped, since for these industries there are no discharges to the lake.

K. Calculate pollution loads for both media

1. From menu bar, select **Window**, then **Calculate**, then **Load...**
2. When information message appears, click **OK** button.
3. In **Load** dialogue box, **Area** and **Media** fields should already show default values. In the field **Media**, add **Air Emission** by keeping Ctrl key down and clicking on the row in the list of media. In the fields **ISIC** and **Pollutant**, select **(ALL)**.
4. Make sure that check boxes **Calculate** and **Show results** are checked.
5. Click **OK** button and wait while DSS/IPC calculates loads.

L. Export loads to Excel

1. From menu bar, select **File**, then **Export**, then **Window to Excel...** (or click **Export to Excel** button on toolbar).
2. When **Export to Excel** dialogue box appears, enter the name of the file (e.g., **LOAD.ASC**) and click **OK** button.
3. When a message confirming export appears, click **OK** button.

M. Calculate pollutant concentrations in both media

1. From menu bar, select **Window**, then **Calculate**, then **Model...**
2. When information message appears, click **OK** button.
3. In **Model** dialogue box, fields **Area, River,** and **Lake** should already show default values. In **Model Type** check boxes, check **Area**, **River Conservative**, **Lake Conservative,** and **Lake Phosphorus**.
4. Make sure that check boxes **Calculate** and **Show results** are checked.
5. Click **OK** button and wait while DSS/IPC calculates pollutant concentrations.
6. Review the results in three windows: **Model [Air Area]**, **Model [Water conservative]**, and **Model [Lake phosphorus]**.

N. Build and analyze water priority list

1. From menu bar, select **Window**, then **CostAnalysis/What-if...**
2. Wait while DSS/IPC calculates priority list.
3. Analyze the spreadsheet, particularly the two rightmost columns. Note the relationship between pollutants that exceed health guidelines concentrations (previous step) and critical and excess pollution loads (current step).
4. Select gray check boxes for the row **BOD5** (both lake and river) and make sure that they are checked with red marks.

O. Export water priority list to Excel

1. From menu bar, select **File**, then **Export**, then **Window to Excel...** (or click **Export to Excel** button on toolbar)
2. When **Export to Excel** dialogue box appears, enter the name of the file (e.g., **PRIOR-W.ASC**) and click **OK** button.
3. When a message confirming export appears, click **OK** button.

P. Build and analyze water contributing list

1. Click **Next** button and wait while DSS/IPC calculates contributing list.
2. Analyze the list.
3. Click check boxes for all the rows where **Ann.Avg.Conc.** values are not zeros, and make sure that they are checked with red marks.

Q. Export water contributing list to Excel

1. From menu bar, select **File**, then **Export**, then **Window to Excel...** (or click **Export to Excel** button on toolbar)
2. When **Export to Excel** dialogue box appears, enter the name of the file (e.g., **CONTR-W.ASC**) and click **OK** button.
3. When a message confirming export appears, click **OK** button.

R. Build and analyze cost list and lake LRMC graph

1. Click **Next** button and wait while DSS/IPC calculates cost list.
2. Review the list, particularly the rightmost column.
3. Select (highlight) any row containing lake data by clicking on its number in the leftmost column of the spreadsheet.
4. Click **LRMC – Across processes** button and wait while DSS/IPC builds LRMC graph for the lake.
5. Analyze the graph.

S. Export lake LRMC graph table to Excel

1. From menu bar, select **File**, then **Export**, then **Window to Excel...** (or click **Export to Excel** button on toolbar)
2. When **Export to Excel** dialogue box appears, enter the name of the file (e.g., **LRMC-L.ASC**) and click **OK** button.
3. When a message confirming export appears, click **OK** button.

T. Build and analyze river LRMC graph

1. From menu bar, select **Window**, then **Cost Analysis Cost List [Water]** in the Window List
2. Select (highlight) any row containing river data by clicking on its number in the leftmost column of the spreadsheet.
3. Click **LRMC – Across processes** button and wait while DSS/IPC builds LRMC graph for the river.
4. Analyze the graph.

U. Export river LRMC graph table to Excel

1. From menu bar, select **File**, then **Export**, then **Window to Excel...** (or click **Export to Excel** button on toolbar).
2. When **Export to Excel** dialogue box appears, enter the name of the file (e.g., **LRMC-R.ASC**) and click **OK** button.
3. When a message confirming export appears, click **OK** button.

V. Build and analyze air priority list	1. Change default media back to air. From menu bar, select **Options**, then **Defaults...**; then in **Defaults** window select **Air Emission** in the field **Media** and click "**OK**" button . 2. From menu bar, select **Window**, then **CostAnalysis/What-if...** 3. Wait while DSS/IPC calculates priority list. 4. Analyze the spreadsheet, particularly the two rightmost columns. Note the relationship between pollutants that exceed health guidelines concentrations and critical and excess pollution loads. 5. Select gray check boxes for the row **TSP, SO2,** and **NOX** and make sure that they are checked with red marks.
W. Export air priority list to Excel	1. From menu bar, select **File**, then **Export**, then **Window to Excel...** (or click **Export to Excel** button on toolbar). 2. When **Export to Excel** dialogue box appears, enter the name of the file (e.g., **PRIOR-A.ASC**) and click **OK** button. 3. When a message confirming export appears, click **OK** button.
X. Build and analyze air contributing list	1. Click **Next** button and wait while DSS/IPC calculates contributing list. 2. Analyze the list. 3. Click check boxes for all the rows with **TSP** except for **Road Transport** and make sure that they are checked with red marks.
Y. Export air contributing list to Excel	1. From menu bar, select **File**, then **Export**, then **Window to Excel...** (or click **Export to Excel** button on toolbar). 2. When **Export to Excel** dialogue box appears, enter the name of the file (e.g., **CONTR-A.ASC**) and click **OK** button. 3. When a message confirming export appears, click **OK** button.
Z. Build and analyze air cost list and LRMC graph	1. Click **Next** button and wait while DSS/IPC calculates cost list. 2. Analyze the list, particularly the rightmost column. 3. Select (highlight) the first row by clicking on the number 1 in the leftmost column of the spreadsheet. 4. Click **LRMC – Across processes** button and wait while DSS/IPC builds LRMC graph. 5. Analyze the graph .
AA. Export air LRMC graph table to Excel	1. From menu bar, select **File**, then **Export**, then **Window to Excel...** (or click **Export to Excel** button on toolbar). 2. When **Export to Excel** dialogue box appears, enter the name of the file (e.g., **LRMC-A.ASC**) and click **OK** button. 3. When a message confirming export appears, click **OK** button.
AB. Finalize the analysis in Excel	1. Open your 8 files in Excel. 2. Use information in the files to answer the questions.

Answers to the problems

Air

1. Pollutants whose levels exceed the health guidelines are TSP (120 μg/m^3), SO_2 (58 μg/m^3), and NO_x (184 μg/m^3).
2. Major contributors to the ambient levels:
   TSP: cement industry, large coal boilers, and diesel transport; then small coal boilers and stoves, and steel industry
   SO_2: small coal boilers and stoves, diesel transport, and large coal boilers
   NO_x: road transport.
3. (a) The least-cost strategy for achieving the level of less than 70 μg/m^3 TSP includes the following measures: high PM controls (~90 percent), supported by waste prevention programs and good housekeeping (WPP/GH), at the cement plant; WPP/GH at the steel mill; and moderate PM controls (~75 percent) at large coal boilers. (b) To achieve a level of less than 50 μg/m^3 TSP, the following measures should be implemented: high controls (~90 percent) at large coal boilers; very high controls (~98 percent) at the steel mill; and very high controls (~98 percent) at the cement plant. Note that transport sector measures are not included in the analysis.
4. The annualized cost is US$1.3 million for the first set of measures and nearly US$11 million for the second set of measures. To provide sufficient incentive to achieve the targeted level of pollution abatement, the emission charge on TSP should be set at US$13/ton for program (a) and US$363/ton for program (b).
5. The second set of measures largely exhausts the potential for controlling large sources. Further improvement in the pollution situation—i.e., reducing the ambient levels of particulates below 40 μg/m^3—requires controls on transport and small-source emissions.

Water

1. The annual average BOD_5 level is slightly higher in the river (12.5 mg/l) than in the lake (11.6 mg/l) but in both cases exceeds the target level.
2. There is only one pollution source for the lake—the new meat-processing plant. The major sources of BOD_5 in the river are textile manufactures (especially cotton and wool) and municipal sewage. The contribution of the other meat plant is small.
3. (a) The least-cost set of measures to reduce the average ambient level of BOD_5 in the river below 4 μg/m^3 includes adoption of WPP/GH at the wool-processing textile factory and the meat plant; biological and chemical treatment of municipal sewage; upgrading of wastewater treatment at the cotton-processing factory from primary to secondary and tertiary treatment, complemented by WPP/GH; and secondary treatment (with WPP/GH) at the textile factory that manufactures synthetics materials. The annualized cost of this program is US$20.3 million. (b) To reduce the BOD_5 level below 4 μg/m^3 in the lake, it is necessary to implement primary (with chemicals) treatment at the meat plant, in addition to WPP/GH. The cost is US$48,000 per year.
4. A pollution charge of US$767/ton BOD_5 would encourage the implementation by industries and municipal services of pollution abatement measures that are needed to clean up the river. To create a similar incentive for the meat plant discharging to the lake, the charge rate should be raised to US$1,043/ton BOD_5.
5. The answer depends on individual judgment; discussion with other users would be helpful in maximizing the benefit of the exercise.

Advanced Questions

Answers should be compared with those of others doing the problems.

Annex A

Derivation of the Limit Concentration Values for Selected Air and Water Pollutants in the DSS/IPC

Abbreviations are as follows: AW, atomic weight; GLV, general limit value; kPa, kiloPaskale; MW, molecular weight.

Ammonia

Evaluation date: 6-94

General description

Ammonia is a colorless gas with a strong, penetrating odor. It is extremely soluble in water up to a concentration of 530 g/l at 20°C, forming ammonium- and hydroxy ions. In the atmosphere, ammonia is converted into nitrogen oxide when it reacts with hydroxyl free radicals. The vapor pressure is 882 kPa at 20°C [1, 2, 3].

MW: 17

1 ppm = 0.8 mg/m^3

Odor threshold in air: 0.8–4 mg/m^3

Evaluation for air

Since there were no indications for a carcinogenic activity and since ammonia is not genotoxic, a threshold extrapolation method was used to derive a RECOMMENDED VALUE.

Long-term studies in animals have not shown any effects at levels below 35 mg/m^3. Only high-level accidental exposures pose an occasional acute health hazard (temporary blindness, severe eye damage, irritation of the glottis) for the general population [1, 2, 4]. An occupational limit value of 18 mg/m^3 was derived to protect against irritation to eyes and respiratory tract and minimize discomfort among uninured workers [4].

By applying a factor of 10^{-2} to the occupational limit value, a RECOMMENDED VALUE of 180 mg/m^3 has been derived.

Peak exposure: The threshold for irritating effects is 16–50 mg/m^3, while the estimated lethal concentration for humans is 5,000–10,000 mg/m^3. Workers did not have any respiratory complaints at concentrations below 500 mg/m^3. A short-term occupational exposure limit of 27 mg/m^3 has been derived to protect uninured workers [4].

A RECOMMENDED VALUE$_{peak}$ of 2,700 mg/m^3 has been derived by applying a factor of 10^{-1} to the short-term exposure limit.

References

1. WHO (World Health Organization)/IPCS. 1986. Environmental Health Criteria 54: "Ammonia." Geneva.
2. WHO (World Health Organization)/IPCS. 1994. Environmental Health Criteria. "Nitrogen Oxides." First draft. Geneva.
3. WHO (World Health Organization). 1993. *Guidelines for Drinking Water Quality*. Vol. 1: *Recommendations,* p. 40. 2d ed. Geneva.
4. ACGIH (American Conference of Governmental Industrial Hygienists). 1986. *Documentation of the Threshold Limit Values and Biological Exposure Indices*. 5th ed. Cincinnati, Ohio.

Carbon monoxide

Compartment: air

Evaluation date: 1-94

Physical and chemical properties

Carbon monoxide is a colorless, odorless, tasteless gas that is slightly soluble in water [1, 2].

MW: 28

1 ppm = 1.15 mg/m^3

Evaluation for air

Since there were no indications that carbon monoxide is a genotoxic carcinogen, a threshold extrapolation method was used to derive a RECOMMENDED VALUE.

WHO derived a 8h GLV of 10 mg/m^3 to protect people against cardiovascular and neurobehavioral effects [1].

By correcting the WHO GLV of 10 mg/m^3 by linear extrapolation for continuous exposure, an RECOMMENDED VALUE of 3,300 mg/m^3 was established.

Peak exposure: WHO derived a 1h GLV of 30 mg/m^3 to prevent carboxy hemoglobin levels from exceeding 2.5-3% in nonsmoking populations [1]. Therefore a RECOMMENDED $VALUE_{peak}$ of 30,000 mg/m^3 has been established.

References

1. WHO (World Health Organization). 1987. *Air Quality Guidelines for Europe.* WHO Regional Publications, European Series, 23. Copenhagen.
2. WHO (World Health Organization)/IPCS. 1979. Environmental Health Criteria 13: "Carbon Monoxide." Geneva.

Cyanide (CN)

Compartment: drinking water

Evaluation date: 8-93

General description

Cyanide is a cation formed by dissociation of, e.g., hydrogen cyanide, sodium cyanide, or potassium cyanide. It is very soluble in water. It is used in several metal treatment industries [2].

MW: 26

Evaluation for drinking water

WHO derived a GLV of 0.07 mg/l based on effects on behavior and serum biochemistry observed in a 6 m pig study [1]. Therefore a RECOMMENDED VALUE of 0.07 mg/l has been established.

References

1. WHO (World Health Organization). 1993. *Guidelines for Drinking Water Quality.* Vol. 1: *Recommendations,* p. 46. 2d ed. Geneva.
2. *The Merck Index: An Encyclopedia of Chemicals, Drugs and Biologicals.* 1989. 11th ed. Merck & Co.

Hydrogen fluoride

Compartments: air and drinking water

Evaluation date: 11-93

General description

Hydrogen fluoride is a colorless gas (above 19°C) or liquid with a pungent odor. It is completely soluble in water [3, 5].

MW: 20

1 ppm = 0.8 mg/m^3

Odor threshold = 0.03 mg/m^3 [4]

Evaluation for air

Since there were no indications that hydrogen fluoride is a genotoxic carcinogen, a threshold extrapolation method was used to derive a RECOMMENDED VALUE.

Repeated exposure of experimental animals to a concentration of 5.6 mg/m^3 resulted in mild irritation of the respiratory tract; exposure to 13.6 mg/m^3 resulted in damage to the lungs, liver, and kidneys. In animals exposed to 2.5 mg/m^3, no injurious action was observed [3].

In humans, exposure to concentrations higher than 2.4 mg/m^3 resulted in redness of the skin and in burning and irritation of nose and eyes [3]. No skeletal fluorosis was seen in workers exposed for less than 10 y at levels estimated to be no greater than 2.5 mg/m^3 [5]. An occupational limit value of 2 mg/m^3 (as F) [1, 2] and an occupational ceiling limit of 2.5 mg/m^3 [3] were derived.

By applying a factor of 10^{-2} to the occupational limit value of 2 mg/m^3, a RECOMMENDED VALUE of 20 mg/m^3 was established.

References

1. SZW (Dutch Ministry of Social Affairs and Work Procurement), Dutch Expert Committee for Occupational Standards. 1992. "List of Dutch MAC Values 1992" (in Dutch).
2. SZW (Dutch Ministry of Social Affairs and Work Procurement), Dutch Expert Committee for Occupational Standards. 1986. "A Health-Based Recommended Occupational Exposure Limit for Fluorine, Hydrogen Fluoride, and Inorganic Fluoride Compounds." Report 8605 R.
3. ACGIH (American Conference of Governmental Industrial Hygienists). 1986. *Documentation of the Threshold Limit Values and Biological Exposure Indices.* 5th ed. Cincinnati, Ohio.
4. Van Gemert, L. J., and A. H. Nettenbreier. 1977. *Compilation of Odor Threshold Values in Air and Water.* National Institute for Water Supply, Central Institute for Nutrition and Food Research TNO, the Netherlands.
5. ATSDR (Agency for Toxic Substances and Disease Registry). 1991. *Toxicological Profile for Fluorides, Hydrogen Fluoride and Fluorine (F).* ATSDR/TP-91/17. Atlanta, Georgia.

Hydrogen sulfide

Compartment: air

Evaluation date: 8-93

General description

Hydrogen sulfide is a flammable gas with a characteristic odor of rotting eggs. Its solubility in water is 4.1 g/l. It is used in the manufacture of chemicals, in metallurgy, and as an analytical agent [1].

MW: 34.1

Evaluation for air

WHO derived a GLV of 150 mg/m^3 based on eye irritation occurring at exposure to 15 mg/m^3 [1].

Therefore a RECOMMENDED VALUE of 150 mg/m^3 has been established.

References

1. *The Merck Index: An Encyclopedia of Chemicals, Drugs and Biologicals.* 1989. 11th ed. Merck & Co.
2. WHO (World Health Organization). 1987. *Air Quality Guidelines for Europe.* WHO Regional Publications, European Series 23, p. 233. Copenhagen.

Lead

Compartments: air and drinking water

Evaluation date: 8-93

General description

Lead is a bluish or silvery-gray soft metal used in the production of lead acid batteries. It is also used in plumbing fittings, as an antiknock compound in gasoline, and as solder in water distribution systems [1, 2].

AW: 207

1 ppm = 8.5 mg/m^3

Evaluation for air

The IARC concluded that the evidence for carcinogenicity of lead was inadequate in humans and sufficient (inorganic lead) or inadequate (organolead) in animals (IARC group 2B or group 3) [3]. To derive a RECOMMENDED VALUE, a threshold extrapolation method was used.

WHO derived a GLV of 1 mg/m^3 based on a long-term human study in which elevated protoporphyrine was observed [1]. Given the latest research on the adverse impact of lead, a RECOMMENDED VALUE of 0.5 mg/m^3 has been established.

Evaluation for drinking water

WHO derived a GLV of 0.01 mg/l based on increased blood lead levels observed in metabolic studies with infants [2]. Therefore a RECOMMENDED VALUE of 0.01 mg/l has been established.

References

1. WHO (World Health Organization). 1987. *Air Quality Guidelines for Europe.* WHO Regional Publications, European Series 23, p. 242. Copenhagen.
2. WHO (World Health Organization). 1993. *Guidelines for Drinking Water Quality.* Vol. 1: *Recommendations,* p. 49. 2d ed. Geneva.
3. IARC (International Agency for Research on Cancer). 1987. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Suppl.7: Over-

all Evaluation of Carcinogenicity: An Updating of IARC Monographs Vols. 1 to 42. Lyon, France.

Nitrogen dioxide

Compartment: air

Evaluation date: 2-94

Physical-chemical properties

Nitrogen dioxide is a reddish-brown gas or a colorless liquid (below 21°C). It can be spontaneously formed by oxidation of nitric oxide (NO) in air. Nitrogen dioxide is soluble in water and decomposes, forming nitric oxide and nitric acid. It is a precursor of ozone (O_3) in the ambient air (see below).

MW: 46

1 ppm = 2 mg/m^3

Odor threshold: 220–440 mg/m^3

Evaluation for air

Since there are no indications that nitrogen dioxide is a genotoxic carcinogen, a threshold extrapolation method was used to derive a RECOMMENDED VALUE.

Inhalation of concentrations of 20–40 mg/m^3 were mildly irritating to the eyes, nose, and respiratory tract [1]. At exposure levels above 3.8 mg/m^3 clear changes occur in the pulmonary function of healthy humans. A mild effect has been reported at 0.9 mg/m^3 for asthmatics and at 1.9 mg/m^3 for normal subjects. Therefore, WHO derived a GLV of 150 mg/m^3 [2].

Based on the GLV, a RECOMMENDED VALUE of 150 mg/m^3 has been established.

Peak exposure: In asthmatics exercising during exposure to 560 mg/m^3 a change in pulmonary function occurred within the physiological range. In humans exposed for 1 h/d to 500 mg/m^3 no adverse effects were observed. Based on these observations, WHO derived a 1 h GLV of 400 mg/m^3 [2]. Therefore, a RECOMMENDED VALUE$_{peak}$ of 400 mg/m^3 has been established.

References

1. ACGIH (American Conference of Governmental Industrial Hygienists). 1986. *Documentation of the Threshold Limit Values and Biological Exposure Indices*. 5th ed. Cincinnati, Ohio.
2. WHO (World Health Organization). 1987. *Air Quality Guidelines for Europe*. WHO Regional Publications, European Series 23. Copenhagen.

Ozone (O_3)

Compartment: air

Evaluation date: 6-94

Physical-chemical properties

Ozone is a bluish gas at normal temperature. It is one of the strongest oxidizing agents. Ozone is formed indirectly by the action of sunlight on nitrogen dioxide and reactive volatile organic compounds.

MW: 48

1 ppm = 2 mg/m^3

Evaluation for air

Since there were no indications that ozone was a genotoxic carcinogen, a threshold extrapolation method was used to derive a RECOMMENDED VALUE.

Ozone is injurious at relatively low concentrations and at short-term exposure periods. At high concentrations, ozone causes lung effects such as pulmonary congestion, edema and hemorrhage. Exposure of animals to concentrations slightly above 2 mg/m^3 for 1 y and 6 h/d caused bronchitis and bronchiolitis [2]. WHO derived a 8 h GLV of 100–120 mg/m^3 [1].

By correcting the WHO guideline value of 100 mg/m^3 for continuous exposure a RECOMMENDED VALUE of 30 mg/m^3 was established.

Peak exposure: Short-term acute effects are notable, beginning with eye irritation due to exposure to nonozone oxidants at ozone levels of 200 mg/m^3. In children, 1 h average concentrations of 160–300 mg/m^3 caused decreased pulmonary function. WHO derived a 1 h GLV of 150-200 mg/m^3 [1].

Therefore, a RECOMMENDED VALUE$_{peak}$ of 150 mg/m^3 has been derived.

References

1. WHO (World Health Organization). 1987., *Air Quality Guidelines for Europe*. WHO Regional Publications, European Series 23, p. 315. Copenhagen.
2. ACGIH (American Conference of Governmental Industrial Hygienists). 1986. *Documentation of the*

Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, Ohio.

Particulates < 10 microns (PM_{10})

Compartment: air

Evaluation date: 6-94

Physical-chemical properties

Airborne particulate matter is a complex mixture of substances. PM_{10} is respirable particulate matter with a diameter mostly < 10 mm. Black smoke is a carbon-containing aerosol with a particle diameter < 5 mm [1].

Evaluation for air

Nuisance particulates (biologically "inert" dusts) can reduce visibility, cause deposits in eyes, ears, and nasal membranes, and cause injury to the skin or mucous membranes [2].

WHO derived GLV values for particulates in combination with sulfur dioxide. A GLV (1 y) of 50 mg/m^3 was established for black smoke [1]. The USEPA proposed a yearly average of 40–65 mg/m^3, while in a Dutch criteria document a yearly average of 40 mg/m^3 was proposed for PM_{10} to prevent decreased lung function and respiratory complaints [3, 4]. These values were considered too high, as a recent study showed that effects (increase in bronchitis in children) can occur at a yearly PM_{10} concentration of about 40 mg/m^3 [4]. A suitable guideline value is not available because from the present data set a NOAEL cannot be determined.

Based on WHO and EPA yearly averages of 50 mg/m^3, the RECOMMENDED VALUE has been established at 50 mg/m^3 for PM_{10}. It should be noted, however, that adverse effects at lower levels have been established and that WHO waived the limit value for PM_{10}.

Peak exposure: A GLV (1 day) of 125 mg/m^3 was derived by WHO for black smoke. For thoracic particles (equivalent to PM_{10}), a tentative GLV (1 day) of 70 mg/m^3 was proposed [1]. The USEPA proposed a daily average of 150 mg/m^3 for PM_{10}. In 1987 a daily average of 140 mg/m^3 was established for PM_{10} in the Netherlands to prevent serious effects such as mortality and irreversible lung damage [3, 4]. Recent studies, however, have shown that a daily concentration of 140 mg/m^3 can result in decreased lung function and respiratory complaints [4]. Based on the tentative GLV (1 day) of 70 mg/m^3 for PM_{10}, the RECOMMENDED VALUE$_{peak}$ has been established at 70 mg/m^3 for PM_{10} [1].

References

1. WHO (World Health Organization). 1987., *Air Quality Guidelines for Europe.* WHO Regional Publications, European Series 23, p. 338. Copenhagen.
2. ACGIH (American Conference of Governmental Industrial Hygienists). 1986. *Documentation of the Threshold Limit Values and Biological Exposure Indices.* 5th ed. Cincinnati, Ohio.
3. Van der Meulen, A., P. J. Rombout, C. J. Prins, P. G. N. Kramers, G. J. van Esch, E. Heijna-Merkus, A. C. Besemer, H. J. Huldy, H. C. M. Mulder and J. Venselaar. 1987. "Criteria Document Fine Particulate Matter" (in Dutch). RIVM Report 738513 006. RIVM, Bilthoven, the Netherlands.
4. Annema, J. A., H. Booij, J. M. Hesse, A. van der Meulen, and W. Slooff, eds. 1994. "Criteria Document Fine Particulate Matter" (in Dutch). RIVM Report 710401 029. RIVM, Bilthoven, the Netherlands.

Sulfur dioxide

Compartment: air

Evaluation date: 6-94

Physical-chemical properties

The major proportion of sulfur emissions from combustion sources is emitted as sulfur dioxide, which is further oxidized to sulfur trioxide in the atmosphere (5–10% per hour). In the presence of moisture, sulfuric acid is formed, present as an aerosol. Sulfur dioxide is a colorless gas that is readily soluble in water [1].

MW: 64

1 ppm = 2.6 mg/m^3

Odor threshold in air: > 1 mg/m^3

Evaluation for air

Effects of sulfur dioxide on the respiratory tract (bronchoconstriction, bronchitis) were observed in animals and workers at a concentration of 10 mg/m^3 and in asthmatic subjects at a concentration of 1 to 2.6 mg/

m^3. Based on these data WHO derived a 1 y GLV of 50 mg/m^3 [1].

Therefore, a RECOMMENDED VALUE of 50 mg/m^3 has been determined.

Peak exposure: WHO derived a 1 h GLV of 350 mg/m^3 to prevent respiratory effects [1]. Therefore, a RECOMMENDED $VALUE_{peak}$ of 350 mg/m^3 has been determined.

References

1. WHO (World Health Organization). 1987. *Air Quality Guidelines for Europe*. WHO Regional Publications, European Series 23, p. 338. Copenhagen.

Annex B

Activities Likely to Generate Hazardous Waste

- Petrochemical processes and pyrolytical treatments (furnace bricks; oil/water/sludge mixtures; oil-contaminated bleaching earth; acid tar; sulfur-containing residue from desulfurization; oil/water mixture; tar residue from coal tar production; sludge from wastewater treatment; residues of liquidous and pasteous organic substances from aromatic, aliphatic, and naphtenic products; residues from alkali washing of fuels)
- Natural gas production (mercury-containing sludge and filter material; sulfur-containing residues)
- Production and application of zinc, production of zinc oxide(zinc ashes and slags; jarosite)
- Production and application of lead (lead ashes and slags; lead-containing filter dust)
- Production and application of cadmium (cadmium-containing filter dust)
- Production and application of arsene (arsene-containing filter dust)
- Production of cast iron (furnace dust)
- Production of iron and steel with oxyconverters or electrofurnaces (filter dust; fly ash; other dusts)
- Production of primary and secondary aluminum (filter dust; electrode residues; furnace bricks)
- Nonferrometallurgical processes (heavy metal-containing furnace bricks; arsene slag)
- Hardening of steel (cyanide, nitrate- or nitrite-containing sludge; hardening salt)
- Production and application of asbestos and asbestos-containing materials (asbestos-containing residues)
- Production and application of enamel (enamel sludge and residues)
- Production of chlorine with the diaphragm-electro process (asbestos-containing residues
- Phenol production (phenol and phenol/water mixtures)
- Manufacture of metal products (selene-containing metal waste; beryllium-containing metal waste; cooling liquid based on oil products, oil/water sludge mixture)
- Metal surface treatment, such as pickling, galvanizing, cleaning, degreasing, and thermal zinc coating (acid, acid residue, or acid mixture; alkali, alkali residue, or alkali mixture; galvanizing liquid based on sulfide, chromium[VI], cyanide, copper, zinc, cadmium, nickel, or tin; copper-pickling liquid; halogene-free sludge from a bath of organic solvents; halogen-containing sludge from a bath of organic solvents; phosphating sludge; sludge from pickling bath)
- Treatment of galvanizing and comparable baths and water treatment for metal surface treatment processes (metal hydroxide sludge with chromium, cadmium, copper, zinc, nickel, or silver; heavy metal–containing eluate of ion exchangers; heavy metal–containing concentrate of membrane systems)
- Production of acids and ammonia (acid- or ammonia-containing residues)
- Production and application of solvents (contaminated halogene-free or halogenic aromatic, ali-

phatic, or naphtalenic solvents; contaminated halogene-free solvents based on phenols, ketones, ethers, acetates, alcohols, or glycols; contaminated halogenated phenols; contaminated solvents based on nitrogen-containing aromates, naphtenes, or aliphatics; contaminated sulfur-containing solvents; bottom stills)

- Removal of paint layers by means of blasting (paint residues)
- Production and application of paint, lacquers, varnishes, inks, and coatings (residues of paint, lacquers, varnishes, inks, and coatings which have not fully hardened; sludge from water treatment for production)
- Production and application of glue, adhesives, and resins (residues of glue, adhesives, and resins, not from animals, that have not fully hardened; resin oil residue)
- Production and application of latex (residue of latex emulsion, not fully hardened)
- Production and application of paint removers (residues)
- Printing and photocopying with liquidous inks (residues of ink, cleaning solvents, etc.)
- Production or application of photochemicals (residues of fixation, developing, and bleaching agents)
- Production or application of organic peroxides (residues)
- Production or application of halogenated hydrocarbons or aromatic, aliphatic, or naphtenic hydrocarbons (residues of organic substances based on halogenated hydrocarbons; residues of aromatic and other organic substances)
- Production or application of organic nitrogen or oxygen compounds (residues, but not vegetable or animal hydrocarbons, proteins, fat and fatty acids)
- Production or application of silicon compounds, except adhesive pastes (residues)
- Production of textiles (residues of textile-dyeing chemicals)
- Production or application of polymers (plastics, etc) and their raw materials (residues of additives such as colorants, stabilizers, or fire protection agents; residues of plasticizers; residues of monomers of vinyl chloride and acrylonitrile; nonhardened residues of rubber-emulsion or rubber solution, rubber sludge and PVC)
- Production of cosmetics (residues of nonvegetable or nonanimal raw materials)
- Production of pharmaceuticals (residues of the production of drugs, except for animal and vegetable substances)
- Production or formulation of pesticides (product residues; wastewater sludge; residues of hexachloro hexane and hexachloro benzene)
- Production, formulation, or application of wood conservation chemicals (residues of products; wastewater sludge; residues of conservation baths; wood alkali bath)
- Cleaning, emptying, and maintenance of tanks and oil/water separators of ships, vehicles, and mobile and stationary storage tanks, washwater and sludge (oil-containing residues, washwater and sludge; cargo residues; oil-water-sludge-mixture and oil containing air filters of oil, grease, sludge, or fuel separation)
- Cleaning of drum for chemicals (product residues; wastewater sludge)
- Treatment processes for wastewater and contaminated air emissions (sludge from fertilizer industry wastewater treatment; sludge for the treatment of fluoric acid-containing wastewater; heavy metal-containing residues of ion exchangers; flue gas cleaning residues)
- Purification processes for organic liquids (contaminated filters and filter material)
- Waste treatment processes, such as incineration, distillation, separation, and concentration techniques (slags of hazardous waste incineration, fly ash from incineration of waste, except ash from incineration of municipal wastewater treatment sludge; flue gas cleaning residues; cable burning residues; battery acid; bottom stills)
- Shredding of metal and plastics and rubbers (shredder waste)
- Chemical processes in laboratories for research, monitoring, and education (laboratory waste)
- Application of amalgam by dentists (amalgam-containing waste)
- Vehicles and machinery maintenance and repair (oily residues; filters, and filter material)
- Health centers (human parts; animals and animal parts for testing purposes; waste from departments with quarantine patients; waste from microbiological laboratories; sharp objects such as injection needles; large quantities of blood, plasma, and other pasteous and liquidous waste; cytostatica)

Annex C

Recommended Values for Area Characteristics Used in Dispersion Models

Recommended values for downtown/area average density factors

To estimate critical pollutant levels in heavily populated downtown urban areas, an empirically determined ratio of local peak to urban average levels can be selected and applied. Such ratios depend also on the spatial distribution of the low-level sources, in which case a qualitative assessment is sufficient. The following list provides critical downtown to spatial average concentrations ratios:

Area description	*Em.dens.factor*
Uniform emission density throughout the city (theoretical case)	1.4
Cities without pronounced downtown area activities	3.0 - 4.5
Cities with pronounced downtown area activities (most usual case)	6.0 -6.4

Recommended values for area roughness

Select an appropriate value using the examples below as a guide.

Type	*Example*	*Value*
Flat land	Polderland with few trees	0.03
Farm land	Airfield, agricultural land, polder with many trees	0.10
Cultivated land	Greenhouse land, open area with much overgrowth, scattered houses	0.30
Residential area	Area with densely-located but low buildings, wooded area, industrial area with obstacles that are not too high	1.0
Urban area	Large city with high buildings, industrial area with high obstacles	3.0

THE WORLD BANK
1818 H Street, N.W.
Washington, D.C. 20433 USA

Telephone: 202-477-1234
Facsimile: 202-477-0565
Internet: www.worldbank.org