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WORKING PAPER

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diagrams

Joint UNDP/UNIDO/APCTT Workshop on Environmental Considerations and Waste Recycling in the Chemical, Metallurgical and Engineering Industries

9 to 13 December 1991, Manila, Philippines

Paper 2: Chemical Pollution from Industry-Management and Control

January 1992

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ERL

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Approved by: Eamonn Barrett

Position: Technical Director

Date: 14 January 1992

CONTENTS

1 INTRODUCTION

1.1 BACKGROUND

For many years much industrial pollution control has been carried out essentially on an end of pipe basis, and a wide range of unit processes (physical, chemical and biological) have been developed to service the needs of industry.

Such end of pipe systems range from low intensity to high intensity, from low technology to high technology and from low cost to high cost. Most are destructive processes in that they provide no return to the operating company in terms of increased product yield or lower operating cost except in those circumstances where reduced charges would then apply for discharge to municipal sewer.

It should be noted that in all cases the size (and hence cost) of end of pipe treatment bears a direct relationship firstly to the volume of wastewater to be treated and then to the concentration of pollutants contained in the discharge. For example, the size of most physical-chemical reactors (balancing, neutralising, flocculation, sedimentation, flotation, oxidation, reduction etc) is determined by hydraulic factors such as surface loading rate and retention time.

On the other hand the size of most biological reactors is determined by pollution load; for example kg COD per kg of mixed liquor volatile suspended solids (MLVSS) per day in the case of suspended growth type systems, and kg COD per m^3 of media or reactor volume in the case of fixed film type systems.

It is evident therefore that reduction of emissions by action at source can have a significant impact on the size and hence the cost of an end of pipe treatment system. On this basis it should be established practice in industry that no capital expenditure for end of pipe treatment should be made until all waste reduction opportunities have been exhausted. This has not often been the case and many treatment plants have been built which are both larger and more complicated than necessary.

Increased environmental pressure and awareness now requires industry to meet tighter environmental standards on a global basis.

In many countries such requirements generally cannot be met by conventional end of pipe solutions without seriously impacting on the economic viability of the individual industries.

Accordingly much more emphasis has to be placed on source management as a necessary first step to reduce to a minimum the extent of end of pipe treatment to be provided.

Source management can be defined as 'the development of a full understanding of the nature of all waste streams (aqueous, gaseous or solid) and the exact circumstances by which they are generated in order to eliminate or minimise pollution before it arises'.

1.2 *INTEGRATED SOURCE CONTROL*

The essential components of source management, referred to in this paper as integrated source control, embrace a number of key technical, management and operational initiatives.

Key technical initiatives involve identification of opportunities for:

- application of 'cleaner' processes or processing methods;
- enhanced housekeeping practices;
- water conservation including reuse and recycle;
- waste avoidance or minimisation;
- materials recovery and/or reuse.

Key management initiatives include:

- senior management awareness and commitment;
- better training of technical staff and operatives;
- a management structure which positively links production, pollution control and environmental management;
- disciplined monitoring of performance.

The potential benefits to be obtained in achieving optimum source management are represented diagrammatically in *Figure 1.1* and include:

- enhanced product yield;
- reduced raw materials inventory;
- reduced end of pipe treatment requirement.

Potential benefits must be identified on an industry by industry basis; such potential benefits including both direct process benefits (primary benefits) and basic infrastructure benefits (secondary benefits). These are depicted diagrammatically in *Figure 1.2*.
In support of integrated source control it is reported that 30 to 60 percent of pollution can be eliminated by reduction of waste and emissions at source (PREPARE Working Group, Preventive Environmental Protection Approaches in Europe).

Further support for integrated source control is summarised as follows.

- Industry can maximise profits by increasing efficiency while at the same time maintaining environmental concerns.

- Pollution prevention is more environmentally effective, more technically sound and more economical than conventional controls.

- Conventional controls are 'tools of last resort'.

- Often little or no capital expenditure is required, just tightening up of procedures can produce major financial and environmental benefits.

Integrated source control in isolation is not sufficient to achieve the overall objective of cost effective pollution control on cost effective environmental management. This requires detailed consideration of optimised end of pipe control for the irreducible minimum of wastes, in addition to integrated source control.

1.3 *OPTIMISED END OF PIPE CONTROL*

Optimised end of pipe treatment involves technical, management and operational initiatives; the management and operational initiatives being the same as those identified for integrated source control (ie a commitment at all levels, with better training to ensure efficient operation and performance monitoring of end of pipe systems).

Key technical issues concerning optimised end of pipe treatment could include provision of:

- effective segregation of waste water streams for optimised pretreatment, energy recovery etc;
- effective flow and load pre-balancing;
- control systems to prevent over-dosing of reagents;
- upgrading of existing facilities.

An overall summary of the principal components of cost effective pollution control and benefits is included as *Figure 1.3*.

1.4 *SCOPE OF PAPER NO 2*

The objective of this paper (Paper No 2) is to identify a procedure by which cost effective pollution control can be achieved through a combination of:

- integrated source control; and

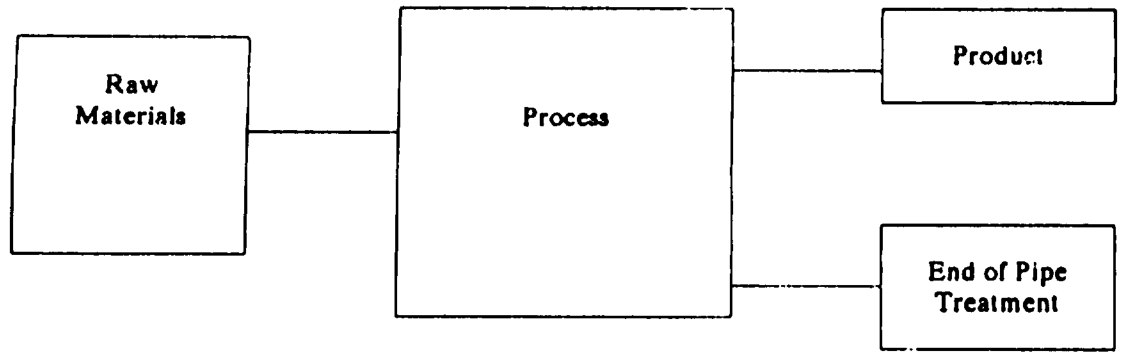
- optimised end of pipe control.

Section 2 identifies the principal implementation steps including an approach to waste auditing, a management procedure designed to identify areas of poor management, bad housekeeping and inefficient process control. In addition, *Section* 2 covers the basic procedure to identify opportunities which are economic for conservation of water, minimisation of waste and recovery of materials, and for application of 'cleaner' technologies.

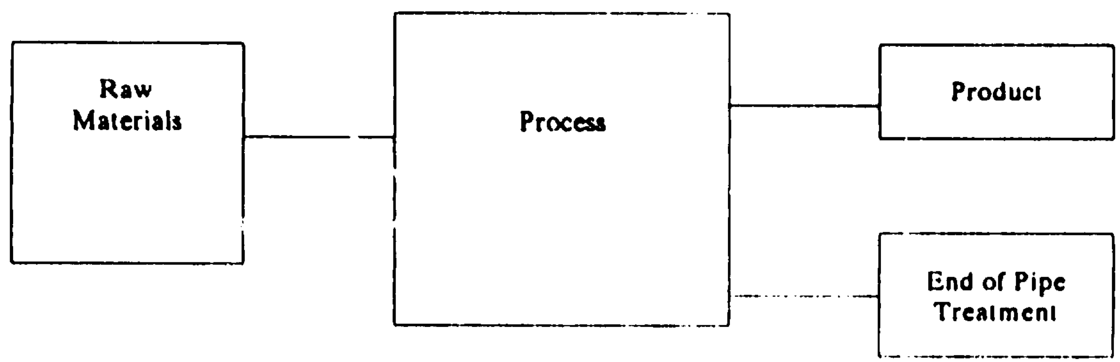
Section 3 provides examples of integrated source control firstly on a non process basis and then on a process specific basis. *Section 4* provides examples of optimised end of pipe control.

Typical audit review questions are provided in Annexes 1 to 5.

Figure 1.1 *Benefits of Integrated Source Control*



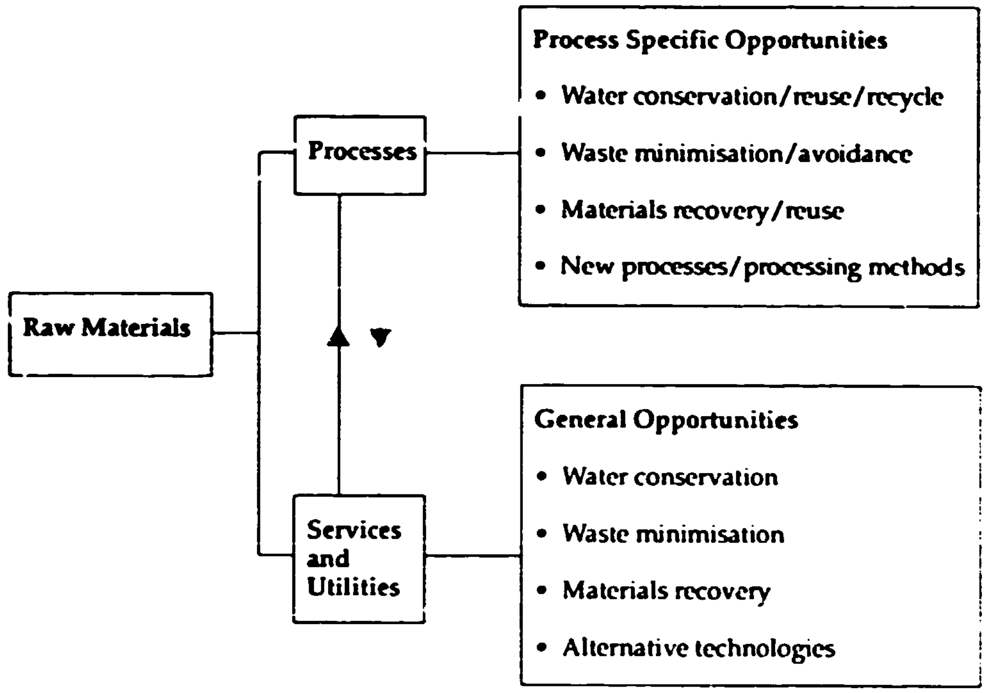
Before Integrated Source Control



After Integrated Source Control

An estimated 30 to 60 percent of industrial pollution can be climated by reduction of waste and emissions at source"
....PREPARE working-group (Preventative Environmental Protection Approaches in Europe)

Figure 1.2 Integrated Source Control - Primary and Secondary Benefits



Definitions:

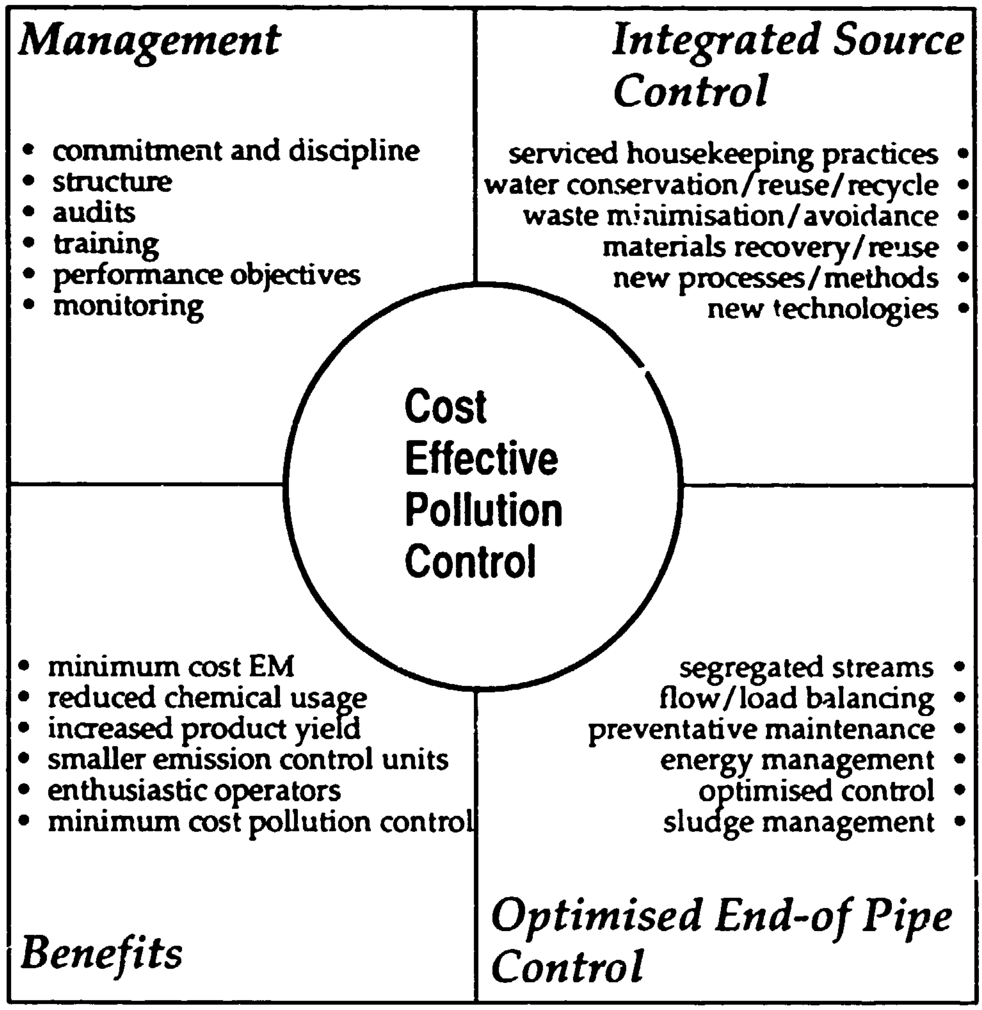
- **Water conservation/reuse/recycle**
  a reduction in water usage per unit of production achieved by application of conservation, reuse and recycle technologies

- **Waste minimisation/avoidance**
  a reduction in pollutant load per unit of production achieved by application of waste minimisation and avoidance techniques

- **Materials recovery/reuse**
  a reduction in pollutant load per unit of production achieved by recovery of material from waste either directly or through renovative technologies

- **New processes/processing methods**
  the application of new processes or processing methods which achieve reductions in water usage and waste generation per unit of production

Figure 1.3 Cost Effective Pollution Control
Overall Summary



EM : Environmental Management

2.1 KEY ISSUES

Figure 2.1 depicts the key elements involved in the identification and the sustained achievement of cost effective pollution control. In this context cost effective pollution control equates to good environmental management. The key issues can be defined as follows:

- *Effective management and training* - the introduction and sustainment of a disciplined approach to pollution control and environmental management. This involves senior management commitment to specific objectives including a cradle to grave philosophy, establishment of a management structure which positively links production to environmental management and training programmes for technical and operating personnel.

- *In-house process control* - the achievement of optimum efficiency in relation to production and processing methods including the introduction, where feasible, of cleaner processes (alternative technology) or processing methods (substitute materials and/or reformulations, process modifications and equipment redesign).

- *Good housekeeping* - the rethinking of localised habitual practice and the identification and implementation of new practices and procedures.

- *Water conservation/reuse/recycle* - the achievement of optimum efficiency in relation to water use looking at possible elimination of use, regulation of use to specific requirement, sequential use or reuse and in-process recycle.

- *Waste recovery and/or reuse* - the identification and implementation of opportunities to recover process chemicals and materials for direct reuse or for reuse elsewhere through renovation or conversion technology.

To achieve cost effective pollution control and environmental management it is therefore necessary to:

- promote environmental awareness at three levels within the company hierarchy;

- ensure full management commitment to environmental performance;

- establish a review team to carry out an initial audit of present production methods, housekeeping practices, procedures and factory support services and to identify opportunities for integrated source control and optimised end of pipe treatment;

- establish objectives for overall environmental performance; also specific performance targets on a process by process basis including utilities;

- establish a management structure which positively links production, pollution control and the environment with clearly defined responsibilities and lines of communication to managing director level;

- introduce formal training procedures for technical and operational personnel;

- establish monitoring programmes and procedures designed to continuously assess process efficiency and environmental performance;

- carry out regular environmental audits to ensure standards are being maintained;

- establish and maintain a data base with relevant information and documentation on performance and on efficient use of resources and reduction of waste production.

A disciplined approach to auditing and implementation is required if the full potential for integrated source management and optimised end of pipe control is to be achieved on a sustainable basis.

On an industry wide basis, there are many examples of failure to realise the potential environmental and cost benefits following installation of new plant and equipment designed to achieve conservation, reuse, recycle and recovery of water and other useful materials, or introduction of new processing methods or technologies.

Such failures often can be attributed to choice of inappropriate technology or maloperation. Choosing the wrong technology occurs when implementation decisions are made in isolation without due regard to overall environmental objectives and operating constraints. Maloperation often is the principal reason why the potential benefits of low waste technology are not fully realised. It is prevalent when the attitude of operators, managers and support technical staff is dominated by production objectives only.

Under production orientated circumstances, equipment installed to conserve water, minimise waste or recover materials tends to be by-passed at times of crises or in the interest of production output. Such attitudes also reflect badly on the performance of end of pipe treatment systems, ie the end of pipe system is regarded as a 'magic box' which is capable of handling anything and everything production departments wish to discharge (strong spent solutions, off-spec batches, spillages, leakages, etc). In reality a wastewater treatment plant or emission control system is designed to operate efficiently within specific limits only.

Accordingly the attitude of managers, supervisors, technical staff and operators to integrated source control and optimised end of pipe treatment is as important as technology itself.

An overall procedure to achieve cost effective pollution control is depicted in *Figure 2.2.* and described below.

2.2 ENVIRONMENTAL AWARENESS AND MANAGEMENT COMMITMENT

Pollution control and environmental awareness must be promoted at three levels within the company hierarchy.

(i) *Managerial and supervisory staff* should be made fully aware of environmental priorities and policies and have a detailed knowledge of regulatory requirements and related operational factors and constraints. Managers and supervisors must be motivated to fully apply such priorities and policies. This involves encouraging managers and supervisors to gather and study information on environmental requirements, environmentally compatible operations and plant management.

(ii) *Technical staff* should be delegated responsibility to incorporate environmental considerations into plant operation and maintenance, and in the treatment and disposal of emissions. This involves motivating technical staff to plan for optimum process scheduling and to monitor plant operators' performance accordingly.

Technical staff should ensure that plants for treatment of emissions operate according to target emission loadings and/or characteristics. In addition, plants should be frequently supervised to ensure that emission loadings or characteristics do not fall outside prescribed standards.

(iii) *Plant operators* should be delegated responsibility for raw material usage and emission control as well as normal process control. Management support should include specific training and motivation to enable operators to detect and tackle any operational problem that could give rise to adverse environmental impact.

Diagrams depicting environmental awareness, cost benefit awareness and managerial commitment are included in *Figures 2.3, 2.4* and *2.5* respectively.

2.3 MANAGEMENT STRUCTURE

As outlined in *Section 2.1*, a key requirement for successful application of integrated source control and optimised end of pipe control is a management structure which positively links production, pollution control and environmental management.

The traditional approach of divorcing production personnel from the true cost implications of utilities supply (water, steam etc) and emissions control (wastewater treatment, wastes treatment and disposal) can be counter productive.

As a practical illustration, consider the case of a chemicals production unit. This unit utilised batch processing techniques to manufacture a range of inorganic and organic chemicals and produced wastewater with an average inorganic and organic chemicals and produced wastewater with an average volume of 5000 m^3/d and an average COD load of 21 t/d. A revised management plan to allocate costs for wastewater treatment to individual profit centres on a 'polluter pays' principle resulted in a reduction in average wastewater volume from 5000 to 2700 m^3/d and in COD load from 21 to 13 t/d.

A second example involves a metal preparation and finishing establishment. In this case considerable investment was made by management in water conservation devices, including conductivity controllers and in direct metals recovery using electrolytic techniques. All equipment provided fell into disrepair at an early date because an appropriate management structure with support training had not been established. Operators continued to function on the basis of production only.

A management and operating structure is required therefore to ensure that production personnel have responsibility for integrated source control procedures and have full awareness of emissions control requirements. An appropriate structure is depicted in *Figure 2.6*. Also it is necessary to ensure that the true costs of pollution control and the cost benefits of integrated source control and optimised end of pipe control are debited/credited as appropriate.

2.4 *INITIAL AUDIT OF PRACTICES, PROCEDURES AND OPPORTUNITIES*

An initial audit of practices, procedures and opportunities is required to establish baseline environmental conditions. It involves a critical assessment and review of present production and processing methods and housekeeping practices and procedures. In addition, it looks at identification of opportunities for new processes or processing methods and for conservation, reuse, recycle and recovery of water and other useful materials.

The principal requirements of the audit are summarised in *Figures 2.7* and *2.8*.

The review team delegated with the task of undertaking the initial audit ideally should comprise:

- works director;
- production manager(s);
- technical manager;
- chemist/chemical engineer;
- accountant;
- specialist consultant.

The audit should be carried out by 1-2 people, referring to the review team as appropriate.

In addition to the principal objectives of the audit it is appropriate that the review team take the opportunity to fully assess all environmental risks as potential risk areas. On this basis the principal areas of investigation should include:

- raw materials and utilities;
- processes and integrated source control;
- end of pipe emission control systems;
- final emissions and discharges;
- storage and handling;

Example review questions under the above headings are documented in Annexes 1 to 5. The questions are designed to obtain a clear understanding of present performance (for comparison with existing performance targets and experience elsewhere) and the potential for change. All questions must be answered honestly and substantiating evidence or documentation must be provided where available.

It is appropriate to allocate a potential change factor (1, 2, 3) to relevant current operations and/or procedures to identify specific areas (individual processes or utilities) with greatest potential for change; ie to achieve optimum efficiency in production and processing methods including the introduction of cleaner processes (alternative technology) or processing methods (substitute materials and/or reformulations, process modifications and equipment redesign). In this case factor 3 should indicate the greatest potential for change.

It is also appropriate to allocate an environmental risk category (low, medium, high) to each current operation or procedure as an aid to overall environmental management.

Examples of high and medium risk categories are summarised below. If in doubt, a higher risk category should be allocated to a particular operation at the initial stage. Following subsequent detailed assessment, a lower category (in terms of priority action) can be introduced if appropriate.

High risk categorisation (H) covers major environmental concerns such as:

- known adverse environmental impacts;
- suspect integrity of storage vessels;
- use of untrained personnel;
- lack of control over chemical and waste storage;
- contamination of ground and groundwater in areas of high permeability.

Medium risk categorisation (M) covers issues such as:

- heavy reliance on manual control systems, eg for switching off water inputs when processes are not in use;

- insufficient emergency holding capacity, eg wastewater treatment plant not provided with side stream containment or adequate balancing facilities;
- contamination of ground and groundwater from poor housekeeping in areas of low permeability.

2.5 *EVALUATION*

Based upon the answers to questions listed in the Annexes 1 to 5, it will be possible to list specific areas of potential change with particular reference to opportunities for:

- raw material substitution and/or reformulation, process modifications, or for introduction of cleaner processes based upon in-house knowledge (ie cleaner processes or processing methods);
- conservation of water by direct reduction, reuse or recycle;
- waste avoidance or waste minimisation;
- potential opportunities for materials recovery (for direct reuse) or for conversion to a by-product of value (ie materials recovery).

All potential opportunities should be listed on a process by process basis under the headings noted above, including general housekeeping improvements. Opportunities concerning utilities (eg cooling water) should be handled in the same way.

In parallel to the initial audit it is necessary to carry out a review of relevant literature to identify specific water use and waste generation information for similar industries elsewhere, and to establish relevant opportunities involving cleaner processes or processing methods, water conservation, reuse and recycle, waste avoidance and minimisation and materials recovery.

A schedule of costs and potential returns can then be developed and decisions taken on schemes to implement and new procedures to introduce on a technical and economic basis. Examples of typical opportunities are illustrated in *Section 3*. The procedure is depicted in *Figure 2.9*.

2.6 *IMPLEMENTATION*

Based upon the results of the audit and the necessary constraints placed on each facility as a result of work in progress and future plans, it will be possible to draw up a list of actions for new plant installation, existing plant upgrading and for new operating practices and procedures. Priority to individual actions is allocated by the addition of a target completion date.

In addition, it will be possible to identify specific performance targets by which key operations will be monitored and measured on an ongoing basis. The implementation process is depicted in *Figure 2.10*.

2.7 *TRAINING*

The successful implementation of an enhanced strategy for integrated source control and optimised end of pipe treatment often is dependent on the introduction of adequate and appropriate training programme for:

- managers and supervisors;
- technical staff;
- operatives.

Key requirements of such training programmes are summarised in *Figure 2.11*.

2.8 *MONITORING*

Following implementation of enhanced strategies, a key requirement is the introduction of a monitoring programme particularly the routine checking of raw material usage and emissions per unit of production with comparison of data against specific performance criteria.

In addition there is a requirement for routine checking of maintenance procedures and programmes and the introduction of improvements wherever practicable.

Key requirements of a successful monitoring programme are depicted diagrammatically on *Figure 2.12*. The results of the monitoring programme include implementation of new opportunities whenever appropriate.

2.9 *REVIEW AUDIT*

Requirements of the periodic review audit are summarised in *Figure 2.13*. Such a review audit includes identification of new opportunities for evaluation and implementation.

Figure 2.1 Industrial Water and Wastewater Management

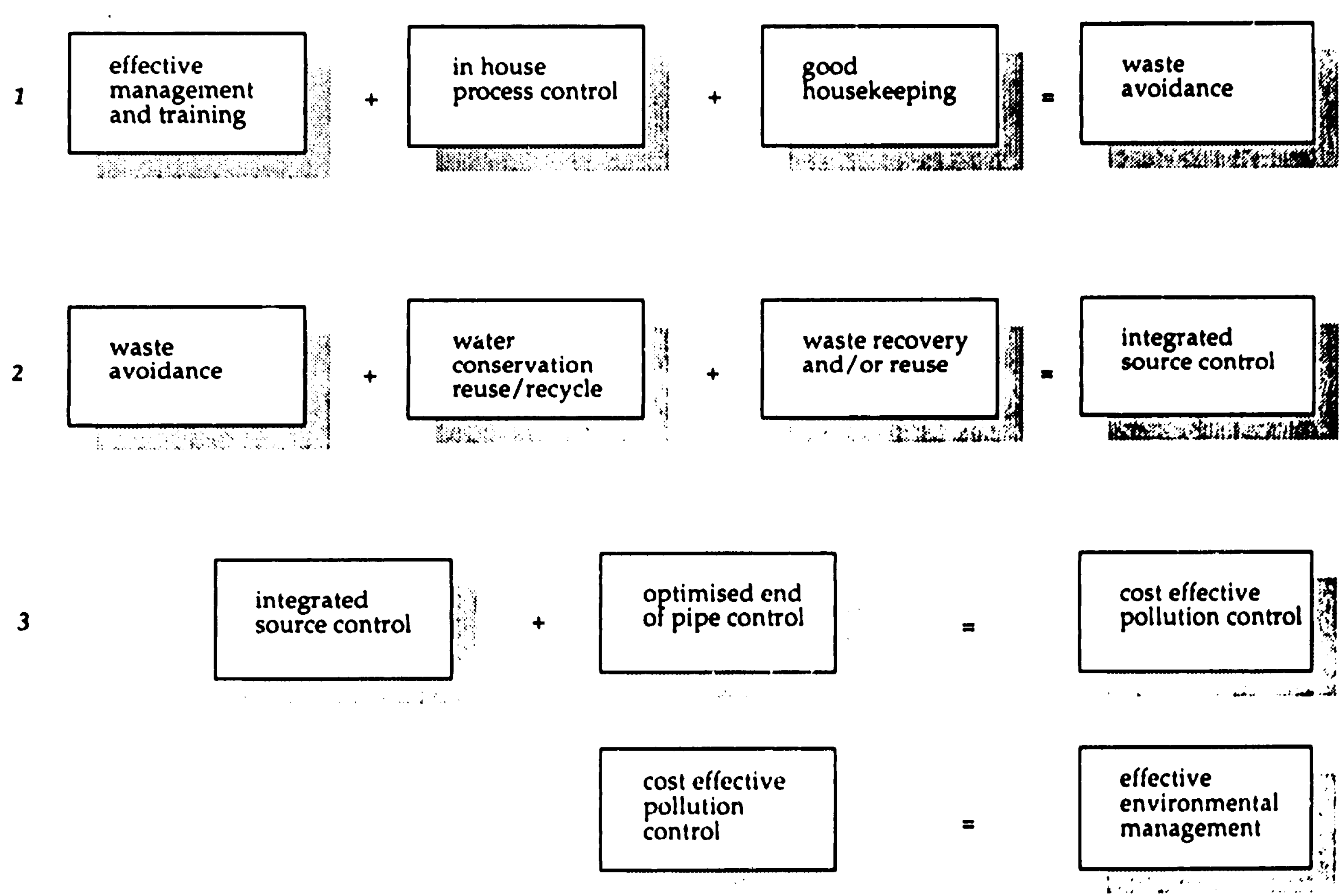


Figure 2.2 ***Procedures to Achieve Cost Effective Pollution Control***

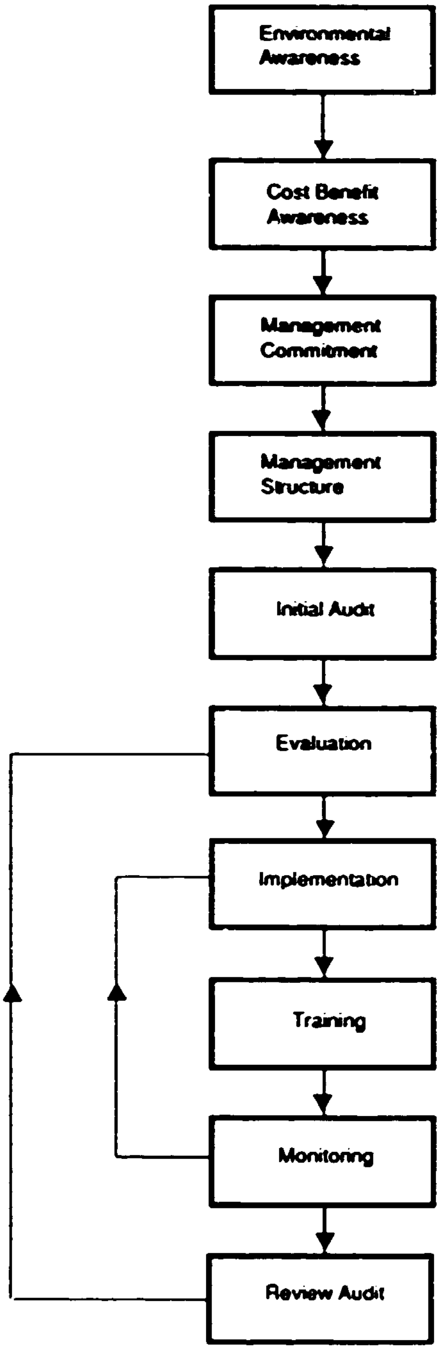


Figure 2.3 ***Procedures to Achieve Cost Effective Pollution Control***
1. Environmental Awareness

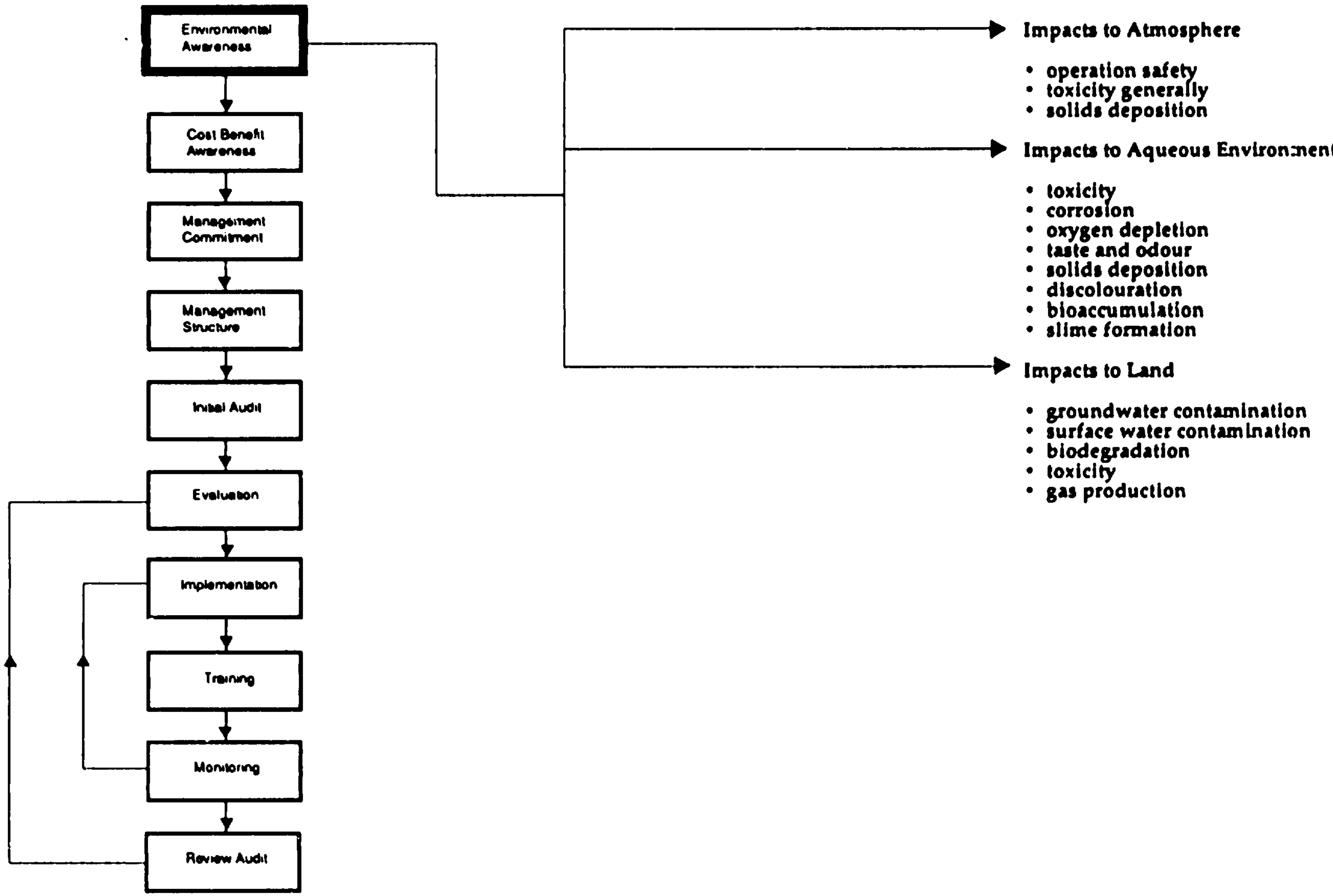


Figure 2.4 *Procedures to Achieve Cost Effective Pollution Control*
2. Cost Benefit Awareness

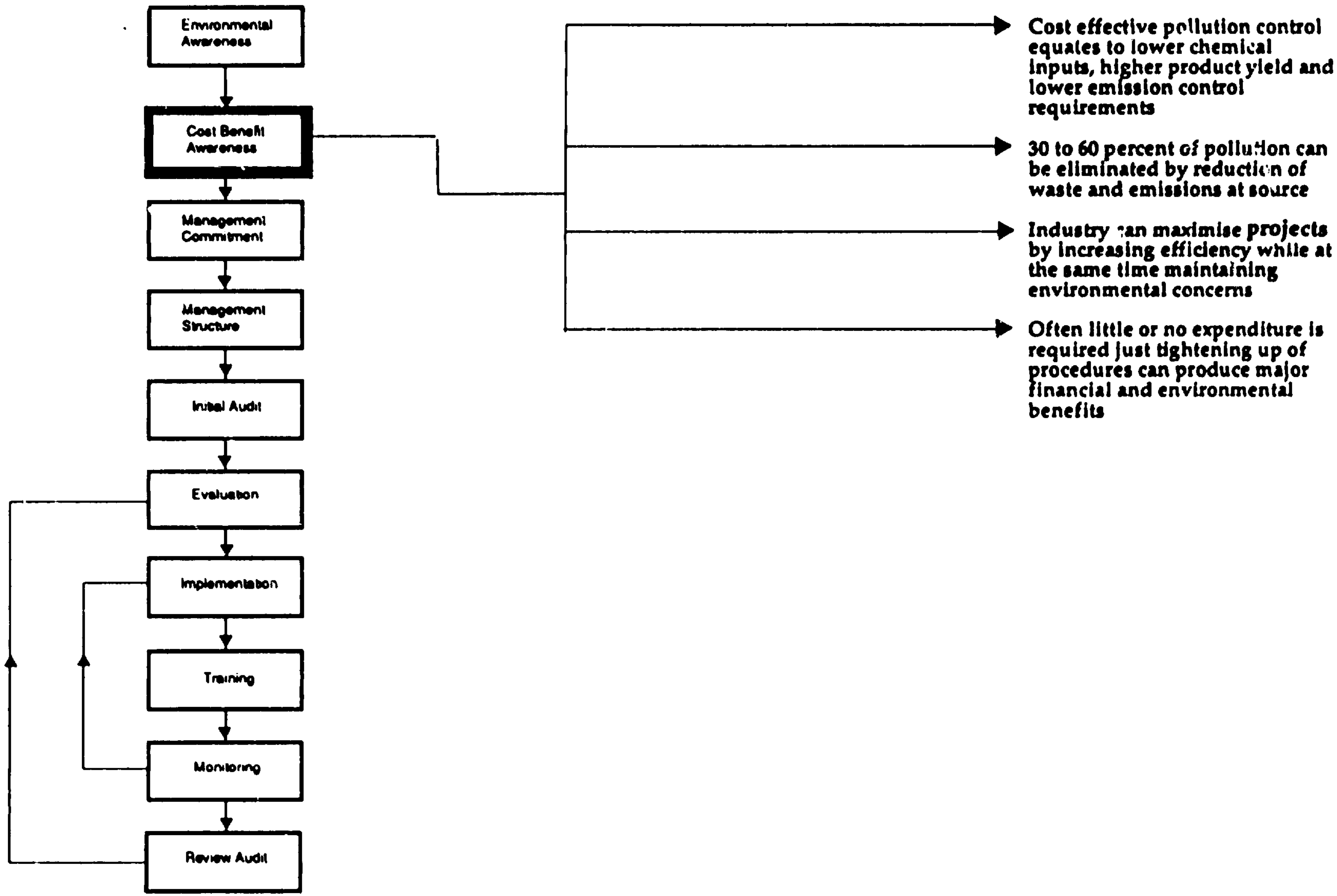


Figure 2.5 *Procedures to Achieve Cost Effective Pollution Control*
3. Management Commitment

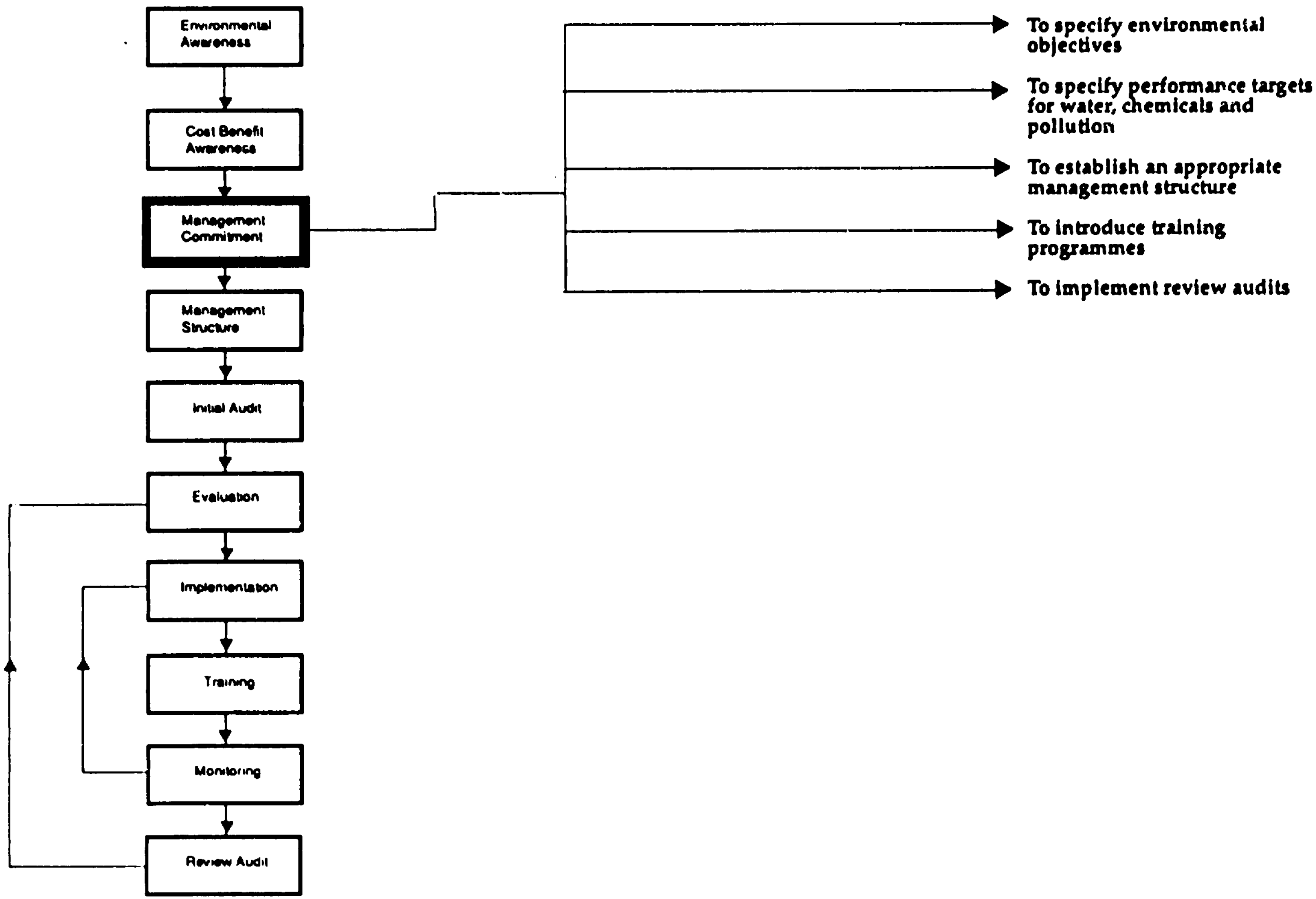


Figure 2.6 *Procedures to Achieve Cost Effective Pollution Control*
4. Management Structure

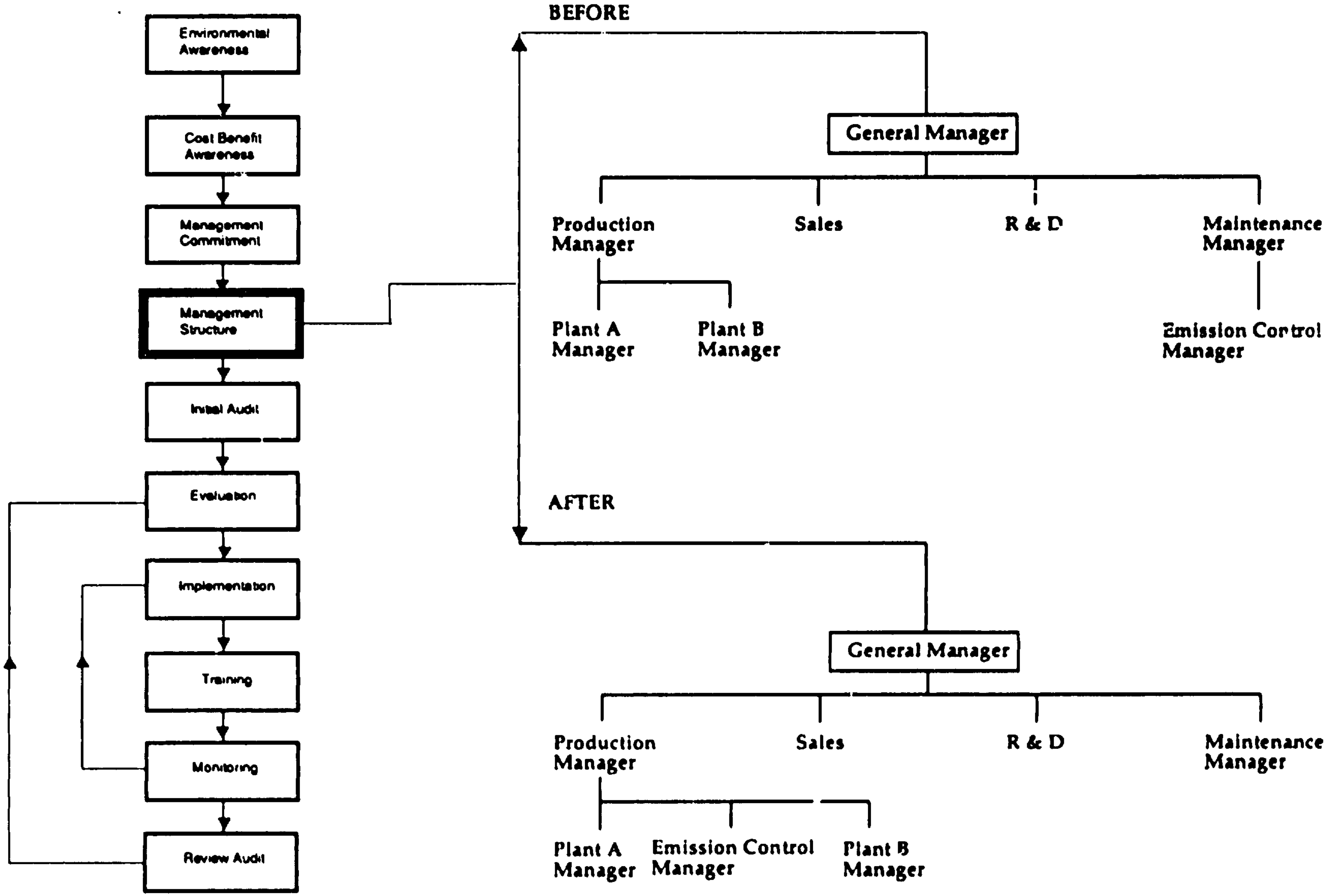


Figure 2.7 *Procedures to Achieve Cost Effective Pollution Control*
5. Initial Audit

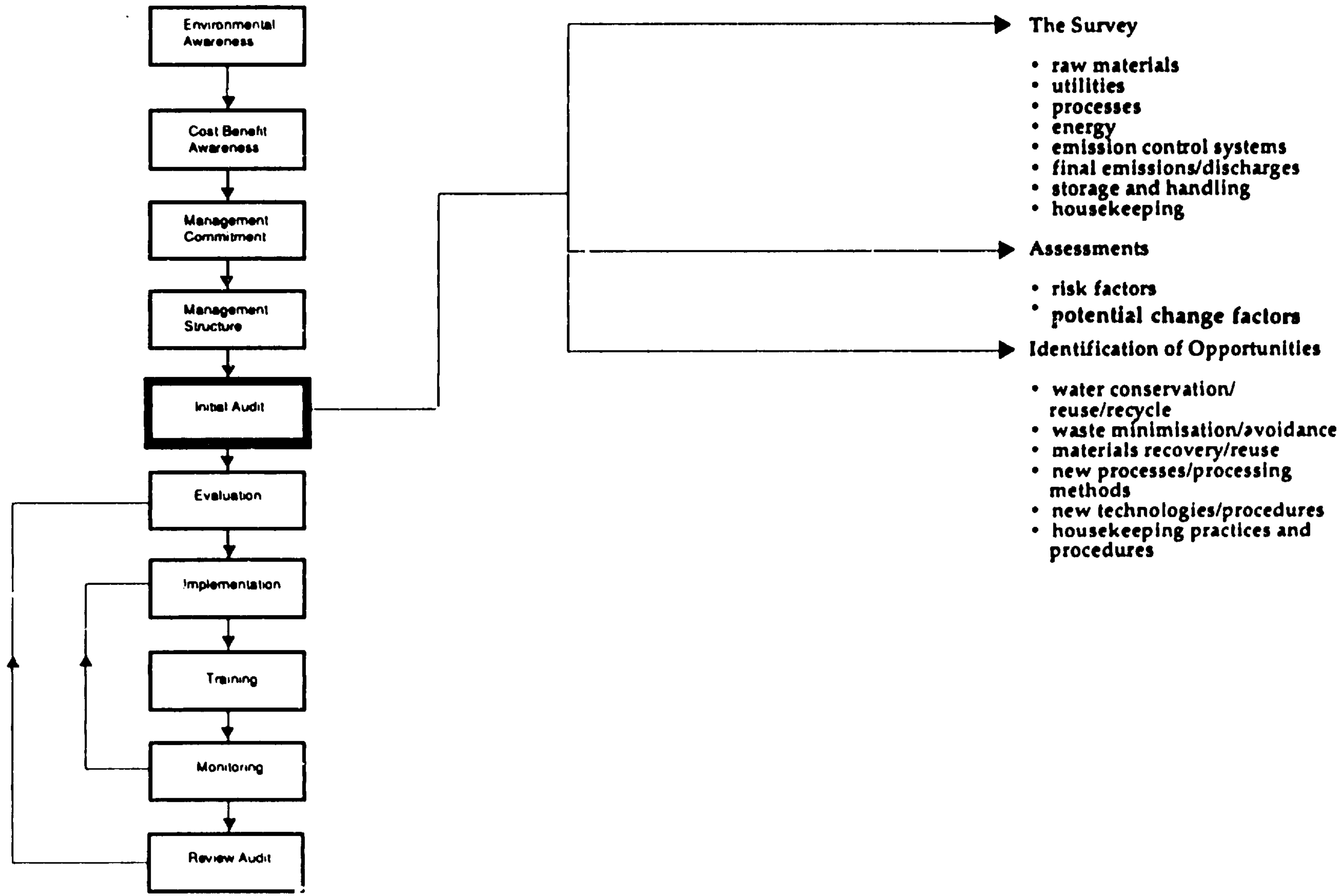
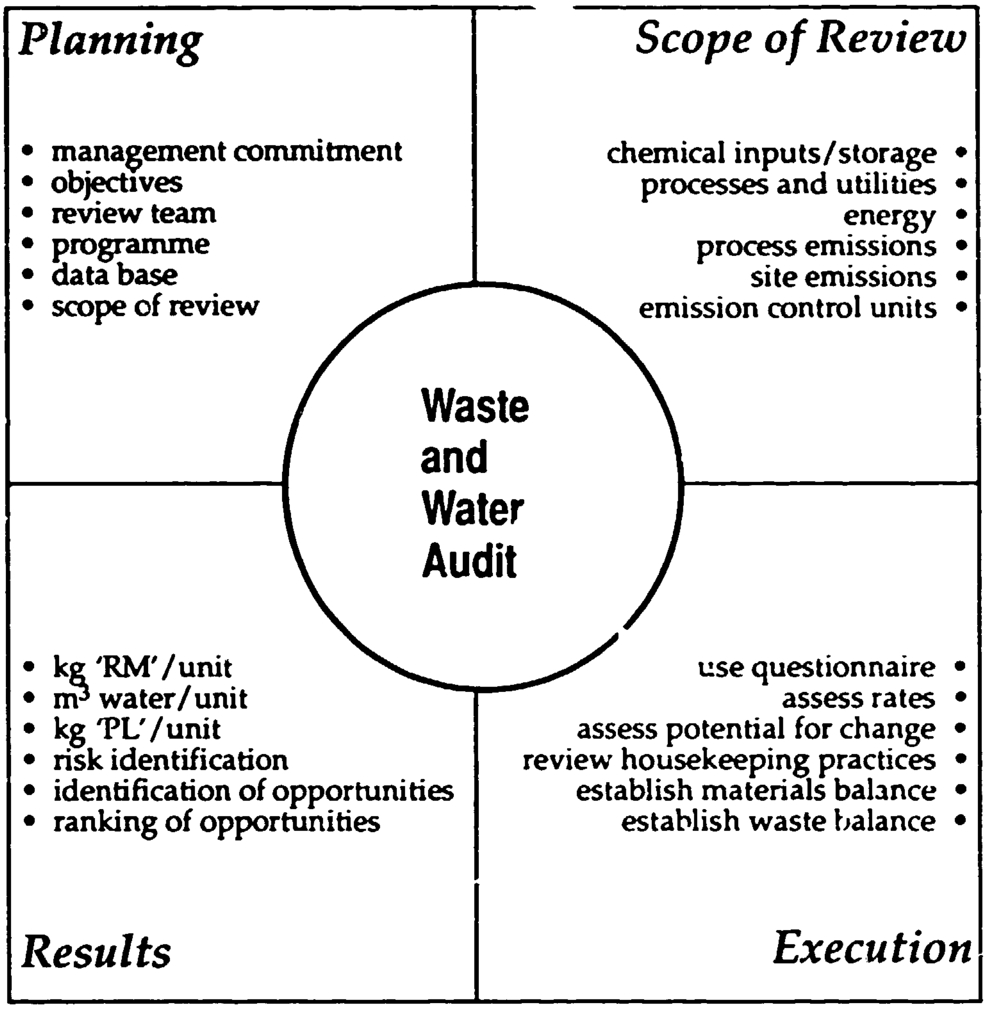


Figure 2.8 ***Procedures for Cost Effective Pollution Control***
Waste and Water Audit



RM : Raw materials expressed as individual chemicals

PL: Pollution load expressed as COD, BOD, toxic metals etc

Figu.

Procedures to Achieve Cost Effective Pollution Control
6. Evaluation

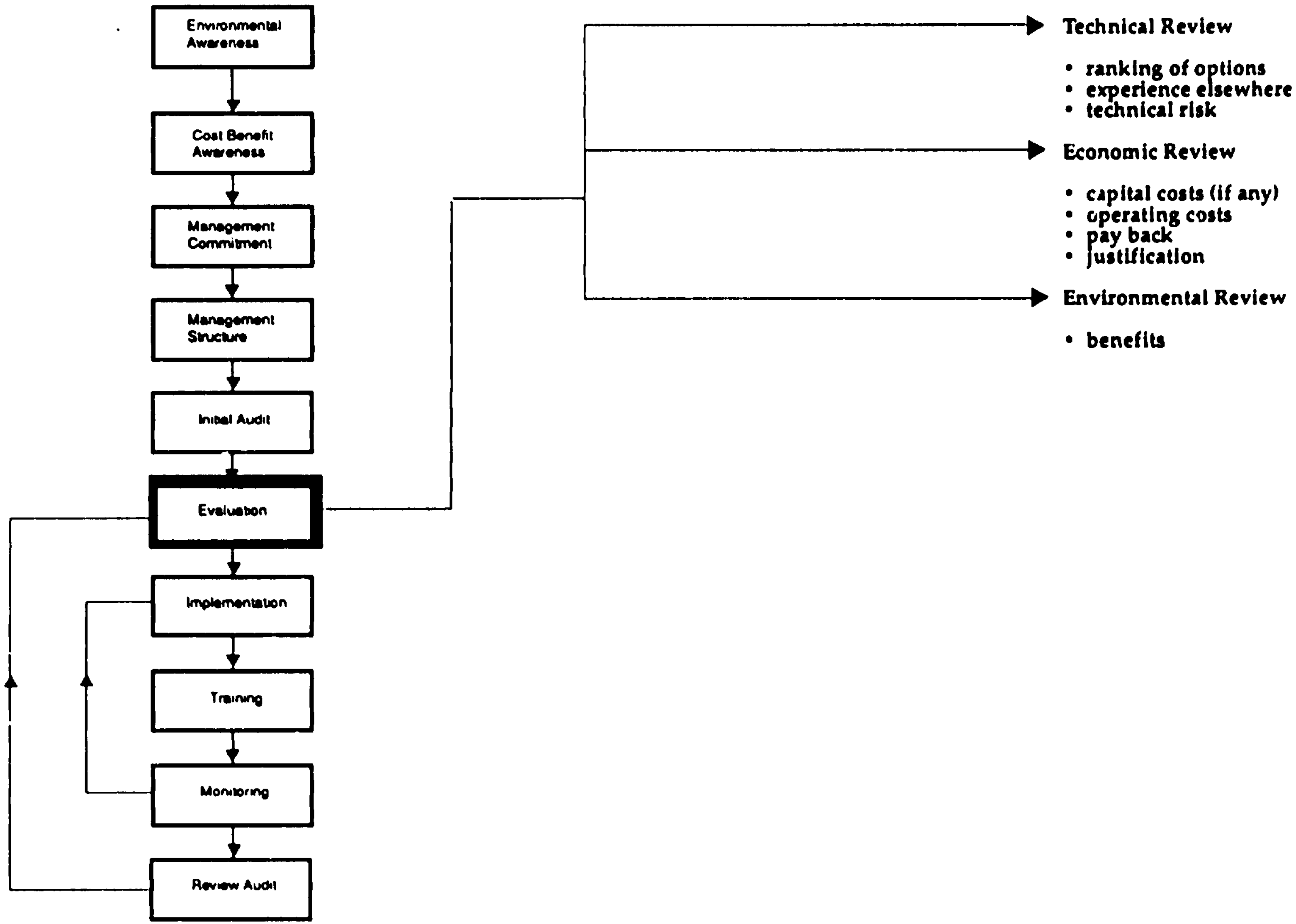


Figure 2.10 *Procedures to Achieve Cost Effective Pollution Control*
7. Implementation

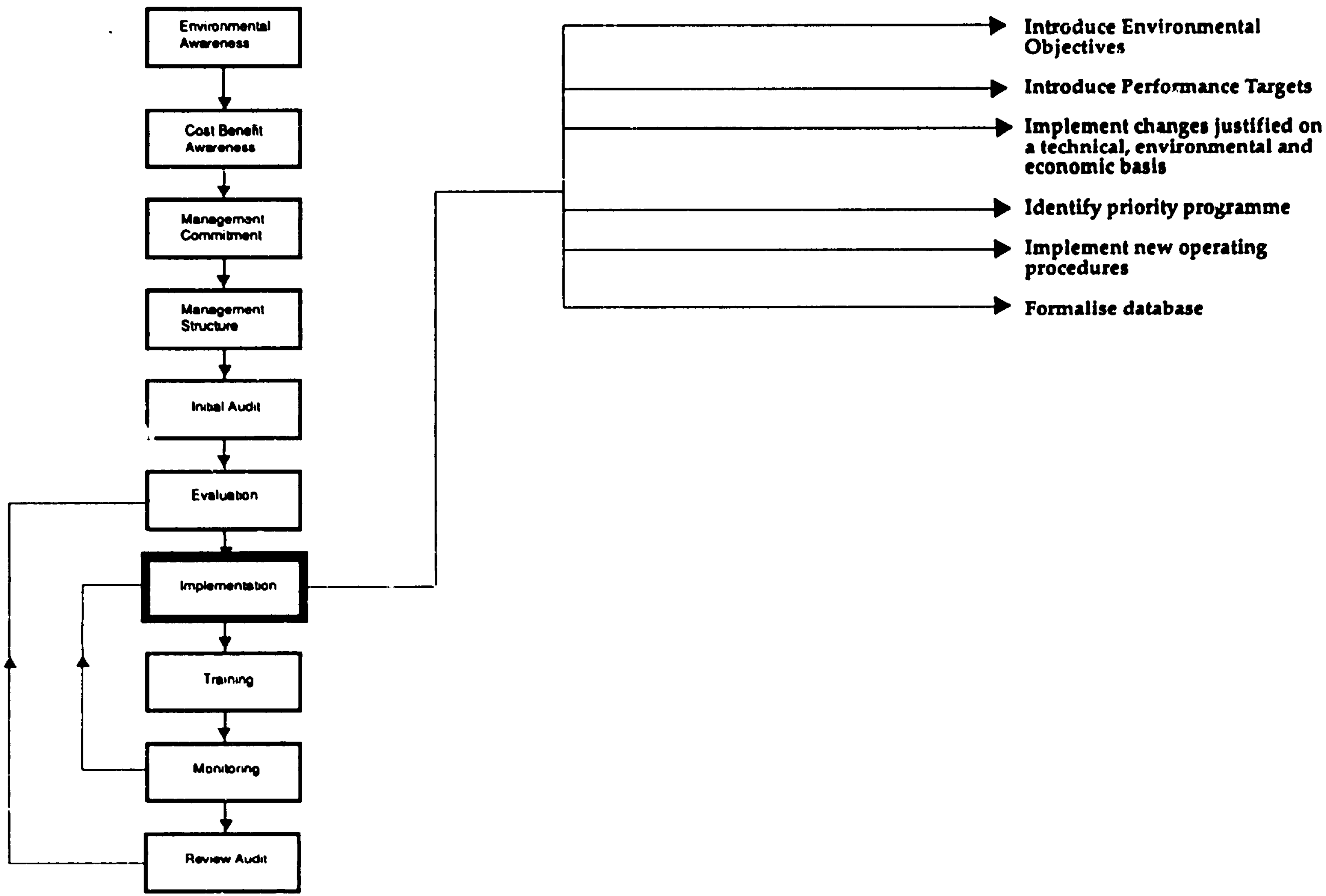


Figure 2.11 Procedures to Achieve Cost Effective Pollution Control 8. Training

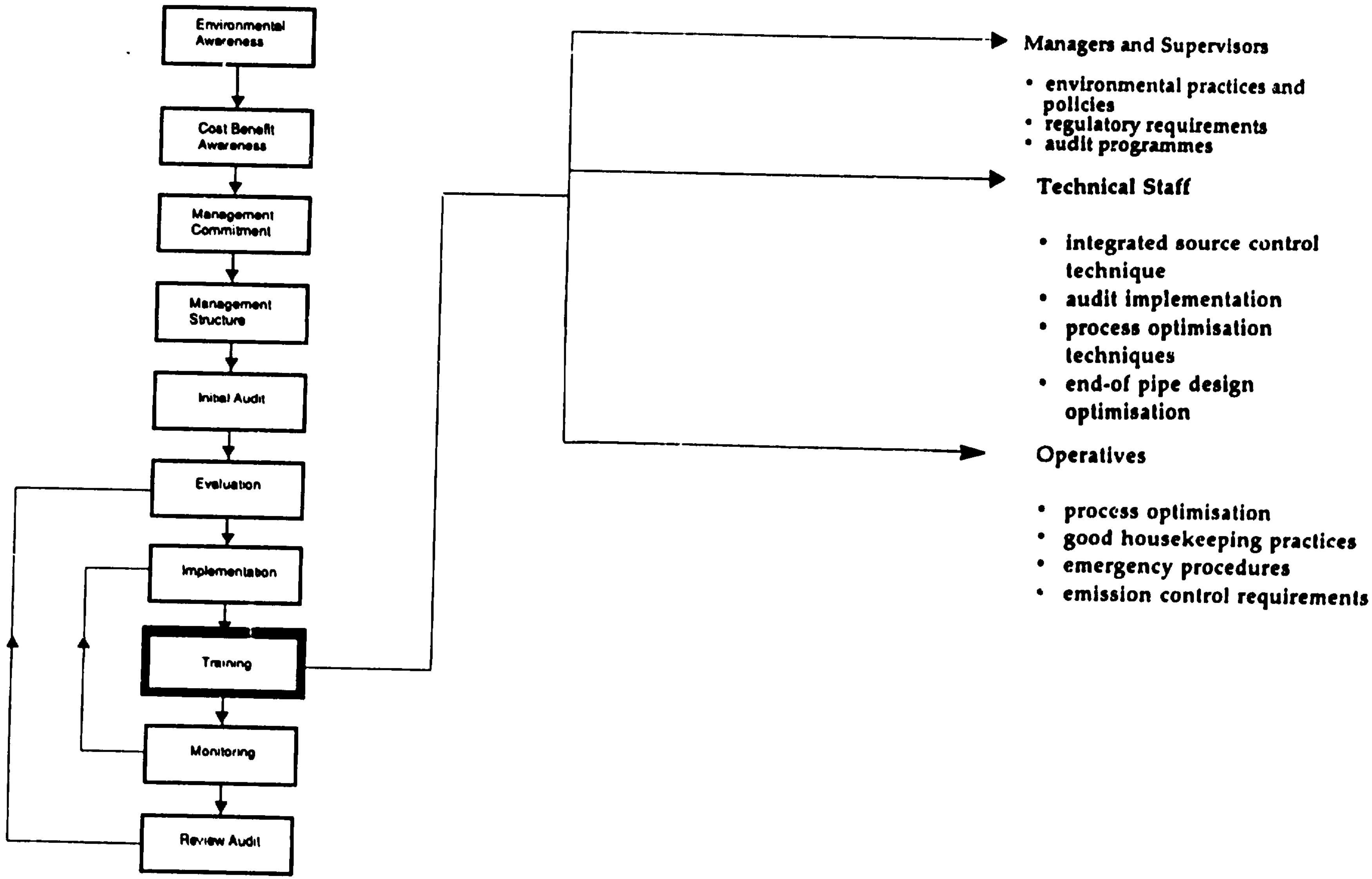


Figure 2.12 Procedures to Achieve Cost Effective Pollution Control 9. Monitoring

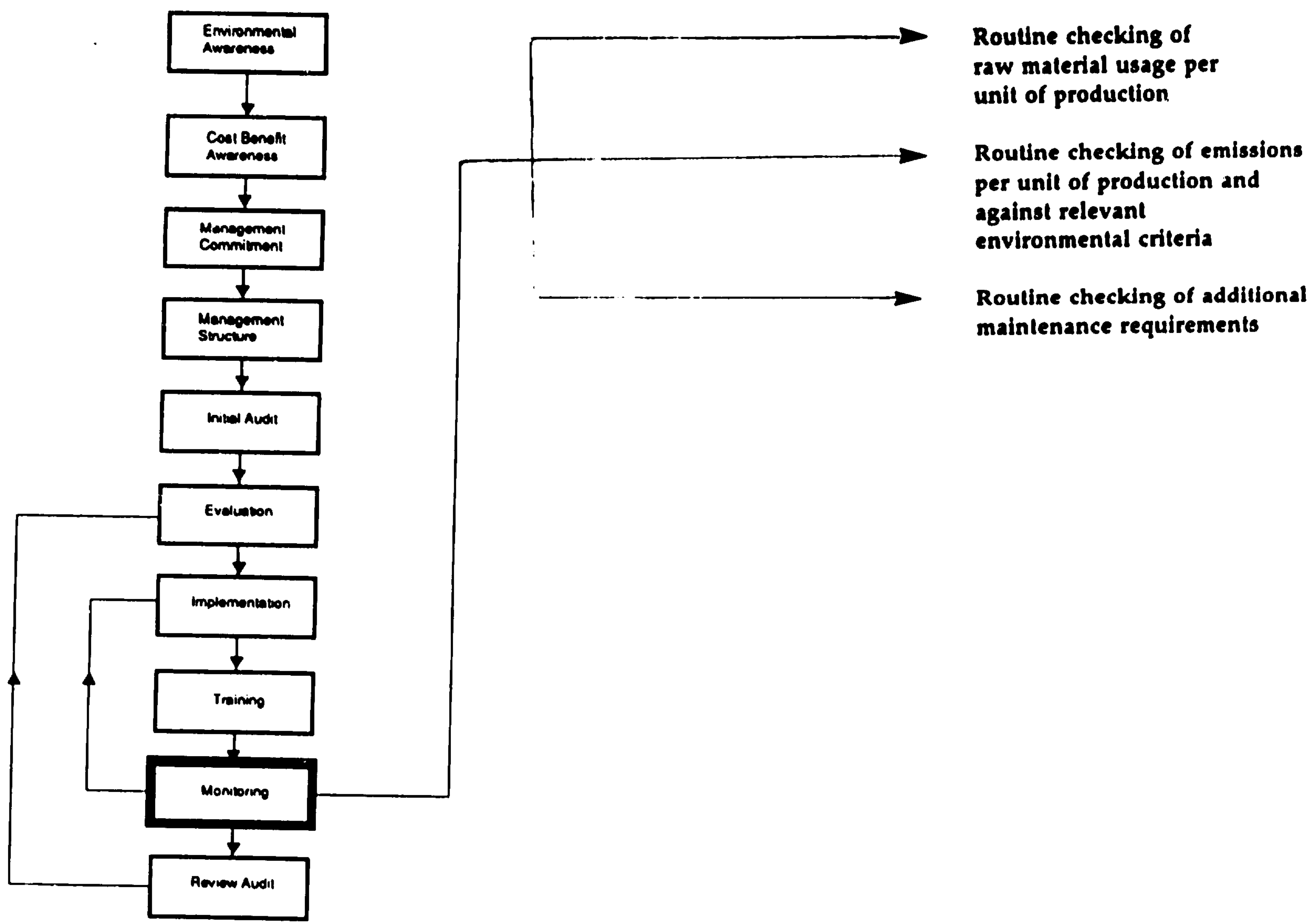
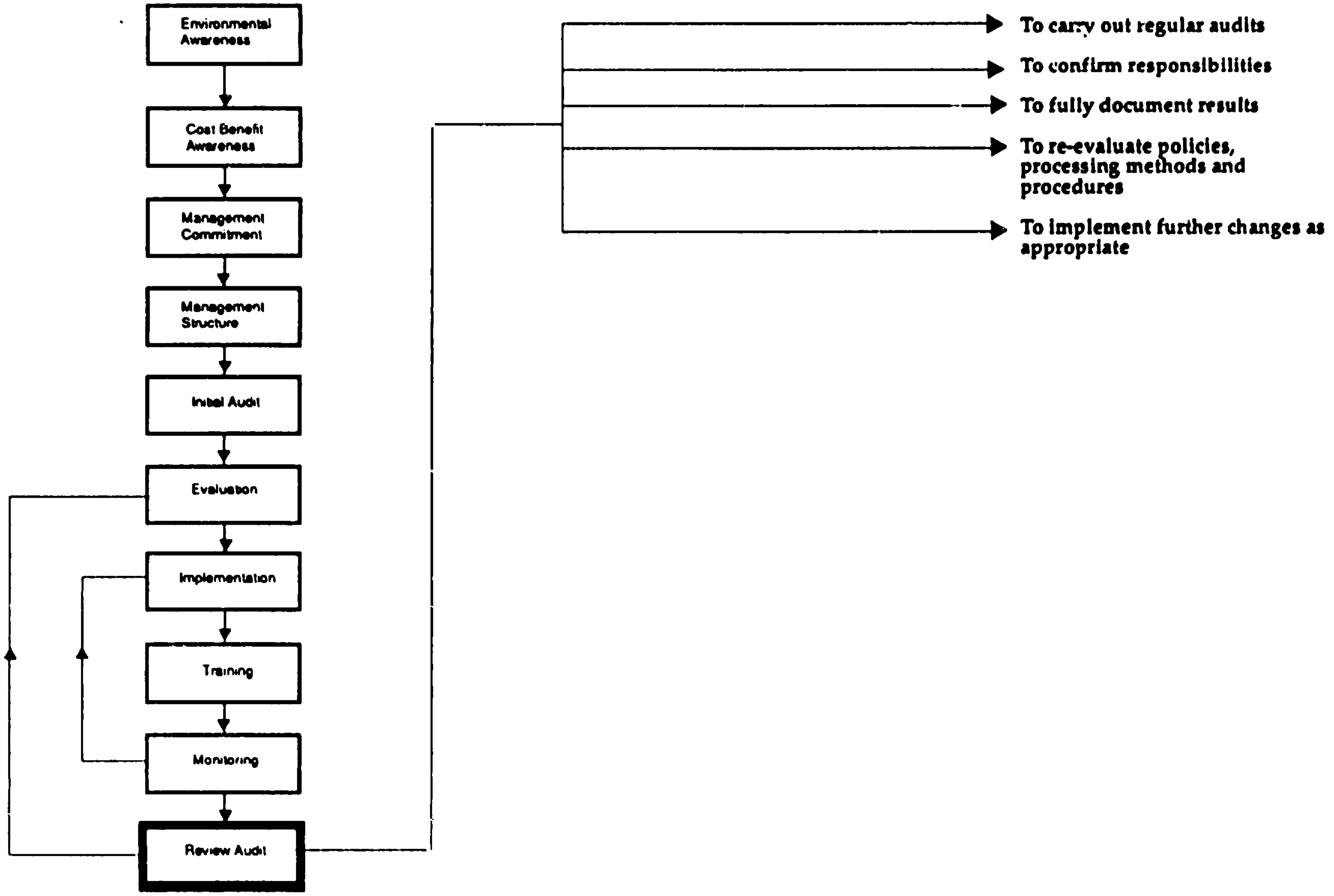


Figure 2.13 ***Procedures to Achieve Cost Effective Pollution Control***
10. Review Audit



3 *INTEGRATED SOURCE CONTROL - EXAMPLES*

The principal components of integrated source control and the benefits obtained by implementation are summarised in *Figure 3.1*.

Opportunities include both water conservation *(Figure 3.2)* and waste minimisation *(Figure 3.3)*.

Basic procedures to achieve integrate source control are summarised in *Figure 3.4*.

Typical examples of a general nature are depicted in *Figure 3.5*. Non process specific opportunities are listed in *Figure 3.6*.

Opportunities relating to batch and continuous chemical processing are shown in *Figures 3.7* and *3.8* respectively.

As an example, process specific opportunities relating to the hides and skins industry are summarised in *Figure 3.9* and identified in greater detail in *Tables 3.1 to 3.4*. The following principal headings are used:

- cleaner processes or processing methods;
- water conservation/reuse/recycle;
- waste minimisation/waste avoidance;
- materials recovery.

Also as an example, process specific opportunities relating to the pulp and paper industry are summarised in *Figure 3.10* and identified in greater detail in *Tables 3.5 to 3.8*.

Process specific opportunities relating to the metal preparation and finishing industry are summarised in *Table 3.11*.

Figure 3.1 *Procedures for Cost Effective Pollution Control*
Integrated Source Control

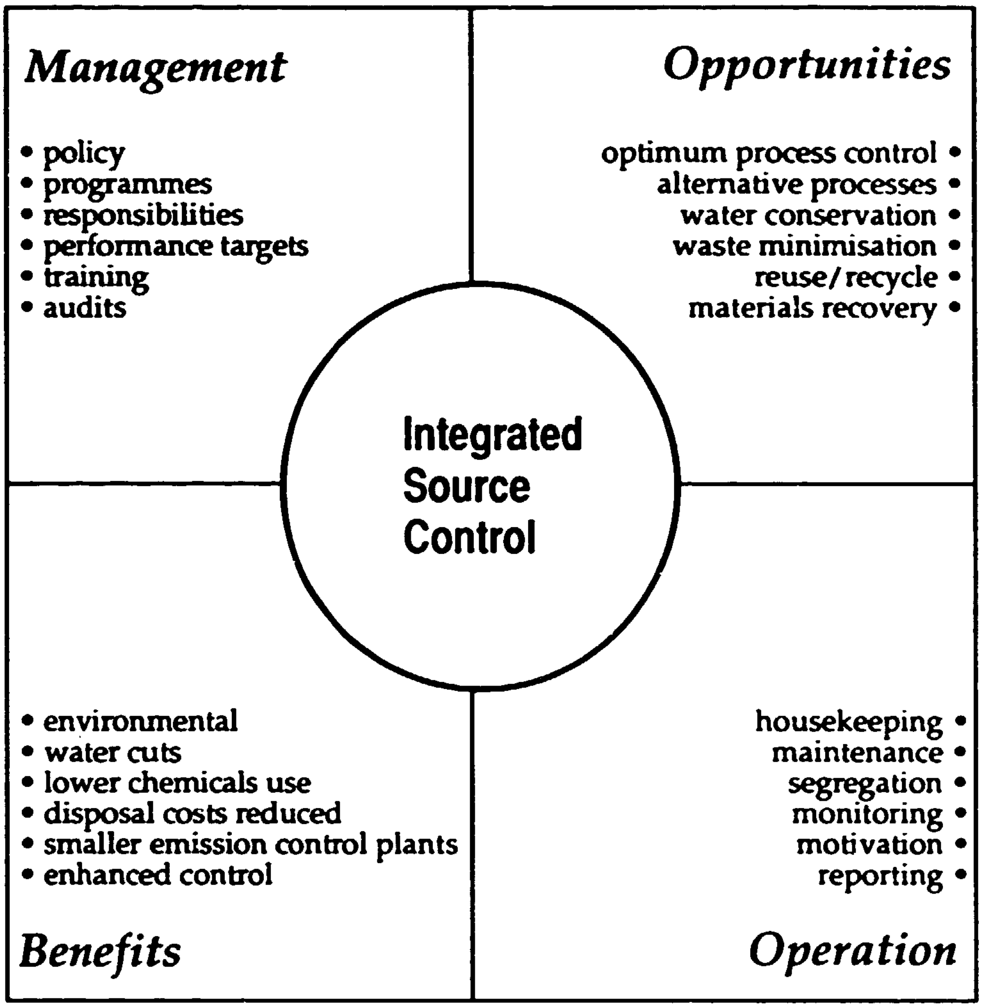


Figure 3.2 **Water Conservation**

control	*water inputs and outputs*
organise	*water usage "audit"*
nominate	*a water management officer*
specify	*preventative maintenance*
eliminate	*uncontrolled overflows*
regulate	*water pressure*
verify	*water balance*
allocate	*responsibilities*
train	*operators, supervisors, managers*
install	*water meters and controllers*
optimise	*monitoring programmes*
nurture	*water conservation "thinking"*

maximise	*process efficiency*
initiate	*waste management "audit"*
nominate	*a waste management officer*
investigate	*clean technology opportunities*
minimise	*risks of spillage, leakage*
instigate	*at source recovery opportunites*
segregate	*"Active" solids from water*
automate	*cleaning operations*
train	*operators, supervisors, managers*
improve	*housekeeping practices & procedures*
optimise	*monitoring programmes*
nurture	*water avoidance "thinking"*

Figure 3.4 ***Procedures for Cost Effective Pollution Control***
Integrated Source Control - Procedures

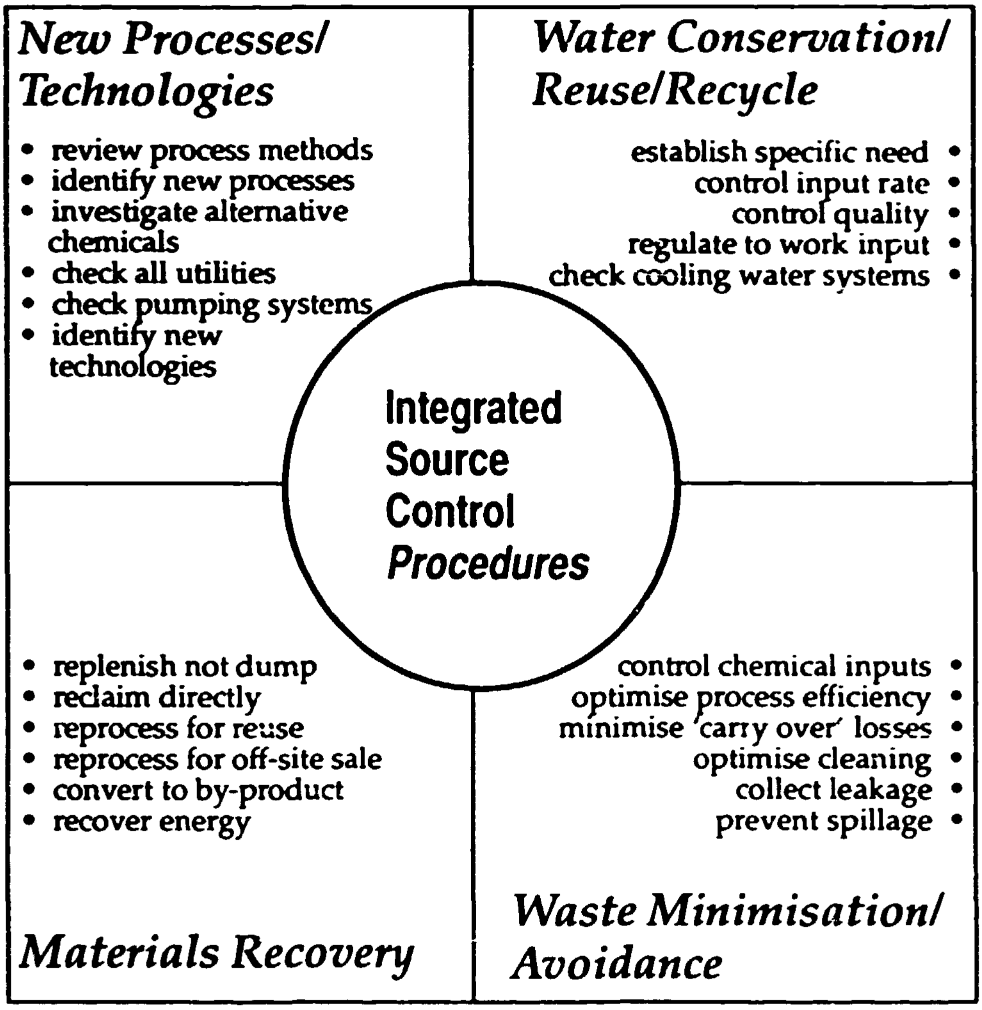
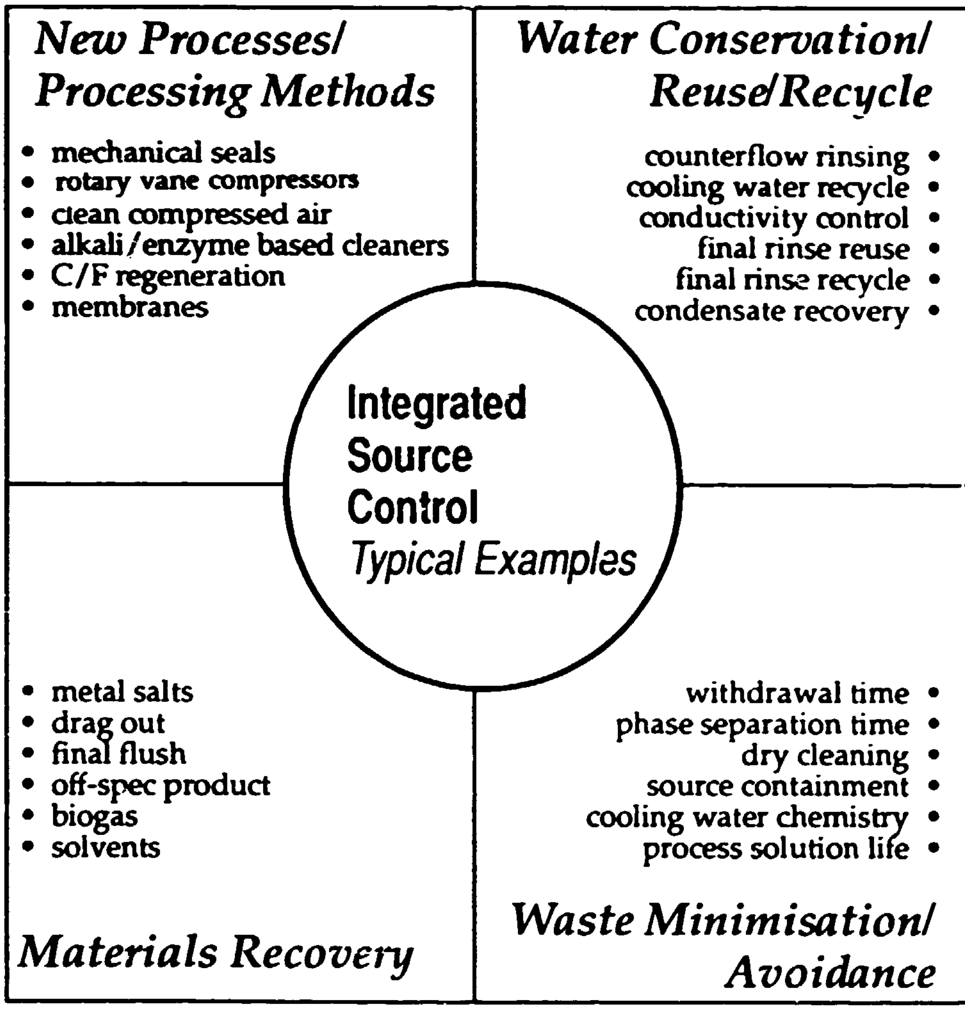


Figure 3.5 ***Procedures for Cost Effective Pollution Control***
Integrated Source Control - Typical Examples (General)



C/F: Counterflow

Figure 3.6

INTEGRATED SOURCE CONTROL
NON PROCESS SPECIFIC OPPORTUNITIES

- ***Water conservation/reuse/recycle***
  - Counterflow rinsing: use 2 or 3 rinse stations
  - Cooling water: recycle rather than once through
  - Quality control: input to meet quality requirement
  - Batch washing: reuse final wash for first wash
  - Wash water: reuse for less critical duties
  - Condensate: recover, also eliminate steam leaks

- ***Waste minimisation/avoidance***
  - Withdrawal time: allow time for dewatering
  - Phase separations: enhance efficiency
  - Dry cleaning procedures: use wherever possible
  - Cooling water: select appropriate control chemicals
  - Process solutions: prolong usage factor

- ***Materials recovery/reuse***
  - Metals salts: recover electrolytically
  - Drag out: recover directly
  - Batch cleaning: recover first flush
  - Off-spec product: collect for reprocessing
  - Energy: recover heat energy, generate biogas
  - Solvents: recover on site for reuse

- ***Alternative technologies/procedures***
  - Pumps: use mechanical seals rather than packed glands
  - Compressors: use rotary vane units rather than liquid ring units
  - Cleaners: use alkali or enzyme based cleaners, not solvents
  - Membranes: use membranes as an alternative to ion exchange
  - Ion exchange: use counter current regeneration techniques
  - Compressed air: use clean compressed air to prevent corrosion, leakages

Figure 3.7

INTEGRATED SOURCE CONTROL
BATCH CHEMICAL PROCESSING

- ***Process Control***
  - optimise mass balance
  - input raw materials accurately
  - control reactor conditions (temperature, pressure)
  - allow time for efficient phase separation
  - slow down procedures
  - collect off-spec material for reprocessing
  - enhance reaction rates (concentration factor etc)

- ***Plant Cleaning***
  - optimise campaign working to minimise cleaning requirements
  - recover first flush
  - reuse final rinse sequentially
  - use clean-in-place procedures

- ***Support Utilities***
  - contain spillage for recovery
  - detect leakage
  - optimise cooling water management
  - optimise steam usage
  - consider energy recovery

Figure 3.8

INTEGRATED SOURCE CONTROL
CONTINUOUS CHEMICAL PROCESSING

- ***Process Control***
  - input chemicals accurately and regulate concentrations
  - regulate and control water to specific requirements
  - consider side stream contaminant removal
  - consider side stream process solution enhancement
  - control reactor conditions (temperature etc)
  - minimise "drag out" of process solutions
  - replenish process solutions to prolong run times

- ***Plant Cleaning***
  - question plant clean down frequency
  - use pressure cleaning techniques
  - include automatic shut off on cleaning systems

- ***Utilities***
  - recycle cooling water directly
  - reuse cooling water for other duties
  - optimise steam usage
  - consider energy recovery

Figure 3.9

THE HIDES AND SKINS INDUSTRY
INTEGRATED SOURCE CONTROL - PROCESS SPECIFIC OPPORTUNITIES

- ***New Processes/Processing Methods***
  - curing - safe insecticides
    curing - green hides
    curing - reduced salt
  - dehairing - enzymes
  - deliming - ammonia free
  - degreasing - enzymes
  - tanning - chrome free
  - finishing aqueous media

- ***Water Conservation/Reuse/Recycle***
  - process vessels - low float
  - process vessels - batch washing
  - bating wash - recycle to soak
  - neutralisation wash - recycle to soak
  - second lime wash - reuse as first lime wash

- ***Waste Minimisation/Avoidance***
  - dehairing - low sulphide
  - chrome tanning - high chrome exhaustion
  - vegetable tanning - high utilisation

- ***Materials Recovery/Reuse***
  - dehairing - hair save by filtration
  - dehairing - separation of unhairing/liming
  - chrome tanning - chrome recovery/recycle

Figure 3.10

THE PULP AND PAPER INDUSTRY
INTEGRATED SOURCE CONTROL - PROCESS SPECIFIC OPPORTUNITIES

- ***New Processes/Processing Methods***
  - Debarking of wood - dry method
  - Kraft pulping - replace sulphide with anthraquinone
  - Solvent pulping - organic solvents
  - Kraft pulping - extended delignification
  - Straw pulping - use of $Na_2CO_3/NaOH/O_2$
  - Pulp washing - filter belt washers
  - Biopulping - enzymes
  - Biopulping - fungi
  - Biobleaching - enzymes
  - Straw bleaching - oxygen
  - Wood pulp bleaching - chlorine dioxide
  - Wood pulp bleaching - $O_2/H_2O_2/O_3$
  - Paper making - retention and drainage aids

- ***Water Conservation/Reuse/Recycle***
  - Bagasse wetting - reuse of wastewater
  - Paper machines - reuse of whitewater

- ***Waste Minimisation/Avoidance***
  - Bagasse depithing - solids separation/water recycle
  - Pulp screening - hot screening after washing
  - Evaporator condensates - methanol/TRS removal by stripping

- ***Material Recovery/Reuse***
  - Solvent pulping - lignum recovery
  - Soda or kraft liquor - lignin recovery by UF
  - Non-wood pulps - desilication (black liquor recovery)
  - Non-wood pulps - small scale recovery furnaces for black liquor

Figure 3.11

THE METAL PREPARATION AND FINISHING INDUSTRY
INTEGRATED SOURCE CONTROL - PROCESS SPECIFIC OPPORTUNITIES

- *New Processes/Processing Methods*
  - Chrome plating - trivalent chromium basis
  - Solvent cleaning - alkali/enzyme cleaning
  - Solvent cleaning - on site recovery systems
  - Passivation - chrome free
  - Process solutions - free of complexing agents

- *Water Conservation/Reuse/Recycle*
  - Conductivity control
  - Product movement control
  - Counterflow rinsing
  - Spray rinsing
  - Rate regulation

- *Waste Minimisation/Avoidance*
  - Drag out minimisation
  - Drag out containment and reuse
  - Drag out concentration and reuse
  - Use of low concentration process solutions
  - Design of work operations

- *Materials Recovery/Reuse*
  - Electrolytic recovery of metals
  - Reverse osmosis concentration of metal salts and reuse
  - Electro-dialysis concentration of metal salts and reuse
  - Ion exchange recovery processes
  - Recovery by chemical reactions

Table 3.1 ***The Hides and Skins Industry***
Integrated Source Control 1 - Cleaner Processes or Processing Methods

Process	Technology	Benefits
• Curing hides and skins	• Use of safe insecticides • Use of green hides • Use of reduced salt (15%)	• Reduced potential toxicity • Reduces effluent salinity by 60% • Reduces effluent salinity by 50%
• Dehairing	• Use of enzymes	• Reduces sulphide usage by 40%
• De-liming	• Ammonia free processing	• Reduced effluent ammonia content
• Degreasing	• Use of enzymes	• Elimination of solvent use • Reduced VOC emissions
• Tanning	• Chrome free (elun) tanning	• Chrome free solid wastes from splitting
• Finishing processes	• Use of aqueous media for finishing processes	• Elimination of solvent use • Reduced VOC emissions

Table 3.2 ***The Hides and Skins Industry***
Integrated Source Control 2 - Water Conservation/Reuse/Recycle

Process	**Technology**	**Benefits**
• Processing vessels - general	• Low float operation • Batch washing	•Reduced water consumption •Reduced chemical costs •Smaller effluent plant
• Bating wash liquors • Neutralisation wash liquors	• Recycle to soaking salted or green hides	•Reduced water consumption
• Second lime wash	• Reuse as first lime wash	•Reduced water consumption

Table 3.3 *The Hides and Skins Industry*
Integrated Source Control 3 - Waste Avoidance/Waste Minimisation

Process	Technology	Benefits
• Dehairing	• Low sulphide	• Reduced sulphide emissions
• Chrome tanning	• High chrome exhaustion	• Reduced chrome content in effluent (by 90%)
• Vegetable tanning	• High utilisation	• Reduced BOD load

Table 3.4 ***The Hides and Skins Industry***
Integrated Source Control 4 - Materials Recovery

Process	Technology	Benefits
• Dehairing	• Hair-saving by filtration	•Reduced sulphide discharge •Reduced BOD discharge •Hair recovery
	• Separation of unhairing/liming	•Materials recovery •Reduced pollution load (60%)
• Fleshings	•	•Materials recovery •Eliminates difficult solid waste
• Chrome tanning	• Chrome recovery/recycle	•Reduced materials inventory •Reduced chromium content in effluent

Table 3.5

The Pulp and Paper Industry
Integrated Source Control 1 - Cleaner Processes or Processing Methods

Process	Technology	Benefits
• Debarking of wood	• Dry debarking	• Reduced water consumption • Reduced BOD discharge
• Kraft pulping	• Replace sulphide with antraquinone	• Reduced TRS
• Solvent pulping	• Use of organic solvents	• Lignin recovery • Recovery aqueous emissions
• Kraft pulping	• Extended delignification	• Reduced chlorine demand • Reduced emission of organic chlorides
• Straw pulping	• Use of $Na_2CO_3/NaOH/O_2$	• Enhanced chemical recovery
• Pulp washing (incl. straw)	• Use of filter belt washers	• Enhanced black liquor recovery
• Biopulping	• Use of enzymes	• Reduced emissions
• Biopulping	• Use of fungi to pre-soften wood chips	•
• Biobleaching	• Use of xylanase	• Reduced organic chlorides
• Straw bleaching	• Use of oxygen	• Reduced organic chlorides
• Wood pulp bleaching	• Use of chlorine dioxide	• Reduced discharge dioxins, furans
• Wood pulp bleaching	• $O_2/H_2O_2/O_3$	• Eliminates use of chlorine
• Paper making	• Retention and drainage aids	• Enhanced whitewater recycle

Table 3.6 *The Pulp and Paper Industry*
Integrated Source Control 2 - Water Conservation/Reuse/Recycle

Process	Technology	Benefits
• Bagasse wetting during storage	• Reuse of wastewater	• Reduced water usage
• Paper machines	• Reuse of whitewater	• Lower water costs • Reduced wastewater discharge

Table 3.7 *The Pulp and Paper Industry*
Integrated Source Control 3 - Waste Avoidance/Waste Minimisation

Process	Technology	Benefits
• Bagasse depithing	• Immediate mechanical separation of solids and water recirculation	•Reduced water consumption •Reduced SS discharge
• Pulp screening	• Hot screening after washing	•Reduced BOD discharge •Reduced SS discharge
• Evaporator condensates	• Removal of methanol and TRS by stripping/incineration	•Reduced BOD discharge •Reduced TRS

Table 3.8 *The Pulp and Paper Industry*

Process	Technology	Benefits
• Solvent pulping	• Use of organic solvents	• Lignin recovery • Recovery chlorine demand
• Soda or kraft black liquor	• Use of ultrafiltration membranes	• Lignin recovery
• Non-wood pulps	• Desilication	• Black liquor recovery
• Non-wood pulps	• Small scale recovery furnaces	• Black liquor recovery

4 *OPTIMISED END OF PIPE CONTROL*

Optimised end of pipe control involves technical, management and operational initiatives. Technical initiatives include factors such as:

- source management as defined in Chapter 3;
- stream segregation (eg of incompatible waste streams or of waste streams with potential value);
- flow and load balancing (to maximise self neutralisation and to optimise hydraulic and load based unit operations);
- by-product generation (eg methane from anaerobic digestion, sludges with fertilizer value, protein value materials etc);
- choice of control systems to ensure reliability and robustness;
- choice of batch rather than continuous treatment to provide enhanced control of discharge quality; also to increase potential for process intensification.

Key issues involved in optimised end of pipe control are summarised in *Figures 4.1 and 4.2*.

Figure 4.1 ***Procedures for Cost Effective Pollution Control***
Cost Effective End of Pipe Control

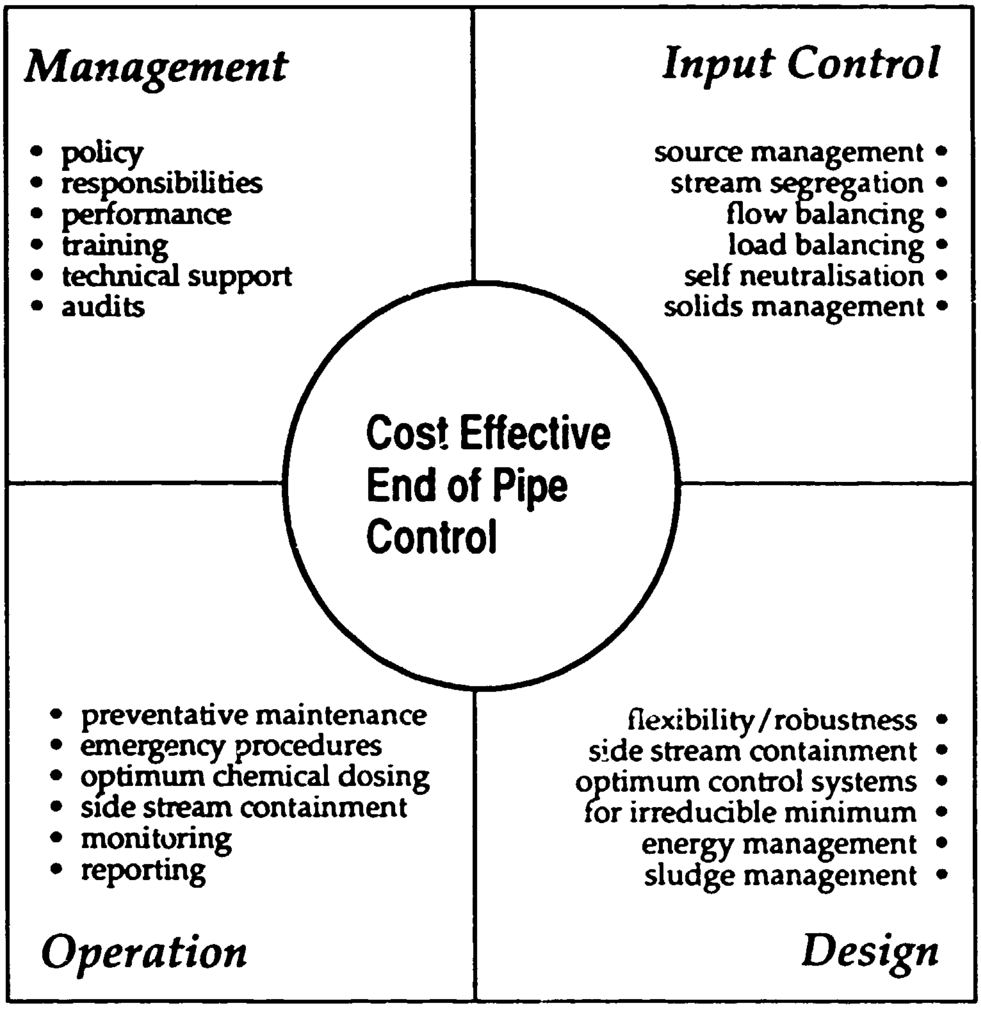


Table 4.2

COST EFFECTIVE POLLUTION CONTROL
OPTIMISED END OF PIPE TREATEMENT

- ***Segregation***
    - of solvents
    - of incompatible waste streams
    - of waste streams with potential values

- ***Flow/Load Balancing***
    - self neutralisation
    - optimisation of hydraulic based unit operations
    - optimisation of load based unit operations

- ***By-product Generation***
    - methane from anaerobic digestion
    - water for reuse
    - sludges with fertilizer value

- ***Batch (cf continuous) Treatment***
    - exact control of discharge quality
    - potential for intensification

- ***Choice of Control Systems***
    - robust and reliable
    - importance of location to avoid fouling
    - accurate reagent dosing
    - controlled oxygenation

Annex 1

Audit Review Questions Raw Materials and Utilities

1 RAW MATERIALS

1.1 Are all raw materials used on site documented in an inventory?

Provide schedule of raw materials. Identify sources of raw materials.
Identify risk category - H/M/L.

1.2 Has one individual been nominated responsible for the maintenance of the inventory?

Identify nominated individual.
Identify risk category - H/M/L.

1.3 Are records kept on quantities of raw materials used and unit costs? eg

- basic raw materials
- mains water
- borehole water
- chemicals
- solvents
- energy

Provide records of consumption for all raw materials for the last 12 months.
Identify risk category - H/M/L.

1.4 Has an environmental assessment been carried out on all raw materials used?

Provide environmental assessment documentation.
Identify risk category for each raw material used - H/M/L.

1.5 Has the potential for using alternative, less damaging materials been considered?

Identify changes already introduced. Identify potential for further change.
Identify risk category - H/M/L.
Identify potential change factor - 1/2/3.

1.6 Has the potential for optimum use of raw materials through conservation of resource to minimisation of losses been considered?

Identify achievements to date. Identify potential for further achievements.
Identify risk category - H/M/L.
Identify potential change factor - 1/2/3.

1.7 Has the potential for reuse/recycle/recovery been considered for all materials in use or likely to be introduced?

Identify opportunities already introduced. Identify potential opportunities.
Identify risk category - H/M/L.
Identify potential change factor - 1/2/3.

1.8 Are disposal requirements and implications considered before introducing any materials?

Provide examples.
Identify risk category - H/M/L.

Annex 2

Audit Review Questions Processes and Integrated Source Control

2.1 Are all processes used on site documented in an inventory?

Provide schedule of processes.
Identify risk category - H/M/L.

2.2 Has an individual been nominated responsible for the maintenance of this inventory?

Identify nominated individual.
Identify risk category - H/M/L.

2.3 Has an environmental impact assessment been carried out for all unit processes?

Provide details of assessments.
Identify risk category for each process - H/M/L.

2.4 Have all hazards associated with use of process materials been identified, eg

Identify schedule of risks.
Identify risk category on a hazard by hazard basis - H/M/L.

2.5 Has the potential for using alternative, less damaging processes been considered?

Identify changes already introduced. Identify potential for further change.
Identify risk category - H/M/L.
Identify potential change factor - 1/2/3.

2.6 Has consideration been given to the conservation of water through application of integrated source control on a process by process basis? eg

- conservation of water
- reuse of water
- recycle of water

Identify achievements to date. Identify potential opportunities.
Identify risk category - H/M/L.
Identify potential change factor - 1/2/3.

2.7 Has consideration been given to the avoidance or minimisation of waste through application of integrated source control on a process by process basis? ie

- minimisation of process solution losses through re-design of working procedures;

- minimisation of process solution losses through application of direct recovery procedures.

Identify achievements to date. Identify potential opportunities.
Identify risk category - H/M/L.
Identify potential change factor - 1/2/3.

2.8 Has consideration been given to the recovery of materials through application of integrated source control on a process by process basis? eg

- direct or indirect recovery of materials by side stream treatment;
- process solution enhancement through side stream removal of contaminants;
- conversion of waste to by-product of value.

Identify achievements to date. Identify potential opportunities.
Identify risk category H/M/L.
Identify potential change factor -1/2/3.

2.9 Are records kept of specific raw material usage on a process by process basis?

Provide specific material usage schedules on a process by process basis for the past 12 months.
Identify risk category - H/M/L.

Annex 3

Audit Review Questions End of Pipe Emission Control Systems

3 *END OF PIPE EMISSION CONTROL SYSTEMS*

3.1 Are design details and specifications for end of pipe emission control systems fully documented in an inventory?

Provide details of all end of pipe control systems (for aqueous emissions, gaseous emissions and waste arisings).
Identify risk category - H/M/L.

3.2 Has an individual been nominated responsible for the maintenance of this inventory?

Identify nominated individual.
Identify risk category - H/M/L

3.3 Are end of pipe emission control systems monitored on a regular basis to ensure compliance with design requirements (inputs and outputs)?

Provide monitoring information over the last 12 months.
Identify risk category on a system by system basis - H/M/L.

3.4 Have all end of pipe systems been regularly checked for integrity and correctness of operation?

Provide reports for the last 12 months.
Identify risk category in relation to integrity on a system by system basis - H/M/L.

3.5 Are alternative processes available which would further reduce environmental impact on a technical and economic basis.

Identify potential opportunities.
Identify risk category - H/M/L.
Identify potential change factor -1/2/3.

Annex 4

Audit Review Questions Final Emissions and Discharges

4 *FINAL EMISSIONS AND DISCHARGES*

4.1 Are all emissions and discharges documented in an inventory? eg

- process effluent
- domestic wastewater
- cooling water
- stack emissions
- hazardous wastes
- non-hazardous wastes

Provide schedule of emissions
Identify risk category - H/M/L.

4.2 Has one individual been nominated responsible for the maintenance of this inventory?

Identify nominated individual.
Identify risk category - H/M/L.

4.3 Are emissions and discharges to sewer, surface water or groundwater controlled by regulations?

Provide details of relevant regulations. Provide details of specific emission standards required.
Identify risk category - H/M/L

4.4 Are final emissions and discharges to sewer, surface water or goundwater fully quantified and characterised on an ongoing basis?

Provide monitoring data on relevant emissions and discharges for the last 12 months.
Identify risk category - H/M/L.

4.5 Do emissions and discharges to sewer, surface water or goundwater fully comply with relevant regulations?

Provide data on extent of compliance.
Identify risk category on an emission by emission basis - H/M/L.

4.6 Are emissions and discharges to atmosphere controlled by regulations?

Provide details of relevant regulations. Provide details of specific emission standards required.
Identify risk category - H/M/L.

4.7 Are final emissions and discharges to atmosphere fully quantified and characterised on an ongoing basis?

Provide monitoring data on relevant emissions and discharges for the last 12 months.
Identify risk category - H/M/L.

4.8 Do emissions and discharges to atmosphere fully comply with relevant regulations?

Provide data on extent of compliance.
Identify risk category on an emission by emission basis - H/M/L.

4.9 Are emissions and discharges of waste to off-site disposal controlled by regulations?

Provide details of relevant regulations. Provide details of specific controls and requirements.
Identify risk category - H/M/L.

4.10 Are emissions and discharges to off site disposal fully quantified and characterised on an ongoing basis?

Provide monitoring data on all disposal arrangements for the last 12 months.
Identify risk category - H/M/L.

4.11 Do emissions and discharges of waste to off-site disposal fully comply with relevant regulations?

Provide data on extent of compliance.
Identify risk category on a waste type basis - H/m/l.

4.12 Are the Contractors responsible for disposal competent?

Provide evidence.
Identify risk category - H/M/L.

4.13 Do all waste handling procedures comply with existing legislation?

Provide confirmation of compliance.
Identify risk category - H/M/L.

4.14 Are records kept of the fate of wastes produced on site?

Provide documentation for the last 12 months.
Identify risk category - H/M/L.

4.15 Are records kept on the amount of waste generated per unit of production?

Provide specific waste generation data for the last 12 months.
Identify risk category - H/M/L.

4.16 Are contingency/emergency plans in place in the event of accidental emission/discharge?

Provide documentary evidence.
Identify risk category - H/M/L.

Annex 5

Audit Review Questions Storage and Handling

5 STORAGE AND HANDLING

5.1 Does an inventory exist for all materials (raw materials, products, by-products, waste materials) stored on site?

Provide schedule of materials stored on site.
Identify risk category - H/M/L.

5.2 Have all legal requirements associated with storage and handling of materials been identified?

Provide schedules of applicable legal requirements. Provide details on how the regulations are enforced.
Identify risk category - H/M/L.

5.3 Are raw process and waste materials stored in a safe and appropriate manner? eg

- bulk acids in tanks - bunded with secondary containment
- flammable materials in a fire protected, ventilated store
- powders and pellets in areas fitted with dust extraction
- segregation of non compatible materials.

Provide details of existing storage arrangements, including plans and specifications.
Identify risk areas.
Identify risk category - H/M/L.

5.4 Has consideration been given to the requirements for segregation of incompatible materials?

Provide details on type of wastes stored in specific areas.
Identify risk areas.
Identify risk category - H/M/L.

5.5 Are all stored materials labelled clearly and correctly?

Identify schedule of omissions.
Identify risk category - H/M/L.

5.6 Has consideration been given to the measures required to contain and/or monitor for spills or leaks? eg

- provision of adequate bund capacity
- use of sealants
- provision of blind gully pots
- atmospheric vapour/gas monitoring
- groundwater monitoring
- surface water monitoring

Provide details on existing arrangements for all storage areas including drawings and specifications where available. Identify risk areas.

Identify risk category - H/M/L.

5.7 Has the integrity of raw material, process and waste storage areas been checked on a regular basis? eg

- ground quality monitoring
- inspection of tanks, containers, bunds etc

Provide details and records.
Identify risk category - H/M/L.