FRASER RIVER
ACTION PLAN

Technical Pollution Prevention Guide for Brewery and Winery Operations in the Lower Fraser Basin

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TECHNICAL POLLUTION PREVENTION GUIDE FOR BREWERY AND WINE OPERATIONS IN THE LOWER FRASER BASIN

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Prepared for:

Environment Canada
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North Vancouver, B.C.

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DISCLAIMER

Any comments regarding this report should be forwarded to:

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NOTICE

This project was funded by Environment Canada under the Fraser River Action Plan through its Fraser River Pollution Abatement Office. The report has been subjected to Environment Canada's peer review, and has been approved for publication.

This document is intended as advisory guidance to Breweries and Wineries in British Columbia in developing approaches to pollution prevention. Compliance with occupational safety and health laws is the responsibility of each individual business, and is not the focus of these documents.

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EXECUTIVE SUMMARY

Over the last few decades, the adverse impacts of industrial wastes and/or pollutants on the environment have become a major concern of regulatory agencies and businesses. Traditionally, waste management efforts have focused primarily on “end-of-pipe” treatment methods which simply transfer pollutants from one medium to another. It was then realized that in order to effectively avoid or minimize the potential adverse environmental impacts, efforts should be concentrated on preventing the generation of pollutants through the use of more efficient processes and improved management of resources (raw materials, water and energy).

In the long run, this approach proved to be more economical and financially rewarding for industry. It also contributed to improved environmental health, public relations and employee morale.

Recently, the British Columbia Ministry of Environment, Lands and Parks has adopted an approach to pollution prevention and a hierarchy to provide order and direction for companies developing a pollution prevention program. A primary component of a pollution prevention program is the development of a pollution prevention plan.

This guide was funded by Environment Canada as part of their Fraser River Action Plan to assist the breweries and wineries located in the Lower Fraser River basin to enhance their environmental performance and to help the industry lower their cost of waste management.

The objective of this project was to develop a Technical Pollution Prevention Guide (TPPG) for brewery and winery operations in the Lower Fraser basin. The guide is designed for the use of plant operators, plant managers and regulatory agencies. The TPPG enables operators to develop a facility-specific pollution prevention plan, and to undertake voluntary, internal environmental and compliance audits.

The Technical Pollution Prevention Guide for Brewery and Winery Operations includes the following:

- a brief introduction to pollution prevention, procedure and benefits;
- a general description of the brewery and winery industry including processes, resources, products, by-products and wastes;
- a review of waste sources and discharge factors from various processes of environmental concern associated with breweries and wineries;
- Best Management Practices of breweries and wineries; and,
- a detailed step-by-step procedure for development of a facility-specific pollution prevention program including worksheets and information concerning program organization; environmental reviews and assessments; the selection of pollution prevention options; and preparing, implementing and evaluating the plan.

RÉSUMÉ

Au cours des dernières décennies, l'incidence défavorable des déchets industriels et/ou des matières polluantes sur l'environnement est devenue une source de préoccupation importante pour les organismes de réglementation et les entreprises. Depuis toujours, les efforts pour gérer efficacement les déchets se sont concentrés principalement sur un système de traitement « en aval », système qui ne fait que transférer les polluants d'un milieu à un autre. On a enfin réalisé que, pour éviter, ou, à tout le moins, minimiser l'incidence défavorable possible des déchets sur l'environnement, il fallait s'employer à prévenir l'émergence de polluants en utilisant des méthodes plus efficaces, et en perfectionnant notre gestion des ressources (matières premières, eau et énergie).

Avec le temps, cette approche s'est révélée plus économique et plus enrichissante financièrement pour les industries. Elle a aussi contribué à améliorer l'état de l'environnement, les relations publiques et le moral des employés.

Récemment, le ministère de l'Environnement, des Terres et des Parcs de la Colombie-Britannique a adopté une approche pour la prévention de la pollution et créé une structure afin d'orienter les sociétés qui mettent sur pied un programme de prévention de la pollution. Première étape de ce programme : élaborer un plan de prévention de la pollution.

Ce projet a été financé par Environnement Canada dans le cadre du Plan d'action du Fraser pour aider les brasseries et les vineries situées dans le bassin du bas Fraser à améliorer leur rendement sur le plan écologique et pour les aider à diminuer les coûts de gestion de leurs déchets.

L'objectif de ce projet : élaborer un guide technique de prévention de la pollution destiné aux brasseries et aux vineries du bassin du bas Fraser. Ce guide a été conçu à l'intention des exploitants d'installations, des directeurs d'usine et des organismes de réglementation. Le guide offre aux exploitants les outils nécessaires pour élaborer un plan de prévention de la pollution adapté à leur type d'installations, et il les encourage à entreprendre volontairement à l'interne des évaluations environnementales et des vérifications de conformité.

Le guide technique de prévention de la pollution pour les brasseries et les vineries comprend :

- une brève introduction à la prévention de la pollution (méthodes et avantages);
- une description générale des industries de la brasserie et de la vinification, notamment de leurs procédés de fabrication, des ressources utilisées, des produits, des sous-produits et des déchets qu'elles engendrent;
- une analyse des sources de déchets et des facteurs de décharge associés à différentes méthodes qui sont en usage dans les brasseries et les vineries et qui suscitent des préoccupations d'ordre écologique;
- des suggestions de pratiques de gestion exemplaires pour les brasseries et les vineries;
- une marche à suivre détaillée pour l'élaboration d'un programme de prévention de la pollution qui comprend une fiche de travail et des informations concernant l'organisation du programme; des vérifications et des évaluations environnementales; le choix des options pour la prévention de la pollution; et la préparation, la mise en oeuvre et l'évaluation du plan.

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1.0 INTRODUCTION

1.1 Background

Over the last few decades, the adverse impacts of industrial wastes and/or pollutants on the environment have increasingly become a major concern of regulatory agencies and businesses. Traditionally, waste management efforts have focused primarily on "end-of-pipe" treatment methods which simply transfer pollutants from one medium to another. It was then realized that in order to effectively avoid or minimize the potential adverse environmental impacts associated with pollutants and wastes, industries should not only better control emissions and discharges, but also prevent generation of pollutants through the use of more efficient processes and improved management of resources (raw materials, water and energy).

Within a management hierarchy, pollution prevention should be the top priority and should include: prevention and reduction, recycling and reuse, treatment, and disposal (Dickens, 1993). Consequently, pollution prevention planning becomes of major importance in minimizing adverse environmental impacts resulting from industrial activities. A primary component of a pollution prevention program is the development of a pollution prevention plan.

With the increasing industrial base of the Fraser River basin, environmental control over contaminant discharges becomes of greater concern to ensure fisheries and water quality protection. Breweries and wineries represent a source of these contaminant discharges. By incorporating pollution prevention planning into the general operation procedures of breweries and wineries, major corporate benefits can be realized while simultaneously avoiding and/or minimizing potential adverse environmental impacts on the Fraser River.

1.2 Scope and Objectives

The overall objective of this project is to develop a Technical Pollution Prevention Guide (TPPG) for brewery and winery operations in the Lower Fraser basin. The TPPG is designed for the use of plant operators, plant managers and regulatory agencies. The TPPG enables the operators to develop a facility-specific pollution prevention plan, and to undertake voluntary, internal environmental and compliance audits.

2.0 POLLUTION PREVENTION

The Canadian Council of Ministers of the Environment (CCME) defines pollution prevention as the use of materials, processes or practices that reduce or eliminate the creation of pollutants or wastes at the source. Furthermore, it includes practices to reduce the use of materials, energy, water and other resources.

BC Environment (BCMOE, 1996a) has adopted a pollution prevention hierarchy which provides order and direction for companies developing a pollution prevention program. The BCMOE hierarchy and the CCME definition highlight the major difference between pollution control and pollution prevention. While pollution control is essentially an "end-of-pipe", "react and treat" approach to waste management, pollution prevention is the elimination of waste at its source, or an "anticipate and prevent" approach (UNEP, 1995). As such, pollution prevention can be seen as the most effective approach to environmental protection when compared to other forms of waste management.

Dickens (1993) described industrial pollution prevention as a result of changes in product, process and/or management system. As breweries and wineries are characterized by high resource consumption, pollution prevention within these industries can be expected to focus primarily on minimization of resource consumption, increasing process efficiency and environmental training of operators.

2.1 Potential Benefits

There are a number of incentives for minimizing/eliminating waste, both for industry and society at large (Yapijakis, 1992). These benefits may include:

- ***Economic gains***

  The potential economic benefits for a company from pollution prevention include reduced costs for waste management. In addition, savings may be realized through a reduction in costs for insurance rates, environmental clean-up, legal liability, and health and safety costs (Yapijakis, 1992; BCMOE, 1996a). As a result, pollution prevention can be seen as an internal source of company funds which can be used to improve its overall competitive strength (Dickens, 1993).

- ***Improved environmental health***

  Pollution prevention reduces the amount of pollutants being released to the environment. This minimizes the potential adverse impacts associated with environmental degradation and results in a cleaner environment (UNEP, 1995; BCMOE, 1996a).

- ***Improved public relations***

  The public interest in pollution prevention has been continuously increasing. Consequently, a company can improve its public image in the marketplace by adopting pollution prevention as a part of its management policy (UNEP, 1995; BCMOE, 1996a).

- ***Improved employee morale***

  By adopting a pollution prevention program, the overall work environment improves due to increasing employee interest and participation in pollution prevention. This results in a corresponding improvement in employee morale, teamwork and productivity.

- ***Reduction in liability***

  Pollution prevention reduces both long- and short-term liabilities and improves employee safety (Yapijakis, 1992; British Columbia Ministry of Environment, Lands and Parks, 1996a). Furthermore, by adopting pollution prevention as a business strategy, companies may ease future legal liabilities and real estate transactions.

- ***Legislative compliance***

  Pollution prevention helps the facility to meet the current environmental legislation and to avoid extra waste management costs (Dickens, 1993; British Columbia Ministry of Environment, Lands and Parks, 1996a).

- ***New developments***

  Pollution prevention focuses research and development in areas with the greatest potential for economic and environmental benefits. This could result in the development and implementation of new technologies or processes which may provide the company with new assets and a competitive edge (Yapijakis, 1992; BCMOE, 1996a).

2.2 Pollution Prevention Planning

Pollution prevention planning is a systematic, continuous, comprehensive examination of the operations at a facility with the goal of minimizing all types of waste products (Royds Consulting Ltd., 1995). The plan seeks to integrate environmental and economic decision-making, and requires companies to incorporate environmental considerations into their business strategies through:

- conducting an environmental review of operations;

- prioritizing and ranking potential changes in operating procedure and management practices to maximize environmental protection and to generate economic benefits; and,
- creating, implementing and monitoring a comprehensive, facility-wide pollution prevention plan (BCMOE, 1995).

The need for a systematic approach to pollution prevention has led to the development of pollution prevention programs incorporated in the management systems. These management systems include the organizational structure, responsibilities, practices, procedures, processes and resources for implementing the pollution prevention actions needed. In order for these systems to be beneficial, the following actions should be incorporated in preparing and implementing a pollution prevention program (UNEP, 1995):

- management commitment;
- clear identification of all environmental issues and associated company goals;
- clear lines of responsibility and accountability for environmental issues;
- adequate budget and resources;
- clear company targets for lowering resource consumption and discharges;
- regular monitoring of environmental performance;
- striving for continuous improvement in environmental performance;
- programs on environmental training and awareness;
- effective accident reporting and investigation;
- effective contingency planning for potential environmental mishaps; and,
- effective communication procedures with the employees and the public.

3.0 INDUSTRIAL PROFILE

3.1 Industry Description

Although production of alcoholic beverages has been practiced for centuries, the process is still as much an art as it is a science. However, there have been refinements and increased recovery of by-products, but the basic operation has changed very little (Ontario MOE, 1986). The following sections provide a basic description of the operations practiced in the manufacture of beer and wine.

3.1.1 Breweries

3.1.1.1 Resources

Resources consumed by the brewing industry include water, energy and grist materials (barley, corn and rice), adjuncts and auxiliary materials such as Kieselguhr, caustic soda and detergents. Adjuncts are used to reduce the costs of production, to adjust the balance in the composition of the wort, and to produce (if desired) a "lighter" beer (UNEP, 1995). The production of one hectolitre of normal lager beer requires about 15 kg of malt and adjunct. The adjunct content does not exceed 30% of the brewing material.

Hops are added to the beer to give it a bitter taste and a pleasing aroma. It can be added in the form of natural hops, or more commonly, as hop extract or powder.

Water consumption generally ranges from 4-10 hl/hl beer depending on the packaging and pasteurizing process, the age of the plant and the type of equipment. Furthermore, raw water temperature will affect water consumption, as water is often used as a cooling medium. A recent study at Heineken determined that breakdown of water use in a brewery (6.5 hl/hl beer) was as follows (UNEP, 1995):

- raw material 1.3 hl/hl
- cleaning 2.9 hl/hl
- cooling water 0.7 hl/hl
- other (domestic, losses) 1.6 hl/hl

However, water consumption may amount to two to three times the above figure, especially where the raw water temperature is high (UNEP, 1995). A breakdown of water use in various areas of two breweries (in Germany and South Africa) is shown in Table 3.1.

Heat consumption is influenced by process and production characteristics such as packing method, pasteurization technique, type of equipment, by-product treatment, etc.

Table 3.1 Water Use in Various Areas of a Brewery Operation

Processing area	Water Use (hl/hl beer)	
	Pöhlmann, 1980	BPCE, 1986 (1)
Brewhouse	1.8 - 4.2	1.4 - 3 (1.75)
Cellars, including filtration	0.8 - 1.7	1.0 - 1.5 (1.15)
Packaging, including pasteurization	0.9 - 1.9	1.3 - 1.8 (1.50)
Utilities (engine room, boiler, cooling and amenities)	1.25 - 3.3	0.7 - 1.9 (2.25)

(1) the data between brackets show average value *Source*: BPCE, 1986

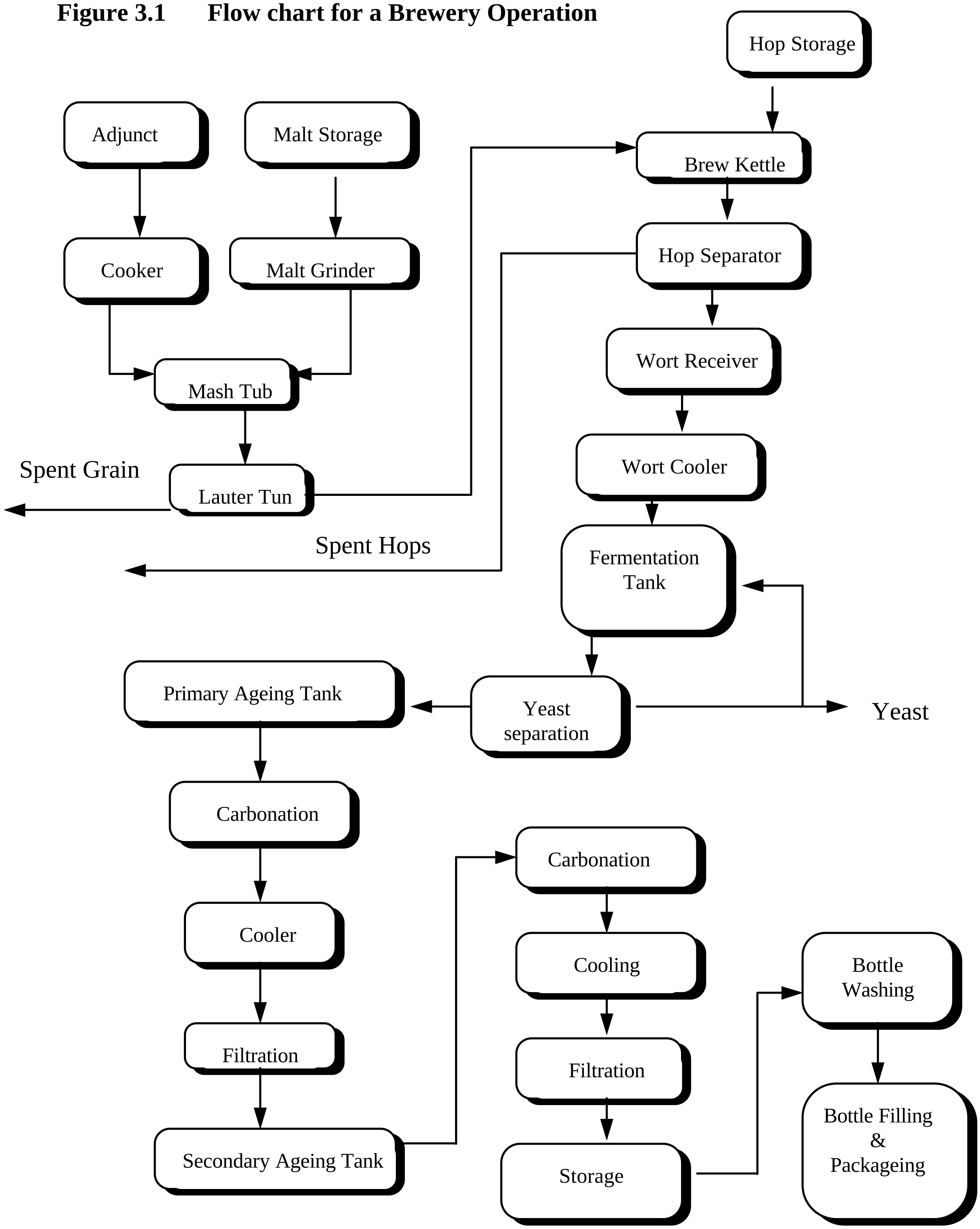
In a brewery (without a heat recovery system from boiling wort), heat consumption can be two to three times higher than a well run brewery. Heat consumption in a well run brewery is 150-200 MJ/hl.

Electricity consumption, in a well run brewery, is about 8-12 kwh/hl, depending on process and production characteristics. Some breweries consume up to twice as much due to inefficient production and lack of energy consciousness (UNEP, 1995).

Auxiliary materials used in beer production are as follows:

- Kieselguhr is used for filtering beer at a rate of 100 - 300 g/hl depending on initial clarity, yeast cell count and beer type.
- Caustic soda is used for cleaning at 0.5-1.0 kg (30% NaOH)/hl. High consumption can be due to no or little recovery during equipment cleaning and to problems with the bottle washer. This increases the pH of wastewater.
- Detergents and acids may be used for cleaning. The consumption rate depends on the cleaning procedures.
- Packaging materials include non-returnable bottles, cans, crown corks, cardboard, plastic stretch and shrink wraps, etc. (UNEP, 1995).
- Other materials are used including glue (used for labels and cardboard boxes) and a range of additives such as enzymes, antioxidants, foam stabilizers and colloidal stabilizers (finings, silica, tannic acid, etc.).

Figure 3.1 Flow chart for a Brewery Operation



Source: Ontario MOE, 1986

3.1.1.2 Process Description

The brewing process involves malting of grain, milling and mashing, wart cooling and fermentation, packaging, and pasteurization (Figure 3.1). The following section includes a brief description of the various brewing processes.

Malt

Malt is derived from a cereal grain, usually barley, after being germinated for a limited period and then dried. Malting is usually not carried out on a brewery site but is an integral part of the brewing industry (BPCE, 1986). The barley undergoes the malting process to convert it to a form suitable for brewing. During the malting process, enzymes are generated, the grain cell walls are broken down and some proteins are hydrolyzed.

The malting process of barley includes cleaning, sorting, steeping, germination, drying and polishing. The barley is cleaned of dust and foreign materials and then sorted according to size with the smallest kernels (grade IV) being sold as animal feed.

The barley water content is increased to about 45% by steeping in water. During this time the water is changed two to three times and the grains are aerated. The grains may start germination before moving to the germination boxes.

The germination process prepares the grain content to undergo the enzymatic reaction. The steeped grain is placed in boxes with false bottoms made of perforated steel plate and fitted with a mechanical turner which turns the grain layer once every eight hours. The grain is placed in the germination boxes in a layer of one metre deep for 120 - 190 hours. Air is blown through the germinating grain to control temperature and moisture content.

The germinated grain is then dried in a kiln to stop the germination process and to prepare the grain for storage. The moisture content of the grain is reduced to 4% and flavour, aroma and colour are developed. During the drying process, sulfur dioxide may be introduced to bleach the kernels and lower the pH of the malt. The dried malt is then polished (by removing rootlets which sprouted during germination) and stored in silos for a minimum of four weeks before usage. The removed rootlets are sold as animal feed.

Milling and Mashing

Malted barley is ground (either dry or wet) in a malt grinder so that the husk is left intact while the rest becomes very coarse powder, rich in starch and enzymes. The enzymes quickly degrade the starch to sugar on contact with water. The product, called sweet wort, is a mixture of partially degraded starch, sugars, enzymes, proteins and water (BPCE, 1986). The wort is separated from the spent grains by straining through a porous filter in the lauter tun where the grains are sprayed or "sparged" with water in order to extract the maximum amount of useful material. The washings are monitored for sucrose content and when they reach 1° on the Plato scale, sparging is stopped (BPCE, 1986).

The spent grains are collected for off-site disposal, usually as animal feed, and the last runnings from the lauter tun are normally discharged to drain. Some spent grains may find their way into the final effluent. The temperature of the wort during straining is about 75 - 78^{o}C.

Spent grains, spent hops and trub represent a valuable source of protein for animal feed. The spent grain yields typically 125-130 kg wet for every 100 kg of malt and its composition is 28% protein, 8% fat and 41% nitrogen-free substances (BPCE, 1986).

At this stage, hops or hop extracts, sugars or syrups, and coagulants (of proteins or tannins) are added. The sweet wort is usually boiled for about l.5 hours to inactivate the enzymes; sterilize and concentrate the wort; and precipitate proteinaceous material (hot trub). The hop provides the bitter taste and coagulates the colloidal proteins. The wort is then clarified in a hydro-cyclone to remove hot trub and other insoluble material.

Wort Cooling and Fermentation

In order to prepare for fermentation, the hopped wort is cooled to about 10^{o}C. Further precipitation of proteins and tannin (known as cool trub or fine break) occurs during the cooling and aeration in preparation for fermentation which may continue from 2 - 16 days.

Yeast is added in the fermentation vessel to induce fermentation of sugar wort which is converted to CO_2, alcohol, heat and new yeast cells. When the fermentation process has reached completion, the yeast is drawn off and used for a new batch of wort with the excess being disposed of as a by-product. The surplus yeast can be resold as animal feed. On a dry solids basis, the yeast contains 50-60% proteins, 15-35% carbohydrates and 2-12% fat making it another valuable source of protein for animal feed (BPCE, 1986).

Following the primary fermentation, the produced beer (green beer) is transferred to storage or maturation vessels for a certain period of time before filtration. During storage, the excess yeast and other suspended solids precipitate, the beer matures, stabilizes, and becomes saturated with CO_2. Precipitated yeast (known as tank bottoms) is removed by settling. Finings (fish collagens) are added after maturation to promote flocculation of any remaining yeast or proteins and the mixture is filtered through a filtration unit coated with a filter slurry of Kieselguhr and/or lucilite. The result is a clear or "bright" beer and a spent filter slurry which is highly polluting and a particular problem for municipalities because it settles very easily and tends to block sewers and pipes (BPCE, 1986).

If high gravity brewing is practiced, it is usual to blend with sterile de-aerated water to normal gravity after fermentation. Other additions at this stage include stabilizers to promote longer shelf life and foam improvers to retain a stable, white foam when the beer is poured (BPCE, 1986).

Prior to filtration, the beer may be centrifuged, cooled to $-1^{o}C$ to $-1.5^{o}C$ to precipitate any suspended solids. The beer is then filtered in a Kieselguhr (diatomaceous earth) filter followed by a filter cloth.

Following filtration, stabilizing agents, colour and primings (sugar) may be added. CO_2 concentration in the beer is then adjusted and the beer is transferred to the bright beer tank for packaging.

Packaging and Pasteurization

Bright beer is stored and then filled into bottles or cans. In the process of filling, a small volume of beer (drip beer) is spilt. Bottling is usually preceded with bottle washing to remove any residual beer mold, cigarette butts, labels and dust particles. Bottle washing and pasteurization requires large volumes of water. The bottles are transported on a conveyor from the bottle washer to the filling machine for filling and capping. During filling, oxygen should be prevented from coming in contact with the beer.

Effluent from these stages is generally high volume and low strength due to dilution. The main pollutants are drip beer from fillers, beer from pasteurizer breakages and beer residues in returned bottles (BPCE, 1986).

Beer is sterilized either by tunnel pasteurization after bottling or flash pasteurization before bottling. The bottles are then labeled and packed in crates, cartons or other forms of transport packaging.

3.1.2 Wineries

Wine is the fermented juice of the fruit of one of several grape species of the genus *Vitis*, most often of cultivars of *Vitis vinifera*, with or without the addition of sugar, grape concentrate, or reduced must (boiled-down grape juice), herbs, flavours or alcohols. Over 95% of the world's wine is made from varieties of *V. vinifera*, possibly because of the more subtle flavours of most *V. vinifera* wines (Othmer, 1980). Wine making is still something of an art, as far as quality is concerned, but today most of the world's wine is produced by modern technology.

Grapes contain 15% - 25% sugar which increases to 30% - 40% when the grapes are partially dried. The percentage of sugar in the grapes, the extent of the fermentation, and the losses or additions of alcohol during treatment and storage determine the percentage of alcohol in the finished product, Since at least 9% (vol.) alcohol is usually necessary to prevent rapid acetification or spoilage, sugar must sometimes be added (chaptalization) to permit fermentation to reach the required alcohol content. A minimum sugar content of 16.4% is therefore necessary to produce a wine of 9% alcohol. Usually, the sugar content of grape juice is determined with a hydrometer. The Brix or Balling hydrometer, used in the United States, reads in grams of sugar per 100 grams of liquid. In Europe, the specific gravity hydrometer (Oechesle) or other special hydrometers are employed; in Australia, the Baumé hydrometer is used (Othmer, 1980).

The pH of normal grape juice in moderate climatic zones is 3.0 - 3.6, and the titratable acidity is 0.5% - 1% (calculated as tartaric acid). In this range, most deleterious organisms grow slowly or not at all, thus allowing rapid growth of the desirable yeast. The relatively high titratable acidity and low pH of musts aid in the extraction of colour from the skins and in wine clarification. In other fruits, the acidity is due to malic, citric, oxalic and isocitric acids in varying proportions. This acidity is usually high enough to permit a disease-free fermentation and a stable product, unless diluted with too much water. Moreover, some fruit and berry wines must be sweetened to mask excessive acidity.

Only a small amount of nitrogenous material (0.3% - 1.0%) is found in grapes. However, this material is of considerable significance for yeast nutrition, bacterial stability and flavour development, presumably because of the many amino acids present. During fermentation, the total amino acid content decreases, although the content of some acids may be higher in the finished wine than in the must because of their release by autolysis of yeast cells. The most important amino acid reported in grape juices or wines are alanine, arginine, aspartic acid, cystine, glutamic acid, glycine, histidine, isoleucine, leucine, lysine, threonine, tryptophan, tyrosine and 1-valine. In other fruits, yeast propagation is limited by low nitrogen, and a nitrogen-containing compound is added to stimulated yeast growth. Apple and pear juices, for example, ferment slowly for this reason (Othmer, 1980).

Red wine (from red grapes) also contains considerable tannins, which affect taste, colour, oxidation-reduction potential and rate of ageing.

The pectins of some fruit and grapes are a source of difficulty in juice clarification. They are rather insoluble in alcohol and precipitate during fermentation.

Wines are normally produced by fermentation with the yeast *Saccharomyces cerevisiae*, sometimes with *S. bayanus* or *S. oviformis*. These and other yeasts, found in grapes or fruit, multiply rapidly in the sweet juice, eventually causing fermentation. Pure yeast cultures are usually added at a rate of 1% - 3% (Othmer, 1980). The actively fermenting culture is grown in sterilized must.

To prevent growth and competition of undesirable organisms, 50 - 200 mg/L sulfur dioxide are usually added two hours before the pure yeast culture is added. The sulfur dioxide acts as a selective antiseptic and permits more or less unrestricted growth of the added yeasts. The warmer the must and the poorer its quality, the more sulfur dioxide is needed (usually >150 mg/L). The sulfur dioxide kills or inhibits the growth and activity of undesirable bacteria and yeasts, increases the extraction of colour and soluble material from the skins, and acts as an antioxidant. Other components, such as sugar, water, acid or nitrogenous materials (e.g., urea or ammonium phosphate) are added at the same time.

Process Description

The grapes are crushed in combined stemmers and crushers. These remove the stems first by centrifugal force and then crush the berries. The actual crushing may be done by centrifugation or by passing the fruit through rollers or by both. Must pumps transfer the must to the fermentors or presses.

Fermentation tanks may be made of wood, concrete, stainless steel, or iron lined with epoxy resins or a thin layer of stainless steel; they may be open or closed. Open wooden or concrete tanks were formerly used for red musts and closed containers for white musts. Today, stainless steel or lined iron tanks are used for both red and white fermentation, for the storage of wines during clarification, for early maturing white table and dessert wines, and for blending and storage before bottling. Large open tanks may have coils, preferably of stainless steel, for cooling or heating, but most are now partially or wholly jacketed. In some wineries, the temperature is computer controlled.

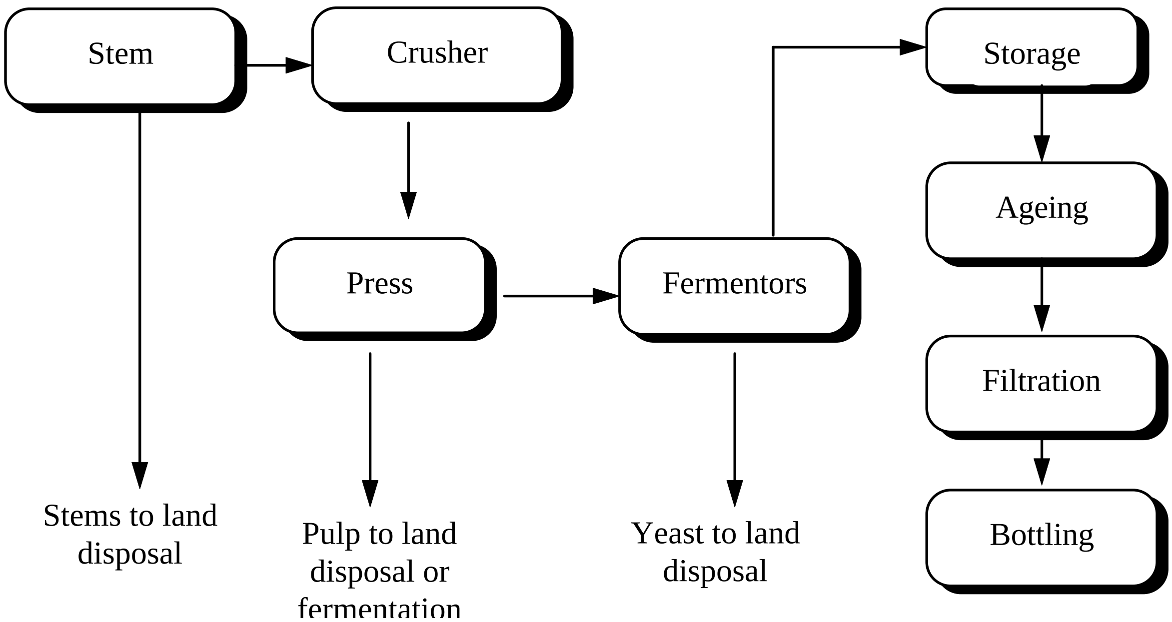
After fermentation, the residue (i.e., stems and skins) often called "pomace" or "marc", must be transferred from the fermentor to the press. In some wineries, electric elevators are lowered into the tank and the pomace is raised to the top. From there, it is either dumped directly into the press or into a trough with a continuous belt or chain to carry it to the press. In other wineries, the fermentation tanks are raised above the floor and the tank's floor steeply slanted. The pomace is flushed with wine from the bottom into the conveyor and to the press. This wine can be used for distillation; water can also be used for the flushing, but the diluted wine can only be used for distillation (Othmer, 1980).

The oldest type of press still in use is the screw-type basket press. This press is more expensive to operate but produces a relatively clear juice from both red pomaces or white musts. The continuous press, the most popular type, does not operate as well on fresh must, but is the cheapest to operate with fermented pomace and gives a high yield of liquid, which is usually cloudy. When the press wine is distilled, the cloudiness is of no importance.

Figure 3.2 shows the process for a wine making operation.

Equipment cleaning produces a significant amount of wastewater. Solid wastes generated in the wine making process include skins and lees, or sediment left in the bottom of the fermentor. The wastes are trucked to a distillery for recovery of the alcohol which is returned to the winery for fortification (strengthening) of some types of wine.

Figure 3.2 Flow chart for a Wine Making Operation



Source: Ontario MOE, 1986

Pulp remaining after the juice has been removed is discharged from the press (or from the fermentor, since some wines are fermented "on the skins" or the skins are added to the fermentors). The pulp is trucked away and usually ploughed into the ground in a vineyard. The sediment is removed either in the form of filter cake or tank washings. Depending on the design of the filter, the filter cake can be trucked away for disposal or washed down the sewer.

3.2 Waste Materials

3.2.1 Breweries

Brewery wastes generated include (Ontario MOE, 1986):

1. Water treatment wastes, caustic boil-out solutions used for clean-ups in the brew house, and soak solutions and caustic rinses in the bottling area.
2. Organic loading, spent grain and hops, filter cakes in dry form and accidental losses from operational errors and leaking equipment.

3.2.1.1 Solid Wastes

Table 3.2 shows solid waste generated from a brewery with a capacity of 170,000 hl/month (BPCE, 1986).

Table 3.2 Solid Wastes Generated from a Brewery

Solid Waste	Generation Rate
Spent grains (80% m/m[(1)] moisture)	20 t/100 m^3 brewed
Surplus yeast (90% m/m moisture)	3 m^3/100 m^3 brewed
Kieselguhr (70% m/m moisture)	0.6 m^3/100 m^3 packaged
Ash	1.7 t/100 m^3 packaged
Malt and Corn Dust	250 kg/100 m^3 brewed
General (incl. cardboard, plastic, glass and tires)	180 t/month

(1) m/m: Mass per Mass

Source: BPCE, 1986

Solid waste mainly consists of organic material residuals from the process including spent grains and hops, trub, sludge, surplus yeast, label sludge, Kieselguhr, powdered carbon and broken glass (SEPA, 1991).

Spent grains

The amount of spent grains is normally 14 kg/hl wort with a water content of 80%. In a well designed and efficiently working brewhouse, the difference between the actual yield of extract and the laboratory yield should be less than 1% (UNEP, 1995).

Yeast

Excess yeast is produced during fermentation and only a part can be reused. The amount of spent yeast slurry is 2-4 kg (10-15% dry matter content) per hl beer produced. The BOD value is around 120,000-140,000 mg/L (UNEP, 1995).

Trub

Trub is a slurry consisting of entrained wort, hop particles and unstable colloidal proteins coagulated during wort boiling. It is separated prior to wort cooling and represents 0.2-0.4% of the wort volume with a dry matter content of 15-20%. Its content of wort and extract depends on how efficiently the wort and trub are separated. The BOD value of trub is around 110,000 mg/kg wet trub. Trub suspension is added to spent grains or sent directly to the sewers (UNEP, 1995).

Other solid wastes from a brewery are:

- glass cullets from the packaging area;
- Kieselguhr from the filtration process;
- paper pulp from the bottle washer;
- paper, plastic and metal from received auxiliary material (especially packaging materials); and,
- waste oil and grease (Lenhardt, 1995).

3.2.1.2 Liquid Wastes

The brewing process requires a significant amount of water and produces wastewater with high biochemical oxygen demand and suspended solid content. Wastewater generated from beer manufacturing amounts to 65-70% of the water intake volume.

The effluent contains: maltose, dextrose, wort, trub, spent grains, yeast, filter slurry (Kieselguhr and lucilite), green beer and bright beer. This effluent will have a high organic pollution load and a relatively high solid pollution load (BPCE, 1986).

Weak wort

Weak wort is 2-6% of the wort volume. This increases the BOD of the wastewater significantly.

Rinse Water

Rinse water, which may contain product or raw material, represents 45% of the total water use in a brewery (UNEP, 1995).

Residual Beer

Residual beer is beer lost during the various production stages which include:

- residual amount of beer after emptying of process tanks (the residue amount depends on how efficiently the tanks are emptied);
- pre-runs and after-runs in the Kieselguhr filter result in a mixture of beer and water, which is discharged into the sewer;
- using water to clean process pipe lines, beer is pushed out with water, and a mixture of water and beer results;

- beer rejected in the packaging area due to wrong filling height, quality defects, or incorrect placement of labels;
- returned beer;
- exploding bottles as a result of poor quality, poor bottle inspection, or lack of temperature control in the tunnel pasteurizer; and,
- use of solid additions for maturing beer resulting in loss of beer and yeast.

Residual beer will equal 1-5% of total production. Most of it can be collected and reused in brewery process. Any amount not collected is discharged as effluent (UNEP, 1995).

Quantity of wastewater depends on the amount of water used. A portion of the waste used is not discharged in the wastewater including: the water in the beer, evaporated water and water content in the spent grains, yeast and Kieselguhr. This amounts to about 1.5 hl/hl beer (UNEP, 1995).

Brewery wastes are extremely variable due to variation in production activity by season, by day of the week and by the time of day. With the exception of the bottling machine, all processes are batch operations, resulting in batch discharges of wastes. In a small operation, one batch per day may pass through the brew house. Fermentation may last several days and ageing may last several weeks so none or several units may be emptied and cleaned out on any particular day. In addition, there is a weekly variation. On Monday, everything in the brewery is clean and ready to go. By Friday, the normal shutdown day, accumulations and carry-over of washing operations increases the daily loadings. These variations double the daily waste loadings later in the week (Ontario MOE, 1986).

3.2.2 Wineries

The principal winery wastes are pomace, lees, stillage bottle washings, cooling waters, and salt waters from ion-exchange processes. The pomace consists of dewatered grape skins, seeds and pulp (Tofflemire, 1972). Pomace can be used to produce seed oil.

A small plant generates 8.172 hectare litres (hl) of wine per tonne of grapes. Waste loadings are in the range of 217.8 g/hl of BOD and 53.8 g/hl of suspended solids. The amount of water used and the concentration of the waste components vary considerably, depending on the cooling water systems and general procedures (Ontario MOE, 1986).

3.2.2.1 Solid Wastes

About 100 kg of pomace is generated when one tonne of grapes is crushed (Nakata, 1994). One tonne of pomace of 50% moisture contains 9 kg nitrogen, 9 kg potassium (as potassium carbonate), and 2.3 kg phosphorous with seed oil as a potentially recoverable by-product (Tofflemire, 1972).

Pulp, remaining after the juice has been removed, is discharged from the press (or from the fermentor, since some wines are fermented "on the skins"). The rest of the process involves removing solids to leave the wine clear. The sediment is removed either in the form of filter cake or tank washings (Ontario MOE, 1986).

One tonne of grapes produces 600-700 L of natural wine, and 100-120 kg of solid waste (SRKCE, 1993).

3.2.2.2 Liquid Wastes

On average, wastewater generated in the manufacture of wine is about 70% of the water intake with a range of 60-95% depending on the degree to which "once-through" cooling is practiced (SRKCE, 1993).

4.0 ENVIRONMENTAL CONCERNS

The primary environmental impacts that can be attributed to the production of beer and wine are the result of noise, emissions to air, wastewater discharges and inefficient waste handling system (SEPA, 1991). Potential adverse environmental problems that may be associated with the operation of these facilities include:

- Surface Water Pollution

  The uncontrolled discharge of untreated wastewater can lead to depletion of dissolved oxygen in surface water and generation of noxious odours. Furthermore, wastewater may contain nutrients which stimulate aquatic plant growth and contribute to eutrophication.

- Groundwater Pollution

  Contamination from leaking fuel and chemical storage tanks, and from the handling of fuel and chemicals around the facility can result in local groundwater pollution.

- Occupational Health and Safety:

  The main occupational health concerns tend to be related to exposure to excessive noise and contact with potentially dangerous substances or materials (such as ammonia, caustic acid) (UNEP, 1995).

The objective of this section is to highlight some potential areas of environmental concern that can be found within a brewery and/or winery with respect to the potential for pollution and the consumption of water, raw materials, power and heat.

4.1 Contaminant Discharges

The main pollutants generated in the brewery and winery process include wastewater discharges, air emissions and solid waste. Table 4.1 shows the potential contaminant sources in a brewing operation. The adverse environmental impacts resulting from various contaminant discharges are shown in Table 4.2.

Table 4.1 Potential Adverse Environmental Concerns Associated with Various Winemaking and Brewing Stages.

Stage	Environmental/Health Concern
Brewhouse	• high discharge of organic matter • high energy consumption • high water consumption • dust problems • caustic wastes from system cleaning
Fermentation/Beer Processing	• high discharge of organic matter • high water consumption • handling of solid waste • caustic wastes from cleaning operations
Packaging	• high discharge of organic matter • high energy consumption • high water consumption • handling of solid waste • high noise level • caustic wastes from cleaning
Ancillary Operations	• high water consumption • high energy consumption • solid waste handling • chemical handling • high noise level • special waste generation • ammonia

Source: UNEP, 1995

Table 4.2 Contaminant discharges from Brewery and Winery operations

Pollutant	Description/Concern
Biochemical Oxygen Demand (BOD)	• measures the depletion of dissolved oxygen due to biodegradation of organic compounds • causes suffocation of aquatic life
Chemical Oxygen Demand (COD)	• similar to BOD but takes into account more stable organic compounds • better indication of long-term impacts than BOD
Suspended Solids	• suffocate aquatic life • create anaerobic conditions • may damage equipment and treatment systems
pH	• high/low pH damages aquatic life
Nitrogen (including nitrate and ammonia)	• nitrate is the oxidized form of nitrogen • ammonia is toxic to fish • stimulates growth in plants and causes water weed problems • eutrophication • causes groundwater pollution
Phosphorus (phosphate)	• stimulates growth of aquatic plants • causes eutrophication • causes groundwater pollution
Temperature	• fluctuating temperatures may have a negative impact on aquatic life
Volatile Organic Compounds (VOCs)	• form photochemical oxidants which are toxic to humans and damage crops • cause acid rain and global warming
Chloroflourocarbons (CFCs)	• destruction of the ozone layer
Greenhouse gases (CO_2, CH_4, NOx, SO_2)	• global warming
Odour	• a nuisance
Noise	• employee health and safety • environmental disturbance
Dust	• localized or regional air pollution

Source: Masters, 1991; SEPA, 1991; Passant et al., 1993; UNEP, 1995

4.1.1 Wastewater Discharge

Brewery and winery wastewaters are characterized by high BOD and Total Suspended Solids (TSS) concentrations with wide variations in wastewater flow and contaminant concentration. The potential adverse environmental impacts associated with these discharges are an important consideration in preparing a pollution prevention plan. The main characteristics of environmental concern that can be associated with brewery and winery wastewater include:

- BOD concentrations;
- TSS concentrations;
- pH;
- nitrogen and phosphorus concentrations; and,
- temperature.

4.1.1.1 Breweries

The concentration of organic substances in brewery wastewater discharges primarily depends on the wastewater-to-beer ratio and the amount of organics ultimately discharged to the wastewater stream. For example, if trub and spent hops are discharged to the wastewater stream, they can contribute up to 20% of the total daily organic loadings (BPCE, 1986).

In general, brewing operations (including fermentation, filtration and ageing) produce a low-flow, neutral pH, high strength waste, while high-flow plants generate wastewater with a high pH and low strength (Cronin, 1996). The production of non-alcoholic beer can also increase the strength of brewing wastewater even further with the addition of condensed alcohol to the waste stream (UNEP, 1995).

A breakdown of wastewater generated from a brewery operation was reported by BPCE, 1986 (Table 4.3). The wastewater produced during the malting process, which is mainly excess steeping and cleaning water, has a COD of 800-1,200 mg/L. Approximately 0.5-1.5% (by weight) of the barley ends up in the wastewater as organics (e.g., pentose, sucrose, glucose, cellulose, protein and minerals) and (inorganic salts including potassium and calcium silicate, sulfate and phosphate) (Huang and Hung, 1987; de Vegt et al., 1992).

Water treatment can also represent a source of wastewater discharges. When the ion exchange unit is regenerated, strong acid and caustic materials are used and end up as waste with pH ranging from 2-12. Unless these wastes are collected and neutralized, the wastewater could adversely affect the wastewater treatment plant operation, resulting in environmental degradation (Ontario MOE, 1986).

The effluent from a brewery is generated from the brew kettle, fermentor, storage, and various cleaning operations, and may contain residues such as trub, spent grains, Kieselguhr, and yeast. As a result, the wastewater from these processes has a high COD (3,000-5,000 mg/L), high temperature (30-35°C), high TSS, and high pH (Ontario MOE, 1986; Huang and Hung, 1987; de Vegt et al., 1992; UNEP, 1995).

Another major source of wastewater pollutants in a brewery is the rinsing and cleaning of equipment, bottling and bottle washing. For example, residual product loss during packaging could represent a significant portion of a brewery's BOD load, especially where old equipment is still in use. Furthermore, bottle washing produces a wastewater with a moderate COD (2,000-3,000 mg/L) and temperature (25-30°C), and a high pH as a result of alkaline cleaning of returnable bottles (SEPA, 1991; de Vegt et al., 1992; UNEP, 1995).

Table 4.3 Sources of High-Organic Effluent in a Brewery Process

Source Effluent	kg COD/hl Brewed
Trub from hot wort receiver	0.32
Last runnings - FV/SV transfer	0.27
Lauter tun last runnings	0.25
Cleaning fermentation vessels	0.14
Spent filter slurry	0.14

FV - Fermentation Vessel
SV - Storage Vessel

Source: BPCE, 1986

The cleaning of equipment and packaging produces both acidic and basic wastewater and large variations in wastewater pH. In general, the overall pH of the effluent will be a function of the production activities and may range from pH 7-12 (SEPA, 1991; Cronin, 1996).

In addition to organic compounds, brewery wastewater contains nitrogen and phosphorus, which can result in adverse environmental impacts due to aquatic toxicity, eutrophication and groundwater pollution. Nitrogen primarily comes from malt, adjuncts and nitric acid used for cleaning. Nitrogen concentration in the discharges depends on water ratio, amount of yeast discharged and cleaning agents used. In some cases, a high nitrogen concentration is not a concern due to lack of sufficient amounts of nitrogen for aerobic treatment (SEPA, 1991; de Vegt et al., 1992; UNEP, 1995).

Phosphorus, which comes from the malting process and cleaning agents, is usually found in concentrations ranging from 30-100 g/m^3 depending on water ratio and cleaning agents used (UNEP, 1995).

4.1.1.2 Wineries

Winery wastewater originates from several production processes including bottle washings, cooling system, saltwater ion-exchange units, and pomace and lees filtration. Typically, it is not lacking in nitrogen and phosphorus, and it may have a low pH (Tofflemire, 1972; Ontario MOE, 1986).

The winery's pollution load typically varies from 0.208 - 0.685 kg of COD/hl (Table 4.4), and the majority of the pollution load can be attributed to washing and cleaning operations. In addition, there are seasonal peaks in organic load associated with maximum pressing activity and the refiltration of the newly fermented wine (SRKCE, 1993).

Table 4.4 Wastewater Contaminant Loadings from a Wine Making Process

Parameter	Wastewater Produced (m^3/d)	Specific Effluent Volume	Specific Pollution Load	
		m^3/hl	kg/COD/hl	kg/TDS/hl
Range	10,600 - 28,000	0.147 - 0.159	0.208 - 0.685	0.049 - 0.318
Average	19,000	0.153	0.404	0.110

Source: BPCE, 1986

A major source of organic loadings in winery wastewater can be associated with the discharge of stillage and lees, the bottom sediments that accumulate during the storage of wine (Table 4.5).

Other compounds with high BOD levels that may be found in winery wastewater include: alcohol; sugars (glucose and fructose); organic acids (acetic, lactic, citric, malic, succinic and tartaric); soluble proteins; peptides; trace metals; and tartrates.

4.1.2 Emissions to Air

The main emissions to air from the manufacture of beer and wine may include VOCs, greenhouse gases, odour, noise and dust.

Table 4.5 Analysis of Lees and Stillage

Parameters	Lees	Conventional Stillage	Lees Stillage	Pomace Stillage
Total solids (mg/L)	186,000	20,100	68,000	13,180-32,100
Volatile solids (%)	94.8	87.4	86.5	77.0-89.4
Suspended solids (m/L)	l52,000	3,120	59,000	18,700
BOD (mg/L)	163,000	11,000	20,000	2,400
Volatile acids (mg/L)	7,800	1,900	2,480	380
Total acidity (mg/L as $CaCO_3$)		3,170	9,860	1,220
pH	40	4.7	3.8	6.8-3.7
Total N (mg/L)	9,950	271	1,532	330
NH_3 (mg/L)	56	2.8	45.1	4
Total P (mg/L)	1,300	11,150	4,284	1,310

Source: Tofflemire, 1972

In a recent study, the U.S. Environmental Protection Agency (USEPA) and the California Air Resources Board, concluded that breweries were only minor sources of emissions of volatile organic compounds (VOCs) to the atmosphere.

Several greenhouse gases may also be produced in the beer and wine making process including:

- carbon dioxide (a by-product of fermentation);
- nitrous oxide (a by-product of the internal combustion engine); and,
- sulphur dioxide (if used during kilning).

In breweries, approximately 16 kg of CO_2 is generated in boilers burning fossil fuel for each hl of beer produced. This is much greater than the amount generated during fermentation, which is approximately 3 kg/hl of beer produced (UNEP, 1995).

Although odours from breweries and wineries are considered to be harmless, they represent an environmental nuisance and should be avoided wherever possible. In breweries, for example, a smell may be experienced in the vicinity of malthouses, particularly when drying the sprouted barley. In addition, odours may also be caused by emissions from the fermentation process, vapour and stack emissions from mashing and wort boiling (SEPA, 1991; UNEP, 1995).

Noise may represent an environmental concern for breweries and wineries. For example, exposure to noise levels in excess of 85 dBa for an extended period of time may result in deafness, and in many cases this level may be exceeded, especially when old equipment is used. The main sources of noise in breweries and wineries include fans, compressors, cooling towers and refrigeration units. (SEPA, 1991; UNEP, 1995).

Dust, which can result from the handling of grains during cleaning, loading and malting, is another type of emission to air that represents an environmental concern as it can result in localized or regional air quality problems (UNEP, 1995).

4.1.3 Solid Waste Disposal

The primary areas of solid waste production in a brewery and winery are:

- malting (particulates and rootlets);
- tumbling (grape stalks and particulates);
- wort separation (spent grains);
- filtration (filtrate, e.g., Kieselguhr, yeast and pomace);
- the packaging area (glass, paper, cardboard, plastic and metal);
- bottle washer (paper pulp); and/or,

- ancillary operations (paper, cardboard, oil and grease, paints and thinners, etc.).

4.2 Water Consumption

4.2.1 Breweries

Large amounts of water are consumed in the production of beer and wine. Most of the water used (65% - 70%) is discharged as wastewater after being used in various processes such as (BPCE, 1986; Lenhardt, 1995; UNEP, 1995):

- cooling;
- cleaning of packaging material (e.g., bottle washing);
- pasteurization;
- rinsing and cleaning of process equipment;
- steeping, mashing, sparging, etc. (typically 5 m^3 of water is used to produce one tonne of malted barley);
- cleaning of floors and equipment;
- soap lubricant on conveyors in the packaging area;
- vacuum pump for filler; and,
- flushing of filler.

In a study of water and wastewater management in the breweries of South Africa, Binnie & Partners Consulting Engineers (BPCE, 1986) reported that the specific water intake (SWI) in the brewing process ranged from 5.5-8.8 m^3 of water per m^3 of beer produced, with a typical value of 6.65 m^3/m^3. A further breakdown of the usage into the main water-consuming areas is provided (Table 3.1).

4.2.2 Wineries

In a winery, the overall water intake is split approximately evenly between washing and cooling, and SWI values ranging from 80 to 440 L/hl wine processed have been reported (SRKCE, 1993); however, reported value of water use in Canada was 1200 L/hl (Ontario MOE, 1986).

Bottling represents a major water consumption process in wineries. The actual SWI for this process depends on the type of packaging (e.g., new or recycled, glass or plastic, etc.), the degree of water recycling, and the age and efficiency of the equipment. SWI value ranges from 0.3-2.1 L/bottle with an average of 1.5 L/bottle. A relatively small portion of water is used for equipment and floor washdown, and for make-up for losses from heating and cooling (SRKCE, 1993).

5.0 BEST MANAGEMENT PRACTICES

5.1 Introduction

Best Management Practices (BMPs) emphasize the source control of all wastes generated at a facility through relatively inexpensive adjustments to process and/or operating procedures. Consequently, they can be seen to represent a multi-media approach to pollution prevention (EEC, 1995). Although substantial reductions in pollution creation may occur through simple modifications to the operation, or improvements to management practices, it should be stressed that in order to ensure the effectiveness and efficiency of a particular BMP, action in one area needs to be coordinated with those in others (UNEP, 1995).

For breweries and wineries in particular, BMPs can be expected to include initiatives in production operations and management. The objective of this section is to provide breweries and wineries with information for identification of potential pollution prevention options for their facility. As such, the main focus of this section is to describe some potential BMPs that may be used by the facility to reduce the consumption of resources, increase the recovery of resources and by-products, improve waste management techniques, and modify existing operational management strategies.

5.2 Resource Consumption

Traditionally, the focus of environmental protection measures has been on emission control and reduction; however, as in many other industries, the inefficient use of inputs (water, energy and raw materials) in a brewery or winery can have environmental impacts. Therefore, the prevention and/or minimization of potential adverse environmental impacts resulting from industrial operations should not only include the improved management and control of emissions and discharges, but also a cutback in the consumption of process inputs such as water, raw materials and energy.

5.2.1 Water Use

The reduction in the amount of water consumed in a brewery or winery will have several environmental and economic benefits, including conservation of water resources, and consequently, lower wastewater discharge volumes. This potentially allows less costly wastewater treatment equipment (RCL, 1995).

Water conservation should not compromise plant sanitation or safety considerations and should only be used in conjunction with initiatives intended to reduce the pollutant loadings in the effluent, such as resource and by-product recovery, and waste loadings reduction (BPCE, 1986; NCI, 1995).

5.2.1.1 Production

There are several production modifications that may be employed to reduce water consumption at a brewery or winery (BPCE, 1986; SRKCE, 1993), including:

- installation, monitoring and control of water meters at various sections of the operation;
- stopping water flow during breaks, with the exception of water used for cleanup;
- dry milling of malted barley in breweries;
- minimization of transfer of last runnings;
- improved production efficiency, especially in the packaging lines;
- installation of low-flow nozzles or equipment sprays;
- reduction of water pressure on equipment spray nozzles;
- installation of flow control valves and an automatic valve to interrupt the water supply when there is a production stoppage; and,
- replacement of old equipment (e.g., the water consumption of new bottle washers is approximately 0.5 hl/hl bottle volume compared to as high as 3-4 hl/hl for an old one).

5.2.1.2 Cleaning

Close attention should also be paid to the consumption of water during cleanup procedures (BPCE, 1986; SRKCE, 1993):

- use a closed system for cleaning operations;
- use a stiff broom or brush to remove attached solids prior to wash down, so as to reduce effluent pollutant loadings;
- use low-volume/high-pressure washers, or use equipment for mixing water jet and a compressed air stream which will reduce water consumption by 50% - 75% when compared to a low-pressure system;
- compressed air should be used instead of water whenever possible; and,
- hoses should be fitted with shutoff nozzles to prevent wastage when not in use.

5.2.1.3 Preventative Maintenance

Substantial amounts of water can also be lost due to the lack of proper maintenance. Consequently, preventative maintenance is essential if water consumption within a brewery or winery is to be kept low. Implementation of a preventative maintenance plan allows the facility to run more efficiently, and thus improve its productivity.

5.2.2 Raw Materials

A reduction in the consumption of raw materials used (per unit of product) will not only save the company money in reduced purchasing costs, but it will also reduce the amount and cost (both financial and environmental) of waste production, lower effluent pollutant loadings, and reduce the strain on natural resources. The following should be implemented:

- Improve brewhouse yield through process changes, mill adjustments, lauter tun renewal, and/or the installation of alternative processes such as a new mash filter.

- Reduce resource consumption and waste pollutant loadings by preventing Kieselguhr from entering the drains. This can be achieved through the use of gravity settling or plate-and-frame filters (BPCE, 1986), and reducing Kieselguhr consumption through improved yeast settling by:

    - selecting better quality malt;
    - optimizing brewhouse procedures;
    - using flocculent yeast strains;
    - installing well designed storage and transfer equipment; and,
    - providing longer storage periods.

- Reduce resource consumption by packaging modification, including the substitution of glass bottles with recyclable Polyethylene terephthalate (PET) bottles, the use of waterproof labels, and a reduction in the use of glue (BPCE, 1986; SEPA, 1991).

5.2.3 Energy

A reduction in energy consumption is also an important consideration in a pollution prevention program and in lowering the operational cost. While energy conservation measures reduce the amount of pollution created in the production or use of energy (e.g., CO_2, NO_X, SO_2, ash, etc.), pollution prevention measures reduce the energy requirements for waste handling and treatment (SEPA, 1992).

Reduce energy consumption by implementing measures aimed at the conservation of electricity, thermal energy and fuel.

5.2.3.1 Electricity

Breweries and wineries can consume significant quantities of electricity in both production processes and operation of the facilities. However, there are several methods that can be employed to help conserve electricity in these facilities (USEPA, 1992; UNEP, 1995), including:

- implementation of good housekeeping measures such as turning off equipment and lights when not in use;
- use of fluorescent lights and/or lower wattage lamps;
- use of more efficient equipment when replacing old equipment (such as motors and heating units);
- installation of computerized controllers to better regulate motor output;
- installation of timers and thermostats to control heating and cooling; and,
- preventative maintenance of operational processes and pipes so as to improve efficiency and minimize losses.

5.2.3.2 Thermal Energy

The conservation of thermal energy is another significant concern for the reduction of energy consumption levels in breweries and wineries. The following are some measures that may be employed in attempt to control the loss of thermal energy (USEPA, 1992):

- improve or increase insulation on heating or cooling lines, pipes, valves or flanges, refrigeration systems, bottle washers and pasteurizers. Insulation represents a cheap and effective way to reduce energy consumption;
- institute preventative maintenance to reduce leakages and avoid steam trap bypass. For example, a leaking steam valve can emit approximately 1 kg of steam per hour, which corresponds to approximately 700 kg of oil per year, and a leaking seal can lose up to 3-5 kg of steam per hour, or 2,100-3,500 kg of oil per year (UNEP, 1995).
- Use of more efficient equipment, the adjustment of burners for optimal air/fuel ratios, the insulation of steam pipes, and the systematic maintenance of process operations to ensure their efficiency (USEPA, 1992; UNEP, 1995);
- ensure hot water tank is of appropriate size so as to optimize hot water production; and,
- perform a hot water balance of the entire facility to determine when, where and how hot water is being utilized, and identify areas where reductions in consumption can be made.

5.2.3.3 Fuel

The consumption of fuel (e.g., oil, coal, natural gas, etc.) can be reduced through minor adjustments to operating processes and implementing a preventative maintenance program. Preventative maintenance of steam pipes can represent a significant opportunity to reduce resource consumption and increase cost savings for a facility.

5.3 Resources Recovery

Resource recovery focuses primarily on the reclamation of water, raw materials and energy so that it may be reused in various operational processes; thus reducing the requirements for new resources and the amount of material being discharged as waste.

5.3.1 Water

In breweries and wineries, several operational processes could incorporate some form of water recovery and reuse. For example, water use in cleaning systems could be minimized by recycling some of the rinse waters (BPCE, 1986). In the bottle washers, “clean” water could be used for the last two rows of rinsing nozzles, and then collected and recycled for use in the previous rinsing nozzles prior to discharge. Furthermore, if installed, a crate washer could reuse the water discharged from the bottle washer (UNEP, 1995). Also, the use of upward nozzles to wash vertical tanks instead of filling the tanks during washing reduces water use even further (RCL, 1995).

5.3.2 Raw Materials

In a brewery, for example, discharged trub, weak wort and residual beer represent significant BOD loadings in the wastewater and a financial loss to the facilities. Trub can be returned to the mash kettle or lauter tun in an effort to recover extract, or it can be separated from the hot wort and returned to the spent grains. To avoid extract loss, weak wort can also be collected and used in the mashing of the next brew. Finally, residual beer (e.g., drip beer from filling, etc.) can be collected and either dosed directly into the filter line, if of high quality, or added to the hot wort, or pasteurized and blended in the fermentation tanks, if oxidized or contaminated (UNEP, 1995).

Both breweries and wineries may also be able to recover cleaning chemicals (e.g., caustic) by improving and/or optimizing the cleaning process. Furthermore, a caustic settling tank can be installed to remove impurities and sediment from the bottle washer when not in operation. Once the sediment has been removed, the caustic can be returned to the bottle washer and reused. If the tank is insulated, only reheating of the caustic after long periods of shutdown will be necessary. This process, which is relatively cheap and effective, can increase the lifetime of the caustic from 1-3 weeks up to 3-6 months. However, care must be taken when handling the settled sediment which should be neutralized prior to disposal (UNEP, 1995).

The use of returnable or recyclable packaging is another form of resource recovery that may be employed by breweries and wineries. However, it should be noted that this practice may involve a significant increase in water use for washing. Therefore, the benefits associated with the reduction in raw material consumption must be weighed against the impact of increased water consumption and wastewater discharge before a facility decides to rely on recycled packaging (BPCE, 1986).

5.3.3 Energy

There are several methods of energy recovery that can be considered by both breweries and wineries to reduce energy consumption; however, most are expensive and should only be considered once measures for reducing energy consumption have been made first (UNEP, 1995).

The vapour condensate produced during boiling represents a significant source of energy and water consumption, odour and Volatile Organic Compounds (VOC) emissions. For example, the loss of 1 m^3 of vapour condensate at 85°C is equivalent to the consumption of approximately 8.7 kg of oil. Therefore, the recovery of vapour condensate could represent a major savings in energy consumption for a brewery or winery, and would help to minimize the release of environmental pollutants such as odour and VOC emissions (UNEP, 1995).

To recover and increase energy efficiencies, a brewery or winery may use waste heat to produce hot water for use in various operational processes and cleaning. A brewery's or winery's hot water systems should be designed so that the hot water needed in operation is produced from waste heat, and no hot water is discharged as effluent. Should there be excess hot water, recovered heat could also be used, for example, to heat buildings or to dry spent grain or yeast prior to disposal (UNEP, 1995).

5.4 By-Product Recovery

By-product recovery is another cost effective pollution prevention option that can provide a facility with significant economical benefits while simultaneously reducing waste production (NCI, 1995). Potential by-products of brewery and winery operations include:

- **spent grains**, which can be used as an adsorbent for removing VOC emissions or organic material from effluent, or to produce fertilizers, bread, and/or animal feed (BPCE, 1986; Manning and Chiesa, 1991; Chaing et al., 1992; UNEP, 1995);
- **spent hops, hot trub** and other solid proteinaceous materials can be combined with spent grains and sold as animal feed (BPCE, 1986; UNEP, 1995);

- **yeast** (which can be collected from fermentation and storage tanks, and the filter line) can be sold for animal or human consumption (Lange, 1993; UNEP, 1995);
- **grape pomace and stems**, which can be used to produce acetone, butanol and fertilizer, and burned in co-generation plants (Manning and Chiesa, 1991; Logsdon, 1992; Lange, 1993);
- **tartaric acid** from winery wastewater, which can be recovered and used as an acidulant in food processing and pharmaceutical industry (Smagghe et al., 1991); and,
- **fermentation gases** from breweries and wineries can be collected to produce saleable carbon dioxide. This would also reduce ethanol emissions (Passant et al., 1993).

5.5 Waste Management

The quality and quantity of the wastes produced at a brewery or winery vary widely due to differences in the process design and the management practices used (BPCE, 1986). However, there are several methods that can be employed to minimize potential adverse environmental impacts. These methods can be divided into three main categories:

- waste loadings reduction;
- waste volume reduction; and,
- treatment and disposal.

5.5.1 Waste Loadings Reduction

Measures aimed at reducing the pollutant loadings in brewery or winery effluent are an important consideration of any pollution prevention plan, especially when water consumption levels are being reduced (BPCE, 1986). The reduction of effluent pollutant loadings can be achieved by segregation of the waste stream. This involves two main considerations:

1. the separation of pollutants from water and wastewater so as to minimize the amount of dissolved and suspended contaminants; and,

2. the separation of high- and low-strength waste streams.

For breweries and wineries, the separation of pollutants to reduce contaminant loadings in the effluent involves ensuring that as much of the raw material goes into the final product as possible. Therefore, the prevention of spills and leaking equipment is extremely important. For example, in a winery, older filter presses may lose a great deal of juice which represents an extremely high BOD. The replacement of old filters with new and more efficient ones could drastically reduce BOD levels in the waste stream.

A further consideration is the efficient and complete removal of waste material from tanks and equipment prior to cleanup. This minimizes the amount of high BOD washed down into the effluent waste stream (Ontario MOE, 1986).

In breweries and wineries, the reduction of effluent pollutant loadings through the separation of contaminants can be achieved in a number of ways. For example, BOD levels could be reduced through the use of waterproof labels and a reduction in the amount of glue used in packaging (BPCE, 1986; SEPA, 1991). In a brewery, BOD levels can be reduced through the storage of trub and spent hops so that they may be disposed of with spent grains, and by ensuring that residual beer is completely removed from tanks and equipment prior to cleanup (BPCE, 1986; UNEP, 1995). Finally, dry milling of the malt can also significantly reduce a brewery's total pollution loadings by minimizing the production of steep liquor (BPCE, 1986).

Cleaning procedures in a brewery or winery are also an important consideration in the reduction of effluent pollution loadings through the separation of contaminants. For example, use of a computer controlled cleaning system minimizes the likelihood of acid or caustic discharge surges that may accompany breakdowns (SEPA, 1991). Furthermore, loose solids should be swept or brushed from surfaces prior to cleaning, and screens should be placed in floor drains to prevent solid materials from being washed into the liquid waste stream (SRKCE, 1993; RCL, 1995).

The segregation of high- and low-strength wastewater is another method for reducing contaminant loadings, and it allows less contaminated waste streams to be discharged directly to the sewer after screening, thus reducing the volume of liquid waste that needs to be treated (Ontario MOE, 1986). Therefore, the segregation of the different process waste streams based on strength, is highly recommended. For example, a brewery may segregate the cooling water from the wort cooler, fermentors, compressors and refrigeration systems, and final spray water from the bottle washer (Ontario MOE, 1986).

Flow equalization for the effluent produced by a brewery or winery through temporary storage can also be advantageous in reducing pollutant loadings. This reduces the fluctuations in effluent strength and volume associated with varying production schedules, and eliminates the strain on treatment facilities. However, the effluent should not be held for too long as it may become anaerobic and odour problems may result (BPCE, 1986).

5.5.2 Waste Volume Reduction

Wastewater flow can be reduced by recovering alcohol using hydrophobic adsorbents (Lange, 1993), and by segregating low-strength wastewater.

Reverse osmosis and/or ultrafiltration can be used to separate wash water (weak wine or beer contaminated with inorganic chemicals) into a sterile alcohol solution (which can be recycled) and a waste inorganic salt solution (contaminated with organic substances of high molecular weight) (Birkbeck and Wallace, 1985; Manning and Chiesa, 1991).

5.5.3 Treatment and Disposal

Once the pollutant loadings and volume of waste have been reduced, the remaining waste must be treated and disposed of in an environmentally sound manner. This may involve sending the waste off-site to be treated in a municipal wastewater treatment plant or treating the waste on-site using pretreatment measures, aerobic or anaerobic digestion, wetlands, and/or composting.

5.5.3.1 Off-Site Treatment and Disposal

Off-site treatment and disposal of wastes produced at a brewery or winery may involve landfilling, discharge to municipal sewers, and/or application to land. For example, Kieselguhr constitutes a large amount of the solid waste volume from a brewery and despite the fact that there are several recycling methods under investigation, it is currently not possible to completely replace new Kieselguhr with recycled. Instead, waste Kieselguhr should be pressed and disposed of in landfills. Alternatively, it could be used in the production of cement or bricks, or it may be applied to land; however, care must be taken to avoid runoff to nearby water courses (UNEP, 1995).

It may also be possible to dispose of the wastewater created by a brewery or winery through land application in areas where adequate amounts of land are available, and climatic and soil conditions are favourable. This option represents the lowest cost and most environmentally friendly disposal alternative (Ontario MOE, 1986; SRKCE, 1993; UNEP, 1995).

Discharge to the municipal wastewater treatment plant following pretreatment on-site can provide an optimal treatment approach since the potential need for nutrient addition to treat brewery and winery wastewater would be avoided, and the economic costs of treatment can be lessened. Nevertheless, it may be necessary to pretreat the wastewater prior to discharge so as to avoid potential sewer system adverse impact, and to ensure the proper operation of the municipal treatment facility (UNEP, 1995).

5.5.3.2 Pretreatment

Wastewater from breweries and wineries may need to be pretreated in order to improve the operation of treatment processes, and to protect against sewer or treatment system damage. As solids tend to block equipment and may result in odour problems if left to decay, one common form of pretreatment is solids removal (BPCE, 1986; SRKCE, 1993). This can be achieved by using screens and/or sedimentation basins providing they are cleaned regularly. More sophisticated, self-cleaning screens are also available (e.g., rotating or vibrating), but they are more expensive and require systematic maintenance (BPCE, 1986; SRKCE, 1993).

Wastewater neutralization and pH control is another common form of pretreatment and can be carried out:

- in production areas;
- using acid or caustic to neutralize spent detergent in central neutralization tanks;
- by CO_2 neutralization of caustic in the cleaning system or of overflow from bottle washers; and,
- by biological neutralization, which occurs naturally without the addition of acid or caustic. This process, which is difficult to control, requires a hydraulic retention time of at least 3-4 hours (UNEP, 1995).

Neutralization of brewery or winery wastewater can also be achieved through the collection of high-strength liquid wastes of varying pH and storing them in equalization basins for a certain period of time prior to treatment (BPCE, 1986; SEPA, 1991).

5.6 Management Strategies

There are also a number of pollution prevention measures that can be taken at the management level to encourage better environmental performance, including:

- the use of a resource management system;
- the creation of policy initiatives;
- an increase in the training and awareness of employees; and,
- initiatives to improve health and safety.

5.6.1 Resource Management Systems

The objective of a resource management system is to control the flow of resources so as to limit their consumption and avoid unnecessary losses. Furthermore, it is intended to provide management with a tool for controlling resource consumption and setting resource saving targets. As such, a resource management system should:

- ensure that resource consumption resulting from inefficient processes and procedures are detected and corrected;
- maintain an optimal level of resource consumption; and,
- stimulate new resource-saving options (UNEP, 1995).

In a resource management system, consumption of resources used is monitored. The monitoring results are then analyzed and compared with resource consumption targets, the previous week's consumption figures, and, if available, those of other facilities. A report is then generated showing resource consumption rates and associated variances.

In order for a resource management system to be successful, the facility will have to appoint a manager to oversee the systems implementation and operation. It is essential that the selected person has a good rapport with the employees. Support of the employees can be improved further through the initiation of a bonus plan to successfully reduce resource consumption. Care must be taken in the design of the system to ensure it is cost-effective and supplies the necessary amount of information to control resource consumption without significantly increasing the manager's workload. A good place for a brewery or winery to begin is the initiation of an energy and water resource management system. Basic metering equipment can be used to monitor the consumption of energy and water in the main production areas of the facility, and/or the areas consuming the greatest amounts of these resources (UNEP, 1995).

Once the meters have been installed, the system manager can estimate the energy and water requirements of each area. This enables the manager to identify areas to target, set consumption rates and encourage the specific areas to consume as little energy and water as possible (UNEP, 1995).

5.6.2 Policy Initiatives

In addition to the creation of a company policy on pollution prevention, several other policy initiatives can be incorporated to aid in pollution prevention by:

- "Design For Environment";
- environmental reporting;
- purchasing; and,
- cooperative initiatives.

Integration of pollution prevention with all company decisions is a management strategy to improve resource efficiency, reduce regulatory compliance burden, respond to customer needs, and address public concern over environmental issues (Dickens, 1993).

By adopting "Design for Environment" as a company policy, environmental issues and regulatory compliance become a part of business decisions. Furthermore, environmental issues become business opportunities and are systematically and strategically evaluated in an effort to improve the company's regulatory compliance. As a result, the company will begin to:

- provide products and package systems that do not create waste management problems for their customers;
- move away from end-of-pipe pollution control;
- modify product design and manufacturing technology to eliminate pollution; and,
- use management systems that give pollution prevention the same priority as product quality, customer service and finance (Dickens, 1993).

5.6.2.2 Environmental Reporting

Another pollution prevention policy that a brewery or winery could initiate is voluntary environmental reporting. This provides a company with a means to publicize their pollution prevention goals and objectives, and the progress they have made towards achieving them. Environmental reporting also improves a company's public image, boosts employee morale, and provides an incentive to increase pollution prevention at the facility. Furthermore, it provides industry with an additional resource for information on environmental management trends and issues, as well as the new and emerging ideas in pollution prevention. As such, environmental reporting can be seen to be integrally linked with the pollution prevention process.

5.6.2.3 Purchasing

A purchasing policy can be adopted in a pollution prevention program for a brewery or winery. For example, potential suppliers can be selected based on their environmental credentials. Environment-friendly resources could be selected over resources that have been exposed to pesticides, or those which cannot be recyclable once utilized. Although these resources may be a little more expensive, their use will result in an overall savings to the company due to reduced waste treatment costs, increased regulatory compliance, improved production efficiency, and a reduction in the potential of environmental degradation (UNEP, 1995).

5.6.2.4 Cooperative Agreements

As environmental issues can have national or even international dimensions, a concerted action by all of industry is required if the potential for environmental degradation is to be effectively minimized. One way this could be achieved is through the creation of cooperative pollution prevention initiatives amongst various different companies and types of industries.

Breweries or wineries could also become involved with regional, national and/or international business associations, which would help them to:

- monitor environmental issues and trends;
- set up pollution prevention programs and resource management systems;
- follow environmental regulatory trends;
- establish pollution prevention targets;
- identify potential pollution prevention options;
- set production standards;
- follow technological advancements; and,
- gain information on new procedures and processes.

5.6.3 Employee Training and Awareness

The installation of BMPs to realize the pollution prevention goals of a facility is not just a managerial process. In fact, the successful implementation and operation of BMPs must ultimately be accomplished by the employees. As all employees need to work together to achieve pollution prevention in a facility, appropriate environmental training of employees and managers is a necessary component of a successful pollution prevention program (SRKCE, 1993).

Although training will help to increase environmental awareness among employees, there are several additional measures that may be used by management to improve environmental performance. One particular measure is a monitoring program, in which resource consumption is measured and compared to production figures (UNEP, 1995). For example, the Miller Brewing Company uses energy bulletin boards which are constantly updated, providing employees with information on post daily electrical costs, progress in achieving electrical consumption goals, and energy "tips". As such, these boards track the facility's progress in reducing energy consumption, and increase the employees' awareness of the importance of electricity conservation (Payne, 1985).

Awards, prizes and incentives may be used to increase employee participation and commitment. For example, Anheuser-Busch Brewing Company has initiated an annual "Environmental Stewardship and Leadership Award", which is presented to an employee or a team of employees for accomplishment in recycling, conservation of natural resources, waste minimization, community involvement, or wildlife protection. This award, which judges applicants based on reduction in environmental impacts, uniqueness, sustainability, cost effectiveness and initiative, encourages the employees to improve environmental performance at the facility and provides recognition for initiatives in pollution prevention (UNEP, 1995).

5.6.4 Health and Safety

Employee health and safety is another important consideration of a pollution prevention program at a brewery or winery. In addition to an occupational safety policy and clear, well understood set of safety procedures, the following health and safety measures should also be implemented where necessary (UNEP, 1995):

- the inhalation of, or contact with, caustic or acid may result in severe burns and damage to tissues. Therefore, emergency showers and eye rinsing equipment should be installed where caustic and acid are stored and access to tanks which are automatically cleaned should be strictly controlled;
- as inhalation of high concentrations of CO_2 may result in asphyxia and death, areas where CO_2 may be present should be clearly marked and equipped with CO_2 detection and emergency ventilation equipment;
- the inhalation of, or contact with ammonia, is extremely hazardous. Therefore, areas where ammonia may be present should be clearly marked, and automatic shutoff valves on piping and emergency ventilation systems should be installed;
- dust explosion precautions should be undertaken in the malt silo plant and conveyor system. In addition, as the inhalation of Kieselguhr dust may cause pulmonary disease, dust control equipment should be installed and workers should use protective breathing equipment;
- proper training in lifting, use of forklifts and other lifting equipment should be provided to prevent injuries. Areas where forklifts are in use should be clearly marked;
- exposure to noise levels in excess of 85 dBa for long periods of time may result in deafness. Therefore, noise reduction programs should be initiated and employees should wear suitable ear protection and have their hearing examined regularly. In addition, areas with high noise levels should be clearly marked and enclosed if possible;
- in wet areas, non-slip floors should be installed;
- while being filled, bottles are pressurized and may explode. Therefore, the bottle filler should be equipped with a screen, and workers should wear eye protection and gloves; and,
- bottle washers should be properly ventilated to avoid explosions that may result from hydrogen production when aluminum foil come in contact with caustic.

Employees should be informed about the hazards of chemicals handled in the facility and be trained in the proper management of these chemicals. Material Safety Data Sheets (MSDS) should be available for the workers. A centralized storage area for chemicals should also be designated to facilitate greater control.

6.0 DEVELOPMENT OF A FACILITY-SPECIFIC POLLUTION PREVENTION PROGRAM

6.1 Introduction

A thorough and ongoing evaluation of the facility practices and operations through a pollution prevention program enables the facility operator to conduct an environmental audit and to examine facility compliance with the regulations. Figure 6.1 depicts the major stages in the development of a pollution prevention program, and Table 6.1 provides a detailed description of the procedure for developing the pollution prevention plan, with reference to the text and worksheets to be used.

This section provides a description of the procedure to develop of a facility pollution prevention plan. Worksheet forms used to prepare the plan are provided in Appendix A.

6.2 Program Organization

Organization of a pollution prevention program requires the involvement of all employees and a strong commitment to environmental protection. Employees will feel committed to pollution prevention when they actively participate in organizing the program and are encouraged to participate in:

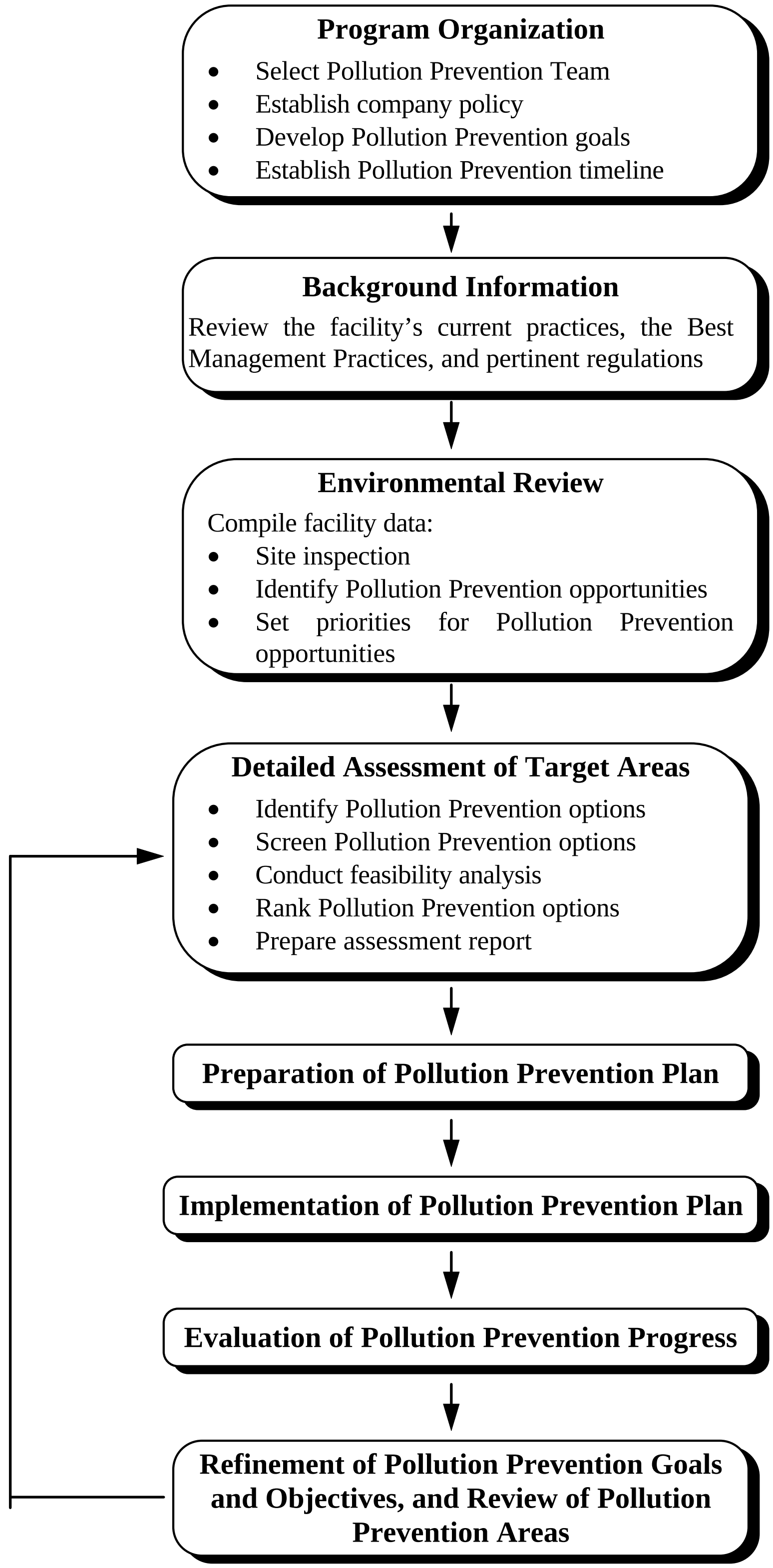
- defining company pollution prevention goals and objectives;
- identifying areas of pollution sources;
- suggesting measures to eliminate or reduce the potential for pollution creation; and,
- modifying operations for safer waste handling.

The organization of a pollution prevention program requires selection of a special pollution prevention team, development of a company pollution prevention policy, and setting of program goals and objectives.

6.2.1 Team Member Selection

The pollution prevention team consists of one or more persons, depending on the size of the facility. The general responsibilities of the team include developing and implementing the pollution prevention plan. The capabilities and attitudes of the team are essential for the success of the program. As with other areas of the facility operation, a successful program will require integration and uninterrupted planning, implementation, modification and maintenance of the plan at its different stages.

Figure 6.1 Pollution Prevention Program Development



Adapted from USEPA, 1992

Table 6.1 Procedure for developing a Pollution Prevention Plan

Step	Item	Details	Source of Information and Worksheet to be Used
1	Program Organization	• Select pollution prevention team	• Section 6.2.1 • Facility Commitment - Worksheet 1
		• Establish company policy	• Section 6.2.2 • Facility Commitment - Worksheet 1
		• Develop pollution prevention goals	• Section 6.2.3 • Facility Commitment - Worksheet 1
		• Prepare pollution prevention timeline	• Section 6.2.4 • Program Timeline - Worksheet 2
2	Background Information	• Review process information, facility current practices, regulations, BMPs, BATs	• Section 6.3 • Section 3.0 Industrial Profile • Process Information - Worksheet 3
3	Environmental Review	• Compile facility data	• Section 6.4.1 • Section 3.0 Industrial Profile • Section 4.0 Areas of Environmental Concern • General Facility Profile - Worksheet 4 • Facility Description - Worksheet 5 • Site Layout - Worksheet 6 • Raw Material Information - Worksheet 7 • Product/By-Product Information - Worksheet 8 • Waste Materials Information - Worksheet 9 • Waste Management Methods - Worksheet 10
		• Site inspection	• Section 6.4.2
		• Summary of environmental review results	• Section 6.4.3 • Environmental Review Results - Worksheet 11
		• Prioritize pollution prevention opportunities	• Section 6.4.4 • Pollution Prevention Areas - Worksheet 12

All worksheets are shown in Appendix A.

Table 6.1 Developing Pollution Prevention Plan (Continued)

Step	Item	Details	Source of Information and Worksheet/Form to be Used
4	Detailed Assessment of Targeted Areas	• Identify pollution prevention options	• Section 6.5.1 • Pollution Prevention Options - Worksheet 13
		• Screen pollution prevention options	• Section 6.5.2
		• Conduct feasibility analyses	• Section 6.5.3
		• Rank pollution prevention options	• Section 6.5.4 • Ranking of Options - Worksheet 14
		• List pollution prevention options to be implemented	• Section 6.5.5 • Options to be Implemented - Worksheet 15
5	Write Pollution Prevention Plan	• Prepare a three-year implementation schedule	• Section 6.6 • Implementation Schedule - Worksheet 16
6	Implement Pollution Prevention Plan		• Section 6.7
7	Measure Pollution Prevention Progress		• Section 6.8

All worksheets are shown in Appendix A.

The members of the team should have substantial environmental, technical, business and communication skills as well as thorough knowledge of the company. The characteristics and expertise of the team members should include:

- management and leadership capability;
- a complete understanding of the company's operating procedures;
- a thorough knowledge of the facility's operation;
- a knowledge of the applicable environmental regulations and facility discharge permits;
- knowledge of the specific health and safety regulations that apply to the facility;
- an understanding of pollution prevention principles and techniques;
- a knowledge of the currently available technology for pollution prevention in the production of beer/wine; and,
- an understanding of the potential environmental impact of discharges from beer/wine operations.

The team leader should be capable of developing and implementing the pollution prevention program. Ideally, the leader would be the manager of the facility with sufficient authority to keep the program on track and to ensure that pollution prevention becomes an integral part of the overall corporate plan.

Once selected, the names of the pollution prevention team and their responsibilities should be outlined on Worksheet 1 (Appendix A).

6.2.2 Company Policy

The basis for a corporate program is the commitment of the company to the successful realization of that program (Yapijakis, 1992). The company should develop a pollution prevention policy statement which states the reason for establishing the pollution prevention program. Two examples of such policies are shown in Table 6.2. The pollution prevention policy should be written on the pollution prevention Worksheet 1 (Appendix A).

Workers' participation has a significant effect on the success of the pollution prevention program. The pollution prevention team leader should hold a meeting with the employees in order to publicize the policy, emphasize the company's commitment to pollution prevention, and encourage employee participation. This will establish a positive atmosphere and may elicit worthwhile pollution prevention suggestions.

Table 6.2 Examples of Company Policy Statements

- **POLICY STATEMENT EXAMPLE 1**

"(The Company Name) is committed to excellence and leadership in protecting the environment. In keeping with this policy, our objective is to reduce waste and emissions into the surrounding environment. We strive to minimize adverse impact on the air, water and land through pollution prevention and energy conservation. By successfully preventing emissions, we can achieve cost savings and improve the environment. (The Company Name)'s environmental guidelines include the following:

⇒ Environmental protection is everyone's responsibility. It is valued and displays commitment to (The Company Name).

⇒ We will commit to including pollution control and energy conservation in our operation.

⇒ (The Company Name) is committed to identifying and implementing pollution prevention through encouraging and involving all employees.

⇒ Technologies and methods which substitute hazardous materials and utilize other source reduction techniques will be given top priority in addressing all environmental issues.

⇒ (The Company Name) seeks to demonstrate its responsible corporate citizenship by adhering to all environmental regulations. We promote cooperation and coordination between industry, government and the public toward the shared goal of preventing pollution at its source."

- **POLICY STATEMENT EXAMPLE 2:**

"At (The Company Name), protecting the environment is a high priority. We are pledged to eliminate or reduce emissions to the water, soil and air, and to minimize our use of energy and generation of all wastes, whenever possible. When waste cannot be avoided, we are committed to recycling, treatment and disposal in ways that minimize undesirable effects on air, water and land."

Adapted from USEPA, 1992; WRITAR, 1991; MOWM, 1991

6.2.3 Pollution Prevention Goals

The program leader will need to establish goals that state the long-term direction of the pollution prevention program. The goals should be well-defined, achievable, meaningful to all employees, and adaptable to changing conditions in the facility.

Pollution prevention goals can be either qualitative (such as, "achieve a significant reduction in BOD discharges from the facility"), or they can be quantitative (e.g., "reduce TSS concentrations in the wastewater stream by 90%").

Although quantitative goals are more difficult to develop, they are worth the extra effort. They spell out the operator's commitment, and give both participants and observers a method for measuring progress. Goals should be consistent with the company's pollution prevention policy and may have been stated in general terms in the policy statement.

Once set, the goals should be entered on Pollution Prevention Worksheet 1 (Appendix A). Later on, as the pollution prevention program becomes more focused, and the pollution-specific aspects of the operation become better known, the goals can be refined. They can be adjusted as the program matures, and as lessons are learned. Periodic goal achievement review and adjustment will keep the program active and visible within the company.

6.2.4 Pollution Prevention Program Timeline

Once the pollution prevention team is selected, the company pollution prevention policies and goals are outlined, a timeline for starting and completion dates of the pollution prevention program tasks should be established using Worksheet 2 (Appendix A). This will enable the pollution prevention team to plan its activities with minimal time and costs required to complete the program.

6.3 Background Information

In order to characterize the facility’s operations and to identify areas where pollution prevention actions may prove beneficial, the pollution prevention team needs to review existing process information, current practices and regulatory requirements, and familiarize themselves with the Best Management Practices (BMPs) and Best Available Technologies (BATs) for their industry.

Worksheet 3 should be used to record the availability and location of existing sources of process information that will be needed to prepare and evaluate the pollution prevention program.

6.4 Environmental Review

An environmental review of the facility is a key component of any pollution prevention program. It provides facility-specific background information necessary to identify areas of environmental concern. This information can be used to evaluate the effectiveness of pollution prevention in improving these areas. Furthermore, it highlights areas where information is missing, lacking or outdated.

The pollution prevention team can conduct an environmental review of the facility by: compiling facility data, site inspection, identification of pollution prevention areas and assigning priorities to pollution prevention opportunities.

6.4.1 Plant Data Compilation

The plant data collection should be done using the least amount of time, keeping in mind that the goal of the program is to prevent pollution not to collect data. Much of the data needed for the pollution prevention program may be available as a regular part of plant operations, the accounting system, or in response to existing regulatory requirements.

This task involves the collection of available facility data regarding:

- process description;
- raw materials used;
- products and by-products;
- waste materials;
- waste management methods; and,
- environmental permit requirements.

This data can be gathered from the following sources:

- operating procedures, logs and manuals;
- purchase records;
- material inventories records;
- product specifications;
- product, raw materials and energy costs;
- waste shipment manifests:
- solid wastes, wastewater and air emission sample analysis and measurement data;
- environmental audit reports;
- permits or permit applications;
- water and sewer costs, including surcharges;
- operating and maintenance costs;

- cost of waste disposal;
- waste handling, treatment, disposal costs and revenues;
- process flow diagrams;
- design and actual material sheet balances for production and pollution control processes;
- operating manuals and process description;
- equipment specification and sheet data;
- equipment layout and product composition and batch sheets;
- material safety data sheets;
- product and raw material inventory records;
- employee interviews; and,
- literature.

The data gathered about the facility will be used to identify areas of opportunity for pollution prevention and to set priorities for a detailed site assessment. The focus of the site assessment will be concentrated on specific areas identified from examination of the data.

6.4.1.1 Process Description

A description of the facility operations provides a basis for the identification of areas of environmental concern. A general outline of the processes involved in the making of beer and wine has been provided in Section 3.1.

Worksheet 4 will be used to list general information concerning the facility, major operations, primary products and regulatory information. A more detailed description of facility operations is provided using Pollution Prevention Worksheet 5. This description should include:

- a flow diagram (with material and energy balance) for the production process, from the time the raw materials arrive at the facility, to the time the final product is packaged and shipped;
- annual production levels; and,
- liquid and solid wastes removal, treatment and disposal procedures.

Use Worksheet 6 to record a site layout showing the location of each process area, sewers and treatment systems.

6.4.1.2 Resources

The main resources utilized in the production of beer and wine include: raw materials used in production (such as malt, adjunct and grape juice), product additives, cleaning solvents and chemicals, product packaging materials and energy.

Record type, quantities, qualities, handling/storage and cost of production resources used at the facility in Worksheet 7.

6.4.1.3 Products/By-Products

There are several products and by-products that are created by breweries and wineries. As these outputs potentially represent major economic value, it is important that details concerning rates of production, amounts, revenue generating capabilities and potential users are recorded. This will be done by the pollution prevention team using Pollution Prevention Worksheet 8.

6.4.1.4 Waste Materials

After describing the products and by-products of the facility, use Pollution Prevention Worksheet 9 to collect data on the quantities and qualities of wastes generated on-site. This information will be used later on in the program to evaluate the overall effectiveness of implemented pollution prevention options.

6.4.1.5 Waste Management Methods

Information concerning waste management methods used in the facility need to be gathered to provide a background against which potential pollution prevention options can be identified and compared. Use Pollution Prevention Worksheet 10 to record the following for each waste generated at the facility:

- reuse, recovery and recycling methods;
- waste treatment methods;
- cost of waste management; and,
- storage and disposal methods.

6.4.1.6 Environmental Regulations

The pollution prevention team should prepare a list outlining the regulatory and permit requirements of the facility for wastewater, air, solid waste and other discharges into the receiving environment. This information will be used in selecting and evaluating pollution prevention options in order to ensure that the facility continues to comply with waste management regulations, environmental permits and local municipal bylaws.

6.4.2 Site Inspection

The objective of a site inspection is to review the accuracy of the information collected and to gather more information about waste material and energy and water use. The site inspection will provide information needed to identify the pollution source problem areas, and prioritize the environmental problems to be addressed. A preliminary site inspection will be conducted to prioritize the process, operations and wastes that will be addressed during the subsequent detailed assessment phase. During this phase, the team will target the most important waste problems.

Prioritization of waste streams will be based on:

- compliance with current and anticipated regulations;
- cost of waste management (waste treatment and disposal);
- quantity of wastes;
- hazardous properties of the waste;
- potential for pollution prevention;
- potential for recovery of valuable by-products;
- minimization of wastewater discharges; and,
- reduction of energy costs.

The priorities set in this stage will guide in the selection of areas for the detailed assessments. Also, specific areas may be targeted based on the volume of waste produced or the cost of waste disposal.

The result of the preliminary assessment may be reflected in refining the pollution prevention goals. During the preliminary assessment, the program team will have identified opportunities for pollution prevention and have established priorities. This will accurately define short- and long-range objectives.

Detailed Site Inspection

The detailed assessment will focus on specific areas targeted by the preliminary assessment with the objective of gathering data for later analysis. The assessment will be done in depth in each production process, interviewing workers and compiling necessary data that may not have been collected before. The worker's interview will help the team to understand the data already collected and identify factors that are not well documented and for which data will need to be gathered. During this process, the team may identify some options that can be implemented quickly and with little cost or risk.

The site assessment should be well planned to achieve predetermined goals. The plan should include an agenda that covers all points that require clarification. The agenda should be provided in advance to the operators in the area being assessed. The inspection should be conducted to coincide with the time when the operation of concern generates the waste.

The following should be addressed during the site inspection:

- Monitor the operation at different times during all shifts especially when waste generation is highly dependent on human involvement.
- While interviewing the operators in the assessed areas, discuss the waste generation aspects of the operation and their familiarity with the impacts of their operation on other operations.
- Discuss housekeeping aspects of the operations, check for signs of spills and leaks, and notice overall cleanliness and sources of odours and fumes.
- Assess level of coordination of environmental activities between various departments.
- Assess administration controls for cost accounting, material purchasing and waste collection procedures.

The information gathered in this stage may include:

- quantity and characteristics of waste streams and air emissions;
- origin of waste streams in the production or treatment processes;
- permit requirements for these wastes;
- amounts of a specific raw or input material in the waste stream;
- quantities of materials lost in the form of volatile emissions efficiency of the production process;
- contaminant sources that can be segregated;
- good housekeeping practices to reduce waste material; and,
- controls to improve process efficiency.

The production process should be followed from the point where input material enters the work site to the point where products and wastes exit. The waste sources to be inspected include: production process, piping, maintenance operations, housekeeping practices, storage areas for raw materials, and intermediate products and finished products.

The analysis of data on production process includes preparing a material and energy balance as a means of analyzing pollution sources as pollution prevention opportunities.

The material balance can be used to organize data, identify data gaps, and estimate missing information. The material balance is useful if there are points in the production process where it is difficult or uneconomical to collect or analyze samples. It is also useful in identifying inaccurate readings in measured releases.

6.4.3 Identification of Pollution Prevention Areas

Although the typical areas of environmental concern for the breweries and wineries of the Lower Fraser River basin are outlined in Section 4.0 of this Guide, the purpose of this stage is to identify those areas of environmental concern that are specific to the facility. Use Pollution Prevention Worksheet 11 to summarize those processes and activities identified as areas of environmental concern.

6.4.4 Assigning a Priority List of Pollution Prevention Opportunities

The team can now develop criteria for identifying and selecting process areas for further pollution prevention opportunities. Typical criteria for prioritizing areas as targets for pollution prevention options are:

- compliance with the best management practices;
- cost of waste management (pollution control, treatment and disposal);
- compliance with current and anticipated environmental regulations;
- impacts on environment (air, soil, stormwater runoff, groundwater and surface water);
- impacts on public health;
- potential environmental and safety liability;
- hazardous properties of waste, including toxicity, flammability, corrosivity and reactivity;
- available budget for pollution prevention projects; and,
- potential for implementing on-site reuse or recycling.

Also, priorities for improvements should be given to the quality of discharges or air emissions into adjacent sensitive environments (such as water bodies, schools, playgrounds, hospitals, etc.).

Using Pollution Prevention Worksheet 12, the list of potential pollution prevention areas are then assigned a priority based on the above criteria. The ranking of these areas will be based on the degree of pollution the area is contributing, and on the compliance with the best management practices.

6.5 Detailed Assessment

The site inspection forms completed during the environmental review identify specific problems in various areas of the facility. These forms need to be reviewed to ensure their accuracy, and a thorough and detailed site inspection of the targeted areas should be conducted to identify operating parameters and other factors that were missed or insufficiently documented.

The areas of environmental concern identified on Pollution Prevention Worksheet 12 will then undergo a detailed assessment to identify and screen various pollution prevention options. This assessment will be based on the prioritized list of potential sources of contamination. Low priority process areas should also be evaluated, but implementation of pollution prevention options may be executed at a later date.

Once the detailed assessment is complete, the selected options will be incorporated in the pollution prevention plan and implementation schedule.

6.5.1 Identification of Pollution Prevention Options

In order to identify potential pollution prevention options, it is necessary to retrieve information from a variety of sources. However, facility-specific pollution prevention options need to be developed to ensure effectiveness of the pollution prevention program. Therefore, it is important to review outside industrial sector-specific technical information sources (EEC, 1995; NCI, 1995). These might include:

- federal, provincial and local environmental agencies, and CCME (Canadian Council of Ministers of Environment);
- USEPA (U.S. Environmental Protection Agency) and state environmental agencies;
- trade associations;
- Canadian Standards Association (Standards and Guidelines);
- equipment manufacturers and suppliers;
- other beer and wine operations;
- qualified employees; and,
- consultants.

Despite the need for facility-specific options, it should be stressed that reduction/elimination of pollution waste at the source will always be the preferred pollution prevention option. For breweries and wineries, this can be achieved in many ways; including:

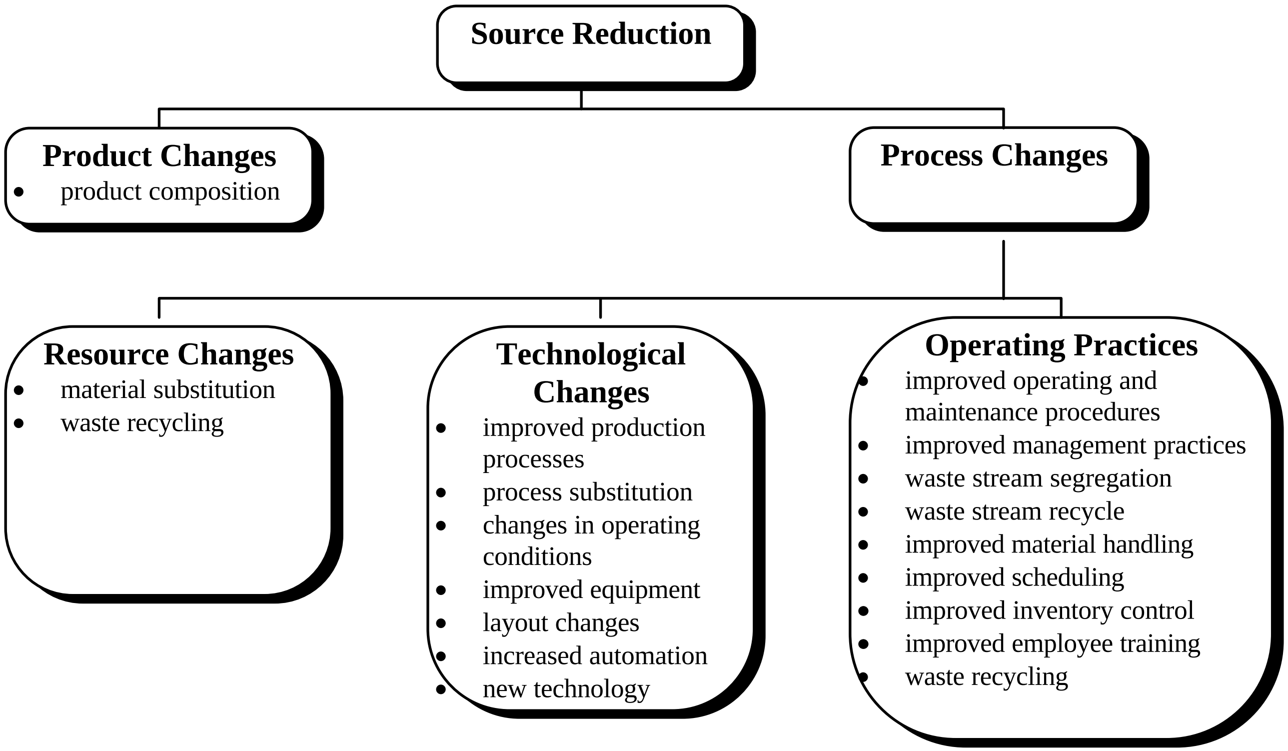
- changing attitudes towards waste/pollution production;
- improving management and operational processes and products; and,
- improving technology (UNEP, 1995).

It is important to note that pollution prevention is not simply the implementation of new technology. By changing employee attitudes towards waste/pollution production, improvements may result without the need for major economic outlays for new or alternative technology. Furthermore, simple improvements to management and operational processes and products may also result in desired pollution reductions without the need to change technology (UNEP, 1995). Figure 6.2 portrays the various pollution prevention options that can be used by breweries and wineries to achieve the reduction/elimination of pollution at its source.

Some of the general available options for the breweries and wineries include the following:

1. Improving the site layout to improve the flow of material in the plant.
2. Improving operational procedures to minimize negative impact on the environment by emphasizing:
   - Good housekeeping
   - Preventative maintenance practices:
     - ♦ maintain equipment history cards on equipment location, characteristics and maintenance;
     - ♦ maintain a master preventative maintenance schedule;
     - ♦ keep vendor maintenance manual handy; and,
     - ♦ maintain a manual or computerized repair history file.
   - Emergency Response plan
   - Training for:
     - ♦ operation of the equipment to minimize energy use and material waste;
     - ♦ proper material handling to reduce waste and spills;
     - ♦ current waste management regulation;
     - ♦ impact of wastes generated;
     - ♦ detecting and minimizing material loss to water, land and air; and,
     - ♦ emergency procedures to minimize lost material during accidents.
   - Waste segregation:
     - ♦ Segregate liquid wastes and apply liquid/solid waste separation to lower loadings to the stream.
   - Employee participation:
     - ♦ solicit employee suggestions for waste reduction ideas.

Figure 6.2 General Pollution Source Reduction Options



* Adapted from Yapijakis, 1992; USEPA, 1992; Freeman, 1995

6.5.2 Screening of Pollution Prevention Options

To evaluate pollution prevention options, technical, environmental and economic feasibility analyses need to be conducted. Since feasibility analyses can be costly, the proposed pollution prevention options should be screened by the assessment team prior to the analysis stage. As a result of this screening process, some options will be found to have no cost or risk attached and can be implemented immediately; whereas, other options will be found to have marginal value or to be impractical, and will not be considered any further. Those options that are neither implemented nor rejected will generally be found to require feasibility assessment before implementation.

The screening process does not require a detailed or costly study. Screening procedures can simply be an informal review with a decision made by the pollution prevention team members. The following questions should be considered in option screening:

- Which option will best achieve the goal of preventing environmental pollution?
- Which are the main benefits to be gained by implementing this option (e.g., saving cost of remediation, compliance, liability, workplace safety, etc.)?
- Do the necessary materials and technologies exist to develop the option?
- How much does it cost? Does it appear to be cost-effective, meriting an in-depth economic feasibility assessment?
- Can the option be implemented within a reasonable amount of time without excessively disrupting normal operations?
- Does the option have a good track record? If not, is there convincing evidence that the option will work as required?
- What other areas or operations at the facility will be affected by implementing this option?

The informal review is a procedure by which the assessment team selects the options that appear best based on the discussion and examination of each option. As is the case when the team is proposing options, their approach to screening should employ group decision-making techniques whenever possible.

In the more complicated situations, the team may need to use the Weighted Sum Method (Appendix B) or another similar technique designed for use in complex decision-making situations.

Once this screening stage has been completed, use Pollution Prevention Worksheet 13 to list the prioritized target areas (see Pollution Prevention Worksheet 12) and the various screened options associated with each.

6.5.3 Feasibility Assessments

The final product of the screening phase is a prioritized list of pollution prevention options. These options should now be examined to determine which are technically, environmentally and economically feasible, and to prioritize them for implementation.

6.5.3.1 Technical Evaluation

The pollution prevention team will perform a technical evaluation on each of the pollution prevention options listed on Worksheet 13. The following questions provide the criteria against which each option will be evaluated:

- Will the option reduce the potential of pollutant discharges to the environment?
- Will the option reduce the potential of environmental contamination?
- Is the option safe for the workers?
- Will the product quality be improved or maintained?
- Is space available for this option?
- Are the changes compatible with all procedures' work flow and production rates?
- Will the option require more labour to operate?
- How long will the operations on the facility be stopped during installation?
- Will the vendor provide acceptable service?
- Will the new system create other environmental problems?

If it is not apparent whether a specific pollution prevention option is technically feasible, further information should be obtained.

6.5.3.2 Environmental Evaluation

In this step, the pollution prevention team will weigh the advantages and disadvantages of each option with regard to protecting the environment and human health.

To conduct a sound evaluation, the team should review the environmental aspects of the specific design of targeted areas and/or the operational procedures within them. Some of the pollution prevention options may require a more thorough environmental evaluation than others, especially if they involve process or equipment changes.

It should be noted that it may not be possible to identify all the environmental costs and benefits associated with a particular pollution prevention option (NCI, 1995).

6.5.3.3 Economic Evaluation

Estimating costs and benefits of most pollution prevention options applicable to breweries and wineries is straightforward. If a project has no significant capital costs, the decision is relatively simple. Its profitability can be judged by whether or not it reduces or prevents pollution. For example, improving the operating practices would not require extensive analysis before they are adopted. However, other options which have significant capital cost or risk attached to them should undergo detailed economic evaluation following the consideration of the technical and environmental criteria (EEC, 1995).

The U.S. Environmental Protection Agency (USEPA, 1992) has adopted the Total Cost Assessment (TCA) for evaluating pollution prevention projects. The TCA analyzes direct costs, indirect costs, liability costs, and less tangible benefits over a long period of time (Table 6.3).

The following is a brief explanation of each of the costs that need to be considered by the pollution prevention team:

Direct Costs

Direct costs for pollution prevention are those directly incurred by the company through implementation (e.g., capital, operation and maintenance). As this may represent a net cost to the company, confining the costs analysis to direct costs may lead to the incorrect conclusion that pollution prevention is not a sound business investment.

Indirect Costs

These costs will usually result in a net savings to the company since there would be savings in administration, regulatory compliance and on-site management costs.

Liability Costs

The reduction in liability associated with pollution prevention may also offer significant net savings to the brewery or winery. Potential reductions in liability costs (e.g., penalties, fines, cleanup costs, damage claims, etc.) can make pollution prevention more profitable, particularly in the long term.

Estimating future liability costs is subject to a high degree of uncertainty. It may, for example, be difficult to estimate liabilities for production processes. Similarly, damage claims that may result from allegations of contamination of the operation site or neighbouring sites, may be difficult to estimate. However, it may be possible to estimate such liability by citing penalties reported on claims for similar violations of the Waste Management Act, or calculating the cost of site cleanup if pollution prevention measures are not taken (USEPA, 1992; EEC, 1995).

Table 6.3 Cost Assessment Table

Cost	Description
Direct Costs	• Capital Expenditures ♦ Buildings ♦ Equipment & installation ♦ Utility connections ♦ Project engineering • Operation & Maintenance Costs ♦ Raw materials ♦ Labour ♦ Waste disposal ♦ Water and energy • Value of recovered materials
Indirect Costs	• Savings in Administrative Costs • Regulatory Compliance Costs ♦ Permitting ♦ Record keeping & reporting ♦ Monitoring cost • Insurance • On-site Waste Management ♦ Storage ♦ Handling ♦ Disposal
Liability Costs	• Penalties • Fines • Personal Injury • Property Damage • Cleanup Costs
Less Tangible Benefits	• Increased income due to: ♦ Enhanced company image ♦ Improved product quality ♦ Increased productivity due to improved employee morale ♦ Improved relationship with regulators

* Adapted from USEPA, 1992; EEC, 1995; NCI, 1995

Less Tangible Benefits

Pollution prevention may deliver substantial benefits due to improved company image, increasing company income and an improved relationship with regulators. These less tangible benefits are difficult to measure; however, they should be incorporated into the assessment wherever possible (USEPA, 1992). Alternatively, the less tangible benefits may be evaluated qualitatively in the cost assessment (EEC, 1995).

It should be noted that since many of the liabilities and less tangible benefits of pollution prevention will occur over a long period of time, the economic assessment should consider a longer time frame, rather than the three to five years typically used in the economic evaluation of other types of projects. Although this increases the uncertainty of the cost factor used in the analysis, it emphasizes the importance of implementing the pollution prevention options (USEPA, 1992; EEC, 1995).

While it may be quite easy to obtain information on direct costs, estimating some of the future liabilities and less tangible costs may be more difficult (USEPA, 1992). However, while undertaking the analysis, the pollution prevention team should attempt to incorporate all the direct costs associated with the particular option, and as many of the indirect costs as possible (EEC, 1995).

To account for the time value of the investment during the life of proposed projects, several financial indicators can be used; the three most common are (USEPA, 1992):

- Net Present Value (NPV);
- Internal Rate of Return (IRR); and,
- Profitability Index (PI).

As the IRR and PI indicators do not permit the ranking of options based on their net financial benefit, the NPV indicator should be used in the development of pollution prevention plans. The NPV is calculated over the lifetime of each option to determine whether the implementation of the particular option will result in net financial savings or losses, based on the assumptions used in the financial analysis (EEC, 1995). Discussion of these indicators is beyond the scope of this study and would be found in economic analysis texts.

6.5.4 Ranking of Pollution Prevention Options

Use Pollution Prevention Worksheet 14 to report the rank of each pollution prevention option. The following guidelines for ranking pollution prevention options should be observed:

- Pollution prevention options required by the regulations or the permits, or which have no cost or risk attached to them, have highest priority.

- The remaining options are ranked according to decreasing environmental benefits and NPV.

6.5.5 Pollution Prevention Options Report

Prepare a report containing the results of the detailed assessment regarding the pollution prevention options. This report should include:

- proposed pollution prevention options;
- option screening results; and,
- feasibility analysis results.

The screened pollution prevention options should be listed together with results of the feasibility study. Use Worksheet 14 to present a summary of the detailed assessment report.

6.6 Preparing the Pollution Prevention Plan

Once Worksheet 14 and the pollution prevention options report have been completed, the pollution prevention team will write a report that summarizes the results of the pollution prevention program developed for the facility. The facility pollution prevention plan will include the following:

1. Pollution Prevention Worksheet 1 which includes:
    - a written policy of the management support for the pollution prevention plan and a commitment to achieve the goals established; and,
    - the scope and objectives of the pollution prevention plan.
2. Pollution Prevention Worksheet 5 which includes:
    - a description of the facility operations; and,
    - a description of waste management practices at the facility.
3. A summary of review results from all completed Pollution Prevention Worksheets, including waste discharges from the plant, treatment and disposal of wastes, current pollution prevention activities, regulatory requirements, and prioritized waste streams or process areas for detailed assessment.
4. A plan to perform a detailed assessment, or a summary of assessment results, including facility-specific criteria for prioritizing pollution prevention options, and a listing of feasible pollution prevention options (Pollution Prevention Worksheet 14).
5. A selection of pollution prevention options to be implemented. For each selected option, the area of the facility affected should also be identified (Pollution Prevention Worksheet 15).

6. An implementation schedule (Pollution Prevention Worksheet 16) which presents the planned pollution prevention implementation activities and personnel responsibilities for each of the three calendar years following the completion of the pollution prevention plan. When developing this schedule, other production, training and management schedules should be consulted so as to avoid potential economic losses resulting from the disruption of the operations in these areas.

6.7 Implementing the Pollution Prevention Plan

The selected pollution prevention options should be implemented according the schedule outlined in the pollution prevention plan. This will include securing the necessary funding for those projects that require capital expenditures, and obtaining the required permits. Other pollution prevention options that do not require significant capital expenditures or training can be implemented immediately.

The pollution prevention process does not end with implementation. Continued management emphasis on pollution prevention will be required to ensure success of the pollution prevention program. Furthermore, it is necessary to track the effectiveness of the pollution prevention plan in achieving its objectives and to modify options that do not meet the original performance expectations. Above all, use the knowledge gained in developing the pollution prevention program to continue to evaluate and fine tune the pollution prevention plan.

6.8 Evaluating Pollution Prevention Progress

The progress achieved in pollution prevention should be evaluated. The objective of a progress assessment is to conduct quantitative analysis of pollution reduction after implementing the pollution prevention options. This information can then be used by the facility operator to evaluate achievements and to guide future modification of pollution prevention plans.

The achievements of the implemented options should be compared to the initial goals, as stated in the pollution prevention report, and the anticipated results outlined in the plan (Pollution Prevention Worksheet 13). By reviewing the program's achievements, the team can assess the degree to which goals are being met, review and fine tune the plan, and determine what economic benefits have resulted from pollution prevention. In addition, the evaluation procedure may provide several indirect benefits; including:

- identification of new pollution prevention options and potential cost savings;
- confirming employees' commitment to environmental policies and responsibilities;
- improving relations with regulators; and,

- allowing management to give, and receive, credit for good environmental performance resulting in an improvement in company image, morale, productivity and commitment to pollution prevention.

In addition to the ongoing evaluation of the pollution prevention plan, an annual progress report should be prepared to document and track the efforts at the facility. The report should contain the following information:

- progress towards pollution reduction/prevention goals;
- pollution prevention options implemented;
- facility areas affected;
- operational practices affected; and,
- problems encountered during implementation of pollution prevention options.

Based on this annual progress report, the company may decide to re-evaluate its pollution prevention goals and objectives (e.g., set higher standards), conduct a detailed assessment study to re-evaluate and improve implemented options, or assess the feasibility of new pollution prevention options, as shown in Figure 6.1.

GLOSSARY

Adjusted decibel	A unit used to show the relationship between the interfering effect of a noise frequency or band of noise frequencies and a reference noise power level of -85 dBm, abbreviated dBa.
Autolysis	The destruction of cells or tissues by their own enzymes.
Bright beer	Beer after maturation and the final filtration stage when remaining traces of yeast and proteins are removed.
Chaptalization	The addition of sugar, to permit fermentation to reach the required alcohol content.
Chasing	The use of water (or other medium) to transfer process liquids.
Cullet	Scraps of waste glass that can be remelted.
Decibel	A unit of expressing the relative intensity of sounds on a scale from zero for the average least perceptible sound to about 130 for the average pain level.
Fermentation	The production of ethanol and carbon dioxide as a result of the action of yeast on sugars.
Finings	Chemical aids used for the clarification of wine.
High Gravity Brewing	The practice of producing and fermenting wort at a higher original gravity than is required to package. The original gravity is adjusted by dilution with water at the final filtration stage.
Green beer	Beer which has not undergone maturation.
Hops	A natural material added to sweet wort to impart bitterness and flavour. They may be whole hops or in powder, pellet or extract form.
Kieselguhr	Filtration medium used to remove traces of yeast and proteins from beer after maturation.
Lauter tun	The vessel in which spent grains are removed from the sweet wort.
Lees	Proteinaceous material precipitated during fermentation. The lees are removed by filtration and can be used in animal feed.
Lucilite	Alternative filtration medium to Kieselguhr.
Malt	A cereal grain, usually barley, which has been germinated for a limited period and then dried.
Marc	More frequently called "pomace".

Mash tun	The vessel in which sugars are extracted from malt by enzymes on the addition of water to produce sweet wort.
Mashing	The process carried out in the mash tun.
Must	Boiled-down grape juice.
Tunnel Pasteurization	The beer is pasteurized in bottles or cans, meaning that both beer and container are pasteurized in a closed unit.
Plato scale	A scale based on pure sucrose solutions used to describe sugar content.
Pollution prevention program	An ongoing, overall examination of the facility, with the goal of minimizing contamination of the environment through changes in the input material and production processes, and improvements in operating practices.
Pomace	Crushed pulp after pressing ,sometimes called "marc".
Sparge	The spraying of grains in the lauter tun with water in order to extract the maximum amount of useful material from the grain.
Specific effluent volume	The effluent volume for a particular period divided by the product volume for the same period (i.e., volume of effluent per unit volume of product).
Specific water intake	The water intake for a particular period divided by the product volume for the same period (i.e., volume of water intake per unit volume of product).
Storage vessel	Vessel in which beer is stored during maturation.
Trub	Proteinaceous material precipitated both when wort is boiled in a kettle and when it is subsequently cooled (also known as hot break and cold break).
Weak wort	The wort remaining in the lauter tun after wort has been strained off and the grain bed has been washed out with sparging water.
Whirlpool	The vessel in which hot trub is separated from the wort by centrifugation.
Wort	The liquid resulting from the mashing process. It is a mixture of partially degraded starch, sugars, enzymes, proteins and water.

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APPENDIX A

Example Pollution Prevention Worksheets

Pollution Prevention Worksheet 1
Facility Commitment to Pollution Prevention

Prepared by:____________________________________ Date:______________________

Facility Name:

Pollution Prevention Team

Team Leader:

Team Member	Title	Responsibility

Management Policy

* Write a management policy expressing support for planning, and a commitment to implement pollution prevention activities to achieve the established goals at your facility.

Scope and Objectives

* Identify the areas and/or operational practices of your establishment to be covered by the plan. State the goals to be achieved through implementation of the pollution prevention options.

Management Signature

Date:	Signature:	Position:

Pollution Prevention Worksheet 2
Pollution Prevention Program Timeline

Prepared by:_________________________ Date:_______________

Task	Year	Month											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Gather background information													
Gather facility data													
Perform site inspection													
Identify pollution prevention areas													
Prioritize pollution prevention opportunities													
Identify pollution prevention options													
Screen pollution prevention options													
Conduct technical evaluation													
Conduct environmental evaluation													
Conduct economical evaluation													
Rank pollution prevention options													
Prepare assessment report													
Prepare pollution prevention plan													
Prepare implementation schedule													
Implement pollution prevention plan													
Measure pollution prevention success													
Refine goals and objectives													
Review pollution prevention areas													

Comments: ____

____

____

Pollution Prevention Worksheet 3
Process Information

Prepared by:___________________________________ Date:______________________

Document	**Status**			
	Complete? (Y/N)	Current? (Y/N)	Document Number	Location
Process flow diagrams				
Material/energy balances:				
• Design				
• Operating				
Flow/amount measurements:				
• Raw materials				
• Products/By-products				
• Water				
• Wastewater				
• Solid waste				
Analytical data				
Costs:				
• Raw materials				
• Water				
• Energy				
• Packaging				
• Waste management				
Revenue:				
• Products				
• By-products				
Process descriptions				
Operating manuals				
Equipment list/specifications				
Piping/instrument diagrams				
Inventory records (emission)				
Flow diagrams				
MSDS Sheets				
Operator logs				
Production schedules				
Annual reports				
Environmental audit reports				
Permits/permit applications				
Others: •				

Pollution Prevention Worksheet 4
General Facility Profile

Prepared by:______________________________ Date:____________________

General Facility Information	
Parent Organization:	Facility Name:
Address:	Address:
City/Province:	City/Province:
Postal Code:	Postal Code:
Telephone/Fax:	Telephone/Fax:

Production Information	
Major Operations:	Primary Product(s):
	Annual Production Level(s):
	SIC Code(s):
Describe any seasonal variation in the operation of the facility:	

Regulatory Information

				Permit No.
1)	Liquid Waste Permit	❑ Yes	❑ No	
2)	Air Permit	❑ Yes	❑ No	
3)	Others (please list on separate sheet)	❑ Yes	❑ No	

Pollution Prevention Worksheet 5
Description of the Facility Operations

* Include a flow chart and a description of the facility's production processes, commencing with the arrival of raw materials and ending with the shipment of final products. Also include the procedure for liquid and solid waste removal, handling, treatment and disposal. Extra sheets may be used as required.

Prepared by:___________________________________ Date:_____________________

sheet (___) of (___)

Pollution Prevention Worksheet 6
Site Layout

* Provide a site layout showing the location of process areas, storage areas, sewers and wastewater treatment systems. Where possible, include elevations and direction of stormwater runoff.

Prepared by:______________________________ Date:____________________

Pollution Prevention Worksheet 7
Raw Material Information

Prepared by:_________________________________ Date:____________________

Attribute	Description		
	Resource (__1__)	**Resource (__2__)**	**Resource (__3__)**
Material name			
Use			
Supplier/Source			
Component(s) of concern			
Annual consumption (units:_____)			
Unit cost ($ per ____)			
Overall annual cost ($)			
Delivery method (truck, tanker, etc.)			
Packaging, shipping container (type, size)			
Unloading method (forklift, manual, etc.)			
Storage location (outdoor, warehouse, etc.)			
Transfer method (forklift, pump, conveyor, etc.)			
Shelf life			
Packaging disposal method (e.g., return to supplier, recycle, landfill, etc.)			
Supplier would accept return of:			
• packaging (Y/N)			
• expired materials (Y/N)			
Alternate suppliers			
Acceptable substitute(s), if any			

sheet (___) of (___)

Comments: ____

____

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Pollution Prevention Worksheet 8
Product/By-Product Information

Prepared by:___________________________________ Date:_____________________

Attribute	Description		
	Product (___)	**Product (___)**	**Product (___)**
Product/By-Product Name			
Consumer(s)			
Component(s) of concern			
Annual production (units:_____)			
Unit revenue ($ per ____)			
Annual Revenue			
Packaging (type, size, amount)			
• Refundable (Y/N)			
• Containers returnable (Y/N)			
• Recyclable/reusable (Y/N)			
On-site storage location			
Transfer method (e.g., forklift, pump, conveyor, etc.)			
Shelf life			
Shipping method (e.g., truck)			
Possible to change product specifications, makeup and packaging (Y/N)			
Consumer would accept:			
• relaxed specifications (Y/N)			
• altered makeup (Y/N)			
• different packaging (Y/N)			

sheet (___) of (___)

Comments: ____

____

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Pollution Prevention Worksheet 9
Waste Materials Information

Prepared by:________________________________ Date:____________________

Attribute	Description		
	Waste (___)	**Waste (___)**	**Waste (___)**
Material name			
Source/origin			
Media (e.g., solid, liquid, gas)			
Component(s) and/or attribute(s) of concern			
Regulatory requirements			
Annual waste generation (units:_____)			
Cost ($ per _______)			
Overall cost (per year)			

sheet (___) of (___)

Comments: ____

____

____

Pollution Prevention Worksheet 10
Waste Management Methods

Prepared by:____________________________________ Date:______________________

Attribute	Description		
	Waste (____)	**Waste (____)**	**Waste (____)**
Material name			
Method(s) of waste reuse			
• Other reuse potential (Y/N)			
Method(s) of by-product recovery			
• Other recovery potential (Y/N)			
Method(s) of waste recycle			
• Other recycling potential (Y/N)			
Waste treatment method(s) (e.g., anaerobic digestion, aerated lagoons, filtration, municipal sewer, etc.)			
Sludge disposal method(s) (e.g., discharge to sewer, landfill, on-site recycle, dewatering, etc.)			
Unit disposal cost ($ per _____)			
Annual disposal cost			
Waste shipping method			
Loading method (e.g., forklift)			
Shipping container size & type			
• Returnable (Y/N)			
• Recyclable/reusable (Y/N)			

sheet (___) of (___)

Comments: ____

____

____

Pollution Prevention Worksheet 11
Summary of Environmental Review Results (page 1 of 2)

The worksheet includes two parts: Part one includes general practices such as good housekeeping, employee training, preventative maintenance, spill control/spill prevention, emergency response plans; Part two includes site layout and operational practices.

(A) General Practices

Prepared by:___________________________________ Date:______________________

General Practice	Current Practice	Recommended Practice

Comments: ____

____

____

Pollution Prevention Worksheet 11
Summary of Environmental Review Results (page 2 of 2)

(B) Operational Practices

* The worksheet will include deficiencies in site layout and operational practices in each production area.

Prepared by:______________________________ Date:__________________

Area of Facility	Current Practice	Recommended Practice

Comments: ____

____

____

Pollution Prevention Worksheet 12
Summary of Identified Pollution Prevention Areas

* List, in order of priority, areas which are targets for the pollution prevention program. Include the areas where pollution prevention will achieve the greatest protection of water, air and/or employee health and safety. Also, provide the criteria for the ranking of each target area. Extra sheets may be used as required.

Prepared by:______________________________ Date:____________________

Priority	Target Area or Process	Ranking Criteria
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

sheet (___) of (___)

Comments: ____

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Pollution Prevention Worksheet 13
Pollution Prevention Options

Prepared by:______________________________ Date:__________________

Target Area or Process:			Priority:
Option Attribute	**Option (___)**	**Option (___)**	**Option (___)**
Option			
Brief description			
Anticipated impact on waste stream(s)			
Anticipated impact on resource(s)			
Anticipated impact on product(s)			

Target Area or Process:			Priority:
Option Attribute	**Option (___)**	**Option (___)**	**Option (___)**
Option			
Brief description			
Anticipated impact on waste stream(s)			
Anticipated impact on resource(s)			
Anticipated impact on product(s)			

sheet (___) of (___)

Comments: ____

Pollution Prevention Worksheet 14
Ranking of Pollution Prevention Options

Prepared by:___________________________________ Date:______________________

Target Area	Pollution Prevention Option		Analysis Results		Rank
	#		NPV ($)	Required?*	

sheet (___) of (___)

∗ "Required" means that the pollution prevention option is required by regulations or permit. Please answer with "yes" or "no". If the answer is "yes", then the option is given first priority.

Comments: ____

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Pollution Prevention Worksheet 15
Pollution Prevention Options To Be Implemented

Prepared by:________________________________ Date:____________________

Meeting Date	
Meeting Coordinator	
Meeting Participants	

Description	**Option (____)**	**Option (____)**	**Option (____)**
Target Area(s) or Process(es) Affected			
Selected Pollution Prevention Option			
Option Rank			
Rationale for Implementation			

Description	**Option (____)**	**Option (____)**	**Option (____)**
Target Area(s) or Process(es) Affected			
Selected Pollution Prevention Option			
Option Rank			
Rationale for Implementation			

sheet (___) of (___)

Comments: ____

____

____

Pollution Prevention Worksheet 16
Pollution Prevention Implementation Schedule

* Develop a schedule for the implementation of the pollution prevention options selected. Indicate when, in the next three years, the options or phases of options will be implemented. Extra sheets may be used as required.

Prepared by:____________________________________ Date:______________________

Pollution Prevention Option		**Estimated Implementation Date**														
		Year			**Month**											
#		1	2	3	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.

sheet (___) of (___)

Comments: ____

APPENDIX B

Weighted Sum Method

Weighted Sum Method

The weighted sum method is an approach to quantitatively screen and rank various pollution prevention options. This approach includes three steps.

1. Identify the important criteria derived from the program goals:

As an example of program goals:

- reduction in wastes generated.
- reduction in waste disposal cost
- reduction in raw material cost

Program restraints, such as limited availability of funds, should also be considered. Examples of limiting factors include:

- low capital cost
- low operating maintained cost
- short implementation period with minimal disruption of plant operations.

Each parameter is given a weight on a scale of 0 to 10. For example, if reduction of waste disposal costs are very important, then it may be given a weight of 10. Criteria that are not important are not included or are given a low weight.

2. Rate each option with respect to each individual criterion.
3. Finally, the rating of each option for a particular criterion is multiplied by the weight of the criterion. The options with the best overall ratings are then selected for the technical and economic feasibility analysis.

Example:

ABC Company has determined there were three pollution prevention options available (A, B and C) and three criteria are used to evaluate these options. The weights for the criteria were as follows:

Criteria	Weight
Reduction of waste disposal cost	10
Reduction in liability	8
Ease of Implementation	6

Each pollution prevention option was ranked with respect to the above criteria as follows:

Criteria	Option rating		
	A	B	C
Reduction of waste disposal cost	8	5	3
Reduction in liability	6	8	5
Ease of Implementation	2	5	9

4. Then, the overall rating of the options were as follows:

Criteria	Weight	A		B		C	
	(1)*	(2)	(3)	(4)	(5)	(6)	(7)
Reduction of waste disposal cost	10	8	80	5	50	3	30
Reduction in liability	8	6	48	8	64	5	40
Ease of Implementation	6	2	12	5	30	9	54
Total			140		144		124

* Note that:

(3) = (2) × (1)
(5) = (4) × (1)
(7) = (6) × (1)

From the above table, the total scores of options A, B and C are 140, 144 and 124, respectively. In this case, options A & B should be selected for further evaluation because their scores are high and close to each other.