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A Review Of Sources Of Ground-Water Contamination From Light Industry

Technical Assistance Document

EPA/440/6-90/005

A REVIEW OF SOURCES OF GROUND-WATER CONTAMINATION FROM LIGHT INDUSTRY

OFFICE OF WATER
OFFICE OF GROUND-WATER PROTECTION
U.S. ENVIRONMENTAL PROTECTION AGENCY

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EXECUTIVE SUMMARY

This document addresses the potential impact of light industrial activities on wellhead protection areas. The term "light industry" refers to industrial, commercial, or retail establishments that manage substances or engage in manufacturing, fabrication, or service activities that are one step or more removed from the production of primary products from raw material. These activities, which may pose a potential threat to ground-water quality, are minimally-regulated or non-regulated by Federal laws.

Several States and local governments have adopted innovative approaches for controlling light industries. These approaches may involve source identification, zoning and other controls to limit land uses in wellhead areas, and public education and technology transfer to encourage industries to adopt management controls. Other jurisdictions have also placed strict prohibitions on activities that are allowed in wellhead areas, including restricting specific light industry types. These activities may be adopted as part of a comprehensive Wellhead Protection Program. Examples of these activities include:

- Watershed Rules and Regulations - Local or State agencies may adopt land-use plans to protect public water supplies.

- Ground-Water Management Areas - State agencies may develop management plans for designated areas to institute land use and source controls to protect ground-water quality.

- Ground-Water Standards - Many States have adopted standards to protect their ground water. Standards may be either numeric, specifying a maximum concentration for a particular contaminant, or narrative, specifying a general prohibition on types of discharges or identifying a general quality goal.

- Ground-Water Classification - Several States have classified their ground water and specified differential protection measures according to the classification.

The Federal Safe Drinking Water Act Amendments of 1986 mandated the U.S. Environmental Protection Agency (EPA) to work with the States to develop Wellhead Protection (WHP) Programs to protect ground-water supplies of public drinking water. Under Section 1428 of the Act, each State and Territory was directed to submit a WHP program to EPA by June 19, 1989. Wellhead Protection Programs have six major components: (1) designation of roles and duties of State and local agencies; (2) delineation of wellhead protection areas; (3) identification of contaminant sources; (4) development of management approaches for the wellhead area; (5) preparation of contingency plans for replacement water supplies; and (6) planning and siting of new wells. This document discusses aspects of the third and fourth components outlined above.

A variety of anthropogenic sources may threaten wellhead areas, including heavy industry, waste disposal sites, light industry, on-site wastewater disposal, and agricultural practices, as well as others. While heavy industry and agriculture are acknowledged and increasingly recognized as sources of contamination, light industry and on-site wastewater disposal are also pervasive contaminant sources and frequently are not subject to the same types of controls.

Many types of light industries may threaten wellhead areas. These industries are found in increasing numbers throughout the United States, as light industrial parks and suburban developments spread into formerly rural areas. A number of light industry types are addressed in this document, such as electroplating and polishing services, wood and lumber treating operations, furniture refinishing and repair services, auto repair shops, road deicing operations, scrap metal and auto junkyard dealers, and laundry and dry-cleaning establishments. These light industries manage a variety of contaminants, including heavy metal-containing solutions and acid baths in electroplating services, pentachlorophenols and other preservatives in wood treating operations, solvents and varnishes in furniture refinishing shops, used oils and degreasers in auto repair shops, salts in road deicing operations, spent battery acids and solvents in scrap dealerships, and detergents and solvents such as trichloroethylene in dry-cleaning establishments. **Because these light industries are found in large numbers throughout the country, there is a widespread potential for wellhead contamination from these sources.**

A wide variety of constituents have contaminated ground water at light industrial facilities. The most prevalent groups of contaminants include organics and metals/inorganics. Typical organic contaminants include benzene, dichloroethylene, dioxins, methylene chloride, pentachlorophenol, perchlorethylene, toluene, trichloroethane, trichloroethylene, and xylene. Typical metals/inorganics include arsenic, chromium, copper, lead, nickel, nitrates, and sodium chloride. These contamination incidents are most frequently associated with waste management and waste disposal activities.

Following sound management controls can serve as an important component of a Wellhead Protection Program to control ground-water contamination by light industry. Many cases of contamination have been documented involving spills and leaks to soil, improper waste disposal in septic systems, and releases from underground storage tanks and pipelines. In a number of cases, light industries have prevented or minimized such contamination incidents by following management controls, such as storing raw materials and wastes on impermeable pads and in covered areas; collecting runoff from material storage areas; placing drip pans under machinery and in process areas; segregating hazardous materials from disposal in septic systems; minimizing the intensive use of contaminants such as road salts in sensitive areas; inspecting and monitoring underground storage tanks and pipelines; cleaning up spills promptly after they occur; and training personnel to follow sound material management practices. **Over the long-term, the potential for ground-water contamination by light industry can also be reduced by adopting waste minimization practices, such as waste recycling, raw material substitution, and waste treatment.**

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1.0 Introduction

1.1 Overview of this Document

This document is one of a series of Technical Assistance Documents (TADs) prepared by the Office of Ground-Water Protection of the U.S. Environmental Protection Agency. This TAD discusses the problem of ground-water contamination caused by light industrial raw material, production, and waste management practices. While larger industries have come under increasing Federal and State regulation over the past few years as a means of controlling activities that can result in ground-water contamination (U.S. EPA, 1987) there is a growing awareness that other smaller and either unregulated or minimally-regulated industries and businesses also manage materials that may pose a threat to ground water and wellhead protection areas (U.S. Office of Technology Assessment, 1987). This TAD is intended to assist managers in identifying and controlling potential light industrial sources of contamination that may pose a threat to public water supplies.

EPA prepared this document as part of its ongoing effort to assist State and local governments in developing Wellhead Protection Programs. Wellhead Protection Programs have six major components (U.S. EPA, 1988): (1) designation of roles and duties of State and local agencies; (2) delineation of wellhead protection areas; (3) identification of contaminant sources; (4) development of management approaches for the wellhead area; (5) preparation of contingency plans for replacement water supplies; and (6) planning and siting of new wells. This document is designed to support the third and fourth tasks outlined above (i.e., the identification of light industrial sources of ground-water contamination and the development of management programs to control these sources). Specifically, this document focuses on a group of industries that are increasing in significance in many wellhead areas. The number of light industries in this country and the corresponding threat to public water supplies is growing. Furthermore, many of these light industries are locating in rural and suburban areas which have not previously been host to businesses that manage hazardous materials. As a result, wellhead areas in these regions may become threatened.

- **Organization**

This document is a part of the series of technical assistance documents prepared by EPA to support State and local Wellhead Protection Programs. Companion documents in this series include Developing a State Wellhead Protection Program: A User's Guide to Assist State Agencies Under the Safe Drinking Water Act (EPA 440/6-88-003), Guidelines for Delineation of Wellhead Areas (EPA 440/6-87-010), and Wellhead Protection Programs: Tools for Local Governments (EPA 440/6-89-002). The information provided in these previous documents is not repeated in detail in this TAD; however, those documents are cited where appropriate. Instead, this document focuses on light industries as a potential contaminant source in Wellhead Protection Areas and broadly discusses approaches for minimizing potential impacts.

This document is organized in six chapters. In Chapter 1, following this introduction, Section 1.2 defines what is meant by the term "light industry." Section 1.3 outlines the methods the Agency used to gather information characterizing light industry, and section 1.4 presents a summary of the results of the initial data-gathering effort for this document, including findings concerning the extent of ground-water contamination.

Chapter 2 focuses on the materials handled (Section 2.1) and the material management practices followed (Section 2.2) by light industry that can lead to ground-water contamination. Section 2.3 outlines general conclusions concerning the light industrial practices that may threaten Wellhead Protection Areas.

Chapter 3 contains a discussion of Federal, State, and local controls to address ground-water contamination by light industry. This discussion first outlines Federal statutes in Section 3.1. Section 3.2 discusses State and local options for controlling light industry, which may include land use restrictions or zoning to control the location of light industries over vulnerable sources of ground water. Finally, Section 3.3 describes an approach that State and local governments may adopt to develop programs to control light industries in Wellhead Protection Areas.

Chapter 4 focuses on the technical controls that light industries have adopted to minimize the potential for ground-water contamination. Section 4.1 describes management controls that industries have followed to ensure that "good housekeeping" principles are adopted at facilities, and section 4.2 discusses waste minimization techniques that some industries have instituted to limit the production of potential contaminants. The chapter concludes in Section 4.3 with an analysis of the role these management controls and waste minimization techniques can play in a Wellhead Protection Program.

Finally, Chapter 5 summarizes the findings of this document, and Chapter 6 lists the references collected by the Agency to support this analysis.

1.2 Definition of "Light Industry"

As used in this document, the term "light industry" refers to industrial, commercial, or retail establishments that are not generally addressed under Federal hazardous waste or hazardous material control laws or regulations. This term is not new. It has been used in the manufacturing and service sectors for many years and has generally been thought to define those manufacturing, fabrication, or service industries that are one step or more removed from the production of primary products from raw material. For example, chemical manufacturing may be thought of as heavy industry, while paint formulating is light industry. This document takes that definition one step further by also focusing on the waste generation and management practices of the industry to define its status.

Federal hazardous waste laws and hazardous material control laws and regulations are discussed in Chapter 3 and generally include the Resource Conservation and Recovery Act (RCRA), Comprehensive Environmental Response Compensation and Liability Act (CERCLA or "Superfund"), Safe Drinking Water Act (SDWA), Clean Water Act (CWA), Toxic Substances Control Act (TSCA), and Federal, Insecticide, Fungicide and Rodenticide Act (FIFRA). Although these laws have imposed controls on a wide range of industries and hazardous material handling practices, they have tended to focus only on the larger manufacturing industries which manage the majority of hazardous wastes and hazardous materials in this country. Other smaller industries and businesses have not been as stringently controlled, either because the Federal statutes focus on industries that manage wastes or materials above a threshold amount or because the materials managed by the smaller industries are not considered "hazardous." Nonetheless, EPA and many States have discovered that these lower quantity or "non-hazardous" materials managed by light industry can still contaminate Wellhead Protection Areas.

In certain hydrogeologic settings, even very small amounts of hazardous material can contaminate large areas of ground water; both community and private supply wells have been contaminated by light industries (Ford and Quarles, 1987). Furthermore, materials that are not generally regarded as hazardous commonly contaminate ground-water supplies. Such contaminants include nitrates and biological substances, like bacteria and viruses.

As background for this document, a data-gathering effort was completed to characterize those light industries that pose the greatest potential threat to ground water (see Section 1.3). Based on this effort, 20 light industry sectors were identified as potentially significant sources of ground-water contamination. These sectors include the following:

- Agricultural Products and Services
- Mining and Quarrying
- Highway Deicing
- Textile and Apparel Products
- Lumber and Wood Preserving
- Printing and Publishing
- Chemical Product Blending
- Leather Products
- Mineral Products: Glass and Cement
- Metal Products
- Machine Shops
- Electronics and Electronic Equipment
- Transportation Maintenance
- Scrap Trade and Metal Container Recyclers
- Chemical and Petroleum Storage and Sales
- Automotive Repair, Services, and Parking
- Personal Services: Laundry, Pest Control, and Photofinishing
- Repair Services: Furniture, Welding, and Septage Services
- Amusement and Recreation
- Educational, Medical, and Engineering Laboratories

The portion of the American economy represented by these light industries is growing and dynamic - changing and adapting over time. Hence, controlling these sources of contamination, especially in wellhead protection areas, is increasing in importance. While the extent of light industrial practices is increasing, the areas or regions where these industries are found is also changing. As more and more sections of the country become "suburbanized," light industries are appearing in formerly rural areas and give rise to more numerous sources of ground-water contamination. Because public water supply wellhead areas are often located in these rural or suburban regions, the widespread growth in the number of contaminant sources is a major concern with regard to wellhead protection.

The growth in light industrial activity is best illustrated by the evolution in industrial parks from the early developments that contained mainly heavy industries to today's light industrial or high technology parks. Most current industrial park developments are oriented toward the needs of light industry, research, and general office-type operations. As a result, the number of industrial parks that are now being zoned for activities other than heavy manufacturing has risen dramatically in the last 10 years (Battelle, 1988)

The development of industrial parks has a long history in this country, and the nature of these parks has changed over time. In general, industrial parks can be characterized in one of five types, as described below. However, it is difficult to determine precisely how many of these various industrial park types exist. A "high technology park" may also be described as a research park, industrial park, science center, technology center, or even an office park. Hence, these five industrial park types should be thought of as a continuum (Battelle, 1988):

- Research Parks. The major activities associated with this type of development include research, engineering, and certain types of office and administrative activities. In virtually every case, these facilities exclude any business related to light manufacturing, distribution, and certain other associated business activities.

- Technology Parks. The technology park is characterized by research and development activities, high technology and light manufacturing activities, office and administrative functions, and a wide range of services. Technology parks are similar to research parks, but also contain manufacturing components. Technology parks are generally less than 10 years old.

- Office/Mixed Use Parks. These developments provide facilities not only for office-type operations, but also for a wide range of light manufacturing, storage, distribution, and other business support services.

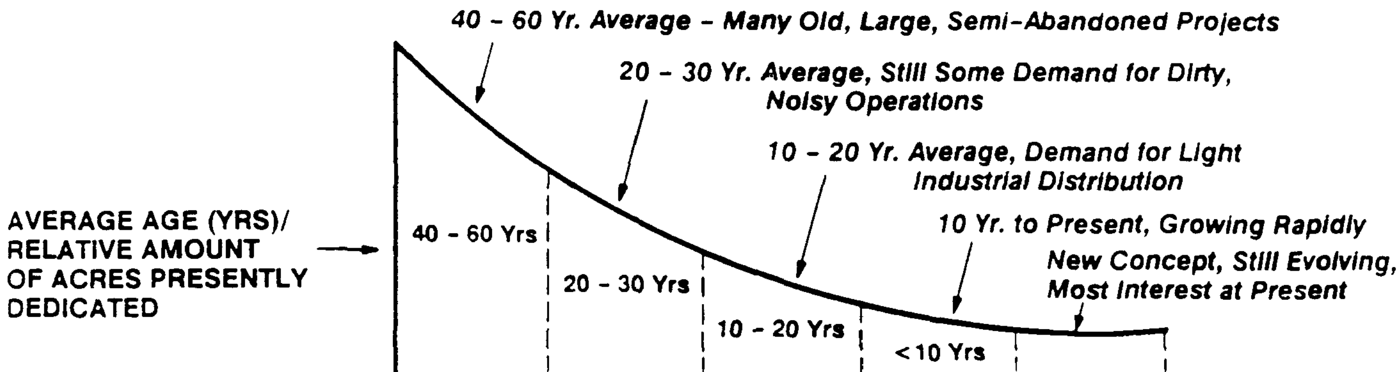
- "AAA" Industrial and Distribution. Standard and "AAA" industrial parks are oriented toward production, service, and distribution. The "AAA" implies high grade, relatively clean industrial and distribution processes. They often include distribution facilities, rail sidings, outside and underground storage, and activities that may produce emissions and wastes. They have flexible land uses and have less rigorous landscaping and architectural design.

- Industrial. These facilities represent the older type of industrial park. They consist of basic industrial components such as oil refineries and heavy manufacturing facilities. Large volumes of raw materials and wastes are often stored on these sites. Although managing these facility types is of critical importance in wellhead areas, these heavy industrial parks are not addressed in this document.

Exhibit 1 outlines the continuum of industrial park types. The exhibit illustrates the range in ages of most parks form older heavy industry to newer light industry parks. Although not all light industries are found in industrial parks, the move to light industrial development is increasing. Hence, understanding the potential ground-water impacts associated with these industrial parks is a critical component of effective wellhead protection. Wellhead Protection Program managers should be aware that many of these parks contain businesses and industries that manage hazardous materials. The types and volumes of contaminants that may be introduced into Wellhead Protection Areas from these light industrial parks is discussed in the following chapter.

Exhibit 1

The Evolution from Heavy Industrial to Light Industrial Parks



Type of Park:	industrial	"AAA" Industrial and Distribution	Office/ Mixed Use	Technology	Research Park
Zoning:	Heavy Industrial	Light Industry Distribution	Office/ Mixed Use	Research Mixed Use Office	Research
Type of General Activities:	Production	Production and Distribution	Distribution, Office Administra-tion	Research and Devel-opment, Office Ad-ministration	Research and Develop-ment

Decreasing water demand for process/ →
decreasing volume of waste generated →

1.3 Summary of Data Collection for this Document

A limited data-gathering effort was conducted to investigate the light industrial activities outlined in this document. This effort focused on identifying the nature and extent of ground-water contamination caused by light industrial facilities. Because of the very broad scope of the analysis, the data-gathering effort was not designed to serve as a definitive characterization of either the light industry universe or the extent of wellhead area contamination caused by light industrial facilities. Instead, the data-gathering effort provided only a "first-cut" overview of the scope of the problem.

Information was gathered from a variety of sources and included a broad literature review and series of phone contacts. Many of the information sources, however, provided either incomplete or poorly-documented case studies. Only those incidents with sufficient information to identify the characteristics of the contamination event accurately were included in this review. Furthermore, those cases that could not be identified as involving non-regulated or minimally-regulated light industrial activities were not included. For example, if the contamination incident resulted from an illegal activity, such as "midnight dumping" of hazardous waste shipments, or a release from a regulated underground chemical or petroleum storage tank, the incident was not included in the review. Information for this document is based on 182 case studies of ground-water contamination associated with light industrial facilities.

The cases identified in the review do not, of course, encompass the universe of known contamination incidents. The difficulties encountered in gathering the case study information indicate that more cases of ground-water contamination by light industry may have occurred, but documentation for those cases is not readily available. For example, some cases of contamination may have been addressed through privately funded and managed cleanups that involved little or no State or local government activity. As a result, sufficient information to summarize such incidents is not available. EPA anticipates that more cases of contamination may yet be discovered as the level of awareness concerning ground-water vulnerability in Wellhead Protection Areas increases with time. Hence, the number of reported and well-documented cases of contamination may also increase. Nonetheless, the information gathered to date does provide a limited indication of the nature and extent of the threat to ground water posed by light industry. The characteristics of light industrial waste and material management practices that are associated with ground-water contamination incidents are described in Chapter 2.

In addition, Chapter 6 of this document lists the references that were identified and used to characterize the light industry sectors and appropriate management controls and waste minimization techniques for raw material and waste management.

1.4 Analysis and Conclusions: The Threat to Ground Water from Light Industry

Over seventy light industries that are associated with documented contamination incidents were investigated for this document. These light industries include agricultural, light manufacturing and processing, mining, road maintenance, warehousing and wholesaling, transportation, personal and business service, research, and entertainment activities. The incidents of ground-water contamination reviewed by EPA encompass urban, suburban, and rural settings in over 30 States. Many of the contamination incidents were noted to have occurred either near public water supplies or in Wellhead Protection Areas. Furthermore, many of the incidents involved documented contamination of public and private water wells; however, it is not possible to estimate either the number of wells closed due to light industry contamination or the number of people exposed to contaminants.

In response to these findings, a discussion of management controls that have been used by some light industries is provided in Chapter 4 of this document. That discussion principally addresses the poor housekeeping practices found in many of the light industry case studies. In these examples, many light industries have not adequately managed raw and waste materials by failing to cleanup leaks and spills or by disposing of compounds improperly, such as discharging industrial wastes to septic systems or directly to the soil. Also, improper material storage in uncovered or unlined storage areas and handling of container and tank rinsate from pesticide and chemical storage units was implicated as a contamination source in a number of cases, as well as leaks and ruptures of underground storage tanks and material handling pipelines. Finally, the misuse or overuse of materials such as road salts and pesticides was identified as a contamination source.

Among the light industries reviewed in this report, a few stand out as having a high potential for contamination of ground water. These light industries include electroplating and polishing services, wood and lumber treating operations, furniture refinishing and repair services, auto repair shops, road deicing operations, scrap metal and auto junkyard dealers, and laundry and dry-cleaning establishments. The potential for ground-water contamination caused by these light industries is widespread, as these types of businesses are found in large numbers throughout the country. Their general characteristics are as follows:

- Electroplaters and Metal Fabricators: The industries in this sector manipulate the form or modify the surface of metals physically, chemically, and/or electrically. Typical processes include forging, stamping, etching, engraving, coating, polishing, grinding, painting, and electroplating. The by-products of these activities include not only metal scraps but a wide variety of chemicals and solutions that pose a threat to ground water. Of special interest are wastes such as spent solvents and still bottoms, paint residuals, acid and alkaline solutions, plating and stripping solutions, waste oils, heavy metal wastewater sludges, and metal dusts (U.S. EPA, 1986). These wastes may reach ground water through deliberate and accidental dumps, accidental spills, leaks, and floor wash (Environment Canada, 1984).

- Wood Preservers and Treaters: The wood preserving industry encompasses establishments primarily engaged in treating wood, sawed or planed in other establishments, to prevent decay and to protect against fire and insects (U.S. EPA, 1986). Typical wood preservatives include pentachlorophenol (PCP), creosote, chromated copper arsenic, and ammoniacal copper arsenate. These preservatives are applied to the wood by steaming, boultonizing, and kiln or air drying either under pressure or in a vacuum. All of these processes produce wastewater treatment sludges. Wastewater sludges from creosote and PCP processes are listed as RCRA hazardous wastes. Other wastes include leftover preservative material in delivery containers; process steam condensate containing water with creosote, PCP, wood fibers and other materials; sludge from process tanks; storm runoff from work areas containing spilled and leached preservatives; and process cooling waters that come in contact with the wood preservatives. "Kick-back" of preservatives from the wood frequently occurs resulting in preservatives being spread around the treatment area. In addition, preservatives may leach from treated wood stored in yard storage areas. While the amount of preservative that leaches from wood is typically quite low, all preservatives are somewhat soluble in water. Some preservers have installed drip tracks and pads in storage areas to collect leached preservatives, but this practice may not be followed at all facilities (U.S. EPA, 1986)

- Furniture and Wood Strippers and Refinishers: Furniture strippers commonly use methylene chloride to remove the finish from a piece. Methylene chloride is dissolved in a solution of methanol or isopropyl alcohol and water; smaller quantities of acetone, perchloroethylene, and toluene may also be present. The mixture is applied by brush, spray, or dipping; the finish is scraped or brushed off; and the piece is rinsed before refinishing. Some furniture strippers may use a five-step process that entails dipping in a methylene chloride stripping solution, followed by a caustic bath, rinse, neutralization with hydrochloric or phosphoric acid, and final rinse (Connecticut Dept. of Environmental Protection, 1984). Methylene chloride stripping solution is commonly recycled in the furniture industry; caustic solutions, however, become weaker with use and must be discarded. These wastes typically contain high concentrations of methylene chloride along with alcohols, metals, and other solvents. Many shops engaged in furniture stripping also conduct furniture refinishing operations. These shops may handle stains, containing mineral spirits, pigments and alcohol; varnish, shellac, or polyurethane, containing denatured alcohol, resins, petroleum distillates and toluene diisocyanate; or enamel, lacquer, and acrylic paints, which contain toluene, pigments, halogenated hydrocarbons, and glycol ether.

- Auto Repair Shops: Auto repair activities encompass such operations as glass replacement, transmission, exhaust system and engine repair, and tire retreading. Most businesses in this group are small scale operations employing less than ten persons. This is especially true for auto body/paint shops which are specialized and may employ one to three workers (Tennessee Department of Economic and Community Development, 1986). Larger scale operations usually are less specialized and may provide a full range of repair and maintenance services. The major threat to ground water posed by these industries arises from the disposal of such waste products as gasoline, diesel fuel, oil, and degreasing solvents. Auto body and paint shops produce spent paint/solvent waste which is classified as a RCRA ignitable hazardous waste.

- Road Deicing Operations: Highway departments, their contractors, and other private parties stockpile and spread substantial quantities of deicing materials on streets and other paved areas. Ground water may be affected by improper storage or by washoff of these materials from road surfaces. Excessive or improper application to street surfaces adds to the potential for contamination. Salts are commonly used as highway deicing agents, alone or in combination with abrasives such as sand, gravel, or ash. Sodium chloride is by far the most commonly used deicing agent. Calcium chloride is also used, often together with sodium chloride. Urea, an organic chemical, is generally used on airport runways rather than salts because it is less corrosive.

- Scrap and Junkyards: Scrap yards, salvage yards, junk yards and metals recyclers, which accept or buy scrap automobiles, "white goods" such as refrigerators and scrap metals, are found throughout the country. The vast bulk of the materials managed in these yards are stored in the open, often directly on the ground, where metal corrosion and oil releases can occur. These establishments most often gather ferrous and nonferrous metals for secondary smelting and recycling. "Battery breaking," or the disassembly of automobile storage batteries for recovery of the lead plates inside, may occur. Barrels or drums used to contain hazardous materials -- with or without some or all of their contents -- may also be handled and recycled by such facilities. Agricultural chemical and pesticide containers make up the bulk of recycled drums, especially in the Midwest. Many recyclers purchase the barrels and clean them up for resale as trash or storage containers. Processes used to store, handle, clean, and transport these containers can cause ground-water contamination. Substantial quantities of used oil, gasoline, and antifreeze also may be generated in these yards. PCB-laden oils may be released from large electric utility transformers and can be released from small capacitors and transformers included in household appliances. Combustible fuels may be recovered for sale or for on-site burning.

- Laundry and Dry Cleaning Establishments: Dry cleaning entails laundering garments in non-aqueous degreasers and solvents rather than water and detergents. Typically, the garments are agitated within large machines containing the solvents then spun, removed, and dried in a separate machine. The contaminated solvents are filtered, distilled, and returned for reuse. Distillation can be done in-house with the appropriate equipment. Newer dry-cleaning machines, referred to as dry-to-dry machines, are entirely self-contained and do not require the transfer of wet garments to a drier. The threat to ground water from dry cleaning operations stems from the solvents used for the cleaning process. The most common solvent used is tetrachloroethylene (also called perchloroethylene), although fluorocarbon-113 and petroleum solvents are used as well (U.S. EPA, 1987). All three of these solvents are volatile and toxic and capable of contaminating ground water. The most common routes of solvent release are through spills during handling and storage (solvent typically is transported and stored in 55 gallon drums) and leaks from cleaning equipment gaskets and other interconnections (Institute for Local Self-Reliance and Connecticut DEP, 1984). Spent filter sludges and cartridges, used for recycling the solvents, also can contain significant amounts of residual solvent. To a lesser extent, drying vents allow the condensation and dripping of solvents onto the ground, and water collected during solvent distillation (typically less than one gallon per month) can cause contamination if not collected and disposed of properly (Institute for Local Self-Reliance and Connecticut DEP, 1984).

Although many of the above-listed light industries have been identified as past sources of ground-water contamination, much of this potential threat to Wellhead Protection Areas is being mitigated through the adoption of improved raw and waste material management practices. Light industries are instituting these practices as a result of the enforcement of existing Federal, State, and local laws and through voluntary adoption of improved material management practices. With regard to existing Federal law, RCRA standards for hazardous waste management require that generators manage their wastes properly in tanks or containers and arrange for transport of the wastes to permitted on-site or off-site disposal facilities. Many of the past cases of improper waste management at dry cleaners, electroplating facilities, and wood preservers, for instance, are being prevented by RCRA standards for small and large quantity generators (see Chapter 3).

In addition to controls mandated by Federal law, certain State and local authorities are enforcing more stringent standards on the siting of light industries and the practices followed by the industries. The liabilities associated with improper waste management have also led many industries to adopt management practices that are protective of the environment. Furthermore, the increasing costs associated with waste management and disposal have encouraged industries to adopt waste minimization techniques to limit the generation of waste products. **As a result, many of the types of past contamination incidents reviewed by EPA will be prevented in the future.**

Nonetheless, while light industrial management practices are improving, many of the material handling processes followed by light industry still remain unregulated or minimally-regulated. As discussed below in Chapter 3, generators of less than 100 kg/month of hazardous waste are not stringently regulated under the current RCRA program. In addition, leaks or spills of raw materials or products are not controlled under RCRA and may not be fully addressed under CERCLA or other authorities. Furthermore, there are no data available to accurately assess the extent of voluntary adoption of management controls and waste minimization techniques by light industry. **Therefore, Wellhead Protection Program managers and other State and Local officials should be aware that existing controls may not be adequate to ensure that hazardous materials are managed in a manner that will prevent contamination of Wellhead Protection Areas.** Protecting these public water supplies may require local jurisdictions to either impose limitations on the siting of light industries in Wellhead Protection Areas or encourage the widespread adoption of management controls. Examples of such State and local programs are discussed in Chapter 3.

The following chapter provides a broad overview of the raw and waste materials managed by light industries that may pose a threat to Wellhead Protection Areas.

2.0 Overview of the Problem: Raw Material and Waste Management

This chapter describes the material management phases and potential contaminants handled by light industries. The chapter concludes with a discussion of the significance of light industrial material management for wellhead protection.

2.1 Phases of Material Management and Mismanagement and the Potential for Ground-Water Contamination

EPA has identified five general phases of material management by light industry that may pose a threat of ground-water contamination:

- Raw material and product delivery, transport, and transfer. Leaks and spill incidents may occur while managing raw and waste materials during transport between storage and use locations, through processing areas, and to disposal sites.

- Raw material and product storage. Contaminants can be released into ground water when storage tanks or containers fail. Rusted barrels can leak; holding tanks can fail due to faulty design, construction, or maintenance; fires, collisions, and other accidents may cause spills, and improper operation may result in unplanned releases.

- Material processing and manufacturing. Production processes are subject to malfunctions, spills, or leaks or may involve planned releases of materials.

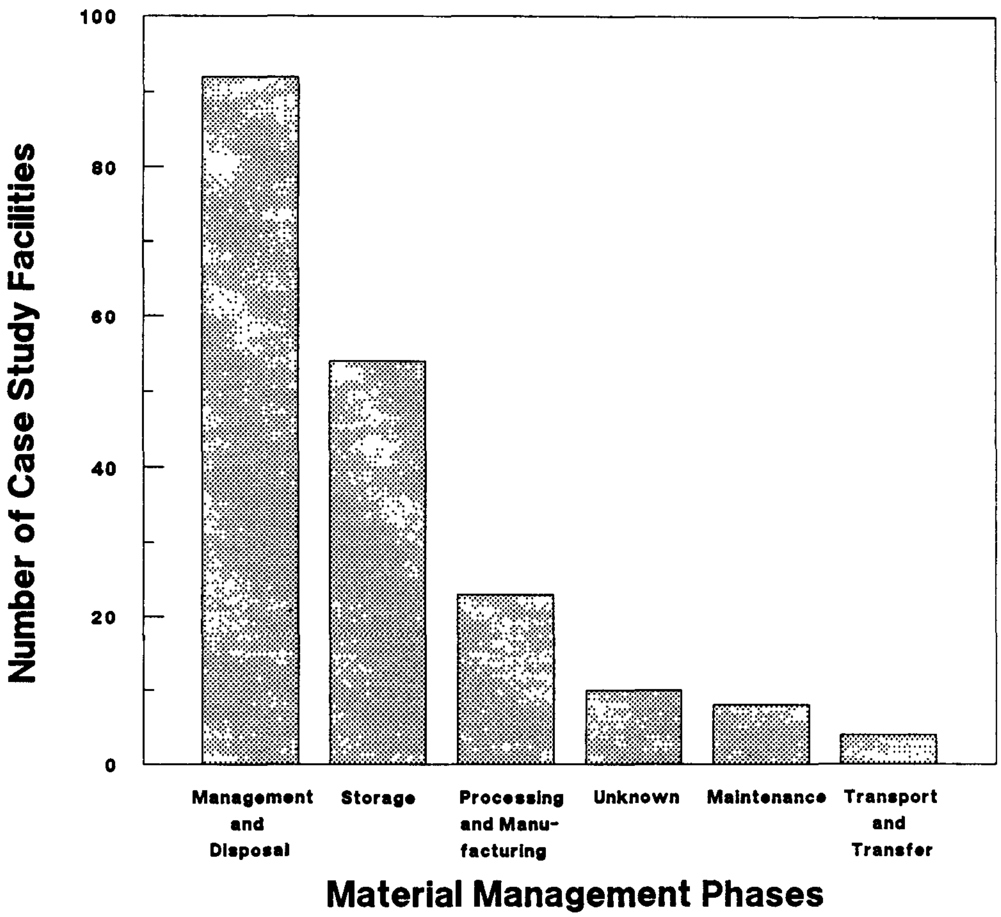
- Waste Management and Disposal. On-site waste treatment and disposal may cause ground-water contamination (e.g., in septic systems which are poorly designed or inappropriate to treat the waste products) or may involve material-handling processes subject to accidents. Disposal into sewers may lead to contamination if sewers leak.

- Process and site maintenance. Potential contaminants may be released during the maintenance of buildings, equipment, or vehicles.

Ground-water contamination can occur at any one of these phases of material management. Exhibit 2 illustrates the frequency with which the various phases were involved in the ground-water contamination incidents reviewed by EPA. The exhibit demonstrates that contamination incidents are most frequently associated with waste management and waste disposal activities.

EXHIBIT 2

Distribution of Material Management Phases in Ground-Water Contamination Case Studies 1/



1 Data for this exhibit were compiled from the summary of 182 case studies of ground-water contamination at light industrial facilities.

Waste management generally involves packaging or preparing wastes for off-site shipment and transferring wastes to storage areas through pipelines or other conduit. Releases can occur through leakage from waste containers or temporary storage tanks. In addition, a number of light industries have experienced releases from pipelines used to transport wastewaters to storage tanks or containers for further treatment or management. Because light industries generally do not dispose of their waste materials on-site, proper waste management prior to off-site shipment is critical for the protection of Wellhead Protection Areas. Such management practices include inspecting waste storage tanks and containers to ensure that they are not leaking and maintaining catchment basins and berms to contain releases. Furthermore, removing waste materials from a light industry site in a timely manner helps to ensure that the wastes will not be abandoned and left in place.

Improper waste disposal has also occurred at many light industry facilities. Any occurrence of improper waste or material management that results in a release to soil or ground water which is not cleaned up constitutes improper waste disposal. For example, light industries, such as auto repair shops or electroplaters, have experienced releases to soil that have not been addressed through soil excavation or other remediation. Such improper waste disposal often leads to ground-water contamination. Some light industries also improperly dispose of their hazardous wastewaters in septic systems or other on-site wastewater disposal systems which are not capable of adequately treating many hazardous wastes. As a result, contaminants discharged into a septic system may pass through the system's soil infiltration field and into ground water. **Properly segregating wastes and preventing hazardous wastes from entering septic systems is the best means of ensuring that such ground-water contamination will not occur.**

All of the phases of material management at individual light industrial facilities are also prevalent at light industrial parks, although the nature of the potentially contaminating activities may differ with the different park types. Furthermore, the layout and construction of the parks themselves may impact wellhead areas by affecting water runoff patterns and by introducing fertilizers and pesticides into the area as part of landscaping practices. In general, the number of potentially contaminating activities, as well as the quantities of contaminants, increases with the degree or level of industrial activity at an industrial park. The quantity of contaminants present also generally increases with the degree or level of industrial orientation, although the hazard posed by even a small volume of contaminants may still be severe. For example, a small amount of a very hazardous material introduced into a wellhead area from a mixed use park could be more harmful than large amounts of a less hazardous substance introduced from a heavy industry park. The industrial park activities with the potential to contaminate ground water are illustrated in Exhibit 3.

2.2 Materials Managed by Light Industrial Facilities

Light industries manage a wide range of materials that may potentially contaminate ground water. Virtually all materials managed at larger or heavy industry facilities are also found at light industry facilities, though in smaller quantities. In general, these contaminants include the following:

- Petroleum Products. Fuels (e.g., gasoline, diesel) and their additives (benzene, xylene), grease, oil, and PCBs.

EXHIBIT 3

INDUSTRIAL PARK ACTIVITIES WITH POTENTIAL TO CONTAMINATE GROUND WATER

	Science Parks	Technology Parks	Office/ Mixed Use	"AAA" Industrial	Industrial
Storage, On-Site					
Above-ground storage container or impoundment failure				•	•
Underground storage tank failure		•	•	•	•
Leaks, spills, fires	•	•	•	•	•
Disposal					
On-site septic tank, treatment inadequate, seepage lagoon			•	•	•
Sewer leak	•	•	•	•	•
Processing/Production					
Leaks, spills, overflows		•	•	•	•
Transporter/Transfer					
Spills (large quantity)		•	•	•	•
Leaks (small quantity from pipeline or vehicle)	some	•	•	•	•
Maintenance Activities					
Handling, use, disposal of cleaning materials	•	•	•	•	•
Handling, use, disposal of waste material (e.g., used oil)		•	•	•	•
Landscaping					
Maintenance and salt application	•	•	•	•	•
Impoundments and streams	•	•	•	•	•
Vegetation maintenance	•	•	•	•	•
Livestock (ducks and geese)	•	•	•	•	•

Source: Battelle, 1988

- Other Organics. Chemicals used as solvents, process chemicals in printing, photography, textiles, dry cleaning, electronics, furniture stripping, tanning, refrigerants, lubricants, dyes, adhesives, preservatives, disinfectants, and as feedstocks for chemical, pharmaceutical, and plastic production.

- Pesticides. Organic chemicals used for insecticides, fungicides, herbicides, and rodenticides.

- Metals and Other Inorganics. Acids, alkalis, metals, salt, cyanides, detergents, and nitrates.

- Microorganisms. Viruses and bacteria.

Exhibit 4 illustrates the frequency with which contaminants managed by light industry were reported in the case. As demonstrated in the exhibit, a wide variety of constituents have contaminated ground water at light industrial facilities. The most prevalent general groups of contaminants observed in the case studies include organics and metals/inorganics. Although these categories are very broad and encompass a large number of constituents, the case study information generally is not sufficiently detailed to support a more specific analysis.

For those case study reports that do contain constituent-specific information, typical organic contaminants include benzene, dichloroethylene, dioxins, methylene chloride, pentachlorophenol, perchlorethylene, toluene, trichloroethane, trichloroethylene, and xylene. Most of these organics appear to be used as solvents in production or cleaning processes. Typical metals/inorganics reported in the case studies include arsenic, chromium, copper, lead, nickel, nitrates, and sodium chloride.

The following section analyzes the implications of the case study findings with regard to wellhead protection.

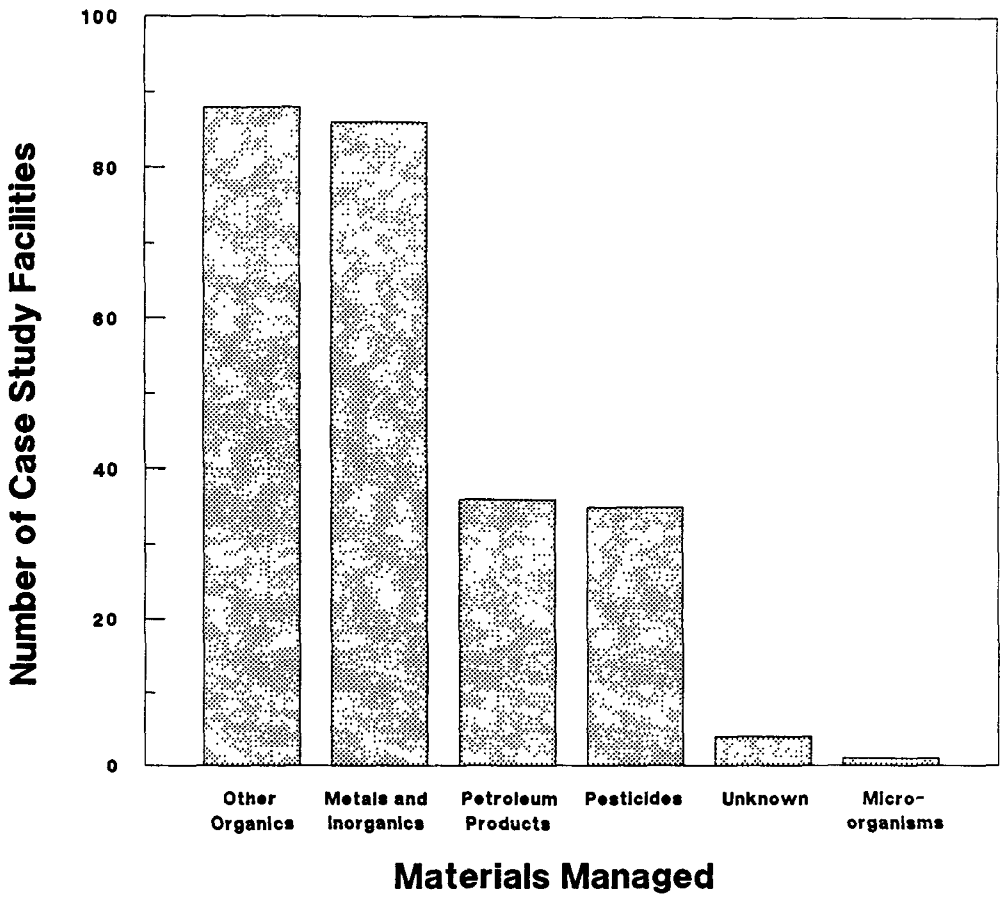
2.3 Analysis and Discussion

Information from the light industry ground-water contamination case studies summarized in Sections 2.1 and 2.2 encompasses a wide range of industry types, material management practices, and contaminants. Although the true extent of Wellhead Protection Area contamination caused by light industry is unknown at this time, the data gathered for this analysis reveal certain patterns concerning the threats light industry pose to ground-water quality.

The most prevalent material management phase associated with the ground-water contamination cases involved waste management and disposal. Improper storage of raw material and product storage was cited as the next most common contamination source. The predominance of waste management and disposal activities in the ground-water contamination cases is not unexpected. These cases involve activities such as improper disposal in septic systems and illegal dumping or abandonment of wastes. Although many of these practices are currently addressed by RCRA requirements (see Chapter 3), illegal or negligent disposal may still occur. Similarly, raw material and product storage has also come under increasing regulatory control, especially for those practices involving underground storage tanks (RCRA Subtitle I). Enforcing existing Federally-mandated standards and controls for waste management and product storage may serve as one means of limiting contamination resulting from these material management phases at light industry facilities.

EXHIBIT 4

Distribution of Materials Managed by Light Industrial Case Study Facilities [1]



[1] Data for this exhibit were compiled from the summary of 182 case studies of ground-water contamination at light industrial facilities.

The prevalence of the organic and inorganic constituents observed in the case studies is also expected. The organic contaminants are primarily solvents used as parts cleaners and as carriers for other substances. These organics are used in a variety of light industries, such as wood preserving and dry cleaning, and many of the organics are mobile in the soil and ground water environments. Similarly, the inorganic constituents observed in the case studies are also in widespread use by light industry, especially in electroplating and metal fabrication industries. Most all of the constituents observed in the case studies are regulated as hazardous wastes by RCRA or hazardous substances by CERCLA. The exceptions include nitrates, sodium chloride, and BOD, although these contaminants are also addressed under drinking water criteria.

In sum, the case study findings indicate that: (1) waste management and product storage processes pose the most prevalent release threats to ground water, and (2) a wide variety of potentially harmful constituents are managed at light industry facilities and are involved in release incidents.

3.0 Controls on Light Industry: Federal, State, and Local Roles

In this chapter, we outline the various Federal controls that may affect light industry practices. Selected State and local initiatives are also discussed. The chapter concludes with an analysis of the interrelationships among Federal, State, and local activities and the manner in which they can be used together to develop an efficient and effective means of evaluating and regulating ground-water threats from light industrial sources. EPA prepared this discussion to help Wellhead Protection Program managers and other officials understand and develop appropriate management controls for light industry within their jurisdictions.

3.1 Regulating Material Management by Light Industry under Current Federal Law

A variety of Federal laws and regulations control the management of hazardous materials and wastes. However, many of these Federal requirements impose only limited controls on light industry, while leaving certain potentially contaminating activities or substances unregulated. The following section describes several of these Federal laws and regulations. The discussion highlights the manner in which these requirements either do or do not apply to certain light industry practices. The major Federal Regulations controlling the management of hazardous materials are:

- RCRA (Resource Conservation and Recovery Act);
- CERCLA (Comprehensive Environmental Response, Compensation and Liability Act);
- SDWA (Safe Drinking Water Act);
- CWA (Clean Water Act);
- TSCA (Toxic Substances Control Act); and
- FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act).

The application of each of these regulations to light industry management practices is discussed below.

- <u>Resource Conservation and Recovery Act (RCRA)</u>. RCRA addresses the management of hazardous and solid wastes under Subtitles C and D of the statute, respectively. These portions of RCRA address only <u>waste</u> materials and not raw materials or products. For example, pesticides that are packaged for sale are not a hazardous waste. The material may become a hazardous waste, however, when the pesticides are discarded. In contrast, under Subtitle I of RCRA, standards are provided for underground storage tanks (USTs) that are used to manage chemical and petroleum <u>products</u>. Each of these RCRA program areas may impose controls on certain activities of light industry.

Subtitle C of RCRA recognizes three classes of hazardous waste generators (40 CFR 262.34): (1) generators of greater than 1,000 kg/month of hazardous waste (large quantity generators); (2) generators of between 100 and 1,000 kg/month of hazardous waste (small quantity generators - SQGs); and (3) generators of less than 100 kg/month of hazardous waste (conditionally exempt small quantity generators or very small quantity generators - VSQGs). Large quantity generators and most small quantity generators must meet specified requirements, including: obtaining an EPA ID number, properly managing the waste in tanks or containers (40 CFR 262.34), manifesting off-site shipments of the waste, and maintaining records and regular reporting. **Generators of less than 100 kg/month of hazardous waste, or**

conditionally exempt small quantity generators, however, are not required to meet the technical requirements for RCRA generators (40 CFR 261.5). Many of the types of light industries described in this document fall in this class of conditionally exempt small quantity hazardous waste generators.

Exhibit 5 illustrates the relative breakdown between the number of small quantity generators and very small quantity or conditionally exempt generators. Estimates of the breakdown between SQGs and VSQGs suggest that there are approximately 175,000 generators in the 100 to 1,000 kg/month category and 455,000 generators of less than 100 kg./month (U.S. EPA, 1985). Although EPA estimates that these two groups of generators represent approximately 98 percent of all hazardous waste generators in the United States, the total volume of waste managed by these groups amounts to less than 0.5 percent of the total quantity of waste generated annually. **Nonetheless, these small and conditionally exempt generators still manage approximately 630,000 metric tons of hazardous waste per year (U.S. EPA, 1985). The vast number of these generators and the relative lack of regulatory control on their operations raises the potential for ground-water contamination.**

Concerns that arise from the activities of these operations can be traced, at least in part, to several factors:

- Many operators of smaller facilities are not aware that they may be generating hazardous wastes, or that their disposal practices could result in contamination of ground water.

- Facilities that do not generate large volumes of waste may nonetheless handle large volumes of hazardous raw materials which should be of concern to local planners seeking to protect their water supply. Wood preservers, furniture strippers, and pesticide applicators are only three examples of industries that typically do not generate large volumes of waste, yet may have large volumes of chemicals stored on site.

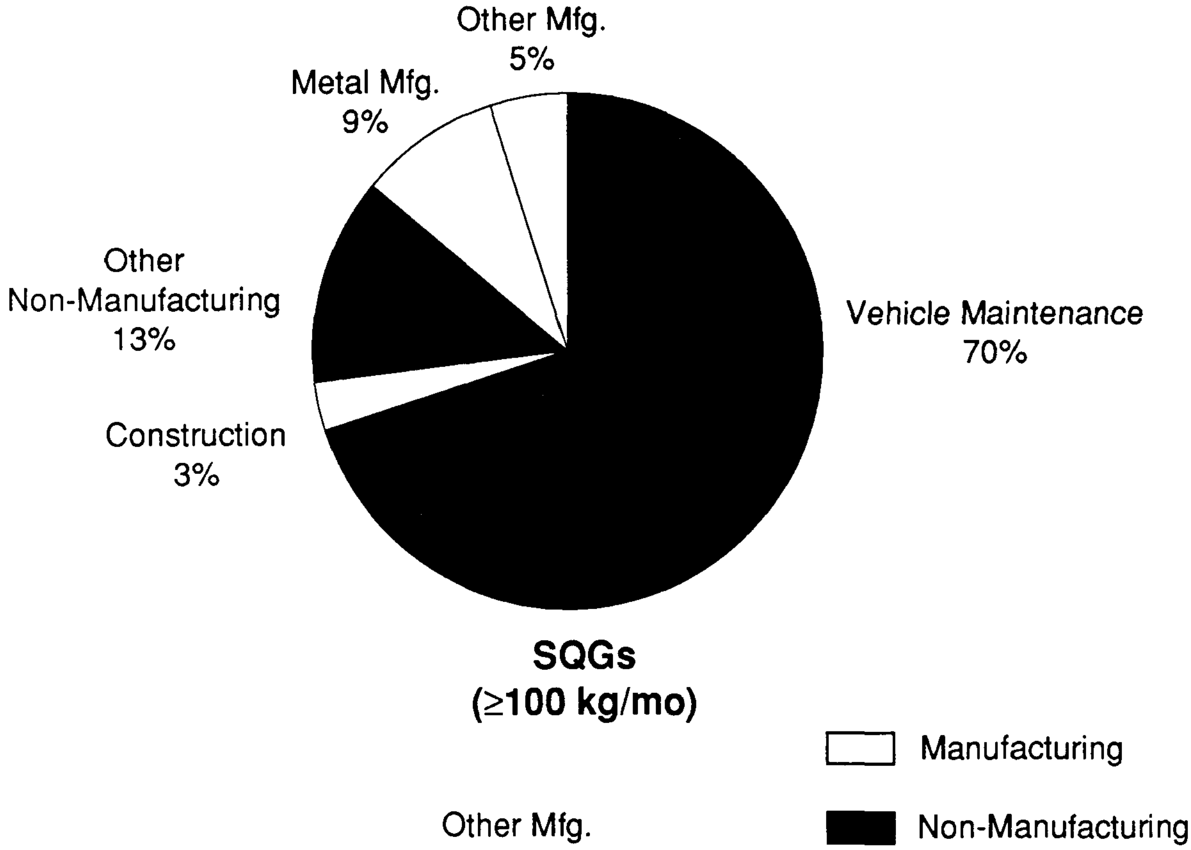
- Even small volumes of hazardous raw or waste materials can contaminate a water supply, particularly if the material is discharged in a Wellhead Protection Area.

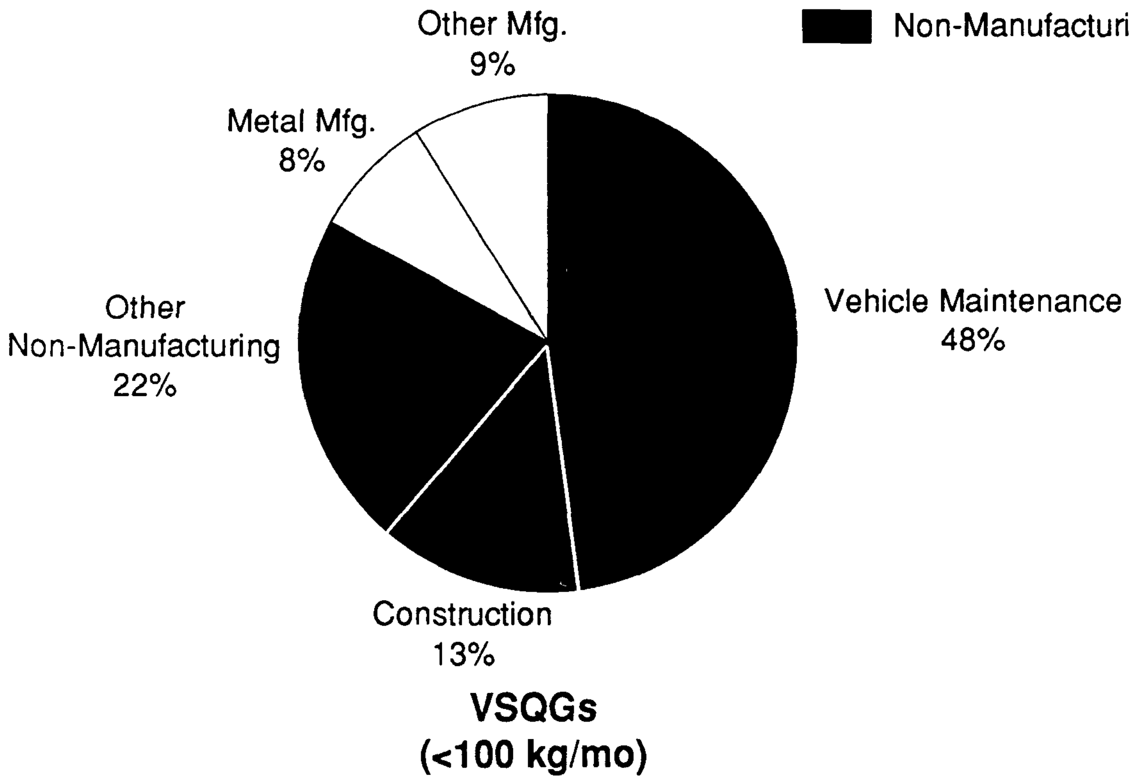
Certain types of wastes that typically might be managed by light industries have been specifically exempted from regulation under RCRA. These wastes include agricultural irrigation return flows, materials that are recycled in closed systems, and wastewaters that are disposed of in sewers or publicly-owned treatment works (POTWs) (40 CFR 261.4 (a)). Furthermore, recycled materials such as used batteries and used oil are not regarded as hazardous waste under RCRA. However, if these materials are disposed of, they must be managed as hazardous waste.

RCRA Subtitle D regulates other types of wastes defined as solid wastes, including household garbage, mining wastes, wastes from oil and gas production, and cement kiln dust waste (40 CFR 261.4(b)). It is important to note, however, that although these "solid wastes" must be managed in compliance with the criteria outlined under RCRA Subtitle D, these criteria apply only to the solid waste management facilities that ultimately dispose of the waste (40 CFR Part 257). In effect, the light industries that generate solid waste are not regulated under RCRA Subtitle D. Hence, light industries that are either generators of solid waste or conditionally exempt generators of hazardous waste are only minimally regulated by the RCRA hazardous waste controls.

Exhibit 5

Distribution of Small Quantity Generators by Industry Group:
SQGs and VSQGs





Source: Small Quantity Generator Survey data and analysis of secondary industries

The Subtitle I program of RCRA regulates approximately 1.5 million underground storage tanks that are used to store chemical and petroleum products. The program bans the installation of unprotected new tanks, requires tank owners to notify EPA of the number of tanks in use, establishes standards to clean up releases from the tanks, and imposes technical standards and inspection requirements for existing tanks (40 CFR Part 280). Subtitle I differs from Subtitle C and D in that it applies technical standards to processes that manage products, not wastes. The UST program addresses the petroleum storage tanks used by light industries, such as automobile service stations and dealerships, and the chemical storage tanks found at light industries, such as agricultural supply services and certain electroplating shops and electronic equipment manufacturers. However, the UST program applies only to tanks with at least ten percent of their volume buried underground. Furthermore, the following types of tanks are specifically exempted from the Subtitle I controls: farm and residential tanks with a holding capacity of less than 1,100 gallons; on-site tanks storing heating oil; septic tanks; pipelines regulated under other laws; surface impoundments; systems for collecting storm water and wastewater; flow-through process tanks; and liquid traps or associated gathering lines related to operations in the oil and natural gas industry (40 CFR Part 280). Thus, although Subtitle I presents a level of protection against leakage from certain types and volumes of hazardous materials containers, **non-regulated activities within a wellhead area can pose an equivalent threat to a water supply.** Furthermore, RCRA does not stipulate provisions that govern raw materials handling practices within an industry.

- <u>Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)</u>. The best known component of CERCLA is the remedial action program which addresses past releases of hazardous substances to the environment. Many cases of ground-water contamination by light industry are currently being addressed under Superfund. **In addition, Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) imposes certain emergency planning and notification requirements on facilities that handle hazardous materials.** The first of these requirements, found in sections 301-303, 311, and 312 of Title III, is known as the "emergency planning and community right-to-know" program. This program requires facilities to notify State officials of the presence of "extremely hazardous substances" at their location, and to supply local officials with a list of all materials stored on site in volumes that exceed threshold quantities established by EPA (40 CFR Part 355 and 40 CFR Part 370). These provisions were adopted to enable communities with participating facilities to establish emergency planning and notification procedures, based on the materials located within the community. Section 302 authorizes State officials to designate additional facilities (e.g., those which handle lesser amounts of regulated materials) as subject to the planning requirements.

Additional provisions within Title III relate to notification requirements for releases of hazardous materials. Section 304 of SARA requires immediate notification to local and State emergency planning committees if any of the listed hazardous substances are released from a facility (40 CFR Part 302.4 and 40 CFR Part 355), as well as follow up emergency notice. A second program, under SARA Section 313, requires that all releases of hazardous substances, both routine and accidental, as well as off-site shipments of waste containing listed toxic chemicals, must be reported to EPA (40 CFR Part 372). Although both of these programs require light industries to notify EPA of releases of hazardous substances, Title III contains no explicit cleanup requirements. **Title III, like RCRA, does not impose any conditions on materials handling practices; it only requires inventories and reports.**

- <u>Safe Drinking Water Act (SDWA)</u>. The SDWA mandates controls on certain waste management activities to prevent the contamination of drinking water supplies. In particular, EPA has promulgated regulations under the SDWA to control the disposal of wastes in underground injection wells (40 CFR Part 144). The SDWA regulates five general classes of underground injection wells. Class I wells are those that are used to dispose of hazardous or other industrial waste. Class II wells are used to dispose of materials such as brines and oil drilling wastes. Class III and IV wells are other types of disposal wells which are far less common. Class V wells include the remaining types of waste disposal wells, including shallow dry wells and certain types of septic systems. Many contamination events caused by light industry involve the improper disposal of wastes in these Class V wells. Although some controls are now being imposed on disposal in Class V wells, improper waste disposal by light industry in these wells still occurs. **Changes to the Federal regulatory requirements may impose tighter controls on disposal in Class V wells in the future.**

The 1986 amendments to the SDWA include provisions that require States to establish Wellhead Protection Areas around public water supply wells. These provisions require, among other things, the identification of all potential sources of contamination within the Wellhead Protection Areas and a description of control measures to protect the water supply. These activities and control measures include light industrial operations.

Clean Water Act (CWA). The CWA addresses the restoration and maintenance of the chemical, physical, and biological integrity of the Nation's waters through the reduction and elimination of toxic pollutant discharges; providing States with financial assistance for the construction of publicly owned waste treatment works; development and implementation of areawide waste treatment management plans for the control of pollutant sources in each State; development of technology necessary to eliminate pollutant discharge into oceans, coastal and navigable waters; and for assessment and management of nonpoint sources of pollution nationwide.

Provisions under CWA applicable to the control of light industrial sources of ground-water contamination include nonpoint source pollution control programs (Section 319), effluent permitting guidelines (Section 304), and stormwater permitting requirements currently under development under the National Pollutant Discharge Elimination System (NPDES; Section 402).

- Toxic Substances Control Act (TSCA). TSCA regulates the use of new and existing chemical substances and mixtures. Under Section 5 of TSCA, manufacturers of new chemical substances must notify EPA through the submittal of a pre-manufacture notice (PMN) at least 90 days prior to commencing manufacture or import of the substance for non-exempt commercial purposes. EPA will then review the new chemical substance and may impose restrictions on the manufacture, processing, distribution, use, or disposal of the substance. In some cases, companies may have conducted toxicity testing prior to beginning to manufacture the substance. As a result of this process, EPA may restrict the use of certain chemical products either handled or produced by light industries.

TSCA also regulates the use and disposal of polychlorinated biphenyls (PCBs). For example, EPA is instituting a nationwide program in which the PCB-containing fluids in electric transformers and capacitors are being replaced with other polyelectrolytes. TSCA further requires that waste PCBs from these and other applications must be disposed of in approved landfills or incinerators or EPA-approved alternative disposal technologies. Light industries that either use machinery containing PCBs or collect scrap materials containing PCBs must comply with these TSCA controls.

- Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). FIFRA addresses the registration and use of pesticides in the United States. The act has been used to indirectly protect ground water through the pesticide registration program. A manufacturer must generally submit a variety of health and safety data before EPA can register a pesticide (40 CFR Part 152). If EPA determines that use of a pesticide will result in unreasonable adverse effects on the environment, including ground-water contamination, EPA may deny registration. Among other options, EPA can impose packaging and labelling requirements and restrict the use of a pesticide. Cancellation of a registration is also possible if product use generally causes unreasonable adverse effects on the environment. Each pesticide must have a label that contains detailed directions for use. All users, including light industry, must comply with these requirements.

Applicability of Federal Controls to Light Industry

The preceding discussion illustrates that certain light industrial practices are regulated by Federal law, principally under Subtitles C and I of RCRA. These regulations, however, are limited to the listed waste disposal and storage practices and materials. **While the regulations do govern most major generators, much of the light industrial sector is exempt.**

Provisions of SARA Title III apply to any facility that uses hazardous materials in excess of the listed threshold quantities, but even this expansion of the regulated community does not encompass all light industrial facilities. Furthermore, the statute only requires an inventory of materials; management practices or guidance are neither provided nor mandated.

TSCA and FIFRA impose restrictions on the use of a limited number of materials that could pose a threat to a community's ground water, and the SDWA regulates some activities that affect ground-water quality.

Thus, **the Federal programs, although providing comprehensive regulation of major generators of waste and handling of select materials, provides little regulation of production processes and small-scale waste management practices.** These limitations can be traced in part to the sheer number of facilities that would be brought under the Federal umbrella, if it were to become all inclusive. Additional constraints on a Federal role arise from traditional reliance on State regulation of activities relating to the ground-water resource. Various States and local governments have taken additional steps to protect their ground water, which include measures relating to light industrial activities.

Many States and local governments have adopted control programs under the broad mandates of RCRA, CERCLA, or other Federal or State statutes. A comprehensive summary of State and local programs is beyond the scope of this document. Nonetheless, in the following section we briefly describe State and local approaches for controlling light industries. This chapter concludes with a description of the interrelationship among Federal, State, and local programs and how the various authorities can be combined to prevent the occurrence of ground-water contamination from light industrial activities.

3.2 State and Local Approaches for Controlling Light Industry

The Federal government delegates to the States a broad police power to legislate on behalf of the public health, safety, and welfare. This power can be used to protect ground-water resources from various forms of industrial contamination. While the authority is broad, it is tempered by limitations imposed by the principle of Federal preemption, language found in State constitutions, and rulings of Federal and State courts.

Programs adopted by States that can help to protect ground water from contamination due to light industrial activities include:

- Watershed Rules and Regulations - Local agencies in New York State, for instance, are authorized to adopt land-use plans to protect public water supplies.

- Ground-Water Management Areas - Washington State's Department of Ecology will designate areas that have identified concerns over ground-water quality; a management plan is tailored to suit the local needs.

- Ground-Water Standards - Many States have adopted standards to protect their ground water. Standards may be either numeric, specifying a maximum concentration for a particular contaminant (see, e.g., Alaska, New Hampshire, Texas), or narrative, specifying a general prohibition on types of discharges or identifying a general quality goal (see, e.g., Arizona, Michigan, North Carolina). Some States have adopted both types of standards to ensure comprehensive protection of the resource.

- Ground Water Classification - Several States (e.g., Connecticut, South Carolina, Vermont) have classified their ground water and specified differential protection measures according to the classification.

A number of States, such as Illinois and Wisconsin, have enacted legislation to authorize adoption of ground-water protection measures by local government. Illinois' legislation includes provisions that authorize the creation of setback zones around wells and an inventory of facilities and activities surrounding the wellhead (Illinois Municipal Code, Section 11-25-4). Wisconsin municipalities were given authority to adopt zoning ordinances "to encourage the protection of groundwater resources" by legislation passed in 1984 (Wisconsin Assembly Bill 595).

> The town of Rib Mountain in Marathon County, Wisconsin, adopted land-use regulations to protect its ground-water supplies. The ordinance uses overlay zoning to create two districts within the recharge basin for municipal wells. Lands overlying the sand and gravel aquifer have greater restrictions imposed on use than more upgradient areas in the watershed. Commercial and industrial uses are prohibited in Zone A, which is in close proximity to the wells. In Zone B, these uses are allowed as conditional uses, if they meet certain requirements to protect ground water.

Local governments have other sources of regulating authority in addition to ground-water specific State legislation; police powers have been delegated to local government in most States. This authority can be implemented to protect ground-water supplies by means of direct or indirect controls, such as land-use plans, zoning ordinances, site plan review, and design standards. **Health ordinances are an effective means for communities to regulate potential contaminants through their police powers.** This approach controls materials use regardless of the location of the facility, as opposed to regulating the location of the facilities.

> In 1979, the Cape Cod Planning and Economic Development Commission (CCPEDC) developed a model health ordinance for use by towns on the Cape to control the use, storage, and disposal of toxic and hazardous materials. The model ordinance has three major components:
>
> - Prohibition - Discharges of toxic or hazardous materials are prohibited.

- Registration - Owners or operators of facilities storing a quantity of materials which exceed a threshold amount (established in regulations by the town) must register the type and amount of materials with the Board of Health (BOH).

- Inspection/Enforcement - The BOH is authorized to conduct inspections of sites where toxic and hazardous materials are stored or used.

In practice, the BOH identifies all firms or individuals who may be subject to the ordinance, notifies them of the need for compliance, provides a list of materials considered to be toxic or hazardous and threshold amounts of the materials, and supplies a registration form which must be completed within a specified period of time. The BOH will inspect the facility if the forms are not completed on time. If inspection reveals that forms are in error or unsatisfactory practices are observed, the BOH may require corrective measures to improve storage, use, or disposal practices. Fines for violation of corrective orders are up to $200 per day.

The Town of Barnstable adopted the model ordinance as a Town Bylaw in 1979, the first community in the nation to adopt a local toxic and hazardous materials handling bylaw. Barnstable is a major business and population center located in the middle of the Cape, with the largest concentration of light industrial and commercial development. Ninety percent of these establishments are located within a four square mile area and all are within the zone of contribution for several of Barnstable's public water supply wells. Since several hundred facilities are affected by the town's bylaw, a strong implementation program has been undertaken.

Barnstable officials were particularly concerned that the only industrial zone in the town overlies the zone of contribution for eight public wells supplying Hyannis. A large part of the industrial area is occupied by a privately-owned industrial park which, as of 1986, was only five percent developed. The town does not wish to discourage development, but must act to protect the water supply, which cannot be moved. Additional facilities of concern are located outside the industrial park, but within the zones of contribution.

The Barnstable BOH received a technical assistance grant from CCPEDC to pay for a staff person working with the local health agent for a year to compile a comprehensive list of materials considered to be toxic or hazardous, and to develop the registration form. Since then the BOH procedures and forms have been refined, and the BOH reports that 100 percent compliance with the bylaw by covered facilities has been achieved with only two visits.

One of the most influential land-use control approaches utilized by local governments involves zoning. Local governments typically establish zoning and subdivision requirements that prescribe types of approved uses for land and buildings. Industrial zoning ordinances traditionally divide industrial areas into "light" and "heavy" districts. The controls on heavy industries are generally more restrictive, as these industries are considered most offensive. Some communities, however, have recognized the potential for contamination from light industry and have imposed fairly comprehensive controls on these activities when they are located in Wellhead Protection Areas.

> The Dade County, Florida, Wellfield Protection Program is an evolving set of activities that were initiated in the mid-1970's when volatile organic compounds were detected in a number of water supply wells. The sources of these compounds included leakage and runoff, spills and improper disposal, and effluent from heavy and light industrial activities, domestic and municipal waste treatment plants, leaking sewer systems, and agricultural and urban runoff. Development of the program was undertaken primarily within the Dade County Department of Environmental Management to ensure long-term protection of drinking water.
>
> Section 208 studies under the Clean Water Act allowed the county to delineate wellfield areas of influence and establish a basis for regulating hazardous material use, storage, and disposal. The Dade County Wellhead Protection Ordinance regulates the type and density of wastewater discharged within each of five zones in the area of influence, based on soil conditions. The ordinance prohibits the use of hazardous materials within the area of influence.
>
> The Dade County program provides the following restrictions on light industry within the wellfield protection zones:
>
> 1. No new hazardous materials activities;
> 2. No new nonresidential activities except on sewers;
> 3. Only "low risk" nonresidential activities permitted;
> 4. Annual permitting and inspection of all nonresidential uses;
> 5. Density restrictions as a function of travel time to wells;
> 6. No expansion of existing uses unless a net decrease in environmental risk is demonstrated;
> 7. Progressively more stringent stormwater disposal requirements as wells are approached;
> 8. Best available technology is required for sewer construction;
> 9. Expedited sewering of unsewered areas;
> 10. Canal construction or improvement to create hydraulic boundaries between wells and pollution sources;
> 11. Expedited cleanup of known pollution sources;
> 12. Creation of approved hazardous waste transfer stations outside of the protection zones;
> 13. Limitations on transportation of hazardous materials through the protection zone;

14. Installation of air-stripping equipment at water treatment plants to reduce volatile organic compounds which may already be in the ground water; and
15. Variances require a 4/5 affirmative vote from the appeals board.

The preceding examples illustrate some of the regulatory tools that can be used by local officials to protect their water supply from identified threats. **Equally important to an effective program is an understanding of the ground-water system and the potential for contamination. This understanding and evaluation is critical to ensuring that a regulatory program addresses potential problems without being overly restrictive.**

Citizens of Spokane, Washington formed a planning group in 1977 to develop a strategy for protecting their underground source of drinking water. The committee spent their first year developing a data base of ground-water quality, and reaching a common level of understanding of ground-water hydrology and water pollution problems before beginning to develop a plan. Their study showed that water quality was deteriorating due to human activities, including industrial development and chemical spills resulting from storage, transportation, and use of chemicals. Specific incidents that could be traced to industrial sources include the contamination of private wells by organic cleaning solvents leaching from a county landfill, and contamination of additional wells by cyanide originating from pot linings disposed of at an aluminum reduction plant. The citizen's group released a Water Quality Management Plan in 1979, which included recommendations for controlling chemical spills and leaks through a combination of land use and zoning regulations, development and enforcement of best management practices, and public education.

Ordinances adopted by Spokane County in 1983 established an Aquifer Sensitive Overlay Zone and established procedures for proper handling and disposal of hazardous and critical materials in the home and the workplace. The zoning ordinance encourages business and industry using "critical materials" to locate outside of the sensitive area by setting performance criteria for facility design which require the retention of spills or leaks and the prevention of subsurface infiltration by defined materials, as well as prohibiting chemical waste disposal in the sensitive area. The critical materials ordinance and critical materials handbook include requirements for management controls for handling and storage of materials; spill prevention, control, and clean up plans; and identifying critical materials and critical materials use activities. Building permits for new construction are reviewed to determine chemical use and to check for appropriate design where chemicals are used or stored. Secondary containment is required for underground storage tanks and associated piping, and spill response and shipping requirements have been established for transportation of critical materials. By adopting the term "critical materials" the committee sought to avoid confusion or the limitations associated with Federal and State hazardous waste regulations.

Projects proposed in the sensitive zone are compared with a Critical Materials Activity List developed from an Industrial Survey performed by the Washington Department of Ecology (DOE) and an Industrial Waste Survey performed for DOE. A review of spills in the Spokane area revealed that spills generally result from the transfer of liquids between containers or from material transfer lines. The ordinance, therefore, contains guidelines that include provisions for materials handling:

- Employee training;
- Materials properties to be considered when choosing a material for a specific containment or storage use; and
- Criteria for determining the required containment volume for secondary systems (e.g., include potential precipitation and means for separating precipitation from chemicals).

The ordinance also requires facilities that elect to locate in the sensitive areas to prepare a spill plan. The plan is to include facility-specific information:

- Description of physical facilities and the nature of operations utilizing critical materials;
- Notification procedures in the event of a spill;
- Identification of potential sources of spills;
- Spill control procedures; and
- Training programs for personnel.

The materials manual also contains design concepts to stimulate ideas for materials containment (e.g., covered loading areas, double walled pipes, perimeter drains, and floor drains).

Local citizens have voted to create aquifer protection districts, which assess a monthly user charge of $1.25 per month to all customers located over the aquifer and an additional $1.25 per month to all those who discharge wastes through a drainfield system. These funds, supplemented by a $0.0025 sales tax, defray the costs of new sewerage projects and fund additional aquifer protection programs. All commercial and industrial customers within a district are required to connect to a sewer within one year of its completion, while new facilities are required to connect immediately. Commercial and industrial facilities outside of service areas must connect to county sewers unless the utilities district determines that connection is not economically feasible.

Placing direct limitations on development is only one of the options available to local officials. Regulators can condition approval of a proposed development on the adoption of management plans by the developer or property manager. Developers of private industrial parks, for example, can be required to (or can voluntarily impose) covenants, conditions, and restrictions (CC&Rs) on park tenants that serve to supplement zoning restrictions. The CC&Rs often act in conjunction with zoning controls to impose limits on industrial "nuisances." For example, the lessee may be required to submit a detailed site plan containing a report which addresses environmental issues related to the operation, such as the volume of hazardous wastes produced or the anticipated load on sewage treatment facilities. CC&Rs may also prohibit discharges of hazardous materials from a site or restrict the use of underground storage tanks. Wellhead Protection Program managers can use these public and private controls to assist in ground-water protection.

Additional information regarding the potential tools for protecting ground water can be found in the publication Wellhead Protection Programs: Tools for Local Governments, USEPA/OGWP.

3.3 Analysis and Discussion

The preceding sections indicate that **there is no single source of authority for evaluating or regulating light industrial practices.** There are, however, a variety of statutes at both the Federal and State levels which can provide the means for evaluating and minimizing threats to Wellhead Protection Areas. Local governments have additional options available to them through their police powers and traditional land-use planning and regulation techniques.

Two of the initial steps to take in developing a management program for light industry involve the evaluation and definition of 1) the resource to be protected, and 2) the potential sources of concern. Resource evaluation is beyond the scope of this document. The reader is referred to EPA's Guidelines for Delineation of Wellhead Areas (EPA 440/6-87-010) as a starting point for this effort. Several of the regulatory authorities cited in this section, however, can be used to ascertain the nature of light industrial operations; an integral part of evaluating sources.

The permit and notification requirements of RCRA and SARA Title III, respectively, provide two avenues for identification of light industrial activities in Wellhead Protection Areas. The files of the State division of hazardous waste contain the name, location, and materials handled for all RCRA generators in a given State. This source of information can provide a first level of scrutiny by identifying most of the major and many of the minor handlers of hazardous materials in the vicinity of a wellfield. The Small Quantity Generator provisions of RCRA encompass many light industrial facilities. In addition, some States have used their RCRA authority to regulate Very Small Quantity Generators, those facilities that generate less than 100 kg/month of hazardous waste. Massachusetts' VSQG program, for instance, requires such facilities to register with the Department of Environmental Quality Engineering (DEQE). Although these facilities are not required to obtain a RCRA ID number or manifest, they must comply with certain reporting requirements:

- Types and quantities of hazardous waste produced;
- Recycling, treatment, or disposal plans; and
- Name and location of facility or generator receiving VSQG waste.

The VSQG requirements effectively expand the available data base to include all generators of hazardous waste. Although this option provides additional information for regulators and planners, the program also creates an additional administrative burden - the ratio of VSQGs to SQGs is approximately 2.6 to 1.

- **Public Participation**

Massachusetts has incorporated another feature into its SQG program which could be of value to any State or community seeking to reduce light industrial contamination of ground water. The hazardous waste division of DEQE has established a public participation group that works with industries and local governments looking at behavior patterns and providing compliance assistance. Fact sheets, videos, information programs, and other educational materials are all part of the compliance assistance program. As noted in the Cape Cod experience cited above, industries are often willing and able to eliminate problem areas once they have the information in hand to recognize and correct potential problems. The State personnel are able to address a wide audience by providing training and information to local government officials, who can use these methods in their own community. These techniques can be used effectively at both the State and local level with only a limited expenditure of resources.

- **Inventorying**

The notification requirements of SARA Title III dictate that all facilities handling quantities of hazardous materials in excess of EPA threshold amounts must provide a list of these materials to community planners. The significance of these requirements is that they apply to quantities of materials that are involved in the manufacturing or other processes at the facility, not just the waste materials. These requirements allow community and State officials to obtain an expanded picture of the light industrial scene, since many facilities may handle sufficient quantities of hazardous material to qualify for Title III notification, yet not generate the amounts of hazardous waste necessary to require filing as a RCRA large quantity generator. Wood preservers or furniture strippers, for example, may handle or store large volumes of materials but generate only small amounts of waste. Materials handling is as significant as waste handling in the vicinity of the wellhead, because poor practices in either aspect of facility operations can result in contamination of the water supply. Although the Title III regulations do not include the authority to regulate materials handling, local officials, armed with the knowledge of storage and use of hazardous materials in the wellhead area, may decide to impose materials handling requirements through local controls.

- **Source Identification**

The SDWA Amendments of 1986 require States to develop management plans for wellhead protection, including identification and control of potential sources of contamination. Some States have already established programs to accomplish these same goals. States wishing to adopt a Wellhead Protection Program can utilize the information available through RCRA and Title III, as described above, to identify sources of contamination. State initiatives can also provide explicitly for adoption of local ground-water protection measures. Any of these measures at the State level can incorporate provisions that include controls on light industry.

Once a community has identified the Wellhead Protection Area and the location of light industrial facilities that overlie the Wellhead Protection Area, planners will need to determine the threat that these facilities pose to the water supply. **Each community will need to review and evaluate the existing framework of State and Federal controls and determine whether additional protection is needed for their water supply.** As noted above, few of the current regulatory programs provide controls on materials handling, production processes, and management of small quantity waste streams. Localities may determine that local initiatives are needed to provide adequate safeguards against contamination. This decision will be based in part on the nature and extent of the Wellhead Protection Area and, in part, on the governing local politics.

Communities can use the wide range of planning authorities and police powers available to fashion a Wellhead Protection Program specific to their own needs. The examples provided in Section 3.2 illustrate some of the options that local governments have adopted to protect Wellhead Protection Areas from light industrial contamination. Each community should refer to these and other examples, but fashion their own program to meet their own situation. The appropriate decision for some communities may be to restrict all industrial activities in the wellhead area through zoning. Other communities may determine that a limited ban, coupled with controls on activities is appropriate. These controls can be in the form of design standards for facilities to reduce the chance of contamination in the event of a release, bans on the use of certain materials, or restrictions on use in the form of materials handling or best management practices. The following chapter presents descriptions of some light industrial practices that pose potential threats to Wellhead Protection Areas and the management controls that have been used by some industries to address the potential for contamination.

4.0 Minimizing Ground-Water Contamination by Light Industry

Several control techniques have been used by light industry to prevent ground-water contamination. These techniques range from low-cost management controls to more sophisticated technology-based waste minimization techniques. This section presents an overview, illustrated with case studies, of management controls and waste minimization practices for protecting Wellhead Protection Areas. The section concludes with an analysis and discussion of the role of industry groups and local governments in promoting the use of management controls.

4.1 Management Controls for Preventing Ground-Water Contamination

This section discusses seven management controls that have been recommended by various State and local governments and that have been adopted by many light industries. These management controls are directly applicable to wellhead protection. The following seven management controls illustrate the broad range of activities that many light industries have adopted to reduce the threat of ground-water contamination in Wellhead Protection Areas.

(1) Controlling spillage in loading and unloading of raw materials and wastes (Connecticut Department of Environmental Protection, 1984). Spillage may occur at material transfer points (e.g., loading and unloading areas) at a variety of light industries, such as gas stations, small fuel storage facilities, farm co-ops, or chemical storage facilities. Through poor operating practices, gasoline, oil, pesticides, fertilizers, and chemical solvents are frequently spilled on the ground. Improper use of hoses during material transfers also results in spillage. When these spillage problems can not be avoided, contamination can best be prevented through the installation of catchment basins beneath material handling areas. These basins may drain to holding tanks. Spilled material can then be removed to a treatment facility for final disposal or, if the waste is compatible with the local POTW operations, the waste may be treated and discharged to municipal sewer lines. These catchment basins should be coated with impermeable materials to prevent the leakage of materials through the basin to ground water.

Example: An agricultural supply company in Hospens, Iowa has caused contamination of nine wells, including two municipal wells. Approximately 31,000 square feet of soil was found to be contaminated at the materials loading operations area. Contaminants included pesticides and carbon tetrachloride. The handling practices employed at the loading area were the primary cause of the ground-water contamination. The threat can be addressed by installing basins that drain to holding tanks with proper secondary containment.

(2) Managing contaminated runoff from the rinsing and cleaning of tanks and containers. Many pesticide applicators, asphalt mixing trucks, crop dusters, and lawn services clean off their holding tanks and/or spraying equipment on open ground. Such cleaning should only be conducted over catchment basins and contaminated runoff from the cleaning process should be collected for on-site recycling and reuse or off-site management (Cape Cod Aquifer Management Project, July 1988)

Example: A crop dusting company in Marianna, Florida routinely purged and then flushed the airplane's pesticide tanks onto the ground after each dusting run. This practice resulted in soil contamination and subsequent contamination of public water supply wells. The contaminant plume is 2,000 feet in length and contains many different types of pesticides. Clearly linked to the purging and *runoff from rinsing the pesticide tanks, this ground-water contamination could have been avoided with minimal runoff control.*

(3) Preventing improper disposal in septic systems or dry wells. Light industrial generators of solvents and other hazardous wastes, such as auto repair shops, electroplaters, furniture strippers, car washes, dry cleaners, and light manufacturing plants, have been known to dispose of their wastes in septic systems or dry wells. The types of wastes that are disposed in septic systems and dry wells should be strictly controlled (U.S. EPA, 1986).

Septic systems generally consist of two units: a septic tank and a leaching system. Bacteria in the septic tank anaerobically decompose solid material discharged into the tank. Effluent from the septic tank then flows into the soil leaching system. As the wastewaters flow through the soil leachfield, some pollutants are filtered, sorbed onto the soil, or undergo aerobic degradation. Although septic systems can effectively treat and dispose most domestic wastewaters, these systems cannot treat all wastes. Nitrates and volatile organic solvents are generally not removed in the septic tank nor are they bound in the soil. Furthermore, the ability of the soil to immobilize heavy metals, pathogens, and phosphates can be exhausted over time. **As a result, if these contaminants are introduced into the septic system, they can migrate relatively easily through the soils and into the ground water.** Hence, disposal of industrial wastewaters containing metals and organic solvents should be prevented. These types of wastewaters can be disposed either through hook-up to a sewer system or through the use of "milk-run" pick-ups to gather and transport hazardous materials for disposal.

Dry and shallow wells have also been cited as an important source of ground-water contamination. Contamination has occurred through improper disposal of wastewaters in these wells and through the movement of surface contaminants into the wells during storm events. These wells include municipal, industrial, irrigation, and livestock wells and unplugged test holes. Many older wells are improperly constructed with an absence of casing. Therefore, contaminants that enter the wells can move into all water-bearing strata. Furthermore, these abandoned wells are frequently left uncapped, increasing the likelihood for contamination. Disposal in these wells is controlled by the underground injection control program under the Safe Drinking Water Act. Discharging to shallow wells should be prevented and the waste management shifted to recycling or off-site disposal. In addition, **all abandoned wells should be capped to prevent the entry of any contaminants.**

Example: A Dutchess County, New York dry cleaner routinely disposed solvent wastes into the company's septic system. This improper waste management caused a 1,500 foot long plume of various hazardous solvents and metals that contaminated wells for an apartment complex. The remedial action cost $2 million. Proper handling and disposal of the wastes could have completely prevented the ground-water threat.

(4) Minimizing the intensive use or overuse of materials, such as road salts and agricultural chemicals. Many incidents of ground-water contamination have been linked to the storage and use of road salts. Furthermore, agricultural chemicals are frequently used to control vegetation growing in utility or road right-of-ways. Preventing or limiting the use of these materials in areas of high ground-water vulnerability or switching to other methods of road and right-of-way maintenance will help minimize ground-water contamination. For example, abrasives or other road deicers such as potassium chloride have been substituted for sodium chloride, which is a common ground-water contaminant. Similarly, in some areas Wellhead Protection Program managers are returning to mechanical methods of vegetation

control, such as mowing, to maintain right-of-ways. (Massachusetts Dept. of Environmental Quality Engineering, May 1982)

Example: In Wisconsin, a seed culturing facility intensively applied pesticides with heavy watering. The heavy use of pesticides, such as atrazine, is causing a threat to ground water. The extent of contamination is not yet determined, but correctly managing the use of the pesticide and controlling water applications would reduce the threat to ground water.

(5) Preventing leakage from underground storage tanks and pipelines. Underground storage tanks are a well known source of contamination. Trucking companies, highway departments, and auto service stations use underground tanks to store petroleum products. Other industries, such as agricultural supply services, may use tanks to store chemical pesticide and fertilizer products. In addition, product delivery or internal material management pipelines may leak and contaminate ground water. Many of these underground storage tanks and pipelines are regulated under Subtitle I of RCRA, but smaller tanks and certain types of pipelines may not be addressed under current controls. Leaks from underground storage tanks and pipelines result from defects in materials, improper installation, corrosion, or mechanical failure of the pipes and fittings. Many underground storage tanks installed prior to the RCRA Subtitle I controls were simply made of bare carbon steel. The corrosion of these bare steel tanks is by far the most serious cause of leaks. In addition, leaks from pipe fittings or tanks damaged during installation are a serious threat. The following practices can ensure that such leaks are identified and addressed:

- Closely monitor the inventory in the tanks to determine whether product is lost through leaks;
- Conduct regular pressure leak testing of tanks and pipe fittings;
- Require annual testing of unprotected steel tanks and piping systems, especially for those aged 15 years or more;
- Install leak-detection systems to monitor continuously for releases;
- Install cathodic corrosion protection systems, especially in highly corrosive environments;
- For new tanks, conduct a tightness test and inspection for the complete tank and piping system before the tank is filled; and
- Install systems to prevent overfilling of the tanks, such as feed cut-off systems and by-pass systems to standby tanks. (Massachusetts Dept. of Environmental Quality Engineering and FR 37082, 1988)

Example: A leaking underground storage tank at a gasoline station in Walpole, Massachusetts released approximately 3,000 gallons of gasoline. The release contaminated 23 wells with constituents such as benzene and toluene. Better controls on the underground tank system could have greatly decreased the ground-water contamination.

(6) Controlling improper storage of raw materials or product stockpiles. Materials stored on the ground and in uncovered areas may leak or leach hazardous materials. Such problems can be prevented by storing materials in covered areas and on pads with drains or over catchment basins. These control measures are especially effective for materials, such as treated lumber, that may leach hazardous materials if they are exposed to rain or the elements. (Long Island Regional Planning Board, 1983)

Example: Eight well contamination incidents in Rhode Island have been recorded due to the improper storage of salt used to deice highways. At these locations, the salt piles were neither covered nor stored on a containment pad. High levels of chloride and sodium have contaminated the ground water after leaching from the storage sites. Lack of protection of the salt from the weather has caused significant loss of salt to and contamination of the ground water.

(7) Following general good housekeeping practices to catch spills and leaks. General operating procedures should include placing drip pans or catchment basins under machinery or material storage areas. Released materials captured in this way should be managed through reuse and recycling or proper containment followed by off-site disposal. (U.S. EPA, 1988)

Example: A printed circuit board manufacturer in St. Louis Park, Minnesota contaminated ground water with trichloroethylene (TCE) and heavy metals. The source of contamination was an unnoticed and uncaptured leak in the wastewater management system. Ground-water contamination resulted from the absence of a secondary containment in the wastewater management system.

4.2 Long-Term Solutions: Pollution Prevention - Source Reduction, Recycling, and Treatment

Combining management controls with technology-based techniques for minimizing the generation of waste will enhance the prospects for long-term protection of Wellhead Protection Areas. EPA encourages pollution prevention, i.e., the reduction or elimination, to the extent feasible, of any waste that is generated and subsequently treated, stored, or disposed (U.S. EPA/OSWER, October 1987). This section presents the three pollution prevention categories recognized by EPA. For each category, a "composite" case study is presented to illustrate the potential threat to Wellhead Protection Areas posed by waste generation. Each "composite" case study combines a description of a ground-water contamination case and a description of an applicable pollution prevention technique. These composite cases illustrate the manner in which the three general pollution prevention techniques may support wellhead protection activities.

(1) Source reduction. Source reduction often involves changes to input materials, technology changes, and procedural or organizational changes. Source reduction techniques include the following:

- Training and supervision, which provides information and incentives to employees to effectively minimize waste generation;

- Production planning and sequencing, which requires planning to ensure that only necessary operations are performed and optimized to reduce waste generation;

- Process/equipment adjustment or modification, which involves changing process parameters, equipment, or the process itself to reduce the amount of waste generated;

- Raw material substitution, which replaces existing raw materials with raw materials that will result in the generation of less waste;

- Loss prevention and housekeeping, which involves maintaining and managing equipment and materials in such a way so as to minimize the opportunity for spills, leaks, and other undesired releases of hazardous materials; and

- Waste segregation and separation, which involves avoiding the mixing of different types of hazardous and/or non-hazardous wastes so as to best utilize any individual waste stream that is recoverable or usable in its existing composition.

Example: *A Dade County, Florida facility repairs diesel truck fuel injectors. Before repair, fuel injectors are completely cleaned by removing any fuel, oil, grease, dirt, or other contaminants that may inhibit the mechanic's ability to repair the parts. The facility employed strong organic solvents such as methylene chloride and cresylic acid to remove the dirt and fuel, followed by an aqueous rinse step to remove any remaining solvent and dirt. The company produced waste solvents from the initial solvent cleaning step and solvent-laden rinsewaters from the aqueous rinsing process. The waste solvent/dirt mixture was sent off-site for disposal. The contaminated rinsewaters were routed to the facility's septic system which was ineffective in digesting the organic chemicals. These chemicals were then discharged into the septic system soil absorption field thereby contaminating soil and the shallow water table with methylene chloride and cresylic acid. The contamination of water in the wellhead area will create a significant risk to those who consume the ground water if the releases continue or if a cleanup of the contaminated soil and ground water is not performed. The cost of contamination removal will be extensive.*

The company could employ an in-line heated aqueous cleaning system to clean the injectors before repair, replacing the solvent cleaning process involving the organic chemicals. The in-line system cleans the parts with an aqueous cleaner, then follows with a water rinse. This cleaning system reuses the aqueous cleaning solution. The system also uses rinsewaters to replenish the evaporative losses from the cleaning tank, instead of wasting them by discharge to the septic system. The cleaning system requires a hot gas drying step after the cleaning process. When replacing the spent cleaning solution, the vendor maintains the cleaning system by removing the accumulated sludge. The sludge then is disposed by the vendor as a hazardous waste. This practice eliminates any discharge to the septic system from the initial cleaning operation. This waste minimization practice prevents further contamination of the ground water underlying the facility's septic discharge area. In addition, the sludge is less dangerous and a smaller quantity than the waste solvents that were drummed and sent off-site for disposal in the previous practice. If the facility had used the aqueous cleaning system throughout its life, the initial *contamination of ground water could have been avoided. Because solvent discharge to the septic system is stopped, ground-water contamination is eliminated and health risks to the community are reduced. Additional cost savings result from eliminated solvent purchase and disposal despite the cost of the new cleaning system and the drying step. The payback period for the change is estimated at five years. (Office of Safe Waste Management, Massachusetts, October 23, 1986)*

(2) Recycling. Recycling involves the use, reuse, or reclamation of a hazardous waste as an effective substitute for a commercial product or as an ingredient or feedstock. This use, reuse, or reclamation can occur on-site, or it can be done by off-site recycling services or waste exchanges. Examples of recycling include using a small on-site still to recover degreasing solvents or selling waste pickling acids as feedstocks for fertilizer manufacturing.

Example: A facility in Corvallis, Oregon deposits chrome onto the surface of parts with electroplating. The electroplating process employs a series of tanks into which the parts are submerged to deposit the chromium onto the part surfaces (process tanks), and to rinse the excess chromium from the surfaces (rinse tanks). The facility generated an estimated 1,000 gallons per year of waste rinsewater from the plating process, with chromium as the hazardous constituent. There was no attempt to prevent the loss of chromium to the rinsewaters. The chromium rinsewaters were disposed into a dry well on-site resulting in the chromium contamination of approximately 350 tons of soil and 2.4 million gallons of ground water. Approximately $2.5 million will be required to clean up the contaminated soil and ground water.

The company could employ a closed-loop evaporation system to recover the chromium from the rinsewater (USEPA, March 1989). The system increases the chromium concentration in the rinsewater effluent by driving off the water. The concentrated rinsewater solution then is returned to the original plating bath, thus conserving chromium, and no longer generating the chromium-bearing rinsewaters. This waste minimization practice prevents further contamination of the ground water underlying the facility. If the facility had used this waste minimization practice throughout its life, the initial contamination of ground water could have been avoided. Additional cost savings result from chromium conservation (chromium usage is reduced by more than 97 percent). The chromium raw material cost savings alone ensure a payback period of less than one year for the waste minimization project.

(3) Treatment. Treatment, the least preferred pollution prevention technique, involves processing the hazardous waste after it is produced to reduce its toxicity or volume. Waste toxicity can be reduced by destroying certain chemicals the waste contains, such as volatile organics. Volume reductions may be accomplished by filtering or drying a waste to reduce its water content. Because treatment still involves the production of the hazardous waste, source reduction and recycling are preferable pollution prevention techniques.

Example: A Wausau, Wisconsin facility provides printing and graphic reproduction services. The facility uses inks and solvents in the development of the printing and graphics products. Solvents for ink formulation and equipment cleaning include perchloroethylene; trichloroethylene; 1,2,trans-dichloroethylene; toluene; and xylene. Most of the wastes were generated by two unit operations: (1) residual and unused ink mixtures from the graphics production group, and (2) solvent wastes from the equipment cleaning operations. Because of the organic chemicals contained in these wastes, they are a mixture of RCRA listed *hazardous wastes. Both the residual and unused inks and the spent cleaning solvents were disposed in a manner that resulted in ground-water contamination. The practice resulted in ground-water contamination by perchloroethylene (100 ppb), trichloroethylene (100 ppb), 1,2,-trans-dichloroethylene (339 ppb), toluene (concentration unspecified), and xylene (concentration unspecified). Three high-yield production wells were contaminated causing a drinking water health threat. The contamination cleanup expense included cost of a granular activated carbon adsorber to treat the contaminated ground water, in addition to the labor cost to install, operate, and maintain the treatment operation.*

The company could employ the following techniques in order to reduce the amount of hazardous wastes produced in the printing process: (1) filtration and reuse of waste inks for house colors, and (2) distillation of the solvents from the cleaning process for reuse. The inks are reused in various products which do not require exact matching of colors (Campbell and Glenn, 1982 and San Diego Department of Health Services, 1987). This practice reduces to a large degree the waste and unused inks disposed with the solvent wastes. The distillation of the cleaning solvents allows reuse of these recycled solvents for ink preparation and cleaning purposes, which eliminates the bulk disposal of used inks and organic solvents. The only material requiring disposal is the sludge that forms in the distillation unit. The sludge resulting from the distillation process is sent off-site for disposal. The waste minimization practices prevent further contamination of the ground water by reusing inks and recycling solvents. Direct cost savings result from lowered ink and solvent purchase and reduced waste and sludge disposal costs. The payback period for the change is about one year.

4.3 Analysis and Discussion

Management controls and waste minimization techniques often require careful planning, creative problem solving, changes in perspective regarding material handling, and some capital investment. Nonetheless, in addition to protecting Wellhead Protection Areas, light industries have adopted such practices to save money through more efficient use of valuable resources, reduced regulatory compliance costs, and reduced waste treatment disposal costs. Other, less tangible benefits to light industry from such practices include reduced financial liabilities (the less waste generated, the lower the potential for cleanup and third-party compensation due to environmental releases) and enhanced image in the community (local residents respond favorably to environmentally responsible behavior by industry).

Industry groups and local governments can and do play a major role in promoting management controls and waste minimization techniques by helping disseminate information and transferring technology to light industry regarding management controls (e.g., through training seminars, workshops, guidance materials). **Also, local governments can develop location and design standards in order to protect Wellhead Protection Areas.** For example, the citizens of Spokane, Washington formed a planning group to develop a strategy for protecting their ground water and released a Water Quality Management Plan which includes recommendations for controlling chemical spills and leaks through methods such as land use and zoning regulations, development and enforcement of best management practices, and public education.

Chapter 3 of this document presents several other successful State and local Wellhead Protection Programs. Most, if not all of these programs encourage and/or require facilities within the Wellhead Protection Area to implement management controls and waste minimization techniques. For example, part of the Cape Cod Planning and Economic Development Commission plan that protects Wellhead Protection Areas involves "milk runs" to many of the smaller, largely conditionally exempt, generators in the area in order to pick up wastes produced. Aggregating these waste quantities secures a more reasonable disposal rate. Without this practice, the generators, which are not otherwise required to dispose of the waste in any particular fashion, could begin discharging wastes into sewer lines or with regular solid waste.

In sum, **management controls are being applied by light industries in many jurisdictions as an effective part of Wellhead Protection Programs.** Furthermore, waste minimization techniques that have been adopted by larger industries may also be incorporated by light industry to better ensure long-term protection of Wellhead Protection Areas.

5.0 Conclusions

This document has provided a broad overview of the potential impact of light industrial activities on Wellhead Protection Areas. There are many wellhead areas already defined throughout the United States and many more will be delineated in the next few years. Although the precise number of light industries located within and in close proximity to Wellhead Protection Areas is not known at this time, this document will assist Wellhead Protection Program managers in identifying and controlling these sources of potential contaminants. As the number of light industries continues to increase in this country and more light industries become located in formerly rural and suburban areas, the potential impact on Wellhead Protection Areas may also increase.

The limited data collection effort conducted to support this analysis indicates that a broad array of light industry types have been associated with past ground-water contamination incidents. Waste management and disposal activities are identified as the main source of contamination, while production processes and raw material and product storage are also a significant source of contaminant releases. A variety of contaminants are involved in releases from light industries, with chlorinated solvents and metals identified as the most prevalent constituents in ground water. However, the actual risk to human health and the environment posed by light industries is unknown.

Among the issues involved in determining the actual threat to public health and the environment from light industrial activity is an assessment of the extent of exposure to release events. The extent of exposure to a population is a function of factors such as the number of potential points of release, the volume of individual releases, the mobility of released constituents in the environment, and the proximity of the exposed population to releases. Light industrial activity in this country is extensive; therefore, there are many potential points of release. Light industries also have the capability to release materials that are mobile in the environment and toxic. Furthermore, because many of these light industries are located in or near Wellhead Protection Areas, there is a high potential for exposure to releases through drinking water supplies. **What is largely unknown at this time is the volume and frequency of likely releases from light industries. The data reported in this document provide a limited overview of the topic, but this information is far from conclusive. Nonetheless, based upon the information available to date, most releases from light industries appear to be of small to moderate size, compared to those observed from larger industries.** Although this conclusion is very preliminary in nature and may change as more information is gathered, the data suggest that the potential for small to medium-size releases from the large number of light industries located in Wellhead Protection Areas may pose a threat to populations relying on ground water for their drinking water supplies.

Several State and local governments have developed innovative approaches for protecting Wellhead Protection Areas from these light industrial sources of contamination. These approaches include aggressive source identification, zoning, other land use controls, and education and technology transfer activities to encourage light industries to adopt protective management controls. Several of the management controls and waste minimization techniques that have been recommended by EPA and State and local authorities and adopted by certain light industries are presented in Chapter 4. These management controls and waste minimization techniques can be adopted as an integral part of a Wellhead Protection Program. **As presented here, these management controls and waste minimization techniques represent activities that have been or can be applied at light industrial facilities to limit the threat of releases to ground water. These practices are described as guidance to illustrate the types of activities that have been adopted by industry; however, they do not represent techniques that can be applied in all instances or that may be appropriate for all light industries.** References that Wellhead Protection Program managers may use to identify practices and techniques that may be appropriate for individual light industries are available on request from EPA.

6.0 References

The sources listed below were used to develop the discussions in chapters 1 through 4 of this document.

Althoff, W. F., Clearly, R.W., and Roux, P.H. 1981. Aquifer Decontamination for Volatile Organics: A Case History. Ground Water. 19(5): 495-504.

American Chemical Society. July 1981. Survey of Laboratory Practices and Policies for Employee Protection from Exposure to Chemicals.

American Chemical Society. September 28, 1982. Report from the CSC/CCPA/CEI Task Force on RCRA on Clarification and Recordkeeping for Laboratory Waste Chemicals.

American Chemical Society. 1986. RCRA and Laboratories.

Boateng, K., Evers, P.C., Testa, S.M. 1984. Groundwater Contamination of Two Production Wells: A Case History. Groundwater Monitoring Review. 4(2): 24-31.

California Department of Health Services. July, 1986. Alternative Technology for Recycling and Treatment of Hazardous Wastes, Third Biennial Report.

Cantor, L.W., Knox, R.C., and Fairchild, D.M. 1988. Ground Water Quality Protection. Lewis Publishers, Chelsea, MI, 562 pp.

Cape Cod Planning and Economic Development Commission. 1987. Cape Cod Regional Hazardous Waste Management Plan for Small Quantity Generators. Prepared by SEA Consultants, Cambridge, Massachusetts.

Central Connecticut Regional Planning Agency. February, 1981. Guide to Groundwater and Aquifer Protection, Town of Burlington.

Clark, F.W. and Sanborn P.M. 1985. Evaluation of Contamination by Organics and Heavy Metals in Soil and Bedrock Aquifer. Second Annual Eastern Regional Groundwater Conference, Proceedings. July 16-18, 1985. pp. 529-542.

Connecticut Department of Environmental Protection. 1984. Protecting Connecticut's Groundwater - A Guide to Groundwater Protection for Local Officials.

Conservation Law Foundation. 1984. Underground Petroleum Storage Tanks: Local Regulation of A Groundwater Hazard (A Massachusetts Prototype).

Duffy, W.J., Moose, R., and Tomalavage, S.J. 1980. Contamination of Ground Water Supplies by Trichloroethylene - Three Case Histories. Third Annual Madison Conference on Applied Research Practice on Municipal and Industrial Waste, Proceedings. September 10-12, 1980. pp.187-200.

Elliot, R.W. 1985. Toluene Loss Investigation and Remedial Action of Two Geologically Complex Industrial Sites in Eastern Nebraska. Petroleum Hydrocarbons and Organic Chemicals in Ground Water - Prevention, Detection, and Restoration, Proceedings. November 13-15, 1985. pp.374-396.

Environment Canada. March, 1987. Catalogue of Successful Hazardous Waste Reduction/Recycling Projects. Prepared for Industrial Programs Branch, Conservation & Protection by Energy Pathways Inc. and Pollution Probe Foundation.

Environment Canada. January, 1984. Technical Manual - Waste Abatement, Reuse, Recycle and Reduction Opportunities in Industry

Epstein, S., L. Brown, and C. Pope. 1982. Hazardous Waste in America. Sierra Club Press.

Freeze, R.A. and J.A. Cherry. 1979. Groundwater. Prentice-Hall, Inc. Englewood Cliffs, NJ.

Georgia Institute of Technology. April 1985. The Georgia Tech Hazardous Waste On-Site Consultation Program: Approach and Results.

Illinois Environmental Protection Agency. January, 1988. A Primer Regarding Certain Provisions of the Illinois Groundwater Protection Act.

Institute for Local Self-Reliance. (no date). Proven Profits from Pollution Prevention - Case Studies in Resource Conservation and Waste Reduction.

James, R.B., Eisenberg, D.M., and Oliveri, A. 1984. Regulation of Underground Storage Tanks in the San Francisco Bay Area. Seventh Annual Madison Waste Conferences Municipal and Industrial Waste, Proceedings. September 11-12, 1984. pp.325-334.

Latsha, J.L. 1987. VOC Removal from Groundwater - A Case History. Water Pollution Control Association of Pennsylvania Magazine. 20(5):6-9.

Long Island Regional Planning Board. 1985. Nonpoint Source Management Handbook. Hauppauge, New York.

Massachusetts Department of Environmental Management, Massachusetts Hazardous Waste Source Conference Proceedings, October 17, 1984.

Massachusetts Department of Environmental Quality Engineering. July, 1987. The Management of Toxic and Hazardous Materials in a Zone of Contribution on Cape Cod, (Tara Gallagher, ed.).

Massachusetts Department of Environmental Quality Engineering. August, 1987. Pesticides and Drinking Water, Responsibilities of Massachusetts Boards of Health.

Massachusetts Department of Environmental Quality Engineering. May, 1982. Groundwater Quality and Protection - A Guide for Local Officials.

Massachusetts Department of Environmental Quality Engineering. (no date). Requirements for Small Quantity and Very Small Quantity Generators of Hazardous Waste; Satellite Accumulation of Hazardous Waste.

Massachusetts Department of Environmental Quality Engineering. February, 1988. Hazardous Waste Fact Sheets for:

Vehicle Maintenance and Autobody Repair
Used Oil
Space Heaters (burning waste oil)
Underground Tanks Storing Waste Oil
Graphic Artists, Printers, and Photographers
Laboratories
Construction Companies
Furniture Manufacturers, Finishers, Refinishers, and Woodworkers
Drycleaners
Metal Finishers

Boatyards and Marinas
Golf Courses
Small Engine Repair Shops

Massachusetts Special Water Commission on Water Supply. December 1986. Contamination in Municipal Water Supplies.

National Water Well Association - 3rd National Symposium and Exposition on Aquifer Restoration and Groundwater Monitoring, May 1983.

National Water Well Association - 4th National Symposium and Exposition on Aquifer Restoration and Groundwater Monitoring, May 1984.

National Water Well Association - 6th National Symposium and Exposition on Aquifer Restoration and Groundwater Monitoring, May 1986.

National Conference on Control of Hazardous Material Spills, Proceedings, Miami Beach, FL, April 11-13, 1978.

National Conference on Control of Hazardous Material Spills, Proceedings, Louisville, KY, May 13-15, 1980.

National Governors Association. June, 1988. State Hazardous Waste Minimization Programs. Prepared by ICF Incorporated.

New York Department of Environmental Conservation. July, 1988. Regulations for Chemical Bulk Storage.

New York Department of Environmental Conservation. August, 1983. Report of the Central Southern Tier Groundwater Critical Recharge Area Project for Erwin, New York.

New York Department of Environmental Conservation. January 1983. Technology for the Storage of Hazardous Liquids: A State of the Art Review.

New York State Environmental Facilities Corporation: Industrial Materials Recycling Program Annual Report[s], New York State Environmental Facilities Corporation, 1982, 1983, 1984, 1985, 1986, 1987.

North Carolina Department of Natural Resources. May 1985. Profits of Pollution Prevention - A Compendium of North Carolina Case Studies.

North Carolina Department of Natural Resources and Community Development. (no date). Accomplishments of North Carolina Industries - Case summaries.

Office of Management and Budget. 1987. Standard Industrial Classification Manual.

Oliveria, D.P. and Sitar, N. 1985. Ground Water Contamination from Under Ground Solvent Tanks, Santa Clara, California. Fifth National Symposium and Exposition on Aquifer Restoration and Ground Water Monitoring, Proceedings. May 21-24, 1985. pp. 691-708.

Ontario Ministry of the Environment. June, 1983. Blueprint for Waste Management in Ontario.

Ontario Waste Management Corporation. (no date). Industrial Waste Audit and Reduction Manual: Case Study 2 -- Steel Pickling.

Patrick, R., Ford, E. and Quarles, J. 1987. Groundwater Contamination in the United States. University of Pennsylvania Press, Philadelphia, 513 pp.

Pima Association of Governments. May, 1988. Metropolitan Tucson Basin Water Quality and Pollution Source Assessment (Draft).

Portland, Oregon. May, 1988. Columbia South Shore Hazardous Materials Containment Facilities Design Handbook. (Also, local ordinance restricting certain high risk and hazardous materials industry and activities.)

Pyles, D., Stimpson, K., Bowden, R., and Wu, B. 1985. Wausau Wisconsin: A Case Study of an Immediate Removal Action to Secure and Investigate a Contaminated Water Supply. Eighth Annual Madison Waste Conference on Municipal and Industrial Waste, Proceedings. September 18-19, 1985. p. 509.

Quality of Ground Water Symposium - March, 1981: ed. by W. van Duijvenbooden, P. Glasbergen (Elsevier Scientific Publishing Company, 1981)

Quince, J.R., Ohneck, R.J., and Vondrick, J.J. 1985. Response to an Environmental Incident Affecting Ground Water. Fifth National Symposium and Exposition on Aquifer Restoration and Ground Water Monitoring, Proceedings, May 21-24, 1985. pp. 598-608.

Roberts, J.R., Cherry, J.A., and Schwartz, F.W. 1982. A Case Study of a Chemical Spill: Polychlorinated Biphenyls (PCBs): History, Distribution, and Surface Translocation. Water Resources Research. 18:525-534.

Schenectady County Planning Commission. (no date). Groundwater Supply Source Protection, A Guide for Localities in Upstate New York.

Southern California Association of Governments. May, 1985. Hazardous Waste Management Plan for Small Quantity Generators: Final Report.

Southern Tier Central Regional Planning and Development Board. June 1985. Formal Report of the Central Southern Tier Groundwater Critical Recharge Area Project.

Spokane Water Quality Management Program coordination Office and Technical Advisory Committee. July 1986. Critical Materials Handbook.

Tacoma, Washington - Groundwater Protection Ordinance, May, 1988. Contains General Guidance and Performance Standards for Underground and Aboveground Tanks and for Spill Prevention and Management.

Tennessee Department of Economic and Community Development, August 1986(a). Hazardous Waste Management Assistance: Electroplaters.

Tennessee Department of Economic and Community Development, August 1986(b). Hazardous Waste Management Assistance: Paper Products Manufactures.

Tennessee Department of Economic and Community Development, August 1986(c). Hazardous Waste Management Assistance: Printers and Publishers.

Tennessee Department of Economic and Community Development, August 1986(d). Hazardous Waste Management Assistance: Dry Cleaners.

Tennessee Department of Economic and Community Development, August 1986(e). Hazardous Waste Management Assistance: Automobile Body Repair and Paint Shops.

Tennessee Department of Economic and Community Development. August 1986 (f). Hazardous Waste Management Assistance: Furniture Fabricators.

University of Tennessee, Energy, Environment and Resource Center. Measures to Promote the Reduction and Recycling of Hazardous Wastes in Tennessee.

U.S. Department of Commerce. 1985. Census of Manufacturers.

U.S. Environmental Protection Agency/Office of Water Program Operations. October, 1980. Design Manual: Onsite Wastewater Treatment and Disposal Manual. EPA 625/1-80-012.

U.S. Environmental Protection Agency/Office of Drinking Water. October, 1983. Sanitary Survey Training.

U.S. Environmental Protection Agency/Office of Solid Waste. April, 1984. Assessment of Hazardous Waste Mismanagement Damage Case Histories.

U.S. Environmental Protection Agency. 1985. Protection of Public Water Supplies from Ground-Water Contamination. U.S. EPA Technology Transfer Publication. EPA/625/4-85/016.

U.S. Environmental Protection Agency. February, 1985. National Small Quantity Hazardous Waste Generator Survey.

U.S. Environmental Protection Agency/Office of Solid Waste. July, 1985. Regulatory Impact Analysis: Proposed Standards for the Management of Used Oil.

U.S. Environmental Protection Agency/Office of Ground-Water Protection. July, 1985. Septic Systems and Ground-Water Protection: A Program Manager's Guide and Reference Book.

U.S. Environmental Protection Agency. August, 1985. The Scrap Metal Recycling Industry.

U.S. Environmental Protection Agency/Office of Solid Waste. January, 1986. Analysis of the Combined Impact of Various EPA Regulatory Initiatives on Generators of 100-1000 Kg/Mo.

U.S. Environmental Protection Agency/Office of Solid Waste. October, 1986. Report to Congress: Waste Minimization Issues and Options, Volume II.

U.S. Environmental Protection Agency/Office of Ground-Water Protection. 1987. An Annotated Bibliography of Wellhead Protection References, EPA 440/6-87-014.

U.S. Environmental Protection Agency/OSW. February, 1987. Characterization of Releases from Non-Subtitle C Technologies.

U.S. Environmental Protection Agency Region III, Philadelphia, PA. April, 1987. Hazardous Waste Minimization Manual for Small Quantity Generators in Pennsylvania.

U.S. Environmental Protection Agency/Office of Solid Waste and Emergency Response. October 1987. Waste Minimization: Environmental Quality and Economic Benefits. EPA/530-SW-87-026.

U.S. Environmental Protection Agency Water Engineering Research Laboratory. March, 1988. Information for Wellhead Protection Managers on the Potential Impacts of Selected Sources of Groundwater Contamination with Emphasis on Activities Associated with Agricultural Irrigation and Light Industrial Parks (Draft).

U.S. Environmental Protection Agency/Office of Ground-Water Protection. April 1989. Wellhead Protection Programs: Tools for Local Government.

U.S. Office of Technology Assessment. October, 1984. Protecting the Nation's Groundwater from Contamination (Vols. I and II).

Vermont Department of Environmental Protection. 1984. An Ounce of Prevention -A Ground Water Protection Handbook for Local Officials.

Virginia Water Resources Center (Margaret Hrezo & Pat Nickinson, eds). Nov., 1986. Protecting Virginia's Groundwater: A Handbook for Local Government Officials.

Washington Department of Ecology. December 1986. Ground Water Resource Protection - A Handbook for Local Planners and Decision Makers in Washington State. Prepared by King County Resource Planning.

Winegardner, D.L., Erickson, M. and Quince, J.R. 1985. Aquifer Restoration: Case Histories. Fifth National Symposium and Exposition on Aquifer Restoration and Ground Water Monitoring, Proceedings. May 21-24, 1988. pp. 611-626.

Winegardner, D.L. and Quince, J.R. 1984. Ground Water Restoration Projects: Five Case Histories. Fourth National Symposium and Exposition on Aquifer Restoration and Ground Water Monitoring, Proceedings. May 23-25, 1984. pp. 386-393.

Wisconsin Geological & Natural History Survey. September, 1985. Ground Water Protection Principles and Alternatives for Rock County, Wisconsin.

Wisconsin Geological & Natural History Survey (Born, et. al.). 1988. Wellhead Protection Districts in Wisconsin: An Analysis and Test Application.

Yoder, Douglas. Protection of Wellfields and Recharge Areas in Dade County, Florida. pp. 183-198.