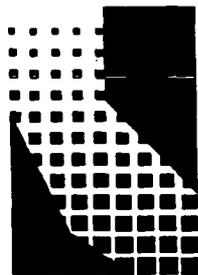


# MEDICAL WASTE ISSUES STUDY



INTEGRATED  
WASTE  
MANAGEMENT  
BOARD

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JUNE 1994



# STATE OF CALIFORNIA

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# MEDICAL WASTE ISSUES STUDY

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## GLOSSARY

Medical waste in California is described using specialized language with technical definitions. The following terms are contained and defined in Chapter 6.1 of the California Health and Safety Code. The definitions cited below apply to these terms throughout the text of this report. Some paraphrasing and condensing of the Chapter 6.1 definitions may have been performed. Not all terms defined in Chapter 6.1 of the Code are included below. The reader should consult the definitions in the Code if a complete text is desired.

### Biohazard Bag

"Biohazard bag" means a disposable red bag which is impervious to moisture and has a strength sufficient to preclude ripping, tearing or bursting under normal conditions of usage and handling of the waste-filled bag. A biohazard bag shall be constructed of material of sufficient single thickness strength to pass the 165 gram dropped dart impact resistance test as prescribed by Standard D 1709-85 of the American Society for Testing and Materials (ASTM), and certified by the bag manufacturer.

### Biohazardous Waste

"Biohazardous waste" means any of the following:

- a) Laboratory waste, including, but not limited to, all of the following:
  - 1) Human or animal specimen cultures from medical and pathological laboratories.
  - 2) Cultures and stocks of infectious agents from research and industrial laboratories.
  - 3) Wastes from the production of bacteria, viruses or the use of spores, discarded live and attenuated vaccines, and culture dishes and devices used to transfer, inoculate and mix cultures.
- b) Waste containing any microbiologic specimens sent to a laboratory for analysis.
- c) Human surgery specimens or tissues removed at surgery or autopsy, which are suspected by the attending physician and surgeon or dentist of being contaminated with infectious agents known to be contagious to humans.
- d) Animal parts, tissues, fluids or carcasses suspected by the attending veterinarian of being contaminated with infectious agents known to be contagious to humans.
- e) Waste, which, at the point of transport from the generator's site, at the point of disposal or thereafter, contains recognizable fluid blood, fluid blood products, containers or equipment containing blood that is fluid or blood from animals known to be infected with diseases which are highly communicable to humans.

- f) Waste containing discarded materials contaminated with excretion, exudate or secretions from humans who are required to be isolated by the infection control staff, the attending physician and surgeon, the attending veterinarian or the local health officer, to protect others from highly communicable diseases or isolated animals known to be infected with diseases which are highly communicable to humans.
- (g) Waste which is hazardous only because it is comprised of human surgery specimens or tissues which have been fixed in formaldehyde or other fixatives, or only because the waste is contaminated through contact with, or having previously contained, trace amounts of chemotherapeutic agents, including, but not limited to, gloves, disposable gowns, towels, and intravenous solution bags and attached tubing which are empty. A biohazardous waste which meets the conditions of this subdivision is not subject to Chapter 6.5 (commencing with Section 25100). These wastes shall be managed as medical waste in accordance with the applicable provisions of Chapter 6.1 and shall be disposed of in accordance with subdivision (a) of Section 25090.
  - (1) For purposes of this subdivision, "chemotherapeutic agent" means an agent that kills or prevents the reproduction of malignant cells.

#### Container

"Container" means the bag or rigid container in which the medical waste is placed prior to transporting for storage or treatment.

#### Enforcement Officer

"Enforcement Officer" means the director or agents, or registered environmental health specialists appointed by the director, and all local health officers, directors of environmental health and their duly authorized registered environmental health specialists and environmental health specialist trainees or the designees of the director, local health officers, or the directors of environmental health.

#### Hazardous Waste Hauler

"Hazardous waste hauler" means a person registered as a hazardous waste hauler pursuant to Article 6 (commencing with Section 25160) and Article 6.5 (commencing with Section 25167.1) of Chapter 6.5 of this division and Chapter 30 (commencing with Section 66001) of Division 4 of Title 22 of the California Code of Regulations.

### Household Waste

"Household waste" means any material, including garbage, trash and sanitary wastes in septic tanks, and medical waste, which is derived from households, farms or ranches.

### Infectious Agent

"Infectious agent" means a type of microorganism, bacteria, mold, parasite or virus which normally causes or significantly contributes to the cause of increased morbidity or mortality of human beings.

### Large Quantity Generator

"Large quantity generator" (LQG) means a medical waste generator that generates 200 or more pounds per month of medical waste.

### Local Agency

"Local agency" means the local health department, as defined in Section 1102, or the local comprehensive environmental agency established in accordance with Section 1155.5 of a county which has elected to adopt a local ordinance to administer and enforce this chapter, pursuant to Article 3 (commencing with Section 25030).

### Medical Waste

"Medical waste" means waste which meets both of the following requirements:

- (1) The waste is composed of waste which is generated or produced as a result of any of the following:
  - (A) Diagnosis, treatment, or immunization of human beings or animals.
  - (B) Research pertaining to the activities specified in subparagraph (A).
  - (C) The production or testing of biologicals. {For purposes of this section, "biologicals" means medical preparations made from living organisms and their products, including but not limited to serums, vaccines, antigens, and antitoxins.}
- (2) The waste is any of the following:
  - (A) Biohazardous waste.
  - (B) Sharps waste.

### Medical Waste Generator

"Medical waste generator" means any person whose act or process produces medical waste and includes, but is not limited to, a provider of health care as defined in subdivision (a) of Section 56.05 of the Civil Code. All of the following are examples of businesses which generate medical waste:

- a) Medical and dental offices, clinics, hospitals, surgery centers, laboratories, dialysis clinics, education and research facilities, those facilities required to be licensed pursuant to Division 2 (commencing with Section 1200) and unlicensed facilities.
- b) Veterinary offices, clinics and hospitals.
- c) Pet shops.

### Medical Waste Management Plan

"Medical waste management plan" means a document which is completed by generators of medical waste pursuant to Sections 25042 and 25052 on forms prepared by the enforcement agency.

### Medical Waste Permit

"Medical waste permit" means a permit issued by the enforcement agency to a medical waste treatment facility.

### Medical Waste Registration

"Medical waste registration" means a registration issued by the enforcement agency to a medical waste generator.

### Medical Waste Treatment Facility

- a) "Medical waste treatment facility" means all adjacent land, structures and other appurtenances or improvements on the land, used for treating medical waste or for associated handling and storage of medical waste. Medical waste treatment facilities are those facilities treating waste pursuant to subdivision (a) or (c) of Section 25090. A medical waste treatment method approved pursuant to subdivision (d) of Section 25090 may be designated as a medical waste treatment facility by the department.
- b) "Adjacent," for purposes of subdivision (a), means real property within 400 yards from the property boundary of the existing medical waste treatment facility.

### Mixed Waste

"Mixed waste" means mixtures of medical and nonmedical waste. Mixed waste is medical waste, except for the following mixtures:

- a) Medical waste and hazardous waste is hazardous waste and is subject to regulation as specified in the statutes and regulations applicable to hazardous waste.
- b) Medical waste and radioactive waste is radioactive waste and is subject to regulation as specified in the statutes and regulations applicable to radioactive waste.
- c) Medical waste, hazardous waste and radioactive waste is radioactive mixed waste and is subject to regulations as specified in the statutes and regulations applicable to hazardous waste and radioactive waste.

### Offsite

"Offsite" means any location which is not onsite.

### Onsite

- a) "Onsite" means a medical waste treatment facility, or common storage facility on the same or adjacent property as the generator of the medical waste being treated.
- b) "Adjacent," for purposes of subdivision (a), means real property within 400 yards from the property boundary of the existing medical waste treatment facility.

### Sharps Waste

"Sharps waste" means any device having acute rigid corners, edges or protuberances capable of cutting or piercing, including, but not limited to, all of the following:

- a) Hypodermic needles, syringes, blades and needles with attached tubing, syringes contaminated with biohazardous waste, acupuncture needles, and root canal files.
- b) Broken glass items, such as Pasteur pipettes and blood vials contaminated with other medical waste.

### Small Quantity Generator

"Small quantity generator" (SQG) means a medical waste generator that generates less than 200 pounds per month of medical waste.

Storage

"Storage" means the holding of medical wastes at a designated accumulation area, as specified in Article 8 (commencing with Section 25080).

Tracking Document

"Tracking document" means the medical waste tracking document specified in Section 25063.

Transfer Station

"Transfer station" means any offsite location where medical waste is loaded, unloaded or stored by a registered hazardous waste hauler during the normal course of transportation of the medical waste.

Treatment

"Treatment" means any method, technique or process designed to change the biological character or composition of any medical waste so as to eliminate its potential for causing disease, as specified in Article 9 (commencing with Section 25090).

## EXECUTIVE SUMMARY

In the Medical Waste Issues Study, the California Integrated Waste Management Board (CIWMB) seeks to characterize the types and quantities of medical wastes entering the solid wastestream, and to identify the effects and potential effects of specific medical waste management options on the health and safety of the public and solid waste industry operators and the State's landfill disposal capacity.

Data collected in this Study indicate that the average large quantity generator (LQG) produces about 5,900 pounds per month of medical waste. The average small quantity generator (SQG) produces only 25 pounds per month. An estimated 83 percent of SQG wastes are sent offsite for treatment, while LQGs utilize offsite treatment for a minimum of 63 percent of their wastes. Analysis of offsite medical waste treatment facility permit applications revealed that a total of approximately 50,000 tons per year of medical wastes were treated by offsite treatment facilities in California during 1991-1992. Based on these data, and using an estimate by CIWMB that a total of 48,580,000 tons of solid wastes were generated during 1992, an estimate is obtained that 0.12 to 0.16 of the total solid wastestream consists of medical wastes.

Among respondents to the small quantity generator (SQG) survey, physicians produce more of all types of medical wastes than dentists and veterinarians. Sharps are the major component (by weight) of medical waste produced by SQGs. The Study identifies sharps as the waste type of greatest concern, due to their ability to puncture the skin and provide a portal of entry for disease transmission.

Although the study did not expose serious industry or enforcement agency concerns, there is ample anecdotal evidence from both solid waste facilities and enforcement agencies that solid waste managers would prefer to be safe, rather than sorry, when it comes to potential occupational injury. A cooperative CIWMB-DHS effort aimed at educating generators and the solid waste industry on the relative merits of existing treatment technologies could reduce the likelihood of injury dramatically. Educated medical waste generators may then incorporate their understanding of ultimate disposal circumstances in their decision-making process as they select treatment modalities.

For all 447 facilities in the LQG database, sharps were the most commonly generated waste (reported by 411, or 92% of the facilities), followed closely by blood and body wastes (reported by 403, or 90% of the facilities). In descending order of frequency, lab wastes (290 facilities or 65%), surgical wastes (221 facilities or 49%), isolation wastes (139 facilities or 31%), and contaminated animal wastes (50 facilities or 11%) were reported. Of the 63 LQGs that responded to the questionnaire, 71 percent reported that they generate blood or body fluids, and 73 percent generate sharps waste. Laboratory waste generation was reported by 36 facilities (58 percent). Thus, LQGs report generating a higher percentage of blood and body fluids than SQGs report.

Surveys of landfill operators, transfer facility operators, solid waste collectors, and local enforcement agencies revealed no complaints of health or safety problems related to the legal or illegal disposal of regulated medical wastes. Operators stated that solid wastes are mechanically compacted and placed into the landfill, and physical contact with these wastes by workers is rare. The exception is a recycling or materials recovery facility. Such facilities often utilize hand-sorting of materials. One materials-recovery-facility survey respondent reported that facility personnel encounter used sharps generated by households on a daily basis. This may be a substantial and growing concern considering the increase in waste handling, particularly hand-sorting, that is likely to occur as cities strive to meet the diversion requirements of the Integrated Waste Management Act of 1989 (Assembly Bill 939).

The offsite medical waste treatment facilities in the state typically receive medical wastes from a distinct region or regions. DHS records indicate that for the period 1991-1992, offsite medical waste treatment facilities operated at 66 percent of their permitted capacity, treating a total of approximately 50,000 tons of medical wastes annually. Facility operators anticipate no lack of capacity in the future, as volumes treated are not expected to increase substantially. Based on the maximum calculated volume of medical waste produced annually in the state (79,360 tons), offsite treatment facilities currently receive and treat a minimum of 63 percent of the total generated medical waste, and may be treating as much as 83 percent. Due to the very small percentage of medical waste in the total solid wastestream, and the fact that offsite treatment facilities are distributed throughout the state, it appears unlikely that any region's solid waste landfill capacity would be affected by medical wastes residuals. Existing disposal options for medical wastes appear to be adequate in California.

New technologies for waste treatment are not expected to have any effects on disposal of treated medical wastes, although in some cases new technologies may provide more effective treatment. Plastics are abundant in the medical waste stream, and a number of operational and proposed alternative technologies recycle mixed plastic in significant proportion.

Wastes treated onsite by SQGs often go directly into the solid wastestream at that point, *i.e.*, treated medical wastes are collected by the facility's solid waste hauler and disposed to the local municipal landfill. Therefore, to prevent potential spread of pathogens, onsite treatment must be performed effectively. Significant percentages of SQGs use autoclaves to treat medical wastes onsite. For instance, 50 percent of laboratories and 22 percent of dentists report the use of autoclaves for waste treatment. Facility personnel often will have used autoclaves for years for sterilization of non-wastes, and are familiar with the operating parameters that must be maintained for this purpose. However, different operating parameters may be required to thoroughly sterilize bulk waste liquids or semi-liquids. If the generators fail to heed the autoclave operating procedures stated in the medical waste statute (H&S § 25090 (c)), the possibility exists that waste treatment could be compromised.

Although no existing health or safety problems have been identified that relate to this issue, this could be an appropriate area of coordination with DHS.

Healthcare-generated waste is an extended waste stream which courses through two principle agency jurisdictions. A key juncture is the point at which medical waste (under the Medical Waste Management Act) once treated, becomes solid waste (under the California Integrated Waste Management Act). Smoothing this transition has been a challenge to staff in both the Integrated Waste Management Board and the Department of Health Services. Continued cooperation between management and enforcement personnel with expertise in applying both Statutes will assure continuity of waste management from its generation, through treatment to ultimate recycling, transformation, or disposal.



## MEDICAL WASTE ISSUES STUDY

### Chapter 1: INTRODUCTION

The mission of the California Integrated Waste Management Board (CIWMB) includes protection of the public health and safety and the environment through waste prevention, waste diversion, and safe waste processing and disposal. In support of this mission, CIWMB commissioned a study to evaluate issues associated with the management of medical waste in California, from the point of generation, through handling and treatment, to disposal of treatment residue in solid waste landfills.

In 1990, the Medical Waste Management Act was promulgated to set up a framework for medical waste management in California. Recent air quality legislation has had a substantial impact on medical waste management by resulting in the closure of most incinerators in California. During this period, public awareness of the potential risks associated with improper management of medical wastes has been heightened. In the Medical Waste Issues Study, CIWMB seeks to characterize the types and quantities of medical wastes entering the solid wastestream; and the potential effects of medical waste management options on public health and the State's landfill disposal capacity.

#### 1.1 The Medical Waste Management Act of 1990

The California Legislature passed the Medical Waste Management Act (MWMA) in 1990 to establish requirements for treatment, handling, and disposal of medical wastes. The MWMA statute is located in Chapter 6.1 of the California Health and Safety Code. The Act sets forth provisions for implementing medical waste management programs at the county and state level including medical waste tracking and generator registration.

Under the requirements of the MWMA, all large quantity generators (LQGs) of regulated medical wastes must register with the appropriate enforcement agency. In California, 25 counties and one city (Berkeley) have elected to have the California Department of Health Services (DHS) function as the implementing agency. The other counties and the cities of Long Beach, Pasadena, and Vernon have implemented their own medical waste management programs in accordance with the provisions of the MWMA. LQGs must register as simply a generator, or as a generator with onsite treatment of medical wastes. LQGs with onsite treatment function under a permit-by-rule provided the appropriate fee is paid and approved treatment technology is employed. Small quantity generators (SQGs) who treat onsite are required to register and function under a permit-by-rule similar to LQGs. However, SQGs who do not treat onsite and have their medical wastes collected by a registered medical waste hauler (or use sharps mailback services) are not required to register with the appropriate enforcement agency. SQGs who haul medical wastes themselves to an offsite treatment facility can do so provided a limited quantity hauler exemption is obtained.

Offsite medical waste treatment facilities are required to be permitted by DHS. A facility must submit a permit application to receive a permit. DHS also regulates all registered medical waste haulers.

The terms used throughout this report are defined as in the MWMA; these definitions are stated in the Glossary to this report. This Study addresses medical waste as regulated under the provisions of the MWMA. The MWMA defines *medical waste* for the purpose of regulating it as:

- Sharps wastes.
- Laboratory waste, including, but not limited to, human or animal specimen cultures from medical and pathology laboratories, and cultures and stocks of infectious agents from research and industrial laboratories.
- Wastes from the production of bacteria, viruses or the use of spores, discarded live and attenuated vaccines, and culture dishes and devices used to transfer, inoculate and mix cultures.
- Waste containing any microbiologic specimens sent to a laboratory for analysis.
- Human surgery specimens or tissues removed at surgery or autopsy, which are suspected by the attending physician and surgeon or dentist of being contaminated with infectious agents known to be contagious to humans.
- Animal parts, tissues, fluids or carcasses suspected by the attending veterinarian of being contaminated with infectious agents known to be contagious to humans.
- Waste which, at the point of transport from the generator's site, at the point of disposal or thereafter, contains recognizable fluid blood, fluid blood products, containers or equipment containing blood that is fluid or blood from animals known to be infected with diseases which are highly communicable to humans.
- Waste containing discarded materials contaminated with excretion, exudate or secretions from humans who are required to be isolated by the infection control staff, the attending physician and surgeon, the attending veterinarian or the local health officer to protect others from highly communicable diseases or isolated animals known to be infected with diseases which are highly communicable to humans.
- Waste which is generated or produced as a result of the diagnosis, treatment or immunization of human beings or animals in research pertaining thereto, or in the production or testing of biologicals.

The MWMA specifically excludes from regulation home health-care-related medical waste, such as used needles generated by insulin users.

## **1.2 Objectives of the Medical Waste Issues Study**

The Medical Waste Issues Study was designed to acquire and analyze data from generators, haulers, treaters, disposal facility operators, and local enforcement agencies within California. The data will be used to identify options for medical waste treatment and the associated human health and capacity concerns related to disposal of treated medical wastes in solid waste landfills. The objectives of the Study are summarized as follows:

- Collection of data from medical waste generators to characterize waste generation types and quantities,
- Collection of data from medical waste generators and treatment facilities to evaluate waste treatment options,
- Evaluation of survey results to determine whether treatment and disposal capacity is adequate,
- Identification of advantages, disadvantages and limitations of potential new medical waste treatment technologies,
- Identification of potential and existing environmental impacts and health risks associated with treatment and disposal options.

## **1.3 Report Overview**

The Medical Waste Issues Study seeks to address the stated objectives by (1) estimating the amount of medical waste generated in the State by large and small quantity generators, (2) determining the composition of the medical wastestream, (3) assessing solid waste facility and hauler handling problems and concerns, (4) identifying new treatment technologies, and (5) assessing environmental and health effects of new technologies.

The organization of this report is consistent with the Study approach. Results of data collection, discussion, and conclusions are presented in the following chapters:

- Chapter 2: This chapter provides the results of surveys of medical waste generation by large and small generators. The generators, data acquisition methodology, medical waste composition, and medical waste quantities are described.
- Chapter 3: Medical waste treatment and disposal methods are discussed. The results from surveys of waste handling by large and small quantity generators are described.

- **Chapter 4:** This chapter provides an assessment of treatment and disposal capacities for medical wastes in California. The problems and concerns identified through surveys of local enforcement agencies, waste treaters, haulers, and landfill operators are also discussed.
- **Chapter 5:** Innovative medical waste treatment and disposal technologies are identified and evaluated. This chapter identifies residuals generated by such treatments, and discusses potential impacts to the solid waste system.
- **Chapter 6:** Potential environmental effects and health risks of medical waste treatment and disposal methods are discussed for each method identified in this Study.
- **Chapter 7:** The conclusions of the Medical Waste Issues Study are presented.

## **Chapter 2: ASSESSMENT OF MEDICAL WASTE COMPOSITION AND QUANTITIES**

### **2.1 Overview**

Medical waste generation data provide a benchmark for understanding the medical waste management system and its effects on solid waste management in the State. The data identify who is generating medical waste, and estimate how much is generated and its composition. This chapter addresses these issues and discusses how the data were collected.

The MWMA groups medical waste generators into small quantity generators (SQG) and large quantity generators (LQG). Large quantity generators are those which produce at least 200 pounds per month of medical waste. SQGs and LQGs both encompass a number of different types of facilities. For example, SQGs include physicians and dentists in small group or individual practice, veterinary hospitals and veterinarians, and small laboratories. LQGs are typically hospital and laboratory facilities, medical research facilities, the larger convalescent hospitals and skilled nursing facilities, and medical group clinics. Medical waste generation data were obtained through mailed questionnaires, file reviews, telephone interviews, and previous studies for 35 counties and one city in the State. These agencies consist of 10 counties that administer their own medical waste management programs (Alameda, Contra Costa, El Dorado, Madera, Monterey, Napa, Santa Clara, San Diego, Shasta, Ventura), and 25 counties and one city for which the California Department of Health Services is the enforcement agency. The DHS-administered counties and the city are identified in Table 2.1.

**TABLE 2.1 Medical Waste Management Program  
List of Counties/Cities Administered by DHS**

<b>DHS Administered Counties &amp; Cities</b>	
1. Amador	14. Riverside
2. Butte	15. Sacramento
3. Fresno	16. San Benito
4. Glenn	17. San Bernardino
5. Imperial	18. San Francisco
6. Kings	19. San Luis Obispo
7. Lake	20. Santa Barbara
8. Los Angeles	21. Solano
9. Mariposa	22. Sutter
10. Mendocino	23. Toulumne
11. Nevada	24. Ventura
12. Placer	25. Yolo
13. Plumas	26. City of Berkeley

**2.2 Qualifications to Use of the Study Data**

Several qualifications to the data acquired during this Study must be recognized in any interpretation of the data. Specific qualifications of this study are:

- The conclusions of this Study are based on data provided voluntarily by facilities who responded to the surveys, and data obtained from DHS file information provided by generators and treatment facilities who are required to register and/or apply for permits. The conclusions assume that no one category of generator was more likely to respond to the surveys than any other; for instance, dentists are not more likely to respond than are physicians.
- This study focuses on facilities regulated under California's MWMA. With the exception of Ventura County where the Yellow Pages were used to identify questionnaire recipients, identification of generators was performed through the use of existing mailing lists and registration and permit file information. Even so, questionnaire returns were received from a significant number of SQGs who are not required to register under the MWMA, but who are regulated as generators.

- Medical wastes that may be generated in households are not dealt with in this Study. Such wastes are excluded from regulation under the MWMA.
- Although SQGs that treat onsite and those that desire to obtain a limited quantity hauler exemption are required to be registered, registration is essentially "voluntary." Enforcement agencies do not have the means to enforce this requirement. Unregistered facilities are only discovered if a complaint is filed against a facility by a member of the public and the enforcement agency is required to investigate. Thus, the number of facilities in the State subject to registration under the MWMA may be underestimated.
- Data from SQGs and LQGs are self-reported. Generators commonly have different recordkeeping practices, red bagging policies, and interpretations of medical waste types. The questionnaire respondents may have varying levels of familiarity with the issues addressed by the questionnaires. Inconsistencies in reporting are inherent in any self-reporting process. However, questionnaires were carefully designed to encourage uniform interpretation by all respondents.
- The surveys were very successful, and return rates were impressive for information that is not required by law to be provided. Some questionnaires appeared to be only partly completed, and some were missing monthly generated quantity information. Due to the large number of returned surveys for SQGs, information that may have been incomplete on some was provided on many others. This resulted in a large database of information for SQGs.

There are far fewer LQGs than SQGs, and although 100 percent of LQGs in the selected counties were sent surveys, and the return rate was reasonably good, the number of LQGs returning questionnaires was judged to be too low to provide statistically reliable information on quantity of each waste type generated. LQG survey information was combined with data from DHS files to obtain reliable estimates of total waste generation, however.

- The study includes data gathered from 35 out of the 59 counties in the State. The counties included in the study represent most of the population in the State.
- The DHS files are primarily from 1990, whereas the surveys in this Study were sent out in 1993. Thus, there may be factors of concern other than source to consider when comparing or combining the DHS data with the survey data. For instance, a major change to the medical waste management system has occurred since the DHS data were collected - the closure of about 90 percent of the State's medical waste incinerators. Therefore, DHS data may overestimate current use of incineration.

- Information on the type of generating facility was obtained for virtually all of the survey records. However, within these broad facility types (physician, dentist, medical group, nursing home, hospital, veterinarian, etc.) the wastes types and quantities generated will vary depending on the types of services offered by the specific facility. Waste types reported by each facility will also be based on the individual facility's red bagging policies and means of classifying its wastes. Thus, conclusions based on generalized facility types may not apply to individual generators.

## **2.3 Medical Waste Generators**

### **2.3.1 Types of Generators**

Medical waste is generated by a variety of health-care-related facilities including physician and dentist offices, clinics, hospitals, skilled nursing facilities, research facilities, research laboratories, clinical laboratories, licensed and unlicensed medical facilities, surgery centers, diagnostic laboratories, and other providers of health care. The Medical Waste Management Act categorizes a facility as a small quantity generator or a large quantity generator based on the amount of medical waste a given facility generates in a month. Large quantity generators are those which produce at least 200 pounds per month of medical waste. Although any type of facility can be a small or large quantity generator, typically large quantity generators consist of hospitals, nursing homes, clinics, medical groups, county or city health departments and laboratories. Physicians, dentists and veterinarians in private practice are most commonly small quantity generators.

### **2.3.2 Regulatory Requirements**

The categorization of medical waste generators by the MWMA is the basis for imposing statutory requirements on the generators. These requirements are set forth in the Health and Safety Code and differ depending on which category--SQG or LQG--a facility falls under. For SQGs, the MWMA requires registration with the applicable enforcement agency of only those facilities that treat medical waste onsite and those facilities that haul their own medical wastes to an offsite treatment facility under a "limited quantity hauler" exemption. All other SQGs are not required to be registered with the applicable enforcement agency under the requirements of the MWMA.

In contrast to the requirements for SQGs, all LQGs in a county must be registered with the applicable enforcement agency. Additionally, LQGs that treat medical wastes onsite must also be permitted for such activity, as required by the MWMA, by the applicable enforcement agency.

The Medical Waste Issues Study follows the MWMA categorization of medical waste generators and analyses medical waste composition and quantities in terms of generating facility size.

## **2.4 Methodology for Data Collection and Analysis**

### **2.4.1 Methodology and Scope**

The methodology used to obtain data for this Study was designed specifically to address issues pertaining to medical waste quantity and composition from SQGs and LQGs, treatment and disposal, and potential problems resulting from mismanagement. Initially, both large and small quantity generators were to be targeted to provide all necessary quantity, composition, and related information through their responses to various exit questionnaires.

Approximately 2,000 questionnaires were mailed to SQGs in 10 counties. About 400 questionnaires were mailed to LQGs in the same counties. Each questionnaire was accompanied by a letter on CIWMB letterhead. The letter was prepared by CIWMB staff to explain the purpose of the Study and request the cooperation of the generator.

A separate database was developed for each of the two generator categories. Based on the category (LQG versus SQG) identified on the questionnaire itself, SQG surveys were input to the SQG database, and LQG surveys were entered in the LQG database. After the data were entered, a sort was performed on each database to determine whether any of the monthly averages fell outside the respective volume for the generator category. In several instances, records did not fit the database in which they were originally entered. These records were removed and placed into the correct database based on the total monthly volume of medical waste that was reported. Since volume is the only criterion that distinguishes LQGs from SQGs, the total monthly volume was the only criterion used to determine whether records were in the correct generator category.

Data obtained from SQGs and LQGs through voluntary questionnaire returns are inevitably limited; therefore, other sources of information were targeted during this Study to compensate for the shortcomings of a mail survey. These additional data sources included DHS registered and/or permitted medical waste generator files, for the additional waste generation data they contained. Over 500 DHS files were reviewed to obtain additional data records for both LQGs and SQGs whose status required them to register. Also, we targeted solid waste haulers and collectors, and interviewed solid waste facility operators, medical waste treatment facilities and local medical waste program enforcement agencies for a more qualitative view of medical and solid waste management in the jurisdictions.

The specific methods employed for acquiring data for SQGs and LQGs, and the type of information that each source was targeted for are discussed in Sections 2.5 and 2.6.

#### **2.4.2 Analysis of Waste Composition**

The medical waste composition data obtained during this Study can be analyzed following two distinct ways. One way is to analyze waste composition for each different type of facility (for instance, a physician generates X percentage of sharps and Y percentage of blood and body fluids). The other way is to analyze the type of medical waste generated by each facility type (for example, of the sharps generated by SQGs, physicians and dentists are the primary generators).

The methodology developed for this study was designed to facilitate either analytical route for evaluation of medical waste composition. Neither the DHS files nor the returned questionnaires consistently provided quantity and waste type information; however, due to the large number of returns, figures are available to calculate the average composition of the medical wastestream generated by each type of facility, total monthly quantities and relative percentages of each type of medical waste.

Understanding of types of facilities generating a given type of medical waste (i.e., sharps, isolation waste, blood and body fluids) can be helpful in addressing potential reduction and recycling methods for a specific waste. This information can enable medical waste management education and awareness programs to focus on the types of facilities that are generating the wastes that may present a problem to the solid waste management system.

The types of medical wastes for which data were requested from generators include laboratory wastes, blood or body fluids, sharps, contaminated animals or bedding, surgical specimens, isolation waste, and chemotherapy waste. The types of facilities generating these wastes are discussed in Sections 2.4 and 2.5. In general, the data indicate that the primary medical waste type generated by SQGs is sharps waste, whereas LQGs, depending on the type of facility and the procedures practiced at that facility, are more likely to generate a variety of medical waste types.

#### **2.4.3 Analysis of Waste Quantities**

One of the objectives of the Medical Waste Issues Study is to estimate the amount of medical waste generated by SQGs and LQGs in California. This estimate is obtained from a combination of the data collected from the mail survey, information obtained from review of DHS files, information from treatment facilities, and information provided in other studies.

Medical waste generated by facilities with onsite treatment typically does not leave the facility as medical waste; it is rendered non-infectious onsite and therefore leaves the facility as solid waste. Waste from facilities that use offsite treatment must be handled as medical waste. However, whether it is treated at the generating facility or at an off-site treatment facility, from the point of view of waste management, the quantity entering the waste stream is the same.

The quantities reported for SQGs and LQGs in Sections 2.5 and 2.6, respectively, reflect the quantity of medical waste generated regardless of whether it is treated onsite or offsite. The distinction between the amounts treated onsite and offsite is discussed in Chapter 3.

## 2.5 Wastes Produced by Small Quantity Generators

### 2.5.1 Methodology and Scope

Medical waste information was obtained from SQGs by reviewing DHS files and from a mailed questionnaire. Information for which SQGs were targeted included facility size and type, medical waste composition and quantity, treatment and handling methods, medical waste haulers and treatment facilities used, and solid waste recycling.

The DHS files contain SQG information for those generators that treat medical wastes onsite, or hold a small quantity hauler exemption for hauling their own medical waste to an offsite treatment facility. DHS is the administering and enforcement agency for the medical waste management program of approximately 40 percent of the counties in the State. DHS-administered counties include both small and large and rural and urban counties across the State, ranging (both geographically and in size) from Plumas County to Los Angeles County. Review of DHS files indicates that approximately 107 SQGs are registered with this State agency.

The DHS files generally contain information on the type of SQG facility, types and amounts of waste generated, type of onsite treatment, and offsite treatment facilities. Data acquired from the files were entered into a database to facilitate storage and quantitative analyses of the information. A copy of the form used to record information from the DHS files, and upon which database information was obtained, is presented in Appendix 1.

Ten additional counties were selected for inclusion in the Study by CIWMB staff. These counties administer their own medical waste management programs and have well-developed programs which the contractor believed would be a good source of data. The ten counties which were targeted for the questionnaire (Alameda, Contra Costa, El Dorado,

Madera, Monterey, Napa, Santa Clara, San Diego, Shasta, Ventura) were carefully selected to complement those for which information was available from the DHS files. Taken together with the DHS-administered counties, the counties in the Study include the majority of the population in the State.

A questionnaire (Appendix 2) was mailed to approximately 33 percent of the known SQGs in each of the ten counties. Approximately 2,000 questionnaires were mailed to SQGs. An impressive 24 percent of the facilities completed and returned these questionnaires. Some of the forms were returned unopened by the postal service because the facility was no longer in operation.

Except for Contra Costa and Ventura counties, the known SQGs were those registered with the county as an SQG treating onsite or holding a limited quantity hauler exemption. Mailing lists were provided for the SQGs by the respective counties. In Contra Costa County, the known SQGs also include SQGs that are not treating onsite and use a registered medical waste hauler for collection. Contra Costa County also provided mailing lists for use in conducting the survey. In Ventura County, the known SQGs for this study included registered and nonregistered SQGs because the mailing list for this county's SQG questionnaires was generated from Yellow Pages directories. A mailing list was not available from Ventura County. Lastly, San Diego County's mailing list did not always distinguish between SQGs and LQGs (hence the 2,000 total mailed to SQGs is approximate). However, based on information from other counties on the percent of SQGs and LQGs, the total number mailed to San Diego County (746) is estimated to include at least one-third of the SQGs in the county.

The questionnaires were designed by SAIC and CIWMB staff to obtain information on facility type and size, medical waste generation, handling and treatment methods, medical waste haulers, and solid waste recycling. Information from the questionnaires was also entered into a computer database.

SQG data were collected from several types of facilities. The facilities are categorized as physician, dentist, veterinarian, laboratory, and other. "Other" includes skilled nursing facilities, home care providers, radiology facilities, chiropractors, a mortuary, physical therapists and an electronic manufacturer.

The number of questionnaire responses returned by each group is provided below in Table 2.2. Physicians, dentists, and veterinarians constitute the majority (88 percent) of these SQGs.

**TABLE 2.2 Small Quantity Generators - Questionnaire Response**

Total Number of Questionnaires Mailed	Number of Responses	Response Rate	Generator Category				
			Physician	Dentist	Veterinarian	Laboratory	Other
1950	473	24%	244	137	36	3	53

**2.5.2 Analysis of Waste Composition**

Table 2.3 presents the Study's findings on the relative generation of waste types reported by respondents in the largest categories of SQGs. Sharps wastes constitute the largest volume of medical wastes generated by each category of SQGs. For instance, as indicated in Table 2.3, sharps waste constituted 51 percent of physicians' wastes, 66 percent of dentists' wastes, and 56 percent of veterinarians' wastes. As expected, contaminated animal wastes constitute a higher percentage of veterinarians' total wastes than seen for other generators. Blood/body fluid wastes constitute a higher percentage of physicians' total wastes than seen for other generators. Laboratory wastes probably constitute a higher percentage of physicians' total wastes than other waste types because private physicians offices often perform simple lab work onsite. With these exceptions, percentages of waste generation were reasonably similar across the major generator categories.

**TABLE 2.3 Percentage of Each Type of Waste Studied Which is Generated by Physicians, Dentists, and Veterinarians**

Waste Type	Physicians	Dentists	Veterinarians
SHARPS - %	51	66	56
BLOOD OR BODY FLUIDS - %	26	18	17
LAB WASTE - %	15	5	6
SURGICAL SPECIMENS - %	2	2	7
ISOLATION WASTE - %	5	9	2
CONTAMINATED ANIMALS - %	1	0	11
Total *	100%	100%	99%

\*Totals do not always sum to 100 percent due to rounding.

**2.5.3 Analysis of Waste Quantities**

Table 2.4 shows the average quantity in pounds per month generated per facility by each generator category, and the relative percentages of each medical waste type calculated from these quantities. Of the three dominant small quantity generator categories, physicians report the highest percentages (per facility) of nearly all kinds of medical wastes. For instance, as indicated in Table 2.4, physicians generated 89 percent of the total amount of lab wastes reported, 82 percent of the total blood/body fluids wastes, and 72 percent of the total sharps wastes. More sharps wastes (24 lbs. per month) are generated per facility than any other medical waste, more than 2.5 times the next highest waste type of blood and body fluids (9.3 lbs per month). In this survey, physicians and veterinarians report generation of about the same amounts (10-10.5 pounds each) of sharps wastes, whereas dentists report far less (3.5 pounds each). A possible explanation for this smaller number is the fact that dentists dispose of only the needle, while physicians and veterinarians dispose of syringe and needle as a unit.

**TABLE 2.4 Relative Contribution by Physicians, Dentists and Veterinarians to the Total Generation of Each Waste Type Studied**

Waste Type	Physicians	Dentists	Veterinarians	Total
SHARPS - % (lbs/mo)	72 (10)	15 (3.5)	13 (10.5)	100 (24)
BLOOD OR BODY FLUIDS - % (lbs/mo)	82 (5.1)	9 (1)	9 (3.2)	100 (9.3)
LAB WASTE - % (lbs/mo)	89 (2.9)	5 (0.28)	6 (1.2)	100 (4.4)
SURGICAL SPECIMENS - % (lbs/mo)	53 (0.3)	11 (0.1)	36 (1.2)	100 (1.6)
ISOLATION WASTE - % (lbs/mo)	72 (0.9)	23 (0.5)	5 (0.4)	100 (3.9)
CONTAMINATED ANIMALS - % (lbs/mo)	42 (0.24)	0 (0)	58 (2.1)	100 (2.3)

## 2.6 Wastes Produced by Large Quantity Generators

### 2.6.1 Methodology and Scope

Medical waste generation data for LQGs was obtained from DHS files and the mail survey. LQGs were targeted for information including facility size and type, medical waste composition and quantity, treatment and handling methods, medical waste haulers and treatment facilities used, and solid waste recycling.

The DHS files contain information on all identified LQGs in the counties administered by DHS. Files were available for 400 such facilities, which are required by the MWMA to register and file a medical waste management plan. The information required in the plan includes the type of facility, types and estimated average monthly quantity of wastes generated, types of onsite treatment, and names of offsite treatment facilities used. The plans were reviewed to obtain the information using a form (Appendix 1). Data acquired from the files were entered into a database to facilitate storage and quantitative analyses of the information.

All known large quantity generators in the ten selected counties were a target of the Waste Generator Survey - LQG questionnaire. A copy of this questionnaire is presented in Appendix 3. In most counties, the targeted LQGs were identified by mailing lists provided by the counties. The exception was Ventura County, for which a mailing list was not

available. LQGs in Ventura County were identified from Yellow Page listings. Information obtained from the mail survey of LQGs in the selected counties was entered into a database, which was then combined with the database of LQG information obtained from DHS files. Questionnaires were mailed to approximately 400 large quantity generators. The rate of return was approximately 16 percent (63 returned surveys).

The LQG database consists of file data from 400 facilities' medical waste management plans, plus the 63 LQGs who responded to the mailed survey. The data available from the plans was less specific than that requested in the survey, thus some details are not available for the majority of the records in this database. As a result, information on the volume of each type of waste generated by a facility is available only for a subset of the LQG database, and the subset (26 facilities) is probably not a large enough one on which to base extrapolations to the LQG population as a whole. Therefore, such extrapolations (*i.e.*, average volumes of wastes generated by generator category) are not presented for LQGs in this report.

## **2.6.2 Analysis of Waste Composition**

Waste generation and composition data were collected from LQGs from several types of facilities including hospitals, clinics, nursing homes, laboratories, research laboratories, and veterinary facilities.

The data from questionnaire returns from the ten representative counties were compiled and are presented in Table 2.5. Table 2.5 indicates that of facilities reporting generation of sharps wastes, 35 percent were clinics, 13 percent were convalescent hospitals, 29 percent were hospitals, and 11 percent were labs. Of the LQG facilities that reported generating blood or body fluids, 36 percent are clinics, 28 percent are hospitals, and 9 percent are convalescent hospitals.

Of the LQGs of all types that responded to the questionnaire, 71 percent reported that they generate blood or body fluids, and 73 percent generate sharps waste. Laboratory waste generation was reported by 36 facilities (58 percent). Thus, LQGs report generating a higher percentage of blood and body fluids than SQGs report.

For all 447 facilities in the LQG database, sharps were the most commonly generated waste (reported by 411 facilities), followed closely by blood and body wastes (reported by 403 facilities). In descending order of frequency, lab wastes (290 facilities), surgical wastes (221 facilities), isolation wastes (139 facilities), and contaminated animal wastes (50 facilities) were reported.

**TABLE 2.5 Comparison of Number of Large Quantity Generators Reporting Generation of Each Waste Type (n = 447)**

Waste Type	Clinics	Convalescent Hospital	Hospital	Lab	Other	Total
SHARPS - %	35	13	29	11	12	100
BLOOD OR BODY FLUIDS - %	36	9	28	13	14	100
LAB WASTE - %	22	0	36	22	20	100
SURGICAL SPECIMENS - %	12	0	65	6	17	100
ISOLATION WASTE - %	12	18	65	0	5	100
CHEMOTHERAPY - %	0	9	91	0	1	100
CONTAMINATED ANIMALS - %	12	0	25	12	51	100

### 2.6.3 Analysis of Waste Quantities

Information on LQG quantities of medical waste is available from 26 of the LQG questionnaires. The quantities presented in this section are as reported by questionnaire respondents. No data extrapolation or interpretation was conducted because of the low number of data points available.

Table 2.6 presents quantity information for LQGs including hospitals, clinics, convalescent hospitals, laboratories, and other. The table lists the ranges of total monthly medical waste generated for each type of LQG. Hospitals display the widest range of quantities generated, which is as expected due to the variability of the size of facilities.

**TABLE 2.6 Large Quantity Generators - Range of Total Monthly Medical Waste Generation**

LQG Type	Total Monthly Waste (pounds)
Hospital	450 to 64,000
Clinic	200 to 3281
Convalescent Hospital	400 to 475
Laboratory	300 to 1800
Other	100 to 3000

For hospitals, a "per doctor" and a "per bed" generation rate were calculated. Table 2.7 presents this information. The variation in generation rates may be due to the makeup of different services that any one hospital may provide, varying red bagging policies, record-keeping practices. Two additional estimates of these generation rates were obtained. One off-site medical waste treatment facility, in response to a questionnaire, estimates a per doctor generation rate of approximately 325 pounds per month. This figure is higher than found in this Study. Also, a sales representative for a large steam sterilization manufacturer estimates per bed generation rates between 90 and 150 pounds per month, which is within the range seen in this Study. Finally, 42 hospitals were surveyed in a national study (Ref 13), and a generation rate of 168 pounds per month per bed was found, a much higher average than reported by Study respondents.

**TABLE 2.7 Large Quantity Generators - Monthly Average Waste Generation for Hospitals**

Average Monthly Waste, in pounds. (highest average)	
Per doctor (11 facilities reporting)	52.79 (213)
Per bed (10 facilities reporting)	64.86 (203)

## 2.7 Statewide Estimates of Medical Waste Quantities

To estimate total medical waste quantities generated in the State, three pieces of data are necessary. Two of these were obtained as a result of this Study, and the third was provided independently by CIWMB. The three data items consist of 1) an estimate of total medical wastes treated in offsite facilities; 2) an estimate of the percentage of total medical wastes generated that are sent offsite for treatment; and 3) an estimate of the total amount of solid waste generated in the State (in 1992, CIWMB estimated that 48,580,000 tons of solid

wastes were generated in California). The estimation method assumes that the total amount of medical waste can be estimated from the total amount of solid waste generated in the state if the percentage of medical waste is known.

The estimate depends on having a figure for medical waste that is treated offsite; this figure was obtained from information required to be reported to DHS by offsite medical waste treaters. DHS files contain permit application information on the nine medical waste treatment facilities in California. Currently, all of the facilities are operating and accepting medical waste for treatment. Information on treated waste quantities was available in permit applications submitted by registered medical waste treatment facilities for either 1991 or 1992 depending on the treatment facility (Ref. 23). Analysis of the permit applications revealed that a total of approximately 50,000 tons per year of medical wastes were treated by offsite treatment facilities in California during 1991-1992.

Data obtained from generator survey responses indicate that SQGs reported an average of 83 percent of their medical wastes are sent offsite for treatment (Section 3.2.1). A similar estimate of the average amount LQGs send offsite for treatment is more difficult to make as fewer data are available. Seventy-seven percent of all LQGs in this Study report that no wastes are treated onsite. These 77 percent produce 63 percent of all LQG wastes. Assuming, then, that *all* medical is treated, a minimum of 63 percent of LQG wastes are treated offsite.

Together, the reported offsite treatment of 63 percent and 83 percent by LQGs and SQGs, respectively, provide a range within which would fall the actual figure for all medical waste treated offsite. Based on the volume of treated medical waste documented in the permit applications (50,000 tons), a range of 60,240 to 79,360 tons per year of *total medical waste* is obtained. This equates to a range of 0.12 to 0.16 percent of the total solid wastestream of 48,580,000 tons for that year.

Several offsite treatment facilities provided estimates that from 50 to 66 percent (depending on the service area) of the medical waste generated in the State is treated offsite (Ref. 22). These estimates are service area dependent, and so are not directly comparable to the state-wide estimate obtained in this Study.

The state-wide estimate obtained in this Study can be compared with the estimate provided in the First Interim Report to Congress on Medical Waste Management in the U.S., May 1990. This Report to Congress estimated that the total medical waste component of the country's solid wastestream averaged 0.3 percent. The percentage of medical waste estimated from data obtained in this Study is slightly less than that stated in the Report to

Congress, but it is within the same order of magnitude (*i.e.*, less than one percent). The small difference in the two estimates can probably be explained by the fact that the geographical areas are different (the Report to Congress was based predominantly on information from east coast states), and therefore demographic and social patterns of solid waste generation may be different.

## Chapter 3: ASSESSMENT OF MEDICAL WASTE TREATMENT AND DISPOSAL

### 3.1 Overview

Medical waste must be treated in accordance with statutory requirements before the treated waste may be disposed as solid waste as defined in Division 30, Public Resources Code, Section 40191. Treatment may occur either onsite, in which case the facility must be registered by the local Medical Waste Management program implementing agency, or in offsite treatment facility, registered by the State Department of Health Services. Because medical waste becomes solid waste once treated, medical waste treated onsite leaves the generating facility as solid waste. However, from the time the medical waste is generated until it is treated, handling of the medical waste is prescribed by Article 8 of the Medical Waste Management Act.

In contrast, when a generating facility relies on an offsite treatment facility to accomplish the statutorily mandated treatment, medical waste leaving the generator must be handled as prescribed by Article 8 and Article 6, from the point of generation until its ultimate treatment. Only after it is treated can it be handled as solid waste. Because all waste remaining after treatment becomes solid waste, as defined in §40191, Public Resources Code, placement into Class III solid waste landfills is the ultimate fate of treated medical waste.

Methods for treatment of medical waste must conform to the requirements of Section 25090 of the Medical waste Management Act. Alternative treatment methods must be approved by DHS before they can be implemented. Three medical waste treatment methods are currently defined and approved in State statute. These approved methods are incineration, discharge of certain liquid and semisolid wastes to the sanitary sewer, and steam sterilization (California Health and Safety Code Section 25090). Any alternative proposed methods must be evaluated by DHS against standards published in DHS's alternative technology evaluation protocol. Table 7-1 describes the alternative treatment methods, for use both offsite and onsite, which have been approved by DHS.

### 3.2 Wastes Treated Onsite Versus Offsite

#### 3.2.1 Small Quantity Generators

Three hundred twenty-seven SQGs who returning the survey estimated quantities of six categories of medical waste and indicated whether they were treated offsite or onsite. The information provided by these facilities revealed the proportion of each waste type treated onsite and offsite (Table 3.1). The data indicate that of all waste types, isolation wastes and sharps are most likely to be treated onsite. However, it should be noted that the total volume of isolation wastes reported was low (327 pounds per month) compared to sharps

wastes (2,670 pounds per month). Since each waste category elicited a different number of respondents, the reliability of these estimates should be expected to vary. Thus, the most dependable estimates are probably those for sharps, blood and body fluids, and laboratory wastes, which constitute the highest volumes of wastes produced. Overall, across all waste types, SQGs sent 83 percent of their wastes offsite for treatment.

**TABLE 3.1 Small Quantity Generators - Percentage of Each Waste Type Treated Offsite Versus Onsite**

Waste Type	Total Volume (lbs/month)	Waste Treated Offsite (%)	Waste Treated Onsite (%)
SHARPS	2670	79	21
BLOOD OR BODY FLUIDS	1277	94	6
LABORATORY WASTE	1028	76	24
SURGICAL SPECIMENS	119	96	4
ISOLATION WASTE	327	68	32
CONTAMINATED ANIMALS	132	100	0

### 3.2.2 Large Quantity Generators

For LQGs, the distribution of wastes by offsite versus onsite treatment was provided by only 47 of the 63 facilities that responded to the questionnaire. Of these, only 26 facilities also provided an estimate of the total volume of waste generated. It is essential to have the total volume figure, because the LQG survey requested only percentages, rather than volumes, for the waste distribution estimates. LQG handling of wastes can best be examined from combined data obtained from all 447 LQGs in the database. The combined data indicate that 23 percent (104) of the LQG facilities reported treating at least some medical wastes onsite, although not all waste from these facilities is treated onsite. This 23 percent had an average total medical waste generation rate of 9,500 pounds per month.

However, the other 77 percent of LQGs report no onsite treatment of wastes (although some of these may not have reported use of Isolysers for sharps wastes). The 285 facilities that reported their total monthly volume of waste together generate a total of 1.4 million

Onsite steam sterilization is popular because it is relatively simple to operate, does not generate regulated air emissions, is inexpensive (one-half to one-third the cost of having medical waste collected and hauled offsite for treatment), and is an approved treatment method under §25090 (c) of the medical waste management act. Onsite costs of steam sterilization average \$0.04/pound (Ref. 21). But the popularity of steam sterilization as a waste treatment is also undoubtedly due to the fact that many medical facilities use autoclaves for disinfection of instruments, devices, and test media. It is important to note that some SQG respondents who reported having an autoclave onsite specifically did not report use of that autoclave to treat medical waste; thus, not all medical facilities which have access to autoclaves necessarily use them for waste treatment.

Training needed to operate an autoclave is minimal because the units are fully self-contained and automated once the waste has been placed in the unit. Facility personnel may have been using autoclaves for years for sterilization, and are familiar with the operating parameters that must be maintained for this purpose. However, State medical waste regulations require the use of specific standard operating procedures and frequent testing for efficacy of treatment {California Health and Safety Code Section 25090(c)}. Even though a facility has been using its autoclave for non-waste disinfection, personnel may not be familiar with the State's requirements to ensure that wastes are rendered noninfectious, and there is a potential that waste treatment may be compromised.

### 3.3.3 Discharge to Sanitary Sewer

Although data obtained from generators during this Study were limited, discharge of certain liquid medical wastes to a sanitary sewer is probably routinely practiced by many medical waste generators. A study conducted for Baxter Healthcare Corporation found that disposal to the sewer is the most common disposal method for liquid medical wastes (Ref. ). Although California regulations do not prohibit disposal of all untreated liquid medical wastes to the sewer {California Health and Safety Code Section 25090(b)}, some such medical wastes are specifically prohibited. These prohibited wastes include wastes containing any microbiological specimens and "laboratory wastes," defined as human or animal specimen cultures, cultures and stocks of infectious agents, wastes from the production of bacteria and viruses, and live and attenuated vaccines. In addition, some localities may have regulations which prohibit disposal of infectious wastes (untreated liquids) to the sanitary sewer. The State's prohibitions would appear to be sufficiently broad as to preclude nearly all disposal of untreated medical waste liquids to the sewer.

pounds per month of medical wastes. Thus, these 285 facilities generated an average of 4,900 pounds per month. This comparison suggests that, on the average, facilities which have no onsite treatment are the ones which generate smaller amounts of medical waste.

### **3.3 Common Onsite Treatment Methods**

The Study found that steam sterilization (autoclaving) is currently the primary treatment method for non-sharps wastes reported by onsite medical waste treaters. Eighteen percent (82/447) of all large quantity generators autoclaved their wastes; only 4.9 percent (22/447) operated onsite incinerators. Approximately 21 percent (140/584) of SQGs reported using an onsite autoclave to treat their medical wastes. Far fewer SQGs operated incinerators (1.4 percent or 8/584).

#### **3.3.1 Incineration**

Incineration was widely employed in the past to treat medical wastes at hospitals. In fact, 146 medical waste incinerators were operated in the State before the Air Resources Board (ARB) adopted dioxin control requirements for medical waste incinerators (Title 14, California Code of Regulations, Section 17707). Local air pollution control districts are required to adopt control measures at least as stringent as those adopted by ARB. The local districts have been adopting dioxin control measures for medical waste incinerators over the past few years (1990-1993) and continue to do so. These regulations have forced many onsite medical waste incinerators to shut down. The few incinerators that retained their DHS offsite treatment facility permits and continued operating have upgraded their equipment to meet new emissions standards, or have modified operations to burn waste types or amounts that do not generate dioxins above threshold levels, or are located in areas of the State which have not yet adopted dioxin control measures. For example, according to the Department of Health Services, a small number of hospital incinerators located in remote areas are currently permitted to burn only pathology and trace chemotherapy wastes.

#### **3.3.2 Steam Sterilization**

To replace onsite incineration or to implement onsite treatment, many medical waste generators are utilizing onsite steam sterilization. Steam sterilization renders medical waste noninfectious by exposing wastes to saturated steam at no less than 121°C for a designated period of a minimum of 30 minutes. Currently, industry representatives estimate that 175-200 steam sterilization units are in use at California hospitals and other LQG facilities (Ref. 21). These self-contained units process anywhere from 20 pounds to close to 1,000 pounds per cycle. An unknown number of very small steam sterilization units (or autoclaves) are also in place in laboratories, small quantity generating facilities, and the like for use only in equipment sterilization.

### 3.3.4 Disinfection/Encapsulation

A significant number of SQGs use an "Isolyser" to treat sharps onsite. "Isolyser®" is the proprietary name for several health care related waste treatment products, and is generically used to refer to their Sharps Management System (SMS®). It consists of a heavy plastic container which, once the waste is treated, fulfills the statutory requirements for a sharps container; a monomeric liquid chemical disinfectant; and a catalyst which, when the container is full, is added to convert the liquid into a semi-solid polymer which is resistant to compression and tampering. The disinfectant and water are placed in the container according to label instructions. As the container fills with syringes, water is added to keep them submerged. When it is 2/3 full, the catalyst is added to polymerize the disinfectant. These units and their contents are then disposed of as solid waste. Isolyser® manufactures four products: Sharps Management System, Liquid Treatment System, Aldehyde Management System, and X-Ray Fluid Treatment System. Since they involve the treatment of hazardous materials, the latter two are not authorized for use in California. The SMS and the Liquid Treatment System Isolyser® systems are approved in California and require no permit to operate (Ref. 4).

### 3.4 Types of Medical Wastes Treated Onsite

The types of medical wastes a facility treats onsite depends greatly on the type of treatment equipment it has available. Facilities with permitted onsite incinerators may be burning a variety of medical wastes depending on conditions in their Air District permits. Only a small number (fewer than five, but this varies as facilities obtain or lose permits) of facilities operating onsite incinerators are permitted to burn all types of medical wastes. Other facilities with onsite incineration are permitted to burn only pathology wastes (State law [Section 25090.5 of the Medical Waste Management Act] requires recognizable anatomical remains,--which are typically handled as pathology wastes--to be incinerated). Incinerators that are permitted to burn all types of medical wastes (laboratory waste, sharps, contaminated animals or bedding, pathology waste, isolation waste, and trace chemotherapy waste) are operating under stringent Air District constraints and emissions monitoring requirements in most areas of the State, in order to maintain dioxin emissions under regulatory limits.

Facilities with onsite steam sterilization units (autoclaves) may treat any type of medical waste, with the exception of pathology and trace chemotherapy wastes, which must be incinerated. Blood and body fluids are commonly disposed of through the sewer system where consistent with Regional Water Quality Control Board waste discharge requirements [Section 25090 (b) (2) of the Medical Waste Management Act] and local ordinance. But can be rendered noninfectious through steam sterilization.

Table 3.2 presents the survey results on the types of treatment that SQG questionnaire respondents are using. The data in Table 3.2 are presented by generator type; this presentation highlights differences in waste handling between generator types. Since any one generator may use more than one method of disposal for a particular waste type, the data in Table 3.2 sum to more than 100 percent across each row.

Table 3.2 indicates that 63 percent of physicians report having a contract with a waste hauler to dispose of their medical wastes, while only 25 percent of laboratories use this method. Of the SQGs who have contract haulers, only 12 percent also report that they treat medical wastes onsite. Thus, the majority (88 percent) of SQGs using contract haulers treat none of their waste, and therefore must have all untreated wastes hauled to a permitted offsite treatment facility by a registered hauler. It appears that wastes treated onsite by SQGs go directly into the solid wastestream at that point, *i.e.*, treated medical wastes are picked up by the facility's solid waste hauler and disposed to the local municipal landfill.

Treatment of sharps waste, which constitutes the majority of SQGs' waste, is discussed in detail in the following section.

**TABLE 3.2** Treatment/Disposal Options Selected by Small Quantity Generators

Treatment Disposal Method	Hauler Contract	Exemption-Self-Haul	Sharps Mail-back	Sanitary Sewer	Autoclave	Isolyser®	Other
Physician (%)	63	8	7	2	4	8	30
Dentist (%)	36	1	28	11	22	32	31
Veterinarian (%)	57	11	16	13	16	22	30
Lab (%)	25	0	0	0	50	0	25
Other SQGs (%)	47	0	11	2	7	16	22

### 3.4.1 Treatment of Sharps

Of all SQGs responding to the survey, 21 percent (124/584) have an autoclave which is used for treatment of medical wastes. However, only two percent (13/584) of all SQGs report using an autoclave to treat sharps.

### 3.5 Medical Waste Collection

Offsite treatment necessitates collection and transport of medical wastes from the generating facilities to a medical waste treatment facility. The MWMA requires that facilities which use offsite treatment facilities for treating their medical wastes must transport the medical wastes to the treatment facility by either a licensed medical waste hauler or as permitted under a "limited quantity hauler" exemption. A limited quantity hauler exemption allows a generator of medical waste to transport up to 20 pounds per load to a permitted offsite treatment facility, transfer facility, or consolidation with another facility's wastes. The intent of a limited quantity hauler exemption is to provide an SQG with a cost-effective means to haul its own medical waste to an offsite treatment facility. A limited quantity hauler exemption can be obtained only by facilities which generate less than 20 pounds per week of medical waste. The generator must obtain [§25061 (b)] a permit, maintain tracking documents, and transport the waste himself to a permitted medical waste treatment facility, transfer station or consolidation point [§25061 (b)]. As indicated in Table 3.2, only a few SQGs hold a limited quantity hauler exemption. Eleven percent of veterinarians and eight percent of physicians report using this option.

Licensed medical waste haulers are required to register with the Department of Toxic Substances Control as hazardous waste haulers, and in addition must comply with the statutory requirements of Section 25062(a) of the MWMA. The more prominent haulers are associated directly with one of the offsite treatment facilities. The offsite treatment facilities (see Section 3.3.2) operate hauler services as an extension of their treatment services. In fact, some offsite treatment facilities will only accept wastes from their own medical waste haulers. Although competition may be a factor, it is claimed that more control over what types of wastes are picked up and delivered can be obtained by this practice. However, independent medical waste haulers who are not specifically associated with a treatment facility also serve small and large quantity generators of medical waste.

All medical wastes transported from the generating facility to an offsite treatment facility must be contained in red plastic bags ("red-bagged") and sharps containers that are clearly labeled with the biohazard symbol. As required by the MWMA, all medical waste containers must be individually tracked from pickup through treatment. Many medical waste haulers have implemented computerized tracking systems to monitor the movement of any given container of medical waste to be in compliance with the MWMA.

SQGs also use one other method for transportation of used sharps to medical waste haulers or offsite treatment facilities. The transportation method is known as "sharps mailback." Sharps mailback involves the generator placing the sharps wastes in a special rigid container and mailing the container to a medical waste hauler or offsite treatment facility through the

Approximately 14 percent (80/584) of all SQGs report use of Isolyser® to treat sharps. 56 percent of all Isolyser® users are dentists, 25 percent are physicians, and 10 percent are veterinarians. Of all SQGs returning questionnaires, 24 percent of dentists, 22 percent of veterinarians, and 8 percent of physicians report using Isolyser®. Thus, the data reveal that about one-fourth of the dentists and veterinarians have chosen the Isolyser® method of treatment for sharps wastes.

Overall, about 16 percent (93/584) of SQGs report some type of onsite sharps treatment. An additional 40 percent (234/584) of SQGs report sending sharps offsite for treatment. Approximately 44 percent of responding SQGs did not indicate either that they treat sharps onsite or that they send sharps offsite for treatment. There are several possibilities that could account for the 44 percent of respondents who did not indicate what they do with sharps wastes:

- Some of these facilities may not generate sharps waste.
- Some may not have identified the onsite treatment that they perform.
- Some facilities may not have identified that they have sharps wastes hauled by a registered medical waste hauler.
- Some of these SQGs may not be handling sharps in compliance with the requirements of State law.

It is possible that some SQGs may not be familiar with State requirements for handling sharps wastes, and thus chose not to specify how their sharps wastes are disposed. The medical waste statute requires that sharps waste which is rendered noninfectious by steam sterilization or alternative treatment method be either destroyed prior to disposal at a landfill, or that public access be prevented.

Fewer data were available on methods used by LQGs to dispose of sharps. Most of the records for LQGs in the Study database result from review of medical waste management plans that are on file with DHS. These plans do not contain details on sharps disposal. For the 63 facilities for which data on this issue are available, the majority of LQGs (79 percent) have their sharps collected by a registered medical waste hauler. Most of the LQGs reporting onsite sharps treatment are using autoclaves for this purpose (5/6 or 80 percent).

Postal Service. Because a majority of SQGs produce only sharps wastes, this method of handling provides an alternative to self-hauling the wastes or contracting with a medical waste hauler. This option is exercised mainly by dentists (28 percent) and veterinarians (16 percent), and to a lesser extent by physicians (7 percent) (Table 3.2).

### 3.6 Offsite Treatment Methods

Offsite treatment of medical wastes refers simply to medical waste that is treated at a facility that is not part of, or associated with, the generating facility. Offsite treatment is conducted at facilities permitted by DHS as medical waste treatment facilities; these facilities do not also generate medical wastes. Under old Title 22, California Code of Regulations (CCR), Article 13, it was common practice for larger medical waste generating facilities equipped with onsite treatment to also function as "offsite" treatment facilities for smaller generators by accepting medical wastes for treatment. Since passage of the MWMA, and with the shutdown of most onsite incinerators, this practice has been mostly eliminated. In fact, only 17 percent of the LQG questionnaire respondents reported that they accept wastes from offsite for treatment by their facility. Anecdotal information suggests that many of these LQG facilities actually receive offsite wastes only from medical facilities technically associated with the LQG. The treatment methods described below are the ones currently in use by California treatment facilities.

#### 3.6.1 Incineration and Steam Sterilization

Incineration and steam sterilization have been described in Sections 3.3.1 and 3.3.2 above.

#### 3.6.2 Microwave

Microwave treatment (irradiation) of medical waste involves treating medical waste by shredding it in the presence of superheated steam, and then subjecting it to microwave energy. The steamed, shredded waste is heated for a specified period of time by a series of microwave generators to kill the microorganisms. The system produces a slightly moist solid residue (Ref. 11). The disinfection process occurs via microwave heating, as opposed to an external heat source (Ref. 15). Any fugitive biohazardous aerosols which might result from the mechanical action on biohazardous waste are captured by maintaining the treatment chamber at negative pressure relative to the outside air, and by means of HEPA (high efficiency particulate are) filters. The resulting waste is unrecognizable as medical waste and may be disposed of as solid waste in a sanitary landfill (Ref. 4 and 11). The system has approval in thirteen other states and is being marketed in those states.

One advantage of microwaving is that it is adaptable for both small and large facilities. The units also can be operated onsite (small benchtop devices) or offsite (large special use devices). Another advantage is that in large special-purpose devices with grinding systems,

waste is rendered unrecognizable as medical waste and significant waste volume reductions are achieved. However these reductions do not necessarily translate to volume savings in landfills, where medical waste treated by other methods compacts well. The large commercial units also are automated and self-contained, requiring little operator training (Ref. 11).

Disadvantages include the potential to emit exhausts of untreated volatile organics, which emit an unpleasant odor; a slight increase in weight of the waste (due to the addition of moisture); and worker exposure to bio-aerosols and possibly microwave radiation. In addition, some landfill operators may refuse to accept treated, shredded waste containing sharps (Ref. 11).

One limitation of microwaving is that it is applicable only to certain waste types. Microwaving is not suitable for animal carcasses, body parts, large pathology samples, large metal objects, or radioactive or chemotherapeutic agents. Table 5.1 provides a summary of the microwave technology.

Health risks associated with microwave systems relate primarily to exposure to pathogens which may either be present on the surfaces of the shredder mechanism or aerosolized during maintenance. Microwaving also has the potential to emit exhaust of untreated volatile organics during loading, cleaning, and/or maintenance. Worker exposure to bio-aerosols and microwave radiation is also a concern (Ref. 11 and 12).

### **3.6.3 Radio Frequency Irradiation**

Radio-frequency irradiation, also known as electrothermal deactivation or dielectric heating, is a method for heating the waste by exposing it to high-strength shortwave radio-frequency radiation. Any fugitive biohazardous aerosols which might result from the mechanical action on biohazardous waste are captured by maintaining the treatment chamber at negative pressure relative to the outside air, and by means of HEPA (high efficiency particulate air) filters. In this process, waste is shredded and then sprayed with water to increase moisture content to 10 percent. The moisture prevents combustion and aids in the heating process. The waste is then placed in insulated containers in a dielectric oven, where it is exposed to low-frequency radio waves. When the waste absorbs the electrical energy, it is heated. Following the heating process, the waste can be disposed in a landfill or used as refuse-derived fuel. Plastics to be used as recycled materials must be segregated at the point of generation. Existing applications of this technology do not include post-treatment segregation of the plastic and fiber streams.

This treatment process is only suitable for large offsite facilities. However, the technology is not for sale; generators must contract with the sole vendor of the technology to have their wastes treated. This process is not suitable to treat animal carcasses, body parts, large pathology samples, or radioactive material. Testing is still underway to determine the effect of this process on air and water quality (Ref. 11).

Workers who enter the treatment chamber need to be equipped with respiratory protection and protective clothing because shredding and compaction can expose workers to airborne microorganisms (Ref. 11).

### 3.7 Types of Medical Wastes Treated Offsite

All types of medical wastes are treated by offsite treatment facilities, although not all types are treated at each facility. For example, treatment facilities that do not have incineration capabilities are prohibited from treating pathology wastes since pathology wastes must be incinerated. Whether or not a facility accepts all types of medical waste, regardless if it is treated at the facility or not, also varies among the facilities. For instance, all BFI facilities accept pathology wastes although such wastes are only treated at the BFI facility in Rancho Cordova (see Section 4.2). However, the other BFI facilities are permitted to temporarily store such wastes until they are transported to the Rancho Cordova facility. Table 4.1 identifies the types of wastes accepted and treated at each facility.

No facility accepts radioactive waste for treatment. All employ measures, general monitoring devices, to detect and prevent the acceptance of low-level radioactive waste.

### 3.8 Residuals Disposal

Residuals generated by onsite and offsite medical waste treatment processes are classified as solid wastes, regardless of the type of treatment. This classification allows residuals to be disposed in class III solid waste landfills.

#### 3.8.1 Onsite Treatment Residuals

Onsite treatment primarily produces two types of treatment residue, incinerator bottom ash and steam-sterilized waste. Incinerator bottom ash is produced during medical waste incineration. Unless the bottom ash contains hazardous constituents, it is classified as a solid waste pursuant to §25023.5, Medical Waste Management Act. Steam sterilized waste has a distinctive appearance resulting from the manner in which the steam sterilization process works. Medical waste is subjected to saturated steam at a minimum of 121°C for at least 30 minutes in a sealed chamber. The steam, under pressure, penetrates a special autoclave bag (made of porous polypropylene) in which the red bags and sharps containers

holding medical wastes have been placed. The red bags are normally melted during the sterilization process and the air is forced from the bag. When removed from the steam sterilization unit after processing, the waste, now classified as solid waste, may appear to have been tightly shrink-wrapped.

The treated medical waste is then disposed to the facility's solid wastestream. For hospitals, steam-sterilization residue comprises about 15 percent of the facility's total solid waste. The solid wastestream, depending on the solid waste management system in the community in which it is generated, is hauled off, either directly to a solid waste landfill or initially to a transfer facility. Solid waste haulers and/or facility operators generally are aware of waste collection vehicles that contain solid wastes from a hospital or other large medical facility and, consequently, monitor the loads from those vehicles closely for any untreated medical wastes. A growing number of solid waste facilities, out of concern for worker safety, refuse to accept autoclaved waste containing sharps.

### **3.8.2 Offsite Treatment Residuals**

Incineration of medical waste produces nonhazardous bottom ash, and steam sterilization produces decontaminated, "shrink-wrapped" solid wastes. Residues from the microwave disinfection unit employed by IES in Oakland are particle-sized solid wastes which are a result of the medical wastes being shredded prior to treatment. Residuals from these treatment processes are considered solid waste.

The Stericycle facility, which uses an electrothermal deactivation unit for waste decontamination, generates recovered plastics for recycling, and refuse-derived fuel. The refuse-derived fuel is used by a waste-to-energy solid waste incinerator facility in Long Beach, California.

Residues produced from offsite treatment facilities are handled at the facilities as solid wastes. For example, decontaminated wastes from a steam sterilization unit are removed from the unit and placed in a roll-off container for transport to a solid waste landfill. Treatment residues are taken directly from the facility to a solid waste landfill. Care must be taken that residues do not first pass through a solid waste transfer facility. In the survey/telephone interview of medical waste treatment facilities, no restrictions or special requirements imposed by solid waste facility operators for disposal of treatment residues

were reported by an offsite treatment facility. However, information outside this study indicates the existence of Class III sites in jurisdictions studied which refuse to accept waste containing treated syringes and hypodermic needles. The fact that no offsite treatment facility employing steam sterilization has implemented a process to destroy sharps wastes may be explained by their location in jurisdictions less concerned about the issue.

Concerns related to handling of medical waste treatment residuals (solid wastes) at solid waste facilities are discussed in Chapter 4.



## Chapter 4: MEDICAL WASTE TREATMENT AND DISPOSAL CAPACITIES AND CONCERNS

### 4.1 Overview

At the request of CIWMB, SAIC obtained information regarding treatment and disposal practices and capacities in California from questionnaires, site interviews and telephone surveys. Based on the information obtained, SAIC evaluated existing treatment and disposal capacities to determine whether any current and anticipated demand can be met by these facilities.

### 4.2 Data Sources

Much of the information in this chapter was obtained from a questionnaire survey of solid waste haulers and collectors, and solid waste facility operators, and a telephone interview of medical waste management program personnel and solid waste enforcement agencies in the ten counties selected for data acquisition. The details of each questionnaire and the telephone interviews are presented below.

#### 4.2.1 Solid Waste Haulers and Collectors

Contract, franchised, and other registered solid waste haulers and collectors in the ten selected counties were surveyed using a questionnaire, a copy of which is presented in Appendix 4. Mailing lists were obtained from the counties. Questionnaires designed to elicit information reflecting their perspective were sent to 76 haulers. Unfortunately, only eight responses were received from haulers - a rate of return of 10 percent.

The solid waste haulers and collectors were surveyed to determine whether they have experienced any operational difficulties as a result of handling legally treated medical waste residues. This information was sought in order to acquire information more qualitative in nature regarding the potential for problems within municipal solid waste operations due to disposal of treated medical waste residues.

This community was also asked about the occurrence of untreated or inadequately treated medical wastes, as medical waste generators who legally treat medical wastes may be less of a concern to haulers and collectors than medical waste generators who mismanage and illegally dispose of medical wastes. On one hand it could be contended that known medical waste generators are not a problem; that it is the unregistered medical waste generators who mismanage and illegally dispose of medical wastes. On the other hand, anecdotal information points to rare but noteworthy problems having significant effect on solid waste management operations brought by legally treated medical waste. It is the latter information which this portion of the study sought to resolve.

None of the haulers who responded reported problems with treated or untreated medical wastes. This may be explained by the fact that, of the total solid wastestream state-wide, less than two-tenths of one percent is non-household medical waste.

#### **4.2.2 Solid Waste Facility Operators**

Solid waste facility operators in the ten selected counties were mailed the Solid Waste Facility Operator Survey. A copy of this survey is presented in Appendix 5. A total of 66 facilities were mailed surveys; 20 facility operators responded, for a return rate of 30 percent.

Information was obtained from solid waste facility operators for a purpose similar to that for solid waste haulers and collectors. Information from this group augments information from the survey of SQGs, LOGs, and treatment facilities. Such information should provide insight into the degree to which treated medical waste residues impact the operations of solid waste facilities. To a lesser extent, information from solid waste facility operators may confirm MWMA Enforcement Agency data on illegal disposal.

#### **4.2.3 Enforcement Agencies**

Telephone interviews of enforcement agency personnel in the ten select counties and DHS were conducted. The enforcement agencies are responsible for responding to occurrences of illegally disposed untreated medical wastes. The telephone interviews were conducted to obtain information regarding occurrences of and problems with illegally disposed untreated medical wastes. Since, in most instances the Medical Waste Management Act EA (enforcement agency) is also the CIWMB certified LEA, the telephone interviews were directed at ascertaining a great deal more than illegal disposal. Any type of problem noticed by the interviewee, be it illegal disposal or solid waste management difficulties, could be brought up in the interview. Appendix 7 is the interview matrix, upon which the protocol was based. Similar to one of the purposes for conducting a mail survey of solid waste collectors and facility operators, information from the telephone interviews was used to develop an understanding of the impact of the treated and untreated medical waste stream upon the municipal solid waste disposal scheme.

#### **4.3 Treatment Facilities and Capacities**

The surveys of treatment facilities were designed to identify their locations, capacities, treatment methods used, characteristics of residues and disposal practices. Currently, nine offsite treatment facilities are operating in California. Eight are permitted by DHS. The remaining unpermitted facility has applied for a permit. Five of the facilities treat medical waste by steam sterilization, one employs steam sterilization and incineration, one incineration, one incineration and microwave, and one radio frequency irradiation. The

information on offsite treatment facilities was obtained from each facility's permit application files maintained by DHS and from a questionnaire soliciting the treatment facilities' unique perspective of the waste stream.

As shown in Table 4.1, the offsite treatment facilities handled approximately 49,883 tons (100 million pounds) of medical waste in 1991.

**TABLE 4.1 Offsite Treatment Facilities and Types of Treatment Provided**

Facility	Treatment Technology	1992 Amounts Treated pounds/month *1991 amounts	Accepted	Permitted Capacity pounds/month	Waste Types Treated <sup>1</sup>
BFI-Fresno	Steam Sterilization	1,029,000	1,050,000	1,300,000	All except pathology
BFI-Rancho Cordova	Incineration	584,000	1,050,000	1,300,000	All
BFI-San Diego	Steam Sterilization	792,600	817,000	2,036,000	All except pathology
BFI-Vernon	Steam Sterilization	1,866,225	1,882,326	2,615,000	All except pathology
Stericycle	Electrothermal Deactivation	2,140,000 (estimated capacity)	Not reported	2,140,000	All except pathology
Integrated Environ. Systems (IES)	Incineration/Microwave	I:720,000* M:432,000*	Not reported	1,800,000	All
TCI	Incineration/Steam Sterilization	I:127,500* S:722,500*	Not reported	1,512,000	All
Security Environ. Systems (SES)	Steam Sterilization	1,300,000*	Not reported	500,000	All except pathology
Medical Waste Environ. Eng. (MWEE)	Steam Sterilization	20,000	22,500	365,000	All except pathology

BFI ships wastes to Rancho Cordova from all other facilities; MWEE ships chemotherapy and pathology waste to incinerator.

Facilities exclude radiological waste but treat trace chemotherapy contaminated materials. Pursuant to Section 25020.5(g) of the MWMA, waste containing trace chemotherapeutics must be incinerated. Quantities greater than trace fall under the jurisdiction of the Department of Toxic Substances Control (DTSC).

The nine operating treatment facilities in California estimate that they handle roughly one-half to two-thirds of the medical waste generated in the State (depending on their service area). Most offsite treatment facilities operate independent of one another, however, the facilities operated by BFI coordinate the treatment of medical waste types between the facilities depending on treatment capabilities of each facility. Therefore, it is possible that some medical wastes might need to be transported substantial distances in order to be treated using the appropriate technology, if that technology were not available nearby.

The treatment facilities generally receive medical wastes from a given region or regions of the state. A facility, for example, in the Los Angeles area would not receive wastes from northern California counties. Information from the questionnaire respondents and the DHS file review was merged to provide some insight into which facilities are serving the medical waste generators in various regions of the state. This information is summarized below in Table 4.2. The regions designated for the purpose of this discussion are indicated on Figure 4.1.

**TABLE 4.2**      **Number of LQGs Using Various Treatment Facilities by Region (See Figure 4.1)**

Treatment Facilities	REGIONS							
	1	2	3	4	5	6	7	8
BFI-Fresno	7	19	0	0	16	5	1	0
BFI-Rancho Cordova	2	11	5	0	1	0	0	0
BFI-San Diego	0	0	0	0	0	0	1	4
BFI-Vernon	0	0	0	0	1	0	86	4
IES-Oakland	11	10	0	0	0	0	0	0
SES-Vernon	0	0	0	0	0	2	53	4
Stericycle-Loma Linda	0	0	0	0	0	0	1	2
TCI-Colton	0	0	0	0	0	0	17	9
Other/Not indicated	18	14	3	0	7	9	54	11

FIGURE 4.1

COUNTIES INCLUDED IN REGIONS  
DESIGNATED IN TABLE 4.2



#### **4.4 Assessment of Treatment Capacity Demand**

Currently, the medical waste management system in California enjoys a surplus of treatment capacity for medical wastes. Currently, the medical waste management system in California enjoys a surplus of treatment capacity for medical wastes. As can be determined from Table 4.1, most of the nine offsite treatment facilities in the state are operating below their maximum capacities. Overall, across all treatment facilities, only 66 percent of existing capacity was utilized in an average month during the period 1991-1992. Respondents to the offsite treatment facility survey do not expect that this surplus will be depleted, as they expect the amount of waste treated offsite to remain constant over the next few years.

There is stiff competition between the treatment facilities to gain or maintain a share of the medical waste market. Therefore, if medical wastes sent offsite for treatment were to increase substantially, it appears likely that offsite treatment facility operators will increase their capacities for treatment, and/or add new facilities.

Finally, total treatment capacity in the state will increase as more facilities install onsite treatment equipment. One sales representative for a major steam sterilization unit manufacturer estimates that it has installed its units in only 15-20 percent of the "eligible" hospitals in California. It should be noted that this manufacturer has installed roughly one-half of the steam sterilization units in the state.

#### **4.5 Assessment of Residuals Disposal Demand**

As discussed in Chapter 2, it is estimated that medical wastes comprise between 0.12 and 0.16 percent of the solid wastestream in California. Residuals from offsite treatment facilities would comprise some smaller percentage, both because not all medical wastes are treated offsite, and because some forms of offsite treatment reduce volume.

Regionally, as identified in Table 4.1, the offsite medical waste treatment facilities in the state typically receive medical wastes from a distinct region or regions. Due to the very small percentage of medical waste in the total solid wastestream, and the fact that offsite treatment facilities are distributed throughout the state, it appears unlikely that any region's solid waste landfill capacity would be affected by medical wastes residuals. Existing disposal options for medical wastes appear to be adequate in California.

#### 4.6 Treatment and Disposal Concerns

Treatment and disposal concerns identified in the surveys focused in two general areas: household wastes, which the MWMA does not include in its definition of medical wastes; and problems associated with regulated wastes. According to the results of the questionnaires and telephone interviews, the occurrence of untreated medical wastes in the solid wastestream is uncommon. Discussion of untreated regulated medical wastes is not the purpose of this report, and will not be further addressed here.

##### 4.6.1 Household Medical Wastes

Household medical waste is both a public health and safety and a solid waste handling problem because it represents a potential hazard in a solid wastestream to which either the public or solid waste management personnel may become exposed. Solid waste management personnel would be exposed during waste collection and handling at a solid waste management facility. However, at a solid waste management facility wastes are normally handled entirely by equipment and waste management personnel are trained to minimize direct handling of any wastes; therefore, it is unlikely that there would be any direct contact.

The exception, as identified by a questionnaire respondent, is a recycling or material recovery facility (MRF). Such facilities often utilize hand-sorting of materials. The respondent that identified this problem reported that facility personnel encounter medical waste on a daily basis. Used needles generated by households are the most frequently encountered identifiable medical waste. Section 25023.8(d) of the MWMA exempts this category of waste from coverage under this Act. Household-generated needles may be a substantial and growing concern considering the increase in waste handling, particularly hand-sorting, that is likely to occur as cities and counties strive to meet the diversion requirements of the Integrated Waste Management Act of 1989 (Assembly Bill 939).

Household medical waste also may be deposited in refuse containers that are accessible to the public or may be littered in areas where it might be encountered by the public. Although there is a perception among the public that household-generated medical wastes are a health concern, in fact, documented exposure to these wastes (as reports to county health departments) was found in the study to be highly uncommon. The greatest problem from households, as perceived by questionnaire respondents, is improperly contained sharps waste.

#### 4.6.2 Regulated Medical Wastes

Medical waste treatment residues enter the solid waste system from facilities with onsite treatment and from offsite treatment facilities. Treated medical waste is solid waste and special tracking is not required.

Treated medical wastes in the solid wastestream present problems and concerns to solid waste management personnel not from the point of exposure to biohazardous wastes (since the wastes are sterilized or disinfected) but from the potential for exposure to soil- or waste-borne pathogens as a result of any injury which may occur when treated sharps wastes are handled. Most of the concern with treated medical wastes in the solid wastestream is from the medical wastes treated by steam sterilization, since sharps are not destroyed during the process. In contrast, treatment by microwave or radio wave (which include grinding) or incineration all ensure that sharps are destroyed during the process.

Sharps from a steam sterilization treatment process are contained within the treatment residue in the original sharps containers. However, there is concern that the sharps may be freed from their containers during compaction at a landfill facility or the "shrink-wrapped" bag containing the treated waste may be broken open at a transfer station or landfill facility.

According to steam sterilization unit sales representatives, the concern is not because treated sharps wastes are infectious, but because the wastes can cause injury. In response to this concern, and as required by Section 25091 (c) of the Medical Waste Management Act, as amended in 1993, some medical waste generating facilities with onsite steam sterilization have recently implemented procedures to process sharps containers separately from other medical wastes to facilitate the destruction of the sharps and containers after they are decontaminated. Destruction is achieved through the use of specialized equipment that shreds sharps wastes into fine pieces.

Because solid waste facility operators are aware of the potential problems (including perceived hazards at public sites) associated with treated medical wastes, most have implemented procedures to handle such wastes, including isolating and immediately covering the wastes at a landfill. One landfill facility operator in San Diego County reported that no problems have been encountered with treated medical wastes despite the facility receiving substantial quantities from the BFI medical waste treatment facility in San Diego. Other questionnaire respondents stated that there have been no reported impacts to a hauler's or facility's operations from the handling of treated medical wastes. Enforcement agency personnel also indicated that medical waste disposal incidents reported to them by solid waste facilities are almost nil.

## Chapter 5: EVALUATION OF INNOVATIVE MEDICAL WASTE TREATMENT AND DISPOSAL TECHNOLOGIES

### 5.1 Overview

The purpose of this section is to identify new technologies for the treatment and disposal of medical waste and to discuss the potential environmental and health risks associated with these technologies. Alternative medical waste treatment and disposal methods are being developed nationally. Some of these technologies have been approved for use in California, however, they were not employed in the State as of early 1993. Other technologies have been submitted to DHS for approval. This section discusses the potential impacts of these new technologies on human health and the environment and on the solid waste system.

To qualify as medical waste treatment, each of these processes is subject to specific minimum standards and limitations (California Health and Safety Code Section 25090).

In the five years that have passed since the U.S. Environmental Protection Agency (EPA) initiated a Demonstration Program (pursuant to the Medical Waste Tracking Act of 1988) there has been a proliferation of medical waste treatment technologies offered by vendors hoping to capitalize on mandated requirements for treatment and destruction. Ranging from new, more efficient steam autoclaves to proposed processes such as gamma irradiation, these technologies offer medical facilities a wide selection of choices in how to treat their medical wastes.

The State of California has responded to the proliferation of treatment methods by requiring vendors to share the costs of evaluation. Vendors are required to develop a testing protocol, follow specified microbiological test procedures, and pay a \$1,000 application fee. Once the process is approved, the vendor is issued a five-year permit to use that process within the State. California is also participating in efforts currently underway at a national level to develop testing and certification protocols that could be followed by all states to streamline the treatment technology approval process (Ref. 4).

### 5.2 Types of Treatment

Article 9 of the Medical Waste Management Act sets out methods whereby medical waste may be treated to render it solid waste (as defined in §40191 of the Public Resources Code (see §25023.5, of the Medical Waste Management Act). Section 25090 (of the Medical Waste Management Act) specifies standards for (a) incineration, (b) discharge to public sewer and (c) steam sterilization. In addition, subdivision (d) states that other alternative

methods may be acceptable if they are (A) approved by the department and (B) result in the destruction of pathogens. Each of the new treatment technologies reviewed below may be approved by DHS acting in its authority under subdivision (d). A summary of all treatment types is provided in Appendix 8.

Although companies may be named as offering certain treatment technologies described in the following sections, the named companies may not be the only purveyors of such technologies, and these sections are not intended as and should not be considered as a complete register of such companies, since changes are frequent. A current list of Alternative Technologies for Treatment of Medical Waste may be obtained from the Department of Health Services Medical Waste Management Program by phoning (916) 327-6904.

### 5.2.1 Thermal Treatment Technologies

Of the three thermal treatment technologies described below, only one, dry heat sterilization, is currently approved for use in California. The study did not provide evidence that this technology is currently in use in the state. Plasma arc has been submitted to DHS and is awaiting approval; pyrolysis has not yet been submitted for review.

#### Dry Heat Sterilization

Dry heat sterilization, also called thermal inactivation, is a method for sterilizing infectious wastes or reusable medical instruments by exposure to heat in the absence of added moisture. The relatively dry environment protects sharps and other steam-sensitive instruments from corrosion during treatment. The process is applicable to both solid and liquid medical wastes. Liquid wastes are treated by a coil or heat exchanger, while solid wastes are treated in an oven chamber. The heat is sufficient to destroy any pathogens present. Dry heat sterilization is not as efficient as steam sterilization due to the lack of steam penetration of the waste. Therefore, to be effective, treatment temperatures must be elevated and/or treatment cycles extended for each waste load (Ref. 10).

Two dry heat systems have received approval from DHS. One facility, Disposal Sciences, Inc., in Englewood, Colorado, offers the Sharps Disposal System (DSI) which uses a dry heat sterilizer in combination with a grinder to treat medical waste sharps. First, reusable sharps collection devices are provided by the vendor. Once filled, the containers are inserted into the portable DSI unit for sterilization. The sharps are ground and rendered noninfectious at the point of use, such as at the nursing station or the clinical office (Ref. 4).

The second approved system in California treats a broader spectrum of medical wastes by dry heat. "MedAway-1," marketed by MedMark International, is a portable system for rendering noninfectious medical wastes such as needles and syringes, Petri dishes, culture plates, and red-bagged waste.

A third dry heat sterilization system submitted to DHS for approval, developed by Spintech, Inc., treats wastes deposited in a canister roughly the size of a coffee can. This system is approved for treatment of sharps only.

One advantage of the sharps disposal system application of dry heat sterilization is there is no liquid discharge, but air emissions from the process are unknown (Ref. 10 and 7). One disadvantage of the original dry heat sterilization processes was their extensive time and energy requirements. A typical dry heat cycle requires temperatures of 320 to 338 degrees Fahrenheit for two to four hours (Ref. 19).

### Plasma Arc

In plasma arc reactors, infectious waste is "vaporized" at temperatures exceeding 3,000 degrees Fahrenheit by the application of highly ionized compressed air. In a plasma arc torch, an electrical arc is discharged through a highly ionized gas, converting the electrical energy to heat. (Lightning is the most common natural example of plasma energy.)

The reactor chamber is a refractory lined vessel which contains: 1) a waste receiving port at the top where waste is loaded into the chamber; 2) a basin at the bottom to collect molten metal and a port that draws off the slag from the basin; 3) an off-gas nozzle to draw off the fuel gases created from the decomposition of the waste; and 4) a plasma arc torch. The waste is fed into the reactor chamber where operating temperatures are between 3,000 and 3,500 degrees Fahrenheit. At these temperatures the waste is chemically changed into two basic components: molten silica-based slag, and off-gases (which can be used as a fuel gas).

Two companies have submitted applications to DHS for plasma torch or "plasma arc" systems. The first application was submitted by Kaiser Permanente in conjunction with a local utility and the second is Retech, Inc.

A third company has projects "under development" in California, Alabama, North Dakota, South Carolina, and Virginia (the Virginia project is for solid waste only), and was granted Alternate Technology Approval in May of 1994. This company, Plasma Energy Applied Technology, located in Norcross, Georgia, states that the advantages of the technology are its low air requirements (1/100th or less than fossil fuel heaters), its high efficiency (85 to 93 percent), and its ability to use a wide variety of gases, including air, helium, hydrogen, argon, and nitrogen (Ref. 11).

The Minnesota Healthcare Partners (Ref. 11) report that the disadvantages of treatment by plasma torch include the requirement for advanced pollution control equipment; the large consumption of electricity and water; the requirement for highly trained employees; the relatively large capital equipment cost; and potentially high operating costs. Air emissions containing low levels of some regulated elements such as heavy metals are also present.

### Pyrolysis

Pyrolysis converts infectious waste into gases and ash using high temperatures (ranging from 800 degrees to 3,500 degrees Fahrenheit) in the absence of air. EnviMed Compliance, Inc., of Rocky Hill, New Jersey has conducted testing and development of this process. A quantity of 20 gallons of infectious and pathology waste is loaded into a sealed vacuum chamber, where it is heated to 800 degrees Fahrenheit. The waste is pyrolyzed (complex molecules are broken down into smaller ones) in the absence of air. The resulting vapors are captured and treated in a second sealed chamber by oxidation at a temperature of 1,000 degrees Celsius. Gases resulting from the oxidation process, which can vary in composition from carbon dioxide and water vapor to hydrogen and carbon monoxide, are filtered and scrubbed prior to discharge.

Medispose of Charlottesville, Virginia has developed a pyrolytic processor capable of treating medical waste on the "hundreds of pounds per hour" scale. They claim reduction of waste to 5-7% of initial weight and 2% of initial volume, again with negligible dioxin formation.

The pyrolysis process appears to handle the full range of infectious and pathology waste. Advantages are that the process completely destroys infectious and pathology waste and achieves significant reductions in waste weight and volume. One manufacturer also claims that by-product gases can be reused, and that the high operating temperatures minimize the formation of dioxins (Ref. 11).

Disadvantages include the possible difficulty of disposing of the ash (since heavy metal contaminants will be present), air emissions possibly containing particulates and heavy metals, the requirement for air pollution control equipment, the large consumption of electricity, the large capital investment, and potentially high operating costs (Ref. 11).

In addition to the testing conducted by EnviMed Compliance, Inc., and Medispose development, Zytel, Inc., in Mt. Prospect, Illinois, has also conducted demonstration testing in Italy (Ref. 11). None of the above firms is currently approved as an alternate technology by DHS.

## 5.2.2 Chemical/Mechanical Treatment

Chemical/mechanical systems are combined systems for shredding the waste and then disinfecting it with a solution containing chlorinated or other chemical compounds. When liquid disinfectants are used, two types of systems are available: closed systems, which recirculate the treatment solution, producing a wet solid residue; and effluent systems, which produce a wet solid residue but which also discharge the diluted treatment solution into a large volume of water (Ref. 11). Recognizable anatomical parts must be incinerated or interred pursuant to § 25090.5, and are therefore not treated using these methods. Conventionally, "pathology waste" is incinerated, even at locations where treatment of the rest of the waste is accomplished by other means.

As noted in EPA's *Guide for Infectious Waste Management* (Ref. 19), chemical disinfection processes are most appropriate for liquid wastes, although they can be used to treat solid wastes if the solid wastes are adequately exposed to the chemical disinfectant. For this reason, mechanical processes such as grinding or shredding are used in conjunction with chemical disinfection. To ensure that adequate treatment of a specific waste can be achieved, the following factors should be considered when making a determination to use chemical disinfection: the types and biology of microorganisms of the wastes; the degree of contamination; the type of disinfectant used; its concentration and quantity; the contact time; and mixing requirements.

The chemical/mechanical treatment processes described below are organized according to type of chemical. Both chlorine-based compounds and other known chemical treatment solutions are discussed. Three vendors have obtained approval in California for small chemical treatment systems not involving grinding or shredding. Two additional vendors have been approved by DHS for marketing larger, chemical/mechanical systems.

### Chlorination/Chlorine Derivatives

Chlorination and chlorine derivatives, specifically hypochlorite and chlorinated isocyanurates, have been used in small clinics and doctors' offices for some time to disinfect reusable equipment. Their application to medical waste began with the introduction of portable sharps disposal systems.

A number of vendors offer onsite sharps disposal systems that grind and chemically disinfect waste sharps. Three such systems are currently approved for use in California (Ref. 4).

In the new large chemical/mechanical treatment systems, medical waste is shredded either with high-speed hammermill blades or with shredders, using large amounts of water treated with chlorine-based disinfectant. The system creates a liquid waste, which is discharged to the sewer. The system is designed for onsite use and has been accepted in a number of states by a variety of manufacturers.

Two large chemical/mechanical treatment systems have been approved in California. One of these, the Infectious Waste Disposal System, operated by Medical SafeTEC, Inc., has been approved in 23 states. The units treat red-bagged waste and sharps waste by grinding and disinfecting with sodium hypochlorite. Individual units require a permit by the appropriate administering health or environmental health agency. The other system is the Condor Medical Waste Treatment System, operated by Winfield Industries (Ref. 4). This system uses a mechanical shredder and chemical oxidizing method. The sanitizer is a solution of chlorine dioxide, made onsite by mixing sodium chlorite and citric acid. Bagged medical waste is placed into the treatment machine, which shreds the bagged waste, sprays it with treatment solution, and grinds it (Ref. 11). Residual solution is recycled, with additional chlorine dioxide added to keep the necessary treatment concentration.

Two additional companies have applied to DHS and are awaiting approval for large chemical/mechanical treatment systems. Ecomed and Premier Medical Technologies, Inc. both offer systems using a chemical disinfectant with a shredder.

Advantages of chemical/mechanical treatment are the volume reduction achieved (Medical SafeTEC reports an 8:1 reduction); the relatively low operating costs; and the design of some of the units which are automated, self-contained and enclosed, thus requiring little handling. In addition, some units have minimal liquid effluent (Ref. 11).

Disadvantages of chemical/mechanical treatment include its lack of suitability for body tissues, animal tissues, large metal objects, radioactive material, and any material incompatible with chlorine. Radioactive material may not be treated as medical waste (Section 25025.2 of the MWMA). The toxicity of chlorine requires special handling and disposal, and requires increased maintenance. In addition, because of the added water the weight of the waste increases significantly despite the volume reduction. Liquid effluent must comply with local sewer regulations, and facilities expecting to install such devices should first check with the local sewer authority to determine the limitations which would apply to an effluent discharge. There are also potential environmental concerns associated with air emissions (employee exposure) and disposal of the treated solids (residual chlorine).

One chlorine-based disinfecting system has been approved for the treatment of liquid waste only. The Saf-Gard Suction Sanitation System, offered by Compliance Resources, Inc., is a suction canister liner containing a germicidal agent to decontaminate blood and body fluids. Disposal in a class III sanitary landfill is limited to specific conditions.

### Other Liquid Disinfectants

A number of other liquid disinfectants have been used to treat medical wastes in chemical/mechanical systems. These solutions include iodophor, alcohols, and glutaraldehyde. All of these solutions are effective in killing vegetative bacteria and lipophilic viruses, and all but alcohols are effective in killing hydrophilic viruses and bacterial spores.

These alternatives to chlorination or chlorine-based solutions are used in the same manner as their chlorinated counterparts, and the contact time required for disinfection (e.g., 10 minutes for lipoviruses and 30 minutes for a broad spectrum of pathogens) is the same for all solutions.

One advantage of these alternative solutions is their shelf life. All can be stored for more than one week, while chlorine-based compounds cannot. A disadvantage of these solutions is that they cannot be used to treat liquid wastes; chlorine-based compounds must be used for that purpose.

Some of the chemical/mechanical systems approved in the State specify that they use chlorine-based compounds, but it is quite possible that these vendors use alternative chemicals as well.

### **5.2.3 Irradiation Treatment**

Several methods of applying radiant energy have been used extensively for the treatment of medical waste in areas other than California. Of those, non-ionizing sources have been favored by both manufacturers and communities where installations have been proposed since the energy they transmit cannot impart radioactivity in the treatment residue. Five methods for treating medical waste with irradiation are described below. Two methods, microwave irradiation and electrothermal deactivation, are approved in California. At the time of this writing, one method, electron beam treatment, had been submitted to DHS for approval. The other two methods, gamma irradiation and ultraviolet irradiation, had not been submitted to California for approval.

#### Electron Beam

Electron beam treatment is widely used for sterilizing medical devices, implants, and reusable medical supplies, and is now being tested for use in treating medical waste. In this process, infectious waste is treated in its original container by exposing it to electrons for 1 to 3 minutes from a non-radioactive electron beam generator. The treated waste is then shredded (Ref. 11).

As the electrons enter the waste material, they create highly reactive molecules that can destroy microorganisms or change the organism's molecular structure. The small quantities of ozone and hydrogen peroxide created as a by-product of the process, combined with the effect of the electrons, render the waste non-infectious while not making it radioactive (Ref. 11).

The effectiveness of the electron beam technology is a function of the radiation the waste receives. The speed of the conveyor (which determines how long the waste is exposed to the beams), and the intensity of the beam are the key variables. Online electronic equipment is used to continually monitor the dose rate of the beam, the distribution of the electrons within the waste material, and the amount of electrons absorbed (Ref. 11).

The electron beam treatment process can handle large volumes of waste in a short period of time. Its potential capacity is 25 to 30 tons per day. Filled drums or boxes are loaded onto an automatic conveyor belt and scanned by the electric beam for a designated amount of time (approximately one to three minutes). This process requires little waste handling.

In addition, the waste is treated prior to shredding, eliminating the occupational exposure risks often associated with the shredding process when shredding occurs before treatment (as in Stericycle and microwave treatment). A full electron beam package requires only 8 square feet of floor space (Ref. 11).

The major disadvantage is that electron beam treatment is expensive. In addition, safety precautions are necessary to prevent employee exposure to electron beams. Shredding must be performed following the electron beam treatment process because the irradiation itself does not change the appearance of the waste; thus, it may not be apparent that a waste has been subjected to treatment. As in most treatment methods involving grinding or shredding, metals can pose problems for the shredder, and the shredder can jam if improperly fed. Metal is also an impediment to electron beams (Ref. 11).

Most of the information that is available about the application of electron beam technology to medical waste has been provided by Nutek Corporation. Nutek's electron beam technology has been granted approval in California. However, they have not yet acquired a medical waste treatment facility permit.

### Gamma Irradiation (Cobalt 60)

One treatment process that has been proposed for the treatment of medical waste, but which is not yet being used for that purpose, is gamma irradiation. Microbial inactivation is accomplished by hydrolyzing water molecules (to  $H_3O^+$  and  $OH^-$ ) within the microorganisms, rendering the waste noninfectious.

One company developing this treatment process also shreds the treated waste to render it unrecognizable. This company also plans to reuse the shredded, treated waste by shipping it to a cement kiln for use as a fuel. Another company plans to separate and recycle the treated plastic residues (Ref. 12).

The Research Triangle Institute reports the process to be highly predictable (Ref. 24). The conditions required for disinfection can be verified using *Bacillus pumilis* or other appropriate test indicator organism. EPA does not recommend (nor would the California Medical Waste Management Act permit) the use of gamma irradiation for treating pathology wastes (Ref. 12).

### Ultraviolet

Ultraviolet (UV) irradiation is used extensively in the treatment of wastewater and is also marketed as a swimming pool and spa water purifier, but is not known to be under consideration for development as a treatment process for non-liquid medical wastes. In its application as a treatment for wastewater, UV is used as a tertiary treatment prior to discharge (Ref. 10). Since most liquid medical wastes are currently discharged to sanitary sewers, medical waste generators and treatment facilities are not likely to be in the market for UV irradiation.

## 5.2.4 Other Treatment Technologies

### Electric Needle Destroyers

A relatively new technology is available in California for dealing with used syringes or hypodermic needles. The technology involves melting the needle while it is still attached to the syringe by inserting the needle into a device resembling an electric pencil sharpener. The device applies an electrical charge to the needle, melting it into a metal ball, or in one device, into a drop of ash. The syringe and resulting metal "hub" are not considered to have been treated, and therefore must still be handled as medical waste.

Although this strategy treats only a portion of the waste, generators (dentists, for example) whose medical waste is predominantly needles may find that this substantially reduces the major component of their medical waste stream.

One such system, "The Needlyzer," offered by Bio-Safety Instruments, Inc., has already been approved in California. Use of this technology does not require a permit from DHS. The system is designed for use in medical offices. Two other vendors have applied to DHS for approval of their similar systems; one called an "Electric Needle Destroyer, and the other called the "Needle Zapper."

### Gas/Vapor Sterilization

The sterilizing agent in gas/vapor sterilization is a gaseous or vaporized chemical disinfectant, such as ethylene oxide or formaldehyde.

The use of ethylene oxide for sterilization is an example of gas sterilization. This gas is commonly used to decontaminate surgical instruments in hospitals and industry, and may have applications for medical waste treatment. Wastes which could potentially be adequately treated using ethylene oxide would include sharps and other dry solid objects with no associated liquids. However, the probable carcinogenicity of ethylene oxide is a strong deterrent to using this substance for medical waste treatment. This treatment method could expose workers to a risk that should be balanced against the other options available to treat the wastes (Ref. 10).

Formaldehyde is classified as a chemical disinfectant when used in solution, however, EPA also recognizes formaldehyde as a gaseous/vapor disinfectant. In either state, formaldehyde is effective in killing vegetative bacteria, lipoviruses, non-lipid viruses, and bacterial spores. Formaldehyde is used in much the same way as chlorine-based compounds in chemical/mechanical disinfection. It requires the same contact time (e.g., 10 minutes for lipoviruses and 30 minutes for a broad spectrum of pathogens). Formaldehyde has a longer shelf life than chlorine-based compounds (e.g., more than one week). Formaldehyde in a gaseous state is not used to treat liquid wastes, as penetration would not be efficient at atmospheric pressure.

### **5.3 Residuals**

Dry heat sterilization processes, including the Sharps Disposal System, "Medaway-1" and others of this type, produce a plastic disk which can be disposed as solid waste. Needle fragments are safely encased in the disk, precluding the risk of puncture. Since, at temperatures reached in plastic extrusion, foreign material such as needles may be separated, a potential for recycling mixed plastics exists. These dry heat sterilization methods reduce waste volume onsite, without the need for disposable sharps containers.

The manufacturer claims that the glass-like slag from plasma torch reactors is nonleachable and can be disposed in a sanitary Class III landfill or sold to a concrete plant for reuse as building aggregate or road fill (Ref. 11).

Pyrolysis produces an ash which represents less than one percent of the original waste volume and two percent of the original mass of the waste.

Large chemical/mechanical treatment systems use liquid disinfectants which must be disposed when spent, and produce a wet solid residue that can be disposed of as solid waste (Ref. 11).

Isolyser's Sharps Treatment System (STS) generates a semisolid-encased mass of disinfected syringes in a compactor-resistant container which may legally be disposed to the municipal waste stream. The Liquid Treatment System (LTS), produces a disinfected gel, which may be disposed of as solid waste.

The treated waste from electron beam treatment is shredded after irradiation. The residue produced is sterile, and can be handled as a solid waste.

Manufacturers developing the gamma irradiation treatment technology have proposed using the shredded, treated waste as fuel in a cement kiln or alternatively, separating and recycling the treated plastic residues (Ref. 12). The treated waste would be considered a solid waste and can be managed just as any other recyclable waste.



## Chapter 6: POTENTIAL ENVIRONMENTAL EFFECTS AND HEALTH RISKS OF MEDICAL WASTE TREATMENT AND DISPOSAL METHODS

### 6.1 Overview

The purpose of this chapter is to discuss the potential environmental and health risks associated with the treatment and disposal of medical waste in California. Alternative medical waste treatment and disposal methods are being developed. However, these technologies must be evaluated to determine the risks to human health and the environment. This chapter discusses the potential impacts of these new technologies and compares them to existing treatment and disposal methods. Because many of the new technologies are in the developmental stage, little is known about their emissions, and subsequently it is difficult to assess their risks. This chapter summarizes the currently available information on these technologies. The health and environmental impacts of these technologies is summarized in Appendix 9.

### 6.2 Background

The health risks associated with medical wastes are primarily occupational, and recent improvements in worker health and safety training are minimizing those risks. However, the aesthetic risks and public fear associated with spills of recognizable medical waste in the environment are well documented. The beach washups in the summer of 1988 created a massive media campaign, documenting and contributing to the public fear and aversion to seeing syringes and IV tubing on beaches and roadsides. The public continues to associate these wastes with the potential for contracting AIDS and other infectious diseases, and therefore demands that governmental agencies do an effective job of controlling these wastes.

Treatment of medical waste reduces the risk to landfill workers and the general public from direct exposure to the waste. However, treatment also introduces additional occupational and environmental risks from emissions generated during the treatment process. Incineration, for example, renders most medical waste noninfectious and unrecognizable, but introduces air emission risks. In a summary of their findings, the Office of Technology Assessment (OTA) (Ref. 12) reported that the viability of non-incineration treatment alternatives (e.g., autoclaving/compaction, microwaving, chemical/mechanical disinfection) is increasing due to relatively lower capital requirements and fewer emission concerns.

In July 1991, the State passed the "air toxic control measure" which requires a 99 percent reduction in dioxins from burned medical waste (Ref. 12). California's strict regulation of incinerators has led to closure of most medical waste incinerators. As a consequence of these closures, wastes that were incinerated will need to be treated by other methods, and some of the alternative treatment processes described in Chapter 5 may become more

common. In addition, the California Department of Health Services is actively reviewing applications from proposed treatment facilities. These facilities offer alternatives ranging from miniature sharps treatment devices to high-tech plasma arc treatment systems.

### **6.3 Discussion of Potential Environmental Impacts**

Medical waste treatment and disposal could impact the air, groundwater, surface water, and the aesthetic quality of the environment. Air contamination is primarily caused by incineration, which can emit dioxins and furans, metals, acid gases, and particulates. A few other treatment processes, including autoclaving, plasma arc and pyrolysis can also emit gases and metals.

Groundwater contamination is a potential threat from landfill leachate. Residues from most treated medical wastes eventually end up in municipal landfills. These wastes include: 1) ash from incinerators and pyrolysis processes, which can contain heavy metals and organics; and 2) dewatered solids from chemical/mechanical processes, which can contain chemical residues. Solid wastes from irradiation processes also may be disposed in landfills; the leachability of these wastes is expected to be about the same as autoclaved wastes.

OTA indicates that if untreated medical wastes are disposed in a landfill there is little health risk from pathogens (Ref. 12). OTA found that "some degree of pathogen survival in a [municipal solid waste] landfill is expected . . . but the likelihood of pathogens migrating from a properly operated landfill is considered extremely low, based on available research." Nevertheless, concerns about whether medical waste disposed to a landfill contributes to leachate which may subsequently have environmental effects are probably best answered on a site-specific basis.

Surface water quality can be affected by medical waste treatment and disposal in a number of ways. Principle among these are discharge of liquid wastes (both treated and untreated) to the sanitary sewer by hospitals; and discharge of liquid effluent from chemical/mechanical systems and autoclaves to the sewer by hospitals and treatment facilities. In areas with combined sewer overflows, these wastes may migrate to surface waters. In 1989, a survey that as many as 215 hospitals pretreated their own wastewater prior to discharging it to sewers (Ref. 16). However, the majority of hospitals do not pretreat their entire effluent stream.

Aesthetic degradation is an important consideration for medical waste management. For example, the beach washups on the entire Eastern seaboard in 1988 prompted Congress to pass the Medical Waste Tracking Act of 1988. Public aversion and fear of disease from recognizable medical waste in the environment cannot be underestimated. In addition, it

should be noted that legally treated medical waste disposed to class III landfills who accept waste from the public has been known to arouse concern when red bags are seen by citizens at landfills. (Personal Communication, William Alexander, City of Santa Clara, Former Site manager, All Purpose Landfill.)

Recent interest in recycling from the health-care waste stream is encouraging. One off-site treatment firm which promotes source-segregation of sharps is able to concentrate a high-plastics-content stream from which a moderate proportion of plastic has been recycled into items such as sharps containers. One alternative technology firm is exploring recycling the entire (plastic plus fiber fraction) medical waste stream into a fiber-reinforced plastic lumber for application in pallets and telephone poles. In addition, the high BTU value of the waste makes it attractive as an alternative fuel for cement kilns and waste-to-energy facilities.

#### 6.4 Health Risks of Medical Wastes

##### 6.4.1 Description of the Affected Population

The potential population affected by medical waste includes health care workers, researchers, waste management workers, and the general public. Health care workers include hospital and clinic health care providers and staff, in-home health care providers, emergency response personnel, veterinarians, and animal technicians. Researchers include laboratory personnel. Waste management workers include janitorial and laundry workers, refuse workers, wastewater workers, maintenance plant operators and repair workers, and waste site cleanup workers. Additional occupations that expose workers to medical waste include lifeguards, morticians, and postal workers (Ref. 1).

The risk of exposure to medical waste depends largely on a person's occupation; however, the general public also may come into contact with unregulated medical waste that is generated by in-home health care or illegal intravenous drug use, or contact with mismanaged regulated medical waste (e.g., beach washups) (Ref. 1).

##### 6.4.2 Description of the Different Types of Exposure

The risks to human health posed by medical waste depend on interaction between the host and the pathogen. Pathogens in medical wastes may include bacteria, viruses, and other microorganisms, such as mycobacteria, yeasts, fungi, parasites, and rickettsia (Ref. 12). The interaction between a host and pathogen can either involve infection or intoxication. The latter refers to an illness due to the effects of a toxin produced by a pathogen, as in botulism from the toxin elaborated by *Clostridium botulinum*. It would require that a sufficient quantity of the toxin be introduced into the victim's system at the time of his/her exposure to the waste. Infection is much more common in that a small number of microorganisms may multiply within the host's body, eventually becoming numerous enough to cause disease.

There are two principals of infectious disease which determine whether a person exposed to infectious material will become ill with the corresponding disease. In order for there to be transmission of an infectious disease, all five "links" in the "infection chain" must be intact. Transmission thus, depends on (1) the presence of an infective agent (2) of sufficient virulence, (3) a sufficient number of infectious agents to cause infection, (4) a susceptible host, and (5) an appropriate portal of entry (Ref. 1). There are four stages of infection: 1) The pathogen must enter the host; 2) It must metabolize using host tissue; 3) It must withstand the host's immune response; and 4) It must cause damage to the host (Ref. 10). The completion of these four stages depends on the presence of an infective agent. The last three phenomena comprise "virulence."

The Agency for Toxic Substances Disease Registry reports that there are four main modes of transmission of infection (Ref. 15):

1. Direct transmission, involving direct contact or droplet spray;
2. Airborne transmission, such as with aerosols;
3. Vehicle-borne or fomite transmission, such as with punctures from sharps or use of an unwashed drinking glass, or touching a restroom doorknob or computer terminal; and
4. Vector-borne transmission, such as contact with, or more typically a bite from, an infected insect (Ref. 12).

The spread of hepatitis B virus (HBV) and the human immunodeficiency virus (HIV) through medical waste has become a public fear. The transmission modes for these viruses is predominantly limited to sexual or direct contact, parenteral transmission (needle punctures, whether for transfusions, sharing of needles, or accidental sticks), and perinatal transmission (between mothers and newborn children). Due to the extremely limited viability of HIV outside a living host, the potential to develop HIV infection from medical waste contact is remote. HBV has a more lengthy viability in the environment, and therefore presents a slightly higher risk of infection from medical waste than does HIV (Ref. 1).

In addition to the risk of infection, medical wastes can pose the risk of radioactivity or toxicity from low-level radioactive wastes, cytotoxics, and hazardous constituents (Ref. 15). Medical waste often contains laboratory solvents and other hazardous chemicals that are inseparably commingled with the medical waste. The presence of chlorine in such substances

can contribute to the formation of dioxins and furans during incineration. Toxic metals, including lead, cadmium, chromium, and mercury also can be found in medical waste. Cadmium and lead are used as thermo- and photo-stabilizers in pigments contained in the plastics (Ref. 1).

#### **6.4.3 Description of the Risks Associated with Each Type of Medical Waste**

While the risk from exposure to medical waste depends on all of the factors described above, the risk also varies by waste type. In order of concern from highest to lowest, the following classification of medical waste types was developed by the Council of State Governments (Ref. 15):

- Sharps
- Cultures and stocks
- Bulk human blood and blood products
- Pathology wastes
- Isolation wastes
- Animal waste
- Unused sharps
- Low-level radioactive waste
- Antineoplastic waste.

#### **Sharps**

Sharps are the category of greatest concern due to their ability to puncture the skin and provide a portal of entry for disease transmission. Sharps need to be treated prior to disposal to prevent human exposure and injury (sterilization and physical destruction or encasement). However, even after several steps are taken to prevent disease transmission to health-care workers (i.e. the use of puncture-resistant, leak-proof containers, treatment to achieve microbiological inactivation, and physical destruction or encasement in appropriate containers) any disposal of sharps to solid waste facilities is still a source of potential hazard to solid waste workers. The reason for this is that no sharps containerization is sufficiently strong to withstand the weight of a solid waste compactor vehicle, with the result that most needles, although sterile when they reach the landfill, will escape their containment and become re-inoculated with soil-borne organisms during compaction. It is fortunate that actual worker contact with the waste is limited.

Alternative treatment methods that would achieve the same protection goals include encapsulation in a polymer matrix or needle destruction following, or in conjunction with, some form of heat, chemical, or steam treatment (Ref. 15).

An attractive substitute to landfilling is the recycling of plastic from the high-plastic-content sharps waste stream. Segregated, sterilized sharps waste may be treated separately by any treatment method which includes grinding. Materials classification methods are used to separate the recyclable plastic (mostly polystyrene and polypropylene) from needle fragments and other contaminants. At the time of this writing, only one treatment firm permitted in California (Stericycle) is implementing such a program.

The Agency for Toxic Substances Disease Registry (ATSDR) compiled the following statistics on the number of injuries from sharps occurring annually:

- Non-hospital employees:

- Registered nurses: 17,800-32,500
- Licensed practical nurses: 10,200-15,400
- Emergency medical personnel: 12,000
- Refuse workers: 500-7,300
- Dental assistants: 2,600-3,900
- Physicians: 500-1,700
- Animal technicians: 400-1,600
- Dentists: 100-300
- Veterinarians: 50-200.

- Hospital employees:

- Janitorial and laundry workers (Housekeepers): 11,700-45,300
- Registered nurses: 9,900-17,900
- Hospital engineers: 12,200
- Licensed practical nurses: 2,800-4,300
- Laboratory workers: 800-7,500
- Physicians, dentists, and interns: 100-400 (Ref. 1).

It is important to distinguish between *injuries* and *infections*, because injuries only rarely become infections. Theoretical estimates of HBV infections potentially occurring in the employees listed above were reported by ATSDR in numbers ranging from 36 to 65 for non-hospital registered nurses to less than one for doctors, dentists, and interns in all hospitals (Ref. 1). The number of HIV infections was estimated to be even lower (Ref. 1). Expressed in terms of percentages of cases of disease probably caused by a given injury, no more than 0.05 to 0.1% of Hepatitis B disease cases occurring annually may be attributed to sharps in medical waste. The theoretical percentage of HIV cases attributable to medical waste sharps was even less, at an estimated <0.003 to 0.01. Non-sharp medical waste that spread other forms of disease was estimated to be even less (Ref. 1).

### Cultures and Stocks

Cultures and stocks are of concern due to the presence of an artificially high concentration of microbiological agents, which would represent an extremely high dose to an exposed individual. In order to eliminate the potential for worker or public exposure to these wastes, complete destruction is recommended, by, for example, incineration, chemical disinfection, thermal inactivation, or steam sterilization. Any of these treatments could be followed by landfilling of the treatment residues (Ref. 15).

### Bulk human blood and blood products

In August, 1987, the U. S. Centers for Disease Control promulgated Universal Precautions under the title *Recommendations for Prevention of HIV Transmission in Health-Care Settings*. Under Universal Precautions, spurred by the increasing occurrence of HIV and hepatitis, it must be assumed that all bulk human blood and blood products are potentially contaminated. If untreated blood and blood products are present in wastes that are subsequently compacted during placement at a solid waste facility, the wastes could spray into the mucous membranes of workers in close proximity to the wastes (Ref. 15).

The Council of State Governments recommends that blood and blood products be discharged to a sanitary sewer, discharged to an approved septic system, or incinerated followed by landfilling of the residue (Ref. 15). However, caution is recommended during these activities. *An approved treatment method should always be employed to render the blood or blood products noninfectious prior to disposal.* Although the pathogens in blood do not find a favorable environment in sewers or septic systems, some potential remains that these disposal methods can result in exposure for waste management personnel from aerosols and splashes. Disposing of untreated blood to the sewer may similarly present a remote risk to the public in the event that combined sewer overflows discharge untreated wastewater to surface waters (Ref. 10).

The Medical Waste Management Act allows discharge of liquid or semiliquid medical waste (medical waste that has not been treated to render it noninfectious) to a "...public sewage system...[if] consistent with the waste discharge requirements ... [of] the California Regional Water Quality Control Board with jurisdiction." The use of septic systems or storm sewers is not permitted.

The MWMA does not regulate disposal to septic systems of blood and blood products waste that has been rendered noninfectious.

Facilities that perform outdoor cleaning of medical waste collection containers or other items that may be contaminated with blood may present a hazard to the public if rinsewater is discharged to the storm sewer. Therefore, such equipment should either be subject to steam sterilization or dry heat sterilization prior to cleaning (Ref. 10).

ATSDR summarized the risks from blood and blood products within a health care setting in its 1990 report to Congress (Ref. 1). This report reviewed the scientific literature for evidence of hepatitis B infection from occupational involvement among nurses, laboratory workers, and janitorial staff. Evidence was found of infection that was attributable to contact with blood and blood products (Ref. 1).

### Pathology wastes

Pathology wastes, or body parts that have been removed in a health care or veterinary facility often offend the public for aesthetic reasons. Section 25090.5 of the MWMA requires that recognizable human anatomical remains (with the exception of noninfectious teeth) must be disposed of by incineration or interment unless otherwise hazardous. Established practice in California is to incinerate all pathology wastes, whether or not recognizable. Disposal of noninfectious veterinary remains is often limited by the Solid Waste Facility Permit of the landfill involved.

### Isolation wastes

Isolation wastes are wastes generated from patients whose illnesses are of such contagiousness that they must be isolated from the general public. Like any other medical waste, isolation wastes may pose a risk of infection to persons coming into close contact with these wastes. California statute requires that "Waste containing discarded materials contaminated with excretion, exudate, or secretions from humans who are required to be isolated by the infection control staff, the attending physician and surgeon, the attending veterinarian, or the local health officer, to protect others from highly communicable diseases or isolated animals known to be infected with diseases which are highly communicable to humans" be handled as a medical waste (H&S §25050.5 (f)). The diseases are classified by Centers for Disease Control as "Biosafety level 4" (Ref. 17).

### Animal waste

One definition of animal wastes are wastes from (usually laboratory) animals that have been exposed to zoonotic diseases; if the diseases are transmissible to humans, these wastes must then be treated to render them noninfectious. Carcasses, body parts, fluids, and bedding can be treated by steam sterilization and grinding or incineration. Residues from both of these processes can then be disposed in a class III sanitary landfill, subject to the conditions of the applicable Solid Waste Facility Permit. Fluids can also be thermally inactivated or chemically disinfected prior to disposal to sanitary sewer or, also subject to limitations of the Solid Waste Facilities Permit, to a sanitary landfill (Ref. 16).

### Unused sharps

Discarded unused hypodermic needles are of concern because of their potential to cause punctures and other physical injury to workers or the public. Moreover, California statute fails to distinguish between used and unused hypodermic needles. Therefore, unused hypodermic needles should be treated as if they are contaminated.

### Low-level radioactive waste

Radioactive waste generally includes solidified liquids, liquid scintillation vials, absorbed liquids, biological wastes, in-vitro wastes, and animal carcasses. Exposure to low-level radioactive wastes over time can expose waste management workers to hazardous levels of radiation. For this reason, the Department of Health Services regulates most radioactive waste disposal, including special packaging, labeling, and requires that they be stored for a sufficient time to allow for radioactive decay. If the particular isotopes used have long half-lives (longer than 90 days), then these wastes must be disposed in a licensed radioactive waste disposal site (Ref. 10). Additionally, DHS Medical Waste Management Program has provided policy guidance for handling low-level radioactive wastes which exceed a threshold of three times background level when they arrive for treatment. The policy may be requested from the Program by phoning (916) 327-6904.

### Antineoplastic drugs

Antineoplastic drugs can volatilize during steam treatment; therefore, they present a risk to workers during autoclave opening and venting. To prevent this risk, these wastes should not be steam sterilized (Ref. 16). Section 25020.5(g) of the MWMA specifies appropriate treatment of wastes which contain trace chemotherapeutic agents or may be carcinogenic.

#### 6.4.4 Potential Health/Environmental Risks by Technology Type

Wastes can be rendered noninfectious through a variety of treatment methods, including incineration and non-incineration treatment alternatives. An appropriate biological testing program to ensure disinfection is required by Section 25090 of the MWMA. Many treatments also render wastes unrecognizable.

Steam sterilization, probably the most common treatment modality, makes no pretense at rendering medical waste unrecognizable. Irradiation, too, does not change the appearance of the waste. Needles or their fragments may be easily seen in treatment residues of dry heat sterilization, microwave, "electrothermal deactivation" (radio wave), and Chemical/Mechanical residues.

"Mechanical treatment" is not a recognized treatment modality in California statute. The processes are an adjunct to chemical sanitation, during which mechanical alteration of the physical properties of the material makes it feasible to disinfect the waste with liquid chemicals. Mechanical treatment processes must be combined with other forms of treatment in order to achieve effective pathogen kill.

#### Thermal Treatment

**Incineration:** As noted elsewhere in this report, incineration of medical waste in California was expected to decrease considerably due to recently implemented air emissions controls on this traditional method of treatment. In practice, because much waste formerly incinerated on-site subsequently went to incineration off-site, and because many remote, rural on-site incinerators were exempt from the law, the change probably was not all that dramatic. Although the public health implications of medical waste incineration are not well documented in the literature, it has been reported that there are risks to burning plastics in old retort pathology incinerators. These units can emit dioxins and furans from incompletely combusted chlorinated products. The potential adverse health impacts associated with these emissions depend on the type of chlorinated product, the route and duration of exposure, and the amount absorbed through exposure and the effective dose (Ref. 1).

Other risks associated with the combustion of medical wastes include emissions of pathogens, metals, acid gases, and particulates. The survival of pathogens after incineration is not well documented in literature, but it is known that pathogens are easily destroyed when exposed to high temperatures and residence times (e.g., incineration under proper operating conditions). The main potential for exposure comes from pathogens that either escape in gases during loading or that survive in the ash or air emissions of an improperly operated unit (Ref. 16).

Metals, such as cadmium, can have toxic and carcinogenic effects (cadmium is a probable human carcinogen and can have other health effects at acute exposures). Acid gases, such as hydrogen chloride (HCl), nitrogen oxides, and sulfur dioxides, can produce acute effects such as eye and respiratory irritation, contribute to acid rain, and enhance the toxic effects of heavy metals. Particulate emissions can absorb heavy metals and organics and lodge in the lungs, potentially causing chronic health effects (Ref. 16).

The ARB *Technical Support Document to Proposed Dioxin Control Measure for Medical Waste Incinerators* (Ref. 14) lists several metals as present in the emissions of a large proportion of the eight medical incinerators tested. Arsenic was found in emissions of seven of the eight; cadmium in all eight; chromium in seven; lead in all eight; manganese in all eight; and mercury in five of the facilities.

The majority (nearly 70 percent) of hospitals in the U.S. use onsite incineration to treat medical wastes, but the type, nature, and use of incinerators varies significantly. Some incinerators are used exclusively for disposing pathology waste; others are used to treat and dispose of infectious and noninfectious medical waste. California reports that as of 1990, most of its 146 operating medical waste incinerators were small, uncontrolled units, 94 percent of which were located onsite. Less than 60 percent of the waste burned in these units is medical waste; the remainder falls into the category of municipal waste (Ref. 16).

Environmental hazards associated with medical waste incineration depend on several factors, including (1) the design of the incinerator; (2) whether it is operated according to specifications (including operator training); (3) the character of the waste stream; (4) continuous v. intermittent operation, and (5) the pollution control devices and procedures associated with the unit and its operation. The pollutants removed from the air emissions through pollution control devices will be concentrated in the fly ash. Bottom ash and fly ash must be periodically tested to determine whether they meet the State's definition of hazardous waste. If found to be a hazardous waste, the ash must be disposed to a Class I landfill; however, if the ash is not hazardous it may be disposed to Class III or Class II sites which are so permitted.

**Autoclaving:** OTA stated in its 1990 report on medical waste (Ref. 16) that there are no reports documenting health impacts from autoclaving. This report also found that autoclaving is not suitable for certain wastes such as antineoplastic agents, radioisotopes, solvents, or other toxic wastes due to the potential for chemicals to be volatilized by steam (workers could be exposed to these chemicals via steam when the workers open the autoclave between process cycles). Medical wastes containing formalin or other carcinogenic compounds also could present a hazard. Autoclaves of the gravity-displacement type do not present this health hazard because steam is vented in a special

outlet vent, where it condenses and drains into the sanitary sewer. However, local, State, and Federal regulations apply to all discharges to the sanitary sewer; the local sewer use permitting authority should be consulted to determine any limitations on discharges to the sanitary sewer.

OTA also reported that the risk of exposure to infectious agents in landfill leachate from disposal of autoclaved waste to municipal landfills is not known. Research has not established a relationship between landfill leachate and disease; however, obtaining evidence of such a relationship would be difficult, and further research is necessary.

Tests comparing clean air exhaust and ambient air in the process area showed "no significant increase" in the microorganisms count from autoclaves manufactured by the GTH Roland North America Company in Houston, Texas (Ref. 11). However, the Minnesota Healthcare Partners (Ref. 11) determined that autoclaving was liable to produce more volatile emissions than either electrothermal deactivation or microwaving. Effluent data from the autoclave/compactor/shredder offered by San-I-Pak, Inc., of Tracy, California, showed elevated levels of formaldehyde and isopropanol in the "blow-down steam" from these units. The vendor explained that the composition of the treated waste will determine the level and composition of air emissions.

**Dry Heat Sterilization:** Both solid and liquid wastes are subjected to sufficient heat in a dry heat sterilization process to destroy any pathogenic organisms in the waste. However, standard operating procedures must be followed to ensure that these temperatures are achieved and that the organisms are exposed for an appropriate length of time (Ref. 10). When operated properly, this treatment technology should produce a treated residue that does not present further threat of disease to waste management workers, the environment, or the public.

In an independent testing laboratory, Disposal Sciences, Inc., of Englewood, Colorado, reported that no organic compounds were detected in any air samples, regardless of the stage of operation sampled. In addition, tests showed that the properly operated equipment did not aerosolize any spores (Ref. 11).

**Plasma Torch:** The volume of gases produced by the plasma torch process is only one tenth that of incineration, and can be burned as fuel. The high temperatures achieved tend to minimize the production of dioxins and furans. Air emissions contain heavy metals and hydrogen chloride, thus requiring advanced pollution controls. The solid residue is non-leachable and can be reused as road aggregate (Ref. 11).

Plasma Energy Applied Technology provided the following data to support its claim that while the "off-gas" is never discharged to the atmosphere, it could emit regulated elements if it is burned as fuel:

POLLUTANT	CONCENTRATION (ppm)
Arsenic	0.01
Barium	0.03
Cadmium	0.01
Chromium	0.02
Lead	0.3
Mercury	<0.005
Selenium	<0.1
Silver	0.001

The gas is comprised of 41 percent hydrogen, 30 percent carbon monoxide, 16 percent nitrogen, 8 percent carbon dioxide, 4 percent hydrocarbons, and 1 percent chlorine/hydrogen chloride. In addition, some particulates are discharged with scrubber water. They claim that the vitrified slag produced is nonleachable (Ref. 11).

**Pyrolysis:** Pyrolysis produces ash and can produce carbon monoxide. The high temperatures achieved in the pyrolysis process minimize the production of dioxins (Ref. 11). EnviMed Compliance, Inc., of Rocky Hill, New Jersey, reported test results on air emissions from a pyrolysis unit. The average emissions provided below were based on treating infectious and pathology wastes at a 20 to 50 pound charge requiring four to eight hours to process in a 20 gallon unit.

<u>Pollutant</u>	<u>Concentration (micrograms/hour)</u>
Cadmium	18
Chromium	103
Lead	368
Mercury	3
Nickel	96

In addition, there were trace particulates and toluene (a hazardous waste). EnviMed did not detect dioxins or furans but did note some complex hydrocarbons and traces of perchlorinates (Ref. 11).

### Chemical/Mechanical Treatment

**Chlorination/Chlorine Derivatives:** In a comparative study of four technologies, including chemical/mechanical treatment, autoclaving, thermal deactivation (dry heat), and microwaving, chlorine-based chemical/mechanical systems raised the greatest concern due to the generation of chlorine gases and operator safety. This process also raised the highest concerns due to high levels of chlorine in the liquid effluent, which could adversely impact the community sewage treatment plant. The chemical/mechanical process also had the highest noise level of the four processes (Ref. 11 and 12).

In addition to the risk to workers from chlorine exposure, there is a potential for fugitive emissions of volatile chemicals during grinding and shredding. For example, one treatment facility, Medical SafeTEC of Indianapolis, whose units operate under negative pressure and are equipped with a 99.9 percent 0.3 micron HEPA filter, reported air emissions containing low levels of chlorides, hydrogen chloride, particulates, and hydrocarbons (Ref. 11). Medical SafeTEC also reported that wastewater effluent from their chemical/mechanical system contained free chlorine at concentrations exceeding a 200 mg/L limit (the facility did not specify on what limit this was based), low levels of chloroform and formaldehyde, and seven dioxin/furan congeners (Ref. 11).

Another treatment facility, MeDETOX International, Inc., of Albuquerque, New Mexico, reported that their closed chemical/mechanical system has emissions of oxygen and nitrogen in a 50:50 mix, and sodium chloride/sodium bicarbonate solution (Ref. 11).

**Other Liquid Disinfectants:** Liquid disinfectants such as iodophor, alcohols, and glutaraldehyde present adverse health and environmental impacts just as chlorine-based compounds do. Iodophor is corrosive, irritates the skin and eyes and is toxic. Alcohols, specifically ethyl and isopropyl, are flammable, toxic, and irritate the eyes. Glutaraldehyde is a skin and eye irritant and is toxic (Ref. 16).

### Health Effects of Irradiation

**Electron Beam:** Little has been reported about the health risks associated with electron beam treatment, except that safety precautions are necessary to prevent employee exposure to electron beams. Nutek Corp. of Palo Alto, California reported that "minute quantities of ozone and hydrogen peroxide are emitted. Shielding eliminates emissions of high energy electrons" (Ref. 11).

**Gamma Irradiation (Cobalt 60):** Health risks associated with gamma irradiation are primarily associated with potential radiation exposure of workers (Ref. 12).

**Ultraviolet Irradiation:** It is assumed that the risks associated with ultraviolet irradiation are similar to those from gamma irradiation, but no documentation could be found at this time.

### Health Effects of Other Technologies

**Ozone Treatment:** Use of ozone to treat certain medical wastestreams is an example of a technology that may be transferred from another waste treatment area. However, investigations of the use of ozone to treat medical wastes are only beginning, and reports of the potential health impacts from ozone treatment could not be located at the time this report was prepared.

**Ethylene Oxide:** Ethylene oxide is a probable carcinogen, and may expose waste treatment workers to a greater risk than the waste itself. For this reason, the EPA has warned against using this method to treat medical waste (Ref. 10).

**Sharps Mailbacks:** Concern has been raised about the potential health hazard of mailing medical wastes in the same mail system as household mail. If accidents were to occur in the mail system, postal workers and possibly the general public could be exposed to untreated medical waste. When waste mail companies operate as transfer stations, they are regulated under §25070. Also, DHS requires that mailback systems be approved as Alternative Technology pursuant to §25090 (d). As part of that approval, compliance with applicable USPS regulations (39 CFR Part 111) must be demonstrated.

**Disposal to the Sanitary Sewer:** Sewers have long been a recognized and accepted option for the disposal of blood, blood products, and other liquid or semi-liquid medical wastes, as long as secondary treatment of wastewater is available. Secondary wastewater treatment is designed to break down microorganisms and remove organic constituents and is usually followed by chlorine disinfection of the wastewater. The sanitary sewer system itself is not designed to disinfect wastewater; treatment occurs at a central municipal treatment facility. Sewage backups at a facility can place medical staff and plumbers at risk. One such incident was reported at the Los Angeles County University of Southern California Medical Center in 1987. A basement pipe burst, dumping potentially contaminated blood and fluids on workers (Ref. 12). Section 25090 (b) (2) of the Medical Waste Management Act requires additionally that discharge of medical waste must be consistent with Regional water Quality Control Board waste discharge requirements for the treatment plant.

## Chapter 7: CONCLUSIONS

The following are major conclusions based on the data obtained and the analyses conducted during the Study.

**Characterization of Medical Waste Generation:** Data collected in this Study indicate that the average LQG produces about 5,900 pounds per month of medical waste. The average SQG produces only 25 pounds per month. An estimated 83 percent of SQG wastes are sent offsite for treatment, while LQGs utilize offsite treatment for an estimated 63 percent of their wastes.

Sharps wastes constitute the largest volume of medical wastes generated by each category of SQGs. For instance, as indicated in Table 2.3, sharps waste constituted 51 percent of physicians' wastes, 66 percent of dentists' wastes, and 56 percent of veterinarians' wastes. As expected, contaminated animal wastes constitute a higher percentage of veterinarians' total wastes than seen for other generators. Blood/body fluid wastes constitute a higher percentage of physicians' total wastes than seen for other generators. Laboratory wastes probably constitute a higher percentage of physicians' total wastes than other waste types because private physicians offices often perform simple lab work onsite. With these exceptions, percentages of waste generation were reasonably similar across the major generator categories.

Of the three dominant small quantity generator categories, physicians report the highest percentages (per facility) of nearly all kinds of medical wastes. For instance, as indicated in Table 2.4, physicians generated 89 percent of the total amount of lab wastes reported, 82 percent of the total blood/body fluids wastes, and 72 percent of the total sharps wastes. More sharps wastes (24 lbs. per month) are generated per facility than any other medical waste, more than 2.5 times the next highest waste type of blood and body fluids (9.3 lbs per month). In this survey, physicians and veterinarians report generation of about the same amounts (10 to 10.5 pounds each) of sharps wastes, whereas dentists report far less (3.5 pounds each).

For all 447 facilities in the LQG database, sharps were the most commonly generated waste (reported by 411 facilities), followed closely by blood and body wastes (reported by 403 facilities). In descending order of frequency, lab wastes (290 facilities), surgical wastes (221 facilities), isolation wastes (139 facilities), and contaminated animal wastes (50 facilities) were reported. Of the 63 LQGs that responded to the questionnaire, 71 percent reported that they generate blood or body fluids, and 73 percent generate sharps waste. Laboratory waste generation was reported by 36 facilities (58 percent). Thus, LQGs report generating a higher percentage of blood and body fluids than SQGs report.

**Medical Wastes and Offsite Treatment Capacities:** The Study calculates a range of 60,240 to 79,360 tons per year of *total medical waste* (0.12 to 0.16 percent of the total solid wastestream of 48,580,000). DHS records indicate that for the period 1991-1992, offsite medical waste treatment facilities operated at 66 percent of their permitted capacity. Facility operators anticipate no lack of capacity in the future, as volumes treated are not expected to increase substantially. The operators estimate that they are currently treating anywhere from 50 to 66 percent of the medical wastestream at this point, depending on the service area. Treatment capacity for medical wastes is not identified as a problem by the facility operators. In addition, the number of generators having onsite treatment is increasing.

**Impact of Medical Wastes on Landfill Capacity:** The Study estimates that medical waste constitutes 0.12 to 0.16 percent of all solid waste generated in California. This is a very low proportion, and is not seen as having any appreciable impact on disposal capacity within the State.

**Impact of the Regulated Medical Waste Stream on Health and Safety:** Surveys of landfill operators, transfer facility operators, solid waste collectors, and local enforcement agencies revealed no complaints of health or safety problems related to the legal or illegal disposal of regulated medical wastes. Operators stated that solid wastes are mechanically compacted and placed into the landfill, and physical contact with these wastes by workers is rare. Previous studies have found that the likelihood of pathogens being transported from a properly operated landfill is extremely low. Thus, even if untreated or inadequately treated medical wastes enter landfills, public health would not be affected under normal operating conditions.

**Concerns Regarding Household Medical Wastes:** Solid waste haulers expressed some concern about household medical wastes, which are not treated prior to disposal and may not be readily identified by collectors. Recycling or materials recovery facilities often utilize hand-sorting of materials. A materials recovery facility reported that employees encounter used sharps generated by households on a daily basis. This may be a substantial and growing concern considering the increase in waste handling, particularly hand-sorting, that is likely to occur as cities strive to meet the diversion requirements of the Integrated Waste Management Act of 1989.

**Autoclaving of Wastes as a Focus for Generator Education Efforts:** Significant percentages of SQGs use autoclaves to treat medical wastes onsite. For instance, 50 percent of laboratories and 22 percent of dentists report the use of autoclaves for waste treatment. Facility personnel often will have used autoclaves for years for disinfection of non-wastes and are familiar with the operating parameters that must be maintained for this purpose. However, different operating parameters may be required to render bulk waste liquids or semiliquids noninfectious. If the generators fail to heed the autoclave operating procedures

stated in the medical waste statute (H&S § 25090 (c)), the possibility exists that waste treatment could be compromised. Although no existing health or safety problems have been identified that relate to this issue, this could be an appropriate area of coordination with DHS.

**Sharps Wastes as a Focus for Generator Education Efforts:** The Study identifies sharps as the waste type of greatest concern, due to their ability to puncture the skin and provide a portal of entry for disease transmission. Sharps are the major constituent of medical waste produced by SOGs. Onsite treatment technologies for sharps that eliminate the risk of needle injuries to solid waste collection personnel are available. However, even the "toughest" of containment systems fail under weight of landfill compaction equipment. Autoclaved sharps containers carry legally treated sharps into the municipal waste stream, where they are often released when the containers rupture under pressure of compacting collection vehicles. The result is a potential occupational health hazard to solid waste employees who must have direct contact to waste. (Examples: a landfill maintenance technician who must repair broken-down equipment where it stands; a collection vehicle driver who must free residual compacted waste which is fouling the compacting machinery; the load-check technician verifying the facility's hazardous waste exclusion program.)

Although the study did not expose serious industry or enforcement agency concerns, there is ample anecdotal evidence from both solid waste facilities and enforcement agencies that solid waste managers would prefer to be safe, rather than sorry, when it comes to potential occupational injury. A cooperative CIWMB-DHS effort aimed at educating generators and the solid waste industry on the relative merits of existing treatment technologies could reduce the likelihood of injury dramatically.

From a strictly health and safety point of view, methods that achieve both disinfection and waste "solidification" onsite are beneficial to the solid waste collector. Such methods include the Isolyser and "Dry Heat Sterilization" ("hockey puck") technologies; the latter obviously possesses an additional safety feature of secure containment at landfills.

Offsite treatment firms who autoclave and landfill their own waste are well aware of the sharps hazard, and school their employees well in the safety aspects of handling this known hazard. Offsite and onsite techniques are available to achieve shredding of waste reduce syringes to such small fragments that the penetrating effectiveness of the broken or bent needle tip has been lost. Melting and recycling technologies reduce needle fragment residues to a concentrated mass in association with other non-recyclable materials, while incinerated needles are highly oxidized and no longer any more dangerous than other sharp objects found in the solid waste stream.

Educated medical waste generators may incorporate ultimate disposal circumstances in their decision-making process as they select treatment modalities.

**Integrated Management of Healthcare-generated Waste:** Finally, observations made during the performance of this contract have lead to the conclusion that challenges related to the management of healthcare-generated waste transcend the separation between the two agencies which oversee this waste stream. The contractor was able to observe first hand the effective interaction between staff representing both the Board and the Department of Health Services Medical Waste Management Program. This is particularly appropriate since a major reason for the regulation of medical waste is the protection of workers in the solid waste industry. Continued cooperation between management and enforcement personnel with expertise in applying both the Medical Waste Management Act and the California Integrated Waste Management Act will assure the continuity of this safeguard from generation, through treatment to ultimate recycling or disposal.

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**APPENDIX 1**

**File Review Form for DHS-Registered Generators**

REGISTERED FACILITY

Generator Name: \_\_\_\_\_  
Business Address: \_\_\_\_\_

Type of Business: \_\_\_\_\_

Contact Person: \_\_\_\_\_  
Phone Number: \_\_\_\_\_

TYPE OF FACILITY:

- Large quantity generator without onsite treatment
- Large quantity generator with onsite treatment
- Small quantity generator with onsite treatment

Type of onsite treatment:

- Incinerator
- Autoclave
- Microwave

TYPE OF MEDICAL WASTE GENERATED	QUANTITY (LBS/MONTH)
Laboratory waste:	_____
Blood or body fluids:	_____
Sharps:	_____
Contaminated animals:	_____
Surgical Specimens:	_____
Isolation waste:	_____

Estimated total monthly waste generated (lbs.) \_\_\_\_\_

If regulated medical waste is transported off site for treatment, list the name of the waste hauler and the name of the treatment facility:

Hauler: \_\_\_\_\_  
Address: \_\_\_\_\_  
Phone: \_\_\_\_\_

Treatment facility: \_\_\_\_\_  
Address: \_\_\_\_\_  
Phone: \_\_\_\_\_

**APPENDIX 2**

**Small Quantity Generator Questionnaire**

# WASTE GENERATOR SURVEY - SQG

A

Type of business: \_\_\_\_\_

Number of Employees: \_\_\_\_\_ Professional Staff: \_\_\_\_\_ Support Staff: \_\_\_\_\_

Type of Medical Waste Generated	Quantity Treated Off-site (lb./month)	Quantity Treated On-site (lb./month)
Laboratory Waste		
Blood or body fluids		
Sharps		
Contaminated Animals		
Surgical specimens		
Isolation waste		
<b>ESTIMATED TOTAL MONTHLY WASTE (lbs.)</b>		

Medical waste is treated or disposed of as follows (check as many as apply):

- |   |  |
|---|--|
| <input type="checkbox"/> Medical waste hauler contract<br><input type="checkbox"/> Limited quantity exemption - self haul<br><input type="checkbox"/> Sharps mail-back service<br><input type="checkbox"/> Sanitary Sewer | <input type="checkbox"/> Autoclave<br><input type="checkbox"/> Isolyzer<br><input type="checkbox"/> Other _____<br>_____ |
|---|--|

If you treat sharps waste on-site:	
How is it treated?	<input type="checkbox"/> Autoclave <input type="checkbox"/> Isolyzer <input type="checkbox"/> Other _____
How is it disposed?	<input type="checkbox"/> As medical waste <input type="checkbox"/> As solid waste

Medical waste is hauled off-site for treatment/disposal by the following registered medical waste hauler: \_\_\_\_\_

Name/address of treatment facility receiving waste: Name: \_\_\_\_\_  
 City: \_\_\_\_\_

Medical waste, once treated is solid waste. Is your treated medical waste picked up by your solid waste hauler (i.e., your garbage man)?  Yes  No If no, who does?

Name/address of solid waste hauler: Name: \_\_\_\_\_  
 City: \_\_\_\_\_

Please indicate the number of solid waste containers which you fill each week:  
 \_\_\_\_\_ 30 gal. Trash Cans; Rollaways: \_\_\_\_\_ 60 gal. \_\_\_\_\_ 90 gal.; \_\_\_\_\_ Small Dumpster

Which of the following do you recycle? (Now = N; Plan To = P)  
 \_\_\_ Paper \_\_\_\_\_ Aluminum \_\_\_\_\_ Glass \_\_\_\_\_ Plastic

Questions? Call (415) 960-5980

Please Fax to: (415) 960-5965

**APPENDIX 3**

**Large Quantity Generator Questionnaire**



**APPENDIX 4**

**Waste Hauler/Collector Questionnaire**

**MEDICAL WASTE STUDY**  
**Solid Waste Facility Operator Survey**

A

Facility Name: \_\_\_\_\_  
Contact Person: \_\_\_\_\_ Phone: \_\_\_\_\_

Is treated medical waste accepted at your facility (including medical waste incinerator ash)?

- Yes  No  Don't know

If you track the amount received, what is the monthly quantity? \_\_\_\_\_ lbs.

Do you have concerns about accepting this type of waste?  Yes  No If so, what? \_\_\_\_\_

Regarding your "waste exclusion" or "load-check" program:

Have you expanded your program to detect and prevent the disposal of other wastes, particularly untreated medical wastes?  Yes  No

- ◆ What do you check for? (mark all that apply)  
 Hazardous waste  Medical waste  Other: \_\_\_\_\_
- ◆ How are loads chosen?  Random  Defined % of total  By source or route
- ◆ How is a load checked? (mark all that apply)  
 Visual, at the entrance gate  Visual, while load is tipped  Visual, after load is tipped  Topped  Spread
- ◆ How often is a load selected for: Visual inspection? \_\_\_\_\_ Spreading/topping? \_\_\_\_\_
- ◆ Approximate percentage of incoming loads checked? \_\_\_\_\_

Has untreated medical waste been found in your incoming waste stream?  Yes  No

Check any types of health care related waste that have been found, whether it is treated or not, in the:

Commercial waste stream:

- Red bags  Sharps containers  Isolyzer containers  Loose needles or syringes  Other

Residential waste stream

- Loose needles or syringes  Containerized needles or syringes  Other

Please estimate the number of incidents per year. \_\_\_\_\_

Was an enforcement agency notified?  Yes  No Which one? \_\_\_\_\_

Was there enforcement action?  No  Yes, please explain \_\_\_\_\_

How was such waste handled? (mark all that apply)

- Removed from the site  Placed in the active face  Buried in another on-site location

In your opinion, has the number of incidents of untreated medical waste being brought to your facility increased or decreased in recent years?  Increased  Decreased

Is there something happening (special program, public awareness campaign, change in the cost for proper medical waste treatment) that might explain the increase or decrease in incidents? \_\_\_\_\_

What, if any, problems have you encountered with disposing of health care related wastes (residential included)? \_\_\_\_\_

How have these incidents impacted the operation of your facility? \_\_\_\_\_

Questions? Call (415) 399-0140

Please Fax to: (415) 399-0299

**APPENDIX 5**

**Solid Waste Facility Operators Questionnaire**

V

**MEDICAL WASTE STUDY**  
**Solid Waste Hauler/Collector Survey**

Company Name: \_\_\_\_\_  
Contact Person: \_\_\_\_\_ Phone: \_\_\_\_\_  
Service Area: \_\_\_\_\_

Please check the boxes which describe the type of service which you provide:

- Residential       Commercial       Debris Box

Please list your restrictions and conditions regarding health care related waste that customers may leave for collection.

\_\_\_\_\_

\_\_\_\_\_

If your restrictions or conditions are not met, is it your policy to:

- Pick up the waste  
 Pick up the waste and remind the customer of your restrictions  
 Leave the waste and inform the customer that they must comply with your restrictions  
 Other \_\_\_\_\_

Have your collectors ever reported finding either commercial or residential health care related waste (e.g., red bags, medical syringes, needles, etc.)?  Yes  No Which waste stream? \_\_\_\_\_

If yes, how often? \_\_\_\_\_

Was it handled according to policy?  Yes  No If not, how did you respond? \_\_\_\_\_

\_\_\_\_\_

Do you collect solid waste from any medical, dental, veterinary, biomedical or research facilities or offices?

- Yes  No (If no, stop here and please return the questionnaire. Thank you.)

Do you:

- Provide service to medical facilities on your regular collection routes?  
 Collect from them on separate routes?

Please estimate: This waste stream represents \_\_\_\_\_ % of your (a) total waste stream, (b) \_\_\_\_\_ % of your time and effort?

Do you have any concerns about collecting the solid wastes from such facilities? \_\_\_\_\_

\_\_\_\_\_

In waste collected from such facilities, have you found medical waste you knew or had reason to suspect was UNTREATED, such as:

- Sharps (syringes or needles)       Red Bags       Other \_\_\_\_\_

How often? \_\_\_\_\_

How do you respond? \_\_\_\_\_

\_\_\_\_\_

What, if any, problems have you encountered with disposal facility operators regarding health care related wastes?

\_\_\_\_\_

Please identify any Registered Medical Waste Haulers operating in your service area. \_\_\_\_\_

\_\_\_\_\_

**APPENDIX 6**

**Treatment Facility File Review Form**

OFFSITE TREATMENT FACILITY FORM

FACILITY NAME: \_\_\_\_\_

ADDRESS: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

PHONE: \_\_\_\_\_

\_\_\_\_\_

CONTACT PERSON: \_\_\_\_\_

1. Treatment method

- \_\_\_\_\_ Steam sterilization
- \_\_\_\_\_ Incineration
- \_\_\_\_\_ Other \_\_\_\_\_

2. Total treatment capacity of facility?

- \_\_\_\_\_ pounds per hour or
- \_\_\_\_\_ tons per day/month/year (circle one)

3. Monthly or yearly amount of waste treated at facility.

- \_\_\_\_\_ tons per year/month biohazardous
- \_\_\_\_\_ tons per year/month sharps

4. How many generators are served by the facility?

- \_\_\_\_\_ Small quantity generators (under 200 lbs per month)
- \_\_\_\_\_ Large quantity generators (over 200 lbs per month)

5. After treatment, is a biological determination made to confirm the adequacy of the treatment? Describe the procedure.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

6. Nature of treatment residue (incinerator ash, sterilized waste, etc.)

\_\_\_\_\_  
\_\_\_\_\_

7. How much treatment residue is generated? (#s per month or year) \_\_\_\_\_

\_\_\_\_\_

8. Where is the treatment residue ultimately disposed? (which landfill)

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**APPENDIX 7**

**Enforcement Agency Interview Matrix**

	Applicability to County (✓ if yes) (i.e., does county have offsite treaters?)	Any health and safety problems/incidents excluding incidents with SW facilities or collectors?	Any environmental impacts/consequences with treatment, handling, or generation?	Incidents/problems with solid waste haulers/facilities involving untreated medical waste?	Incidents/problems with improperly handled medical waste (treated or not) in the MSW stream (particularly sharps)?	Statutory or regulatory violations	Comments
GENERATOR	SOQ						
	LQG						
TREATMENT	Onsite						
	Offsite						
HAULERS	Medical waste hauler						
	Solid waste hauler						
SOLID WASTE FACILITIES	Transfer stations/MRFs						
	Incinerators						
	Landfills						
COMMUNITY	Illegally disposed						
	Residential generator						

## **APPENDIX 8**

### **Summary of Innovative and New Treatment and Disposal Technologies**

### Innovative and New Medical Waste Treatment and Disposal Technologies

Treatment Method	Treatment Technology	Stage of Development	Advantages	Disadvantages	Limitations Compared to Current Technologies
Thermal	Dry Heat Sterilization	Two vendors approved in CA. Portable units available in some other states to anyone who can obtain a State permit.	Wastes are treated on site. Volume is reduced by 85%.	Effect on air quality not known.	Relatively small capacity, onsite devices only. Incineration and autoclaving are available on or off site. Spintech unit is approved for treatment of sharps only.  (Ref. 3)
Thermal	Plasma Torch	Two vendors have applied to CA for Approval. One company has projects "under development" in CA, AL, ND, SC, and VA.	Waste is decontaminated and rendered unrecognizable. Significant reduction in weight and volume. Residue appears to be nonleachable and can be reused. By-product gases are usable as fuel. Volume of gases is 1/10th that of incineration. High temperatures minimize dioxins and furans.	Air emissions contain some heavy metals. Requires advanced pollution controls, due to hydrogen chloride. Requires much electricity and high volume of water. Requires highly trained employees. Large capital investment; may have high operating costs.	Handles full range of infectious and pathology waste.  (Ref. 11)

Medical Waste Issues Study

Treatment Method	Treatment Technology	Stage of Development	Advantages	Disadvantages	Limitations Compared to Current Technologies
Chemical/ Mechanical	Other Liquid Disinfectants	Same as chlorination/ chlorine derivatives.	Waste is decontaminated and rendered unrecognizable. Some have little liquid effluent. Cost effective. Up to 85% volume reduction achieved if dewatered following treatment. Longer shelf life than chlorine-based solutions. Can be used on or off site.	All are toxic; see Section 5 for other health and environmental effects. Sewer authorities may not accept effluent without further treatment; landfills may not accept solid waste. Grinder/shredder may jam. Potential for incomplete decontamination. Potential fugitive emissions during grinding.	Not suitable for body and animal tissue, large metal objects, or radioactive material. Some units can't take large fabrics or bulk liquids. Moderately complex operation (more complex than autoclaving, less complex than incineration). Requires well-trained operators (better trained than autoclaving not as skilled as incineration). Moderate costs (more than autoclaving less than incineration). Cannot be used to treat liquid wastes.  (Ref. 11 and 15)
Irradiation	Electron Beam	One facility awaiting approval in CA. Requires 12-18 month start-up time. Not known if approved elsewhere.	Minor impact on air quality. No liquid effluent. No radioactive material involved. Residue can be disposed as solid waste. Can treat large waste volumes quickly.	High capital costs. Extensive worker safety precautions required. Metals can pose problems for grinder. Requires highly trained personnel. Some landfills may not take waste.	Handles full range of medical/pathology wastes. Applicable to onsite or offsite wastes.  (Ref. 11)
Irradiation	Gamma Irradiation	Not yet approved in CA. Not known if approved elsewhere. Is being developed by at least 2 companies.	Process is highly predictable. Treated waste may be reused as fuel; plastics can be separated and recycled.	Effects on air and water unknown.	Not recommended for treating pathology wastes.

Medical Waste Issues Study

Treatment Method	Treatment Technology	Stage of Development	Advantages	Disadvantages	Limitations Compared to Current Technologies
Irradiation	Ultraviolet	Not known to be under development for solids. (Typically used for treating wastewaters).	Not known.	Not known.	Limited to treatment of wastewaters.
Other Treatment	Electric Needle Destroyers	Two vendors have applied to CA for approval	Reduces risk of needle sticks among waste management workers. Inexpensive, portable.	Syringe is still considered untreated medical waste.	Only applicable to syringes and hypodermic needles. Not considered complete treatment.
Gas/Vapor	Ozone	Not known to be in developmental stage.	Not known.	Not known.	Not known.
Gas/Vapor	Ethylene Oxide	Not known to be in developmental stage.	Not known.	Carcinogenic; poses health risk to workers. (Ref. 10)	Not known.
Gas/Vapor	Formaldehyde	Used to sterilize reusable equipment and preserve specimens for research.	Longer shelf life than chlorine-based compounds.	Toxic and carcinogenic (see section 5). Landfills may not accept solid waste. Potential for fugitive emissions during grinding (if grinding is used).	Cannot be used for liquid wastes. (Ref. 16)

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**APPENDIX 9**

**Human Health and Environmental Impacts of Medical Waste Treatment Technologies**

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**Human Health and Environmental Impacts of Medical Waste Treatment Technologies**

Treatment Technology	Type of Emissions	Health Risks/Environmental Impacts
Dry Heat Sterilization	No pathogen survival, as long as standard operating procedures are followed. Air emissions are unknown. No liquid effluent.	No risk of disease as long as standard operating procedures are followed. Risk to workers unknown. No impact on surface water or groundwater unless landfilled "puck" leaches. Impact on air quality unknown. (Ref. 10 and 11)
Plasma Torch	Volume of gases only one tenth that of incineration. If burned as fuel, emissions include low concentrations of heavy metals. High temperatures minimize dioxins and furans. No pathogen survival as long as standard operating procedures are followed. Solid residues nonleachable. Scrubber water contains some particulates.	No risk of disease as long as standard operating procedures are followed. Risk to workers unknown. No impact expected on groundwater. Impact on air quality far less than incineration. Potential surface water contamination from particulates in scrubber water. (Ref. 11)
Pyrolysis	High temperatures minimize formation of dioxins. Air emissions may contain particulates, heavy metals, carbon monoxide, complex hydrocarbons, toluene, and perchlorinates.	Potential carcinogenic and toxic effects from air emissions if inadequate air pollution controls are utilized. Potential (but unknown) groundwater contamination if landfilled ash leaches.

Medical Waste Issues Study

Treatment Technology	Type of Emissions	Health Risks/Environmental Impacts
Chlorination/Chlorine Derivatives	Chlorine gases emitted. Fugitive emissions of volatile chemicals, chlorides, hydrogen chloride, particulates, and/or microbes during grinding or shredding. High levels of chlorine in liquid effluent. Effluent may also contain chloroform, formaldehyde, and dioxin/furan congeners.	Potential for infection or toxicity from exposure to fugitive emissions during grinding. Potential surface water contamination from liquid effluent. Potential groundwater contamination if landfilled waste leaches. Treated wastes take up valuable landfill space. (Ref. 11 and 12)
Iodophor	Discharges in wastewater. Solid waste saturated with chemical solution.	Presents occupational hazard to workers due to its toxicity, corrosivity, and ability to irritate the skin and eyes. Potential for surface water contamination from wastewater and groundwater contamination if landfilled solids leach (Ref. 16).
Alcohols	Discharges in wastewater. Solid waste saturated with chemical solution.	Presents occupational hazard to workers due to their flammability, toxicity, and ability to irritate the eyes. Potential for surface water and groundwater contamination if landfilled solids leach.
Formaldehyde	Discharges in wastewater. Solid waste saturated with chemical solution.	Presents occupational hazard to workers due to its toxicity and ability to irritate the skin and eyes. Potential for surface water contamination from wastewater, and groundwater contamination if landfilled solids leach (Ref. 16).
Glutaraldehyde	Discharges in wastewater. Solid waste saturated with chemical solution.	Presents occupational hazard to workers due to its toxicity and ability to irritate the skin and eyes. Potential for surface water contamination from wastewater, and groundwater contamination if landfilled solids leach (Ref. 16).

Medical Waste Issues Study

Treatment Technology	Type of Emissions	Health Risks/Environmental Impacts
Ozone	Emissions unknown, but ozone gas emissions possible.	Health and environmental impacts unknown. Aesthetic degradation possible if treated wastes are not ground or shredded prior to landfilling. Treated wastes use valuable landfill space.
Ethylene Oxide	Potential emissions of ethylene oxide gas.	Worker exposure to ethylene oxide gas could be carcinogenic. Aesthetic degradation possible if treated wastes are not ground or shredded prior to landfilling. Treated wastes take up valuable landfill space. (Ref. 10)
Electron Beam	Minute quantities of ozone and hydrogen peroxide are emitted. Potential leakage of high energy electrons if adequate shielding is not in place.	Potential worker exposure to ozone and hydrogen peroxide could have toxic effects. Potential exposure to electron beams could have adverse health effects. Aesthetic degradation possible if treated wastes are not ground or shredded prior to landfilling. Treated wastes use valuable landfill space. (Ref. 11 and 12)
Gamma Irradiation	No known air or liquid emissions. Potential leaks of radiation.	Potential worker exposure to radiation. Aesthetic degradation possible if treated wastes are not shredded prior to landfilling. Treated wastes take up valuable landfill space. (Ref. 12)
Ultraviolet Irradiation	No known air or liquid emissions. Potential (but undocumented) leaks of radiation.	Potential worker exposure to radiation. Aesthetic degradation possible if treated wastes are not shredded prior to landfilling. Treated wastes take up valuable landfill space.





