**A report to the California Legislature**
**On the effect upon the environment**
**Of hydraulic lift tanks**

# REPORT ON

# HYDRAULIC LIFT TANKS

**February 1995**

State Water Resources Control Board
Division of Clean Water Programs
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# HYDRAULIC LIFT TANK REPORT

## EXECUTIVE SUMMARY

Assembly Bill 1061 (Costa), Chapter 432 of 1993, requires the State Water Resources Control Board (SWRCB) to assess the threat of leaks from hydraulic lift tanks (HLTs). The law directs the SWRCB to prepare a report that estimates the number of HLTs in the state and the number of these tanks that have leaked, and evaluates the types of dangers to the environment that HLT leaks might pose.

To estimate the total number of HLTs and the number of these tanks that have leaked fluid into the environment, staff surveyed local regulators, the Department of Industrial Relations (DIR), and the affected industries. To assess the danger that HLT leaks might pose to the environment, SWRCB staff conducted a review of scientific literature to ascertain the toxicology and environmental fate of fluids commonly used in HLTs.

There are an estimated 73,000 HLTs in California, 78 of which have leaked to the environment, as reported to local regulatory agencies. Five of the 27 leaks that reached ground water required cleanup to avoid an adverse impact on drinking water or other current uses of drinking water.

Based on the findings of this report, the SWRCB recommends that all HLTs be permanently exempted from regulation under the Underground Storage Tank law. The Porter-Cologne Water Quality Control Act (Water Code) provides ample authority for the Regional Water Quality Control Boards (RWQCBs) to regulate those few HLTs which may threaten beneficial uses of water.

The following three management practices are recommended to the DIR and the HLT industry to encourage leak prevention and prompt, appropriate response to leaks that do occur.

1) Encourage industry to emphasize the need to repair systems that are found to leak small amounts of fluid continually.

2) Encourage the use of alternative fluids that do not contain any hazardous materials.

3) Encourage industry to develop and install secondary containment on new HLT systems, where feasible. The feasibility of retrofitting existing HLT systems as part of a major overhaul or repair should also be investigated.

# Contents

# SUMMARY AND ANALYSIS OF HYDRAULIC LIFT TANK SURVEY

## I. BACKGROUND AND INTRODUCTION

Assembly Bill 1061 (Costa), Chapter 432 of 1993, requires the State Water Resources Control Board (SWRCB) to assess the threat of leaks from hydraulic lift tanks (HLTs). The law directs the SWRCB to prepare a report that covers the following:

a) The number of tanks holding hydraulic fluid that are in operation in the state, are no longer in use, or are abandoned.

b) An estimate of the number of these tanks that have leaked hydraulic fluid into the environment.

c) An evaluation of the types of dangers to the environment posed by tanks leaking hydraulic fluid.

d) An assessment as to whether the danger posed by leaking hydraulic lift tanks justifies their regulation pursuant to Chapter 6.7 (commencing with Section 25280) of Division 20 of the Health and Safety Code.

Based on the findings of this report, the SWRCB is to recommend replacing the temporary exemption from regulation under Chapter 6.7 with either: 1) their permanent exemption, or 2) their inclusion in the Underground Storage Tank (UST) regulated universe.

To estimate the total number of HLTs and the number of these tanks that have leaked fluid into the environment, staff surveyed local regulators, the Department of Industrial Relations (DIR), and the affected industries. The local regulators consist of the 104 Local Implementing Agencies (LIAs) which all oversee the leak prevention part of the underground storage tank program. *(Note that Regional Water Quality Control Boards have had little regulatory involvement with HLTs.)* The DIR is the state agency that permits and inspects hydraulic elevators. The main industries affected by this legislation are elevator manufacturers and automotive lift manufacturers. Ten elevator manufacturers and the Automotive Lift Institute (ALI) responded to a survey that included most of the questions asked of LIAs, as well as additional questions about relevant industry practices.

To gather additional information on the number of HLTs which have leaked fluid into the environment and the danger that these leaks pose, the SWRCB also surveyed staff at the 21 Local Oversight Program (LOP) agencies, which are under contract with the SWRCB to oversee cleanup of leaks from petroleum USTs. These LOP agencies are a subset of the LIAs, with the exception of the Santa Clara Valley Water District. However, staff at these 21 Local Oversight Program (LOP) agencies are usually different from the staff who oversee the leak prevention side of the UST program. To obtain a more complete picture of the extent of the problem that HLTs might pose, their responses to the same survey questions were solicited.

SWRCB staff anticipated that the survey results would provide limited information on the threat that HLT leaks might pose to the environment and particularly to water supplies. To supplement this survey data, staff conducted a review of scientific literature pertaining to: 1) the composition of hydraulic fluid commonly used in most HLTs in California, 2) the toxicity of typical HLT fluids, and 3) the environmental fate of these typical HLT fluids. There was a dearth of data, most likely the result of the U.S. Environmental Protection Agency's decision to exempt HLTs from the federal regulatory universe, and hydraulic fluid manufacturers' reluctance to divulge trade secret information on the composition of their products.

## II. SURVEY OF LOCAL REGULATORY AGENCIES, DIR, AND THE HLT INDUSTRY

### A. REGULATORY AGENCY SURVEY RESULTS

The intent in contacting the LIA and LOP staffs was to find out how many leaks from HLTs they were aware of and whether any of these leaks had posed an environmental and, especially, a water supply risk. Staff contacted the DIR, elevator manufacturers, and an industry trade association to get a more complete count of the number of HLTs in California.

Staff believed that SWRCB data on the HLT population was incomplete, as the UST regulatory program was not applied on a statewide basis to HLTs until August 9, 1991. On that date, the SWRCB's revised regulations included HLTs over 110 gallons capacity under the definition of an UST (Sec. 2621, Ch. 16, 23 CCR). This capacity limit essentially excludes HLTs that power lifts at automotive

service stations and includes HLTs that power elevators in buildings. This distinction is important in interpreting the results of our survey.

As is the case with all regulatory programs, there was a time gap between the date that statewide regulation of HLTs took effect and the date of actual implementation by LIAs. Some LIAs began to regulate HLTs soon after the regulations changed; others took at least a year to begin regulating them. Differences in regulatory agency responsiveness to this change account for some of the variation in survey responses.

Some of the LIAs counted only HLTs that power elevators, whereas other LIAs counted HLTs at automotive service stations. Some LIAs included all types of HLTs in their survey responses. It was not necessary to choose a definition when we sent out the survey, because LIAs can be more stringent than the minimum state requirements. It is possible that some of the LIAs were regulating all HLTs, even though the State regulations exempted those with a capacity of less than 110 gallons. Our lack of definition led some LIAs to estimate the HLT population and number of leaks, not just report those HLTs that they are actively regulating.

Of the 104 LIAs which received the survey (Appendix 1), 57 *(56 and the Santa Clara Valley District)* responded. In those cases where two different staffs from the same LIA provided information, the LIA consolidated the comments into one response. LIAs and Local Oversight Program agencies (LOPs) reported a total of 26,000 HLTs.

The 57 responding agencies reported 78 confirmed leaks from HLTs. Of the 78 confirmed leaks, 27 are known to have reached ground water. Of these confirmed leaks which reached ground water, five threatened a water supply. The five leaks that may have posed a threat to drinking water were reported to have been easily cleaned up before a current water use was adversely affected.

## B. DEPARTMENT OF INDUSTRIAL RELATIONS AND HYDRAULIC LIFT TANK INDUSTRY SURVEY RESULTS

The Department of Industrial Relations reported that there are 48,000 hydraulic elevators currently in operation throughout California. Ten elevator companies responded to the survey. No abandoned or no-longer-in-use elevators were identified by the elevator companies. Six

leaking hydraulic elevators were reported. In response to a question relating to beneficial use impairment, one elevator company reported that beneficial uses of ground water had been adversely affected by leaking hydraulic elevators. All elevator companies reported that petroleum-based hydraulic fluid is used. One company reported that vegetable-based hydraulic fluid was used on an experimental basis.

The Automotive Lift Institute (ALI) reported that there are 25,000 in-ground lifts currently in operation in California. The ALI, which represents all manufacturers of non-elevator, in-ground hydraulic lifts (primarily those at automobile service stations), stated that it does not know how many automotive lifts have been abandoned or removed.

The ALI estimated that approximately two percent of the 25,000 automotive lifts that they estimated are in California have leaked more than 5 gallons of hydraulic fluid over a one-year period to the underground environment. Of these 460 estimated below-ground leaks, the ALI did not know whether a beneficial use of water has been adversely affected. The ALI stated that hydraulic lifts naturally "leak" oil above ground in order to lubricate the pistons. Such above ground leaks are generally small and can be cleaned up easily during housekeeping and maintenance. The ALI has recommended that either petroleum-based hydraulic oils or biodegradable vegetable-based hydraulic oils be used in hydraulic lifts.

## C. FINDINGS

Based on the combined estimates of the Department of Industrial Relations and the Automotive Lift Institute, SWRCB staff assumed that there are a total of 73,000 (48,000 plus 25,000) HLTs in operation.

The number of leaks reported by LIAs in this survey may be a low estimate, owing to the recent inclusion of HLTs into the statewide UST universe. Nonetheless, the results indicate that reported HLT leaks have had no known adverse impact on drinking water supplies or other beneficial uses of water. These results are consistent with the rationale that the U.S. Environmental Protection Agency presented to justify exempting HLTs from the Federal regulatory program in 1988.

# III. HYDRAULIC FLUIDS USED IN HYDRAULIC LIFT TANKS: CHEMICAL AND PHYSICAL PROPERTIES, ENVIRONMENTAL FATE, AND TOXICITY

The following information was derived from a literature search of materials that are not proprietary.[1] The composition of hydraulic fluids developed by the major oil companies and other manufacturers is trade secret information not subject to public review. Based on the limited availability of data, the analysis of the toxicity and environmental fate of hydraulic fluids is generalized.

## A. COMPOSITION OF HYDRAULIC FLUIDS

Three major classes of hydraulic fluids are available for use in HLTs:

(1) **Petroleum-derived oils (including mineral oils)** - These oils are used for a variety of hydraulic lifts, such as elevators and mobile platforms used in automotive service bays. These products are formulated to be fire-resistant. Various additives, such as stabilizers and antioxidants, are added to improve the products' performance or to extend their useful life in hydraulic lift tanks.

(2) **Vegetable-derived oils** - Since these oils are prone to decompose rapidly, a variety of additives are used to stabilize and preserve them. Vegetable-derived oils are relatively new on the market, and are not as widely used as the petroleum-based oils.

(3) **Synthetic hydraulic fluids** - These are relatively expensive products formulated for specialized applications. They are often composed primarily of synthetic esters or polyglycols. Due to their greater cost, they are used mainly for high temperature and/or high pressure hydraulic systems in industries such as steel manufacturing, and in aircraft, submarines, and ships. Due to their specialized uses, these synthetic products are excluded from further discussion in this review and analysis.

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[1] These sources are listed in the bibliography and appendix.

The petroleum and vegetable base oils used in formulating hydraulic fluids are less dense than water. They are also relatively insoluble in water. If leaks of such hydraulic fluids reach ground water, they would be expected to float above the aquifer, and little of these oils would dissolve in ground water.

The base oils are neither water reactive nor explosive. They are also non-flammable, non-corrosive, and non-conductive.

Benzene is the constituent of petroleum products, including hydraulic fluid, that is of most concern in terms of toxicity and environmental fate. Benzene is a known carcinogen and is relatively mobile in the subsurface environment. Unlike gasoline, jet fuel, and Stoddard solvent, most hydraulic lubricating oils have a benzene content that is kept purposely low to improve the efficiency of the operating HLT systems. One environmental benefit of this low benzene content is that carcinogenic polynuclear aromatic compounds will not form when the fluid is heated as part of the HLT operation.

Additives are usually important in improving the performance of the hydraulic fluids and increasing their useful life. An additive can be defined as a substance that reinforces some desirable property already possessed to some degree by the oil, or imparts a new and desirable property not originally present. Some additives have more than one function. Additive formulations are usually patented, and their formulas are protected as proprietary.

The following are three of the most widely used additives:

(1) zinc dialkyl dithiophosphate

(2) 2, 6-di-t-butyl-4-methyl phenol ("BHT")

(3) lead napthenate

These additives are usually present at very low levels (parts per million) in hydraulic fluid. Due to these small concentrations, neither toxicity nor environmental fate data on them are included in this report.

## B. ENVIRONMENTAL FATE

There is evidence that vegetable base oils used in hydraulic fluid formulations biodegrade if released into soil or surface water. Petroleum base oils, which are often composed of hundreds of

different hydrocarbon compounds and small quantities of metals, biodegrade at different rates. Biodegradation rarely proceeds to uniform chemical end-products in microbial breakdown processes. Larger molecules may break down slowly. In minuscule quantities, biodegradation can be inhibited by a variety of factors, including the amount of methyl group branching on an aliphatic hydrocarbon chain. Mineral oil, a subset of petroleum, is composed primarily of paraffinic hydrocarbons, which are thus more resistant to biodegradation than vegetable oils.

## C. TOXICITY

A computer database search of the literature revealed no reported human toxicity associated with the ingestion of petroleum or vegetable base oils. SWRCB staff assumed that the most probable form of human exposure to hydraulic fluid in ground water is ingestion by means of drinking water. Given the lack of volatility of these base oils, airborne exposure pathways are unlikely, so this potential route of exposure was not examined. It should be noted that no information on these possible routes of exposure was found in the literature search.

Staff also assumed that releases to soil and groundwater were unlikely to cause surface water discharges. As in the case of routes of human exposure, the literature search did not yield more information on this subject. Nonhuman exposures to hydraulic fluid base oils were judged to be unlikely. Similarly, the database search revealed no studies or other information on this item.

## D. CONCLUSIONS

Based on the limited information in the literature, the following summary describes the probable environmental fate of hydraulic lift tank releases involving vegetable and petroleum-derived oils used as hydraulic fluids.

(1) The base oils are relatively insoluble in water.

(2) The base oils are less dense than water, so any release to ground water will tend to float on top of the aquifer.

(3) The base oils have low volatility, tend to adhere to soil particles, and are relatively immobile in a subsurface

environment. Leak plumes would be expected to be small and to not travel far from the point of release.

(4) The base oils are low in aromatic compounds, such as benzene, which pose a hazard in drinking water.

(5) The base oils will biodegrade, at least partially, after they have been released into the environment.

(6) The primary route of exposure after a release will be possible human ingestion via degraded drinking water.

(7) The human toxicity (measured in terms of ingestion) associated with these oils is apparently very low or nonexistent.

(8) It is unlikely that other species of organisms will be adversely affected by HLT releases under the conditions described above.

# IV. RECOMMENDATIONS

## A. PERMANENT EXEMPTION FOR HLTS

Based on the survey results and evaluation of the toxicology and environmental fate and transport data, the SWRCB finds that HLTs pose a minor threat to water quality and the environment, and recommends that the temporary exemption for HLTs under the UST law become permanent.

*RATIONALE FOR THE PERMANENT EXEMPTION*

1) Hydraulic fluids are relatively insoluble in water and thus have limited ability to degrade ground water when leaked into soil.

2) Hydraulic fluids are relatively immobile in soil and do not travel far from the leak source.

3) Petroleum and vegetable-base oils for hydraulic fluid exhibit no or low toxicity to humans.

4) Of the estimated 78,000 HLTs, very few cases of HLT leaks to ground water have been reported, and only five that reached groundwater potentially affected a drinking water supply.

5) Most local implementing agencies lack resources to regulate this segment of the UST universe, given the many demands on their fee-supported programs.

6) The public health and environmental benefits of complying with the UST leak prevention and corrective action requirements do not appear to justify the expense to the regulated community.

7) Most HLTs store a much smaller liquid volume of fluid than other petroleum USTs. Added to this is the fact that when a significant leak occurs, the equipment stops working. Therefore, the likelihood of sizeable HLT leaks relative to fuel tank leaks is much lower.

8) Regional Water Quality Control Boards retain their authority under the Water Code to require cleanup of HLT leaks where beneficial uses of water are adversely affected or threatened.

## B. BEST MANAGEMENT PRACTICES FOR HLTS

The following three management practices are recommended to the DIR and the HLT industry to encourage leak prevention and prompt, appropriate response to leaks that do occur.

1) Encourage industry to emphasize the need to repair systems that are found to leak small amounts of fluid continually.

2) Encourage the use of alternative fluids that do not contain any hazardous materials. For example, Mobil Oil Company has developed a vegetable-based hydraulic fluid that they think is environmentally friendly. Testing of this product, in its virgin and used states, is under way, using California standards for hazardous waste and threat to water quality.

3) Encourage industry to develop and install secondary containment on new HLTs systems, where feasible. The feasibility of retrofitting existing HLT systems as part of a major overhaul or repair should also be investigated.

## *RATIONALE FOR THE BEST MANAGEMENT PRACTICES*

The following reasons are cited in favor of recommending best management practices for HLTs, to complement their permanent exemption from the UST regulatory universe:

1) Soil and ground water degradation in the immediate vicinity of HLTs have been reported.

2) The elevator industry has reported cases of slow leaks that have never been investigated, documented, repaired, or cleaned up.

3) Unidentified components, which may be hazardous, have been and continue to be added to some hydraulic fluids.

4) Small leaks that do not cause equipment to stop working may continue for long periods of time.

5) Some HLTs are installed deeper in the ground than typical fuel tanks.

# Appendix 1

# Survey of Local Implementing Agencies and Local Oversight Programs

LOCAL IMPLEMENTING AGENCIES AND LOCAL OVERSIGHT PROGRAMS

***1. How many hydraulic lift tanks are in your jurisdiction?***

Results:
**Total number of HLTs: 26,115**
**Total number of "*Unknown*" responses: 29**
**Total number of Respondents: 57**

| | |
|---|---|
| City of Anaheim | *Unknown.* |
| City of Bakersfield | 75. *(estimate)* |
| City of Berkeley | 3,000. *(estimate)* |
| City of Burbank | 375. *(estimate)* |
| City of Fremont | *Unknown.* |
| City of Glendale | 200. *(estimate)* |
| City of Hayward | *Unknown.* |
| City of Hollister | 21 |
| City of Los Angeles | 17,346. (9,396 elevator tanks, 7,950 automobile lifts) |
| City of Milpitas | *Unknown.* |
| City of Mountain View | *Unknown.* |
| City of Newark | 25-40. *(estimate)* |
| City of Orange | *Unknown.* |
| City of Oroville | 20. *(estimate)* |
| City of San Leandro | *Unknown.* |

| | |
|---|---|
| City of San Luis Obispo | 35-40. *(estimate)* |
| City of San Rafael | *Unknown.* |
| City of Santa Ana | *Unknown.* |
| City of Santa Clara | 1,120. *(estimate)* |
| City of Sebastopol | 12-15. *(estimate)* |
| City of Sunnyvale | 75. *(estimate)* |
| City of Torrance | *Unknown.* |
| City of Union City | 4 |
| City of Victorville | 120 |
| Alameda County | *Unknown.* "The number of hydraulic lifts is not reported at this time." |
| Alpine County | 6 |
| Amador County | 2. *(estimate)* |
| Humboldt County | *Unknown.* |
| Imperial County | 75. *(estimate)* |
| Kern County | 100. *(estimate)* |
| King County | *Unknown.* |
| Lake County | 75. *(estimate)* |
| Los Angeles County | *Unknown.* |
| Madera County | *Unknown.* |

| | |
|---|---|
| Marin County | *Unknown.* |
| Merced County | *Unknown.* |
| Modoc County | *Unknown.* |
| Monterey County | 200 |
| Napa County | *Unknown.* |
| Nevada County | 57. *(estimate)* |
| Orange County | *Unknown.* |
| Placer County | *Unknown.* |
| Plumas County | *Unknown.* |
| Riverside County | *Unknown.* |
| Sacramento County | 400. *(estimate based on auto service bays and elevators)* |
| San Bernardino County | 850 |
| San Diego County | *Unknown.* |
| San Joaquin County | 1,200. (*estimate based on service facilities -- excludes elevators*) |
| Santa Barbara County | 200. *(estimate)* |
| Santa Clara County | 400. *(estimate)* |
| Shasta County | *Unknown.* |
| Siskiyou County | 64. (22 at gas stations, 42 at miscellaneous shops) |
| Solano County | *Unknown.* |

| | |
|---|---|
| Sonoma County | 45. *(estimate)* |
| Stanislaus County | *Unknown.* |
| Tulare County | *Unknown.* |
| Santa Clara Valley Water District (LOP) | *Unknown.* "13 implementing agencies are responsible for tank permitting and monitoring. [Santa Clara Valley Water District] is responsible for only a site where a leak has occurred." |

*2. How many leaks of these hydraulic lift tanks have leaked into the environment?*

Results:

**Total number of confirmed HLT leaks: 78**
**Total number of estimated HLT leaks: 235**
**Total number of "*Unknown*" responses: 22**
**Total number of Respondents: 57**

| | |
|---|---|
| City of Anaheim | *Unknown.* |
| City of Bakersfield | *Unknown.* "Most are contained in concrete vault-type construction." |
| City of Berkeley | "Approximately 7 in the past 5 years." |
| City of Burbank | *Unknown.* |
| City of Fremont | "Of the approximately 30 tanks sampled in the past 2 or 3 years, approximately 6 [have] leaked." |
| City of Glendale | "5 cases in the last 4 years." |
| City of Hayward | "Approximately 10 known leaks." |
| City of Hollister | None. |
| City of Los Angeles | *Unknown.* |
| City of Milpitas | "One impacted soil only." |
| City of Mountain View | "At least 6 leaks have been documented. Most were discovered during removal." |
| City of Newark | 1 |
| City of Orange | 1 |
| City of Oroville | 1. *(estimate)* |
| City of San Leandro | *Unknown.* |

| | |
|---|---|
| City of San Luis Obispo | 35. *(estimate)* "Almost all that have been removed [and] inspected have had some degree of soil contamination." |
| City of San Rafael | "6 have been removed and resulted in contamination." |
| City of Santa Ana | *Unknown.* |
| City of Santa Clara | 2 |
| City of Sebastopol | *Unknown.* |
| City of Sunnyvale | "3 known cases." |
| City of Torrance | *Unknown.* |
| City of Union City | None. |
| City of Victorville | None. |
| Alameda County | None. |
| Alpine County | *Unknown.* |
| Amador County | *Unknown.* |
| Humboldt County | "Only 5 have been tested -- all of which have leaked." |
| Imperial County | *Unknown.* |
| Kern County | *Unknown.* |
| King County | *Unknown.* |
| Lake County | "One confirmed case." |

| | |
|---|---|
| Los Angeles County | 6 confirmed cases. "We have record on only six sites where confirmed releases of hydraulic lift tanks have occurred. These releases came to our attention because the owners voluntarily registered the tanks as USTs to allow closure oversight and inclusion into the Local Oversight Program (LOP). Three of these sites have been closed." |
| Madera County | None. |
| Marin County | "I know of 4 sites. |
| Merced County | *Unknown.* |
| Modoc County | *Unknown.* |
| Monterey County | "2 or 3 that are known." |
| Napa County | *Unknown.* |
| Nevada County | "2 reported and cleaned-up." |
| Orange County | 19 |
| Placer County | 1 |
| Plumas County | *Unknown.* |
| Riverside County | *Unknown.* |
| Sacramento County | "This agency has overseen or is overseeing remediation at approximately 15 sites due to HLTs." |
| San Bernardino County | 5 |
| San Diego County | "Less than 10 sites reported." *(estimate)* |
| San Joaquin County | "3 known ground water cleanups due to HLTs." |

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|---|---|
| Santa Barbara County | 50. *(estimate)* |
| Santa Clara County | *Unknown.* |
| Shasta County | *Unknown.* |
| Siskiyou County | *Unknown.* |
| Solano County | "One that we are aware of. It was cleaned up. Soil was removed." |
| Sonoma County | *Unknown.* |
| Stanislaus County | 3 |
| Tulare County | "One confirmed. Soil [contamination] only." |
| Santa Clara Valley Water District (LOP) | 100. (*estimate*) "Generally, any corrective action is overseen by RWQCB because most tanks do not meet UST definition. Almost all seem to be minor soil contamination only." |

*3. Of these leaks, how many have reached ground water?*

Results:

**Total number of confirmed HLTs leaks which have reached ground water: 27**
**Total number of HLT leaks which are estimated to have reached ground water: 27**
**Total number of "*Unknown*" responses: 29**
**Total number of Respondents: 57**

| | |
|---|---|
| City of Anaheim | *Unknown.* |
| City of Bakersfield | None. |
| City of Berkeley | 1 |
| City of Burbank | *Unknown.* |
| City of Fremont | 1 |
| City of Glendale | None. |
| City of Hayward | None. |
| City of Hollister | None. |
| City of Los Angeles | *Unknown.* |
| City of Milpitas | None. |
| City of Mountain View | *Unknown.* |
| City of Newark | 1 |
| City of Orange | None. |
| City of Oroville | 0 |
| City of San Leandro | *Unknown.* |

| | |
|---|---|
| City of San Luis Obispo | *Unknown.* "(Exact number is unknown, but few have documented ground water involvement.)" |
| City of San Rafael | All 6. |
| City of Santa Ana | *Unknown.* |
| City of Santa Clara | 2 |
| City of Sebastopol | *Unknown.* |
| City of Sunnyvale | 1 |
| City of Torrance | *Unknown.* |
| City of Union City | None. |
| City of Victorville | *Unknown.* |
| Alameda County | None. |
| Alpine County | *Unknown.* |
| Amador County | *Unknown.* |
| Humboldt County | *Unknown.* |
| Imperial County | *Unknown.* |
| Kern County | *Unknown.* |
| King County | *Unknown.* |
| Lake County | "Ground water is contaminated at the site with petroleum hydrocarbons. However, it is unknown whether the contamination originated from HLTs, other USTs, or a combination." |

| | |
|---|---|
| Los Angeles County | Of the sites noted [in Item 2], only one release has been confirmed to have reached ground water and is currently under the oversight of our Local Oversight Program (LOP). |
| Madera County | None. |
| Marin County | 2 |
| Merced County | *Unknown.* |
| Modoc County | *Unknown.* |
| Monterey County | None. |
| Napa County | *Unknown.* |
| Nevada County | None. |
| Orange County | 4 |
| Placer County | 1 |
| Plumas County | *Unknown.* |
| Riverside County | *Unknown.* |
| Sacramento County | 2 of the known leaks have reached ground water. |
| San Bernardino County | *Unknown.* |
| San Diego County | *Unknown.* |
| San Joaquin County | 2 |
| Santa Barbara County | 25. *(estimate)* |
| Santa Clara County | *Unknown.* |

| | |
|---|---|
| Shasta County | *Unknown.* |
| Siskiyou County | *Unknown.* |
| Solano County | None. |
| Sonoma County | *Unknown.* |
| Stanislaus County | None. |
| Tulare County | *Unknown.* |
| Santa Clara Valley Water District (LOP) | 3 to 5. |

*4. Of the leaks which reached ground water, how many threatened a water supply, e.g., required cleanup action to protect a water supply?*

Results:

**Total number of HLTs leaks that reached ground water and threatened a water supply: 5**

**Total number of "*Unknown*" responses: 29**

**Total number of Respondents: 57**

| | |
|---|---|
| City of Anaheim | *Unknown.* |
| City of Bakersfield | None. |
| City of Berkeley | None. |
| City of Burbank | *Unknown.* |
| City of Fremont | One. |
| City of Glendale | None. |
| City of Hayward | None. |
| City of Hollister | None. |
| City of Los Angeles | *Unknown.* |
| City of Milpitas | None. |
| City of Mountain View | *Unknown.* |
| City of Newark | None. |
| City of Orange | None. |
| City of Oroville | None. |
| City of San Leandro | *Unknown.* |

| | |
|---|---|
| City of San Luis Obispo | *Unknown.* "(All ground water involvement cases referred to RWQCB.)" |
| City of San Rafael | 2 |
| City of Santa Ana | *Unknown.* |
| City of Santa Clara | None. |
| City of Sebastopol | *Unknown.* |
| City of Sunnyvale | 0. |
| City of Torrance | None. |
| City of Union City | None. |
| City of Victorville | *Unknown.* |
| Alameda County | None. |
| Alpine County | *Unknown.* |
| Amador County | *Unknown.* |
| Humboldt County | *Unknown.* |
| Imperial County | *Unknown.* |
| Kern County | *Unknown.* |
| King County | None. |
| Lake County | *Unknown.* |
| Los Angeles County | None. "The release noted in Item 3 has not effected a water supply with identified beneficial uses." |
| Madera County | None. |

| | |
|---|---|
| Marin County | (*Unknown.*) "We do not get our water from ground water." |
| Modoc County | *Unknown.* |
| Merced County | *Unknown.* |
| Monterey County | *Unknown.* |
| Napa County | *Unknown.* |
| Nevada County | None. |
| Orange County | None. |
| Placer County | None. |
| Plumas County | *Unknown.* |
| Riverside County | *Unknown.* |
| Sacramento County | 2. |
| San Bernardino County | *Unknown.* |
| San Diego County | *Unknown.* |
| San Joaquin County | None. "Of the two cases, both required some type of cleanup action; neither are threatening [a] public water supply well." |
| Santa Barbara County | None. |
| Santa Clara County | *Unknown.* |
| Shasta County | None. |
| Siskiyou County | *Unknown.* |

| | |
|---|---|
| Solano County | None. |
| Sonoma County | *Unknown.* |
| Stanislaus County | 0 |
| Tulare County | *Unknown.* |
| Santa Clara Valley Water District (LOP) | None. |

***Additional Comments:***

| | |
|---|---|
| City of Anaheim | "Due to the exemption (under 110 gallons), we have no records of these tanks. We are unaware of any tanks exceeding 110 gallons." |
| City of Bakersfield | *N/A* |
| City of Berkeley | "[None of the leaks threatened a water supply.] (But one did reach a storm drain.)" |
| City of Burbank | "Per Cal OSHA Elevator Division, there are 323 registered hydraulic lifts with in ground cylinders. Approx 50 other service station lifts." |
| City of Fremont | "All 6 [confirmed leaks] that leaked required over-excavation. At least 3 required extensive over-excavation (depths of 28 feet below grade) in order to protect the water supply. . . Please note that while I realize these structures are exempt from the underground tank law, we require sampling as part of closure as relates to ultimate FACILITY closure..." |
| City of Glendale | *N/A* |
| City of Hayward | "Because many of these types of systems are below 110 gallons in capacity, many are not regulated. Therefore, it is very difficult to respond accurately on the number of systems and the environmental impacts." |
| City of Hollister | *N/A* |
| City of Los Angeles | *N/A* |
| City of Milpitas | *N/A* |

| | |
|---|---|
| City of Mountain View | ". . . Every time we have called the State Water Board in the past with questions about hydraulic lift tank issues (i.e., spills, monitoring, etc.), we have been told by the staff that they are currently exempt and not to worry about them. As a result, we have no records on any of them." |
| City of Newark | "Ground water is extremely shallow. . .None of the leaks threatened water supply. Although, the local water district, Alameda County Water District, requires oil and grease cleanup to 20 to 30 ppm TOG [total oil and grease]. |
| City of Orange | *N/A* |
| City of Oroville | *N/A* |
| City of San Leandro | *N/A* |
| City of San Luis Obispo | *N/A* |
| City of San Rafael | *N/A* |
| City of Santa Ana | "Currently, [Santa Ana] has no record of how many of these tanks are in the City and we have no knowledge of their location." |
| City of Santa Clara | *N/A* |
| City of Sebastopol | *N/A* |
| City of Sunnyvale | "In Santa Clara County, all ground water is deemed to have beneficial use. Therefore, the one case having ground water impact was required to undergo cleanup. However, not all ground water is designated as a drinking water supply. The ground water contaminated by leaking HLTs is not a drinking water supply." |
| City of Torrance | *N/A* |

| | |
|---|---|
| City of Union City | *N/A* |
| City of Victorville | *N/A* |
| Alameda County | *N/A* |
| Alpine County | *N/A* |
| Amador County | "Not regulated." |
| Humboldt County | "Although hydraulic oil does not pose the toxic threat to ground water that gasoline does, we suspect that some of our cases may involve commingling of hydraulic oil with fuel constituents. There is also the possibility of past use of incorrect fluid with hydraulic lift tanks which would increase the likelihood of system leakage and tend to confound sample results and pose unknown threats to ground water quality. It may be appropriate to regulate lift tanks, but it should be on a level which is consistent with their use and potential hazard." |
| Imperial County | *N/A* |
| Kern County | "Though the [Kern County] program suspects that there may be 100 sites which have hydraulic lift tanks, this information is very difficult to obtain from service companies. This program has never regulated hydraulic lift tanks." |
| King County | "We currently have no hydraulic lift tanks registered with our Department." |
| Lake County | "The one [confirmed leak] we are aware of is currently undergoing cleanup." |

| | |
|---|---|
| Los Angeles County | "We currently have no count as to the number of hydraulic lift tanks within the Department's jurisdiction (Los Angeles County, not including the cities of Los Angeles, San Fernando, Santa Monica, Torrance, Long Beach, Vernon, Burbank, Glendale, and Pasadena) although the number is believed to be substantial, in the tens of thousands. As an exempt agency under the original provisions of Chapter 6.7, the County excluded regulating such containers as USTs unless the systems included a stand-alone storage tank or exceeded a capacity of 110 gallons. Some hydraulic lift tanks were registered under Water Code Section 13173 (since repealed) and a few were later permitted inadvertently or at the specific request of the owner (to allow closure oversight). However, since no unique codes exist for such tanks in the SWEEPS database, we cannot readily identify these sites. Hydraulic lifts are regulated by the Department of Industrial relations, Division of Occupation Safety and Health Administration, who should be able to identify the location of such facilities. |
| Madera County | *N/A* |
| Marin County | "I personally think that they should be regulated since a lot of the seals over time give way. Or make it a law that they should use a non-hazardous oil in them." |
| Merced County | *N/A* |
| Modoc County | *N/A* |
| Monterey County | *N/A* |
| Napa County | "Occasionally, [leaking HLTs] come to our attention in some manner. RWQCB is the agency that oversees cleanup." |
| Nevada County | *N/A* |

| | |
|---|---|
| Orange County | "[The number of HLTs] cannot be accurately determined at this time. A detailed study is needed in order to provide an accurate number." |
| Placer County | *N/A* |
| Plumas County | *N/A* |
| Riverside County | "The County of Riverside, Department of Environmental Health would like to recommend that the temporary exemption for hydraulic lift tanks become a permanent exemption. |
| Sacramento County | "Both ground water contamination cases did affect ground water sources that have been designated municipal beneficial uses. Therefore, in both cases a drinking water supply was threatened. However, both contaminated sites were remediated." |
| San Bernardino County | *N/A* |
| San Diego County | "Recommend SWRCB check with RWQCB [to determine how many HLTs have leaked into the environment]." |
| San Joaquin County | *N/A* |
| Santa Barbara County | Permitting and regulating the removal of hydraulic lift units, rather than permitting the operating systems, would probably be a practical and effective way to handle releases from hydraulic units. Release reporting will be required for all occurrences. |
| Santa Clara County | *N/A* |
| Shasta County | *N/A* |

| | |
|---|---|
| Siskiyou County | The remedial action taken place at sites that have hydraulic lifts are due to underground tanks or piping leaks. The cleanup has always been per the Regional Water Quality Control Board in that area. There are numerous sites under cleanup. Never was there a mention of hydraulic fluid being considered as part of the contamination sample for. |
| Solano County | *N/A* |
| Sonoma County | This County does not keep or maintain records regarding hydraulic lifts. However, we estimated that about 10% of our UST facilities have hydraulic lifts. |
| Stanislaus County | "There have been two HLT leaks that were confined to the soil zone, but were still a threat to a water supply. The contamination never reached ground water because the ground water level was intermittently deep due to six consecutive drought years. Had the two HLTs not been removed and had there not been extensive over-excavation of the contaminated soils, the ground water would have been contaminated as soon as the ground water level rose. Consequently, in both cases a water supply would have been directly affected." |
| Tulare County | *N/A* |
| Santa Clara Valley Water District (LOP) | "Generally, leaks have only reached ground water [where] the depth to water is very shallow, i.e., less than 10 feet. . . . [None of the leaks threatened a water supply.] Although one to three leaks have been at sites where there is ongoing unrelated ground water cleanup action. These are sites overseen by the San Francisco Bay Regional Water Board." |

# Appendix 2

# Survey of Manufacturers

MANUFACTURERS

***1. How many hydraulic elevators are operating in California?***

Results:
**Total number of hydraulic elevators: 4,711**
**Total number of "*Unknown*" responses: 5**
**Total number of Respondents: 10**

| | |
|---|---|
| Armor Kone, Inc. | *Unknown.* |
| Dover Elevator Company | 3,130. "This response represents the total number of units presently under service contract with Dover Elevator in California. Units installed by Dover, but not under contract are not included." |
| Fujitec America, Inc. | 52 |
| Lerch, Bates & Associates, Inc. | "Plenty." (*Unknown*) |
| Millar Elevator Service, Co. | (*Unknown*) "Thousands! This information is available through the Elevator Division of the California Department of Industrial Relations." |
| Mitsubishi Elevators & Escalators | 79. (71 in-ground with sealed protective PVC casing, and 8 above ground.) |
| Montgomery Elevator Company | *Unknown.* |
| Otis Elevator Company | *Unknown.* |
| Schindler Elevator Corp. | 1450. |

| | |
|---|---|
| Schumacher Elevator Company, Inc. | None. |

*2. How many hydraulic elevators in California are no longer in use or are abandoned, but the jack assemblies still remain in the ground?*

Results:
**Total number of abandoned hydraulic elevators: 0**
**Total number of "*Unknown*" responses: 6**
**Total number of Respondents: 10**

| | |
|---|---|
| Armor Kone, Inc. | *Unknown.* |
| Dover Elevator Company | "No elevators that Dover had in service have been removed or abandoned |
| Fujitec America, Inc. | None. |
| Lerch, Bates & Associates, Inc. | (*Unknown*) "A few." |
| Millar Elevator Service, Co. | (*Unknown*) "This information is available through the Elevator Division of the California Department of Industrial Relations." |
| Mitsubishi Elevators & Escalators | None. |
| Montgomery Elevator Company | *Unknown.* |
| Otis Elevator Company | *Unknown.* |

| | |
|---|---|
| Schindler Elevator Corp. | *Unknown.* |
| Schumacher Elevator Company, Inc. | None. |

*3. How many hydraulic elevators in California have experienced small amounts of fluid loss on a continuous or sporadic basis (leaked more than 5 gallons on an annual basis)?*

Results:
**Total number of hydraulic elevators experiencing losses: 6**
**Total number of "*Unknown*" responses: 5**
**Total number of Respondents: 10**

| | |
|---|---|
| Armor Kone, Inc. | (*Unknown*) 50%. *(estimate)* |
| Dover Elevator Company | "None.. . . We interpret this question with reference to the closed hydraulic system. All elevator jack pistons carry a light film of oil on the polished piston. The oil is captured and either returned to the tank by an external pump, or collected in a container in the elevator pit. |
| Fujitec America, Inc. | None. |
| Lerch, Bates & Associates, Inc. | (*Unknown*) "A few." |
| Millar Elevator Service, Co. | (*Unknown*) "We [in the San Francisco Bay Area] deal with two or three per year." |
| Mitsubishi Elevators & Escalators | None. |
| Montgomery Elevator Company | *Unknown.* |
| Otis Elevator Company | "We are aware of 6 hydraulic elevators in California which [have] failed a full load test since June, 1991, [in which the failure is] believed to be a result of a leak. |
| Schindler Elevator Corp. | *Unknown.* |

| | |
|---|---|
| Schumacher Elevator Company, Inc. | None. |

***4. Of these leaks, how many have affected a beneficial use of water (e.g., ground water used for drinking, surface water used for aquatic habitat or recreation)?***

Results:
**Total number of hydraulic elevators affecting a beneficial use of water: 0**
**Total number of "*Unknown*" responses: 6**
**Total number of Respondents: 10**

| | |
|---|---|
| Armor Kone, Inc. | *Unknown.* |
| Dover Elevator Company | None. |
| Fujitec America, Inc. | None. |
| Lerch, Bates & Associates, Inc. | (*Unknown*) "A few." |
| Millar Elevator Service, Co. | (*Unknown*) "This information is available through the Elevator Division of the California Department of Industrial Relations." |
| Mitsubishi Elevators & Escalators | None. |
| Montgomery Elevator Company | *Unknown.* |
| Otis Elevator Company | *Unknown.* Only the owners of the lifts would have such information. |
| Schindler Elevator Corp. | *Unknown.* |

| | |
|---|---|
| Schumacher Elevator Company, Inc. | None. |

***5. What types of hydraulic fluids are used in hydraulic lifts?***
***petroleum products*** _____
***other (please describe)*** _____
***don't know*** _____

Results:
**Petroleum Products: 7**
**Other: 1 (Vegetable Oil)**
**Don't Know: 3**
**Total number of Respondents: 10**

| | |
|---|---|
| Armor Kone, Inc. | Petroleum Products: AW HYD 32 - Golden West Lubricants |
| Dover Elevator Company | Petroleum Products: Type 32 hydraulic fluid. |
| Fujitec America, Inc. | Petroleum Products: Shell Tellus #32 or equivalent. |
| Lerch, Bates & Associates, Inc. | Petroleum Products: Hydraulic Oil<br>Other: Dover has experimented with vegetable oil. Results were good, but cost for the oil is high ($8 per gallon vs. $2 per gallon). Most hydraulic elevators use 125-300 gallons. |
| Millar Elevator Service, Co. | Petroleum Products and Don't Know . |
| Mitsubishi Elevators & Escalators | Petroleum Products: Shell Tellus #32 or equivalent. |
| Montgomery Elevator Company | Petroleum Products. |
| Otis Elevator Company | Petroleum Products: Conoco Oil #32. |
| Schindler Elevator Corp. | Don't Know. |

| | |
|---|---|
| Schumacher Elevator Company, Inc. | Don't Know. |

*5. Additional Comments*

| | |
|---|---|
| Armor Kone, Inc. | *N/A.* |
| Dover Elevator Company | *N/A* |
| Fujitec America, Inc. | *N/A.* |
| Lerch, Bates & Associates, Inc. | *N/A.* |
| Millar Elevator Service, Co. | *N/A.* |
| Mitsubishi Elevators & Escalators | *N/A.* |
| Montgomery Elevator Company | *N/A.* |
| Otis Elevator Company | "When [a leak] occurs, Otis immediately removes the elevator from service as a safety precaution, and notifies the owner both of those facts and alerts the owner that he may have to meet government reporting requirements, if any. We do not keep centralized records on the quantity of oil which may have leaked or whether the leak may have extended to soil or water. We also do not know the age of those lifts, or whether they were all Otis equipment. (Otis also services non-Otis equipment.)" |

| | |
|---|---|
| Schindler Elevator Corp. | *N/A.* |
| Schumacher Elevator Company, Inc. | *N/A.* |

# Appendix 3

# Survey of Automotive Lift Institute

AUTOMOTIVE LIFT TANKS

*1. How many in-ground automotive lifts are operating in California?*

Results:
**Number of Respondents: 1**

| | |
|---|---|
| AUTOMOTIVE LIFT INSTITUTE, INC. | "The current manufacturers of in-ground automotive lifts estimate that about 48% of all in-ground lifts installed in California, or approximately 12,000 lifts, are full-hydraulic lifts utilizing underground hydraulic lift tanks." |

*2. How many in-ground automotive lifts in California are no longer in use or are abandoned, but the jack assemblies still remain in the ground?*

Results:
**Number of Respondents: 1**

| | |
|---|---|
| AUTOMOTIVE LIFT INSTITUTE, INC. | "Your question #2 is actually three questions: 1) how many ground lifts in California are no longer in use; 2) how many of those were properly treated before being deactivated; and 3) how many are abandoned. . . . The current manufacturers of in-ground automotive lifts estimate that there are approximately 1,500 in-ground lifts no longer in use in California. However, an unknown number of these lifts no longer in use have been deactivated in accordance with lift manufacturers' recommendations. (Manufacturers of these lifts have prepared recommended procedures for deactivating any in-ground hydraulic lift regardless of whether it has no tank, an above ground tank, or an underground tank.) Another unknown number of these lifts may have been abandoned." |

*3. How many in-ground automotive lifts in California have experienced small amounts of fluid loss on a continuous or sporadic basis (leaked more than 5 gallons on an annual basis)?*

Results:
**Number of Respondents: 1**

| | |
|---|---|
| AUTOMOTIVE LIFT INSTITUTE, INC. | "In considering your question #3, we must assume that the reference to 'small amounts of fluid loss' and '(leaked more than 5 gallons on an annual basis)' relate to underground loss of oil and does not include the small amount 'surface' loss that occurs with the intended lubrication of the piston. This is generally 'small' and can easily be cleaned-up during 'housekeeping,' but it can vary depending on the age of the lift as well as the frequency and thoroughness of maintenance performed. . . The current manufacturers of in-ground automotive lifts estimate that underground leakage of more than 5 gallons on an annual basis has occurred in less than 2% of all in-ground lifts in California, or less than 500 in-ground lifts." |

*4. Of these leaks, how many have affected a beneficial use of water (e.g., ground water used for drinking, surface water used for aquatic habitat or recreation)?*

Results:
**Number of Respondents: 1**

| | |
|---|---|
| AUTOMOTIVE LIFT INSTITUTE, INC. | "The current manufacturers of in-ground automotive lifts are not aware of any leaks (from in-ground automotive lifts) which have affected a beneficial use of water." |

*5. What types of hydraulic fluids are used in in-ground automotive lifts?*
*petroleum products* _____
*other (please describe)* _____
*don't know* _____

Results:
**Number of Respondents: 1**

| | |
|---|---|
| AUTOMOTIVE LIFT INSTITUTE, INC. | "Your question #5 cannot be answered in terms of what fluid is actually used in hydraulic automotive lifts. We can only inform you of what oil the lift manufacturers recommend be used in the lifts they market. After that, it is up to the lift owner to follow those recommendations. . . . The current manufacturers of in-ground automotive lifts recommend that the following oils be used in in-ground lifts: 1) petroleum-based (motor) oil containing additives (i.e. anti-foam, anti-rust and anti-oxidation agents); or 2) vegetable oil-based (biodegradable) hydraulic fluids formulated for hydraulic automotive lifts. (Lift manufacturers recommend against the use of 'hydraulic' fluids for they tend to foam under pressure." |

*Additional Comments:*

| | |
|---|---|
| AUTOMOTIVE LIFT INSTITUTE, INC. | Our Federal government, in concluding that hydraulic lift tanks should be exempt under their Guidelines, carefully considered the points which are used in our discussion. Documentation on their findings appear in the Federal Register of that era, which we suggest you use as a reference source in your Report to the State Legislature when recommending that the current temporary exemption for hydraulic lift tanks be made permanent. . . . Virtually all in-ground lifts are hydraulically operated, either in part or fully. NOTE: As used [throughout this response], the word 'lift(s)' will mean 'in-ground automotive lift(s)'. . . . An estimated 10,000 lifts currently installed in California are semi-hydraulic (air over oil) and, because they do not utilize a hydraulic lift tank, we believe consideration of them can be excluded from your final report on underground tanks. . . . The following is a brief explanation of the operation of semi-hydraulic lifts offers our reason for this belief. Compressed air is injected into the sealed cylinder assembly, putting pressure on the entrapped oil which causes the piston to rise. Approximately 43 gallons of hydraulic oil is entrapped in a single post lift which is the most common type used in automotive service facilities. This type of lift begins to malfunction when the system is approximately three (3) gallons low on oil, thus alerting the lift owner/operator that fluid has been lost. . . . |

# Appendix 4

# References

# Appendix 4 - References


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# Appendix 5

# Literature Search

# Appendix C - Literature Search

The literature search conducted in the preparation of this report included the following databases:

(1) The ANALYTICAL ABSTRACTS database corresponds to the printed publication produced by The Royal Society of Chemistry. The printed publication dates back to 1954 and is a comprehensive abstracting service dealing solely with analytical chemistry.

(2) CHEMICAL SAFETY NEWSBASE (CSNB) is produced by the Royal Society of Chemistry (RSC). CSNB provides information on the hazardous and possibly hazardous effects of chemicals and processes encountered by workers in industry and laboratories. The database also covers microbiological and radiation hazards encountered in the workplace.

(3) ENVIROLINE provides indexing and abstracting coverage of more than 1,000 international primary and secondary publications reporting on all aspects of the environment. These publications highlight such fields as management, technology, planning, law, political science, economics, geology, biology, and chemistry as they relate to environmental issues. Enviroline corresponds to the print Environment Abstracts.

(4) MEDLINE (MEDLARS online), produced by the U.S. National Library of Medicine (NLM), is a source for biomedical literature materials. MEDLINE corresponds to three printed indexes: *Index Medicus, Index to Dental Literature,* and *International Nursing Index.* Additional materials not published in *Index Medicus* are included in the MEDLINE database in the areas of communication disorders, and population and reproductive biology.

(5) POLLUTION ABSTRACTS is a resource for references to environmentally related technical literature on pollution, its sources, and its control. Produced by Cambridge Scientific Abstracts, the database corresponds to the printed *Pollution Abstracts.*

(6) POLYMER ONLINE, produced by John Wiley & Sons, is an encyclopedic compilation of polymer science and engineering. The database is the online equivalent to the print *Encyclopedia of Polymer Science and Engineering* (EPS&E), a standard reference work on polymer and plastics technology. The theory and practice of polymer science and engineering, the industrial production and uses of polymeric materials, consumer uses, and the basic concepts of macromolecular science are described in the *Encyclopedia*.

(7) The REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) is a comprehensive database of basic toxicity information for over 100,000 chemical substances, including: prescription and non-prescription drugs, food additives, pesticides, fungicides, herbicides, solvents, diluents, chemical wastes, reaction products of chemical waste, and substances used in both industrial and household situations. Reports of the toxic effects of each compound are cited. In addition to toxic effects and general toxicology reviews, data on skin and/or eye irritation

mutation, reproductive consequences, and tumorigenicity are provided. Federal standards and regulations, NIOSH recommended exposure limits, and information on the activities of the EPA, NOSH, NTP, and OSHA regarding the substance are also included. The toxic effects are linked to literature citations from both published and unpublished governmental reports, and published articles from the scientific literature. The database corresponds to the print version of the *Registry of Toxic Effects of Chemical Substances,* formally known as the *Toxic Substances List* started in 1971, and is prepared by the National Institute for Occupational Safety and Health (NOSH).

(8) TOXLINE covers the toxicological, pharmacological, biochemical, and physiological effects of drugs and other chemicals. It is composed of a number of subfiles, several of which are unique to TOXLINE. About 45% of the approximately 120,000 records added per year are from the TOXBIB subfile, which is derived from MEDLINE. The TOXBIB and BIOSIS (since August 1985) subfiles may be searched using the U.S. National Library of Medicine's Medical Subject Headings (MeSH).