# GENERATION AND MANAGEMENT OF RESIDUAL MATERIALS

1992-1993

Petroleum Refining Performance

STEP
Strategies for Today's Environmental Partnership

One of the most significant long-term trends affecting the future vitality of the petroleum industry is the public's concerns about the environment. Recognizing this trend, API member companies have developed a positive, forward-looking strategy called STEP: Strategies for Today's Environmental Partnership. This program aims to address public concerns by improving our industry's environmental, health and safety performance; documenting performance improvements; and communicating them to the public. The foundation of STEP is the API Environmental Mission and Guiding Environmental Principles.

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The members of the American Petroleum Institute are dedicated to continuous efforts to improve the compatibility of our operations with the environment while economically developing energy resources and supplying high quality products and services to consumers. The members recognize the importance of efficiently meeting society's needs and our responsibility to work with the public, the government, and others to develop and to use natural resources in an environmentally sound manner while protecting the health and safety of our employees and the public. To meet these responsibilities, API members pledge to manage our businesses according to these principles:

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- To advise promptly, appropriate officials, employees, customers and the public of information on significant industry-related safety, health and environmental hazards, and to recommend protective measures.
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- To economically develop and produce natural resources and to conserve those resources by using energy efficiently.
- To extend knowledge by conducting or supporting research on the safety, health and environmental effects of our raw materials, products, processes and waste materials.
- To commit to reduce overall emission and waste generation.
- To work with others to resolve problems created by handling and disposal of hazardous substances from our operations.
- To participate with government and others in creating responsible laws, regulations and standards to safeguard the community, workplace and environment.
- To promote these principles and practices by sharing experiences and offering assistance to others who produce, handle, use, transport or dispose of similar raw materials, petroleum products and wastes.

# Generation and Management of Residual Materials

## Petroleum Refining Performance 1992 - 1993 Survey

**Health and Environmental Affairs Department**

API PUBLICATION NUMBER 333

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# ACKNOWLEDGMENTS

The following people are recognized for their contributions of time and expertise during this study and the preparation of this report:

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## THE REFINERS

At each refinery that participated in the survey, an individual(s) assumed the responsibility to complete the survey questionnaire. Their efforts deserve special recognition and thanks from the industry.

# PREFACE

To improve the quality of the data collected, and its relevance to current developments, each year the American Petroleum Institute (API) reviews all data collected in this survey, and evaluates and revises, as necessary, the data collection forms and instructional materials. Consistent with this ongoing effort to promote the integrity of the survey findings and its utility to the industry, API is implementing a deliberate change in the terminology used in this survey. Henceforth, in this report and all future documents developed in conjunction with this survey, API will use "residual materials or residuals" to refer to what has previously been called "wastes and secondary materials." This change in terminology reflects industry practices--the use of many of these materials as feedstocks or for recycling, reuse, and reclamation. This change helps to reconcile the utilization of these materials in our industry with the regulatory usage of the term "waste."

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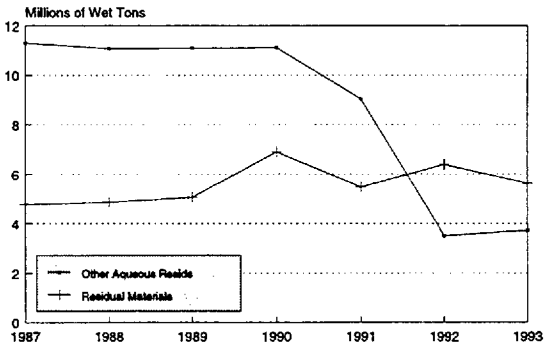
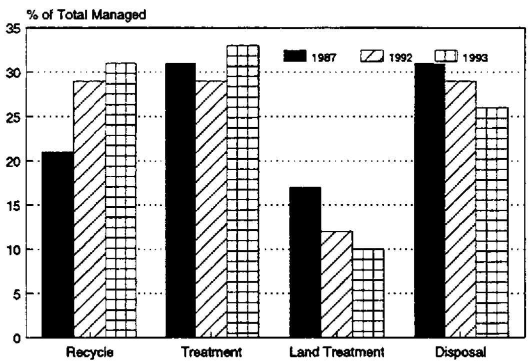
# EXECUTIVE SUMMARY

The addition of 1992 and 1993 information to API's database on refining performance strongly suggests that residual generation patterns and management practices have changed significantly from those observed in the late 1980's. Generation of Other Aqueous Residuals has dropped 69 percent since API's survey began in 1987, while the amount of other residual streams has fluctuated since 1990, due largely to unusual, one-time events. Over the seven year period, the industry has increased its reliance on recycling to manage residual materials, with 40 percent more material recycled in 1993 than in 1987 (1.8 and 1.1 million wet tons, respectively). At the same time, less material is managed in land treatment units and by disposal.



Residuals Generated



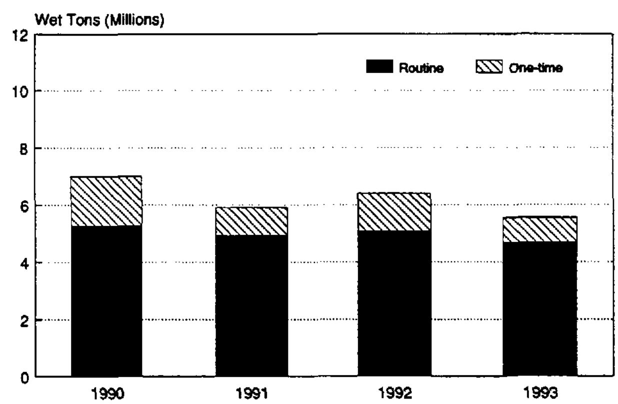
Management of Residual Materials

These observations are based on the responses to questionnaires API mailed to the population of 169 domestic refineries operating in 1992 and the 161 that remained in operation in 1993. Fewer refineries participated in the survey activity than ever before: 91 and 90 respectively, for each year. However, because these respondents represented 63 percent of the refining capacity and spanned the full range of refinery capacity classes (i.e., <10,000 - >400,000 barrels per stream day), the models previously used to create industry-wide estimates retained their validity.

API's survey continues to document how the industry has achieved compliance with the land disposal restrictions on RCRA listed hazardous K-wastes (K048-K052). It has also begun to trace the influence of the Primary Sludge rule and new Toxicity Characteristic criteria under RCRA. For K-waste residual streams, pollution prevention activities implemented by the refiners should be credited with the 62 percent reduction in generation achieved: from approximately 760 thousand wet tons in 1987 to approximately 300 thousand wet tons in 1993. The types of pollution prevention activities performed include both those expected when such programs are initiated--procedural changes that quickly yielded substantial improvements--as well as secondary strategies to enhance recycling and sustain employee awareness.

The three years of data on listed Primary Sludge wastes (F037) show an initial low generation quantity of 130 thousand wet tons in 1991 followed by successive increases to 209 and then 235 thousand wet tons in 1993. In 1992, refiners reported that one third of the amount generated was due to one-time events; this increased to over one half of the quantity reported in 1993. These spikes in generation are consistent with timing of variances EPA had provided to land ban requirements.

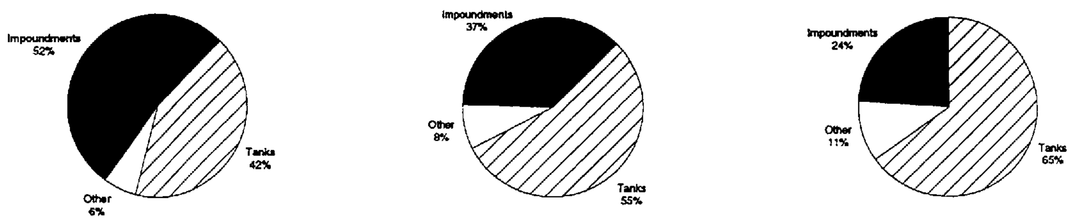
Similar spikes in generation have been noted for other residuals streams, such as **Contaminated soils/solids, Other inorganic residuals, Residual oils/spent solvents, Pond sediments**, and **Other residuals NOS**. Refiners have indicated that these reflect capital improvements (i.e., closure of units, construction and remediation activities). Such events occur infrequently, and as reported in the survey, are considered "one-time" incidences. The quantities of these residuals associated with these abnormal events are substantial, accounting for the increases in residuals noted since 1989, as well as the variability observed in residual generation between 1990 and 1993.



Generation of Residual Materials

The pattern observed for TC wastewaters, however, was successive reductions, rather than increases in generation. The largest quantity was reported in 1991, followed by an 11 percent reduction for 1992, and a 24 percent drop by 1993 (based on the 41 refineries that provided TC data in all three survey cycles). The pie charts presented below illustrate the reduced reliance on surface impoundments to manage TC materials that has occurred over time.

Management of TC Wastewaters




1991
159 million wet tons

1992
141 million wet tons

1993
121 million wet tons

# INTRODUCTION

This report presents information on the generation and management of residual material in the petroleum refining industry during 1992 and 1993. This study differs from previous survey cycles and respective reports in that two years of data were collected and analyzed simultaneously.

The American Petroleum Institute (API) employed this strategy for several reasons. First, collection of the 1992 data had been delayed to avoid conflict with the refiners' completion of the Environmental Protection Agency's (EPA) survey conducted under the authority of Section 3007 of the Resource Conservation and Recovery Act (RCRA). This mandatory survey went to the field in September 1993--exactly when API had planned to send out the forms for collection of its own 1992 data. Recognizing that completion of EPA's 142 page questionnaire would require a substantial manpower effort, API opted to delay administration of its survey.

API, however, was concerned that a delay in collecting the 1992 data could undermine the utility of these data within the refining industry. Refiners had already expressed concern that the three year lag time in publishing the data made it less useful to them. For example, because the 1991 data were published in 1994, information on the first year of land disposal restrictions was released when refiners already had three years of experience with the prohibitions. Thus, while API's survey reports are viewed as the most comprehensive and current source of data on industry practices by those *outside* the industry, to some intimately involved in day-to-day refining operations, the information was too dated to assist in timely management decisions.

After discussing the issue with company representatives on API's General Refining Committee and the Committee on Refining Environmental Controls (CREC), agreement was reached that the 1992 and 1993 data should be collected simultaneously, but the time required to analyze and report results should be reduced substantially. The refiners would therefore shoulder an increased reporting burden, while API, the respective committees involved in the survey, and the contractor would be obligated to expedite handling and review of the survey data.

This report represents the accomplishment of these goals. The survey materials were mailed to refineries in March, 1994, less than one year ago. Publication of this report with 1993 data represents a substantial reduction in the lag time to publication. The refiners part in this collaborative effort is noteworthy for it represents the efforts of front line workers in a time when corporate downsizing already made their jobs more demanding.[1]

[1] Between 1992 and 1994 when the data was collected, the number of employees in refining dropped from 121.8 thousand to 108.5 thousand--an 11 percent reduction (U.S. Department of Labor, *Employment Hours and Earnings,* August 1993, June 1994). This reflects the closing of 22 refineries between 1991 and 1993 and reductions in staff at the remaining 161 operating refineries. At the same time, manufacturing increased, from 593 to 618 billion barrels.

## METHODOLOGY

The survey procedures used for the 1992 and 1993 cycles were the same as previously employed. The census design was based on the listings of operating refineries in the Department of Energy's *Petroleum Supply Annual for 1992 and 1993*. Survey materials were mailed in March 1994. The six week interval originally adopted for form completion was extended to almost seven months to maximize the response rate. Contact was maintained with all refineries during the field administration, with follow-up calls placed to refineries to encourage participation and through a "HELP-line" staffed by a refining expert.

The sections that follow provide more detail on the data collection forms and the estimation procedures used in the study.

### *Data Collection Forms*

The questionnaire was provided in both hard copy form and on an automated disk, written using Clipper, a commercially available compiler for dBase. A copy of the data collection form is presented in Appendix A.

The survey questionnaire had two sections. The first included nine short-answer questions that focused on refinery characteristics such as age, size, complexity of processing, and sewer configuration.

The second section of the questionnaire was a series of one-page "data sheets" that collect empirical information on:

1) the quantities of residual materials **generated;**
2) how they were **managed** (according to the waste management hierarchy steps of recycling, treatment, and disposal); and
3) the amount of materials that were reduced as a result of **pollution prevention** activities.

There were 30 of these *data sheets* for each year, one for each of the residual streams identified in Table 1. (Refer to Appendix A for an example of a data sheet ).

The data sheets were virtually the same as used in the 1991 cycle of the survey. The two page format was retained, wherein codes for the management techniques and pollution prevention activities were printed on the back of the preceding page in a different color. The only modifications made to the forms were clarifications of various instructions, such as the inclusionary criteria for several streams (i.e., Residual oils and spent solvents, Spent acids, and High pH/low pH waters), and the selection of the most appropriate code for pollution prevention activities. These revisions were considered to be minor since edit checks had previously been performed on these same data elements.

**Table 1**
**Refining Residual Streams**

| Category | Constituents |
|---|---|
| Aqueous residuals | Biomass<br>High pH/low pH waters<br>Oil contaminated waters (not wastewaters)*<br>Spent Stretford solution<br>Spent sulfide solution<br>TSD Leachate (F039)***<br>Other aqueous residues NOS** |
| Chemicals/inorganic residuals | Spent acids<br>Spent caustics<br>Residual amines<br>Other inorganic residuals NOS** |
| Contaminated soils/solids | Contaminated soils/solids<br>Heat exchanger bundle cleaning sludge***<br>Residual coke/carbon/charcoal<br>Residual sulfur<br>Other contaminated solids NOS** |
| Oily sludges/other organic residuals | API separator sludge***<br>DAF float***<br>Leaded tank bottoms***<br>Nonleaded tank bottoms<br>Pond sediments<br>Primary sludge (F037)***<br>Primary sludge (F038)***<br>Slop oil emulsion solids***<br>Residual oils/spent solvents<br>Other oily sludges/organic residuals NOS** |
| Spent catalysts | Fluid cracking catalyst<br>Hydroprocessing catalyst<br>Other spent catalysts NOS** |
| Other residuals | Other wastes NOS** |

* Does not include NPDES or POTW wastewaters.
** Not otherwise specified.
*** RCRA-listed hazardous wastes for petroleum refining.

API has used an equation on each data sheet as a quality control measure: the "inputs" of residual materials must balance the "outputs." Inputs include the quantities of residual material Generated plus Treatment Additives and the Net Removed from Storage (i.e., the total amount of material removed from storage minus the amount placed into storage) and constitute the "Total Quantity Managed." As depicted in the equation below, this is balanced by the quantities of the residual *recycled, treated, or disposed.*

Quantity Generated + Treatment Additives + Net From Storage = **Total Quantity Managed**

**Total Quantity Managed** = Quantity Recycled + Quantity Treated + Quantity Disposed

Each data sheet also contains a section to capture information on pollution prevention activities that have been performed. In addition to indicating the quantity of waste reduced, respondents are asked to classify the pollution prevention activity according to the codes displayed below and to then briefly describe the activity performed.

**POLLUTION PREVENTION CODES**

1 = Equipment or Technology Modifications
2 = Procedure Modifications
3 = Reformulation or Design of Products
4 = Substitution of Raw Materials
5 = Improved Housekeeping, Training, or Inventory Control

IN-PROCESS RECYCLE
6 = In refining process units (e.g., crude unit; coker; desalter)
7 = Recovering oil (& dewatering) by filter pressing/centrifugation
8 = Other recycle

OUT-OF-PROCESS RECYCLE
9 = Reuse/reclamation
10 = Other

### *Data Analysis*

The data verification and estimation procedures used were similar to those used previously. Data verification included 28 automated consistency checks for the variables on each data sheet, as well as final range checks across respondents and comparisons with the data previously submitted by the respective refinery. In all cases, any questionable data were verified by direct contact with the facilities to ensure their accuracy.

For each survey cycle, regression analysis has been used to estimate the quantity of residuals generated by the entire industry, based on the information submitted by survey respondents. A critical assumption in this approach is that the factor(s) influencing waste generation for respondents do not differ from those for non-respondents.

Similar to the approach used in 1991, a regression procedure was used to estimate the quantities of 29 residual streams that are generated by most refineries. As before, the regression model used for 1992 and was of the form:

$$\textit{Total Generated Quantity} = [a + b(\textit{Capacity})]^2$$

where a and b were estimated based on the data from responding refineries that were not statistical outliers.

A separate modeling step was used to estimate Other Aqueous Wastes NOS since the generation and management pattern for this stream is quite atypical (with only a few facilities generating this stream, but with several reports of extremely large quantities).

To validate the continued applicability of the model used to estimate the 29 residual streams, the previous model assumption of operating capacity versus the square root of residual generation was examined. Specifically, scatterplots of the 1992 and 1993 data were made. Based on the visual fit of the data and the calculated $R^2$ values of 0.65 for each year, the existing regression model was considered adequate.

To improve regression, outliers that tend to have too much influence on the regression line were deleted. Confidence bands were drawn on the scatterplots of the 1992 and 1993 data to aid in visually identifying outliers. A 99.99 percent confidence interval was arbitrarily chosen to show the widest possible band which would highlight the most extreme, or outlying points. Using this technique, three refineries were identified as outliers for 1992 and two additional refineries were considered outliers for 1993 (i.e., a total of five for 1993). After removing these cases, the final $R^2$ value for 1992 was 0.68, while the 1993 statistic remained 0.65. The final regression equations are

for 1992:

$$G=\sqrt{40.04+0.0009872C}$$

and for 1993:

$$G=\sqrt{46.55+0.0009799C}$$

where, G = residual material generation (wet tons) and
C = operating capacity (barrel per stream day).

This regression model was then used to estimate the total residual generated by each non-respondent by inputting its capacity obtained from statistics maintained by the U.S. Department of Energy into the model, squaring the result and then applying a standard statistical procedure to adjust that number so that the final estimate is unbiased.

To estimate the total amount of residual materials generated for all U.S. refineries, estimates for non-respondent refineries were combined with the data obtained from the survey participants (including the outlier facilities). All residual generation and management data shown in this report are estimates for the population of operating refineries in each survey cycle.

After deriving the total quantity of generated residual, calculations were performed to estimate the generation quantities for each of the 29 residual streams. This is illustrated in the flow chart presented in Figure A. A summary of the procedure used follows:

1) The total reported quantity of residuals was determined by summing, for each stream, the generated quantities from all respondents.

2) The relative contribution of each stream to the total reported quantity was obtained by dividing the individual residual stream generation quantity calculated in (1) by the total quantity of residuals for all 29 streams generated by respondents.

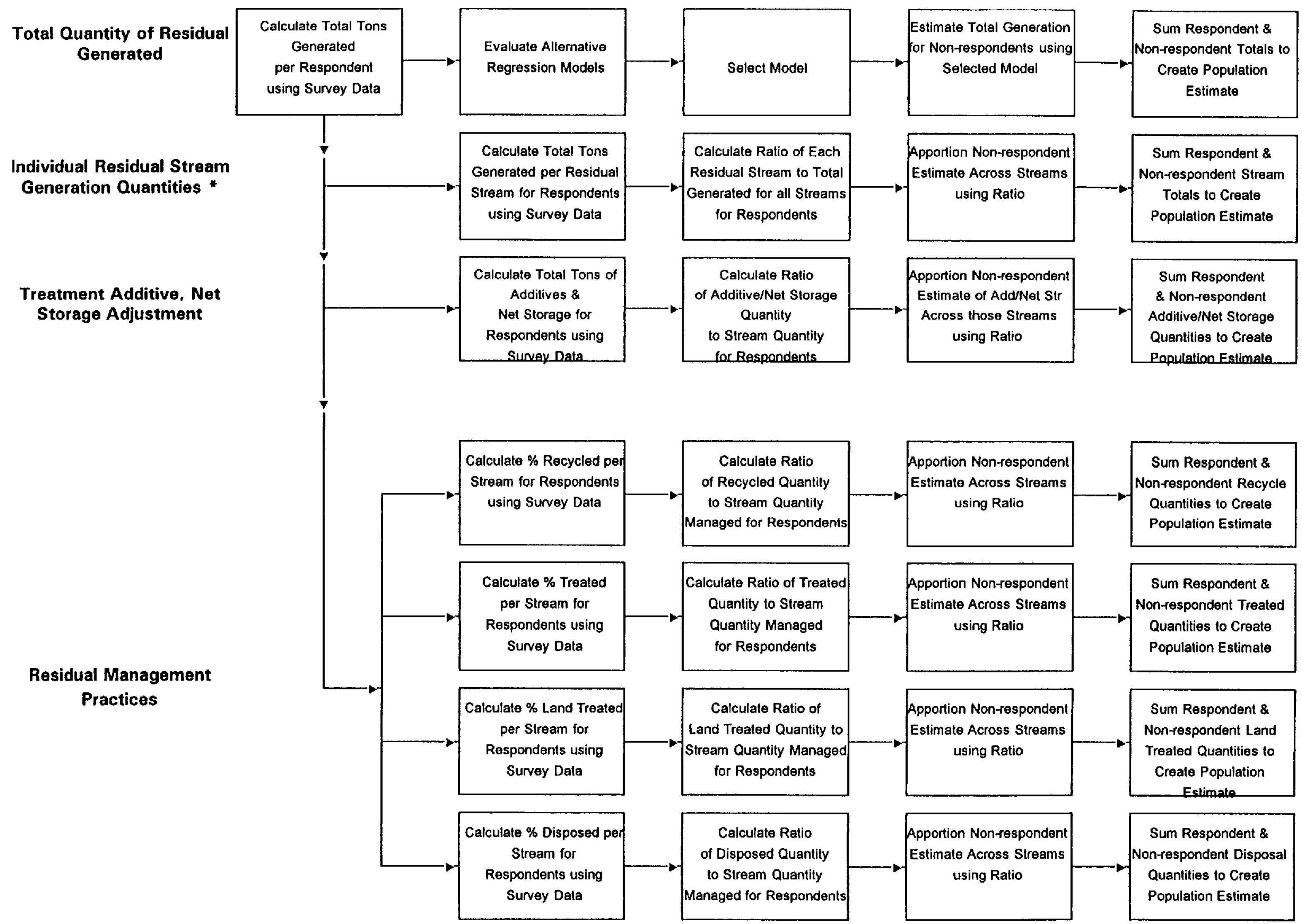
3) Each proportion calculated in (2) was multiplied by the total estimated residual quantity for all non-respondents to get residual quantities, by stream, for non-respondents.

4) Estimated generated quantity for a stream was obtained by summing the corresponding respondent and non-respondent quantities from (1) and (3). This is depicted in the second row of the flow chart.

To obtain the managed quantity of residuals, the proportion of treatment additives and net quantity from storage to generated quantity in each stream was calculated. (Shown in the third row of Figure A.) These proportions were then multiplied by the non-respondent generated quantity for a stream to get estimated amounts of treatment additives and net from storage. Thus, the managed quantity of residuals was calculated by summing (a) generated quantity, (b) treatment additives and (c) net from storage for respondents and non-respondents. As depicted in the last four rows of the flow chart, a similar procedure was used to estimate the quantities of residuals recycled, treated and disposed.

To estimate the quantity of Other Aqueous Residuals generated, the simple ratio technique used in 1991 was employed. In 1992, 14 of the 91 respondents reported generating this stream, while only seven continued to report it in 1993. For each year, the quantity of this stream reported by these refineries was divided by the capacity represented by the group of refineries that responded to the survey. The resulting ratio was then applied to the capacity for all operating refineries.

# Figure A - Statistical Estimation Procedures




* For this chart, STREAM refers to the 29 individual streams included in the analysis.

## RESULTS

### *Response Rate*

In 1992, 91 refineries participated in the survey and 89 refineries provided data for 1993. These were the lowest response counts observed since the survey began. The survey continued to maintain, however, a sizeable core group of 56 refineries that participated in all seven survey cycles.

When the raw count of survey respondents is reviewed in the context of the number of operating refineries, the response rates for 1992 and 1993 are in the ranges previously reported. The overall number of operating refineries in 1992 and 1993 dropped substantially, to 169 and 161, from the 183 observed for the three previous survey cycles. Thus, when the 1992 and 1993 respondents are looked at as part of the population of refineries, the response rates are 54 and 55 percent, respectively. This is within 10 percent of the 64 and 65 percent rates achieved in 1989 and 1988, and comparable to the 56 percent reported for 1990.

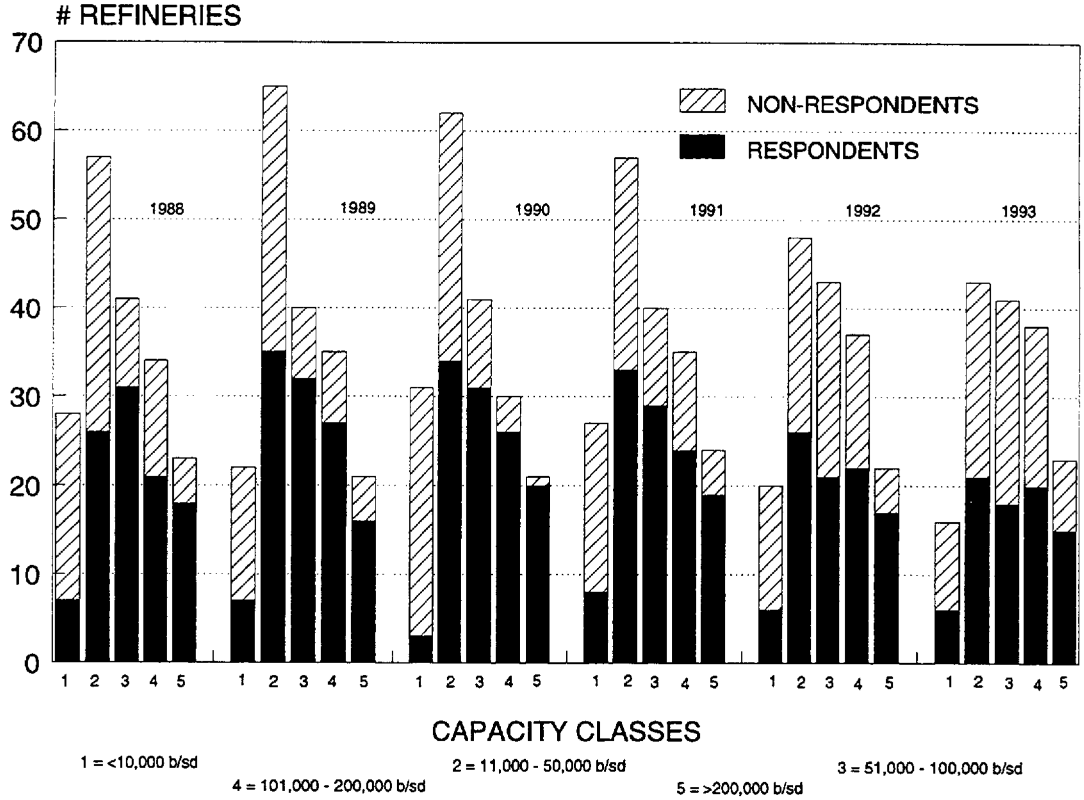
For both 1992 and 1993, the respondents represented 63 percent of the *domestic crude refining capacity* of 10.231 and 10.201 million barrels per stream day. This is lower than previously attained, but is still a substantial response and more than adequate to support the generation of reliable statistical estimates. [2]

This reduction in response rate for this survey appears to be related, in part, to the decrease in the number of operating refineries. The decrease in response between 1991 and 1993 was 21 percent, while the decrease in the number of operating refineries was 12 percent. However, the survey was administered in 1994, when even more closures and changes in operating status had taken place. Some refineries reported that they would not be able to participate because they were transitioning to new ownership and that attendent business issues took priority. Another related consideration is that refineries that closed in 1993 typically had no staff in place during 1994 and therefore could supply no data for 1992.

The closings of these facilities exerted some distinct changes on the distribution of refineries as illustrated in Figure B.

[2] Although the number of refineries has diminished over time, the quality of the model used to create population estimates continues to be quite good as seen by the t-statistic of 13.8. It is anticipated that even if additional refineries choose not to participate in future cycles of the survey, appropriate models could be developed, assuming that the participating refineries continue to adequately represent the full range of capacity classes.

**Figure B**
**Number of Respondents by Capacity Group**



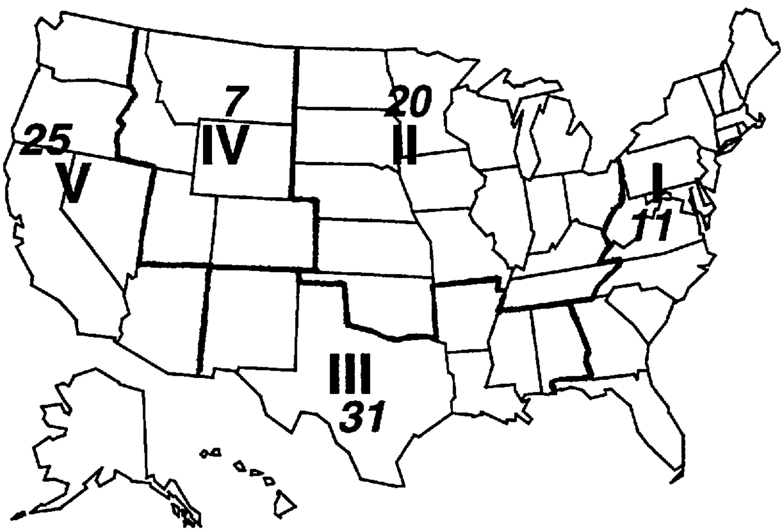

Note the substantial drop in the number of operating refineries (i.e., the combined area of both the respondent and non-respondent bars) in the 10 - 50 thousand barrels per stream day (b/sd) category and the increases, over time, in the two largest capacity classes. Given that no new refineries opened or were reactivated in 1992 and 1993, the increases in the number of operating refineries in the largest categories must reflect increases in capacity at existing facilities.

Regarding the participants in the survey, the graph shows that there were fewer responders in each capacity group, and that the greatest drop was in the 50 - 100 thousand b/sd capacity class. This observation comports with the information obtained during follow-up calls that some refineries and corporations decided not to respond because of the burden involved. In particular, a number of small refineries commented that they would be unable to participate because of the effort they had already devoted to complying with the RCRA 3007 survey. Several other companies, faced with the demands of downsizing, indicated that they could not complete the forms, especially since the two years of data increased the manpower effort required.

***Respondent Characteristics***

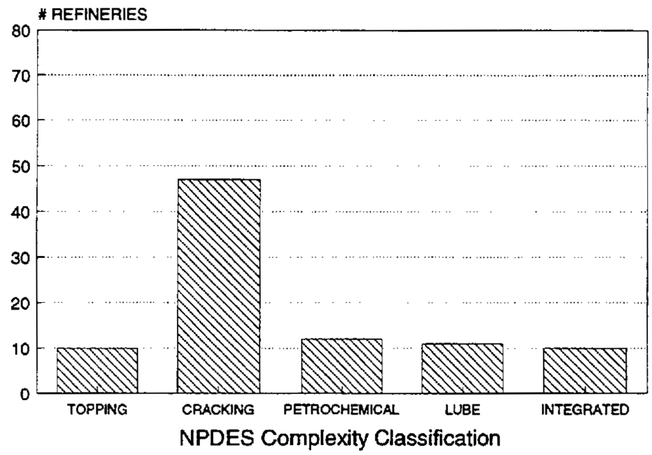
The location of the responding refineries is illustrated in Figure C. The only region with the same number of respondents as previously was PAD I. PAD II, with 20 refineries, had the greatest turnover in respondents, with 14 refineries that had participated in 1991 not participating in this survey. PAD III and PAD IV both had 3 fewer refineries participating, while the western PAD V had four less.

**Figure C**
**Location of Participating Refineries**



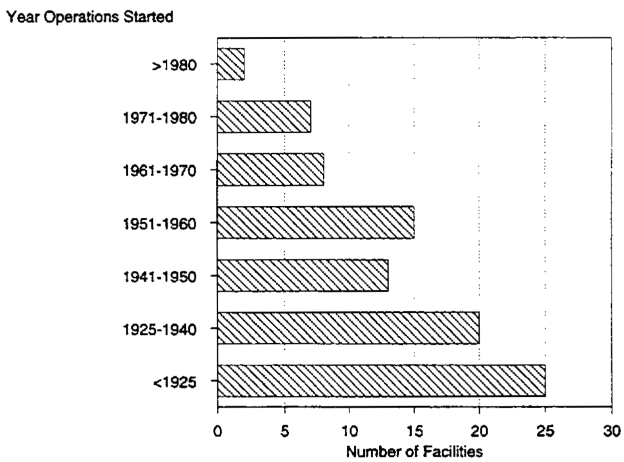

To categorize the complexity of refineries, API uses the NPDES permit classifications that range from the simplest "Topping" type of processing to the more complex “Integrated” system. As shown in Figure D, the "cracking" refineries were the most predominant group, representing 52 percent of the respondents (n = 47). As depicted, the 43 other refineries were fairly evenly distributed across the other complexity categories.

**Figure D**
**Distribution of Respondents by NPDES Complexity Classification**




As the distribution of respondents by the age of refinery shows, very few refineries are new (Figure E). Twenty-five refineries have been in operation for at least 70 years. Half of the refineries that participated in the 1992-93 survey began operations before 1940.

**Figure E**
**Distribution of Respondents by Refinery Age**



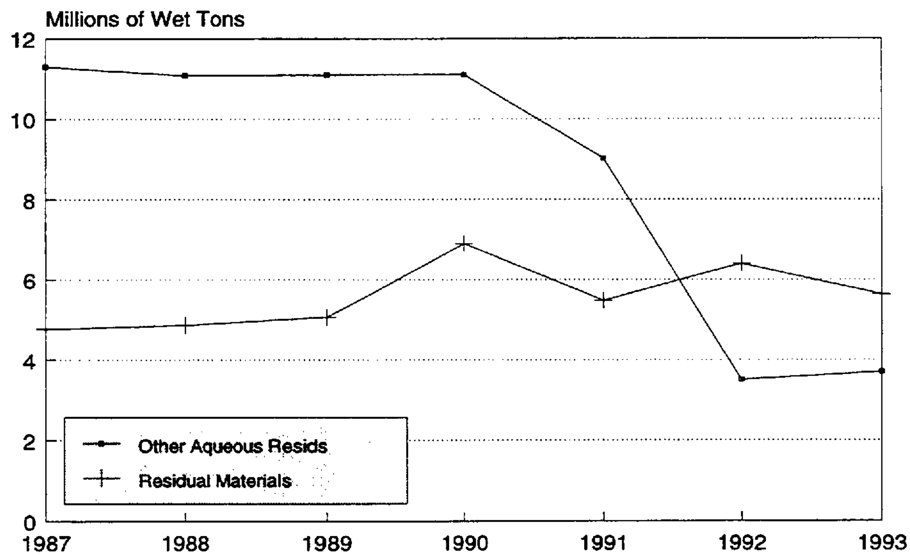

The final descriptive characteristic collected by the survey pertains to a refinery's sewer system and its separation of process water and stormwater. The majority of refineries (57 percent) that responded to the 1992/1993 survey have partially segregated sewer systems, while 23 percent have non-segregated systems and 19 percent have totally segregated systems.

### *Residual Generation*

As described earlier, separate population estimates are performed for the grouping of 29 streams of residual materials and for the amount of Other Aqueous Residuals. For 1992 and 1993, the estimated quantity of residual material generated was 6.398 and 5.547 million wet tons, respectively. The amount of Other Aqueous Residuals generated was 3.510 million wet tons for 1992 and 3.717 million for 1993.

As illustrated in Figure F, the generation estimate for the group of 29 residual streams peaked in 1990, and has fluctuated since then. The overall quantity of these residual materials has remained fairly constant over time, particularly when compared with the generation pattern exhibited by the Other Aqueous Residuals. This stream dropped dramatically in 1990 and appears to have plateaued at a new lower level.

**Figure F**
**Generation of Residual Materials and Other Aqueous Residuals in the Petroleum Refining Industry: 1987 - 1993**




From this graph it appears that 1990 was a pivotal year: the quantity of Other Aqueous Residuals has systematically dropped since then, while the quantity of Residual Materials, which was constant between 1987 and 1989, has fluctuated since it peaked in 1990. These trends can be explained, to a large extent, by regulatory requirements and planning activities undertaken in anticipation of other regulatory initiatives.

The drop in the generation of the Other Aqueous Residuals reflects the phasing out of deep well injection of these residuals by most refineries. EPA has approved a no-migration petition for one refinery that allows the continued use of deep well injection for the management of permitted liquid wastes. In addition, this same facility has dramatically reduced generation of these residuals to a level which is less than half the amount reported previously.

It should also be noted that the Other Aqueous Residual category was used to report a new type of material in 1992 and 1993: recovered groundwater from onsite remediation activity.

The fluctuations in the Residual Materials are contemporaneous with the 1990 RCRA land disposal restrictions for refinery K-wastes, the related specification of treatment standards for listed wastes, RCRA's new Toxicity Characteristic for determining characteristically hazardous wastes, and the Primary Sludge listings. As previously reported, the peak in 1990 was caused by one-time generation of **Contaminated soils and solids** and **Pond sediments.** Both of these materials are associated with site remediation and construction activities, such as the replacement of impoundments with tanks, undertaken by refiners as preparatory steps to comply with the Primary Sludge rule and BDAT standards.

The amount of Residuals reported 1990 included increased quantities of **Spent Caustics**--a trend which continued through 1991, and which has now extended through 1992, as shown in Table 2. The highest quantity of Spent Caustics--1436 thousand wet tons--was reported in 1993. This was more than twice the quantity reported in 1987 when the survey began. (Professional judgement within the industry maintains that this is not truly an increase in the generation of this material, but an improvement in the tracking and accounting of this material as more is reclaimed, regenerated, or sold for out-of-process recycling.)

**Biomass** also had a large quantity reported in 1993. The 801 thousand tons generated, however, was in the range previously reported. The three listed streams under RCRA, **Primary Sludges (F037 and F038)** and **TSD Leachate (F039)** edged upward in 1993.

The amount of **Contaminated soils and solids** generated in 1993 dropped substantially from its peak value of 1,063 thousand wet tons recorded in 1992 to 663 thousand wet tons. Over seventy percent of the material generated in 1992 was reported by 20 refineries that classified it as related to one-time events. The amount reported as due to abnormal events in 1993 dropped more than 300 thousand wet tons, but still constituted the majority of this material generated (58 percent).

In 1993, three of the residual streams that include RCRA K-wastes achieved the smallest generation quantity ever: **API Separator Sludge** at 175 thousand wet tons represented a 58 percent decrease from 1987; **Slop oil emulsion solids** decreased 74 percent from 1987 to 54 thousand wet tons; and three tons of **Leaded tank bottoms** were generated. The quantities of **DAF float** and **Heat exchanger bundle cleaning sludge** were within the ranges previously reported. It is important to note that **API separator sludge** remains one of the most frequently reported streams (n = 70 respondents as shown in Table 3), while the other K-waste streams are generated by less than half of the survey participants (e.g., DAF float was reported by 37 refineries). This suggests that the reduction in generation of API separator sludge is an industry-wide trend.

**Table 2**
**Estimate of Residual Materials Generated by the U.S. Refining Industry: 1991**
(thousands of wet tons)

| Residual stream | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 |
|---|---|---|---|---|---|---|---|
| Spent Caustics | 1,436 | 1,428 | 909 | 889 | 716 | 656 | 675 |
| Biomass | 801 | 716 | 855 | 782 | 642 | 786 | 757 |
| Contaminated soils/solids | 693 | 1063 | 809 | 920 | 512 | 240 | 165 |
| DAF float | 517 | 544 | 406 | 553 | 496 | 655 | 652 |
| Other inorganic residuals NOS | 251 | 364 | 397 | 451 | 440 | 213 | 325 |
| Primary sludge (F037) | 235 | 209 | 130 | | | | |
| FCC catalyst or equivalent | 204 | 203 | 204 | 198 | 182 | 193 | 173 |
| Other oily sludges/organic residuals | 193 | 38 | 54 | 53 | 47 | 61 | 38 |
| API separator sludge | 170 | 178 | 210 | 251 | 419 | 355 | 400 |
| Other residuals NOS | 143 | 488 | 339 | 352 | 325 | 412 | 203 |
| Pond sediments | 138 | 388 | 372 | 1,017 | 313 | 266 | 337 |
| Nonleaded tank bottoms | 127 | 128 | 109 | 194 | 161 | 129 | 216 |
| Residual amines | 116 | 142 | 136 | 75 | 51 | 14 | 13 |
| Primary sludge (F038) | 67 | 54 | 177 | | | | |
| Residual coke/carbon/charcoal | 54 | 53 | 138 | 92 | 129 | 67 | 43 |
| Slop oil emulsion solids | 54 | 77 | 165 | 291 | 272 | 224 | 208 |
| Residual oils/spent solvents | 48 | 33 | 21 | 115 | 31 | 7 | 4 |
| Hydroprocessing catalysts | 47 | 55 | 32 | 31 | 36 | 36 | 40 |
| Residual sulfur | 44 | 53 | 19 | 35 | 52 | 22 | 17 |
| TSD Leachate (F039) | 40 | 13 | 20 | | | | |
| Other contaminated soils NOS | 39 | 32 | 37 | 69 | 53 | 68 | 82 |
| Spent sulfite solution | 29 | 33 | 9 | 1 | 8 | 40 | 42 |
| Other spent catalysts NOS | 29 | 27 | 23 | 39 | 33 | 37 | 33 |
| Oil contaminated waters (not | 27 | 22 | 67 | 8 | 29 | 36 | 28 |
| Spent Stretford solution | 26 | 31 | 25 | 29 | 42 | 49 | 35 |
| High pH/low pH waters | 9 | 16 | 54 | 105 | 91 | 138 | 144 |
| Spent acids | 5 | 7 | 88 | 336 | 8 | 149 | 126 |
| Heat exchanger bundle cleaning sludge | 4 | 3 | 3 | 13 | 2 | 5 | 3 |
| Leaded tank bottoms | 3 | <1 | 1 | 3 | 4 | 8 | 9 |
| Other separator sludges | NA | NA | NA | 97 | 114 | 104 | 79 |
| **Total** | 5,547 | 6,398 | 5,809 | 6,999 | 5,508 | 4,968 | 4,868 |

(The SAS output containing the data for this table is presented in Appendix B, pages B-1 and B-21).

**Table 3**
**Number of Refineries Reporting Each Stream**

| Residual stream<br>Total number of refineries participating | 1993<br>89 | 1992<br>91 | 1991<br>113 | 1990<br>103 | 1989<br>117 | 1988<br>115 | 1987<br>115 |
|---|---|---|---|---|---|---|---|
| Contaminated soils/solids | 80 | 84 | 90 | 87 | 88 | 77 | 77 |
| API separator sludge | 70 | 72 | 76 | 85 | 93 | 94 | 91 |
| Other residuals NOS | 69 | 74 | 83 | 85 | 89 | 85 | 92 |
| Primary sludge (F037) | 69 | 69 | 59 | | | | |
| Nonleaded tank bottoms | 67 | 64 | 69 | 72 | 72 | 75 | 72 |
| FCC catalyst or equivalent | 63 | 69 | 76 | 79 | 84 | 86 | 85 |
| Spent caustics | 62 | 64 | 69 | 66 | 70 | 77 | 79 |
| Other spent catalysts NOS | 59 | 60 | 63 | 57 | 60 | 60 | 62 |
| Residual oils/spent solvents | 58 | 58 | 65 | 56 | 56 | 61 | 52 |
| Other contaminated soils NOS | 53 | 43 | 59 | 56 | 61 | 71 | 70 |
| Hydroprocessing catalysts | 55 | 58 | 57 | 52 | 65 | 60 | 57 |
| Other oily sludges/organic residuals NOS | 54 | 49 | 43 | 42 | 49 | 47 | 49 |
| Heat exchanger bundle cleaning sludge | 52 | 55 | 43 | 51 | 49 | 48 | 49 |
| Residual coke/carbon/charcoal | 51 | 51 | 55 | 50 | 51 | 47 | 48 |
| Other inorganic residuals NOS | 49 | 53 | 62 | 65 | 73 | 73 | 77 |
| Biomass | 45 | 44 | 45 | 44 | 44 | 45 | 47 |
| Residual sulfur | 40 | 37 | 43 | 37 | 42 | 47 | 41 |
| DAF float | 37 | 41 | 44 | 50 | 47 | 50 | 53 |
| Slop oil emulsion solids | 30 | 32 | 32 | 35 | 38 | 43 | 47 |
| Residual amines | 25 | 29 | 32 | 27 | 38 | 36 | 32 |
| Leaded tank bottoms | 15 | 12 | 20 | 27 | 31 | 37 | 38 |
| Pond sediments | 14 | 16 | 25 | 34 | 31 | 29 | 26 |
| High pH/low pH waters | 12 | 9 | 4 | 11 | 11 | 12 | 14 |
| Primary sludge (F038) | 11 | 11 | 14 | | | | |
| Spent acids | 8 | 10 | 20 | 24 | 18 | 23 | 20 |
| Other aqueous residues NOS | 7 | 14 | 14 | 11 | 14 | 12 | 13 |
| Oil contaminated waters (not wastewaters) | 7 | 8 | 10 | 10 | 14 | 10 | 14 |
| Spent Stretford solution | 6 | 6 | 6 | 7 | 11 | 13 | 12 |
| Spent sulfite solution | 2 | 1 | 3 | 1 | 2 | 1 | 1 |
| TSD Leachate | 2 | 3 | 3 | | | | |
| Other separator sludges | NA | NA | NA | 19 | 22 | 20 | 15 |

Several other streams had low values in 1993. **Pond sediments** and **Other residuals NOS** remained within the top ten streams based on generation quantities, although the quantities in 1993 were 64 and 71 percent less, respectively, than the reported quantities for 1992.

The reporting patterns for these streams were quite different (see Table 3). For **pond sediments**, the frequency count dropped to 14 in 1993, while **Other Residuals NOS** continued to be within the top three streams with 69 refiners reporting its generation. This suggests some different reasons for the reductions. Specifically, the reduction in the quantity of pond sediments may be linked to closure of a number of ponds used by the industry.

Reductions in the amount of **Other Residuals NOS** are harder to interpret, because this miscellaneous category is used to report a variety of lab wastes, used drums, batteries, barrels, PCBs, and asbestos. These reductions may reflect some of the progress made by pollution prevention activities. For example, refineries have instituted (and reported in previous survey cycles) programs to remove spent batteries and containers, replaced PCBs and asbestos with less hazardous or non-hazardous materials, and begun inventory controls with lab materials and office paper. It is therefore possible that the drop noted in 1993 reflects some of these activities.

Reductions observed in the reported amounts of **Spent acids** and **High pH/low pH waters** are likely due to the clarification in the inclusionary criteria for these streams which was placed directly on the respective data sheets. Previously, automated edit checks were performed to verify that materials reported in these categories were residuals that were intended to be captured by this survey. Specifically, in designing this survey, it was API's intention to exclude those materials that had specific exemptions under RCRA, such as spent acids targeted for regeneration and aqueous materials that are managed in accordance with other environmental statutes (e.g., NPDES permitted effluents). Use of automated edit checks in previous years enabled API to screen reports of the large quantities of these three streams, but not all reported quantities. Placing the instructions directly on the data sheets appears to have minimized the reporting of small amounts of these streams--the small quantities that it was not pragmatically possible to scrutinize previously.

As would be expected by the trend analysis previously performed with 1987 to 1991 data (published in the 1991 survey report), the quantities of **Hydroproccessing catalysts** continued to remain constant, while between-year fluctuations persisted in the generation of **Nonleaded tank bottoms, Residual coke/carbon/Charcoal, Residual sulfur**, and **Biomass.** Trend graphs that illustrate these patterns are presented in Appendix C.

Looking across all streams, these trend graphs enable the identification of a group of residual streams that have been reduced over time: **API Separator Sludge, Slop oil emulsion solids, Other contaminated soils**, and **High pH/low pH waters**. (DAF float had previously been identified as a member of this group, but the quantities in 1992 and 1993 suggest that the generation pattern may be more stable.)

There is also a group for which generation has increased since API's survey began: **Contaminated soils and solids, Spent caustics**, and **residual amines.** Another grouping worthy of mention are those streams that appear to be affected by periodic peaks, typically associated with abnormal events: **Pond sediments, Residual oils/spent solvents, Other oily sludges/organic residuals, Other contaminated soils, Oil contaminated water (not wastewater)** and **Spent Sulfite solution.**

### *Pollution Prevention*

*Pollution prevention* refers to the reduction or elimination of pollutant discharges to air, water or land. It includes the development of more environmentally acceptable products, changes in processes and practices, source reduction, beneficial use and environmentally sound recycling.

For 1992 and 1993, approximately half of the survey participants reported at least one pollution prevention activity (44 and 46 refineries, respectively).[3] They reported that 235 and 173 thousand wet tons of residuals were eliminated by source reduction activities or beneficial recycling activities.

Because no attempt is made to extrapolate the reports of pollution prevention activities to the population of refineries,[4] these quantities must be reviewed in the context of the quantities of residuals *reported* by survey participants and not the estimated quantities for all U.S. refineries. In both survey years, the quantities attributed to pollution prevention represented 7 percent of the total amount of residual material generated.

Because the pollution prevention quantity is not a population estimate, it is also influenced by the reduced response rate for 1992 and 1993. Thus, it is difficult to interpret how the quantities reported by the 44 and 46 refineries in 1992 and 1993 compare with the 751 thousand wet tons reported by the 61 refineries in 1991.

[3] One company that completed the forms centrally for all of its refineries did not complete the pollution prevention questions for 1993. Because most of these same refineries reported some pollution prevention activities in 1992, it is reasonable to assume that they probably would have continued such practices. Thus the number of refineries reporting pollution prevention activities and the amount of residual affected for 1993 is artificially low.

[4] API has not developed a model to create industry-wide estimates of pollution prevention achievements because it is a relatively new concept for which there is little experience in tracking over time. Pollution prevention (including source reduction) have site specific considerations and are expected to vary significantly over time based on the implementation status of the individual facility (i.e., early efforts may achieve greater reductions than later incremental changes). In addition, API has noted substantial variability in the reporting patterns of these activities. Given these factors that complicate estimation, API has elected to present the reported values. Thus, it is clear that the information presented here underestimate the industry-wide pollution prevention achievements because coming from survey respondents only, they represent only a portion of the activities initiated by the industry.

Table 4 presents the frequency counts for each pollution prevention method. One similarity across years is that refiners report several pollution prevention activities, as indicated by the column totals. On average, refiners reported six pollution prevention activities in 1992 and 1993 compared with the five reported in 1991.

**Table 4**
**Number of Refineries Reporting Each Pollution Prevention Activity**

| **Pollution Prevention Activity** | **# Citations** 1993 | 1992 | 1991 |
|---|---|---|---|
| Equipment or Technology Modifications | 20 | 14 | 24 |
| Procedure Modifications | 11 | 12 | 23 |
| Reformulation or Design of Products | 1 | 0 | 3 |
| Substitution of Raw Materials | 5 | 8 | 13 |
| Improved Housekeeping, Training, or Inventory Control | 22 | 24 | 43 |
| **IN-PROCESS RECYCLE** | | | |
| In refining process units (e.g., crude unit; coker; desalter) | 55 | 60 | 42 |
| Recovering oil (& dewatering) by filter pressing/centrifugation | 16 | 13 | 50 |
| Other recycle | 16 | 12 | 5 |
| **OUT-OF-PROCESS RECYCLE** | | | |
| Reuse/reclamation | 103 | 99 | 66 |
| Other | 14 | 22 | 10 |
| TOTAL | 263 | 264 | 279 |

The pollution prevention activities reported each year have varied. *Equipment and technology modifications* dipped in 1992, but still almost equalled the count observed in 1991, despite the small number of respondents in 1992. *Procedure modifications, substitution of raw materials,* and *improved housekeeping, training and inventory controls* have dropped with each successive cycle. Reciprocally, recycling in process units and out-of-process reclamation activities have both increased each year.

Tables 5a and 5b display the pollution prevention data, breaking it out across streams, providing the frequency counts for the number of times refineries indicated that they performed an activity, the quantity of residual that was affected by the activity, and showing the year that the activity was performed. **API separator sludge** had the highest number of citations in both years, followed by other K-wastes **DAF Float** and **Slop oil emulsion solids,** and other frequently reported streams, **Nonleaded tank bottoms** and **Contaminated soils and solids.**

The table entries for the quantities of residuals that were reduced at the source, recycled or otherwise reused or reclaimed range from extremely small values to many thousands of wet tons. These actual reported values are presented here not to convey a sense of measurement precision, but to attest to the effort refiners devote to responding to this survey, and as an indicator of the refiner's attempts to provide accurate data.

In both 1992 and 1993, refiners reported the largest pollution prevention quantities for **biomass**. This was followed by **DAF float** and **spent caustics. Residual oils/spent solvents** and **Contaminated soils and solids** had large quantities reported in 1992 only. The amount of **Pond sediments** and **Primary sludge** in 1993 was larger than for 1992.

The right side of the table shows whether an activity was performed only in 1992, in 1993 or in BOTH years. As this display shows, most activities were performed by at least one refinery in both years, particularly the recycling procedures. The presentation also highlights the new activities begun in 1993.

A major short-coming of these empirical displays on pollution prevention is that they do not convey *what* is being done to reduce generation and improve handling of residual materials. The stream-by-stream tables presented in Appendix D accomplish this goal. Construction of these tables, a manual process of updating the 1991 tables, enables several general observations about the specific pollution prevention activities.

First, most of the pollution prevention activities reported in 1992 and 1993 were new, and not duplicative of previously reported activity. The exceptions to this pattern involved recycling to cokers and crude units which were sometimes repeated.

Refiners have shifted their creative energies to new streams, introducing procedural modifications with **Primary sludge**, substitution of materials with **Oily residuals** and **spent solvents**, and finding outside markets for materials previously considered worthless: **Contaminated soils, Other inorganic residuals, and Other Residuals NOS**. In particular, note that refiners are sending a variety of streams--not just RCRA regulated streams--to cement kilns for reuse as fuel or feedstock.

Some of the procedural changes seem to run counter to what one might typically consider pollution prevention innovations. For example, rather than routinely adding lime feed to adjust boiler and water softening operations that affect generation of **Other Inorganic Residuals**, one refinery has instituted a monitoring system, so that lime is now added only when test results dictate. Thus, returning to manual procedures, is a step in the right direction.

Another procedural change reported involved the use of treatment chemicals that enhance filtration. Their use has been curtailed by some refiners in an effort to reduce the volumes of residuals requiring further management.

# Table 5a
## Summary of Pollution Prevention Activities

| Residual stream | 1993 | | 1992 | | SOURCE REDUCTION 1 | 2 | 3 | 4 | 5 | RECYCLE IN-PROCESS 6 | 7 | 8 | RECYCLE OUT-OF-PROCESS 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| API Separator Sludge | 31 | 17,878 | 31 | 9,678 | BOTH | BOTH | | | BOTH | BOTH | BOTH | BOTH | BOTH | |
| DAF Float | 24 | 59,018 | 21 | 68,274 | BOTH | 1993 | | | 1993 | BOTH | BOTH | BOTH | BOTH | |
| Slop Oil Emulsion Solids | 18 | 10,884 | 18 | 10,069 | 1992 | | | | 1992 | BOTH | BOTH | BOTH | BOTH | |
| Leaded Tank Bottoms | 5 | 39 | 1 | 25 | | | 1993 | | | | | | BOTH | |
| Pond Sediments | 3 | 49,266 | 2 | 13,508 | | 1993 | | | BOTH | BOTH | | | 1993 | |
| Nonleaded Tank Bottoms | 14 | 5,425 | 14 | 6,010 | 1993 | 1992 | | | | BOTH | BOTH | BOTH | BOTH | 1992 |
| Residual Oils/Spent Solvents | 9 | 2,090 | 16 | 65,105 | 1993 | 1992 | | BOTH | 1992 | BOTH | | | BOTH | 1992 |
| Other Oily Sludges/Organic Wastes | 10 | 2,342 | 6 | 3,776 | BOTH | | | | | BOTH | | | BOTH | 1992 |
| Primary Sludge (F037) | 18 | 20,562 | 13 | 16,278 | BOTH | BOTH | | | BOTH | BOTH | 1993 | | BOTH | |
| Primary Sludge (F038) | 4 | 4,965 | 6 | 8,441 | 1992 | 1992 | | | 1993 | BOTH | 1992 | | BOTH | |
| Heat Exch Bundle Cleaning Sludge | 6 | 53 | 5 | 358 | 1993 | 1993 | | | | BOTH | 1992 | 1993 | BOTH | |
| Contaminated Soil/Solids | 3 | 109 | 12 | 32,017 | | 1992 | | | BOTH | | | 1992 | 1992 | 1992 |
| Residual coke/Carbon/Charcoal | 9 | 155 | 6 | 255 | BOTH | | | 1992 | | 1992 | | | BOTH | BOTH |
| Residual sulfur | 2 | 6 | 3 | 109 | | | | 1992 | | | | BOTH | BOTH | |
| Other contaminated soils | 6 | 662 | 6 | 872 | | | | | | BOTH | | | 1992 | 1992 |

POLLUTION PREVENTION CODES

1 = Equipment or Technology Modifications
2 = Procedure Modifications
3 = Reformulation or Design of Products
4 = Substitution of Raw Materials
5 = Improved Housekeeping, Training, or Inventory Control

IN-PROCESS RECYCLE
6 = In refining process units (e.g., crude unit; coker; desalter)
7 = Recovering oil (& dewatering) by filter pressing/centrifugation
8 = Other recycle

OUT-OF-PROCESS RECYCLE
9 = Reuse/reclamation
10 = Other

# Table 5b
## Summary of Pollution Prevention Activities

| | | | | | SOURCE REDUCTION | | | | | RECYCLE IN-PROCESS | | | RECYCLE OUT-OF-PROCESS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Residual stream** | **1993** | | **1992** | | 1 | 2 | 3 | 4 | 5 | **6** | **7** | **8** | **9** | **10** |
| FCC Catalyst or Equivalent | 13 | 17,026 | 15 | 13,455 | 1993 | | | BOTH | BOTH | BOTH | | 1993 | BOTH | BOTH |
| Hydroprocessing catalysts | 13 | 9,488 | 15 | 19,269 | | | | | | | | BOTH | BOTH | 1993 |
| Other Spent Catalysts | 9 | 649 | 14 | 1,096 | | | | | 1993 | | | | BOTH | 1993 |
| Biomass | 5 | 110,837 | 4 | 105,876 | | | | | | BOTH | | 1993 | BOTH | |
| Oil contaminated water (not WW) | 1 | 1 | 0 | 0 | | | | | | | | | | 1993 |
| High pH/low pH waters | 0 | 0 | 0 | 0 | | | | | | | | | | |
| Other aqueous wastes NOS | 0 | 0 | 1 | 17 | | | | | | | | 1993 | 1992 | |
| Spent Acids | 2 | 120 | 0 | 0 | | | | | | | | | | |
| Spent caustics | 11 | 22,676 | 17 | 45,868 | | BOTH | | BOTH | 1992 | BOTH | | BOTH | BOTH | BOTH |
| Residual amines | 3 | 47 | 4 | 117 | BOTH | | | | | BOTH | | | BOTH | |
| Other inorganic residuals NOS | 9 | 9,757 | 9 | 51,497 | BOTH | 1993 | | | BOTH | 1992 | BOTH | 1993 | BOTH | BOTH |
| Other residuals NOS | 13 | 1,746 | 14 | 4,247 | | 1993 | | 1993 | BOTH | BOTH | | | BOTH | BOTH |
| TOTAL | 26 | 476,217 | 264 | 345,681 | | | | | | | | | | |

POLLUTION PREVENTION CODES

1 = Equipment or Technology Modifications
2 = Procedure Modifications
3 = Reformulation or Design of Products
4 = Substitution of Raw Materials
5 = Improved Housekeeping, Training, or Inventory Control

IN-PROCESS RECYCLE
6 = In refining process units (e.g., crude unit; coker; desalter)
7 = Recovering oil (& dewatering) by filter pressing/centrifugation
8 = Other recycle

OUT-OF-PROCESS RECYCLE
9 = Reuse/reclamation
10 = Other

### *Total Quantity of Residuals Managed*

API has coined the phrase *total quantity managed* to refer to the total amount of residual materials that refineries handle in a given calendar year. As indicated in the following equation, the total quantity managed equals the quantity generated plus treatment chemicals used to facilitate handling of some residuals and adjustments for materials that are placed into or removed from storage:

**Total Quantity Managed** = Quantity Generated + Treatment Additives + Net From Storage

In both 1992 and 1993, the total quantity managed was less than the amount generated. Specifically, in 1992, 6,398 wet tons were generated, but due to the amount placed into storage, refiners managed 6,130 wet tons. Similarly for 1993, the generated quantity was 5,547 wet tons, while the managed quantity was 5,451. (The SAS output containing these data is presented in Appendix B, pages B-1 and B-21).

As shown in Tables 6a and 6b, two streams had large quantities placed into storage in both years: **Contaminated soils and solids** and **Biomass.** In addition, refiners placed over 100 thousand wet tons of **Other residuals NOS** into storage in 1992.

In 1992, **Primary sludge (F037)** had the largest quantity removed from storage (28 thousand wet tons), while in 1993 nine thousand wet tons were placed into storage.

For the remaining streams, the quantities that were moved into or removed from storage were very small, usually less than one ton.

Use of Treatment Additives in 1992 followed the expectation set by the responses to the pollution prevention question. Refiners minimized their use of treatment additives to 30 thousand tons compared with the 55 and 72 thousand wet tons reported in 1987 and 1988. Treatment additives increased to 79 thousand wet tons in 1993; however, over 62 percent of this was reported by one refiner that had an abnormal peak in generation of **Other oily sludges/organic residuals.**

The total quantity of residuals managed for each of the seven survey cycles is displayed in Table 7. As the totals for the columns indicate, quantities managed in 1992 and 1993 were within the range previously observed. The 1992 quantity was the second highest reported, while the 1993 quantity was the second lowest.

**Table 6a**
**Estimates of Residual Materials Managed in 1992** (thousand wet tons)

| Residual stream | Amounted Generated | Net From Storage | Treatment Additives | Total Amount Managed |
|---|---|---|---|---|
| Spent Caustics | 1,428 | (2) | 0 | 1425 |
| Contaminated soils/solids | 1,063 | (110) | 0 | 953 |
| Biomass | 716 | (79) | 4 | 640 |
| DAF float | 544 | (2) | 5 | 546 |
| Other residuals NOS | 488 | (107) | 0 | 381 |
| Pond sediments | 388 | 0 | 3 | 391 |
| Other inorganic residuals NOS | 364 | (5) | <1 | 359 |
| Primary sludge (F037) | 209 | 28 | 10 | 247 |
| FCC catalyst or equivalent | 203 | (6) | 0 | 197 |
| API separator sludge | 178 | (8) | 3 | 174 |
| Residual amines | 142 | 0 | 0 | 142 |
| Nonleaded tank bottoms | 128 | <1 | 2 | 130 |
| Slop oil emulsion solids | 77 | (4) | 1 | 74 |
| Hydroprocessing catalysts | 55 | (3) | 0 | 51 |
| Primary sludge (F038) | 54 | 0 | <1 | 54 |
| Residual sulfur | 53 | (<1) | 0 | 53 |
| Residual coke/carbon/charcoal | 53 | <1 | 0 | 53 |
| Other oily sludges/organic residuals NOS | 38 | <1 | <1 | 38 |
| Residual oils/spent solvents | 33 | 0 | 0 | 33 |
| Spent sulfite solution | 33 | 0 | 0 | 33 |
| Other contaminated soils NOS | 32 | (<1) | 0 | 32 |
| Spent Stretford solution | 31 | (<1) | 0 | 31 |
| Other spent catalysts NOS | 27 | (<1) | 1 | 28 |
| Oil contaminated waters (not wastewaters) | 22 | 0 | 0 | 22 |
| High pH/low pH waters | 16 | <1 | 0 | 16 |
| TSD Leachate (F039) | 13 | 0 | 0 | 13 |
| Spent acids | 7 | 0 | <1 | 7 |
| Heat exchanger bundle cleaning sludge | 3 | <1 | <1 | 4 |
| Leaded tank bottoms | <1 | 0 | <1 | <1 |
| **Total** | 6,398 | -298 | 30 | 6,130 |

**Table 6b**
**Estimates of Residual Materials Managed in 1993** (thousand wet tons)

| Residual stream | Amounted Generated | Net From Storage | Treatment Additives | Total Amount Managed |
|---|---|---|---|---|
| Spent Caustics | 1,436 | (2) | 0 | 1,434 |
| Biomass | 800 | (83) | 5 | 722 |
| Contaminated soils/solids | 693 | (62) | <1 | 631 |
| DAF float | 517 | (<1) | 4 | 520 |
| Other inorganic residuals NOS | 251 | (5) | 1 | 247 |
| Primary sludge (F037) | 235 | (9) | <1 | 226 |
| FCC catalyst or equivalent | 204 | (6) | 0 | 198 |
| Other oily sludges/organic residuals NOS | 193 | 0 | 49 | 242 |
| API separator sludge | 170 | (7) | 5 | 168 |
| Other residuals NOS | 143 | (<1) | 0 | 143 |
| Pond sediments | 138 | 0 | 7 | 145 |
| Nonleaded tank bottoms | 127 | 1 | 2 | 130 |
| Residual amines | 116 | 0 | 0 | 116 |
| Primary sludge (F038) | 67 | (5) | 0 | 62 |
| Residual coke/carbon/charcoal | 54 | (<1) | 3 | 57 |
| Slop oil emulsion solids | 54 | 1 | 1 | 56 |
| Residual oils/spent solvents | 48 | 0 | 0 | 48 |
| Hydroprocessing catalysts | 47 | 4 | 1 | 52 |
| Residual sulfur | 44 | (<1) | <1 | 44 |
| TSD Leachate (F039) | 40 | 0 | 0 | 40 |
| Other contaminated soils NOS | 39 | (<1) | <1 | 39 |
| Spent sulfite solution | 29 | | | 29 |
| Other spent catalysts NOS | 29 | (<1) | 1 | 29 |
| Oil contaminated waters (not wastewaters) | 27 | 0 | 0 | 27 |
| Spent Stretford solution | 26 | 0 | 0 | 26 |
| High pH/low pH waters | 9 | 0 | <1 | 9 |
| Spent acids | 5 | 0 | <1 | 5 |
| Heat exchanger bundle cleaning sludge | 3 | <1 | <1 | 4 |
| Leaded tank bottoms | 3 | 0 | 0 | 3 |
| **Total** | 5,547 | -175 | 79 | 5,451 |

**Table 7**

**Comparison of Residual Material Managed: 1993-1987** (Estimates in thousands of wet tons)

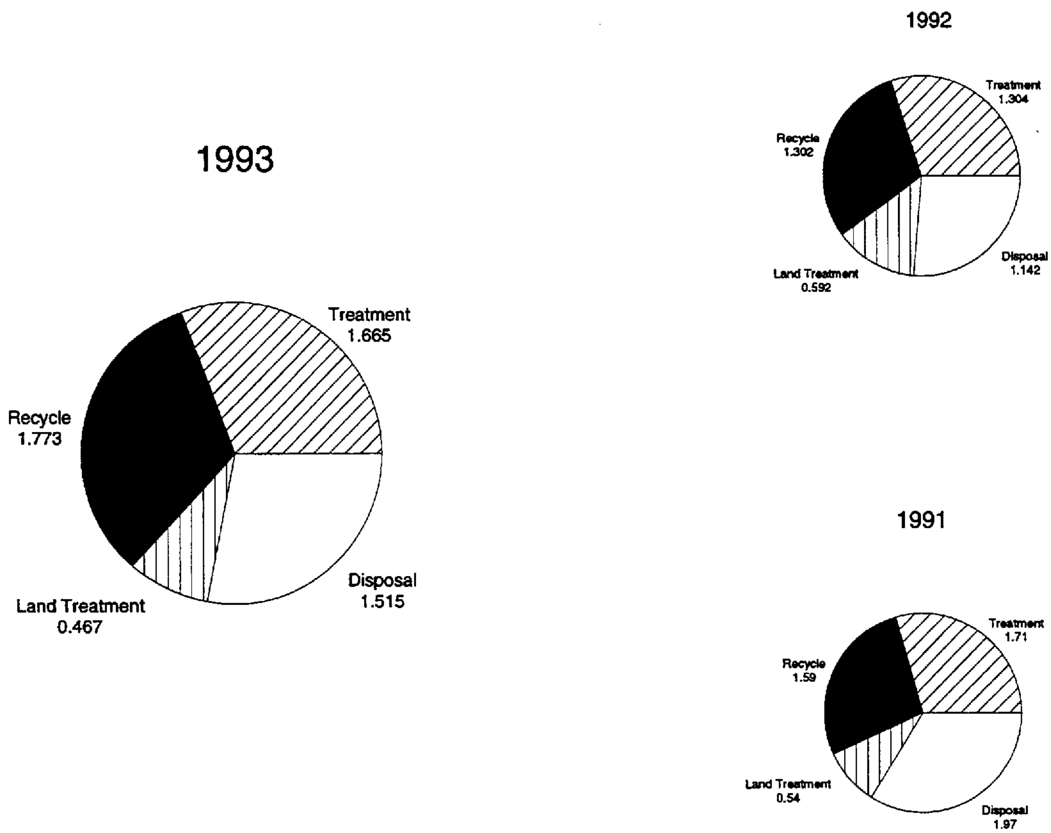
| Residual streams | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 |
|---|---|---|---|---|---|---|---|
| Spent caustics | 1434 | 1425 | 908 | 894 | 716 | 656 | 675 |
| Biomass | 722 | 641 | 862 | 794 | 655 | 749 | 720 |
| Contaminated soils/solids | 631 | 953 | 785 | 915 | 496 | 242 | 186 |
| DAF float | 520 | 546 | 410 | 564 | 521 | 661 | 654 |
| Other Inorganic residuals NOS | 247 | 359 | 393 | 453 | 441 | 221 | 323 |
| Other Oily sludges/organic residuals NOS | 242 | 38 | 54 | 54 | 47 | 61 | 40 |
| Primary Sludge (F037) | 226 | 247 | 133 | NA | NA | NA | Na |
| FCC catalyst/equivalent | 197 | 197 | 204 | 259 | 185 | 189 | 171 |
| API separator sludge | 167 | 174 | 214 | 260 | 425 | 430 | 564 |
| Pond sediments | 145 | 391 | 381 | 1,040 | 273 | 311 | 360 |
| Other residuals NOS | 143 | 381 | 339 | 353 | 325 | 412 | 203 |
| Nonleaded tank bottoms | 130 | 130 | 111 | 196 | 164 | 131 | 218 |
| Residual amines | 116 | 142 | 137 | 75 | 51 | 14 | 13 |
| Primary Sludge (F038) | 62 | 54 | 180 | NA | NA | NA | NA |
| Residual coke/carbon/charcoal | 57 | 53 | 138 | 92 | 137 | 67 | 43 |
| Slop oil emulsion solids | 56 | 74 | 160 | 295 | 262 | 214 | 212 |
| Hydroprocessing catalysts | 52 | 51 | 33 | 30 | 36 | 37 | 39 |
| Residual oils/spent solvents | 48 | 33 | 21 | 115 | 31 | 7 | 4 |
| Residual sulfur | 44 | 53 | 19 | 35 | 52 | 23 | 17 |
| TSD Leachate (F039) | 40 | 74 | 20 | NA | NA | NA | NA |
| Other Contaminated soils NOS | 39 | 33 | 37 | 69 | 53 | 77 | 88 |
| Other spent catalysts | 29 | 28 | 23 | 41 | 33 | 38 | 38 |
| Spent sulfite solution | 29 | 33 | 9 | 1 | 8 | 40 | 42 |
| Oil contaminated waters (not wastewaters) | 27 | 22 | 67 | 8 | 29 | 36 | 28 |
| Spent Stretford solution | 26 | 31 | 25 | 30 | 42 | 49 | 35 |
| High pH/low pH waters | 9 | 16 | 54 | 105 | 92 | 138 | 144 |
| Spent acids | 6 | 8 | 88 | 337 | 8 | 160 | 130 |
| Heat exch bundle cleaning sludge | 5 | 4 | 3 | 13 | 2 | 5 | 3 |
| Leaded tank bottoms | 3 | <1 | 1 | 3 | 4 | 10 | 9 |
| Other separator sludges | NA | NA | NA | 104 | 117 | 110 | 83 |
| **Total** | 5,451 | 6,130 | 5,808 | 7,134 | 5,206 | 5,086 | 5,043 |

### *Management Practices for Residual Materials*

API adopted the framework of the waste management hierarchy to structure the accounting of the handling practices used with residual materials generated by the refining industry. Source reduction activities, a subset of pollution prevention practices, have already been described. This section of the report will provide information on how the industry eliminates the residuals generated--a dynamic interaction between recycling of valuable constituents in the residuals, treatment to reduce volumes and/or neutralize materials, and ultimate disposal of remaining materials.

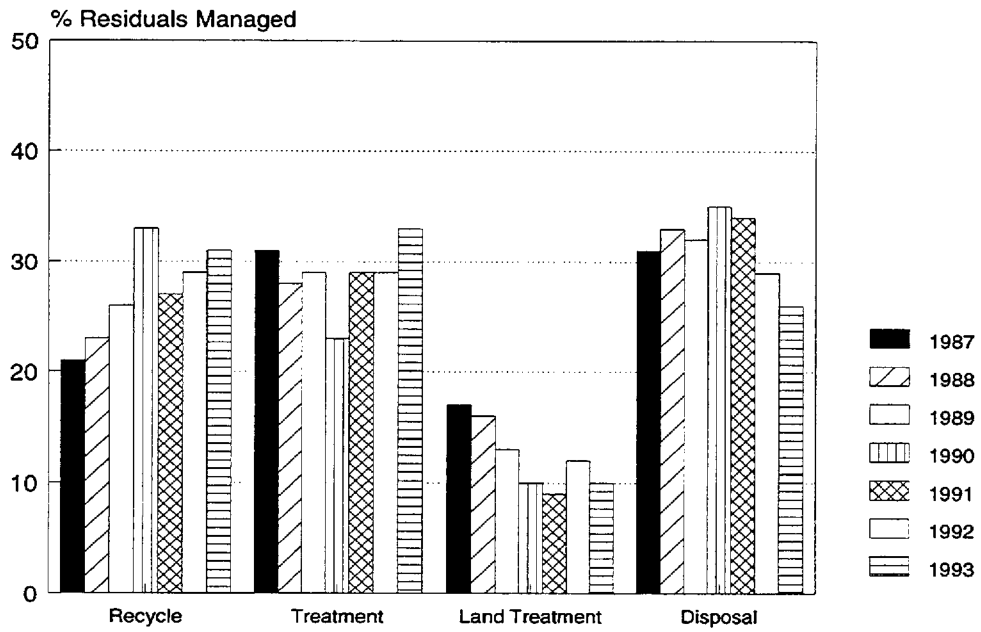
The pie charts presented in Figure G show the quantity of residuals handled by recycling, treatment, land treatment, and disposal for the last three survey cycles. (The SAS output containing these data is presented in Appendix B, pages B-2 and B-22). As indicated, handling practices have remained quite stable. If one looks closely, however, it is apparent that the proportion of residuals recycled in 1993 was slightly greater than that reported in 1991, while the proportion of material that was disposed has also been reduced.

**Figure G**
**Residual Management Practices: 1993 - 1991** (Millions of wet tons)



These changes in handling practices are more pronounced when the data for each handling practice are displayed as a percentage of the total quantity managed in each survey cycle. As shown in Figure H, recycling has increased from just over 20 percent when the survey began to over 30 percent for 1993. Use of treatment has fluctuated, with a low observed in 1990 and a new peak in 1993. Land treatment decreased successively from 1987 to 1991, while disposal exhibited a similar step-wise decrease over the last three survey cycles.

**Figure H**
**Longitudinal Comparison of Residual Management Practices: 1987 - 1993**




The following sections of the report provide more detailed information on each handling practice, and, by describing the contributions of individual streams to the overall management profile, help to explicate the patterns observed in Figure H above.

## Recycling

Among the methods for recycling residuals, *reclamation/regeneration* has remained the most commonly used throughout the seven years this survey has been conducted. In 1993, it accounted for 41 percent, as displayed in Table 8. When the 12 percent of material used in the *coker* (consistent with previous years), and 8 percent recycled to the *crude units* are added to the other in-process methods (including recycling to crude unit), *in-process recycling* accounts for over almost 30 percent of recycled residuals. (The SAS output containing these data is presented in Appendix B, pages B-4 - B-9 and B-24 - B-29.)

In the 1992-1993 cycle, *out-of-process recycling* methods accounted for 20 percent of recycled materials. This was a notable increase from the 5 percent reported in 1991 (the first year in which the survey included this category). Reciprocally, there was a decrease in "not specified" in the 1992-1993 cycle compared with the 1991 cycle.

**Table 8**
**Summary of Recycling Practices**(thousands of wet tons)

| Method of Recycling | 1993 Tons(%) | 1992 Tons(%) | 1991 Tons(%) | 1990 Tons(%) | 1989 Tons(%) | 1988 Tons(%) | 1987 Tons(%) |
|---|---|---|---|---|---|---|---|
| Coker | 220 (12) | 293 (16) | 181 (11) | 192 (10) | 231 (17) | 186 (16) | 148 (14) |
| Crude unit | 140 ( 8) | 135 ( 7) | 217 (14) | 174 ( 9) | 125 ( 9) | 85 ( 7) | 68 ( 0) |
| Reclamation/regeneration | 732 (41) | 788 ( 43) | 772 (49) | 872 (46) | 611 (44) | 434 (38) | 447 (42) |
| Other recycling | | | | 655 (35) | 408 (30) | 474 (41) | 410 (38) |
| In-process* | 151 ( 9) | 96 (3) | 60 ( 4) | | | | |
| Out-of-process* | 356 (20) | 368 (20) | 84 ( 5) | | | | |
| Fuel use* | 60 ( 3) | 61 ( 3) | 78 ( 5) | | | | |
| Not specified* | 115 ( 7) | 86 ( 5) | 198 (12) | | | | |
| **Total** | 1774 | 1827 | 1590 | 1,893 | 1,376 | 1,179 | 1,073 |

*These categories were new for 1991; data were not available for previous years.

Table 9 summarizes recycling methods by residual stream. As in other years, **Spent caustics** made the largest contribution to materials recycled by *reclamation/regeneration*, accounting for close to 90 percent. The 1992-1993 cycle continues the trend of increased amounts of spent caustics reclaimed/regenerated and decreased amounts of other streams. **Hydroprocessing catalysts** make the next largest contribution in 1993, followed by other spent catalysts and FCC catalysts. In 1992, **Residual oils/spent solvents** also contributed to the amount of residuals recycled by reclamation/regeneration, accounting for more than half of the All Other group.

Three streams made up the majority of residuals sent to the *coker* for in-process recycling: **Biomass, DAF float**, and **API separator sludge**. This was consistent with previous years, although the amounts from each stream show some variability, with more **Biomass** sent to the coker in 1992 than in 1993. These streams sent to the coker, however, still constitute only a small fraction, usually less than 5 percent, of the total coker feedstock.

**Table 9**
**Estimated Quantities of Recycled Materials** (thousands of wet tons)

| Recycling Method/Residual Stream | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 |
|---|---|---|---|---|---|---|---|
| **RECLAMATION/REGENERATION** | | | | | | | |
| Spent caustics | 637 | 674 | 486 | 535 | 459 | 243 | 262 |
| Hydroprocessing catalysts | 27 | 45 | 31 | 28 | 32 | 21 | 26 |
| Other spent catalysts | 16 | 6 | 6 | 11 | 8 | 15 | |
| FCC catalyst or equivalent | 11 | 12 | 6 | 7 | 27 | 11 | |
| All others | 41 | 51 | 248 | 299 | 85 | 136 | 212 |
| **Total** | 732 | 788 | 772 | 872 | 611 | 378 | 390 |
| **IN-PROCESS RECYCLE-Coker** | | | | | | | |
| Biomass | 75 | 177 | 67 | 56 | 59 | 27 | 25 |
| DAF float | 47 | 49 | 56 | 75 | 79 | 45 | 82 |
| API separator sludge | 23 | 24 | 31 | 8 | 55 | 73 | 14 |
| All others | 75 | 43 | 27 | 53 | 38 | 41 | 27 |
| **Total** | 220 | 293 | 181 | 192 | 231 | 186 | 148 |
| **Crude unit** | | | | | | | |
| DAF float | 52 | 75 | 72 | 22 | 34 | 19 | 16 |
| API separator sludge | 11 | 11 | 11 | 10 | 24 | 13 | 18 |
| All others | 77 | 49 | 134 | 142 | 67 | 53 | 34 |
| **Total** | 140 | 135 | 217 | 174 | 125 | 85 | 68 |
| **Other In-Process Recycle** | 151 | 96 | 60 | These recycle codes were new for 1991; consequently comparable data were not available for previous survey cycles | | | |
| **Out-of-Process Kiln** | 64 | 43 | 51 | | | | |
| **Other Out-of-process** | | | | | | | |
| Biomass | 116 | 0 | 0 | | | | |
| Spent caustic | 68 | 63 | 20 | | | | |
| Residual coke | 41 | 37 | 0 | | | | |
| Residual sulphur | 31 | 26 | <1 | | | | |
| Other inorganic | 5 | 49 | 7 | | | | |
| Contaminated soils | 3 | 74 | 1 | | | | |
| All Others | 28 | 75 | 5 | | | | |
| **Total** | 292 | 324 | 33 | | | | |
| **Industrial Fuel** | 60 | 61 | 78 | | | | |
| **Other*** | | | | | | | |
| Spent caustics | 33 | 21 | 137 | 123 | 138 | 254 | 232 |
| Biomass | 48 | 58 | 0 | 0 | <1 | 0 | 0 |
| All others | 34 | 7 | 61 | 532 | 271 | 220 | 178 |
| **Total** | 115 | 86 | 198 | 655 | 409 | 474 | 410 |
| **Grand total** | 1,774 | 1,827 | 1,590 | 1,893 | 1,369 | 1,156 | 1,055 |

**DAF float** was by far the largest component of residuals sent to the *crude unit* for recycling, accounting for one third of the material in 1993. **API separator sludge** has the second largest quantity sent to the crude unit, although significantly less than DAF float. The large amount of **Biomass** sent to the crude unit reported in 1991 was not maintained in this survey cycle. Other streams that reported significant quantities recycled via crude units in previous years -- **Nonleaded tank bottoms and Slop oil emulsion solids** -- did not have large quantities in this survey cycle.

The total amount of residuals recycled through *other out-of-process* methods in 1993 has increased significantly from the 1991 amount to about 292 thousand wet tons, approximately 16 percent of the total recycled. In 1993, **Biomass** accounted for 116 thousand wet tons, while the large contributors in 1992 were **Contaminated soils, Spent caustics**, and **Other inorganic residuals.**

Recycling methods that were not specified were reported for less than 6 percent of the recycled materials in 1992 and 1993, most coming from **Biomass.**

As shown in Table 10, activities performed on the ten recycled streams with the highest quantities are most often performed off-site. Exceptions are for oily residual materials: in 1993, **DAF float** with 68 percent performed on-site, and **API separator sludge** with 68 percent performed on-site.

**Table 10**
**Location of Recycling Activities** (thousands of wet tons)

| 1992 Residual Stream | Quantity | % On-Site | % Off-site |
|---|---|---|---|
| Spent caustics | 764 | 48 | 52 |
| Biomass | 273 | 66 | 34 |
| DAF float | 173 | 72 | 28 |
| FCC catalyst or equivalent[5] | 86 | 0 | 100 |
| Contaminated Soils/Solids | 74 | 0 | 100 |
| Other inorganic residuals | 65 | 3 | 97 |
| API separator sludge | 48 | 80 | 20 |
| Hydroprocessing catalysts | 45 | 1 | 99 |
| Residual coke/carbon/charcoal | 41 | 5 | 95 |
| Slop oil emulsion solids | 35 | 62 | 38 |

| 1993 Residual Stream | Quantity | % On-Site | % Off-site |
|---|---|---|---|
| Spent caustics | 739 | 51 | 49 |
| Biomass | 278 | 28 | 72 |
| DAF float | 148 | 68 | 32 |
| FCC catalyst or equivalent[5] | 94 | 0 | 100 |
| API separator sludge | 55 | 68 | 32 |
| Residual coke/carbon/charcoal | 45 | 1 | 99 |
| Slop oil emulsion solids | 36 | 62 | 38 |
| Residual sulfur | 34 | 0 | 100 |
| Hydroprocessing catalysts | 28 | 8 | 92 |
| Other oily sludge | 20 | 31 | 69 |

[5] These data do not represent the continuous in-unit regeneration of catalyst that occurs throughout the refining process, but refer only to the location of recycling activities after the catalyst is spent.

Treatment

As in other years, *wastewater treatment* accounted for the largest quantity of residuals treated, with 87 percent in 1993. The 1992-1993 survey cycle continued the trend begun in 1990 and 1991 with increased quantities of Aqueous chemical wastes/inorganics undergoing wastewater treatment.

Consistent with previous years, *incineration* was next most commonly reported treatment method, but still it accounts for a very small quantity of residuals (8 percent in 1993). This profile is displayed in Table 11. After a significant decrease in 1991, quantities of residuals treated by *chemical/physical* methods increased, although not to the levels of surveys in years before 1991. (The SAS output containing these data is presented in Appendix B, pages B-10 - B-13 and B-30 - B-33.)

**Table 11**
**Summary of Treatment Methods** (thousands of wet tons)

| Method of Treatment | 1993 Tons (%) | 1992 Tons (%) | 1991 Tons (%) | 1990 Tons (%) | 1989 Tons (%) | 1988 Tons (%) | 1987 Tons (%) |
|---|---|---|---|---|---|---|---|
| Wastewater | 1452 (87) | 1,547 (86) | 1,464 (86) | 1,265 (68) | 1,176 (78) | 1,045 (72) | 1,167 (74) |
| Incineration | 130 ( 8) | 175 (10) | 215 (13) | 165 ( 9) | 143 ( 9) | 131 ( 9) | 107 ( 7) |
| Chemical/physical | 42 ( 3) | 33 ( 2) | 3 (<1) | 131 ( 7) | 143 ( 9) | 148 (10) | 117 ( 7) |
| Stabilize/Fixation | 2 (<1) | 7 (<1) | 3 (<1) | 276 (15) | 4 (<1) | 5 (<1) | <1 (<1) |
| Other | 39 ( 2) | 41 ( 2) | 22 (1) | 37 ( 2) | 45 ( 3) | 117 ( 8) | 186 (12) |
| Total | 1,665 | 1,805 | 1,707 | 1,874 | 1,511 | 1,446 | 1,577 |

Table 12 shows that **DAF float** remained the largest oily stream that was dewatered, but in general, other dewatered oily streams showed a decrease in their reliance on wastewater treatment compared with previous years. There was, however, a notable quantity, 107 thousand wet tons, of **Pond sediments** reported (in the "Others" category) in 1992, although this dropped to only 1 thousand wet tons in 1993. Among the aqueous chemical streams, **Spent caustics** increased sharply in its contribution to wastewater treatment. This increase in Spent caustics was accompanied by an equally sharp decrease in the volume of Biomass that was treated in refining wastewater treatment systems. Another difference reported in this survey cycle was the 22 thousand wet tons of **TSD leachate** that was wastewater treated in 1993.

Quantities of residuals treated through *incineration* continue to come primarily from three streams: **Biomass, DAF float**, and **API separator sludge**. As would be expected with incineration specified as BDAT, the slightly higher quantities of API separator sludge that occurred in 1991 were maintained in the 1992-1993 survey cycle. Compared to 1991, there was a notable decrease in **Pond sediments** and **Slop oil emulsion solids** quantities treated by incineration, although the 1993 quantities are similar to those reported before 1991.

The only stream that had a significant quantity treated by *chemical or physical* methods continues to be **API separator sludge**, returning in this survey cycle to quantities that were consistent with amounts compared with 1991. In three out of the seven survey years, including 1993, small quantities of **Biomass** were reported as being treated by chemical/physical methods.

## Table 12
**Estimated Quantities of Residuals Treated** (thousands of wet tons)

| Treatment Method/Residual stream | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 |
|---|---|---|---|---|---|---|---|
| **Wastewater treatment** | | | | | | | |
| *From dewatered oily materials* | | | | | | | |
| DAF Float | 338 | 308 | 208 | 306 | 248 | 236 | 263 |
| Primary Sludge (F037 & F038)* | 83 | 56 | 197 | 51 | 53 | 48 | 32 |
| API separator sludge | 74 | 68 | 113 | 56 | 149 | 136 | 146 |
| Slop oil emulsion solids | 12 | 23 | 58 | 108 | 98 | 57 | 98 |
| Others | 20 | 114 | 110 | 29 | 10 | 472 | 161 |
| Subtotal | 527 | 589 | 576 | 559 | 633 | 529 | 700 |
| *Aqueous chemical wastes/inorganics* | | | | | | | |
| Spent caustics | 660 | 630 | 229 | 132 | 93 | 74 | 87 |
| Residual amines | 113 | 139 | 133 | 71 | 46 | 2 | 2 |
| Other inorganic residuals NOS | 39 | 39 | 70 | 50 | 23 | 39 | 33 |
| Biomass | 34 | 90 | 354 | 288 | 249 | 222 | 234 |
| TSD Leachate (F039) | 22 | 1 | | | | | |
| Oil contaminated waters (not wastewaters) | 21 | 21 | 59 | 1 | 19 | 35 | 26 |
| Spent Stretford solution | 21 | 22 | 18 | 16 | 29 | 39 | 17 |
| All others | 15 | 18 | 25 | 58 | 31 | 594 | 735 |
| **Total** | 1,452 | 1,547 | 1,464 | 1,265 | 1,176 | 1,045 | 1,167 |
| **Incineration** | | | | | | | |
| Biomass | 81 | 74 | 82 | 98 | 103 | 73 | 64 |
| DAF float | 24 | 54 | 58 | 32 | 26 | 47 | 35 |
| API separator sludge | 12 | 26 | 29 | 5 | 7 | 5 | 4 |
| All others | 13 | 21 | 46 | 29 | 7 | 6 | 4 |
| **Total** | 130 | 175 | 215 | 164 | 143 | 131 | 107 |
| **Chemical/physical** | | | | | | | |
| API separator sludge | 19 | 20 | 2 | 13 | 35 | 10 | 2 |
| Biomass | 12 | 0 | 0 | 20 | 0 | 17 | 0 |
| All others | 11 | 13 | <1 | 98 | 128 | 104 | 115 |
| **Total** | 42 | 33 | 3 | 131 | 143 | 131 | 117 |
| **Thermal/Heat** | | | | | | | |
| Contaminated Soils | 18 | 16 | 0 | 0 | 0 | 0 | 0 |
| DAF float | 6 | 6 | 1 | 0 | 0 | 0 | 0 |
| Slop oil emulsion solids | 5 | 7 | 1 | 0 | 0 | 0 | 0 |
| Other | <1 | 7 | 5 | 2 | 6 | 0 | 0 |
| **Total** | 29 | 36 | 7 | 2 | 6 | 0 | 0 |
| **Stabilize/Fixation** | 2 | 7 | 3 | 276 | 4 | 0 | <1 |
| **Weathering/Other** | | | | | | | |
| Biomass | 6 | 5 | 13 | 0 | 0 | 0 | 0 |
| Others | 4 | <1 | 9 | 36 | 49 | 122 | 186 |
| **Total** | 10 | | 22 | 36 | 49 | 122 | 186 |
| **Grand total** | 1,665 | 1,805 | 1,707 | 1,877 | 1,511 | 1,446 | 1,577 |

***Quantities reported for 1987 - 1990 were for Other Separator Sludge**

Table 13 displays the location of treatment activities. As in previous years, most treatment of residuals is performed on-site. In fact, in 1993, all of the top ten streams contributing to residual treatment have 89 percent or more of the quantities processed on-site.

**Table 13**
**Location of Treatment Activities** (thousands of wet tons)

| 1992 Residuals Stream | Quantity | % On-Site | % Off-site |
|---|---|---|---|
| Spent caustics | 632 | 98 | 2 |
| DAF float | 369 | 95 | 5 |
| Biomass | 168 | 80 | 20 |
| Residual amines | 140 | 100 | 0 |
| API Separator sludge | 122 | 80 | 20 |
| Pond sediments | 107 | 100 | 0 |
| Other inorganic | 48 | 88 | 12 |
| Primary sludge (F037) | 41 | 69 | 31 |
| Slop oil emulsion | 37 | 79 | 21 |
| Nonleaded tank bottoms | 25 | 99 | 1 |

| 1993 Residuals Stream | Quantity | % On-Site | % Off-site |
|---|---|---|---|
| Spent caustics | 661 | 99 | 1 |
| DAF float | 369 | 96 | 4 |
| Biomass | 132 | 91 | 9 |
| Residual amines | 113 | 100 | 0 |
| API Separator | 106 | 89 | 11 |
| Primary sludge (F037) | 56 | 94 | 6 |
| Other inorganic | 40 | 98 | 2 |
| Primary sludge (F038) | 39 | 99 | 1 |
| TSD leachate | 22 | 100 | 0 |

## Land Treatment

Land treatment appears on the survey data sheets as a treatment methodology, but is presented separately here because it is considered to occupy an intermediate status between residual treatment technologies and waste disposal practices.

Land treatment has been subjected to some of the land disposal restrictions that began in 1990 (i.e., wastes regulated as hazardous under Subtitle C of RCRA can no longer be land treated or disposed in landfills without meeting treatment standards or unless a no-migration variance has been granted). The decrease in the use of land treatment observed in 1991, continued in the 1992-1993 survey cycle. The 1992 amount was substantially higher than the 1991 amount, but in 1993 the amount returned to 497 thousand wet tons land treated. (The SAS output containing these data is presented in Appendix B, pages B-14 - B-16 and B-34 - B-36.)

Three residual streams make up the majority of this quantity: **Biomass, Contaminated soils,** and **F037 Primary sludge.** In 1992, when a peak in generation was reported, **Pond**

**sediments** also contributed to the land treated quantity. In fact, the difference in total quantity of residuals land treated between 1992 and 1993 can be attributed to the difference in the quantities of Pond sediments land treated (230 thousand wet tons in 1992 compared with only 20 thousand wet tons in 1993).

**Table 14**
**Estimated Quantities of Land Treated Residuals** (thousands of wet tons)

| Residual stream | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 |
|---|---|---|---|---|---|---|---|
| Contaminated soils/solids | 142 | 246 | 268 | 299 | 132 | 28 | 22 |
| Biomass | 143 | 144 | 201 | 267 | 187 | 259 | 236 |
| Primary sludge (F037) | 116 | 58 | 27 | NA | NA | NA | NA |
| Pond sediments | 20 | 230 | 11 | 349 | 127 | 64 | 67 |
| All others | 76 | 32 | 31 | 233 | 263 | 351 | 525 |
| **Total** | **497** | **710** | **538** | **1,148** | **709** | **832** | **850** |

Disposal

Table 15 shows that the refining industry reported the smallest quantity of residuals eliminated by disposal in 1993--1,515 thousand wet tons. This continued the trend of decreased disposal quantities which followed the peak in that occurred in 1990. (The SAS output containing these data is presented in Appendix B, pages B-17 - B-20 and B-37 - B-40.)

**Table 15**
**Summary of Disposal Practices** (thousands of wet tons)

| Method of Disposal | 1993 Tons (%) | 1992 Tons (%) | 1991 Tons (%) | 1990 Tons (%) | 1989 Tons(%) | 1988 Tons(%) | 1987 Tons (%) |
|---|---|---|---|---|---|---|---|
| Impoundment | 43 ( 3) | 51 ( 3) | 110 ( 6) | 129 ( 6) | 113 ( 7) | 245 (15) | 280 (18) |
| Landfills | 1,265 (84) | 1,665 (93) | 1,703 (84) | 1,889 (84) | 1,375 (85) | 1,200 (73) | 1,070 (69) |
| Landspread | 170 (11) | 33 ( 2) | 66 ( 3) | 174 ( 8) | 95 ( 6) | 160 (10) | 109 ( 7) |
| Injection | 36 ( 2) | 36 ( 2) | 35 ( 2) | 36 ( 2) | 15 ( 1) | 30 ( 2) | 40 ( 3) |
| Other | 1 (<1) | 3 (<1) | 60 ( 3) | 8 (<1) | 21 ( 1) | 1 (<1) | 41 ( 3) |
| **Total** | **1,515** | **1,788** | **1,974** | **2,236** | **1,619** | **1,636** | **1,540** |

As in all other survey years, landfills were used to handle the majority of the disposed residuals, accounting for 84 percent of the total 1,515 thousand wet tons disposed. The trend of decreasing quantities of residuals placed in disposal impoundments continued to an all time low in 1993. The quantity of residuals disposed by landspreading increased in 1993 to 170 thousand wet tons, a level comparable to that reported in 1990.

Table 16 displays the methods of disposal by residual streams. *Disposal impoundments* were used principally for handling **FCC catalyst** and **TSD leachate** in 1992 and 1993. The quantities of **Other inorganic residuals** placed in disposal impoundments decreased significantly from previous years.

As in other years, several residual streams have significant quantities disposed in *landfills.* **Contaminated soils/solids** remained the largest stream. The amount of **Pond sediments** fluctuated, with a low of 39 thousand wet tons in 1992 and 111 wet tons in 1993. Although there was an increase in the use of landfills for **Other residuals NOS** in 1992, it returned to an all time low in 1993. This was also true of **Primary sludge** (F037).

The increase in **Biomass** eliminated by *landspreading* in 1993 to 101 thousand wet tons accounts for almost 60 percent of the total landspread quantity, the largest amount in the seven survey years. **Contaminated soils/solids** account for another 34 percent landspread in 1993. The relatively small amount of residual disposed by deep well injection was primarily **Spent caustics**, as in all previous survey years.

Most disposal activity occurs off-site, as shown in Table 17. Two exceptions are disposed **Biomass** and **Spent caustics**. Two-thirds of the quantities of each are disposed on-site.

**Table 16**
**Estimated Quantities of Wastes Eliminated by Disposal** (thousands of wet tons)

| Disposal Method/Residual stream | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 |
|---|---|---|---|---|---|---|---|
| **Disposal impoundment** | | | | | | | |
| FCC catalyst or equivalent | 18 | 25 | 25 | 20 | 14 | 13 | 11 |
| TSD Leachate (F039) | 18 | 11 | 18 | NA | NA | NA | NA |
| Other inorganic residuals NOS | 5 | 7 | 53 | 86 | 65 | 25 | 56 |
| All others | 2 | 8 | 14 | 22 | 34 | 207 | 211 |
| **Total** | 43 | 51 | 110 | 129 | 113 | 245 | 280 |
| **Landfill** | | | | | | | |
| Contaminated soils/solids | 343 | 592 | 480 | 497 | 317 | 189 | 141 |
| Other inorganic residuals NOS | 170 | 230 | 210 | 162 | 227 | 77 | 155 |
| Other residuals NOS | 133 | 356 | 272 | 336 | 315 | 384 | 195 |
| Pond sediments | 111 | 39 | 328 | 405 | 60 | 50 | 7 |
| FCC catalyst or equivalent | 81 | 83 | 118 | 117 | 104 | 115 | 123 |
| Biomass | 68 | 51 | 41 | 32 | 37 | 48 | 41 |
| Nonleaded tank bottoms | 61 | 70 | 75 | 82 | 45 | 42 | 53 |
| Other contaminated soils NOS | 24 | 20 | 31 | 46 | 38 | 69 | 82 |
| Primary sludge (F037) | 21 | 138 | 40 | NA | NA | NA | NA |
| All others | 253 | 84 | 108 | 218 | 212 | 226 | 362 |
| **Total** | 1265 | 1665 | 1703 | 1889 | 1375 | 1200 | 1070 |
| **Landspread** | | | | | | | |
| Biomass | 101 | 5 | 23 | 26 | 15 | 48 | 51 |
| Contaminated soils/solids | 57 | 24 | 6 | 15 | 16 | 11 | 4 |
| All others | 12 | 4 | 37 | 133 | 64 | 101 | 54 |
| **Total** | 170 | 33 | 66 | 174 | 95 | 160 | 109 |
| **Injection** | | | | | | | |
| Spent caustics | 34 | 29 | 32 | 32 | 14 | 24 | 33 |
| All others | 2 | 7 | 3 | 4 | 1 | 6 | 7 |
| **Total** | 36 | 36 | 35 | 36 | 15 | 30 | 40 |
| **Other methods** | | | | | | | |
| **Total** | 1 | 3 | 60 | 8 | 21 | 2 | 41 |
| **Grand total** | 1515 | 1788 | 1974 | 2236 | 1619 | 1636 | 1540 |

**Table 17**
**Location of Disposal Activities** (thousands of wet tons)

| 1992 Residual Stream | Quantity | % On-site | % Off-site |
|---|---|---|---|
| Contaminated soils/solids | 616 | 8 | 92 |
| Other residual NOS | 358 | 28 | 72 |
| Other inorganic residuals NOS | 238 | 8 | 92 |
| Primary sludge (F037) | 140 | 39 | 61 |
| FCC catalyst or equivalent | 109 | 39 | 61 |
| Nonleaded tank bottoms | 70 | 5 | 95 |
| Biomass | 56 | 28 | 72 |
| Pond sediments | 39 | 0 | 100 |
| Spent caustics | 30 | 66 | 34 |
| Residual sulfur | 27 | 1 | 99 |

| 1993 Residual Stream | Quantity | % On-site | % Off-site |
|---|---|---|---|
| Contaminated soils/solids | 400 | 19 | 81 |
| Other inorganic residuals NOS | 176 | 9 | 91 |
| Biomass | 169 | 66 | 34 |
| Other residual NOS | 133 | 14 | 86 |
| Pond sediments | 111 | 0 | 100 |
| FCC or equivalent | 100 | 38 | 62 |
| Nonleaded tank bottoms | 65 | 9 | 91 |
| Spent caustics | 34 | 62 | 38 |
| Other contaminated soils NOS | 25 | 8 | 92 |
| Primary sludge (F037) | 23 | 8 | 92 |

### *Aqueous Residuals*

API's survey does not attempt to capture extensive information on refinery wastewater treatment systems. Because many refinery wastewater treatment systems are regulated under the Clean Water Act NPDES permit system and are historically not subject to full regulation under RCRA, a decision was made during the development of the survey not to request information on these aqueous materials.

Since that time, RCRA rulemakings, in particular promulgation of the new Toxicity Characteristic (TC), have affected some refinery wastewaters. Accordingly, beginning with the 1991 cycle of the survey, API incorporated questions in its survey to obtain data on these residuals. The sections that follow provide data on these TC Wastewaters, as well as the miscellany of aqueous materials that constitute the category of **Other Aqueous Residuals.**

<u>Other Aqueous Residuals NOS</u>

As described in the Methodology section, the data collected on this residual stream was not included in the modeling of the other 29 residual streams. Instead, because of the great variability in the generation quantities, a separate ratio model was used to develop the industry estimates.

In 1992, 14 of the 91 respondents reported generating **Other Aqueous Wastes NOS**, while only seven continued its generation in 1993. The industry wide estimates were 3.510 million wet tons for 1992 and 3.718 million wet tons for 1993. These estimates reflect the influence of one refinery that deep well injects sour waters resulting from processing high sulfur content crude oils. This refinery accounted for 97 percent of the amount of **Other Aqueous Wastes NOS** reported in 1992 and for 94 percent in 1993. Another refinery used this category to report groundwater recovered from site remediation activities, accounting for an additional 2 percent of 1992 quantity and 5 percent for 1993. Thus, the generation pattern previously observed for **Other Aqueous Residuals NOS** has persisted, with large quantities generated by just a few refineries.

The management practices have also remained constant over time, with deep well injection accounting for 99 percent of the material in 1992 and 97 percent in 1993.

<u>TC Wastewaters</u>

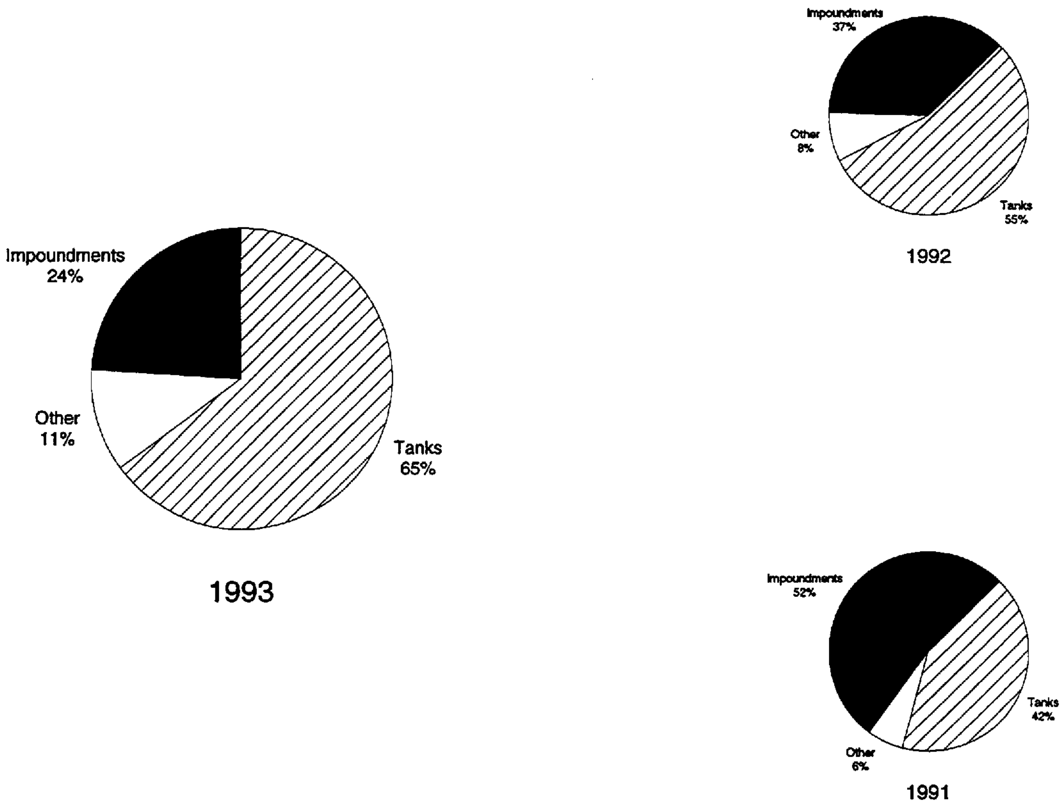
Question 8 in the first section of the questionnaire (refer to the copy of API's questionnaire in Appendix A) requests information on the amount of refinery wastewater that was identified as characteristically hazardous under RCRA. In 1992, 53 respondents reported that 157.75 million tons of their wastewater failed the Toxicity Characteristic Leachate Procedure (TCLP). Similarly, for 1993, 52 respondents reported 128.42 million wet tons.

Because these are reported quantities, and not nationally extrapolated estimates, one cannot compare the total quantities generated in 1992 and 1993 with that reported in 1991 without first controlling for the effect of the drop in overall survey response rates. Consequently, the cohort of 41 refineries that participated in all three survey cycles was examined to gain insight into the generation pattern for TC wastewater. This comparison revealed a systematic reduction over time: from 159 million wet tons in 1991, to 141 million wet tons in 1992, to 121 wet tons in 1993.

Similarly, the management of TC wastewaters has changed over time. As shown in Figure I, in 1991 over half of the material was handled in RCRA permitted surface impoundments, but by 1993, only one quarter was managed in this manner. A reciprocal shift has taken place in the proportion of TC wastewater managed in tanks: increasing from a low of 42 percent in 1991 to 65 percent in 1993.

Deep well injection of TC wastewaters is included in the "Other" management category. Use of this disposal method has remained very low, accounting for only 2 percent of the total amount of TC wastewater in 1992 and 3 percent in 1993.

**Figure I**
**Techniques Used to Manage TC Hazardous Wastewater** (% of total quantity managed)

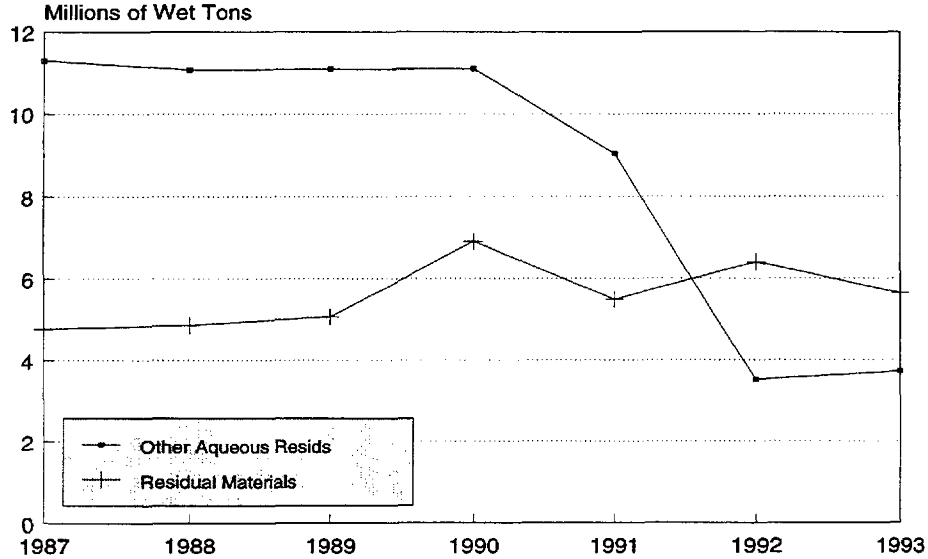



## DISCUSSION

API's database on refinery residuals now spans seven years. The addition of data from 1992 and 1993 strongly suggest that residual generation patterns and management practices for the 1990's differ significantly from those observed during the late 1980's.

Although fluctuations in residual generation patterns were noted in 1990 and 1991, it was the graphic portrayal of the seven years of data that illustrated the differences between decades. As presented earlier in this report (as Figure F) and shown again below, the generation of Residual Materials and Other Aqueous Residuals was relatively static between 1987 and 1989. Since that time, generation of Residual Materials has fluctuated, while Other Aqueous Residuals has decreased, achieving an ultimate cumulative reduction of approximately 10 million tons or 69 percent.

**Figure J**
**Generation of Residual Materials and Other Aqueous Residuals in the Petroleum Refining Industry: 1987 - 1993**

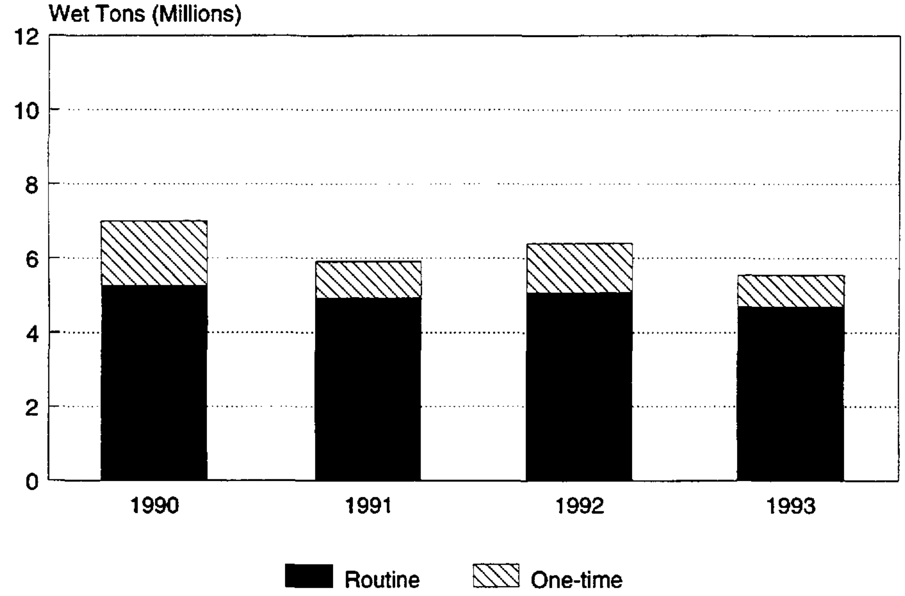



To a large extent, the changes noted in the 1990's--both decreases and increases--reflect the influence of regulatory events. The decrease in Other Aqueous Residuals that began in 1991 coincides with the RCRA land disposal restrictions on refinery K-wastes. These restrictions also curtailed deep well injection of liquid hazardous wastes, unless the refinery had been granted a "no-migration" variance by EPA.

If land disposal restrictions resulted in a reduction in the generation of Other Aqueous Residuals, the logical follow-up question is, why doesn't the graph show a decrease in the generation of other refinery residuals?

Figure K helps to answer this question by contrasting the quantities of residuals generated on a routine basis and those quantities that result from unusual or "one-time" events. As illustrated, routine generation of residuals has dropped 11 percent over the four years, from 5.3 million wet tons in 1990 to 4.7 million wet tons in 1993. Moreover, the amount routinely generated is comparable to the quantity of Residual Materials estimated for 1987 to 1989, shown in Figure J above. Thus, it appears that the fluctuations in the generation rates noted for the last four survey cycles can be attributed to the one-time generation events.

**Figure K**
**Generation of Routine and One-time Residuals: 1990 - 1993**

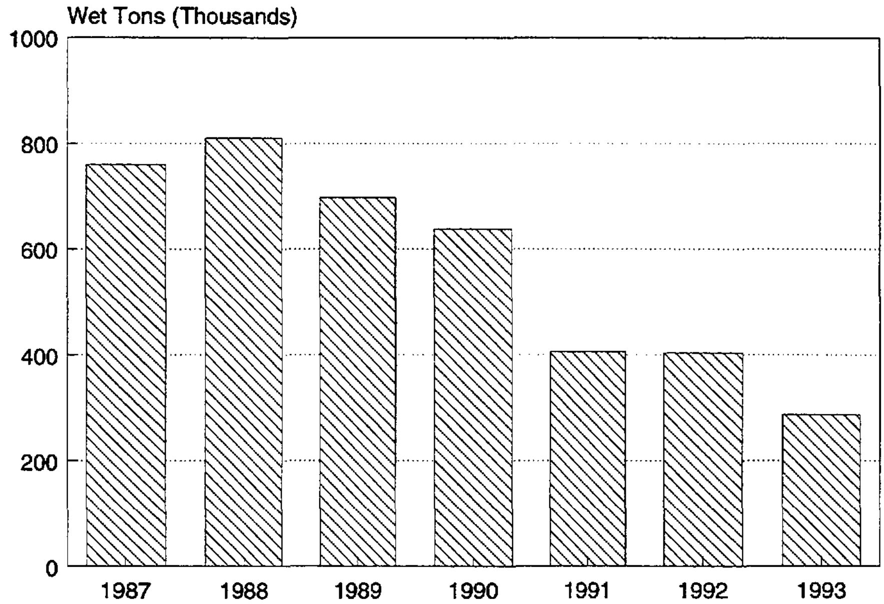



This one-time category has been used to report several residual streams: **Contaminated Soils and Solids, Pond Sediments, Other Oily Sludges and Solids**, and in 1992 and 1993, **Primary Sludge** (F037). From the narrative comments that are provided when refiners designate residuals as being generated on an abnormal basis, it is known that these residuals often result from site remediation activities and changes undertaken in anticipation of new regulations, including construction of new refinery process and/or wastewater treatment units. For example, surface impoundments have been taken out of service to reduce the amount of oily sludges generated and potentially subject to the Primary sludge rulemaking. In addition, new tanks have been installed to handle TC wastewaters, and construction has begun to upgrade sewer systems. Thus it appears that refiners' activities to comply with regulatory initiatives can result in temporary increases in the overall amount of residuals generated, which obscure the trends in routinely generated residuals, specifically the significant reductions achieved in the generation of K-wastes.

How were these reductions achieved? Pollution prevention activities provide the best explanation. By comparing the responses with the pollution prevention question used since 1991 with the source reduction information collected in previous survey cycles, some general observations can be made. Two trends are apparent. First, refiners have prioritized their pollution prevention efforts by initially focusing on selected streams (such as API Separator Sludge) or on groups of streams of similar composition (such as oily sludges and residuals), rather than simultaneously tackling all refinery residuals. Second, this prioritization has resulted in each facility being at variable stages along the pollution prevention continuum, depending on the particular stream of focus.

For example, data indicate that refiners initially concentrated efforts on reducing the generation of K-waste containing residual streams.[6] Figure L illustrates how the generation quantities have declined 62 percent since 1987.

**Figure L**
**Generation of RCRA K-Residuals: 1987 - 1993 (Dewatered Quantities)**




Data from the 1990 and 1991 cycles of the survey indicate that substantial quantities of K-waste residual streams were prevented through the use of good housekeeping procedures that minimized the entry of solids into the wastewater treatment system (e.g., dust control programs that included paving, planting, sweeping and basically, keeping dirt out of the sewer systems), equipment and procedure modifications that enhanced oil recovery (or segregated hazardous residuals from non-hazardous ones, and by the substitution of materials (phase-down of chromium-containing materials and replacement with less toxic phosphate-based compounds). These pollution prevention accomplishments have been considered the "low hanging fruit" of pollution prevention programs--simple, common sense changes that quickly achieve significant reductions without large developmental costs.

Subsequently, the reports of such source reduction activities performed on K-waste residual streams have been replaced by increased reporting of recycling activities, specifically

[6] This includes materials that are hazardous wastes when disposed, as well as materials that are beneficially reused, including ongoing in-process recycling.

increased levels of in-process recycling to crude units and to cokers, as well as the off-site reuse as kiln feed.[7]

Within the last three years (1991-1993), refiners have reported shifts in both the types of streams undergoing pollution prevention reductions, and the types of pollution prevention procedures employed to reduce those streams. For example, the 1992 and 1993 data suggest that refiners have now directed their efforts toward additional streams: **Primary sludges** and large volume non-hazardous materials such as **Contaminated soils, Other inorganic residuals** and **Other residuals NOS**.

In addition, refiners are employing a variety of pollution prevention activities to these streams that appear to be more procedural changes than simply good-housekeeping practices. For example, in 1991 the amount of sand blast grit requiring disposal was reduced by using a recyclable steel grit with a containment procedure. In 1992 and 1993, to reduce generation of **Other Inorganic Residuals**, the addition of lime feed was modified to an as-needed basis, dependent on the monitoring of boiler feed and water softening test results. Other procedural changes reported included improved tank cleaning techniques to enhance oil recovery, reduced flow of water (1 percent per day) to minimize generation of **High pH/low pH waters,** and reduced use of caustics. In addition, there was a general expansion in the efforts to recover, reuse and recycle residuals: **Spent caustics** and chemicals were reused on-site or off-site at other refineries; external markets were identified for other residuals: cement kilns, fertilizer manufacturers, brick, cement, asphalt formulation, fuel use, and paper manufacture.

These types of pollution prevention activities are more information-dependent than the common sense strategies implemented previously. While they tend to rely on existing technologies, they take longer to implement and the changes are incremental. It is likely that some of these improvements can be attributed to the education programs reported by refiners that help employees to re-examine standard operating procedures and look for changes that optimize current practices.

Overall, the information refiners are providing on their pollution prevention progress is consistent with the conceptual stages of pollution prevention described in the Pollution Prevention Continuum, developed by Joel Hirschhorn, formerly of the Office of Technology

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[7] API's data do not suggest that refiners achieved the reductions in K-waste generation by reclassifying these streams. Because of acknowledged ambiguities in the determination of some process units targeted in the original K-waste listing, EPA promulgated the Primary Sludge rule to clarify the regulatory status of some residuals that had previously been reported as K-waste (e.g., residuals from Induced Air Flotation units or from corrugated plate separators). As a result of these clarifications, refiners are required to report these materials as Primary Sludge. Review of the reporting patterns by individual refineries indicate that this happened infrequently, and does not account for the drop in generation of K-wastes. The fact that the number of refineries reporting the K-wastes has remained constant (proportional to the overall response rate), as displayed in Table 3, provides further support. Also, as mentioned previously, the increase in F-wastes reported for 1992 and 1993 have been attributed to one-time events (clean-outs of tanks and impoundments); the remaining amounts of routinely generated material cannot account for the K-waste reductions.

Assessment of the U.S. Congress. The continuum divides pollution prevention into four stages and outlines the technology needs, response time, changes required, knowledge needs, and the return on the investment that occur at each stage. As presented in Figure M, there are four distinct stages of pollution prevention: those driven by common sense, information-dependent, analysis driven, and resulting from research and development activities.

**Figure M**
**Pollution Prevention Continuum**

| | STAGES | | | |
|---|---|---|---|---|
| | COMMON SENSE | INFORMATION DEPENDENT | ANALYSIS DRIVEN | R&D DRIVEN |
| TECHNOLOGY NEEDS | COMMON SENSE | EXISTING TECHNOLOGY | FORMAL ANALYSIS NEW TECHNOLOGY | R&D NEW PRODUCTS NEW PROCESSES |
| RESPONSE TIME | FAST RESULTS | MONTHS | MONTHS YEARS | YEARS |
| CHANGES | PROCEDURAL | MODIFICATION PROCESS | MAJOR CAPITAL | MAJOR CAPITAL |
| KNOWLEDGE NEEDS | AWARENESS | EDUCATION | OVERCOME MIND SET OF ALREADY OPTIMIZED | DESIGN & MARKET NEW PRODUCTS |
| RETURN ON INVESTMENT | HIGH | MEDIUM/LOW | UNCERTAIN | UNCERTAIN |

Based on Hirschhorn, J. *Cutting Production of Hazardous Waste,* in Technology Review, April, 1988.

The message of the continuum is simple: when pollution prevention is first implemented, as long as awareness is high, there will be fast results for a minimal price. As more of the "low hanging fruit" is "picked," one must look elsewhere for additional opportunities. While still using existing technology, processes can be modified. More education on the consequences of modifications and results will take longer.

In the final two stages of the pollution prevention continuum, analyses of new technologies and the development of those technologies are required for additional progress. These stages can take months or years to implement and major capital is required, often with less certain return on the investment.

Where is the industry on this continuum? As noted previously, individual facilities can be at different stages of progress, depending on the particular residual stream. For K-wastes, many refineries have progressed through the common sense stage and are at least in the information dependent stage. For other streams, concurrent activities might place the same facility at two different stages of the continuum. For example, with catalysts, procedural modifications to extend the lifetime of the catalyst can be accomplished at the same time R&D effort is focused on identifying new types of catalysts.

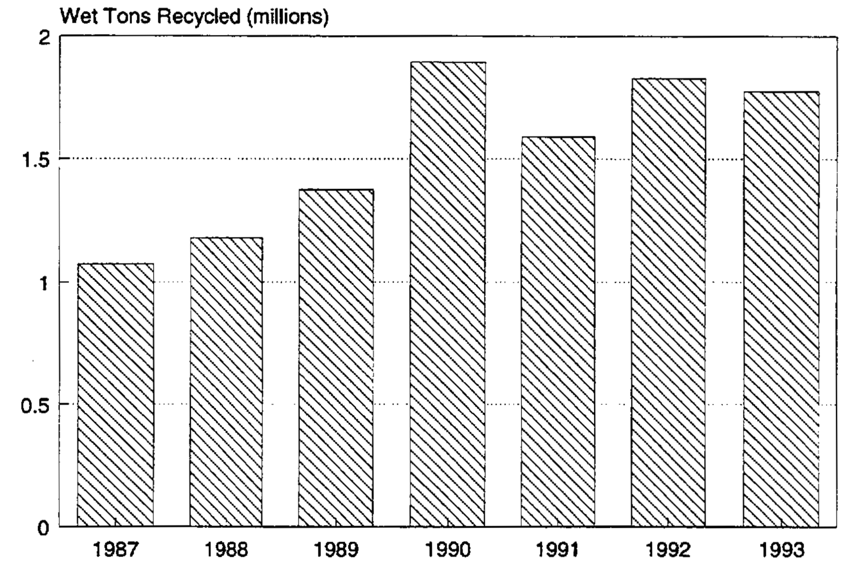
As the continuum suggests, pollution prevention progress can also be measured on the product side of an industry. Over the last 20 years the petroleum industry has implemented successive information and analysis-driven improvements to its fuels: almost all of the lead has been taken out of gasoline; 85 percent of the sulfur has been removed from diesel fuel; gasoline's tendency to evaporate has been reduced and consequently so has its contribution to smog; and oxygen has been added to gasoline to reduce carbon monoxide in many areas. Now, reformulated gasolines and other clean burning fuels exemplify an R&D driven pollution prevention innovation. The industry estimates that refiners will invest $14 billion in the 1990's to equip their plants to produce these new fuels.

Perhaps the more important question is what does all of this mean with regard to evaluating the pollution prevention progress made by the industry, both now and in the future? First, it is important to recognize the achievements already made by the industry. Second, because industry resources are limited, pollution prevention efforts must be prioritized. Third, observers of the industry should realize that future pollution prevention achievements are likely to be less dramatic than the early successes and will require more resources to implement. Fourth, measures to promote technology transfer must be continued. Refiners must have access to information on the types of pollution prevention activities and technologies that are successful to ensure additional progress. Fifth, pollution prevention progress can be accompanied by temporary increases in residual generation. For example, construction of some of the new process units to produce reformulated gasolines are the exact activities that have resulted in increased amounts contaminated soils observed in this survey. Finally, recycling activities--both in-process and out-of-process--as recognized in API's pollution prevention policy, are vital components of pollution prevention. Recycling minimizes waste and disposal needs, and can sustain progress as pollution prevention efforts move beyond the early common sense strategies.

In viewing recycling within the conceptual framework of pollution prevention, its critical role as a component of the industry's strategy to *manage* residual materials should not be overlooked. As broadly recognized, recycling is the preferential manner of eliminating residual materials after source reduction. It is also the approach the petroleum industry has relied on to minimize its need for disposal capacity.

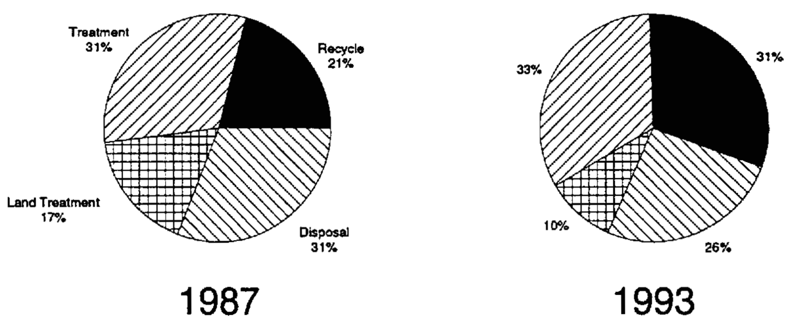
Since the first survey in 1987, the quantity of residuals recycled has increased from 1.073 to 1.774 million wet tons in 1993--a 40 percent increase. As shown in Figure N, the amount recycled showed systematic step-wise increases in the late 1980's when the total residual generation quantities remained constant. Residuals recycled during the 1990's appear to be influenced by the fluctuations in the generation of residuals noted earlier (see Figure J above). When recycling is looked at within this context of the total quantity of residual managed, there has been a 10 percent increase in the use of recycling since 1987.

**Figure N**
**Recycling of Residual Materials: 1987 - 1993**




In addition to illustrating this increase in recycling activity, Figure O shows the changes in the other management practices since 1987.

**Figure O**
**Comparison of Management Practices: 1987 and 1993**




Treatment accounted for management of 31 percent of the residuals in 1987 and 33 percent in 1993, while land treatment and disposal each dropped at least five percent since 1987.

The 26 percent disposed in 1993 was the smallest proportion of residuals disposed in any survey cycle, while the 1993 land treatment proportion was similar to that reported in 1990, and slightly larger than reported in 1991.

These data on residual management suggest that industry practices have evolved over time: recycling has increased; land treatment and disposal have decreased; and treatment continues to account for close to a third of the residuals managed.

It should be noted, however, that this information on management practices includes both those quantities that are routinely generated and those that result from the abnormal one-time events. It should also be pointed out that the data collection forms are not structured to distinguish between the management of routinely generated material and that which results from unusual events. Consequently, these profiles of management practices are influenced by the large quantities of one-time residuals. Recall that over 50 percent of **Pond Sediments** were land treated in 1992 and 1993. For **Contaminated Soils**, over 20 percent was land treated and over 60 percent was disposed in each cycle. **Primary Sludges**, another stream with abnormal quantities, received treatment, as well as having large quantities disposed in 1992 and land treated in 1993. Thus, it is not unreasonable to postulate that the industry's reliance on land treatment and disposal for management of its routinely generated residuals is even lower than the 10 and 26 percent rates illustrated above.

Each new year of data added to API's database has provided more insights into the generation patterns of residual materials by the refining industry and how these materials are managed. While the 1992 and 1993 data have helped to more clearly trace the evolution of change across time, the data have also underscored how difficult it is to assess progress given the ever changing nature of the economic and regulatory milieu in which refineries exist.

It is clear that the generation of residuals has decreased. Reliance on land treatment and disposal technologies has diminished, due to pollution prevention achievements and assiduous efforts to recover and recycle oily materials and to develop new procedures and markets for other residuals.

This survey activity has also resulted in the creation of a valuable database that has been used by the industry, independent researchers, and Federal regulatory agencies. The quality of the database deserves mention. Consistency in the forms used, the edits performed and the analytic procedures employed vouch for the comparability of the estimates across the survey cycles.

Another indication of the quality of the data was achieved this year when API compared its survey responses with the data collected by EPA in its RCRA biennial survey. In its published report of 1991 data, EPA provided a listing, by facility, of the quantities reported by the largest generators. As would be expected, a number of refineries were included in this listing. API compared the values reported to EPA by the group of refineries that had also responded to API's survey (n=14). The differences between the two data sets were remarkably small. The total quantity of residuals managed at each refinery was added to the quantity of TC wastewater it reported. This was compared to the quantities published by EPA. The amount of material reported to API compared well to that reported to EPA (i.e., 90.771 and 95.101 million wet tons, respectively). The difference was only 4.5 percent.

API's database has also helped the industry put EPA's biennial report numbers within a meaningful context. EPA's values are dominated by TC wastewater. Much of this is managed in tanks (42 percent in 1991) and the trend is towards additional tankage (65 percent managed in tanks in 1993), This should temper any initial reaction to the magnitude of the numbers reported. API's ability to track these refineries' generation quantities since 1991 is also useful. As previously observed for all survey respondents, the volumes of TC wastewaters reported by these 14 refineries drop systematically over time, from 79.3 million wet tons in 1991, to 64.0 million in 1992 to 46.4 million for 1993. This 41 percent reduction strongly suggests that the 1991 quantities represent a peak, not dissimilar to other unusual generation events noted in this report that tend to accompany regulatory initiatives.

These benefits of API's survey have not been achieved, however, without significant investments by the industry. The survey has been conducted very efficiently; API's direct expenditures for all seven annual cycles are less than one million dollars. The time and effort refiners devote to completing the forms, as well as that of API staff and member company representatives to direct the survey, are additional, significant, but less easily quantified, costs. Consequently, the industry is exploring ways to streamline future cycles of the survey, minimizing the respondent burden, while maintaining the quality of the data and maximizing its utility to the industry.

# APPENDIX A
# Questionnaire

API ID ______
Leave Blank

1) What was the approximate year this facility began operations? Check the appropriate box.

- ☐ Before 1925
- ☐ 1925 - 1940
- ☐ 1941 - 1950
- ☐ 1951 - 1960
- ☐ 1961 - 1970
- ☐ 1971 - 1980
- ☐ After 1980

2) Which of the following USEPA National Pollutant Discharge Elimination System (NPDES) - Permit Fact Sheet Classifications best describes this refinery?

Check the appropriate box

- ☐ **Topping** - Refinery uses topping and catalytic reforming, but **not** thermal processes or cracking.
- ☐ **Cracking** - Refinery uses topping and cracking, but none of the operations designated in the categories below.
- ☐ **Petrochemical** - Refinery uses topping and cracking, and 1) **at least 15%** of refinery production is first-generation petrochemicals and isomerization products (e.g., BTX, olefins), or 2) the refinery produces second-generation petrochemicals (e.g., alcohols, cumene), and 3) there is **no** lube oil manufacturing.
- ☐ **Lube** - Refinery uses topping, cracking, and lube oil manufacturing processes, but **not** petrochemical operations.
- ☐ **Integrated** - Refinery uses topping, cracking, lube oil, and petrochemical manufacturing processes.

**(NOTE: If your facility does NOT fit one of these categories, please call Wendall Clark at (914) 227-6304 to clarify the types of operations performed at your facility.)**

3) What type of sewer system does this facility have? Check the appropriate box.

- ☐ Non-segregated between process water & storm water
- ☐ Partially segregated between process water & storm water
- ☐ Totally segregated between process water & storm water

API ID ______
Leave Blank

4) Indicate your facility's RCRA permitting status and the regulatory authority for the permit. Check the **ONE** category that best describes this facility.

- ☐ Generator only; no RCRA permit required. (Hazardous waste is NOT treated, stored or disposed of on-site.)
- ☐ Part A filed (interim status).
- ☐ RCRA permit issued.

5) What was this facility's operable crude oil capacity in BARRELS PER STREAM DAY as reported in the Oil & Gas Journal?

For 1992, ________ Barrels per Stream Day

For 1993, ________ Barrels per Stream Day

6) What was the **TOTAL AMOUNT** of crude processed (throughput)?

For 1992, ________ Million Barrels

For 1993, ________ Million Barrels

7) On how many days was crude charged?

For 1992, ________ Days

For 1993, ________ Days

8) Use spaces below to report the amount of **WASTEWATER** (in WET TONS) that failed the **Toxicity Characterstitc (TC)** and that was:

| | | For 1992 | For 1993 |
|---|---|---|---|
| TC Hazardous Wastewater | Managed SOLELY in tanks exempt from RCRA permitting to discharge (TC Wastewater reported here should NOT be reported in any of the following categories) | ______ | ______ |
| | Treated as TC hazardous waste in RCRA permitted surface impoundment prior to discharge | ______ | ______ |
| | Deep well injected | ______ | ______ |
| | Other | ______ | ______ |

**ALL RESPONSES TO QUESTION 8 SHOULD BE MUTUALLY EXCLUSIVE**
(See Page 3 of the Instructions for directions on how to complete these questions.)

## WORKSHEET & CODES FOR FACING DATA SHEET

### INPUTS

**GENERATION**

**ROUTINE** - residuals generated periodically, but according to some schedule (e.g., weekly; semi/ bi-annually; every five years)

**ABNORMAL**- aperiodic or unusual residual generation, such as when a unit is built or closed, or when general remediation or a spill occurs.

**** A comment describing what happened must be provided when a quantity is designated as abnormal.***

### OUTPUTS

**RECYCLE/REUSE CODES**

| R - | Onsite (Captive) | Offsite (Commercial) |
|---|---|---|
| **In-Process Recycle** | | |
| Coker | 200 | 201 |
| Crude Unit | 210 | 211 |
| Cat Cracker | 230 | 231 |
| Other | 960 | 961 |
| **Out-of-Process Recycle/ Non-fuel Reuse** | | |
| Reclamation | 250 | 251 |
| Regeneration | 260 | 261 |
| Cement Kiln Feed | 270 | 271 |
| Other | 970 | 971 |
| **Out-of-Process Recycle/ Industrial Fuel Reuse** | | |
| Cement Kiln | 280 | 281 |
| Other(blast furnace) | 980 | 981 |
| Other | 920 | 921 |

**TREATMENT CODES**

| T - | Onsite (Captive) | Offsite (Commercial) |
|---|---|---|
| Weathering | 310 | 311 |
| Chemical | 330 | 331 |
| Heat | 340 | 341 |
| Impoundment | 370 | 371 |
| Physical | 380 | 381 |
| Wastewater Treatment | 390 | 391 |
| Incineration | 400 | 401 |
| Land Treatment | 410 | 411 |
| Stabilization | 420 | NA |
| Other | 940 | 941 |

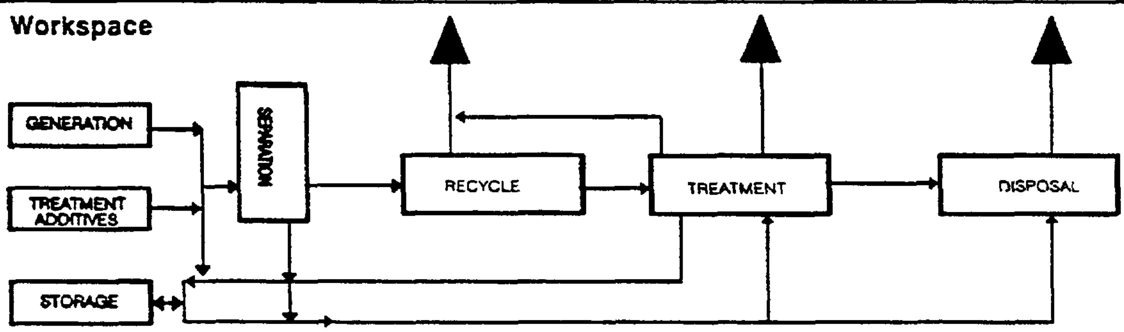
Use "Heat" codes for Thermal Treatment (T340 & 341).

**DISPOSAL CODES**

| D - | Onsite (Captive) | Offsite (Commercial) |
|---|---|---|
| Impoundment | 500 | 501 |
| Landfill | 510 | 511 |
| Landspread | 520 | 521 |
| Injection | 530 | 531 |
| Other | 950 | 951 |

RCRA land disposal restrictions are in effect.

**Workspace**




**POLLUTION PREVENTION** is a multimedia concept that reduces or eliminates pollutant discharges to air, water or land and includes the development of more environmentally acceptable products, changes in processes and practices, source reduction, beneficial use and environmentally sound recycling. Categorize the type of pollution prevention activity performed according to the codes listed below. (The responses to this question will be treated independently from those reported above; it is likely that you will be reporting most, if not all of the same activities under the Recycle sections above.)

1 - **Equipment or technology modifications**
2 - **Procedure modifications**
3 - **Reformulation or redesign of products**
4 - **Substitution of raw materials** (includes captive reuse of catalysts)
5 - **Improved housekeeping; training of personnel or inventory control procedures**

In-process RECYCLE

6 - **In refining process units** (e.g., crude unit; coker; desalter etc)
7 - **Recovering oil (& dewatering) by filter pressing/centrifugation**
8 - **Other recycle**

Out-of-process RECYCLE

9 - **Reuse/reclamation** (e.g., cement kiln feed; catalyst regen; miscellaneous resids for landscaping)
10 - **OTHER.** Describe in comment section.

**CALCULATIONS**

1992

DID YOUR FACILITY GENERATE/MANAGE: **CODE 101 API SEPARATOR SLUDGE (K051)** ________ (YES/NO)

RESIDUAL MANAGEMENT

| INPUTS | | OUTPUTS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| GENERATION | WET TONS | SEPARATION TECHNIQUES | ELIMINATED BY RECYCLE | | ELIMINATED BY TREATMENT | | DISPOSAL | |
| | | Check any performed | WET TONS | CODE | WET TONS | CODE | WET TONS | CODE |
| ROUTINE | ____ | | | | | | | |
| ABNORMAL * | ____ | Decanting ___ | ____ | R ____ | ____ | T ____ | ____ | D ____ |
| HAVE THESE GENERATION QUANTITIES HAD PRIOR DEWATERING? ☐ YES ☐ NO | | Thickening ___ | ____ | R ____ | ____ | T ____ | ____ | D ____ |
| | | Centrifuging ___ | | | | | | |
| TREATMENT ADDITIVES | ____ | Filtering ___ | ____ | R ____ | ____ | T ____ | ____ | D ____ |
| | | | ____ | R ____ | ____ | T ____ | ____ | D ____ |
| STORAGE REMOVED FROM | ____ | | ____ | R ____ | ____ | T ____ | ____ | D ____ |
| PLACED INTO — ( ____ ) | | | | | | | | |
| TOTALS | ☐ | = | ☐ | + | ☐ | + | ☐ | |

**PLEASE CHECK TO MAKE SURE EQUATION BALANCES.**

**POLLUTION PREVENTION**

Did your refinery conduct any activities, change any practices or modify any equipment that **DECREASED** the amount of this residual stream generated or requiring disposal this year?

___ No ___ Yes - Enter amount reduced, ________ wet tons.

Use the listing of codes on the facing page to identify the ONE pollution prevention category that corresponds to the activity your refinery conducted this year. Circle only ONE code number per activity; choose the ONE code that best represents what you did. Use the space for Activity 2 only if you conducted another unique activity (e.g., recycled oily material to the coker and initiated inventory controls).

| Code | Description: |
|---|---|
| 1 2 3 4 5<br>6 7 8 9 10 | Activity 1. Year 19__ ________________ |
| 1 2 3 4 5<br>6 7 8 9 10 | Activity 2. Year 19__ ________________ |

*** Description of ABNORMAL Generation event, and/or codes categorized as "Other".**

A comment must be provided if you indicated ABNORMAL GENERATION above.

**Comments/Calculations:**

API ID# ____________ (LEAVE BLANK)

# APPENDIX B
# SAS Data Tables

API SOLID WASTE SURVEY
1992

Estimated U.S. Total Waste Quantities

| STREAM | Waste Stream | Total Estimated Generation | Total Estimated Net Storage | Total Estimated Treatment Additives | Total Estimated Waste Input |
|---|---|---|---|---|---|
| 101 | API Separator Sludge (K051) | 178,453 | -7,539 | 3,236 | 174,150 |
| 102 | Dissolved Air Flotation Float (K048) | 543,857 | -2,289 | 4,567 | 546,135 |
| 103 | Slop Oil Emulsion Solids (K049) | 76,843 | -3,915 | 925 | 73,854 |
| 104 | Leaded Tank Bottoms (K052) | 628 | 0 | 2 | 629 |
| 106 | Pond Sediments | 387,923 | 0 | 3,171 | 391,095 |
| 107 | Nonleaded Tank Bottoms | 128,197 | 306 | 1,702 | 130,205 |
| 108 | Residual Oils/Spent Solvents | 32,875 | 0 | 0 | 32,875 |
| 109 | Other Oily Sludges & Organic Wastes | 38,374 | -2 | 8 | 38,380 |
| 110 | Primary Sludge (F037) | 208,787 | 27,560 | 10,188 | 246,535 |
| 111 | Primary Sludge (F038) | 54,052 | 0 | 57 | 54,109 |
| 201 | Heat Exchanger Bundle Cleaning Sludge | 3,330 | 190 | 246 | 3,766 |
| 202 | Contaminated Soils/Solids | 1063278 | -110,101 | 0 | 953,177 |
| 203 | Residual Coke/Carbon/Charcoal | 53,199 | 8 | 0 | 53,207 |
| 204 | Residual Sulfur | 53,322 | -442 | 0 | 52,880 |
| 205 | Other Contaminated Soils NOS | 32,154 | -203 | 249 | 32,200 |
| 301 | Fluid Cracking Catalyst or Equivalent | 202,754 | -6,023 | 0 | 196,731 |
| 302 | Hydroprocessing Catalysts | 55,064 | -3,669 | 0 | 51,395 |
| 303 | Other Spent Catalysts NOS | 26,569 | -135 | 1,206 | 27,640 |
| 401 | Biomass | 716,392 | -79,319 | 3,885 | 640,958 |
| 402 | Oil Contaminated Waters NOT Wastewater | 22,337 | 0 | 0 | 22,337 |
| 403 | High pH/Low pH Waters | 16,231 | 79 | 0 | 16,310 |
| 404 | Spent Sulfite Solution | 33,152 | . | . | 33,152 |
| 405 | Spent Stretford Solution | 31,131 | -436 | 0 | 30,695 |
| 407 | TSD Leachate (F039) | 12,500 | 0 | 0 | 12,500 |
| 501 | Spent Caustics | 1427544 | -2,468 | 0 | 1425076 |
| 502 | Spent Acids | 7,407 | 0 | 380 | 7,788 |
| 503 | Residual Amines | 142,410 | 0 | 0 | 142,410 |
| 504 | Other Inorganic Residuals NOS | 363,585 | -4,791 | 537 | 359,331 |
| 601 | Other Residuals NOS | 487,944 | -107,174 | 0 | 380,770 |

## API REFINERY RESIDUALS SURVEY
## 1992

### Estimated Residual Quantities By Management Techniques
(wet tons)

| Residual Stream | Total Managed | Recycled | Treated | Land Treated | Disposed |
|---|---|---|---|---|---|
| API Separator Sludge (K051) | 174,147 | 47,501 | 121,513 | 363 | 4,770 |
| Dissolved Air Flotation Float (K048) | 546,136 | 173,113 | 369,051 | 444 | 3,528 |
| Slop Oil Emulsion Solids (K049) | 73,855 | 35,119 | 37,412 | 0 | 1,324 |
| Leaded Tank Bottoms (K052) | 630 | 59 | 531 | 0 | 40 |
| Pond Sediments | 391,095 | 15,487 | 106,708 | 230,187 | 38,713 |
| Nonleaded Tank Bottoms | 130,205 | 22,896 | 25,404 | 11,612 | 70,293 |
| Residual Oils/Spent Solvents | 32,877 | 31,939 | 42 | 103 | 793 |
| Other Oily Sludges & Organic Wastes | 38,382 | 16,011 | 8,010 | 4,098 | 10,263 |
| Primary Sludge (F037) | 246,534 | 7,838 | 40,675 | 57,988 | 140,033 |
| Primary Sludge (F038) | 54,109 | 23,092 | 23,730 | 0 | 7,287 |
| Heat Exchanger Bundle Cleaning Sludge | 3,766 | 644 | 2,051 | 0 | 1,071 |
| Contaminated Soils/Solids | 953,179 | 74,243 | 16,584 | 245,922 | 616,430 |
| Residual Coke/Carbon/Charcoal | 53,208 | 41,152 | 210 | 1,215 | 10,631 |
| Residual Sulfur | 52,880 | 25,874 | 71 | 0 | 26,935 |
| Other Contaminated Soils NOS | 32,201 | 6,924 | 721 | 4,104 | 20,452 |
| Fluid Cracking Catalyst or Equivalent | 196,732 | 85,536 | 26 | 1,647 | 109,523 |
| Hydroprocessing Catalysts | 51,395 | 45,175 | 3 | 0 | 6,217 |
| Other Spent Catalysts NOS | 27,642 | 9,969 | 51 | 430 | 17,192 |
| Biomass | 640,958 | 273,202 | 168,023 | 144,060 | 55,673 |
| Oil Contaminated Waters NOT Wastewater | 22,337 | 1,370 | 20,967 | 0 | 0 |
| High pH/Low pH Waters | 16,310 | 315 | 13,565 | 38 | 2,392 |
| Spent Sulfite Solution | 33,152 | 33,152 | 0 | 0 | 0 |
| Spent Stretford Solution | 30,695 | 5,262 | 23,268 | 0 | 2,165 |
| TSD Leachate (F039) | 12,500 | 0 | 1,103 | 0 | 11,397 |
| Spent Caustics | 1,425,076 | 763,740 | 631,755 | 0 | 29,581 |
| Spent Acids | 7,787 | 95 | 4,530 | 0 | 3,162 |
| Residual Amines | 142,408 | 648 | 139,874 | 0 | 1,886 |
| Other Inorganic Residuals NOS | 359,331 | 64,924 | 48,276 | 8,100 | 238,031 |
| Other Residuals NOS | 380,769 | 21,434 | 1,371 | 21 | 357,943 |
| | ========== | ========== | ========== | ========== | ========== |
| | 6,130,296 | 1,826,714 | 1,805,525 | 710,332 | 1,787,725 |

API REFINERY RESIDUALS SURVEY
1992

Percentages of Residual Quantities Recycled, Treated, Land Treated and Disposed
By Stream

| Residual Stream | Percent Recycled | Percent Treated | Percent Land Treated | Percent Disposed |
|---|---|---|---|---|
| API Separator Sludge (K051) | 27 | 70 | 0 | 3 |
| Dissolved Air Flotation Float (K048) | 32 | 68 | 0 | 1 |
| Slop Oil Emulsion Solids (K049) | 48 | 51 | 0 | 2 |
| Leaded Tank Bottoms (K052) | 9 | 84 | 0 | 6 |
| Pond Sediments | 4 | 27 | 59 | 10 |
| Nonleaded Tank Bottoms | 18 | 20 | 9 | 54 |
| Residual Oils/Spent Solvents | 97 | 0 | 0 | 2 |
| Other Oily Sludges & Organic Wastes | 42 | 21 | 11 | 27 |
| Primary Sludge (F037) | 3 | 17 | 24 | 57 |
| Primary Sludge (F038) | 43 | 44 | 0 | 13 |
| Heat Exchanger Bundle Cleaning Sludge | 17 | 54 | 0 | 28 |
| Contaminated Soils/Solids | 8 | 2 | 26 | 65 |
| Residual Coke/Carbon/Charcoal | 77 | 0 | 2 | 20 |
| Residual Sulfur | 49 | 0 | 0 | 51 |
| Other Contaminated Soils NOS | 22 | 2 | 13 | 64 |
| Fluid Cracking Catalyst or Equivalent | 43 | 0 | 1 | 56 |
| Hydroprocessing Catalysts | 88 | 0 | 0 | 12 |
| Other Spent Catalysts NOS | 36 | 0 | 2 | 62 |
| Biomass | 43 | 26 | 22 | 9 |
| Oil Contaminated Waters NOT Wastewater | 6 | 94 | 0 | 0 |
| High pH/Low pH Waters | 2 | 83 | 0 | 15 |
| Spent Sulfite Solution | 100 | 0 | 0 | 0 |
| Spent Stretford Solution | 17 | 76 | 0 | 7 |
| TSD Leachate (F039) | 0 | 9 | 0 | 91 |
| Spent Caustics | 54 | 44 | 0 | 2 |
| Spent Acids | 1 | 58 | 0 | 41 |
| Residual Amines | 0 | 98 | 0 | 1 |
| Other Inorganic Residuals NOS | 18 | 13 | 2 | 66 |
| Other Residuals NOS | 6 | 0 | 0 | 94 |

## API REFINERY RESIDUALS SURVEY
1992

### Estimated Residual Quantities Recycled and Percent Of Total Amount Managed By Stream

| Residual Stream | Quantity Recycled (Tons) | Percent Recycled |
|---|---|---|
| API Separator Sludge (K051) | 47,501 | 27.28 |
| Dissolved Air Flotation Float (K048) | 173,113 | 31.70 |
| Slop Oil Emulsion Solids (K049) | 35,119 | 47.55 |
| Leaded Tank Bottoms (K052) | 59 | 9.37 |
| Pond Sediments | 15,487 | 3.96 |
| Nonleaded Tank Bottoms | 22,896 | 17.58 |
| Residual Oils/Spent Solvents | 31,939 | 97.15 |
| Other Oily Sludges & Organic Wastes | 16,011 | 41.71 |
| Primary Sludge (F037) | 7,838 | 3.18 |
| Primary Sludge (F038) | 23,092 | 42.68 |
| Heat Exchanger Bundle Cleaning Sludge | 644 | 17.10 |
| Contaminated Soils/Solids | 74,243 | 7.79 |
| Residual Coke/Carbon/Charcoal | 41,152 | 77.34 |
| Residual Sulfur | 25,874 | 48.93 |
| Other Contaminated Soils NOS | 6,924 | 21.50 |
| Fluid Cracking Catalyst or Equivalent | 85,536 | 43.48 |
| Hydroprocessing Catalysts | 45,175 | 87.90 |
| Other Spent Catalysts NOS | 9,969 | 36.06 |
| Biomass | 273,202 | 42.62 |
| Oil Contaminated Waters NOT Wastewater | 1,370 | 6.13 |
| High pH/Low pH Waters | 315 | 1.93 |
| Spent Sulfite Solution | 33,152 | 100.00 |
| Spent Stretford Solution | 5,262 | 17.14 |
| TSD Leachate (F039) | 0 | 0.00 |
| Spent Caustics | 763,740 | 53.59 |
| Spent Acids | 95 | 1.22 |
| Residual Amines | 648 | 0.46 |
| Other Inorganic Residuals NOS | 64,924 | 18.07 |
| Other Residuals NOS | 21,434 | 5.63 |
| | ========== | |
| | 1,826,714 | |

API REFINERY RESIDUALS SURVEY
1992

Estimated Residual Quantity Handled by Recycle Techniques for Each Residual Stream
(wet tons)

| Residual Stream | Coker | Crude Unit | Desalter | Catalytic Cracker | Other In-Process Recycle | Cement Kiln-Out of Process |
|---|---|---|---|---|---|---|
| API Separator Sludge (K051) | 23,905 | 10,542 | 0 | 1,790 | 796 | 79 |
| Dissolved Air Flotation Float (K048) | 48,664 | 74,967 | 0 | 1,339 | 27,641 | 1,191 |
| Slop Oil Emulsion Solids (K049) | 13,290 | 6,600 | 0 | 1,378 | 0 | 2,238 |
| Leaded Tank Bottoms (K052) | 0 | 0 | 0 | 0 | 19 | 0 |
| Pond Sediments | 1,662 | 13,825 | 0 | 0 | 0 | 0 |
| Nonleaded Tank Bottoms | 3,049 | 14,159 | 0 | 0 | 1,345 | 0 |
| Residual Oils/Spent Solvents | 1,493 | 362 | 0 | 0 | 14 | 127 |
| Other Oily Sludges & Organic Wastes | 349 | 1,335 | 0 | 1,315 | 3,435 | 0 |
| Primary Sludge (F037) | 5,130 | 1,983 | 0 | 0 | 298 | 0 |
| Primary Sludge (F038) | 15,354 | 7,333 | 0 | 0 | 0 | 0 |
| Heat Exchanger Bundle Cleaning Sludge | 520 | 13 | 0 | 0 | 36 | 23 |
| Contaminated Soils/Solids | 22 | 0 | 0 | 0 | 0 | 433 |
| Residual Coke/Carbon/Charcoal | 38 | 0 | 0 | 0 | 0 | 0 |
| Residual Sulfur | 0 | 0 | 0 | 0 | 16 | 0 |
| Other Contaminated Soils NOS | 860 | 466 | 0 | 0 | 0 | 0 |
| Fluid Cracking Catalyst or Equivalent | 0 | 0 | 0 | 6,360 | 8,590 | 24,986 |
| Hydroprocessing Catalysts | 0 | 0 | 0 | 0 | 0 | 0 |
| Other Spent Catalysts NOS | 0 | 0 | 0 | 0 | 0 | 144 |
| Biomass | 177,394 | 1,035 | 0 | 0 | 35,621 | 0 |
| Oil Contaminated Waters NOT Wastewater | 0 | 587 | 0 | 0 | 761 | 0 |
| High pH/Low pH Waters | 0 | 0 | 0 | 0 | 315 | 0 |
| Spent Sulfite Solution | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Stretford Solution | 856 | 0 | 0 | 0 | 0 | 0 |
| TSD Leachate (F039) | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Caustics | 0 | 1,199 | 0 | 1,429 | 2,808 | 0 |
| Spent Acids | 0 | 16 | 0 | 0 | 79 | 0 |
| Residual Amines | 9 | 9 | 0 | 0 | 0 | 0 |
| Other Inorganic Residuals NOS | 820 | 3 | 0 | 0 | 335 | 13,401 |
| Other Residuals NOS | 0 | 650 | 0 | 0 | 0 | 648 |
| | ======== | ======== | ======== | ========= | ========== | ========== |
| | 293,415 | 135,084 | 0 | 13,611 | 82,109 | 43,270 |

Continued on Next Page

API REFINERY RESIDUALS SURVEY
1992

Estimated Residual Quantity Handled by Recycle Techniques for Each Residual Stream (Continued)
(wet tons)

| Residual Stream | Other Out-of-Process | Cement Kiln-Industrial Fuel | Other Industrial Fuel | Reclamation | Regeneration | Other |
|---|---|---|---|---|---|---|
| API Separator Sludge (K051) | 159 | 8,208 | 127 | 1,894 | 0 | 1 |
| Dissolved Air Flotation Float (K048) | 412 | 18,884 | 0 | 11 | 3 | 1 |
| Slop Oil Emulsion Solids (K049) | 0 | 9,802 | 1,470 | 341 | 0 | 0 |
| Leaded Tank Bottoms (K052) | 0 | 40 | 0 | 0 | 0 | 0 |
| Pond Sediments | 0 | 0 | 0 | 0 | 0 | 0 |
| Nonleaded Tank Bottoms | 225 | 591 | 95 | 18 | 0 | 3,414 |
| Residual Oils/Spent Solvents | 14 | 102 | 627 | 29,105 | 81 | 14 |
| Other Oily Sludges & Organic Wastes | 0 | 6,128 | 3,447 | 2 | 0 | 0 |
| Primary Sludge (F037) | 0 | 427 | 0 | 0 | 0 | 0 |
| Primary Sludge (F038) | 0 | 60 | 0 | 345 | 0 | 0 |
| Heat Exchanger Bundle Cleaning Sludge | 0 | 41 | 0 | 11 | 0 | 0 |
| Contaminated Soils/Solids | 73,784 | 2 | 0 | 0 | 0 | 2 |
| Residual Coke/Carbon/Charcoal | 37,246 | 54 | 29 | 0 | 3,400 | 385 |
| Residual Sulfur | 25,845 | 0 | 0 | 2 | 0 | 11 |
| Other Contaminated Soils NOS | 5,467 | 85 | 0 | 46 | 0 | 0 |
| Fluid Cracking Catalyst or Equivalent | 22,186 | 8,901 | 0 | 6,692 | 5,746 | 2,075 |
| Hydroprocessing Catalysts | 0 | 177 | 0 | 43,122 | 1,876 | 0 |
| Other Spent Catalysts NOS | 3,350 | 33 | 0 | 5,885 | 516 | 41 |
| Biomass | 0 | 0 | 0 | 1,312 | 0 | 57,840 |
| Oil Contaminated Waters NOT Wastewater | 0 | 0 | 0 | 22 | 0 | 0 |
| High pH/Low pH Waters | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Sulfite Solution | 33,152 | 0 | 0 | 0 | 0 | 0 |
| Spent Stretford Solution | 0 | 0 | 0 | 4,406 | 0 | 0 |
| TSD Leachate (F039) | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Caustics | 63,121 | 0 | 0 | 484,086 | 189,674 | 21,423 |
| Spent Acids | 0 | 0 | 0 | 0 | 0 | 0 |
| Residual Amines | 3 | 0 | 42 | 430 | 155 | 0 |
| Other Inorganic Residuals NOS | 49,229 | 71 | 0 | 1,065 | 0 | 0 |
| Other Residuals NOS | 10,130 | 1,638 | 96 | 7,208 | 252 | 812 |
| | ============== | ================ | ========== | =========== | ============ | ======== |
| | 324,323 | 55,244 | 5,933 | 586,003 | 201,703 | 86,019 |

# API REFINERY RESIDUALS SURVEY
1992

## Respondent Frequencies For Recycle Techniques For Each Residual Stream

| Residual Stream | Coker | Crude Unit | Desalter | Catalytic Cracker | Other In-Process Recycle | Cement Kiln-Out of Process |
|---|---|---|---|---|---|---|
| API Separator Sludge (K051) | 17 | 24 | 0 | 2 | 3 | 1 |
| Dissolved Air Flotation Float (K048) | 15 | 17 | 0 | 1 | 3 | 3 |
| Slop Oil Emulsion Solids (K049) | 7 | 9 | 0 | 1 | 0 | 1 |
| Leaded Tank Bottoms (K052) | 0 | 0 | 0 | 0 | 1 | 0 |
| Pond Sediments | 1 | 1 | 0 | 0 | 0 | 0 |
| Nonleaded Tank Bottoms | 5 | 12 | 0 | 0 | 2 | 0 |
| Residual Oils/Spent Solvents | 2 | 8 | 0 | 0 | 1 | 1 |
| Other Oily Sludges & Organic Wastes | 2 | 6 | 0 | 1 | 3 | 0 |
| Primary Sludge (F037) | 7 | 12 | 0 | 0 | 1 | 0 |
| Primary Sludge (F038) | 5 | 5 | 0 | 0 | 0 | 0 |
| Heat Exchanger Bundle Cleaning Sludge | 3 | 2 | 0 | 0 | 1 | 3 |
| Contaminated Soils/Solids | 1 | 1 | 0 | 0 | 0 | 1 |
| Residual Coke/Carbon/Charcoal | 2 | 0 | 0 | 0 | 0 | 0 |
| Residual Sulfur | 0 | 0 | 0 | 0 | 1 | 0 |
| Other Contaminated Soils NOS | 1 | 3 | 0 | 0 | 0 | 0 |
| Fluid Cracking Catalyst or Equivalent | 0 | 0 | 0 | 5 | 5 | 15 |
| Hydroprocessing Catalysts | 0 | 0 | 0 | 0 | 0 | 1 |
| Other Spent Catalysts NOS | 0 | 0 | 0 | 0 | 0 | 3 |
| Biomass | 3 | 3 | 0 | 0 | 1 | 0 |
| Oil Contaminated Waters NOT Wastewater | 0 | 2 | 0 | 0 | 1 | 0 |
| High pH/Low pH Waters | 0 | 0 | 0 | 0 | 1 | 0 |
| Spent Sulfite Solution | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Stretford Solution | 1 | 0 | 0 | 0 | 0 | 0 |
| TSD Leachate (F039) | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Caustics | 0 | 2 | 0 | 1 | 3 | 0 |
| Spent Acids | 0 | 1 | 0 | 0 | 1 | 0 |
| Residual Amines | 2 | 1 | 0 | 0 | 0 | 0 |
| Other Inorganic Residuals NOS | 3 | 1 | 0 | 0 | 2 | 1 |
| Other Residuals NOS | 0 | 3 | 0 | 0 | 0 | 3 |
| | ===== | ===== | ======== | ========= | ========== | ========== |
| | 77 | 113 | 0 | 11 | 30 | 33 |

Continued on Next Page

API REFINERY RESIDUALS SURVEY
1992

Respondent Frequencies for Recycle Techniques for Each Residual Stream (Continued)

| Residual Stream | Other Out of Process | Cement Kiln-Industrial Fuel | Other Industrial Fuel | Reclamation | Regeneration | Other |
|---|---|---|---|---|---|---|
| API Separator Sludge (K051) | 1 | 21 | 1 | 2 | 0 | 1 |
| Dissolved Air Flotation Float (K048) | 1 | 12 | 0 | 1 | 1 | 1 |
| Slop Oil Emulsion Solids (K049) | 0 | 14 | 2 | 1 | 0 | 0 |
| Leaded Tank Bottoms (K052) | 0 | 1 | 0 | 0 | 0 | 0 |
| Pond Sediments | 0 | 0 | 0 | 0 | 0 | 0 |
| Nonleaded Tank Bottoms | 1 | 3 | 1 | 2 | 0 | 1 |
| Residual Oils/Spent Solvents | 2 | 3 | 5 | 26 | 7 | 3 |
| Other Oily Sludges & Organic Wastes | 0 | 5 | 4 | 1 | 0 | 0 |
| Primary Sludge (F037) | 0 | 3 | 0 | 0 | 0 | 0 |
| Primary Sludge (F038) | 0 | 2 | 0 | 1 | 0 | 0 |
| Heat Exchanger Bundle Cleaning Sludge | 0 | 3 | 0 | 2 | 0 | 0 |
| Contaminated Soils/Solids | 7 | 1 | 0 | 0 | 0 | 1 |
| Residual Coke/Carbon/Charcoal | 1 | 2 | 1 | 0 | 14 | 2 |
| Residual Sulfur | 3 | 0 | 0 | 1 | 0 | 1 |
| Other Contaminated Soils NOS | 4 | 2 | 0 | 1 | 0 | 0 |
| Fluid Cracking Catalyst or Equivalent | 11 | 4 | 0 | 3 | 4 | 2 |
| Hydroprocessing Catalysts | 0 | 1 | 0 | 43 | 12 | 0 |
| Other Spent Catalysts NOS | 10 | 1 | 0 | 33 | 4 | 1 |
| Biomass | 0 | 0 | 0 | 1 | 0 | 1 |
| Oil Contaminated Waters NOT Wastewater | 0 | 0 | 0 | 1 | 0 | 0 |
| High pH/Low pH Waters | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Sulfite Solution | 1 | 0 | 0 | 0 | 0 | 0 |
| Spent Stretford Solution | 0 | 0 | 0 | 1 | 0 | 0 |
| TSD Leachate (F039) | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Caustics | 24 | 0 | 0 | 21 | 9 | 2 |
| Spent Acids | 0 | 0 | 0 | 0 | 0 | 0 |
| Residual Amines | 1 | 0 | 1 | 3 | 2 | 0 |
| Other Inorganic Residuals NOS | 6 | 1 | 0 | 3 | 0 | 0 |
| Other Residuals NOS | 5 | 7 | 7 | 16 | 2 | 5 |
| | ========== | =============== | ========== | =========== | ============ | ===== |
| | 78 | 86 | 22 | 163 | 55 | 21 |

The SAS System

API ANNUAL REFINING SURVEY
1992

Percent Recycled On-Site and Off-Site

| Waste Stream | Recycled Tons | Percent Recycled On-Site | Percent Recycled Off-Site |
|---|---|---|---|
| API Separator Sludge (K051) | 47,503 | 80 | 20 |
| Dissolved Air Flotation Float (K048) | 173,113 | 72 | 28 |
| Slop Oil Emulsion Solids (K049) | 35,118 | 62 | 38 |
| Leaded Tank Bottoms (K052) | 59 | 0 | 100 |
| Pond Sediments | 15,487 | 100 | 0 |
| Nonleaded Tank Bottoms | 22,895 | 67 | 33 |
| Residual Oils/Spent Solvents | 31,939 | 6 | 94 |
| Other Oily Sludges & Organic Wastes | 16,010 | 19 | 81 |
| Primary Sludge (F037) | 7,838 | 91 | 9 |
| Primary Sludge (F038) | 23,091 | 100 | 0 |
| Heat Exchanger Bundle Cleaning Sludge | 643 | 82 | 18 |
| Contaminated Soils/Solids | 74,242 | 0 | 100 |
| Residual Coke/Carbon/Charcoal | 41,151 | 5 | 95 |
| Residual Sulfur | 25,874 | 0 | 100 |
| Other Contaminated Soils NOS | 6,925 | 19 | 81 |
| Fluid Cracking Catalyst or Equivalent | 85,535 | 0 | 100 |
| Hydroprocessing Catalysts | 45,175 | 1 | 99 |
| Other Spent Catalysts NOS | 9,968 | 0 | 100 |
| Biomass | 273,202 | 66 | 34 |
| Oil Contaminated Waters NOT Wastewater | 1,370 | 43 | 57 |
| High pH/Low pH Waters | 315 | 0 | 100 |
| Spent Sulfite Solution | 33,152 | 0 | 100 |
| Spent Stretford Solution | 5,262 | 16 | 84 |
| TSD Leachate (F039) | 0 | 0 | 0 |
| Spent Caustics | 763,740 | 48 | 52 |
| Spent Acids | 95 | 17 | 83 |
| Residual Amines | 650 | 3 | 97 |
| Other Inorganic Residuals NOS | 64,923 | 3 | 97 |
| Other Residuals NOS | 21,434 | 3 | 97 |
| | ========== | | |
| | 1,826,709 | | |

API REFINERY RESIDUALS SURVEY
1992

**Estimated Residual Quantities Treated and Percent Of Total Amount Managed**
**By Stream**

| Residual Stream | Quantity Treated (Tons) | Percent Treated |
|---|---|---|
| API Separator Sludge (K051) | 121,513 | 69.78 |
| Dissolved Air Flotation Float (K048) | 369,051 | 67.57 |
| Slop Oil Emulsion Solids (K049) | 37,412 | 50.66 |
| Leaded Tank Bottoms (K052) | 531 | 84.29 |
| Pond Sediments | 106,708 | 27.28 |
| Nonleaded Tank Bottoms | 25,404 | 19.51 |
| Residual Oils/Spent Solvents | 42 | 0.13 |
| Other Oily Sludges & Organic Wastes | 8,010 | 20.87 |
| Primary Sludge (F037) | 40,675 | 16.50 |
| Primary Sludge (F038) | 23,730 | 43.86 |
| Heat Exchanger Bundle Cleaning Sludge | 2,051 | 54.46 |
| Contaminated Soils/Solids | 16,584 | 1.74 |
| Residual Coke/Carbon/Charcoal | 210 | 0.39 |
| Residual Sulfur | 71 | 0.13 |
| Other Contaminated Soils NOS | 721 | 2.24 |
| Fluid Cracking Catalyst or Equivalent | 26 | 0.01 |
| Hydroprocessing Catalysts | 3 | 0.01 |
| Other Spent Catalysts NOS | 51 | 0.18 |
| Biomass | 168,023 | 26.21 |
| Oil Contaminated Waters NOT Wastewater | 20,967 | 93.87 |
| High pH/Low pH Waters | 13,565 | 83.17 |
| Spent Sulfite Solution | 0 | 0 |
| Spent Stretford Solution | 23,268 | 75.80 |
| TSD Leachate (F039) | 1,103 | 8.82 |
| Spent Caustics | 631,755 | 44.33 |
| Spent Acids | 4,530 | 58.17 |
| Residual Amines | 139,874 | 98.22 |
| Other Inorganic Residuals NOS | 48,276 | 13.43 |
| Other Residuals NOS | 1,371 | 0.36 |
| | ========== | |
| | 1,805,525 | |

API REFINERY RESIDUALS SURVEY
1992

Estimated Residual Quantity Handled By Treatment Techniques For Each Residual Stream
(wet tons)

| Residual Stream | Weathering | Chemical | Heat | Impoundment | Physical | Waste water Treatment | Incineration | Stabilization and/or Fixation | Other |
|---|---|---|---|---|---|---|---|---|---|
| API Separator Sludge (K051) | 0 | 0 | 7,531 | 0 | 20,110 | 68,185 | 25,687 | 0 | 0 |
| Dissolved Air Flotation Float (K048) | 0 | 0 | 6,466 | 0 | 273 | 308,004 | 54,308 | 0 | 0 |
| Slop Oil Emulsion Solids (K049) | 0 | 0 | 6,897 | 0 | 224 | 22,589 | 7,702 | 0 | 0 |
| Leaded Tank Bottoms (K052) | 0 | 0 | 0 | 0 | 0 | 2 | 529 | 0 | 0 |
| Pond Sediments | 0 | 0 | 0 | 0 | 0 | 106,708 | 0 | 0 | 0 |
| Nonleaded Tank Bottoms | 0 | 106 | 0 | 0 | 209 | 18,718 | 81 | 6,290 | 0 |
| Residual Oils/Spent Solvents | 0 | 5 | 0 | 0 | 0 | 8 | 24 | 5 | 0 |
| Other Oily Sludges & Organic Wastes | 0 | 0 | 0 | 0 | 0 | 7,680 | 330 | 0 | 0 |
| Primary Sludge (F037) | 0 | 0 | 0 | 0 | 0 | 31,968 | 8,707 | 0 | 0 |
| Primary Sludge (F038) | 0 | 0 | 0 | 0 | 0 | 23,509 | 221 | 0 | 0 |
| Heat Exchanger Bundle Cleaning Sludge | 0 | 0 | 0 | 0 | 0 | 231 | 1,788 | 32 | 0 |
| Contaminated Soils/Solids | 0 | 437 | 15,671 | 0 | 32 | 0 | 280 | 164 | 0 |
| Residual Coke/Carbon/Charcoal | 0 | 0 | 0 | 0 | 0 | 0 | 150 | 60 | 0 |
| Residual Sulfur | 0 | 71 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other Contaminated Soils NOS | 3 | 294 | 18 | 0 | 0 | 0 | 98 | 308 | 0 |
| Fluid Cracking Catalyst or Equivalent | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 13 | 0 |
| Hydroprocessing Catalysts | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other Spent Catalysts NOS | 0 | 0 | 0 | 0 | 0 | 0 | 51 | 0 | 0 |
| Biomass | 0 | 0 | 0 | 0 | 0 | 89,505 | 73,916 | 0 | 4,602 |
| Oil Contaminated Waters NOT Wastewater | 0 | 0 | 0 | 0 | 0 | 20,904 | 19 | 44 | 0 |
| High pH/Low pH Waters | 0 | 0 | 0 | 0 | 0 | 13,563 | 2 | 0 | 0 |
| Spent Sulfite Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Stretford Solution | 0 | 0 | 0 | 1,743 | 0 | 21,525 | 0 | 0 | 0 |
| TSD Leachate (F039) | 0 | 0 | 0 | 0 | 0 | 1,103 | 0 | 0 | 0 |
| Spent Caustics | 0 | 1,667 | 0 | 0 | 0 | 630,088 | 0 | 0 | 0 |
| Spent Acids | 0 | 474 | 0 | 0 | 0 | 3,982 | 0 | 0 | 74 |
| Residual Amines | 0 | 412 | 0 | 0 | 0 | 139,460 | 2 | 0 | 0 |
| Other Inorganic Residuals NOS | 0 | 9,137 | 0 | 0 | 0 | 39,124 | 2 | 13 | 0 |
| Other Residuals NOS | 0 | 0 | 0 | 0 | 0 | 24 | 1,336 | 11 | 0 |
| | ========== | ======== | ======= | =========== | ======== | ========= | ============ | ============= | ======= |
| | 3 | 12,606 | 36,583 | 1,743 | 20,848 | 1546893 | 175,233 | 6,940 | 4,676 |

API REFINERY RESIDUALS SURVEY
1992

Respondent Frequencies For Treatment Techniques For Each Residual Stream

| Residual Stream | Weathering | Chemical | Heat | Impoundment | Physical | Wastewater Treatment | Incineration | Stabilization and/or Fixation | Other |
|---|---|---|---|---|---|---|---|---|---|
| API Separator Sludge (K051) | 0 | 0 | 3 | 0 | 4 | 30 | 33 | 0 | 0 |
| Dissolved Air Flotation Float (K048) | 0 | 0 | 1 | 0 | 2 | 20 | 16 | 0 | 0 |
| Slop Oil Emulsion Solids (K049) | 0 | 0 | 1 | 0 | 2 | 13 | 9 | 0 | 0 |
| Leaded Tank Bottoms (K052) | 0 | 0 | 0 | 0 | 0 | 2 | 9 | 0 | 0 |
| Pond Sediments | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| Nonleaded Tank Bottoms | 0 | 1 | 0 | 0 | 1 | 16 | 7 | 2 | 0 |
| Residual Oils/Spent Solvents | 0 | 1 | 0 | 0 | 0 | 3 | 5 | 1 | 0 |
| Other Oily Sludges & Organic Wastes | 0 | 0 | 0 | 0 | 0 | 6 | 6 | 0 | 0 |
| Primary Sludge (F037) | 0 | 0 | 0 | 0 | 0 | 16 | 10 | 0 | 0 |
| Primary Sludge (F038) | 0 | 0 | 0 | 0 | 0 | 8 | 1 | 0 | 0 |
| Heat Exchanger Bundle Cleaning Sludge | 0 | 0 | 0 | 0 | 0 | 6 | 36 | 1 | 0 |
| Contaminated Soils/Solids | 0 | 3 | 2 | 0 | 1 | 0 | 6 | 1 | 0 |
| Residual Coke/Carbon/Charcoal | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 0 |
| Residual Sulfur | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other Contaminated Soils NOS | 1 | 3 | 1 | 0 | 0 | 0 | 3 | 1 | 0 |
| Fluid Cracking Catalyst or Equivalent | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Hydroprocessing Catalysts | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other Spent Catalysts NOS | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 |
| Biomass | 0 | 0 | 0 | 0 | 0 | 6 | 6 | 0 | 1 |
| Oil Contaminated Waters NOT Wastewater | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 1 | 0 |
| High pH/Low pH Waters | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 0 | 0 |
| Spent Sulfite Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Stretford Solution | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 |
| TSD Leachate (F039) | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| Spent Caustics | 0 | 2 | 0 | 0 | 0 | 23 | 0 | 0 | 0 |
| Spent Acids | 0 | 1 | 0 | 0 | 0 | 5 | 0 | 0 | 1 |
| Residual Amines | 0 | 1 | 0 | 0 | 0 | 15 | 1 | 0 | 0 |
| Other Inorganic Residuals NOS | 0 | 2 | 0 | 0 | 0 | 7 | 1 | 1 | 0 |
| Other Residuals NOS | 0 | 0 | 0 | 0 | 0 | 1 | 37 | 1 | 0 |
| | ========== | ======== | ==== | =========== | ======== | ========== | ============ | ============= | ===== |
| | 1 | 16 | 8 | 1 | 10 | 195 | 195 | 11 | 2 |

The SAS System

API ANNUAL REFINING SURVEY
1992

Percent Treated On-Site and Off-Site

| Waste Stream | Treated Tons | Percent Treated On-Site | Percent Treated Off-Site |
|---|---|---|---|
| API Separator Sludge (K051) | 121,513 | 80 | 20 |
| Dissolved Air Flotation Float (K048) | 369,051 | 95 | 5 |
| Slop Oil Emulsion Solids (K049) | 37,412 | 79 | 21 |
| Leaded Tank Bottoms (K052) | 531 | 0 | 100 |
| Pond Sediments | 106,708 | 100 | 0 |
| Nonleaded Tank Bottoms | 25,404 | 99 | 1 |
| Residual Oils/Spent Solvents | 41 | 18 | 82 |
| Other Oily Sludges & Organic Wastes | 8,010 | 96 | 4 |
| Primary Sludge (F037) | 40,675 | 69 | 31 |
| Primary Sludge (F038) | 23,730 | 99 | 1 |
| Heat Exchanger Bundle Cleaning Sludge | 2,051 | 11 | 89 |
| Contaminated Soils/Solids | 16,584 | 86 | 14 |
| Residual Coke/Carbon/Charcoal | 210 | 28 | 72 |
| Residual Sulfur | 71 | 0 | 100 |
| Other Contaminated Soils NOS | 719 | 53 | 47 |
| Fluid Cracking Catalyst or Equivalent | 26 | 100 | 0 |
| Hydroprocessing Catalysts | 3 | 0 | 100 |
| Other Spent Catalysts NOS | 51 | 0 | 100 |
| Biomass | 168,023 | 80 | 20 |
| Oil Contaminated Waters NOT Wastewater | 20,967 | 100 | 0 |
| High pH/Low pH Waters | 13,565 | 100 | 0 |
| Spent Sulfite Solution | 0 | 0 | 0 |
| Spent Stretford Solution | 23,268 | 82 | 18 |
| TSD Leachate (F039) | 1,103 | 94 | 6 |
| Spent Caustics | 631,755 | 98 | 2 |
| Spent Acids | 4,531 | 98 | 2 |
| Residual Amines | 139,874 | 100 | 0 |
| Other Inorganic Residuals NOS | 48,276 | 88 | 12 |
| Other Residuals NOS | 1,371 | 4 | 96 |
| | ========== | | |
| | 1,805,523 | | |

API REFINERY RESIDUALS SURVEY
1992

Estimated Residual Quantities Land Treated and Percent Of Total Amount Managed
By Stream

| Residual Stream | Quantity Land Treated (Tons) | Percent Land Treated |
|---|---|---|
| API Separator Sludge (K051) | 363 | 0.21 |
| Dissolved Air Flotation Float (K048) | 444 | 0.08 |
| Slop Oil Emulsion Solids (K049) | 0 | 0.00 |
| Leaded Tank Bottoms (K052) | 0 | 0.00 |
| Pond Sediments | 230,187 | 58.86 |
| Nonleaded Tank Bottoms | 11,612 | 8.92 |
| Residual Oils/Spent Solvents | 103 | 0.31 |
| Other Oily Sludges & Organic Wastes | 4,098 | 10.68 |
| Primary Sludge (F037) | 57,988 | 23.52 |
| Primary Sludge (F038) | 0 | 0.00 |
| Heat Exchanger Bundle Cleaning Sludge | 0 | 0.00 |
| Contaminated Soils/Solids | 245,922 | 25.80 |
| Residual Coke/Carbon/Charcoal | 1,215 | 2.28 |
| Residual Sulfur | 0 | 0.00 |
| Other Contaminated Soils NOS | 4,104 | 12.74 |
| Fluid Cracking Catalyst or Equivalent | 1,647 | 0.84 |
| Hydroprocessing Catalysts | 0 | 0.00 |
| Other Spent Catalysts NOS | 430 | 1.56 |
| Biomass | 144,060 | 22.48 |
| Oil Contaminated Waters NOT Wastewater | 0 | 0.00 |
| High pH/Low pH Waters | 38 | 0.23 |
| Spent Sulfite Solution | 0 | 0.00 |
| Spent Stretford Solution | 0 | 0.00 |
| TSD Leachate (F039) | 0 | 0.00 |
| Spent Caustics | 0 | 0.00 |
| Spent Acids | 0 | 0.00 |
| Residual Amines | 0 | 0.00 |
| Other Inorganic Residuals NOS | 8,100 | 2.25 |
| Other Residuals NOS | 21 | 0.01 |
| | ========== | |
| | 710,332 | |

API REFINERY RESIDUALS SURVEY
1992

Respondent Frequencies For Land Treatment For Each Residual Stream

| Residual Stream | Land Treatment |
|---|---|
| 0 | 17 |
| API Separator Sludge (K051) | 1 |
| Dissolved Air Flotation Float (K048) | 1 |
| Pond Sediments | 6 |
| Nonleaded Tank Bottoms | 14 |
| Residual Oils/Spent Solvents | 2 |
| Other Oily Sludges & Organic Wastes | 7 |
| Primary Sludge (F037) | 14 |
| Contaminated Soils/Solids | 17 |
| Residual Coke/Carbon/Charcoal | 6 |
| Other Contaminated Soils NOS | 7 |
| Fluid Cracking Catalyst or Equivalent | 3 |
| Other Spent Catalysts NOS | 2 |
| Biomass | 15 |
| High pH/Low pH Waters | 1 |
| Other Inorganic Residuals NOS | 8 |
| Other Residuals NOS | 2 |
| | ========= |
| | 123 |

The SAS System

API ANNUAL REFINING SURVEY
1992

Percent Land Treated On-Site and Off-Site

| Waste Stream | Land Treated Tons | Percent Land Treated On-Site | Percent Land Treated Off-Site |
|---|---|---|---|
| API Separator Sludge (K051) | 363 | 100 | 0 |
| Dissolved Air Flotation Float (K048) | 444 | 100 | 0 |
| Slop Oil Emulsion Solids (K049) | 0 | 0 | 0 |
| Leaded Tank Bottoms (K052) | 0 | 0 | 0 |
| Pond Sediments | 230,187 | 92 | 8 |
| Nonleaded Tank Bottoms | 11,612 | 95 | 5 |
| Residual Oils/Spent Solvents | 103 | 100 | 0 |
| Other Oily Sludges & Organic Wastes | 4,098 | 99 | 1 |
| Primary Sludge (F037) | 57,988 | 91 | 9 |
| Primary Sludge (F038) | 0 | 0 | 0 |
| Heat Exchanger Bundle Cleaning Sludge | 0 | 0 | 0 |
| Contaminated Soils/Solids | 245,922 | 98 | 2 |
| Residual Coke/Carbon/Charcoal | 1,215 | 98 | 2 |
| Residual Sulfur | 0 | 0 | 0 |
| Other Contaminated Soils NOS | 4,104 | 81 | 19 |
| Fluid Cracking Catalyst or Equivalent | 1,647 | 4 | 96 |
| Hydroprocessing Catalysts | 0 | 0 | 0 |
| Other Spent Catalysts NOS | 430 | 100 | 0 |
| Biomass | 144,060 | 98 | 2 |
| Oil Contaminated Waters NOT Wastewater | 0 | 0 | 0 |
| High pH/Low pH Waters | 38 | 100 | 0 |
| Spent Sulfite Solution | 0 | 0 | 0 |
| Spent Stretford Solution | 0 | 0 | 0 |
| TSD Leachate (F039) | 0 | 0 | 0 |
| Spent Caustics | 0 | 0 | 0 |
| Spent Acids | 0 | 0 | 0 |
| Residual Amines | 0 | 0 | 0 |
| Other Inorganic Residuals NOS | 8,100 | 100 | 0 |
| Other Residuals NOS | 21 | 100 | 0 |
| | ========== | | |
| | 710,332 | | |

API REFINERY RESIDUALS SURVEY
1992

Estimated Residual Quantities Disposed and Percent Of Total Amount Managed
By Stream

| Waste Stream | Quantity Disposed (Tons) | Percent Disposed |
|---|---|---|
| API Separator Sludge (K051) | 4,770 | 2.74 |
| Dissolved Air Flotation Float (K048) | 3,528 | 0.65 |
| Slop Oil Emulsion Solids (K049) | 1,324 | 1.79 |
| Leaded Tank Bottoms (K052) | 40 | 6.35 |
| Pond Sediments | 38,713 | 9.90 |
| Nonleaded Tank Bottoms | 70,293 | 53.99 |
| Residual Oils/Spent Solvents | 793 | 2.41 |
| Other Oily Sludges & Organic Wastes | 10,263 | 26.74 |
| Primary Sludge (F037) | 140,033 | 56.80 |
| Primary Sludge (F038) | 7,287 | 13.47 |
| Heat Exchanger Bundle Cleaning Sludge | 1,071 | 28.44 |
| Contaminated Soils/Solids | 616,430 | 64.67 |
| Residual Coke/Carbon/Charcoal | 10,631 | 19.98 |
| Residual Sulfur | 26,935 | 50.94 |
| Other Contaminated Soils NOS | 20,452 | 63.51 |
| Fluid Cracking Catalyst or Equivalent | 109,523 | 55.67 |
| Hydroprocessing Catalysts | 6,217 | 12.10 |
| Other Spent Catalysts NOS | 17,192 | 62.20 |
| Biomass | 55,673 | 8.69 |
| Oil Contaminated Waters NOT Wastewater | 0 | 0.00 |
| High pH/Low pH Waters | 2,392 | 14.67 |
| Spent Sulfite Solution | 0 | 0 |
| Spent Stretford Solution | 2,165 | 7.05 |
| TSD Leachate (F039) | 11,397 | 91.18 |
| Spent Caustics | 29,581 | 2.08 |
| Spent Acids | 3,162 | 40.61 |
| Residual Amines | 1,886 | 1.32 |
| Other Inorganic Residuals NOS | 238,031 | 66.24 |
| Other Residuals NOS | 357,943 | 94.01 |
| | ========== | |
| | 1,787,725 | |

API REFINERY RESIDUALS SURVEY
1992

Estimated Residual Quantity Handled by Disposal Techniques for Each Residual Stream
(wet tons)

| Residual Stream | Disposal Impoundment | Landfill | Landspread | Injection | Other |
|---|---|---|---|---|---|
| API Separator Sludge (K051) | 0 | 4,550 | 0 | 0 | 220 |
| Dissolved Air Flotation Float (K048) | 0 | 3,528 | 0 | 0 | 0 |
| Slop Oil Emulsion Solids (K049) | 0 | 1,105 | 0 | 0 | 219 |
| Leaded Tank Bottoms (K052) | 0 | 24 | 0 | 0 | 16 |
| Pond Sediments | 0 | 38,713 | 0 | 0 | 0 |
| Nonleaded Tank Bottoms | 0 | 70,261 | 20 | 0 | 12 |
| Residual Oils/Spent Solvents | 0 | 785 | 0 | 0 | 8 |
| Other Oily Sludges & Organic Wastes | 14 | 9,922 | 287 | 0 | 40 |
| Primary Sludge (F037) | 1,827 | 137,748 | 352 | 0 | 106 |
| Primary Sludge (F038) | 5,547 | 1,740 | 0 | 0 | 0 |
| Heat Exchanger Bundle Cleaning Sludge | 0 | 1,052 | 0 | 0 | 19 |
| Contaminated Soils/Solids | 0 | 592,397 | 24,031 | 0 | 2 |
| Residual Coke/Carbon/Charcoal | 0 | 10,595 | 36 | 0 | 0 |
| Residual Sulfur | 0 | 26,922 | 2 | 0 | 11 |
| Other Contaminated Soils NOS | 0 | 20,092 | 2 | 0 | 358 |
| Fluid Cracking Catalyst or Equivalent | 25,419 | 83,253 | 851 | 0 | 0 |
| Hydroprocessing Catalysts | 0 | 6,175 | 0 | 0 | 42 |
| Other Spent Catalysts NOS | 0 | 17,101 | 0 | 0 | 91 |
| Biomass | 0 | 50,893 | 4,780 | 0 | 0 |
| Oil Contaminated Waters NOT Wastewater | 0 | 0 | 0 | 0 | 0 |
| High pH/Low pH Waters | 0 | 130 | 0 | 2,262 | 0 |
| Spent Sulfite Solution | 0 | 0 | 0 | 0 | 0 |
| Spent Stretford Solution | 0 | 2,165 | 0 | 0 | 0 |
| TSD Leachate (F039) | 11,397 | 0 | 0 | 0 | 0 |
| Spent Caustics | 0 | 0 | 0 | 29,057 | 524 |
| Spent Acids | 0 | 14 | 0 | 3,148 | 0 |
| Residual Amines | 4 | 309 | 0 | 1,569 | 4 |
| Other Inorganic Residuals NOS | 7,110 | 229,785 | 1,136 | 0 | 0 |
| Other Residuals NOS | 0 | 355,628 | 1,121 | 129 | 1,065 |
| | =========== | ========== | ========== | ========== | ========== |
| | 51,318 | 1,664,887 | 32,618 | 36,165 | 2,737 |

API REFINERY RESIDUALS SURVEY
1992

**Respondent Frequencies for Disposal Techniques for Each Residual Stream**

| Residual Stream | Disposal Impoundment | Landfill | Landspread | Injection | Other |
|---|---|---|---|---|---|
| API Separator Sludge (K051) | 0 | 13 | 0 | 0 | 4 |
| Dissolved Air Flotation Float (K048) | 0 | 8 | 0 | 0 | 0 |
| Slop Oil Emulsion Solids (K049) | 0 | 7 | 0 | 0 | 1 |
| Leaded Tank Bottoms (K052) | 0 | 1 | 0 | 0 | 1 |
| Pond Sediments | 0 | 10 | 0 | 0 | 0 |
| Nonleaded Tank Bottoms | 0 | 48 | 1 | 0 | 1 |
| Residual Oils/Spent Solvents | 0 | 6 | 0 | 0 | 2 |
| Other Oily Sludges & Organic Wastes | 1 | 28 | 2 | 0 | 2 |
| Primary Sludge (F037) | 2 | 44 | 2 | 0 | 3 |
| Primary Sludge (F038) | 1 | 6 | 0 | 0 | 0 |
| Heat Exchanger Bundle Cleaning Sludge | 0 | 9 | 0 | 0 | 2 |
| Contaminated Soils/Solids | 0 | 73 | 6 | 0 | 1 |
| Residual Coke/Carbon/Charcoal | 0 | 34 | 1 | 0 | 0 |
| Residual Sulfur | 0 | 30 | 1 | 0 | 1 |
| Other Contaminated Soils NOS | 0 | 39 | 1 | 0 | 1 |
| Fluid Cracking Catalyst or Equivalent | 1 | 46 | 2 | 0 | 0 |
| Hydroprocessing Catalysts | 0 | 18 | 0 | 0 | 1 |
| Other Spent Catalysts NOS | 0 | 42 | 0 | 0 | 1 |
| Biomass | 0 | 20 | 3 | 0 | 0 |
| Oil Contaminated Waters NOT Wastewater | 0 | 0 | 0 | 0 | 0 |
| High pH/Low pH Waters | 0 | 1 | 0 | 1 | 0 |
| Spent Sulfite Solution | 0 | 0 | 0 | 0 | 0 |
| Spent Stretford Solution | 0 | 1 | 0 | 0 | 0 |
| TSD Leachate (F039) | 1 | 0 | 0 | 0 | 0 |
| Spent Caustics | 0 | 0 | 0 | 9 | 1 |
| Spent Acids | 0 | 1 | 0 | 2 | 0 |
| Residual Amines | 1 | 7 | 0 | 3 | 2 |
| Other Inorganic Residuals NOS | 4 | 41 | 2 | 0 | 0 |
| Other Residuals NOS | 0 | 77 | 2 | 1 | 3 |
| | =========== | ======== | ========== | ========= | ===== |
| | 11 | 610 | 23 | 16 | 27 |

The SAS System

API ANNUAL REFINING SURVEY
1992

Percent Disposed On-Site and Off-Site

| Waste Stream | Disposed Tons | Percent Disposed On-Site | Percent Disposed Off-Site |
|---|---|---|---|
| API Separator Sludge (K051) | 4,771 | 0 | 100 |
| Dissolved Air Flotation Float (K048) | 3,528 | 0 | 100 |
| Slop Oil Emulsion Solids (K049) | 1,323 | 0 | 100 |
| Leaded Tank Bottoms (K052) | 40 | 0 | 100 |
| Pond Sediments | 38,713 | 0 | 100 |
| Nonleaded Tank Bottoms | 70,294 | 5 | 95 |
| Residual Oils/Spent Solvents | 792 | 0 | 100 |
| Other Oily Sludges & Organic Wastes | 10,262 | 69 | 31 |
| Primary Sludge (F037) | 140,034 | 39 | 61 |
| Primary Sludge (F038) | 7,287 | 76 | 24 |
| Heat Exchanger Bundle Cleaning Sludge | 1,071 | 0 | 100 |
| Contaminated Soils/Solids | 616,429 | 8 | 92 |
| Residual Coke/Carbon/Charcoal | 10,631 | 20 | 80 |
| Residual Sulfur | 26,935 | 1 | 99 |
| Other Contaminated Soils NOS | 20,452 | 7 | 93 |
| Fluid Cracking Catalyst or Equivalent | 109,523 | 39 | 61 |
| Hydroprocessing Catalysts | 6,217 | 11 | 89 |
| Other Spent Catalysts NOS | 17,192 | 11 | 89 |
| Biomass | 55,673 | 28 | 72 |
| Oil Contaminated Waters NOT Wastewater | 0 | 0 | 0 |
| High pH/Low pH Waters | 2,392 | 5 | 95 |
| Spent Sulfite Solution | 0 | 0 | 0 |
| Spent Stretford Solution | 2,165 | 0 | 100 |
| TSD Leachate (F039) | 11,397 | 100 | 0 |
| Spent Caustics | 29,581 | 66 | 34 |
| Spent Acids | 3,162 | 0 | 100 |
| Residual Amines | 1,886 | 54 | 46 |
| Other Inorganic Residuals NOS | 238,032 | 8 | 92 |
| Other Residuals NOS | 357,944 | 28 | 72 |
| | ========== | | |
| | 1,787,726 | | |

API SOLID WASTE SURVEY
1993

Estimated U.S. Total Waste Quantities

| STREAM | Waste Stream | Total Estimated Generation | Total Estimated Net Storage | Total Estimated Treatment Additives | Total Estimated Waste Input |
|---|---|---|---|---|---|
| 101 | API Separator Sludge (K051) | 169,611 | -6,956 | 4,641 | 167,296 |
| 102 | Dissolved Air Flotation Float (K048) | 516,901 | -463 | 3,678 | 520,117 |
| 103 | Slop Oil Emulsion Solids (K049) | 53,769 | 687 | 1,099 | 55,554 |
| 104 | Leaded Tank Bottoms (K052) | 3,126 | 0 | 0 | 3,126 |
| 106 | Pond Sediments | 137,677 | 0 | 6,984 | 144,661 |
| 107 | Nonleaded Tank Bottoms | 127,300 | 683 | 1,935 | 129,918 |
| 108 | Residual Oils/Spent Solvents | 48,061 | 0 | 0 | 48,061 |
| 109 | Other Oily Sludges & Organic Wastes | 192,725 | 0 | 49,306 | 242,030 |
| 110 | Primary Sludge (F037) | 234,773 | -9,383 | 497 | 225,886 |
| 111 | Primary Sludge (F038) | 67,104 | -4,796 | 0 | 62,308 |
| 201 | Heat Exchanger Bundle Cleaning Sludge | 4,402 | 83 | 330 | 4,815 |
| 202 | Contaminated Soils/Solids | 693,362 | -62,285 | 45 | 631,122 |
| 203 | Residual Coke/Carbon/Charcoal | 54,356 | -3 | 2,520 | 56,872 |
| 204 | Residual Sulfur | 44,138 | -303 | 75 | 43,910 |
| 205 | Other Contaminated Soils NOS | 38,864 | -303 | 100 | 38,661 |
| 301 | Fluid Cracking Catalyst or Equivalent | 203,624 | -6,332 | 0 | 197,292 |
| 302 | Hydroprocessing Catalysts | 46,962 | 3,854 | 878 | 51,695 |
| 303 | Other Spent Catalysts NOS | 28,704 | -3 | 545 | 29,246 |
| 401 | Biomass | 800,529 | -83,409 | 5,304 | 722,424 |
| 402 | Oil Contaminated Waters NOT Wastewater | 26,563 | 0 | 0 | 26,563 |
| 403 | High pH/Low pH Waters | 8,927 | 0 | 50 | 8,977 |
| 404 | Spent Sulfite Solution | 29,316 | . | . | 29,316 |
| 405 | Spent Stretford Solution | 26,178 | 0 | 0 | 26,178 |
| 407 | TSD Leachate (F039) | 39,582 | 0 | 0 | 39,582 |
| 501 | Spent Caustics | 1435728 | -1,601 | 0 | 1434127 |
| 502 | Spent Acids | 5,376 | 0 | 520 | 5,896 |
| 503 | Residual Amines | 115,633 | 0 | 0 | 115,633 |
| 504 | Other Inorganic Residuals NOS | 250,787 | -4,801 | 850 | 246,836 |
| 601 | Other Residuals NOS | 142,672 | -32 | 0 | 142,640 |

API REFINERY RESIDUALS SURVEY
1993

Estimated Residual Quantities By Management Techniques
(wet tons)

| Residual Stream | Total Managed | Recycled | Treated | Land Treated | Disposed |
|---|---|---|---|---|---|
| API Separator Sludge (K051) | 167,296 | 55,168 | 105,838 | 1,320 | 4,970 |
| Dissolved Air Flotation Float (K048) | 520,118 | 147,625 | 369,221 | 1,616 | 1,656 |
| Slop Oil Emulsion Solids (K049) | 55,555 | 36,270 | 18,782 | 0 | 503 |
| Leaded Tank Bottoms (K052) | 3,127 | 1,769 | 1,283 | 0 | 75 |
| Pond Sediments | 144,661 | 11,563 | 1,296 | 20,488 | 111,314 |
| Nonleaded Tank Bottoms | 129,919 | 36,759 | 13,472 | 14,215 | 65,473 |
| Residual Oils/Spent Solvents | 48,062 | 47,496 | 170 | 217 | 179 |
| Other Oily Sludges & Organic Wastes | 242,029 | 20,379 | 5,590 | 35,837 | 180,223 |
| Primary Sludge (F037) | 225,885 | 30,304 | 55,978 | 116,192 | 23,411 |
| Primary Sludge (F038) | 62,309 | 18,120 | 39,153 | 0 | 5,036 |
| Heat Exchanger Bundle Cleaning Sludge | 4,817 | 1,726 | 1,379 | 0 | 1,712 |
| Contaminated Soils/Solids | 631,122 | 64,721 | 24,543 | 141,872 | 399,986 |
| Residual Coke/Carbon/Charcoal | 56,872 | 45,078 | 2,584 | 107 | 9,103 |
| Residual Sulfur | 43,910 | 33,599 | 65 | 230 | 10,016 |
| Other Contaminated Soils NOS | 38,659 | 10,731 | 746 | 2,141 | 25,041 |
| Fluid Cracking Catalyst or Equivalent | 197,292 | 93,901 | 17 | 3,816 | 99,558 |
| Hydroprocessing Catalysts | 51,694 | 27,580 | 190 | 0 | 23,924 |
| Other Spent Catalysts NOS | 29,246 | 16,398 | 198 | 452 | 12,198 |
| Biomass | 722,425 | 278,489 | 132,239 | 142,826 | 168,871 |
| Oil Contaminated Waters NOT Wastewater | 26,563 | 20 | 21,326 | 220 | 4,997 |
| High pH/Low pH Waters | 8,978 | 84 | 7,924 | 35 | 935 |
| Spent Sulfite Solution | 29,317 | 29,317 | 0 | 0 | 0 |
| Spent Stretford Solution | 26,177 | 2,088 | 21,233 | 0 | 2,856 |
| TSD Leachate (F039) | 39,582 | 0 | 21,829 | 0 | 17,753 |
| Spent Caustics | 1,434,128 | 739,098 | 660,646 | 0 | 34,384 |
| Spent Acids | 5,895 | 53 | 5,144 | 0 | 698 |
| Residual Amines | 115,632 | 1,374 | 113,176 | 0 | 1,082 |
| Other Inorganic Residuals NOS | 246,838 | 15,219 | 40,445 | 14,941 | 176,233 |
| Other Residuals NOS | 142,640 | 8,355 | 950 | 0 | 133,335 |
| | ========== | ========== | ========== | ========== | ========== |
| | 5,450,748 | 1,773,284 | 1,665,417 | 496,525 | 1,515,522 |

API REFINERY RESIDUALS SURVEY
1993

Percentages of Residual Quantities Recycled, Treated, Land Treated and Disposed
By Stream

| Residual Stream | Percent Recycled | Percent Treated | Percent Land Treated | Percent Disposed |
|---|---|---|---|---|
| API Separator Sludge (K051) | 33 | 63 | 1 | 3 |
| Dissolved Air Flotation Float (K048) | 28 | 71 | 0 | 0 |
| Slop Oil Emulsion Solids (K049) | 65 | 34 | 0 | 1 |
| Leaded Tank Bottoms (K052) | 57 | 41 | 0 | 2 |
| Pond Sediments | 8 | 1 | 14 | 77 |
| Nonleaded Tank Bottoms | 28 | 10 | 11 | 50 |
| Residual Oils/Spent Solvents | 99 | 0 | 0 | 0 |
| Other Oily Sludges & Organic Wastes | 8 | 2 | 15 | 74 |
| Primary Sludge (F037) | 13 | 25 | 51 | 10 |
| Primary Sludge (F038) | 29 | 63 | 0 | 8 |
| Heat Exchanger Bundle Cleaning Sludge | 36 | 29 | 0 | 36 |
| Contaminated Soils/Solids | 10 | 4 | 22 | 63 |
| Residual Coke/Carbon/Charcoal | 79 | 5 | 0 | 16 |
| Residual Sulfur | 77 | 0 | 1 | 23 |
| Other Contaminated Soils NOS | 28 | 2 | 6 | 65 |
| Fluid Cracking Catalyst or Equivalent | 48 | 0 | 2 | 50 |
| Hydroprocessing Catalysts | 53 | 0 | 0 | 46 |
| Other Spent Catalysts NOS | 56 | 1 | 2 | 42 |
| Biomass | 39 | 18 | 20 | 23 |
| Oil Contaminated Waters NOT Wastewater | 0 | 80 | 1 | 19 |
| High pH/Low pH Waters | 1 | 88 | 0 | 10 |
| Spent Sulfite Solution | 100 | 0 | 0 | 0 |
| Spent Stretford Solution | 8 | 81 | 0 | 11 |
| TSD Leachate (F039) | 0 | 55 | 0 | 45 |
| Spent Caustics | 52 | 46 | 0 | 2 |
| Spent Acids | 1 | 87 | 0 | 12 |
| Residual Amines | 1 | 98 | 0 | 1 |
| Other Inorganic Residuals NOS | 6 | 16 | 6 | 71 |
| Other Residuals NOS | 6 | 1 | 0 | 93 |

API REFINERY RESIDUALS SURVEY
1993

Estimated Residual Quantities Recycled and Percent Of Total Amount Managed
By Stream

| Residual Stream | Quantity Recycled (Tons) | Percent Recycled |
|---|---|---|
| API Separator Sludge (K051) | 55,168 | 32.98 |
| Dissolved Air Flotation Float (K048) | 147,625 | 28.38 |
| Slop Oil Emulsion Solids (K049) | 36,270 | 65.29 |
| Leaded Tank Bottoms (K052) | 1,769 | 56.57 |
| Pond Sediments | 11,563 | 7.99 |
| Nonleaded Tank Bottoms | 36,759 | 28.29 |
| Residual Oils/Spent Solvents | 47,496 | 98.82 |
| Other Oily Sludges & Organic Wastes | 20,379 | 8.42 |
| Primary Sludge (F037) | 30,304 | 13.42 |
| Primary Sludge (F038) | 18,120 | 29.08 |
| Heat Exchanger Bundle Cleaning Sludge | 1,726 | 35.83 |
| Contaminated Soils/Solids | 64,721 | 10.25 |
| Residual Coke/Carbon/Charcoal | 45,078 | 79.26 |
| Residual Sulfur | 33,599 | 76.52 |
| Other Contaminated Soils NOS | 10,731 | 27.76 |
| Fluid Cracking Catalyst or Equivalent | 93,901 | 47.59 |
| Hydroprocessing Catalysts | 27,580 | 53.35 |
| Other Spent Catalysts NOS | 16,398 | 56.07 |
| Biomass | 278,489 | 38.55 |
| Oil Contaminated Waters NOT Wastewater | 20 | 0.08 |
| High pH/Low pH Waters | 84 | 0.94 |
| Spent Sulfite Solution | 29,317 | 100.00 |
| Spent Stretford Solution | 2,088 | 7.98 |
| TSD Leachate (F039) | 0 | 0.00 |
| Spent Caustics | 739,098 | 51.54 |
| Spent Acids | 53 | 0.90 |
| Residual Amines | 1,374 | 1.19 |
| Other Inorganic Residuals NOS | 15,219 | 6.17 |
| Other Residuals NOS | 8,355 | 5.86 |
| | ========== | |
| | 1,773,284 | |

# API REFINERY RESIDUALS SURVEY
1993

## Estimated Residual Quantity Handled by Recycle Techniques for Each Residual Stream
(wet tons)

| Residual Stream | Coker | Crude Unit | Desalter | Catalytic Cracker | Other In-Process Recycle | Cement Kiln-Out of Process |
|---|---|---|---|---|---|---|
| API Separator Sludge (K051) | 22,759 | 11,265 | 0 | 200 | 1,120 | 1,829 |
| Dissolved Air Flotation Float (K048) | 47,367 | 52,268 | 0 | 0 | 30,899 | 684 |
| Slop Oil Emulsion Solids (K049) | 15,972 | 5,327 | 0 | 14 | 0 | 2,944 |
| Leaded Tank Bottoms (K052) | 2 | 342 | 0 | 0 | 58 | 0 |
| Pond Sediments | 10,783 | 83 | 0 | 0 | 0 | 0 |
| Nonleaded Tank Bottoms | 10,723 | 9,834 | 0 | 0 | 603 | 186 |
| Residual Oils/Spent Solvents | 383 | 45,902 | 0 | 0 | 2 | 0 |
| Other Oily Sludges & Organic Wastes | 438 | 3,674 | 0 | 2,744 | 6,092 | 10 |
| Primary Sludge (F037) | 15,866 | 7,005 | 0 | 0 | 613 | 0 |
| Primary Sludge (F038) | 14,505 | 994 | 0 | 0 | 0 | 0 |
| Heat Exchanger Bundle Cleaning Sludge | 32 | 7 | 0 | 0 | 30 | 13 |
| Contaminated Soils/Solids | 0 | 0 | 0 | 0 | 53,630 | 193 |
| Residual Coke/Carbon/Charcoal | 3 | 115 | 0 | 0 | 0 | 0 |
| Residual Sulfur | 0 | 0 | 0 | 0 | 93 | 0 |
| Other Contaminated Soils NOS | 3,663 | 0 | 0 | 0 | 0 | 0 |
| Fluid Cracking Catalyst or Equivalent | 0 | 0 | 0 | 6,548 | 11,223 | 54,307 |
| Hydroprocessing Catalysts | 75 | 0 | 0 | 0 | 0 | 27 |
| Other Spent Catalysts NOS | 0 | 0 | 0 | 0 | 0 | 77 |
| Biomass | 75,433 | 1,337 | 0 | 0 | 36,473 | 0 |
| Oil Contaminated Waters NOT Wastewater | 0 | 0 | 0 | 0 | 0 | 0 |
| High pH/Low pH Waters | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Sulfite Solution | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Stretford Solution | 900 | 0 | 0 | 0 | 0 | 0 |
| TSD Leachate (F039) | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Caustics | 0 | 618 | 0 | 0 | 761 | 0 |
| Spent Acids | 0 | 8 | 0 | 0 | 45 | 0 |
| Residual Amines | 54 | 557 | 0 | 0 | 0 | 0 |
| Other Inorganic Residuals NOS | 887 | 20 | 0 | 0 | 0 | 4,132 |
| Other Residuals NOS | 389 | 191 | 0 | 0 | 0 | 26 |
| | ======== | ======== | ======== | ========= | ========== | ========== |
| | 220,234 | 139,547 | 0 | 9,506 | 141,642 | 64,428 |

Continued on Next Page

API REFINERY RESIDUALS SURVEY
1993

Estimated Residual Quantity Handled by Recycle Techniques for Each Residual Stream (Continued)
(wet tons)

| Residual Stream | Other Out-of-Process | Cement Kiln-Industrial Fuel | Other Industrial Fuel | Reclamation | Regeneration | Other |
|---|---|---|---|---|---|---|
| API Separator Sludge (K051) | 127 | 14,086 | 492 | 3,212 | 76 | 2 |
| Dissolved Air Flotation Float (K048) | 349 | 14,062 | 1,098 | 777 | 121 | 0 |
| Slop Oil Emulsion Solids (K049) | 0 | 8,668 | 1,611 | 1,176 | 556 | 2 |
| Leaded Tank Bottoms (K052) | 0 | 7 | 0 | 1,360 | 0 | 0 |
| Pond Sediments | 0 | 697 | 0 | 0 | 0 | 0 |
| Nonleaded Tank Bottoms | 163 | 65 | 45 | 15,140 | 0 | 0 |
| Residual Oils/Spent Solvents | 20 | 146 | 692 | 293 | 46 | 12 |
| Other Oily Sludges & Organic Wastes | 17 | 6,660 | 740 | 2 | 0 | 2 |
| Primary Sludge (F037) | 0 | 5,293 | 2 | 1,525 | 0 | 0 |
| Primary Sludge (F038) | 0 | 329 | 0 | 2,292 | 0 | 0 |
| Heat Exchanger Bundle Cleaning Sludge | 0 | 86 | 10 | 1,548 | 0 | 0 |
| Contaminated Soils/Solids | 3,686 | 0 | 0 | 145 | 0 | 7,067 |
| Residual Coke/Carbon/Charcoal | 41,265 | 132 | 115 | 92 | 3,349 | 7 |
| Residual Sulfur | 31,306 | 0 | 0 | 2,193 | 0 | 7 |
| Other Contaminated Soils NOS | 6,569 | 25 | 58 | 50 | 0 | 366 |
| Fluid Cracking Catalyst or Equivalent | 10,022 | 375 | 0 | 6,188 | 4,782 | 456 |
| Hydroprocessing Catalysts | 0 | 153 | 0 | 25,490 | 1,835 | 0 |
| Other Spent Catalysts NOS | 517 | 30 | 0 | 15,402 | 357 | 15 |
| Biomass | 115,898 | 60 | 0 | 1,201 | 0 | 48,087 |
| Oil Contaminated Waters NOT Wastewater | 0 | 0 | 0 | 18 | 0 | 2 |
| High pH/Low pH Waters | 2 | 0 | 0 | 82 | 0 | 0 |
| Spent Sulfite Solution | 4,373 | 0 | 0 | 0 | 0 | 24,944 |
| Spent Stretford Solution | 0 | 0 | 0 | 1,188 | 0 | 0 |
| TSD Leachate (F039) | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Caustics | 67,871 | 0 | 0 | 472,203 | 164,809 | 32,836 |
| Spent Acids | 0 | 0 | 0 | 0 | 0 | 0 |
| Residual Amines | 0 | 23 | 0 | 654 | 33 | 53 |
| Other Inorganic Residuals NOS | 5,185 | 3,129 | 0 | 1,827 | 39 | 0 |
| Other Residuals NOS | 4,288 | 51 | 573 | 2,080 | 28 | 729 |
| | ============== | ============== | ========== | =========== | =========== | ======== |
| | 291,658 | 54,077 | 5,436 | 556,138 | 176,031 | 114,587 |

API REFINERY RESIDUALS SURVEY
1993

Respondent Frequencies For Recycle Techniques For Each Residual Stream

| Residual Stream | Coker | Crude Unit | Desalter | Catalytic Cracker | Other In-Process Recycle | Cement Kiln-Out of Process |
|---|---|---|---|---|---|---|
| API Separator Sludge (K051) | 17 | 17 | 0 | 2 | 2 | 6 |
| Dissolved Air Flotation Float (K048) | 17 | 13 | 0 | 0 | 2 | 3 |
| Slop Oil Emulsion Solids (K049) | 9 | 8 | 0 | 1 | 0 | 1 |
| Leaded Tank Bottoms (K052) | 1 | 1 | 0 | 0 | 1 | 0 |
| Pond Sediments | 4 | 2 | 0 | 0 | 0 | 0 |
| Nonleaded Tank Bottoms | 9 | 10 | 0 | 0 | 3 | 1 |
| Residual Oils/Spent Solvents | 3 | 11 | 0 | 0 | 1 | 0 |
| Other Oily Sludges & Organic Wastes | 5 | 7 | 0 | 2 | 3 | 2 |
| Primary Sludge (F037) | 9 | 10 | 0 | 0 | 1 | 0 |
| Primary Sludge (F038) | 4 | 4 | 0 | 0 | 0 | 0 |
| Heat Exchanger Bundle Cleaning Sludge | 4 | 2 | 0 | 0 | 1 | 3 |
| Contaminated Soils/Solids | 0 | 0 | 0 | 0 | 1 | 1 |
| Residual Coke/Carbon/Charcoal | 1 | 1 | 0 | 0 | 0 | 0 |
| Residual Sulfur | 0 | 0 | 0 | 0 | 2 | 0 |
| Other Contaminated Soils NOS | 1 | 0 | 0 | 0 | 0 | 0 |
| Fluid Cracking Catalyst or Equivalent | 0 | 0 | 0 | 6 | 6 | 20 |
| Hydroprocessing Catalysts | 1 | 0 | 0 | 0 | 0 | 2 |
| Other Spent Catalysts NOS | 0 | 0 | 0 | 0 | 0 | 2 |
| Biomass | 2 | 2 | 0 | 0 | 1 | 0 |
| Oil Contaminated Waters NOT Wastewater | 0 | 0 | 0 | 0 | 0 | 0 |
| High pH/Low pH Waters | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Sulfite Solution | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Stretford Solution | 1 | 0 | 0 | 0 | 0 | 0 |
| TSD Leachate (F039) | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Caustics | 0 | 1 | 0 | 0 | 4 | 0 |
| Spent Acids | 0 | 1 | 0 | 0 | 1 | 0 |
| Residual Amines | 3 | 2 | 0 | 0 | 0 | 0 |
| Other Inorganic Residuals NOS | 2 | 1 | 0 | 0 | 0 | 2 |
| Other Residuals NOS | 1 | 3 | 0 | 0 | 0 | 3 |
| | ===== | ===== | ======== | ========= | ========== | ========== |
| | 94 | 96 | 0 | 11 | 29 | 46 |

Continued on Next Page

API REFINERY RESIDUALS SURVEY
1993

Respondent Frequencies for Recycle Techniques for Each Residual Stream (Continued)

| Residual Stream | Other Out of Process | Cement Kiln-Industrial Fuel | Other Industrial Fuel | Reclamation | Regeneration | Other |
|---|---|---|---|---|---|---|
| API Separator Sludge (K051) | 1 | 25 | 2 | 3 | 1 | 1 |
| Dissolved Air Flotation Float (K048) | 1 | 12 | 1 | 1 | 1 | 0 |
| Slop Oil Emulsion Solids (K049) | 0 | 12 | 1 | 2 | 1 | 1 |
| Leaded Tank Bottoms (K052) | 0 | 2 | 0 | 1 | 0 | 0 |
| Pond Sediments | 0 | 3 | 0 | 0 | 0 | 0 |
| Nonleaded Tank Bottoms | 1 | 4 | 1 | 1 | 0 | 0 |
| Residual Oils/Spent Solvents | 3 | 5 | 2 | 26 | 6 | 2 |
| Other Oily Sludges & Organic Wastes | 1 | 2 | 3 | 2 | 0 | 1 |
| Primary Sludge (F037) | 0 | 15 | 1 | 1 | 0 | 0 |
| Primary Sludge (F038) | 0 | 3 | 0 | 2 | 0 | 0 |
| Heat Exchanger Bundle Cleaning Sludge | 0 | 3 | 1 | 1 | 0 | 0 |
| Contaminated Soils/Solids | 4 | 0 | 0 | 2 | 0 | 3 |
| Residual Coke/Carbon/Charcoal | 3 | 1 | 4 | 1 | 14 | 1 |
| Residual Sulfur | 4 | 0 | 0 | 2 | 0 | 1 |
| Other Contaminated Soils NOS | 4 | 1 | 1 | 1 | 0 | 1 |
| Fluid Cracking Catalyst or Equivalent | 6 | 2 | 0 | 2 | 3 | 1 |
| Hydroprocessing Catalysts | 0 | 1 | 0 | 37 | 11 | 0 |
| Other Spent Catalysts NOS | 4 | 1 | 0 | 28 | 2 | 1 |
| Biomass | 2 | 1 | 0 | 1 | 0 | 1 |
| Oil Contaminated Waters NOT Wastewater | 0 | 0 | 0 | 1 | 0 | 1 |
| High pH/Low pH Waters | 1 | 0 | 0 | 2 | 0 | 0 |
| Spent Sulfite Solution | 1 | 0 | 0 | 0 | 0 | 1 |
| Spent Stretford Solution | 0 | 0 | 0 | 1 | 0 | 0 |
| TSD Leachate (F039) | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Caustics | 21 | 0 | 0 | 22 | 4 | 5 |
| Spent Acids | 0 | 0 | 0 | 0 | 0 | 0 |
| Residual Amines | 0 | 1 | 0 | 2 | 1 | 1 |
| Other Inorganic Residuals NOS | 3 | 2 | 0 | 2 | 1 | 0 |
| Other Residuals NOS | 7 | 6 | 5 | 18 | 1 | 3 |
| | ========== | =============== | ========== | =========== | ============ | ===== |
| | 67 | 102 | 22 | 162 | 46 | 25 |

The SAS System

API ANNUAL REFINING SURVEY
1993

Percent Recycled On-Site and Off-Site

| Waste Stream | Recycled Tons | Percent Recycled On-Site | Percent Recycled Off-Site |
|---|---|---|---|
| API Separator Sludge (K051) | 55,169 | 68 | 32 |
| Dissolved Air Flotation Float (K048) | 147,624 | 68 | 32 |
| Slop Oil Emulsion Solids (K049) | 36,269 | 62 | 38 |
| Leaded Tank Bottoms (K052) | 1,768 | 96 | 4 |
| Pond Sediments | 11,563 | 94 | 6 |
| Nonleaded Tank Bottoms | 36,758 | 97 | 3 |
| Residual Oils/Spent Solvents | 47,495 | 97 | 3 |
| Other Oily Sludges & Organic Wastes | 20,381 | 31 | 69 |
| Primary Sludge (F037) | 30,304 | 81 | 19 |
| Primary Sludge (F038) | 18,119 | 98 | 2 |
| Heat Exchanger Bundle Cleaning Sludge | 1,726 | 92 | 8 |
| Contaminated Soils/Solids | 64,721 | 0 | 100 |
| Residual Coke/Carbon/Charcoal | 45,078 | 1 | 99 |
| Residual Sulfur | 33,599 | 0 | 100 |
| Other Contaminated Soils NOS | 10,732 | 7 | 93 |
| Fluid Cracking Catalyst or Equivalent | 93,902 | 0 | 100 |
| Hydroprocessing Catalysts | 27,581 | 8 | 92 |
| Other Spent Catalysts NOS | 16,398 | 0 | 100 |
| Biomass | 278,488 | 28 | 72 |
| Oil Contaminated Waters NOT Wastewater | 20 | 0 | 100 |
| High pH/Low pH Waters | 83 | 0 | 100 |
| Spent Sulfite Solution | 29,316 | 85 | 15 |
| Spent Stretford Solution | 2,088 | 43 | 57 |
| TSD Leachate (F039) | 0 | 0 | 0 |
| Spent Caustics | 739,098 | 51 | 49 |
| Spent Acids | 53 | 16 | 84 |
| Residual Amines | 1,374 | 45 | 55 |
| Other Inorganic Residuals NOS | 15,219 | 12 | 88 |
| Other Residuals NOS | 8,354 | 7 | 93 |
| | ========== | | |
| | 1,773,280 | | |

API REFINERY RESIDUALS SURVEY
1993

Estimated Residual Quantities Treated and Percent Of Total Amount Managed
By Stream

| Residual Stream | Quantity Treated (Tons) | Percent Treated |
|---|---|---|
| API Separator Sludge (K051) | 105,838 | 63.26 |
| Dissolved Air Flotation Float (K048) | 369,221 | 70.99 |
| Slop Oil Emulsion Solids (K049) | 18,782 | 33.81 |
| Leaded Tank Bottoms (K052) | 1,283 | 41.03 |
| Pond Sediments | 1,296 | 0.90 |
| Nonleaded Tank Bottoms | 13,472 | 10.37 |
| Residual Oils/Spent Solvents | 170 | 0.35 |
| Other Oily Sludges & Organic Wastes | 5,590 | 2.31 |
| Primary Sludge (F037) | 55,978 | 24.78 |
| Primary Sludge (F038) | 39,153 | 62.84 |
| Heat Exchanger Bundle Cleaning Sludge | 1,379 | 28.63 |
| Contaminated Soils/Solids | 24,543 | 3.89 |
| Residual Coke/Carbon/Charcoal | 2,584 | 4.54 |
| Residual Sulfur | 65 | 0.15 |
| Other Contaminated Soils NOS | 746 | 1.93 |
| Fluid Cracking Catalyst or Equivalent | 17 | 0.01 |
| Hydroprocessing Catalysts | 190 | 0.37 |
| Other Spent Catalysts NOS | 198 | 0.68 |
| Biomass | 132,239 | 18.30 |
| Oil Contaminated Waters NOT Wastewater | 21,326 | 80.28 |
| High pH/Low pH Waters | 7,924 | 88.26 |
| Spent Sulfite Solution | 0 | 0 |
| Spent Stretford Solution | 21,233 | 81.11 |
| TSD Leachate (F039) | 21,829 | 55.15 |
| Spent Caustics | 660,646 | 46.07 |
| Spent Acids | 5,144 | 87.26 |
| Residual Amines | 113,176 | 97.88 |
| Other Inorganic Residuals NOS | 40,445 | 16.39 |
| Other Residuals NOS | 950 | 0.67 |
| | ========== | |
| | 1,665,417 | |

API REFINERY RESIDUALS SURVEY
1993

Estimated Residual Quantity Handled By Treatment Techniques For Each Residual Stream
(wet tons)

| Residual Stream | Weathering | Chemical | Heat | Impoundment | Physical | Waste water Treatment | Incineration | Stabilization and/or Fixation | Other |
|---|---|---|---|---|---|---|---|---|---|
| API Separator Sludge (K051) | 0 | 0 | 662 | 0 | 19,138 | 74,073 | 11,965 | 0 | 0 |
| Dissolved Air Flotation Float (K048) | 0 | 0 | 6,145 | 0 | 329 | 338,268 | 24,479 | 0 | 0 |
| Slop Oil Emulsion Solids (K049) | 0 | 0 | 4,671 | 0 | 176 | 11,808 | 2,127 | 0 | 0 |
| Leaded Tank Bottoms (K052) | 0 | 0 | 0 | 0 | 0 | 1,025 | 258 | 0 | 0 |
| Pond Sediments | 0 | 0 | 0 | 0 | 0 | 1,246 | 50 | 0 | 0 |
| Nonleaded Tank Bottoms | 0 | 0 | 0 | 0 | 0 | 12,099 | 426 | 947 | 0 |
| Residual Oils/Spent Solvents | 22 | 0 | 0 | 0 | 5 | 34 | 26 | 82 | 1 |
| Other Oily Sludges & Organic Wastes | 0 | 0 | 0 | 0 | 0 | 5,400 | 190 | 0 | 0 |
| Primary Sludge (F037) | 0 | 53 | 31 | 0 | 7,941 | 44,725 | 3,228 | 0 | 0 |
| Primary Sludge (F038) | 0 | 0 | 0 | 0 | 0 | 38,607 | 546 | 0 | 0 |
| Heat Exchanger Bundle Cleaning Sludge | 0 | 0 | 2 | 0 | 0 | 323 | 1,051 | 0 | 3 |
| Contaminated Soils/Solids | 25 | 141 | 17,593 | 0 | 0 | 0 | 3,168 | 274 | 3,342 |
| Residual Coke/Carbon/Charcoal | 0 | 43 | 0 | 0 | 0 | 2,516 | 15 | 10 | 0 |
| Residual Sulfur | 0 | 65 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other Contaminated Soils NOS | 3 | 40 | 0 | 0 | 0 | 0 | 658 | 43 | 2 |
| Fluid Cracking Catalyst or Equivalent | 0 | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 0 |
| Hydroprocessing Catalysts | 0 | 0 | 0 | 0 | 0 | 0 | 188 | 0 | 2 |
| Other Spent Catalysts NOS | 0 | 165 | 0 | 0 | 0 | 0 | 33 | 0 | 0 |
| Biomass | 5,694 | 0 | 0 | 0 | 12,022 | 33,887 | 80,636 | 0 | 0 |
| Oil Contaminated Waters NOT Wastewater | 0 | 0 | 0 | 0 | 0 | 21,326 | 0 | 0 | 0 |
| High pH/Low pH Waters | 0 | 967 | 0 | 0 | 0 | 6,760 | 0 | 197 | 0 |
| Spent Sulfite Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Stretford Solution | 0 | 0 | 0 | 0 | 0 | 21,233 | 0 | 0 | 0 |
| TSD Leachate (F039) | 0 | 0 | 0 | 0 | 0 | 21,829 | 0 | 0 | 0 |
| Spent Caustics | 0 | 27 | 0 | 0 | 0 | 660,292 | 20 | 0 | 307 |
| Spent Acids | 0 | 0 | 0 | 0 | 0 | 5,142 | 0 | 0 | 2 |
| Residual Amines | 0 | 0 | 0 | 0 | 0 | 112,973 | 203 | 0 | 0 |
| Other Inorganic Residuals NOS | 0 | 876 | 0 | 798 | 0 | 38,701 | 70 | 0 | 0 |
| Other Residuals NOS | 0 | 2 | 0 | 0 | 0 | 16 | 911 | 21 | 0 |
| | ========== | ======== | ======= | =========== | ======== | ========= | ============ | ============= | ======= |
| | 5,744 | 2,379 | 29,104 | 798 | 39,611 | 1452300 | 130,248 | 1,574 | 3,659 |

API REFINERY RESIDUALS SURVEY
1993

Respondent Frequencies For Treatment Techniques For Each Residual Stream

| Residual Stream | Weathering | Chemical | Heat | Impoundment | Physical | Wastewater Treatment | Incineration | Stabilization and/or Fixation | Other |
|---|---|---|---|---|---|---|---|---|---|
| API Separator Sludge (K051) | 0 | 0 | 2 | 0 | 3 | 24 | 27 | 0 | 0 |
| Dissolved Air Flotation Float (K048) | 0 | 0 | 1 | 0 | 2 | 15 | 13 | 0 | 0 |
| Slop Oil Emulsion Solids (K049) | 0 | 0 | 2 | 0 | 1 | 12 | 15 | 0 | 0 |
| Leaded Tank Bottoms (K052) | 0 | 0 | 0 | 0 | 0 | 1 | 7 | 0 | 0 |
| Pond Sediments | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 0 |
| Nonleaded Tank Bottoms | 0 | 0 | 0 | 0 | 0 | 14 | 10 | 1 | 0 |
| Residual Oils/Spent Solvents | 1 | 0 | 0 | 0 | 1 | 2 | 5 | 1 | 1 |
| Other Oily Sludges & Organic Wastes | 0 | 0 | 0 | 0 | 0 | 7 | 13 | 0 | 0 |
| Primary Sludge (F037) | 0 | 1 | 1 | 0 | 2 | 13 | 27 | 0 | 0 |
| Primary Sludge (F038) | 0 | 0 | 0 | 0 | 0 | 6 | 1 | 0 | 0 |
| Heat Exchanger Bundle Cleaning Sludge | 0 | 0 | 1 | 0 | 0 | 6 | 33 | 0 | 1 |
| Contaminated Soils/Solids | 1 | 1 | 4 | 0 | 0 | 0 | 7 | 1 | 3 |
| Residual Coke/Carbon/Charcoal | 0 | 1 | 0 | 0 | 0 | 1 | 3 | 1 | 0 |
| Residual Sulfur | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other Contaminated Soils NOS | 1 | 1 | 0 | 0 | 0 | 0 | 9 | 1 | 1 |
| Fluid Cracking Catalyst or Equivalent | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Hydroprocessing Catalysts | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Other Spent Catalysts NOS | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Biomass | 1 | 0 | 0 | 0 | 1 | 4 | 4 | 0 | 0 |
| Oil Contaminated Waters NOT Wastewater | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 |
| High pH/Low pH Waters | 0 | 5 | 0 | 0 | 0 | 5 | 0 | 1 | 0 |
| Spent Sulfite Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Spent Stretford Solution | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| TSD Leachate (F039) | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Spent Caustics | 0 | 1 | 0 | 0 | 0 | 28 | 1 | 0 | 1 |
| Spent Acids | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 1 |
| Residual Amines | 0 | 0 | 0 | 0 | 0 | 13 | 2 | 0 | 0 |
| Other Inorganic Residuals NOS | 0 | 2 | 0 | 1 | 0 | 6 | 4 | 0 | 0 |
| Other Residuals NOS | 0 | 1 | 0 | 0 | 0 | 1 | 30 | 1 | 0 |
| | 4 | 15 | 11 | 1 | 10 | 176 | 215 | 7 | 9 |

The SAS System

API ANNUAL REFINING SURVEY
1993

Percent Treated On-Site and Off-Site

| Waste Stream | Treated Tons | Percent Treated On-Site | Percent Treated Off-Site |
|---|---|---|---|
| API Separator Sludge (K051) | 105,838 | 89 | 11 |
| Dissolved Air Flotation Float (K048) | 369,220 | 96 | 4 |
| Slop Oil Emulsion Solids (K049) | 18,782 | 89 | 11 |
| Leaded Tank Bottoms (K052) | 1,283 | 80 | 20 |
| Pond Sediments | 1,296 | 96 | 4 |
| Nonleaded Tank Bottoms | 13,472 | 97 | 3 |
| Residual Oils/Spent Solvents | 171 | 71 | 29 |
| Other Oily Sludges & Organic Wastes | 5,590 | 97 | 3 |
| Primary Sludge (F037) | 55,979 | 94 | 6 |
| Primary Sludge (F038) | 39,153 | 99 | 1 |
| Heat Exchanger Bundle Cleaning Sludge | 1,378 | 29 | 71 |
| Contaminated Soils/Solids | 24,543 | 27 | 73 |
| Residual Coke/Carbon/Charcoal | 2,584 | 98 | 2 |
| Residual Sulfur | 65 | 0 | 100 |
| Other Contaminated Soils NOS | 747 | 6 | 94 |
| Fluid Cracking Catalyst or Equivalent | 17 | 100 | 0 |
| Hydroprocessing Catalysts | 190 | 0 | 100 |
| Other Spent Catalysts NOS | 198 | 0 | 100 |
| Biomass | 132,240 | 91 | 9 |
| Oil Contaminated Waters NOT Wastewater | 21,326 | 100 | 0 |
| High pH/Low pH Waters | 7,924 | 92 | 8 |
| Spent Sulfite Solution | 0 | 0 | 0 |
| Spent Stretford Solution | 21,233 | 73 | 27 |
| TSD Leachate (F039) | 21,829 | 100 | 0 |
| Spent Caustics | 660,647 | 99 | 1 |
| Spent Acids | 5,144 | 97 | 3 |
| Residual Amines | 113,175 | 100 | 0 |
| Other Inorganic Residuals NOS | 40,445 | 98 | 2 |
| Other Residuals NOS | 950 | 18 | 82 |
| | ========== | | |
| | 1,665,419 | | |

API REFINERY RESIDUALS SURVEY
1993

Estimated Residual Quantities Land Treated and Percent Of Total Amount Managed
By Stream

| Residual Stream | Quantity Land Treated (Tons) | Percent Land Treated |
|---|---|---|
| API Separator Sludge (K051) | 1,320 | 0.79 |
| Dissolved Air Flotation Float (K048) | 1,616 | 0.31 |
| Slop Oil Emulsion Solids (K049) | 0 | 0.00 |
| Leaded Tank Bottoms (K052) | 0 | 0.00 |
| Pond Sediments | 20,488 | 14.16 |
| Nonleaded Tank Bottoms | 14,215 | 10.94 |
| Residual Oils/Spent Solvents | 217 | 0.45 |
| Other Oily Sludges & Organic Wastes | 35,837 | 14.81 |
| Primary Sludge (F037) | 116,192 | 51.44 |
| Primary Sludge (F038) | 0 | 0.00 |
| Heat Exchanger Bundle Cleaning Sludge | 0 | 0.00 |
| Contaminated Soils/Solids | 141,872 | 22.48 |
| Residual Coke/Carbon/Charcoal | 107 | 0.19 |
| Residual Sulfur | 230 | 0.52 |
| Other Contaminated Soils NOS | 2,141 | 5.54 |
| Fluid Cracking Catalyst or Equivalent | 3,816 | 1.93 |
| Hydroprocessing Catalysts | 0 | 0.00 |
| Other Spent Catalysts NOS | 452 | 1.55 |
| Biomass | 142,826 | 19.77 |
| Oil Contaminated Waters NOT Wastewater | 220 | 0.83 |
| High pH/Low pH Waters | 35 | 0.39 |
| Spent Sulfite Solution | 0 | 0.00 |
| Spent Stretford Solution | 0 | 0.00 |
| TSD Leachate (F039) | 0 | 0.00 |
| Spent Caustics | 0 | 0.00 |
| Spent Acids | 0 | 0.00 |
| Residual Amines | 0 | 0.00 |
| Other Inorganic Residuals NOS | 14,941 | 6.05 |
| Other Residuals NOS | 0 | 0.00 |
| | ========== | |
| | 496,525 | |

API REFINERY RESIDUALS SURVEY
1993

Respondent Frequencies For Land Treatment For Each Residual Stream

| Residual Stream | Land Treatment |
|---|---|
| 0 | 16 |
| API Separator Sludge (K051) | 1 |
| Dissolved Air Flotation Float (K048) | 1 |
| Pond Sediments | 4 |
| Nonleaded Tank Bottoms | 15 |
| Residual Oils/Spent Solvents | 1 |
| Other Oily Sludges & Organic Wastes | 7 |
| Primary Sludge (F037) | 14 |
| Contaminated Soils/Solids | 16 |
| Residual Coke/Carbon/Charcoal | 5 |
| Residual Sulfur | 1 |
| Other Contaminated Soils NOS | 10 |
| Fluid Cracking Catalyst or Equivalent | 4 |
| Other Spent Catalysts NOS | 2 |
| Biomass | 14 |
| Oil Contaminated Waters NOT Wastewater | 1 |
| High pH/Low pH Waters | 1 |
| Other Inorganic Residuals NOS | 14 |
| | ========= |
| | 127 |

The SAS System

API ANNUAL REFINING SURVEY
1993

Percent Land Treated On-Site and Off-Site

| Waste Stream | Land Treated Tons | Percent Land Treated On-Site | Percent Land Treated Off-Site |
|---|---|---|---|
| API Separator Sludge (K051) | 1,320 | 100 | 0 |
| Dissolved Air Flotation Float (K048) | 1,616 | 100 | 0 |
| Slop Oil Emulsion Solids (K049) | 0 | 0 | 0 |
| Leaded Tank Bottoms (K052) | 0 | 0 | 0 |
| Pond Sediments | 20,488 | 100 | 0 |
| Nonleaded Tank Bottoms | 14,215 | 82 | 18 |
| Residual Oils/Spent Solvents | 217 | 100 | 0 |
| Other Oily Sludges & Organic Wastes | 35,837 | 100 | 0 |
| Primary Sludge (F037) | 116,192 | 97 | 3 |
| Primary Sludge (F038) | 0 | 0 | 0 |
| Heat Exchanger Bundle Cleaning Sludge | 0 | 0 | 0 |
| Contaminated Soils/Solids | 141,872 | 94 | 6 |
| Residual Coke/Carbon/Charcoal | 107 | 99 | 1 |
| Residual Sulfur | 230 | 100 | 0 |
| Other Contaminated Soils NOS | 2,141 | 97 | 3 |
| Fluid Cracking Catalyst or Equivalent | 3,816 | 0 | 100 |
| Hydroprocessing Catalysts | 0 | 0 | 0 |
| Other Spent Catalysts NOS | 452 | 100 | 0 |
| Biomass | 142,826 | 86 | 14 |
| Oil Contaminated Waters NOT Wastewater | 220 | 100 | 0 |
| High pH/Low pH Waters | 35 | 100 | 0 |
| Spent Sulfite Solution | 0 | 0 | 0 |
| Spent Stretford Solution | 0 | 0 | 0 |
| TSD Leachate (F039) | 0 | 0 | 0 |
| Spent Caustics | 0 | 0 | 0 |
| Spent Acids | 0 | 0 | 0 |
| Residual Amines | 0 | 0 | 0 |
| Other Inorganic Residuals NOS | 14,941 | 98 | 2 |
| Other Residuals NOS | 0 | 0 | 0 |
| | ========== | | |
| | 496,525 | | |

API REFINERY RESIDUALS SURVEY
1993

Estimated Residual Quantities Disposed and Percent Of Total Amount Managed
By Stream

| Waste Stream | Quantity Disposed (Tons) | Percent Disposed |
|---|---|---|
| API Separator Sludge (K051) | 4,970 | 2.97 |
| Dissolved Air Flotation Float (K048) | 1,656 | 0.32 |
| Slop Oil Emulsion Solids (K049) | 503 | 0.91 |
| Leaded Tank Bottoms (K052) | 75 | 2.40 |
| Pond Sediments | 111,314 | 76.95 |
| Nonleaded Tank Bottoms | 65,473 | 50.40 |
| Residual Oils/Spent Solvents | 179 | 0.37 |
| Other Oily Sludges & Organic Wastes | 180,223 | 74.46 |
| Primary Sludge (F037) | 23,411 | 10.36 |
| Primary Sludge (F038) | 5,036 | 8.08 |
| Heat Exchanger Bundle Cleaning Sludge | 1,712 | 35.54 |
| Contaminated Soils/Solids | 399,986 | 63.38 |
| Residual Coke/Carbon/Charcoal | 9,103 | 16.01 |
| Residual Sulfur | 10,016 | 22.81 |
| Other Contaminated Soils NOS | 25,041 | 64.77 |
| Fluid Cracking Catalyst or Equivalent | 99,558 | 50.46 |
| Hydroprocessing Catalysts | 23,924 | 46.28 |
| Other Spent Catalysts NOS | 12,198 | 41.71 |
| Biomass | 168,871 | 23.38 |
| Oil Contaminated Waters NOT Wastewater | 4,997 | 18.81 |
| High pH/Low pH Waters | 935 | 10.41 |
| Spent Sulfite Solution | 0 | 0 |
| Spent Stretford Solution | 2,856 | 10.91 |
| TSD Leachate (F039) | 17,753 | 44.85 |
| Spent Caustics | 34,384 | 2.40 |
| Spent Acids | 698 | 11.84 |
| Residual Amines | 1,082 | 0.94 |
| Other Inorganic Residuals NOS | 176,233 | 71.40 |
| Other Residuals NOS | 133,335 | 93.48 |
| | ========== | |
| | 1,515,522 | |

API REFINERY RESIDUALS SURVEY
1993

Estimated Residual Quantity Handled by Disposal Techniques for Each Residual Stream
(wet tons)

| Residual Stream | Disposal Impoundment | Landfill | Landspread | Injection | Other |
|---|---|---|---|---|---|
| API Separator Sludge (K051) | 0 | 4,741 | 0 | 0 | 229 |
| Dissolved Air Flotation Float (K048) | 0 | 1,656 | 0 | 0 | 0 |
| Slop Oil Emulsion Solids (K049) | 0 | 480 | 0 | 0 | 23 |
| Leaded Tank Bottoms (K052) | 0 | 70 | 0 | 0 | 5 |
| Pond Sediments | 0 | 111,314 | 0 | 0 | 0 |
| Nonleaded Tank Bottoms | 68 | 60,512 | 4,882 | 0 | 11 |
| Residual Oils/Spent Solvents | 32 | 142 | 0 | 0 | 5 |
| Other Oily Sludges & Organic Wastes | 0 | 180,221 | 0 | 0 | 2 |
| Primary Sludge (F037) | 1,602 | 21,343 | 76 | 0 | 390 |
| Primary Sludge (F038) | 0 | 5,014 | 0 | 0 | 22 |
| Heat Exchanger Bundle Cleaning Sludge | 0 | 1,705 | 0 | 0 | 7 |
| Contaminated Soils/Solids | 0 | 343,083 | 56,901 | 0 | 2 |
| Residual Coke/Carbon/Charcoal | 0 | 8,894 | 209 | 0 | 0 |
| Residual Sulfur | 0 | 10,015 | 0 | 0 | 1 |
| Other Contaminated Soils NOS | 0 | 24,433 | 608 | 0 | 0 |
| Fluid Cracking Catalyst or Equivalent | 18,017 | 81,098 | 410 | 0 | 33 |
| Hydroprocessing Catalysts | 105 | 23,786 | 0 | 0 | 33 |
| Other Spent Catalysts NOS | 0 | 12,198 | 0 | 0 | 0 |
| Biomass | 0 | 67,790 | 101,081 | 0 | 0 |
| Oil Contaminated Waters NOT Wastewater | 25 | 0 | 4,972 | 0 | 0 |
| High pH/Low pH Waters | 0 | 95 | 0 | 840 | 0 |
| Spent Sulfite Solution | 0 | 0 | 0 | 0 | 0 |
| Spent Stretford Solution | 0 | 2,856 | 0 | 0 | 0 |
| TSD Leachate (F039) | 17,753 | 0 | 0 | 0 | 0 |
| Spent Caustics | 0 | 0 | 0 | 33,908 | 476 |
| Spent Acids | 0 | 0 | 0 | 698 | 0 |
| Residual Amines | 4 | 132 | 0 | 938 | 8 |
| Other Inorganic Residuals NOS | 4,947 | 170,046 | 1,240 | 0 | 0 |
| Other Residuals NOS | 0 | 133,275 | 60 | 0 | 0 |
| | =========== | ========== | ========== | ========== | ========== |
| | 42,553 | 1,264,899 | 170,439 | 36,384 | 1,247 |

API REFINERY RESIDUALS SURVEY
1993

Respondent Frequencies for Disposal Techniques for Each Residual Stream

| Residual Stream | Disposal Impoundment | Landfill | Landspread | Injection | Other |
|---|---|---|---|---|---|
| API Separator Sludge (K051) | 0 | 15 | 0 | 0 | 4 |
| Dissolved Air Flotation Float (K048) | 0 | 4 | 0 | 0 | 0 |
| Slop Oil Emulsion Solids (K049) | 0 | 4 | 0 | 0 | 1 |
| Leaded Tank Bottoms (K052) | 0 | 3 | 0 | 0 | 1 |
| Pond Sediments | 0 | 8 | 0 | 0 | 0 |
| Nonleaded Tank Bottoms | 1 | 52 | 1 | 0 | 1 |
| Residual Oils/Spent Solvents | 1 | 2 | 0 | 0 | 1 |
| Other Oily Sludges & Organic Wastes | 0 | 32 | 0 | 0 | 1 |
| Primary Sludge (F037) | 1 | 38 | 1 | 0 | 3 |
| Primary Sludge (F038) | 0 | 6 | 0 | 0 | 1 |
| Heat Exchanger Bundle Cleaning Sludge | 0 | 8 | 0 | 0 | 2 |
| Contaminated Soils/Solids | 0 | 70 | 4 | 0 | 1 |
| Residual Coke/Carbon/Charcoal | 0 | 33 | 2 | 0 | 0 |
| Residual Sulfur | 0 | 30 | 0 | 0 | 1 |
| Other Contaminated Soils NOS | 0 | 44 | 2 | 0 | 0 |
| Fluid Cracking Catalyst or Equivalent | 2 | 40 | 1 | 0 | 1 |
| Hydroprocessing Catalysts | 1 | 18 | 0 | 0 | 1 |
| Other Spent Catalysts NOS | 0 | 42 | 0 | 0 | 0 |
| Biomass | 0 | 23 | 4 | 0 | 0 |
| Oil Contaminated Waters NOT Wastewater | 1 | 0 | 1 | 0 | 0 |
| High pH/Low pH Waters | 0 | 1 | 0 | 1 | 0 |
| Spent Sulfite Solution | 0 | 0 | 0 | 0 | 0 |
| Spent Stretford Solution | 0 | 3 | 0 | 0 | 0 |
| TSD Leachate (F039) | 1 | 0 | 0 | 0 | 0 |
| Spent Caustics | 0 | 0 | 0 | 8 | 1 |
| Spent Acids | 0 | 0 | 0 | 1 | 0 |
| Residual Amines | 1 | 4 | 0 | 2 | 2 |
| Other Inorganic Residuals NOS | 2 | 40 | 2 | 0 | 0 |
| Other Residuals NOS | 0 | 72 | 1 | 0 | 0 |
| | =========== | ======== | ========== | ========= | ===== |
| | 11 | 592 | 19 | 12 | 22 |

The SAS System

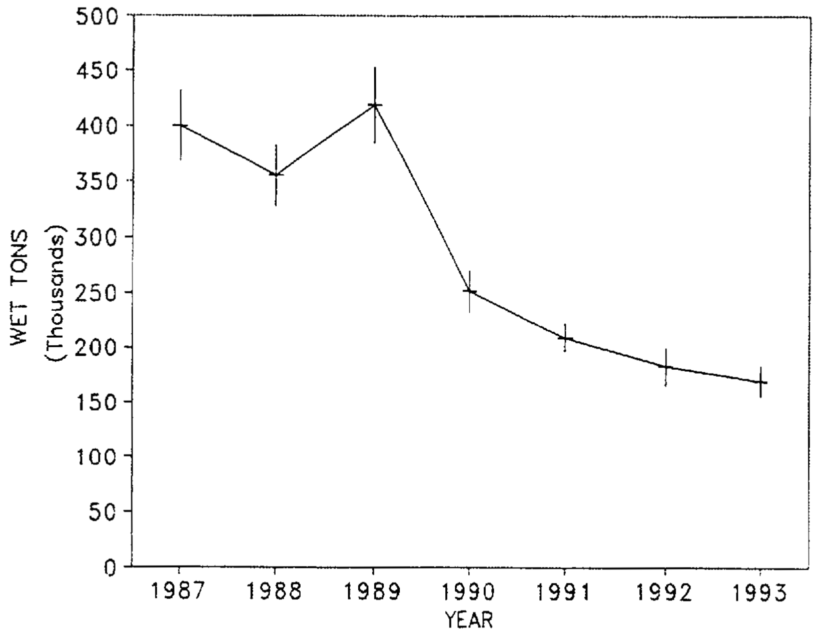
API ANNUAL REFINING SURVEY
1993

Percent Disposed On-Site and Off-Site

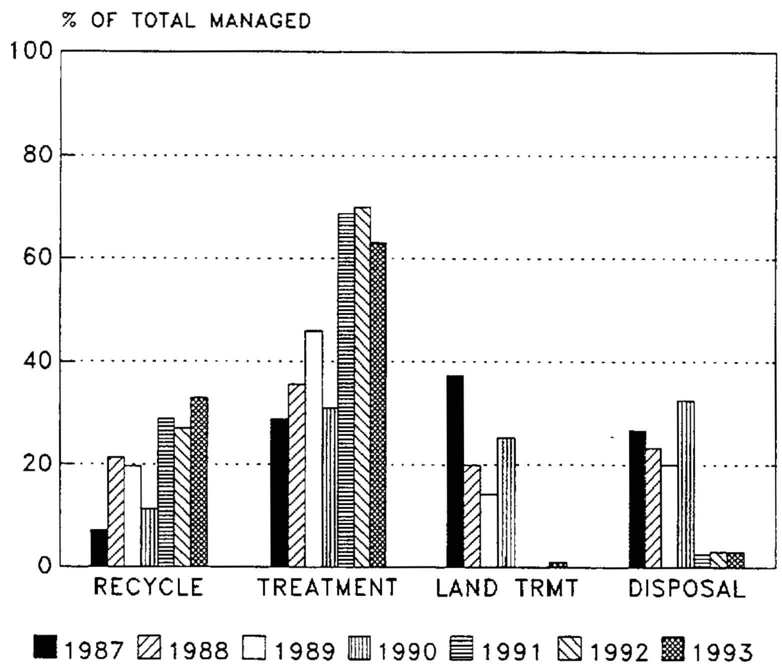
| Waste Stream | Disposed Tons | Percent Disposed On-Site | Percent Disposed Off-Site |
|---|---|---|---|
| API Separator Sludge (K051) | 4,970 | 0 | 100 |
| Dissolved Air Flotation Float (K048) | 1,656 | 0 | 100 |
| Slop Oil Emulsion Solids (K049) | 503 | 0 | 100 |
| Leaded Tank Bottoms (K052) | 75 | 0 | 100 |
| Pond Sediments | 111,314 | 0 | 100 |
| Nonleaded Tank Bottoms | 65,473 | 9 | 91 |
| Residual Oils/Spent Solvents | 178 | 18 | 82 |
| Other Oily Sludges & Organic Wastes | 180,223 | 98 | 2 |
| Primary Sludge (F037) | 23,412 | 8 | 92 |
| Primary Sludge (F038) | 5,036 | 86 | 14 |
| Heat Exchanger Bundle Cleaning Sludge | 1,711 | 0 | 100 |
| Contaminated Soils/Solids | 399,986 | 19 | 81 |
| Residual Coke/Carbon/Charcoal | 9,103 | 14 | 86 |
| Residual Sulfur | 10,016 | 2 | 98 |
| Other Contaminated Soils NOS | 25,041 | 8 | 92 |
| Fluid Cracking Catalyst or Equivalent | 99,558 | 38 | 62 |
| Hydroprocessing Catalysts | 23,924 | 21 | 79 |
| Other Spent Catalysts NOS | 12,198 | 22 | 78 |
| Biomass | 168,870 | 66 | 34 |
| Oil Contaminated Waters NOT Wastewater | 4,997 | 100 | 0 |
| High pH/Low pH Waters | 935 | 0 | 100 |
| Spent Sulfite Solution | 0 | 0 | 0 |
| Spent Stretford Solution | 2,856 | 0 | 100 |
| TSD Leachate (F039) | 17,753 | 100 | 0 |
| Spent Caustics | 34,384 | 62 | 38 |
| Spent Acids | 698 | 0 | 100 |
| Residual Amines | 1,083 | 46 | 54 |
| Other Inorganic Residuals NOS | 176,232 | 9 | 91 |
| Other Residuals NOS | 133,335 | 14 | 86 |
| | ========== | | |
| | 1,515,520 | | |

# APPENDIX C
## Trend Data on Generation and Management Practices (by Stream)

# API Separator Sludge

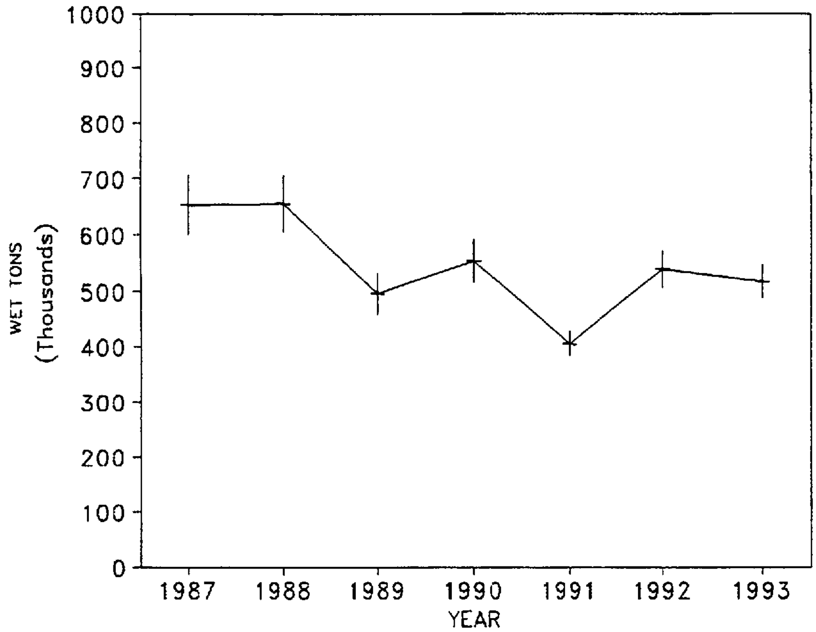



## Generation

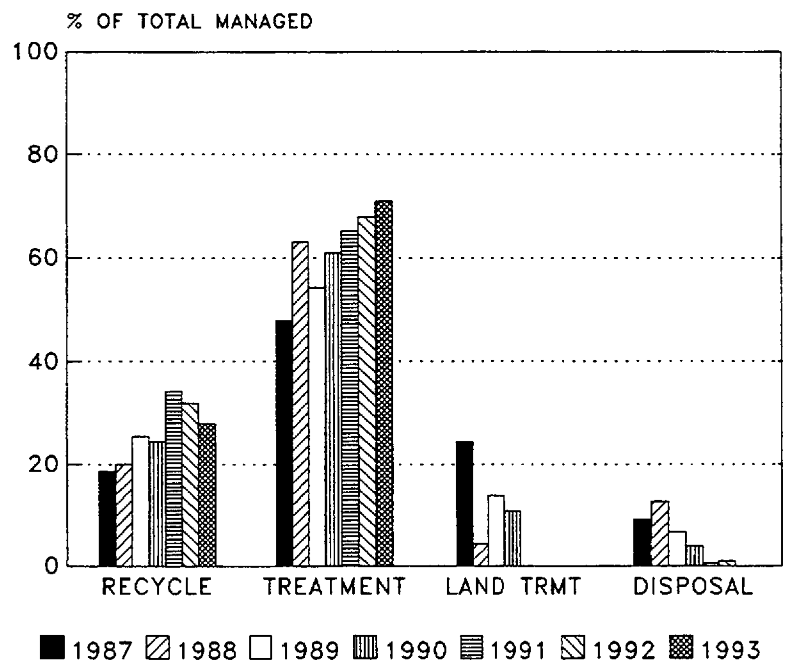



## Management

# Dissolved Air Flotation Float

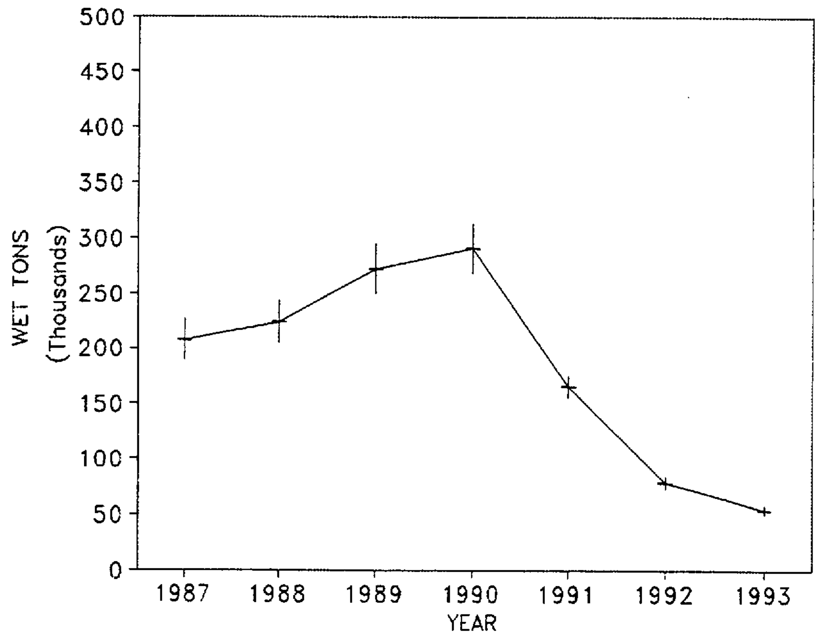



## Generation

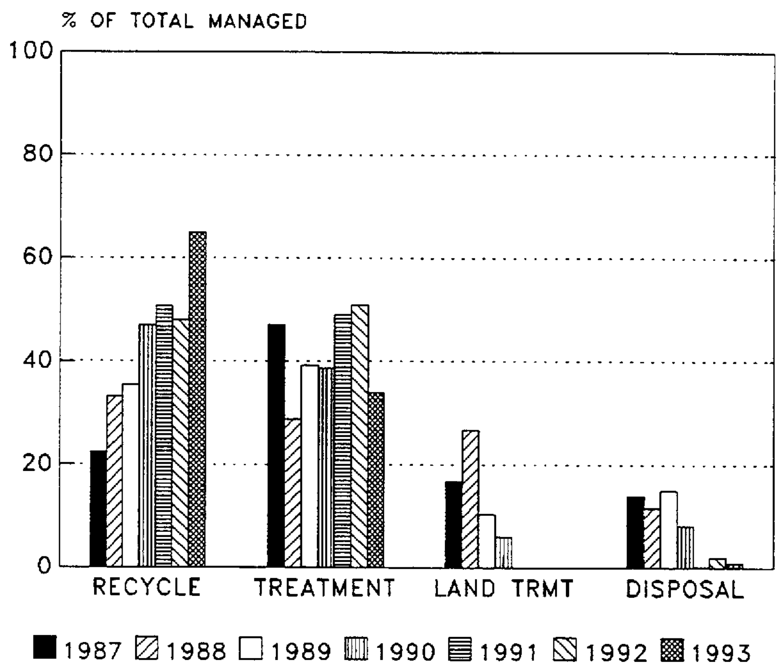



## Management

# Slop Oil Emulsion Solids

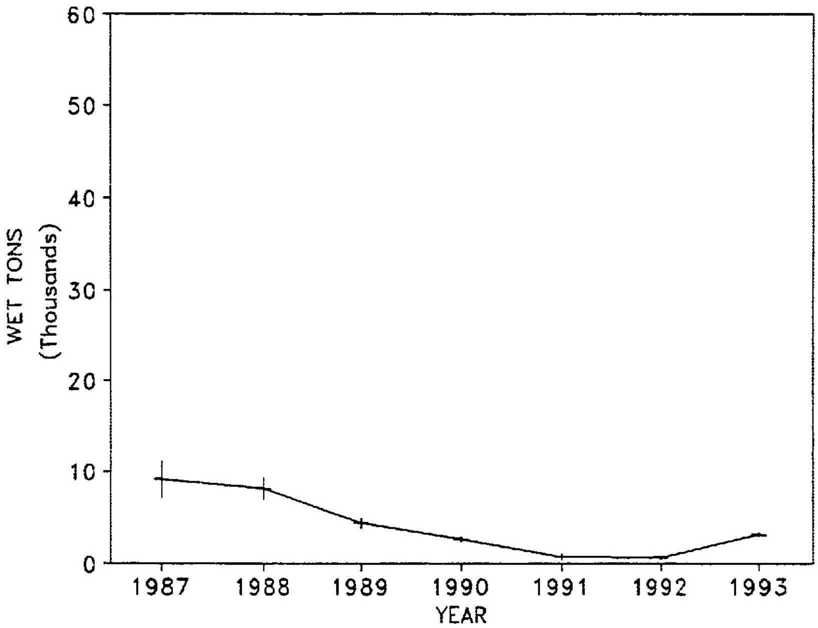



## Generation

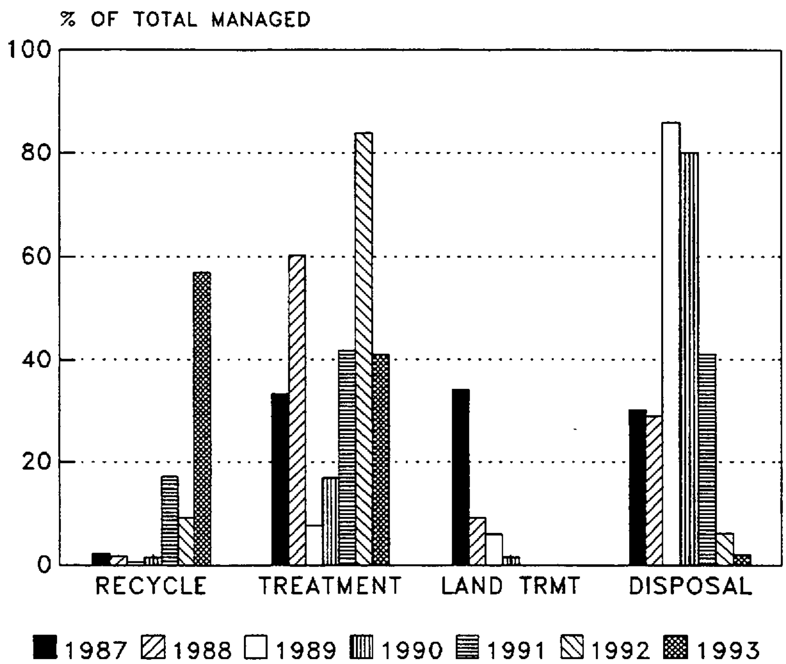



## Management

# Leaded Tank Bottoms

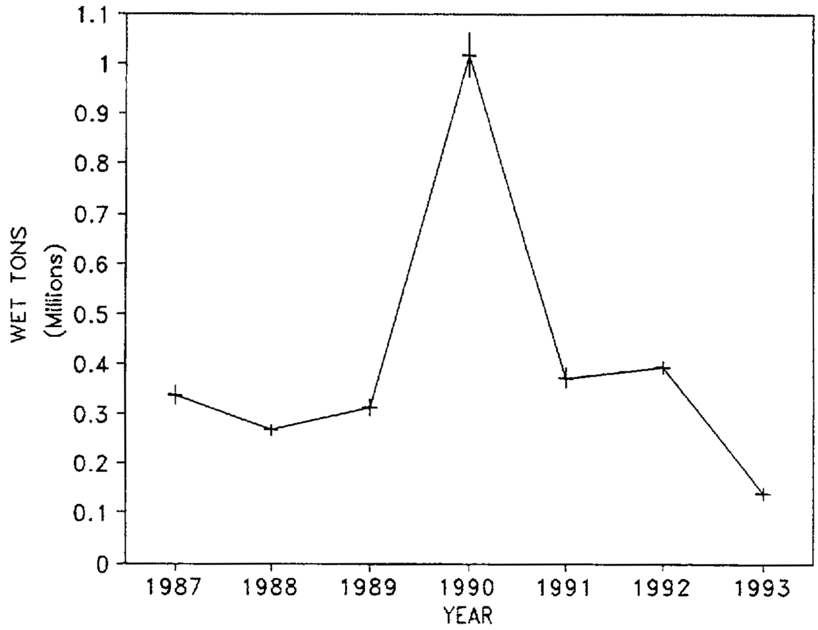



## Generation

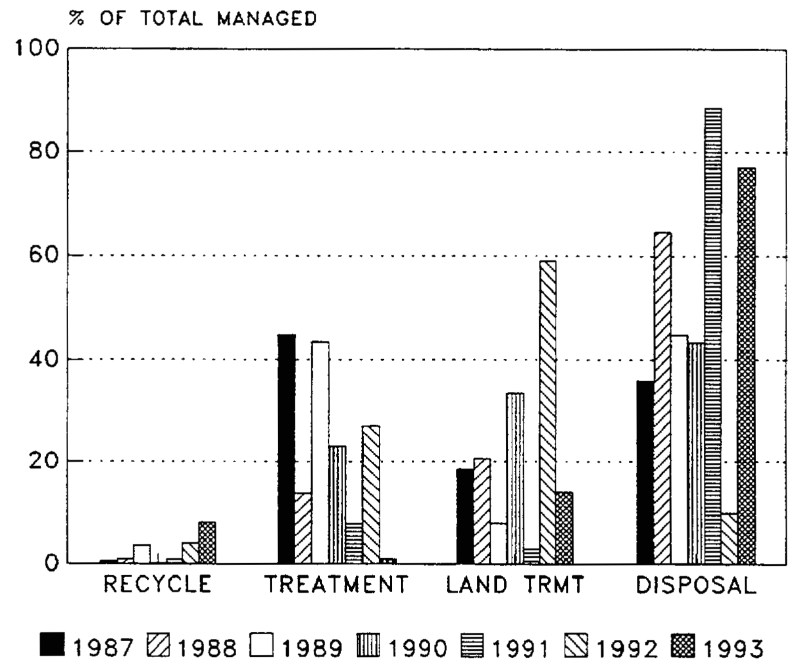



## Management

# Pond Sediments

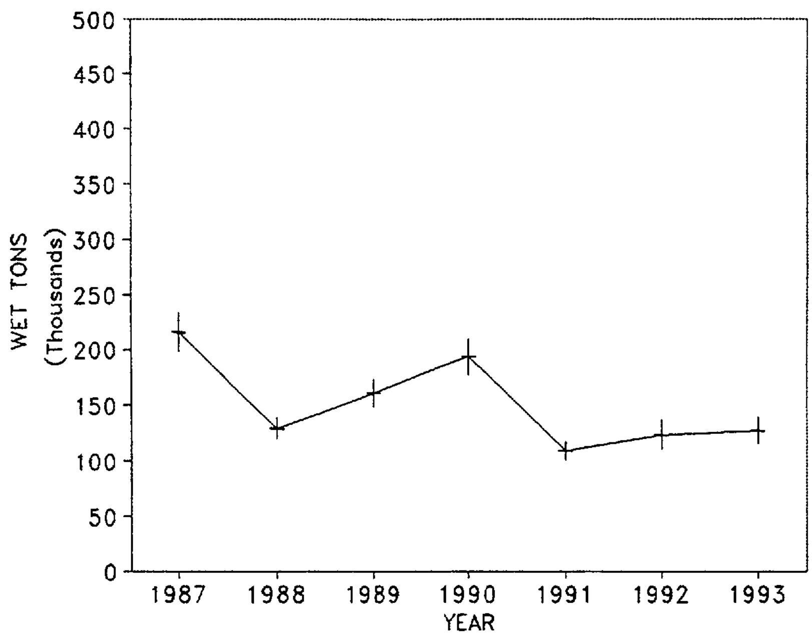



## Generation

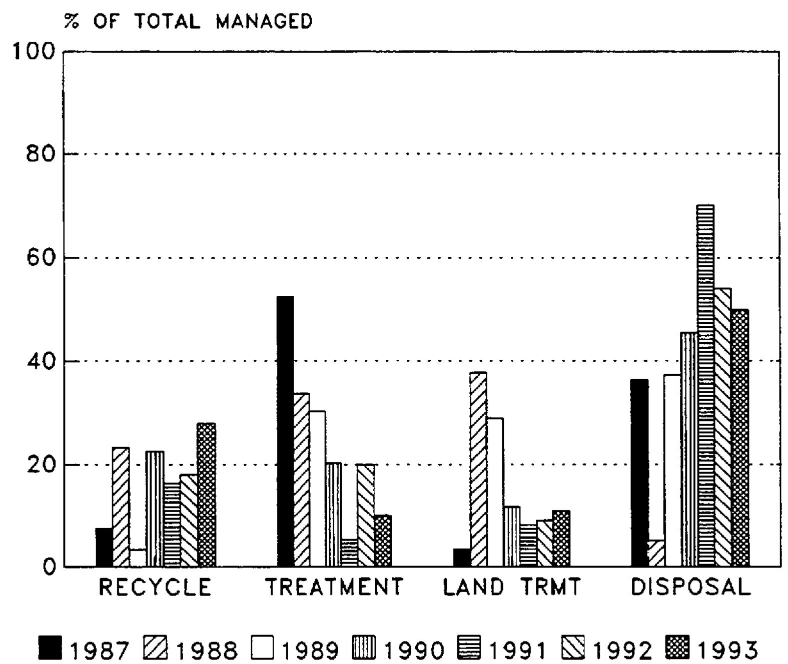



## Management

# Nonleaded Tank Bottoms

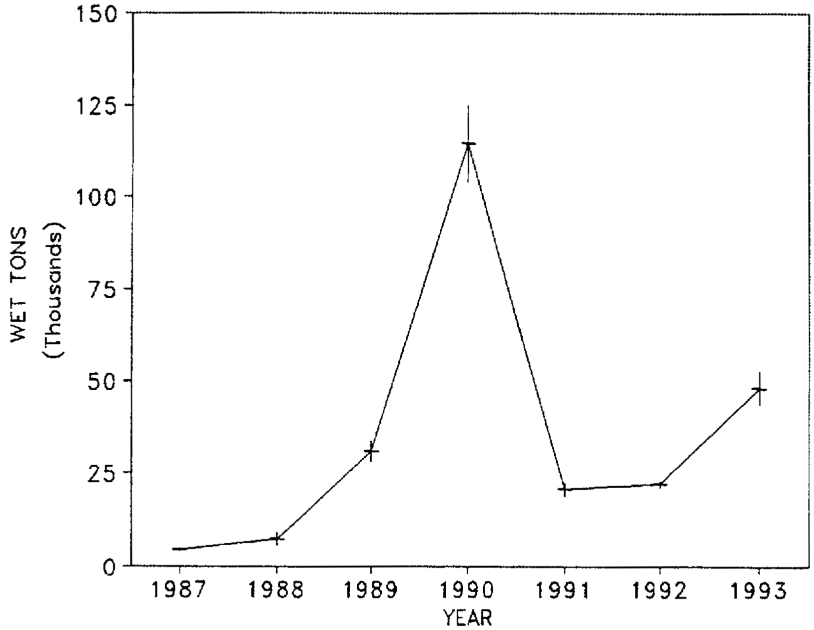



## Generation

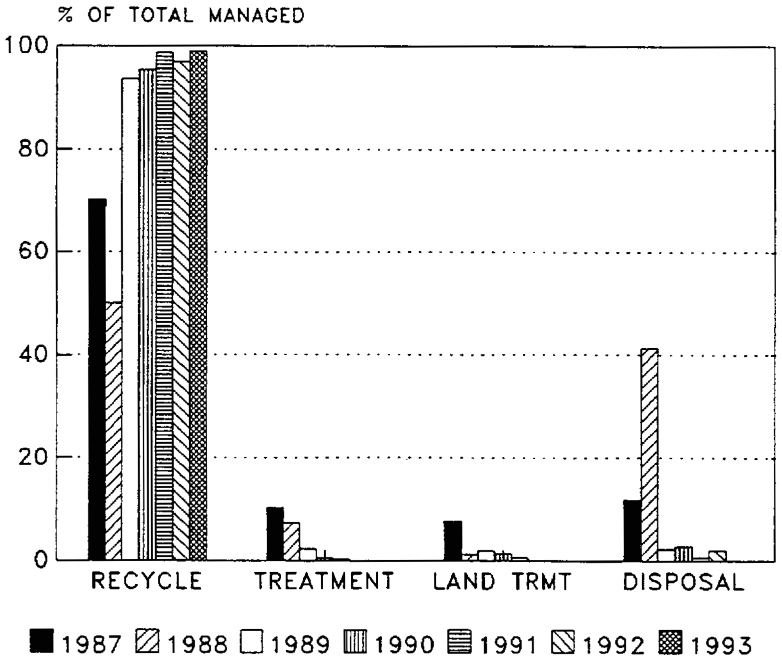



## Management

# Residual Oils/Spent Solvents

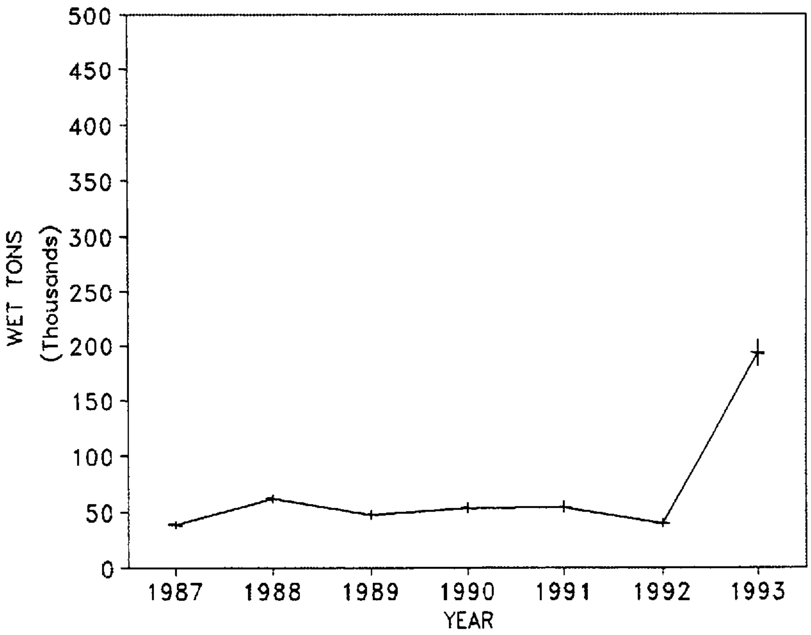



## Generation

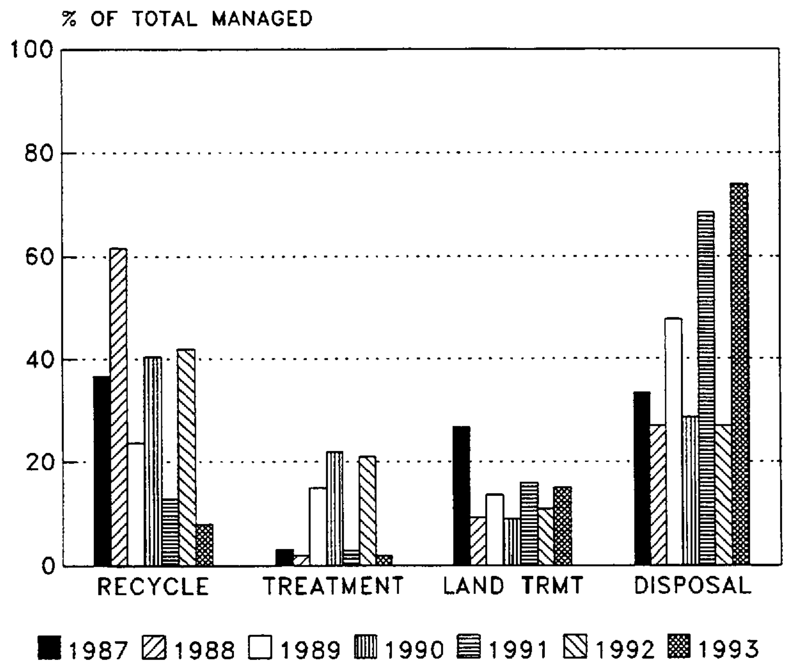



## Management

# Other Oily Sludges and Organic Residuals

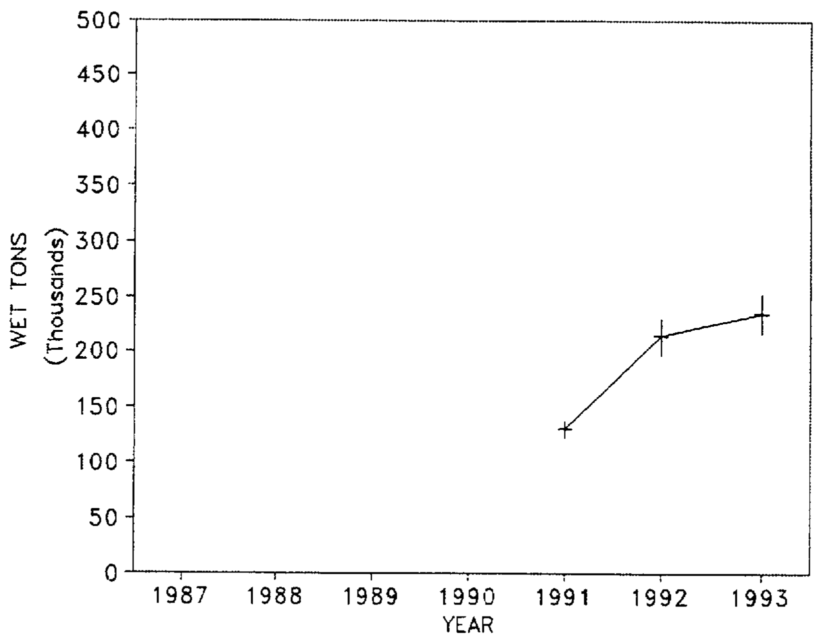



## Generation

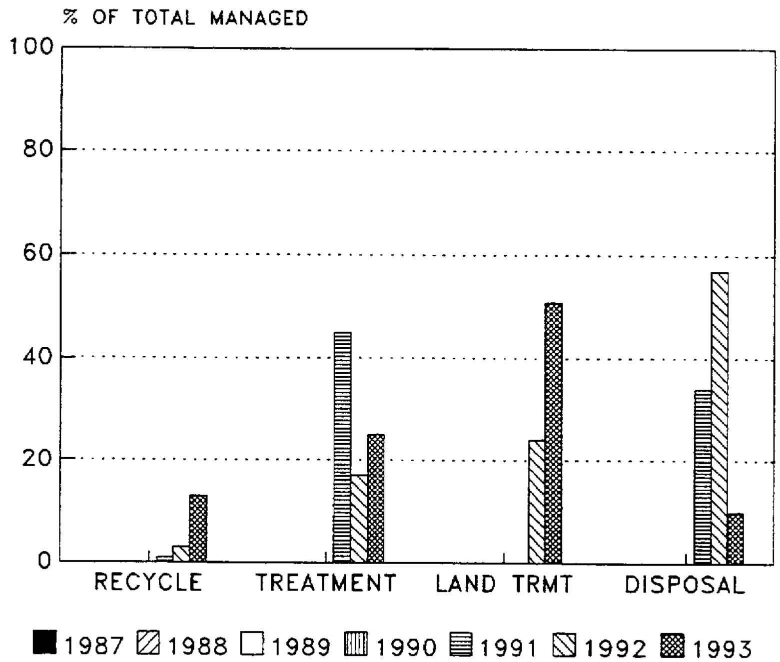



## Management

# Primary Sludge (F037)

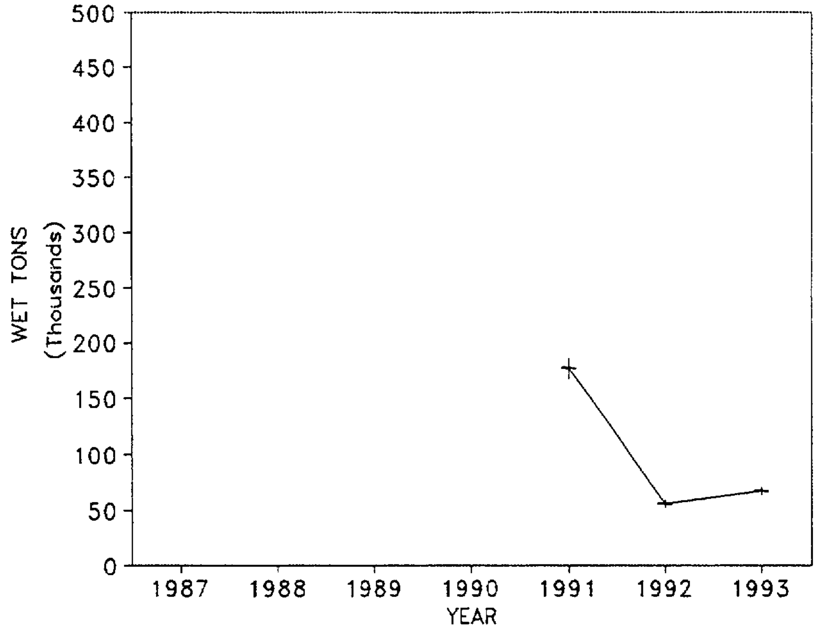



## Generation

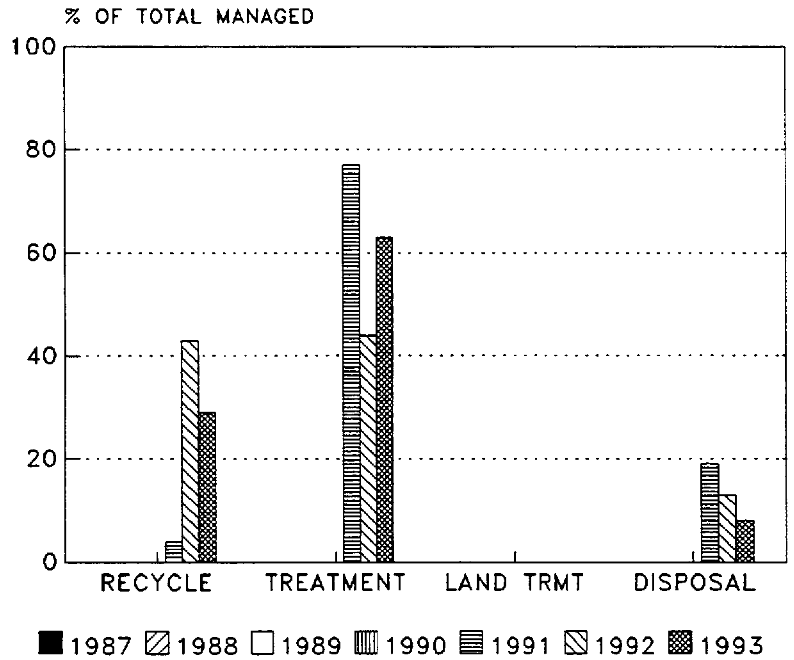



## Management

# Primary Sludge (F038)

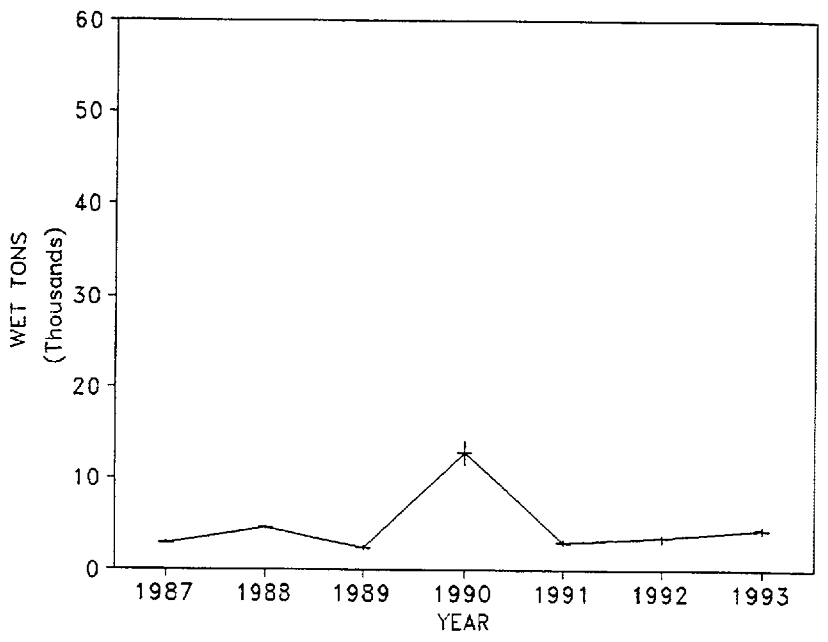



## Generation

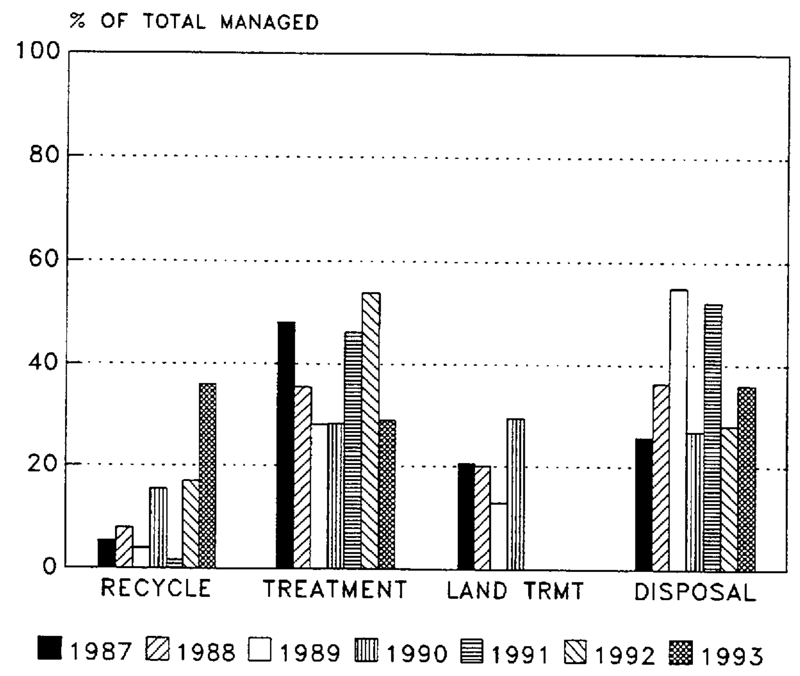



## Management

# Heat Exchanger Bundle Cleaning Sludge

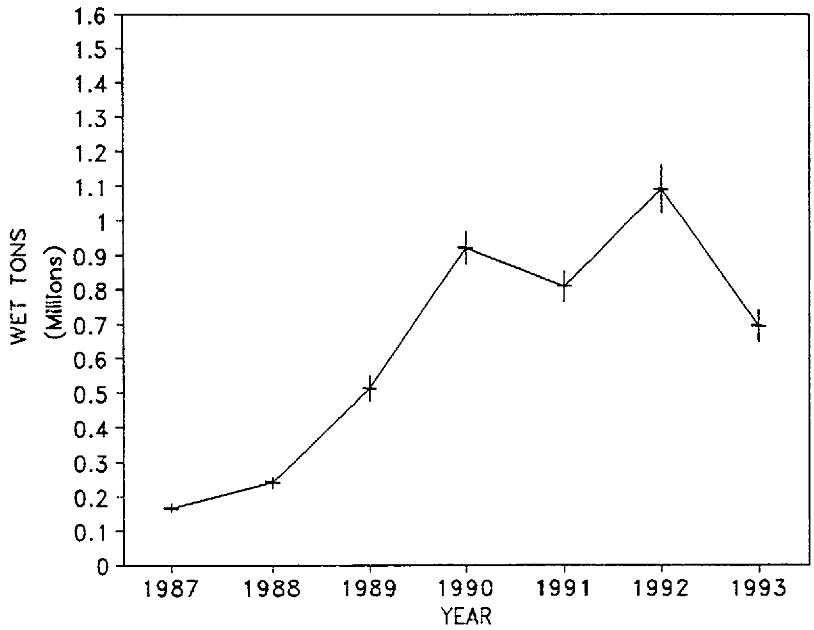



## Generation

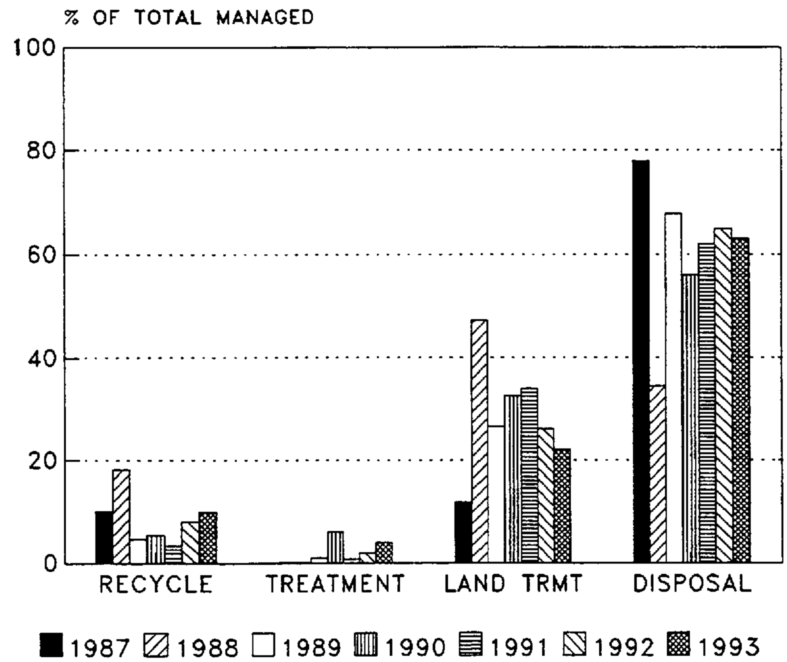



## Management

# Contaminated Soil/Solids

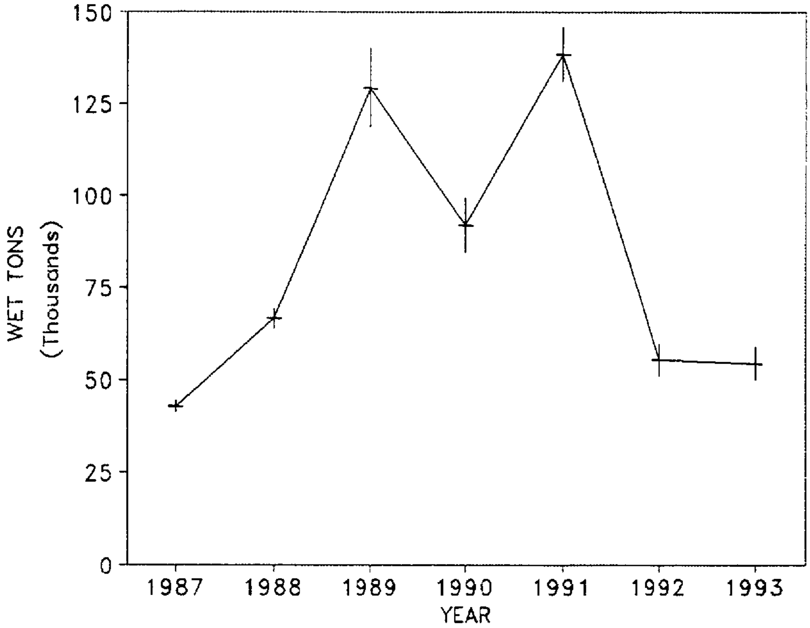



## Generation




## Management

# Residual Coke/Carbon/Charcoal

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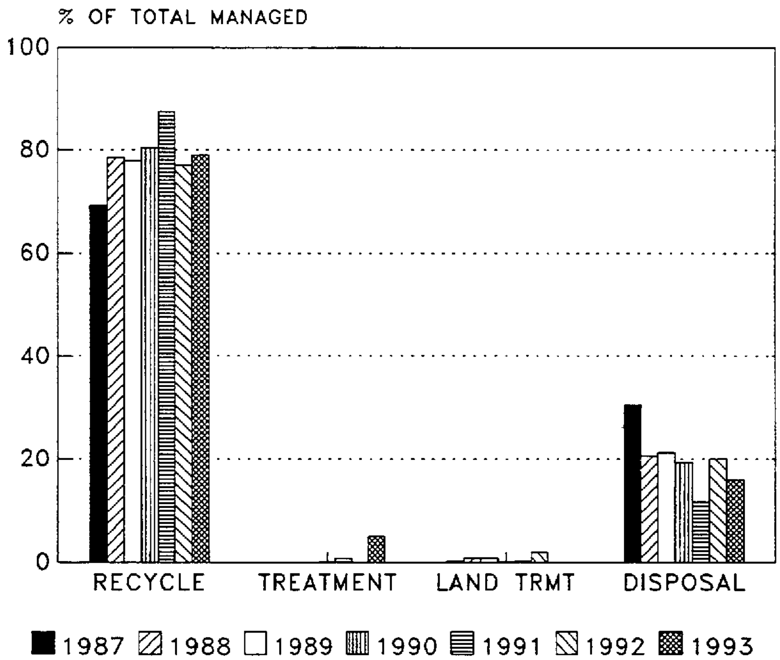
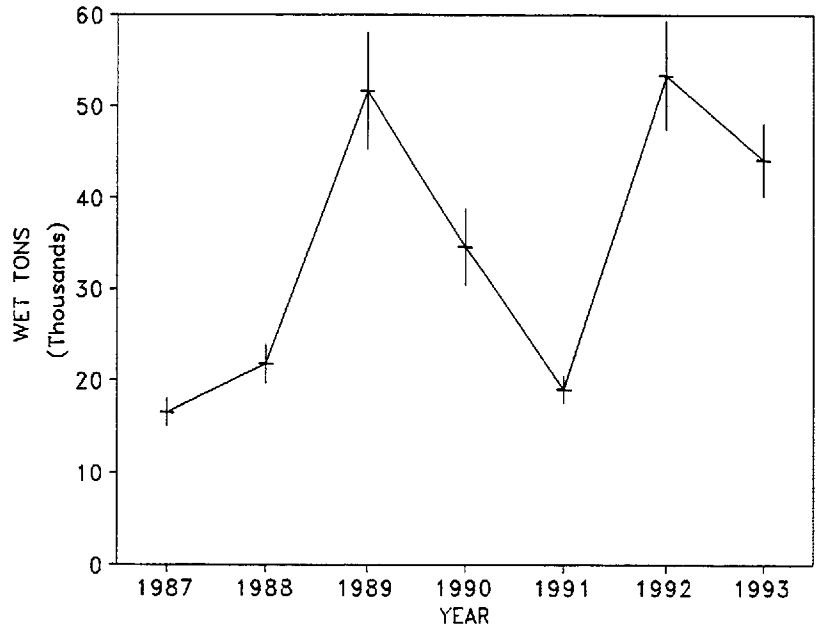



## Management

# Residual Sulfur

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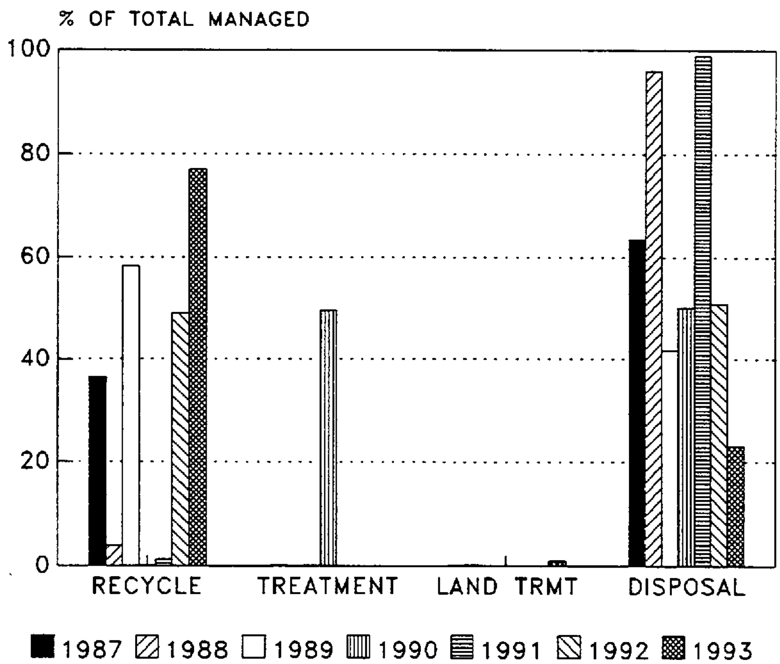
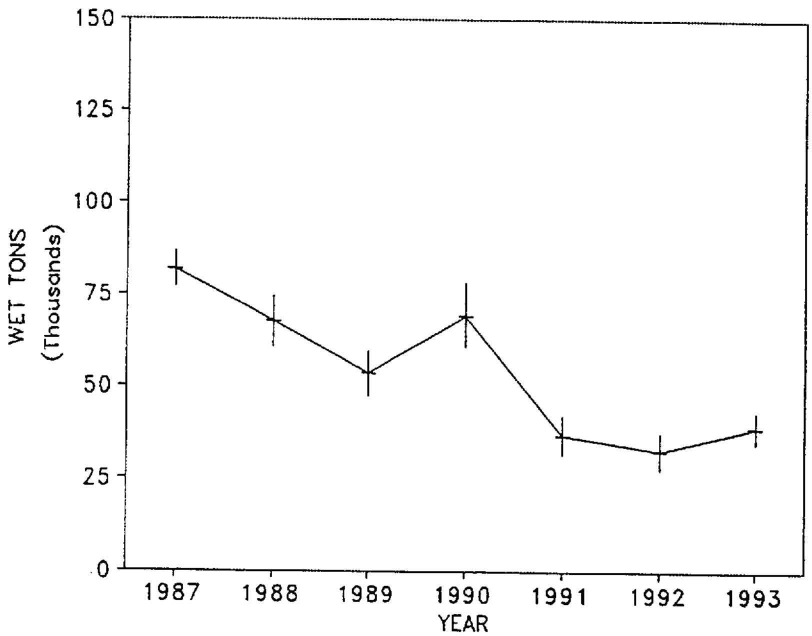



## Management

# Other Contaminated Soils NOS

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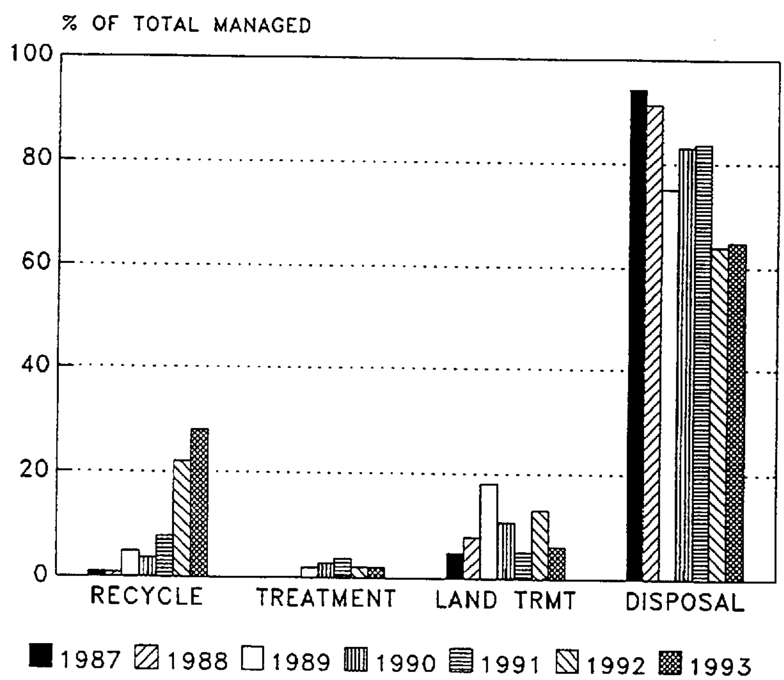
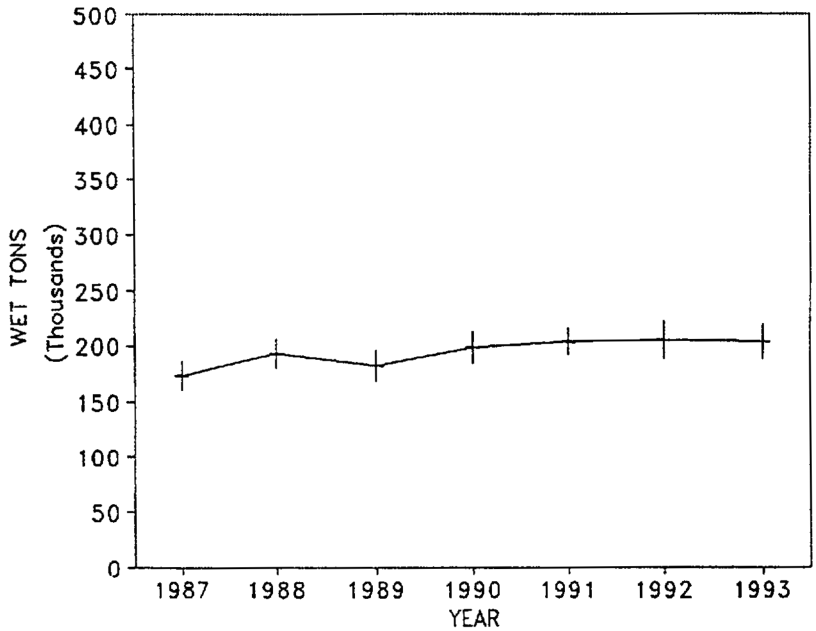



## Management

# Fluid Cracking Catalyst or Equivalent

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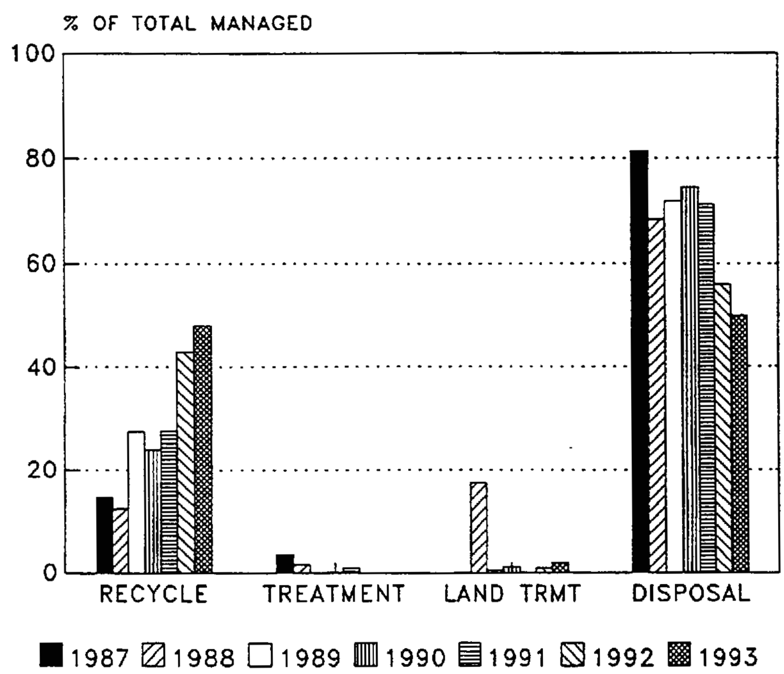
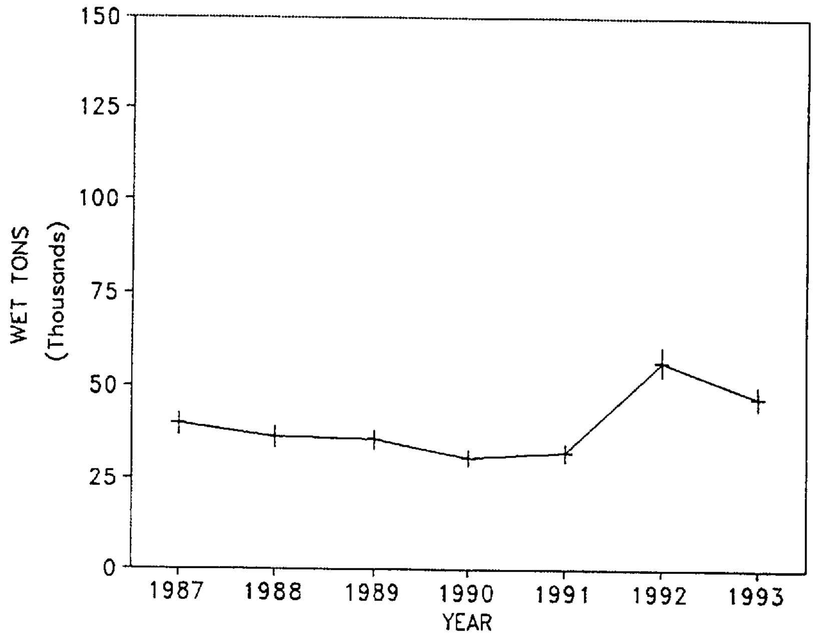



## Management

# Hydroprocessing Catalysts

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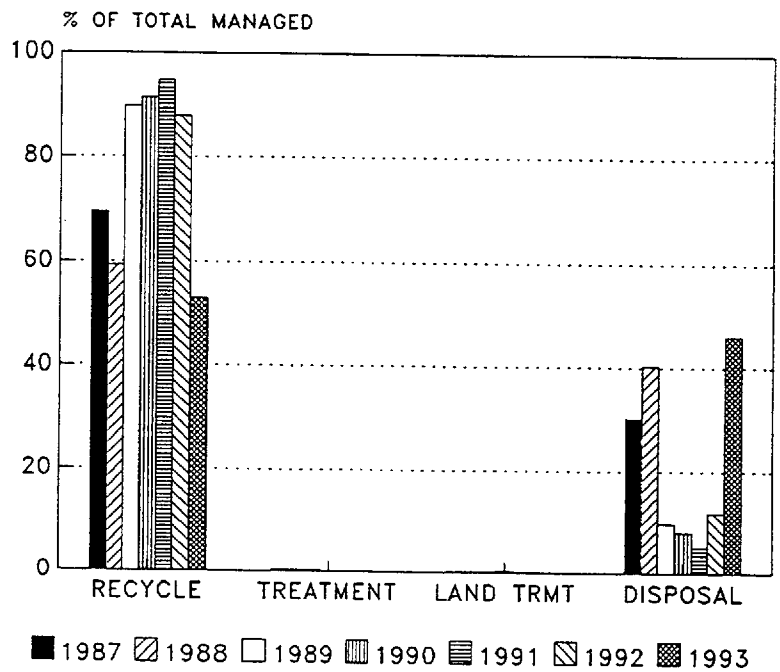
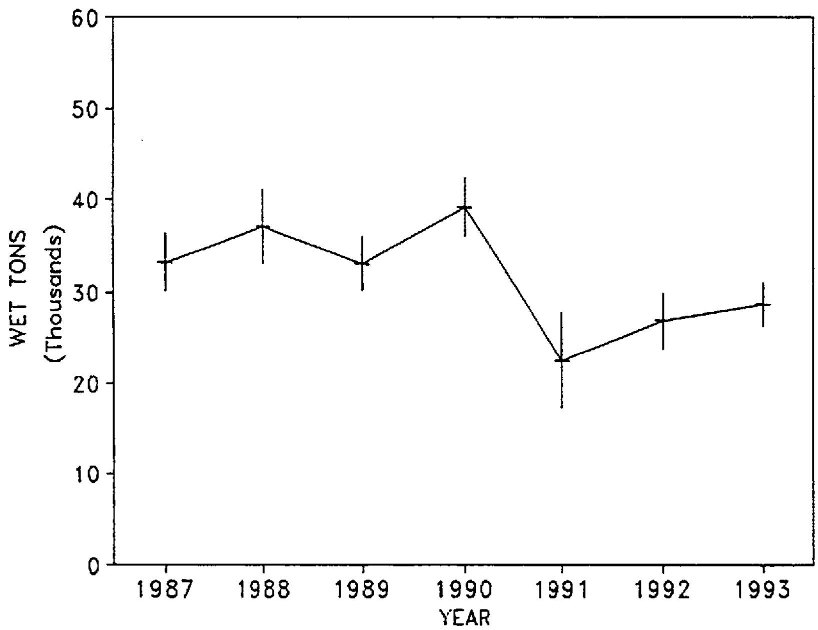



## Management

# Other Spent Catalysts NOS

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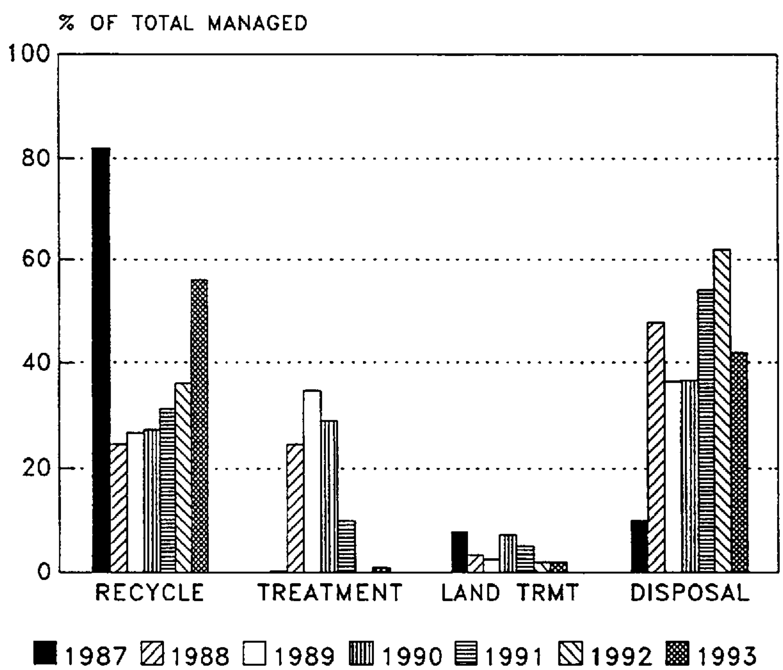
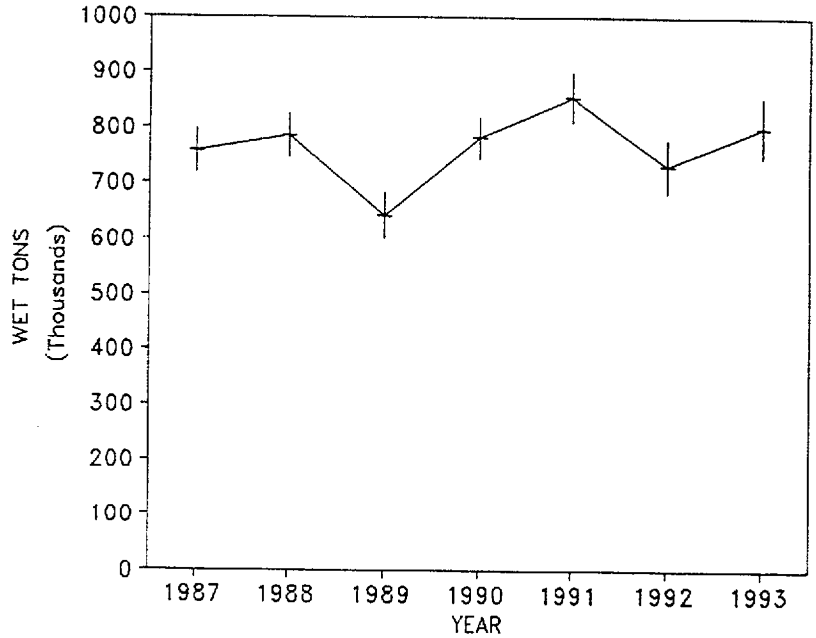



## Management

# Biomass

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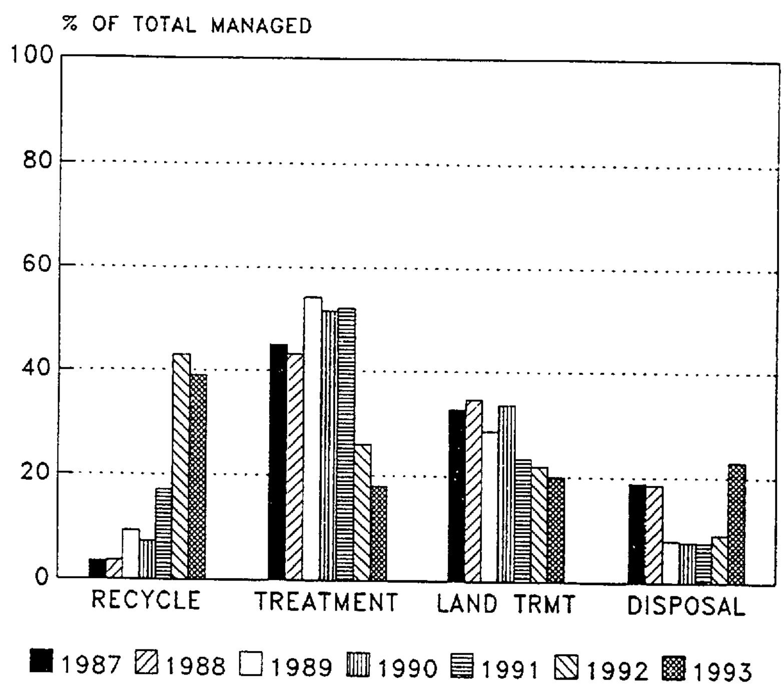
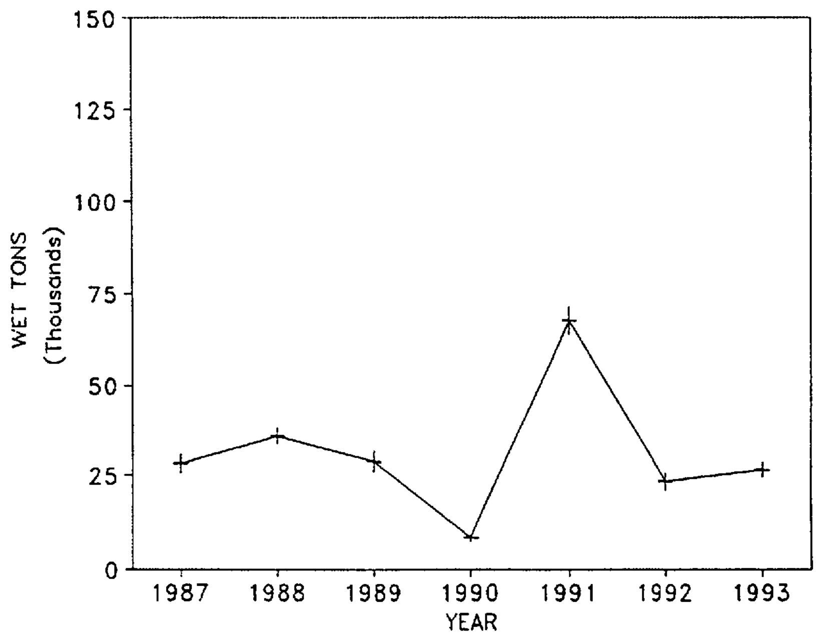



Management

# Oil Contaminated Water Not Wastewater

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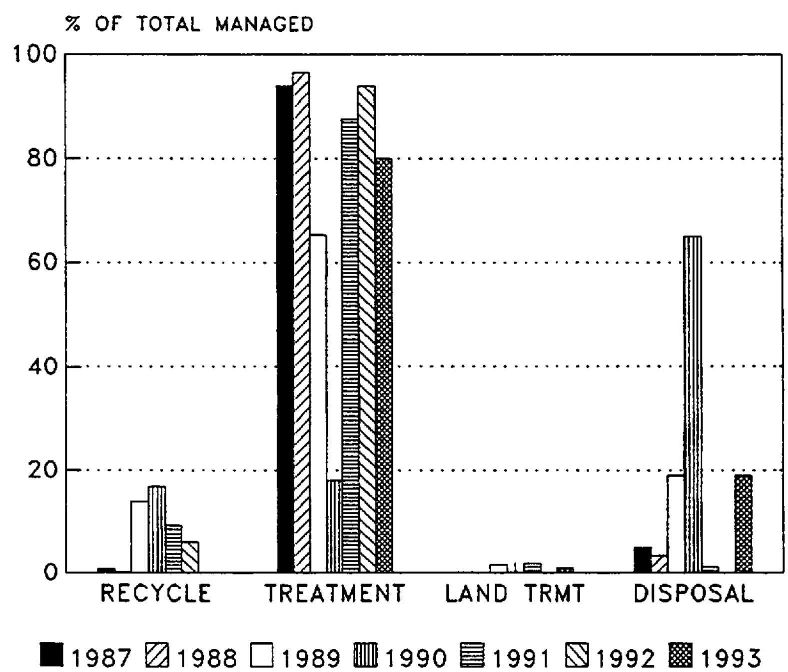
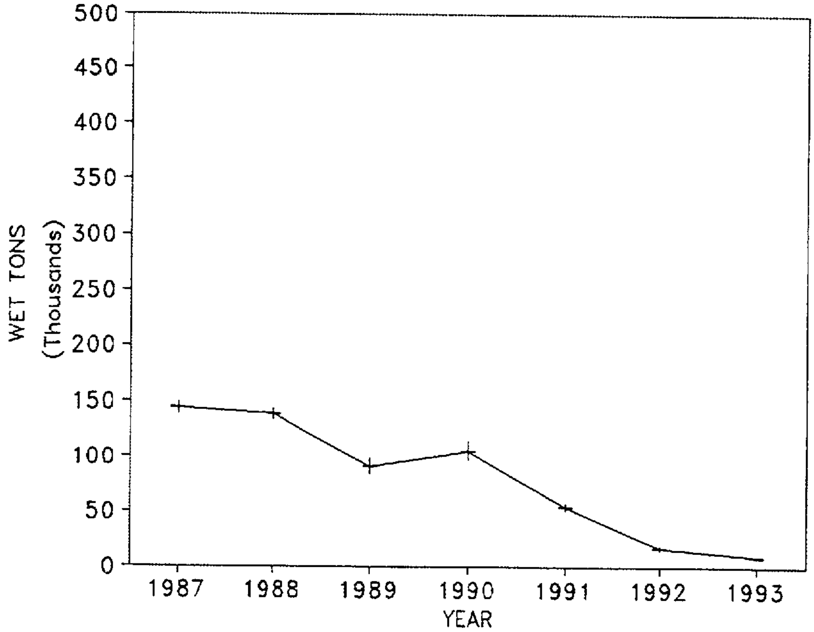



## Management

# High pH/Low pH Waters

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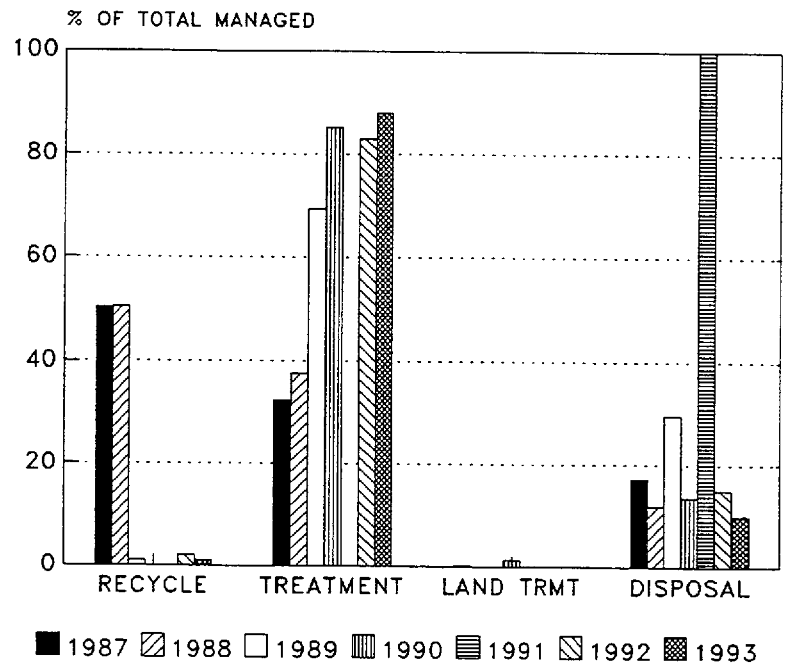
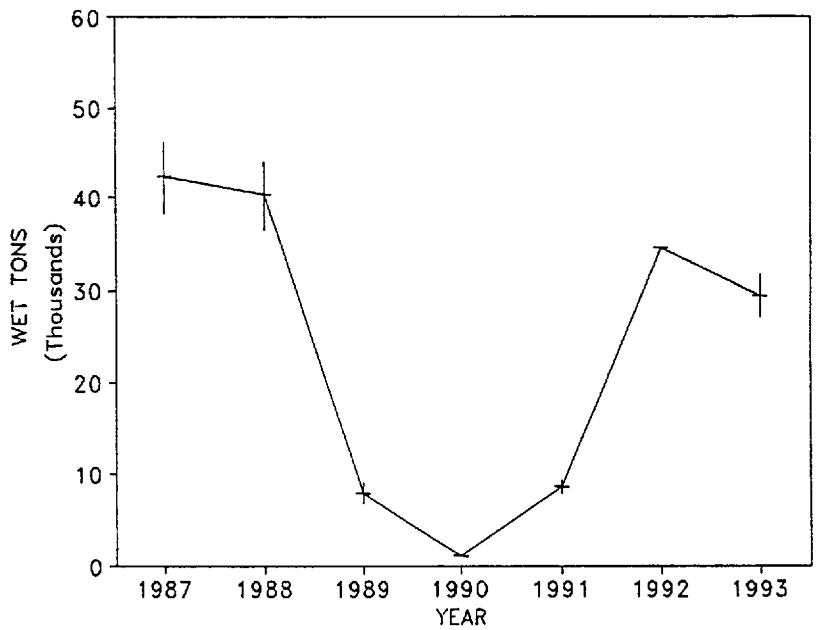



## Management

# Spent Sulfite Solution

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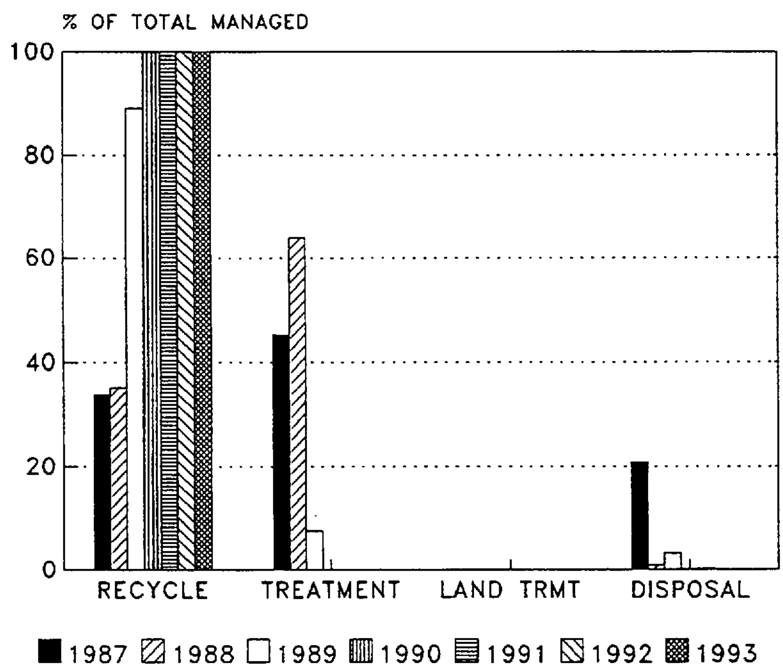
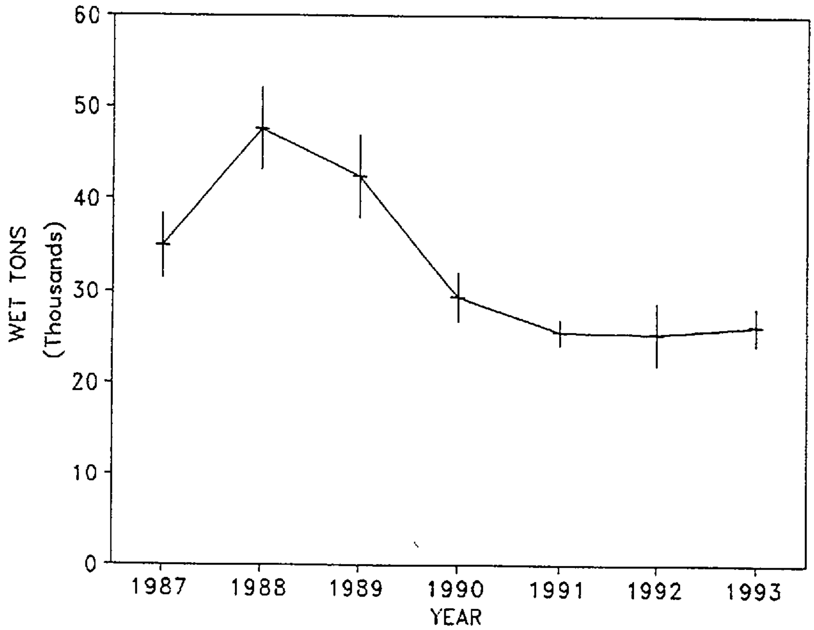



## Management

# Spent Stretford Solution

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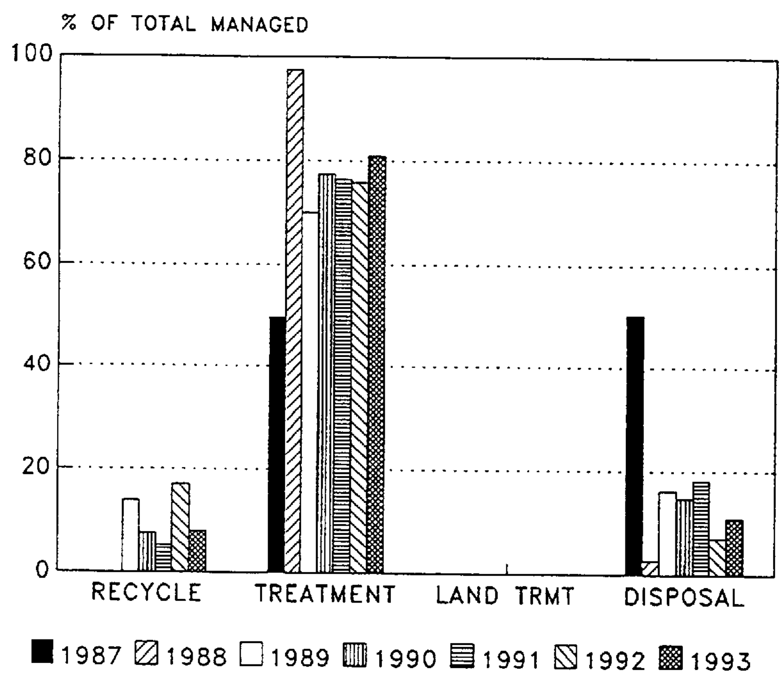
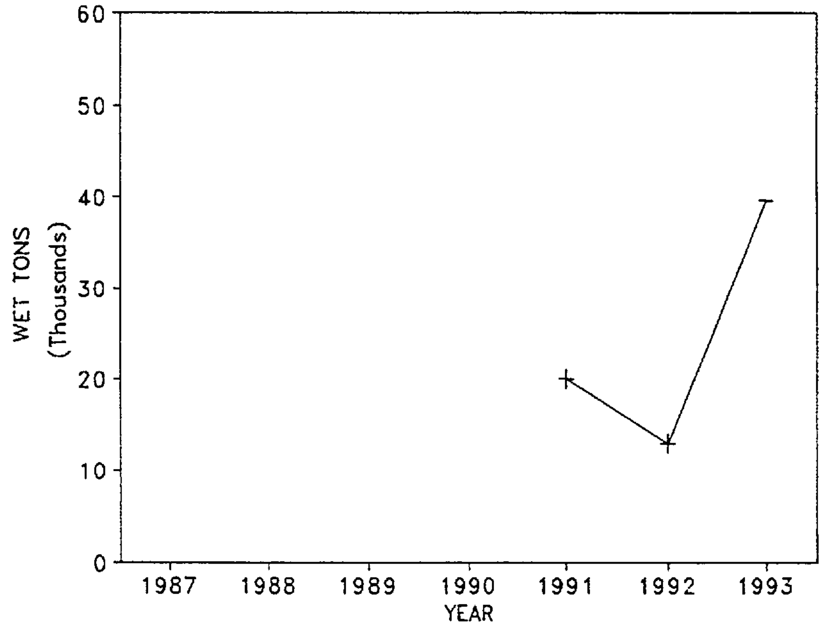



## Management

# TSD Leachate

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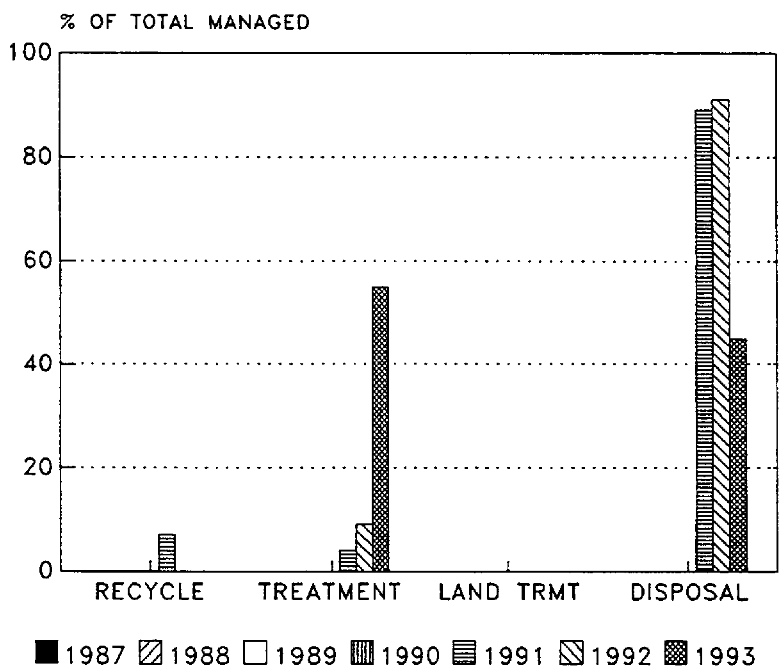
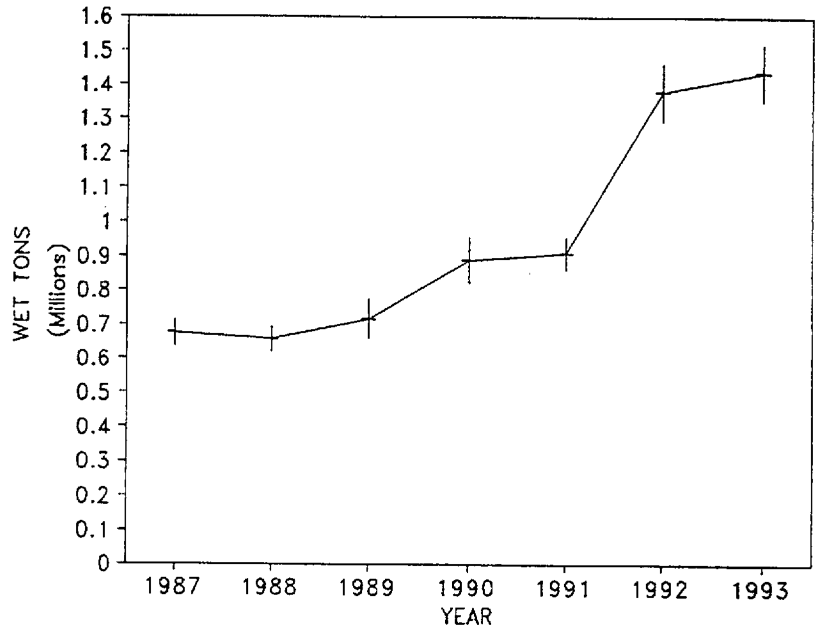



## Management

# Spent Caustics

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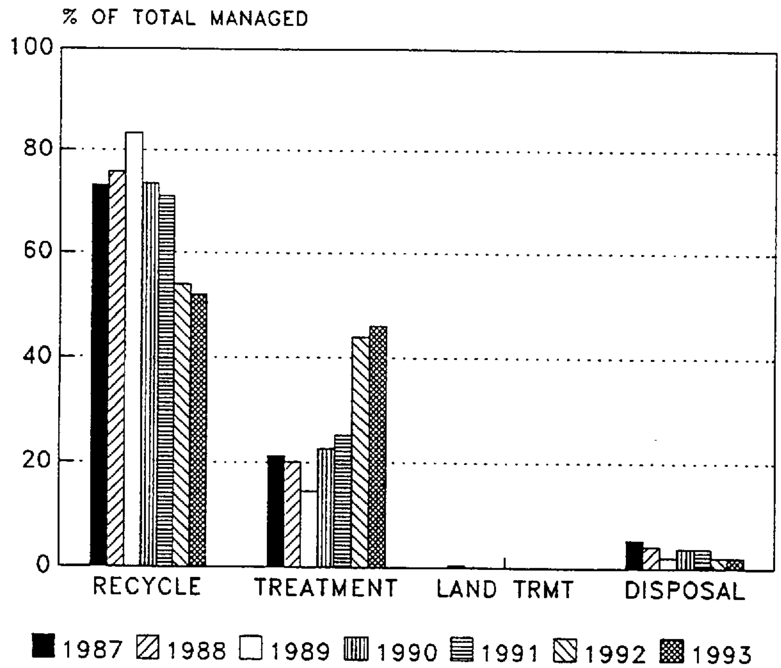
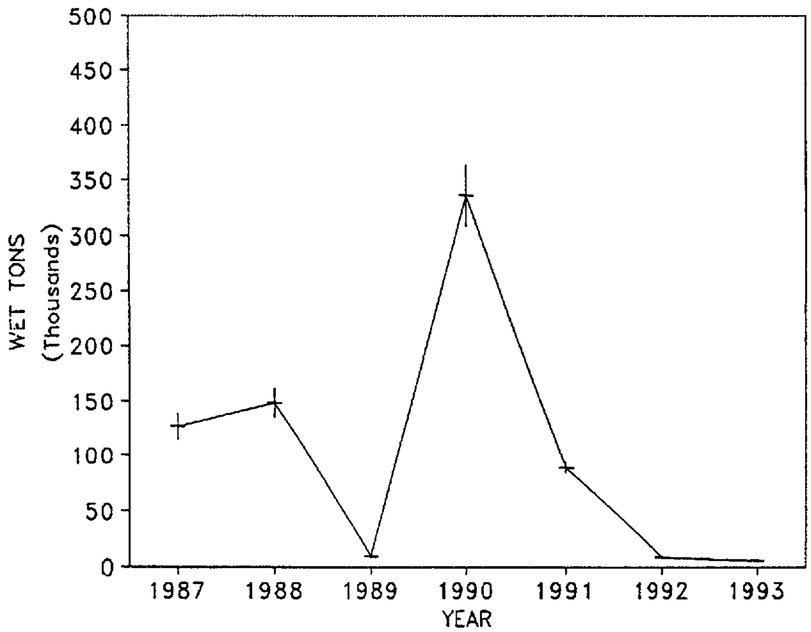



## Management

# Spent Acids

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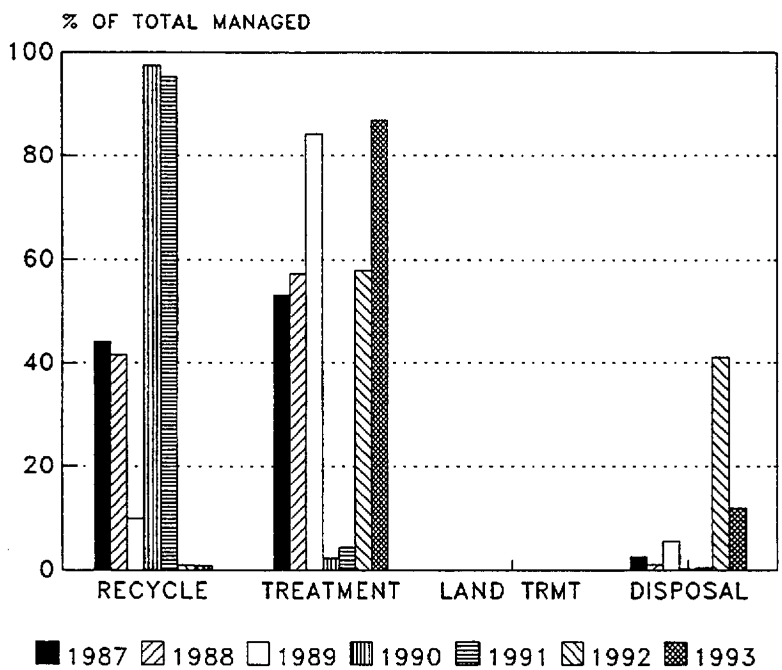
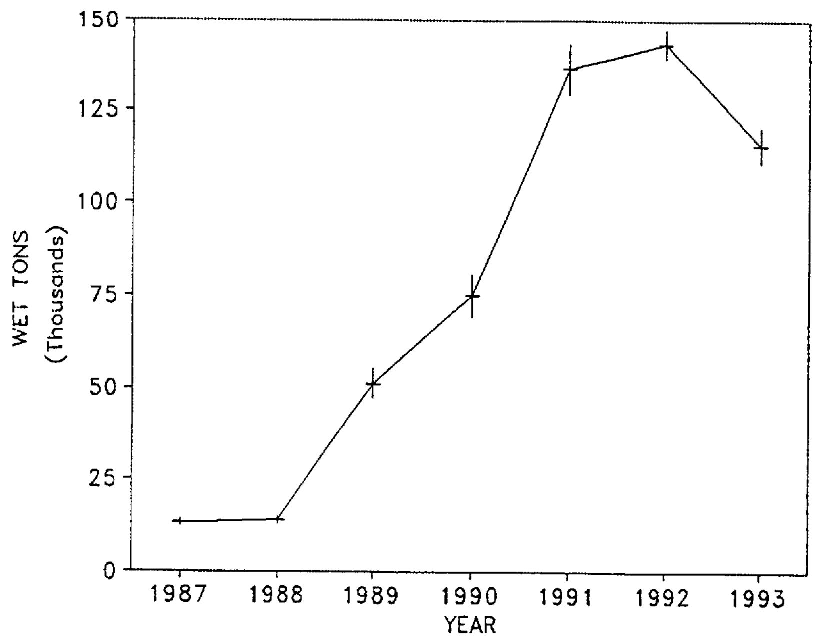



## Management

# Residual Amines

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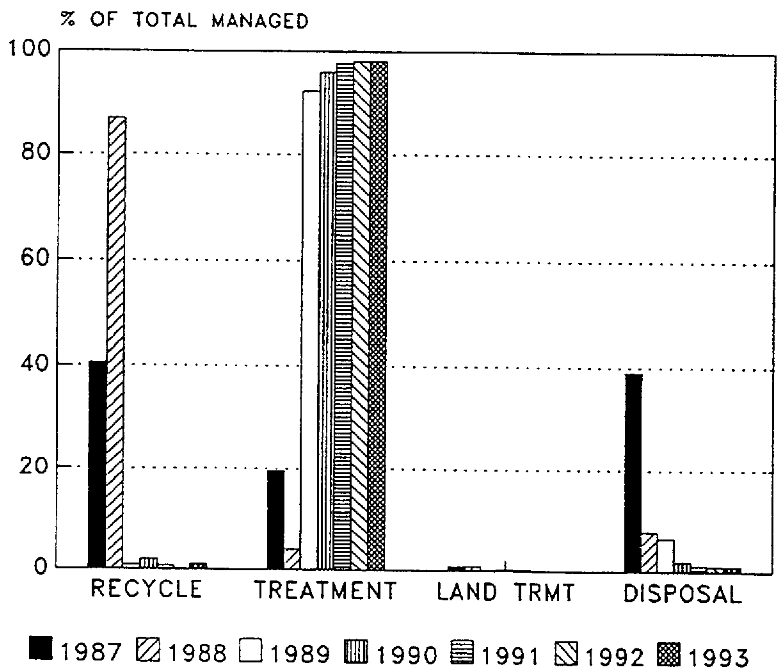
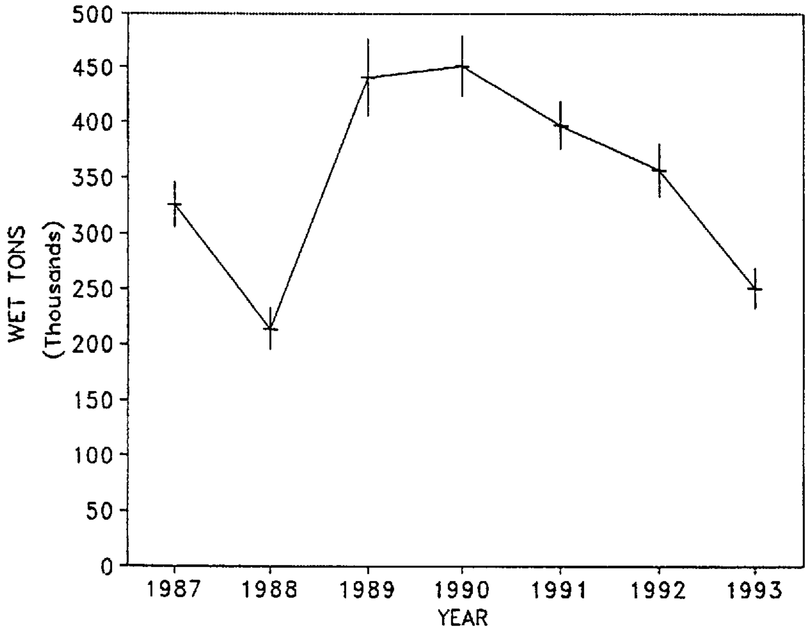



## Management

# Other Inorganic Residuals NOS

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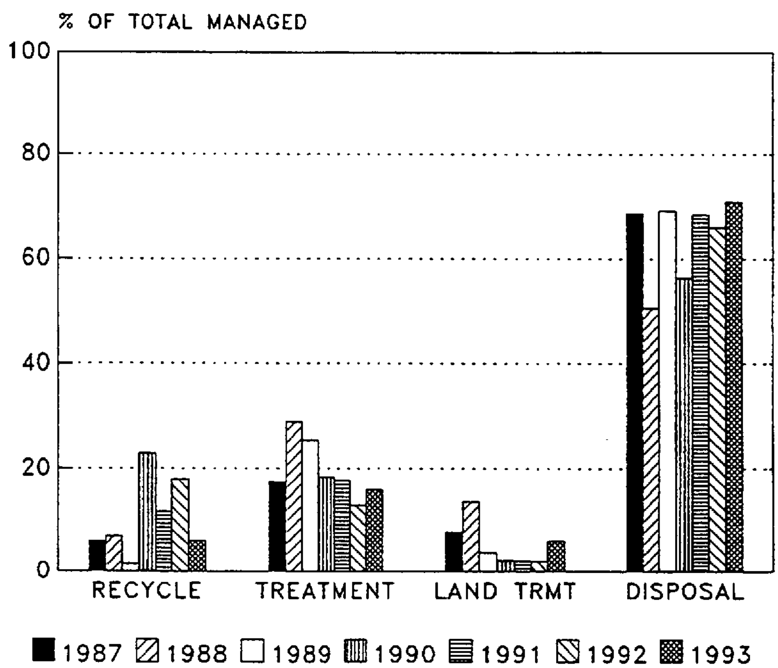
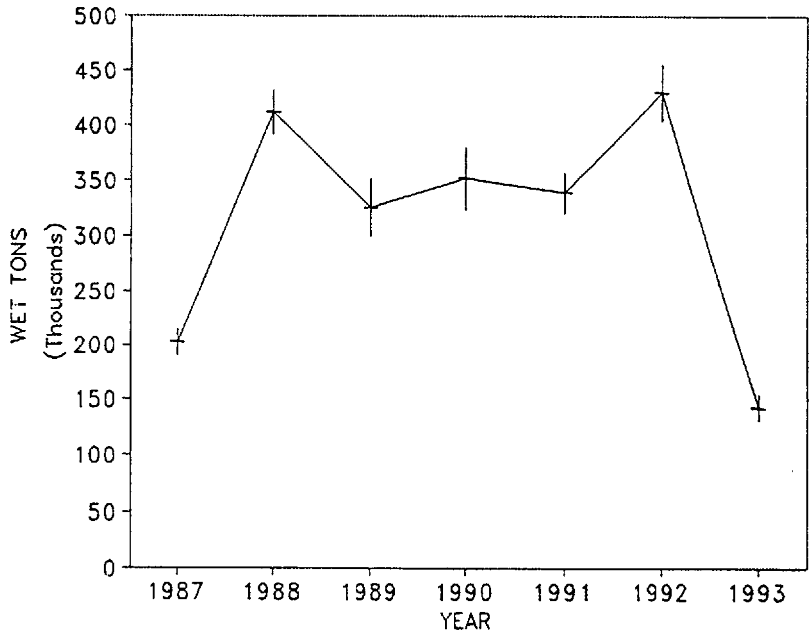



## Management

# Other Residuals NOS

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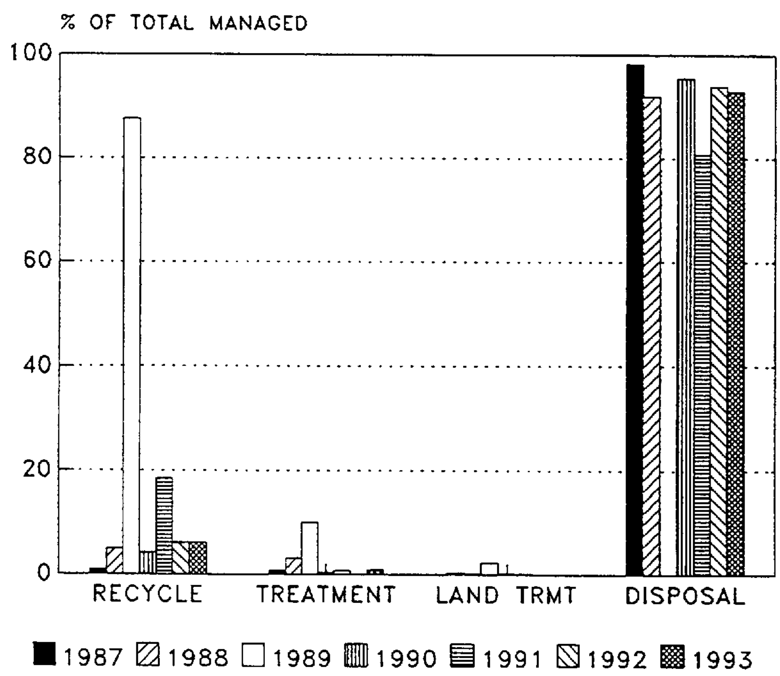


## Management

# APPENDIX D
# Summary of Pollution Prevention Initiatives (by Stream)

# POLLUTION PREVENTION ACTIVITIES: API Separator Sludge

### EQUIPMENT/TECHNOLOGY MODIFICATIONS
Equip/tech modification to reduce carbon carry over

### PROCEDURE MODIFICATIONS
Used gravity thickening which eliminated lime additives
Increase settling time to allow decant

### REFORMULATION/REDESIGN OF PRODUCTS

### SUBSTITUTION OF RAW MATERIALS

### IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS
Improved cleaning, sweeping, housekeeping to reduce solids entering wastewater system
Paving process area to reduce dust
Developed "awareness"/source reduction training program for employees

### IN-PROCESS RECYCLE IN REFINING PROCESS UNITS
Coker modified to accept API separator sludge
Oil & sludge recycle to FCC
Recycle oil to crude unit

### RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION
Centrifuge
Thermal drying
use roll off box w/ filter screen to reduce liquid content
Deoiling in pressure filter
Change to centrifuge operation eliminating additive in final wash

### OTHER RECYCLE

### OUT-OF PROCESS RECYCLE REUSE/RECLAMATION
Reuse as kiln fuel after additional drying of wet centrifuge cake or blending of oil into cake from filter press

# POLLUTION PREVENTION ACTIVITIES: DAF Float

## EQUIPMENT/TECHNOLOGY MODIFICATIONS

Polymer injection increased oil removal efficiency

## PROCEDURE MODIFICATIONS

Stopped use of DAF chemicals
Segregate DAF from Biomass

## REFORMULATION/REDESIGN OF PRODUCTS

## SUBSTITUTION OF RAW MATERIALS

## IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS

Inventory control

## IN-PROCESS RECYCLE IN REFINING PROCESS UNITS

DAF float & sludge sent to coker
DAF float sent to crude unit
Recycle of belt filter press through coker quench cycle
Gravity thickened sludge to delayed coker
Inject DAF float to FCCU riser feed

## RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION

Centrifuge to reduce volume

## OTHER RECYCLE

## OUT-OF PROCESS RECYCLE REUSE/RECLAMATION

Reuse as kiln fuel after additional drying of wet centrifuge cake or blending of oil into cake from filter press
Increase BTU value of filter press feed
Waste petroleum naphtha regenerated

# POLLUTION PREVENTION ACTIVITIES: Slop Oil Emulsion Solids

**EQUIPMENT/TECHNOLOGY MODIFICATIONS**
Replace filter press with vibrating screens

**PROCEDURE MODIFICATIONS**

**REFORMULATION/REDESIGN OF PRODUCTS**

**SUBSTITUTION OF RAW MATERIALS**

**IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS**
Improved inventory controls

**IN-PROCESS RECYCLE**

**IN REFINING PROCESS UNITS**
Recycle to coker
Delayed coking of emulsion
Slop oil recycled to crude units

**RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION**
Use shaker &/or centrifuge and filter press

**OTHER RECYCLE**

**OUT-OF PROCESS RECYCLE REUSE/RECLAMATION**
Reuse as kiln fuel after blending oil into cake from filter press

**OTHER**

## POLLUTION PREVENTION ACTIVITIES: Leaded Tank Bottoms

**EQUIPMENT/TECHNOLOGY MODIFICATIONS**

**PROCEDURE MODIFICATIONS**

**REFORMULATION/REDESIGN OF PRODUCTS**

**SUBSTITUTION OF RAW MATERIALS**

**IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS**

**IN-PROCESS RECYCLE**
**IN REFINING PROCESS UNITS**

**RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION**

**OTHER RECYCLE**

**OUT-OF PROCESS RECYCLE**
**REUSE/RECLAMATION**
Used as cement kiln feed

**OTHER**

## POLLUTION PREVENTION ACTIVITIES: Pond Sediments

**EQUIPMENT/TECHNOLOGY MODIFICATIONS**

**PROCEDURE MODIFICATIONS**

**REFORMULATION/REDESIGN OF PRODUCTS**

**SUBSTITUTION OF RAW MATERIALS**

**IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS**

**IN-PROCESS RECYCLE**
**IN REFINING PROCESS UNITS**
Coker injection
Recovery in crude unit

**RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION**

**OTHER RECYCLE**

**OUT-OF PROCESS RECYCLE**
**REUSE/RECLAMATION**
Use as cement kiln fuel

**OTHER**

# POLLUTION PREVENTION ACTIVITIES: Non-leaded Tank Bottoms

**EQUIPMENT/TECHNOLOGY MODIFICATIONS**

**PROCEDURE MODIFICATIONS**

**REFORMULATION/REDESIGN OF PRODUCTS**

**SUBSTITUTION OF RAW MATERIALS**

**IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS**

**IN-PROCESS RECYCLE IN REFINING PROCESS UNITS**

Reprocessed in coking unit
Recycle separated tank bottoms oil to crude unit
Liquify (heat & recirculate) tank bottoms & charge to RCC

**RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION**

Filter press heavy tank bottoms
Improved oil recovery methods during tank cleaning

**OTHER RECYCLE**

**OUT-OF PROCESS RECYCLE REUSE/RECLAMATION**

Industrial fuel reuse
Cement kiln
Roadmix asphalt feed

**OTHER**

# POLLUTION PREVENTION ACTIVITIES: Residual Oils/Spent Solvents

## EQUIPMENT/TECHNOLOGY MODIFICATIONS

## PROCEDURE MODIFICATIONS

Improve tank cleanings to recover more oil
Use of water washer rather than solvents

## REFORMULATION/REDESIGN OF PRODUCTS

## SUBSTITUTION OF RAW MATERIALS

Use of inorganic solvents other than TCE
Removed chlorinated solvents in I&E shop
Switched to Stoddert solvent that can be recycled in refining slop oil system

## IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS

## IN-PROCESS RECYCLE IN REFINING PROCESS UNITS

Recycle lab & crude unit samples to recovered oil system
Recycle to crude unit
Shipped oil material off-site to be re-refined

## RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION

## OTHER RECYCLE

## OUT-OF PROCESS RECYCLE REUSE/RECLAMATION

Solvents as fuel for cement kiln
Waste oil/spent solvent to reclaimer
Reused in fuel blending
Waste petroleum naphtha used as fuel feedstock

## OTHER

## POLLUTION PREVENTION ACTIVITIES: Other Oily sludges/Organic Residuals

**EQUIPMENT/TECHNOLOGY MODIFICATIONS**
Construction of butadiene saturation unit

**PROCEDURE MODIFICATIONS**

**REFORMULATION/REDESIGN OF PRODUCTS**

**SUBSTITUTION OF RAW MATERIALS**

**IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS**

**IN-PROCESS RECYCLE IN REFINING PROCESS UNITS**
Reprocessed in coker
Sent to RCC after neutralization
ASO recycled
Silky polymer used as feed to RCC after neutralization

**RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION**

**OTHER RECYCLE**

**OUT-OF PROCESS RECYCLE REUSE/RECLAMATION**
Cement kiln fuel

**OTHER**
In-line neutralization to eliminate corrosive characteristic burned in process heater

# POLLUTION PREVENTION ACTIVITIES: F037 Primary Sludge

## EQUIPMENT/TECHNOLOGY MODIFICATIONS

## PROCEDURE MODIFICATIONS

Discontinued use of sandbags for drain covers

Segregate non-hazardous biosolids from primary solids

## REFORMULATION/REDESIGN OF PRODUCTS

## SUBSTITUTION OF RAW MATERIALS

## IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS

Paving, curbing, replacing unlined conveyances w/ hard piping

Lined ditches, erosion control

Closed impoundment

Increase sweeping activities

Implemented source control activities

Eliminated coke fines from entering system

## IN-PROCESS RECYCLE IN REFINING PROCESS UNITS

Initiated delayed coking

Recycle to crude units

## RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION

## OTHER RECYCLE

## OUT-OF PROCESS RECYCLE REUSE/RECLAMATION

Cement kiln feed

Recycled as industrial fuel

## OTHER

# POLLUTION PREVENTION ACTIVITIES: F038 Primary Sludge

## EQUIPMENT/TECHNOLOGY MODIFICATIONS
Modification of equipment for Benzene NESHAP

## PROCEDURE MODIFICATIONS
Do not add solids to enhance filtering

## REFORMULATION/REDESIGN OF PRODUCTS

## SUBSTITUTION OF RAW MATERIALS

## IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS
Improved operation & maintenance of API separators to minimize oily waste load

Improved monitoring WTP to minimize polymer use

## IN-PROCESS RECYCLE IN REFINING PROCESS UNITS
To coker

Recycle to crude unit

## RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION
Recover more oil & water by centrifugation (v. plate & filter press)

## OTHER RECYCLE

## OUT-OF PROCESS RECYCLE REUSE/RECLAMATION
Cement kiln feed

## OTHER

# POLLUTION PREVENTION ACTIVITIES: Heat Exchanger Bundle Cleaning Sludge

**EQUIPMENT/TECHNOLOGY MODIFICATIONS**

**PROCEDURE MODIFICATIONS**

**REFORMULATION/REDESIGN OF PRODUCTS**

**SUBSTITUTION OF RAW MATERIALS**

**IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS**

Placed container barrier around slab

**IN-PROCESS RECYCLE**

**IN REFINING PROCESS UNITS**

Sludge Coking

**RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION**

Improved online exchanger cleaning method prior to bundle removal

Thermal dewatering

**OTHER RECYCLE**

**OUT-OF PROCESS RECYCLE**

**REUSE/RECLAMATION**

Cement kiln feed

Fuels blending

**OTHER**

# POLLUTION PREVENTION ACTIVITIES: Contaminated Soils/Solids

**EQUIPMENT/TECHNOLOGY MODIFICATIONS**

**PROCEDURE MODIFICATIONS**
Calcium sulfate to potential spill areas

**REFORMULATION/REDESIGN OF PRODUCTS**

**SUBSTITUTION OF RAW MATERIALS**

**IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS**
Provide containment for equipment subject to spills

**IN-PROCESS RECYCLE**
**IN REFINING PROCESS UNITS**

**RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION**

**OTHER RECYCLE**

**OUT-OF PROCESS RECYCLE**
**REUSE/RECLAMATION**
Sand blast grit used as feedstock in asphalt manufacturing
Non-hazardous soil used as aggregate by brick manufacturer
Various soil used as aggregate for cold mix asphalt

**OTHER**

## POLLUTION PREVENTION ACTIVITIES: Residual Coke/Carbon/Charcoal

**EQUIPMENT/TECHNOLOGY MODIFICATIONS**

**PROCEDURE MODIFICATIONS**

**REFORMULATION/REDESIGN OF PRODUCTS**

**SUBSTITUTION OF RAW MATERIALS**

**IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS**

**IN-PROCESS RECYCLE**
**IN REFINING PROCESS UNITS**

**RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION**

**OTHER RECYCLE**

**OUT-OF PROCESS RECYCLE**
**REUSE/RECLAMATION**

Reuse charcoal in commercial power plant as fuel

**OTHER**

## POLLUTION PREVENTION ACTIVITIES: Residual Sulfur

**EQUIPMENT/TECHNOLOGY MODIFICATIONS**

**PROCEDURE MODIFICATIONS**

**REFORMULATION/REDESIGN OF PRODUCTS**

**SUBSTITUTION OF RAW MATERIALS**

**IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS**

**IN-PROCESS RECYCLE**
**IN REFINING PROCESS UNITS**

**RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION**

**OTHER RECYCLE**
Spilled sulfur & tank & pit cleanings melted & returned to sulfur storage

**OUT-OF PROCESS RECYCLE**
**REUSE/RECLAMATION**
Sulfur to fertilizer plant

**OTHER**

## POLLUTION PREVENTION ACTIVITIES: Other Contaminated Soils NOS

### EQUIPMENT/TECHNOLOGY MODIFICATIONS

### PROCEDURE MODIFICATIONS

### REFORMULATION/REDESIGN OF PRODUCTS

### SUBSTITUTION OF RAW MATERIALS

### IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS

### IN-PROCESS RECYCLE IN REFINING PROCESS UNITS

Contaminated asphalt/soils reheated to remove asphalt; returned to coker

### RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION

### OTHER RECYCLE

### OUT-OF PROCESS RECYCLE REUSE/RECLAMATION

Molecular sieves used as feed in commercial asphalt plant
To cement kiln as super fuels
Treater clay used in road mix asphalting program
Spent alky alumina & bauxite toe commercial feedstock

### OTHER

## POLLUTION PREVENTION ACTIVITIES: FCCU Catalyst

**EQUIPMENT/TECHNOLOGY MODIFICATIONS**
VOP operating changes in FCCU

**PROCEDURE MODIFICATIONS**

**REFORMULATION/REDESIGN OF PRODUCTS**

**SUBSTITUTION OF RAW MATERIALS**
Reused at another refinery

**IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS**

**IN-PROCESS RECYCLE**
**IN REFINING PROCESS UNITS**
Sold to other refineries as catalyst
Reuse in RCC unit

**RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION**

**OTHER RECYCLE**

**OUT-OF PROCESS RECYCLE**
**REUSE/RECLAMATION**
Used as feed for kiln
Regenerated

**OTHER**

# POLLUTION PREVENTION ACTIVITIES: Hydroprocessing Catalyst

**EQUIPMENT/TECHNOLOGY MODIFICATIONS**

**PROCEDURE MODIFICATIONS**

**REFORMULATION/REDESIGN OF PRODUCTS**

**SUBSTITUTION OF RAW MATERIALS**

Reuse at another refinery

**IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS**

**IN-PROCESS RECYCLE**
**IN REFINING PROCESS UNITS**

**RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION**

**OTHER RECYCLE**

**OUT-OF PROCESS RECYCLE**
**REUSE/RECLAMATION**

HDS regenerated
Regenerate spent desulfurization catalyst
Precious/heavy metals recovery

**OTHER**

# POLLUTION PREVENTION ACTIVITIES: Other Spent Catalysts

**EQUIPMENT/TECHNOLOGY MODIFICATIONS**

**PROCEDURE MODIFICATIONS**

**REFORMULATION/REDESIGN OF PRODUCTS**

**SUBSTITUTION OF RAW MATERIALS**

**IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS**

**IN-PROCESS RECYCLE IN REFINING PROCESS UNITS**

**RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION**

**OTHER RECYCLE**

**OUT-OF PROCESS RECYCLE REUSE/RECLAMATION**

SRU & zeolite to cement plant
Metals reclaimed form spent reformer catalyst
Fluorinated alumina catalyst recycled as feedstock
Regenerated spent ion exchange resin
Metals recovery
Nickel Octowate catalyst to AMAX for nickel recovery

## POLLUTION PREVENTION ACTIVITIES: Biomass

| | |
|---|---|
| **EQUIPMENT/TECHNOLOGY MODIFICATIONS** | **IN-PROCESS RECYCLE IN REFINING PROCESS UNITS**<br>Recycle ASU sludge oils to crude unit<br>Recover in crude unit/coker |
| **PROCEDURE MODIFICATIONS** | **RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION** |
| **REFORMULATION/REDESIGN OF PRODUCTS** | **OTHER RECYCLE**<br>Recycled to re-seed refinery's biotreatment & landtreatment units |
| **SUBSTITUTION OF RAW MATERIALS** | **OUT-OF PROCESS RECYCLE REUSE/RECLAMATION** |
| **IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS** | **OTHER** |

## POLLUTION PREVENTION ACTIVITIES: Oil Contaminated Water not Wastewater

| | |
|---|---|
| **EQUIPMENT/TECHNOLOGY MODIFICATIONS** | **IN-PROCESS RECYCLE**<br>**IN REFINING PROCESS UNITS**<br>Sour water stripped at SRU & returned to process for reuse |
| **PROCEDURE MODIFICATIONS** | **RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION** |
| **REFORMULATION/REDESIGN OF PRODUCTS** | **OTHER RECYCLE** |
| **SUBSTITUTION OF RAW MATERIALS** | **OUT-OF PROCESS RECYCLE**<br>**REUSE/RECLAMATION** |
| **IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS** | |
| | **OTHER** |

## POLLUTION PREVENTION ACTIVITIES: High pH/low pH Waters NONE

**EQUIPMENT/TECHNOLOGY MODIFICATIONS**

**PROCEDURE MODIFICATIONS**
Cut use of water by 1% per day

**REFORMULATION/REDESIGN OF PRODUCTS**

**SUBSTITUTION OF RAW MATERIALS**

**IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS**

**IN-PROCESS RECYCLE**
**IN REFINING PROCESS UNITS**

**RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION**

**OTHER RECYCLE**

**OUT-OF PROCESS RECYCLE**
**REUSE/RECLAMATION**

**OTHER**

## POLLUTION PREVENTION ACTIVITIES: Other Aqueous Waste NOS

| | |
|---|---|
| **EQUIPMENT/TECHNOLOGY MODIFICATIONS** | **IN-PROCESS RECYCLE**<br>**IN REFINING PROCESS UNITS** |
| **PROCEDURE MODIFICATIONS** | **RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION** |
| | **OTHER RECYCLE** |
| **REFORMULATION/REDESIGN OF PRODUCTS** | **OUT-OF PROCESS RECYCLE**<br>**REUSE/RECLAMATION**<br>Hazardous liquids used in fuel blending by contract incinerator |
| **SUBSTITUTION OF RAW MATERIALS** | |
| **IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS** | **OTHER** |

# POLLUTION PREVENTION ACTIVITIES: Spent Caustics

**EQUIPMENT/TECHNOLOGY MODIFICATIONS**

**PROCEDURE MODIFICATIONS**

Use of caustics reduced

**REFORMULATION/REDESIGN OF PRODUCTS**

**SUBSTITUTION OF RAW MATERIALS**

Used to regulate pH of wastewaters

**IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS**

**IN-PROCESS RECYCLE IN REFINING PROCESS UNITS**

Reuse at another caustic scrubber

Recycle spent sulfidic (on-site) & phenolic (off-site)

**RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION**

**OTHER RECYCLE**

**OUT-OF PROCESS RECYCLE REUSE/RECLAMATION**

Used in pulp and paper mill

Reuse for pH control off site

Sent to Merchem for recycle ; crysillite & sulfide recovery

OTHER

## POLLUTION PREVENTION ACTIVITIES: Residual Amines

**EQUIPMENT/TECHNOLOGY MODIFICATIONS**

**PROCEDURE MODIFICATIONS**

**REFORMULATION/REDESIGN OF PRODUCTS**

**SUBSTITUTION OF RAW MATERIALS**

**IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS**

**IN-PROCESS RECYCLE IN REFINING PROCESS UNITS**

Recycle to coker/crude

**RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION**

**OTHER RECYCLE**

**OUT-OF PROCESS RECYCLE REUSE/RECLAMATION**

Regeneration

Initiated use of amine waste in fuel program

**OTHER**

# POLLUTION PREVENTION ACTIVITIES: Other Inorganic Residuals NOS

## EQUIPMENT/TECHNOLOGY MODIFICATIONS

## PROCEDURE MODIFICATIONS

Decant water form sulfex sludge

Better monitoring of boiler feed & water softening operations; lime feed based on test results

## REFORMULATION/REDESIGN OF PRODUCTS

## SUBSTITUTION OF RAW MATERIALS

## IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS

Monitor filter house bauxite regeneration system

Blowndown liquid from scrubber only when needed & at minimum rate necessary

## IN-PROCESS RECYCLE IN REFINING PROCESS UNITS

Recycle to coker/crude unit

## RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION

Dewater and oil recovery

## OTHER RECYCLE

## OUT-OF PROCESS RECYCLE REUSE/RECLAMATION

Raw material for cement kiln

## OTHER

# POLLUTION PREVENTION ACTIVITIES: Other Residuals NOS

**EQUIPMENT/TECHNOLOGY MODIFICATIONS**

**PROCEDURE MODIFICATIONS**

**REFORMULATION/REDESIGN OF PRODUCTS**

**SUBSTITUTION OF RAW MATERIALS**

**IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS**

Switched to portafeed containers for treatment chemicals

**IN-PROCESS RECYCLE IN REFINING PROCESS UNITS**

**RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION**

**OTHER RECYCLE**

**OUT-OF PROCESS RECYCLE REUSE/RECLAMATION**

Batteries sent back to distributor for reuse
Paint wastes to cement kiln
Drums & batteries recycled off-site
Scrap metal reclamation
Lime sludge sent as raw materials to kiln
Drum reconditioning
Paint recovery
Waste concrete solid as fill
Paper recycling

**OTHER**

## POLLUTION PREVENTION ACTIVITIES:

EQUIPMENT/TECHNOLOGY MODIFICATIONS

PROCEDURE MODIFICATIONS

REFORMULATION/REDESIGN OF PRODUCTS

SUBSTITUTION OF RAW MATERIALS

IMPROVED HOUSEKEEPING; TRAINING OF PERSONNEL OR INVENTORY CONTROLS

<u>IN-PROCESS RECYCLE</u>
IN REFINING PROCESS UNITS

RECOVERING OIL BY FILTER PRESSING/ CENTRIFUGATION

OTHER RECYCLE

<u>OUT-OF PROCESS RECYCLE</u>
REUSE/RECLAMATION

OTHER

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