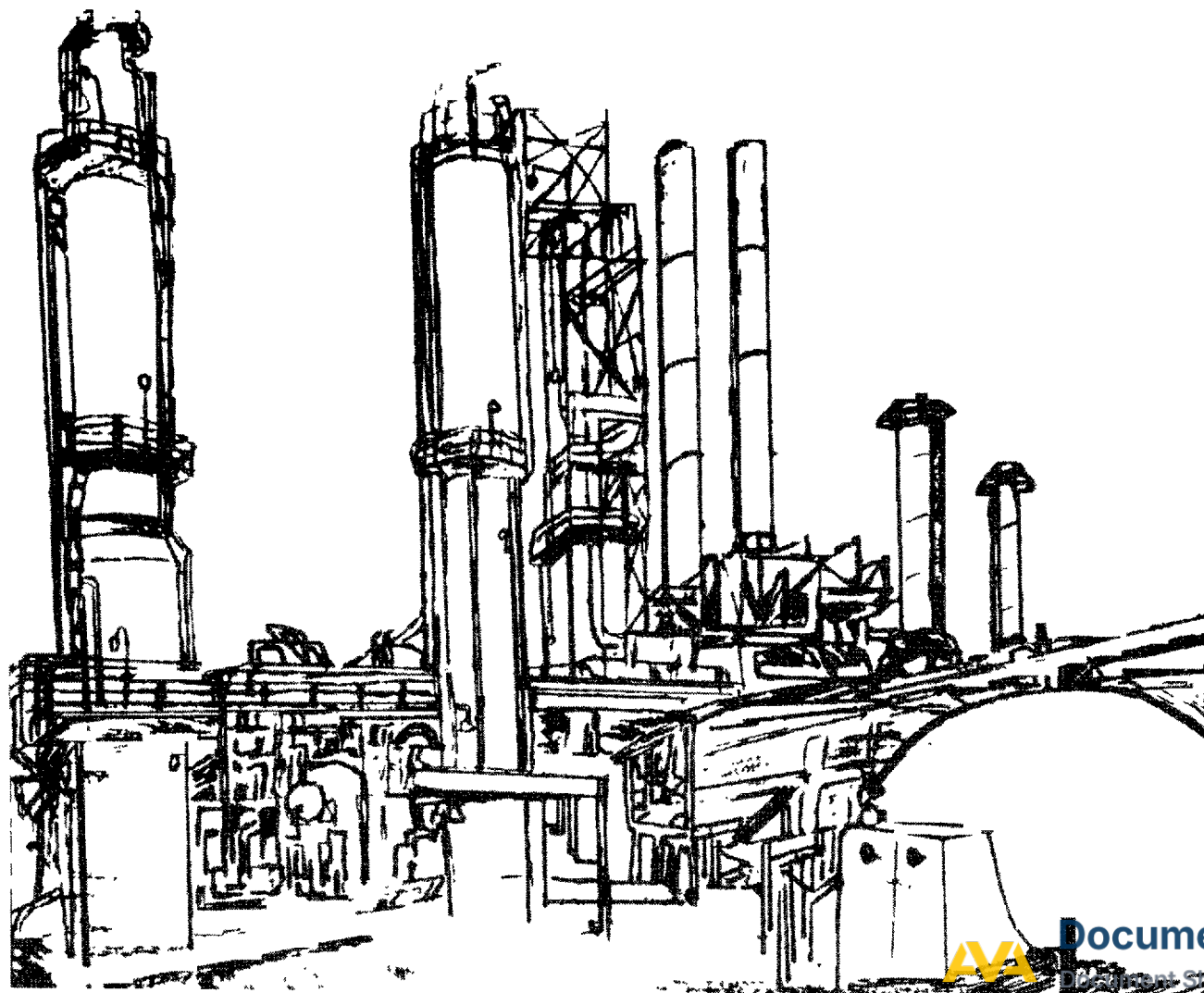


MANAGEMENT OF RESIDUAL MATERIALS: 1997

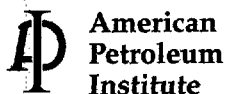
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Management of Residual Materials: 1997

Petroleum Refining Performance

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API PUBLICATION NUMBER 352

PREPARED UNDER CONTRACT BY:

ROB FERRY
THE TGB PARTNERSHIP
HILLSBOROUGH, NORTH CAROLINA

SEPTEMBER 1999



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EXECUTIVE SUMMARY

The 1997 API Refining Residual Survey collected data on the manner in which U.S. petroleum refineries manage their residual materials. This report summarizes the characteristics of the facilities that responded, and presents nationwide trends in residual management practices. The nationwide estimates were determined from a regression analysis of the respondent data in terms of residual quantity in wet tons by refinery capacity in barrels per stream day (bsd).

1997 Refining Residual Survey—Response Level

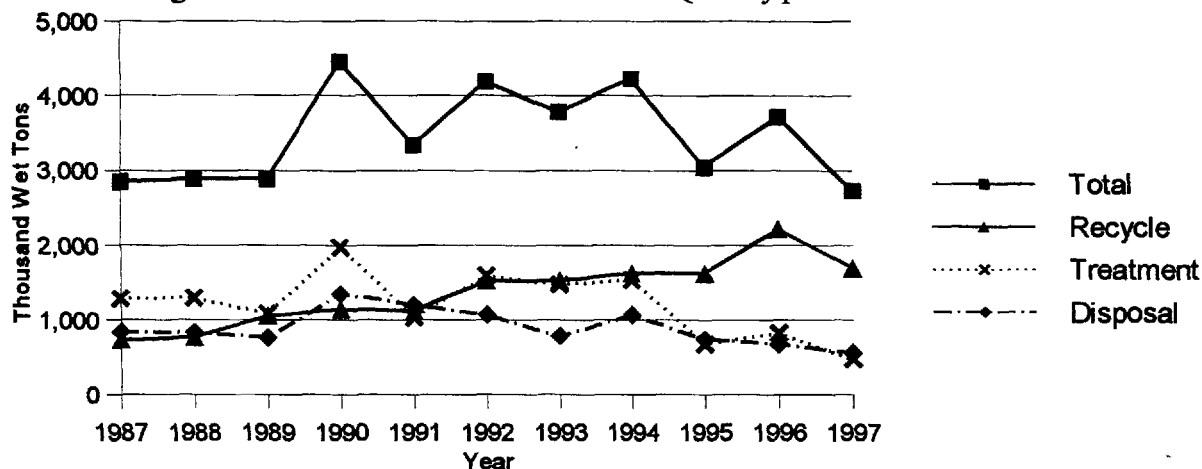
	<u>Estimated U.S. Total</u>	<u>Survey Respondents</u>	<u>Percent</u>
No. of Facilities	152	70	46%
Refining Capacity	16,086,100 bsd	7,328,500 bsd	46%
Residual Quantity	2,736,000 wet tons	1,179,000 wet tons	43%

The 1997 survey collected data on the management of 14 residual streams and requested cost data on six of these streams. By comparison to the quantities reported for 30 residual streams in the surveys prior to 1994, these 14 streams are believed to represent nearly 80% of the total quantity of residuals managed at U.S. refineries. As with previous surveys, data were collected on the age, size, location, and type of refinery, and on the configuration of the wastewater treatment systems.

DIFFERENCE FROM PRIOR YEAR RESULTS

This year's survey continued to seek improvement in the consistency of reported data. Prior to the 1997 survey, the management techniques had included recycling to the *cat cracker*, which referred to routing a residual to a catalytic cracking unit (regardless of whether fluidized bed or other type). Most of the entries for this technique were for *FCC catalyst*. Telephone follow up revealed that this response was generally meant to indicate catalyst either having been cascaded to another cracking unit or sent to another facility for continued use as catalyst. By definition, however, if the material was still in use for its original purpose, it was not yet a residual. Furthermore, entries for other residual streams to the *cat cracker* management technique were generally found to have belonged in a different recycle category. It seemed, then, that the quantity of residuals actually recycled to a cracking unit was very small, and perhaps nonexistent. The *cat cracker* category was therefore deleted from the 1997 survey. Data for prior years were adjusted by deleting quantities shown as *FCC catalyst* routed to a *cat cracker*, and moving all other quantities reported under *cat cracker* to the *other recycle* management technique category.

Trends in Management Practices—Nationwide Estimates of Quantity per Year



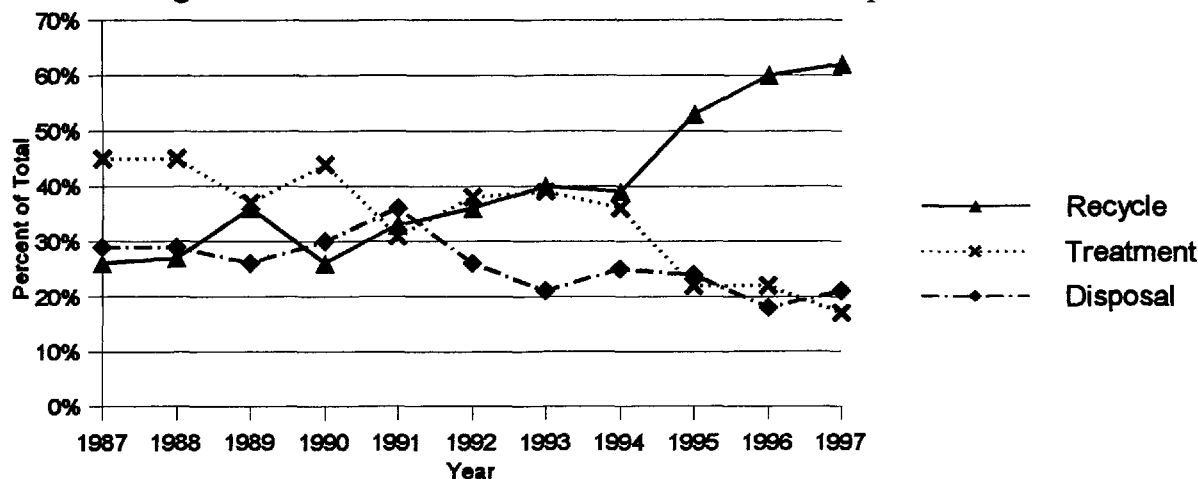
As in the 1995 and 1996 reports, the data for 1987 through 1994 in the preceding chart have been adjusted by deleting the quantities considered to be recovered oil or water rather than true residuals. Prior to the 1995 survey, some facilities had reported the quantity of residual generated prior to dewatering, while others had reported the quantity managed after dewatering. The 1995 survey, however, had specified that only the quantity of residual remaining after dewatering was to be reported, without the recovered water or oil, thus providing for a consistent basis of response and more accurately reflecting quantities of residuals managed. This approach was continued with the 1996 and 1997 surveys.

The specific adjustments made to the 1987 through 1994 data were to delete the amounts shown as managed by *wastewater treatment* from the streams that are reduced by dewatering, which are the *tank bottoms*, *API separator sludge*, *DAF float*, *primary sludges*, *slop oil emulsion solids*, *biomass*, and *pond sediments* streams. Amounts listed as recycled to a crude unit were deleted from these same streams, with the exception of *DAF float* and *slop oil emulsion solids*. The latter two streams had entries in the *crude unit* category for 1995 (and again in 1996), and therefore this category was retained for these two streams in the adjustments of prior years' data.

The reporting units of wet tons indicate that the stream volumes are taken in their as-managed condition, rather than on a dry-solids basis. While residuals that have been dewatered will have a higher percent-solids content than if they had not been dewatered, they may nevertheless include a significant amount of water.

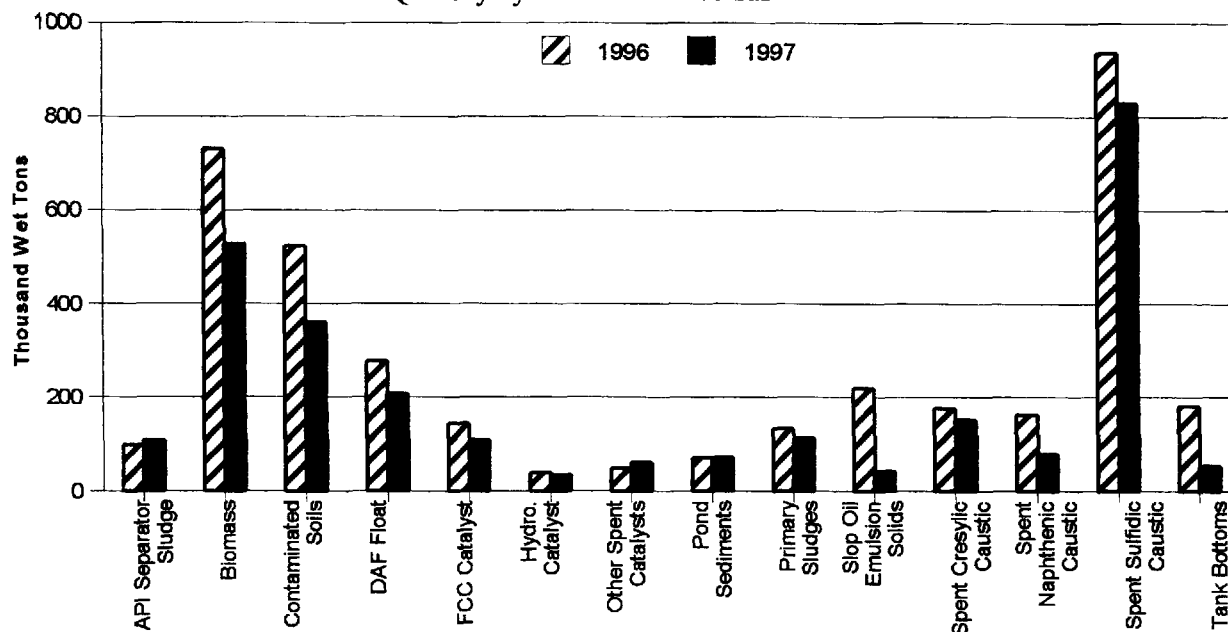
The estimated total quantity of residuals managed at U.S. refineries decreased from 3,721,000 wet tons in 1996 to 2,736,000 wet tons in 1997, a decrease of 985,000 wet tons. The 1997 nationwide estimate continues the downward trend that is evident for the 1990s. The portion of residual material reported as having been *recycled* continues the strong upward trend of recent years, with well over half of the total quantity managed now shown as *recycled*, as shown in the following chart.

Trends in Management Practices—Nationwide Estimates of Percent of Total per Year



The next chart compares residual quantities by stream for 1996 and 1997. Several facilities reported a combined amount of certain residuals associated with wastewater treatment facilities (i.e., *API separator sludge*, *DAF float*, *primary sludges*, and *slop oil emulsion solids*), in that they commingle these streams for management. The sum of these *oily wastewater* residuals decreased from 723,000 wet tons in 1996 to 467,000 wet tons in 1997.

Nationwide Estimates of Residual Quantity by Stream—1996 versus 1997



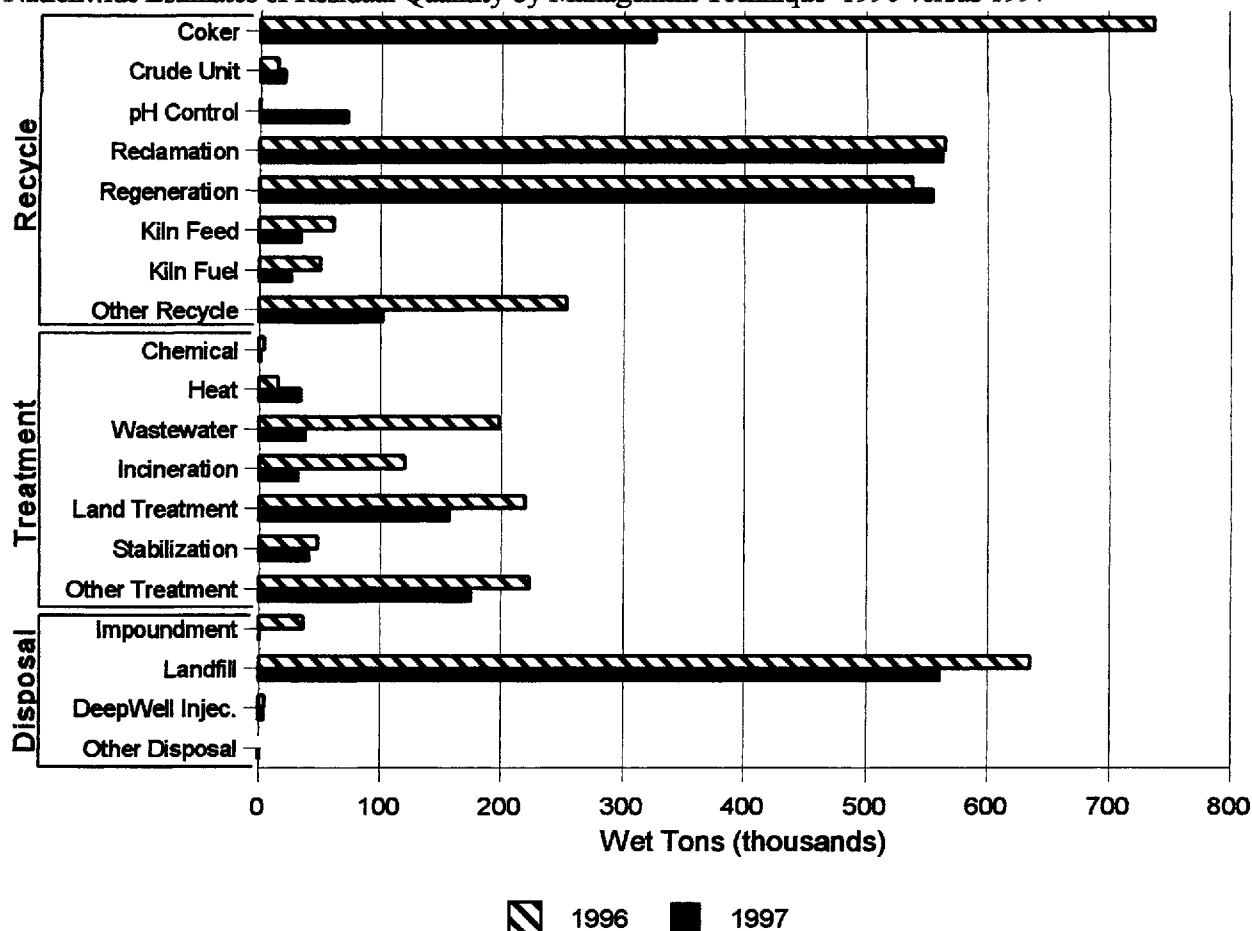
It is apparent that the most significant differences in the quantity per residual stream from 1996 to 1997 are the decreases in the quantities of *biomass*, *contaminated soils*, *slop oil emulsion solids*, *spent sulfidic caustic*, and *tank bottoms*. These five streams, in fact, account for nearly 80% of the total decrease in estimated quantities from 1996 to 1997. Two of these streams (*biomass* and *spent sulfidic caustic*) had accounted for a significant portion of the increase reported in 1996. The subsequent drop suggests that the trend for the 1990s is still downward, despite the one-year increase observed in 1996.

A comparison of the 1996 and 1997 nationwide distribution of residual quantities by management technique is shown in the next chart. Quantities reported as recycled for *pH control* are included in the *other recycle* category in 1996, whereas this technique is a separate category in 1997.

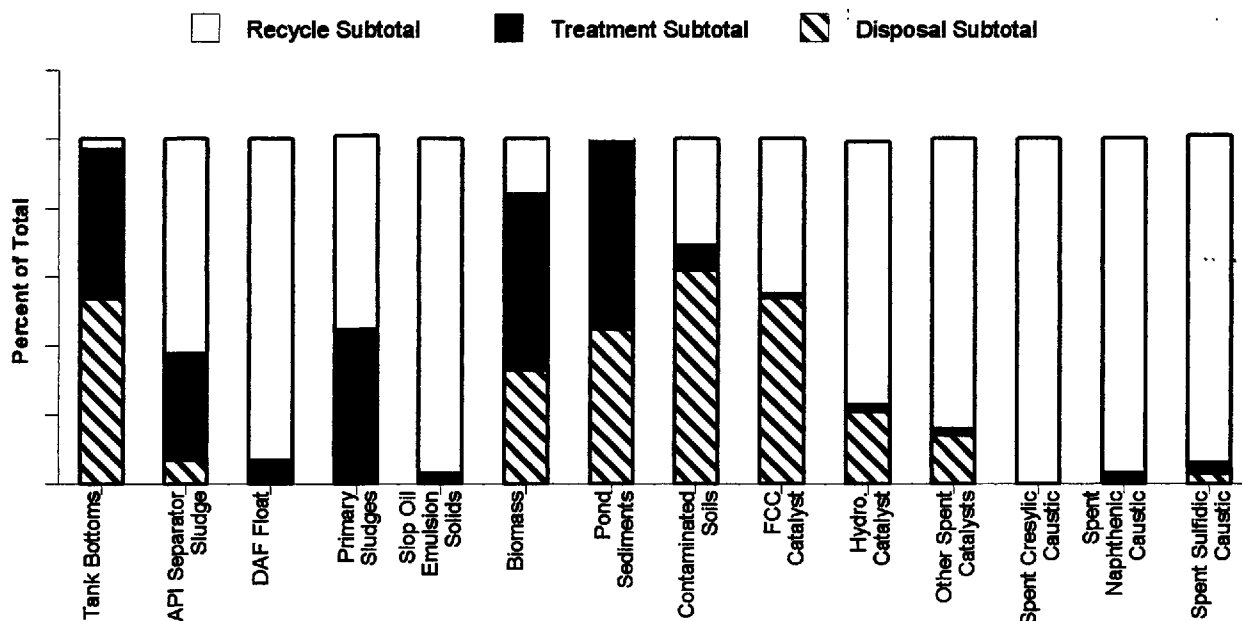
The final chart in this Executive Summary displays the nationwide distribution by management practice for each stream, as estimated from the 1997 survey. The streams that are sometimes dewatered, which include *tank bottoms*, the *oily wastewater* residuals, *biomass*, and *pond sediments*, are on the left side of the chart.

The overall trend of the 1990s continues to be a decline in the total quantity of residuals managed by U.S. petroleum refineries, and the most evident trend of the last three years is the movement toward *recycling* as the dominant management practice.

Nationwide Estimates of Residual Quantity by Management Technique-1996 versus 1997



Nationwide Estimates of Distribution by Management Practice-1997



ES-4

Section 1 METHODOLOGY

LISTING OF REFINERIES

The term 'petroleum refinery' is used differently in various contexts. For purposes of the 1997 API Refining Residual Survey, a refinery is defined as a facility that currently processes crude oil. Facilities that do not have crude units are not included in the survey.

The 1997 survey was distributed in electronic format (i.e., computer software on diskettes), in a similar manner to the 1995 and 1996 surveys. Selected screens from the electronic survey form are presented in Appendix A.

The survey was sent to those U.S. refineries listed as processing crude oil in the *Worldwide Refineries-Capacities as of January 1, 1998* published by the Oil & Gas Journal. Excluding those refineries that were found to not actually process crude or to have been shut down resulted in a final count of 152 refineries. Of these, 70 responded to the survey.

RATIONALE FOR SURVEY CLARIFICATIONS

As was explained in the 1995 and 1996 reports, the survey now specifies that only the quantity of residual remaining after dewatering is to be reported, without the recovered water or oil, thus providing for a consistent basis of response and more accurately reflecting quantities of residuals managed. The quantity reported for each stream, then, is that remaining after any dewatering of the sludge. For those streams that are not defined as RCRA-listed hazardous wastes, the quantity may include both hazardous and nonhazardous materials. Where it was determined that a facility had reported both the quantity of material that was treated and the quantity that was disposed of after treatment, only the quantity treated was included in the analysis.

The reporting units of wet tons indicate that the stream volumes are taken in their as-managed condition, rather than on a dry-solids basis. While residuals that have been dewatered will have a higher percent-solids content than if they had not been dewatered, they may nevertheless include a significant amount of water.

RESIDUAL STREAMS

Earlier annual surveys had collected data on 30 separate residual streams, but the 1994 survey reduced the number of streams to 15 for simplification. These 15 streams were believed to represent approximately 80% of the total quantity of refinery residuals. The 1994 survey had included two separate categories for *primary sludges* (i.e., the F037 and F038 RCRA categories). Combining these two streams into a single *primary sludges* category resulted in 14 streams in the 1995 survey. The 1995 survey also collected information on the cost of managing six of the 14 streams in the survey, compared to three streams having had cost data questions in the 1994 survey. The 1996 and 1997 surveys continued to collect data on these 14 residual streams, as well as soliciting cost data on the same subset of six. The definitions assigned to each stream are listed in Appendix A.

It should be understood that the residual stream labels used in this survey are NOT used in a regulatory sense. Whereas the Environmental Protection Agency (EPA) regulations implementing RCRA have given these terms special meaning, the usage here is in a broader, more generic sense. API's intent is to have survey participants report the management of all residual type materials (e.g., materials that are

byproducts or residuals of petroleum refining operations). This includes residuals that are beneficially recycled or reclaimed, as well as materials that are discarded.

In order to facilitate consistency of response, definitions are provided as pop up messages attached to buttons on the survey form, as shown in the following figure.

Figure 1—Sample Screen from the Survey Form

Clicking the <?> button next to a stream name results in a box popping up with the definition.

Refinery I.D.: 10001

Begin by clicking a stream from the list, continue until complete.

Type of Residual Stream: API Sep. Sludge

when done, click to close

Did your facility manage any of this in 1997? YES NO

click the button below to print reports

To print only a selected stream, enter the number next to the stream button as both From and To in the Page Range

click here to print reports

screen 4.1

MANAGEMENT PRACTICES AND TECHNIQUES

The 1997 survey continued to group management techniques into three categories of management practice—recycling, treatment, and disposal. The management techniques from the 1996 and 1997 surveys, with the definitions assigned to them for the 1997 survey, are listed in Appendix A. *Each of these management techniques is allowed under certain regulatory scenarios.*

Note that the *cat cracker* category has been discontinued as a separate management technique. The results of prior years' surveys have had the quantities from this category added to *other recycle*, for streams other than *FCC catalyst*, to accommodate comparison with the 1997 data. Quantities for *FCC catalyst* that had been assigned to the *cat cracker* category have been deleted from prior years' results, in that catalyst routed to another cracking unit for continued use as catalyst is still performing its initial function, and is therefore not yet a residual.

DATA ANALYSIS

Completed survey forms were received from respondent facilities in the form of data files on diskettes. Data cleaning included a check of the data for self-consistency. For example, if a facility indicated that its classification is 'topping', then it should not have reported any spent FCC catalyst; or if it did not report

having an API separator, then there should not be any API separator sludge. The data were also reviewed visually and statistically for outliers. Follow up phone calls resolved apparent discrepancies, such as whether the quantity had been reported in the correct units and, if so, why the amount differed from expected levels.

As with previous surveys, the data from the respondents were extrapolated to nationwide estimates by applying a regression analysis in which throughput capacity is taken as the explanatory variable. For consistency with previous years, the following form of equation was retained.

$$\sqrt{R} = b_0 + b_1 C$$

Where:

R = total residuals managed by a facility (wet tons),
 b_0 = the y-intercept of the regression line,
 b_1 = the slope of the regression line, and
 C = the throughput capacity of the facility (bsd).

The equation developed from the 1997 survey is

$$\sqrt{R} = 22.8 + 7.17 \times 10^{-4} C$$

with an R^2 measure of correlation equal to 0.58 and a percent error of 9.8%. The statistical analysis is described in more detail in Appendix B.

Section 2 RESULTS

RESPONSE RATE

The 1997 survey response rate is illustrated by several parameters in the following charts.

Figure 2—Response Rate by Refinery Capacity.

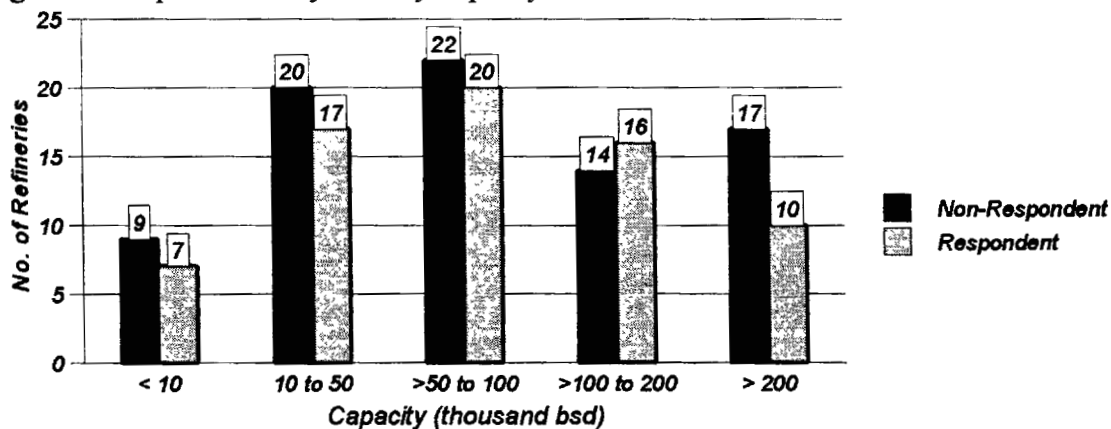


Figure 3—U.S. Department of Energy's Petroleum Administration for Defense (PAD) Regions.

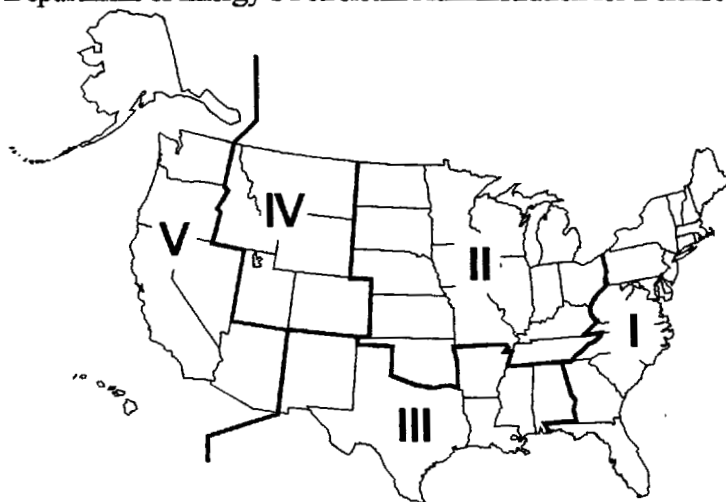


Figure 4—Response Rate by PAD Region.

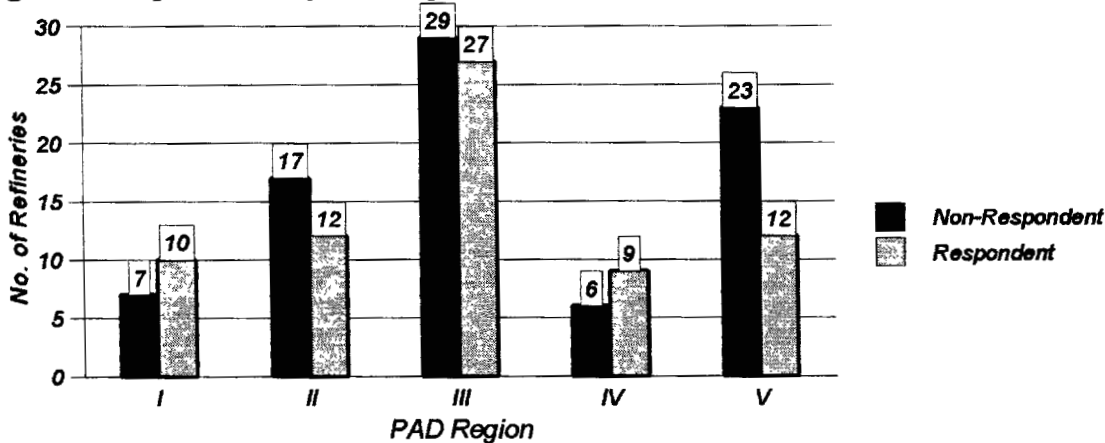


Figure 5—Response Distribution by Complexity of Facility.

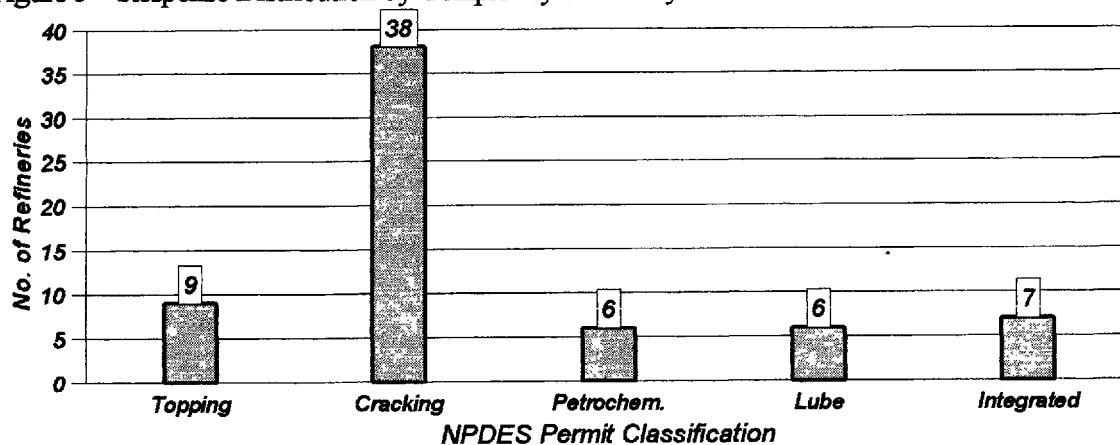


Figure 6—Response Distribution by Age of Facility.

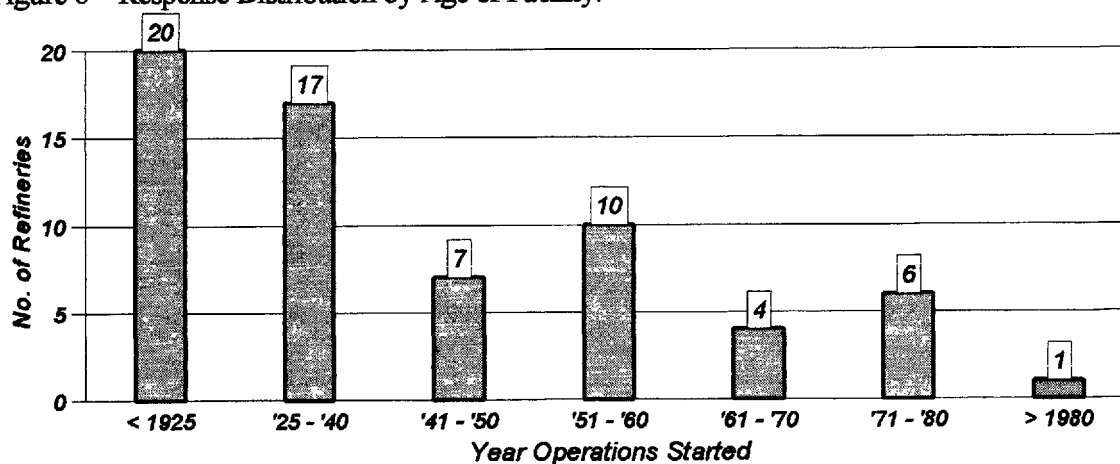
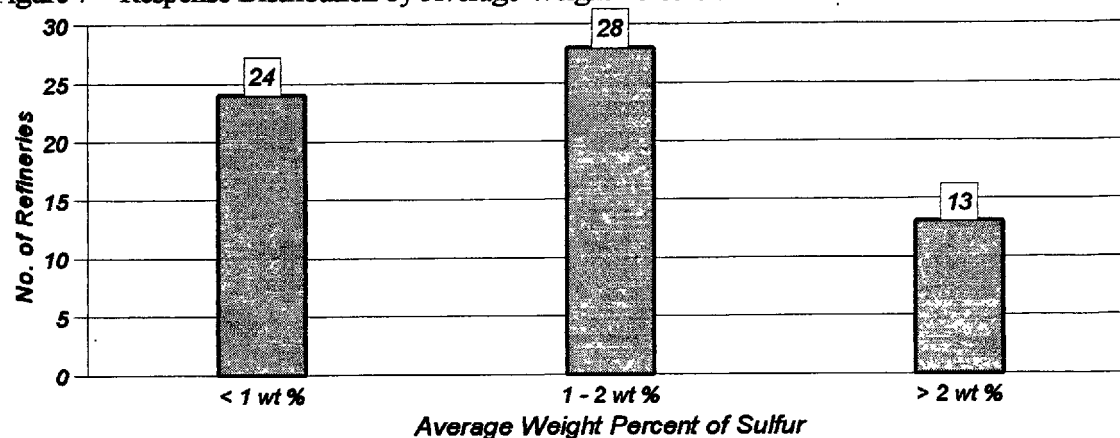


Figure 7—Response Distribution by Average Weight Percent of Sulfur in the Crude Run.



The number of responses for individual categories is sometimes less than the total number of responses, due to some facilities not answering certain questions.

The number of responses from each NPDES Permit Classification for each residual stream is summarized in Table 1 and presented on a percentage basis in Table 2.

Table 1—Number of Facilities in Each NPDES Classification Reporting Each Stream.

	NPDES Permit Classification				
	<u>Topping</u>	<u>Cracking</u>	<u>Petrochemical</u>	<u>Lube</u>	<u>Integrated</u>
Total No. of this type:	9	38	6	6	7
<u>Distribution by Residual Stream:</u>					
API Separator Sludge	4	26	5	3	3
Biomass	1	20	4	4	5
Contaminated Soils	6	33	6	5	7
DAF Float	0	14	1	1	4
FCC Catalyst	0	29	6	3	7
Hydro. Catalyst	2	32	5	4	5
Other Spent Catalysts	1	31	5	2	3
Pond Sediments	1	5	1	0	1
Primary Sludges	5	32	6	5	6
Slop Oil Emulsion Solids	0	12	4	4	3
Spent Cresylic Caustic	0	16	2	2	3
Spent Naphthenic Caustic	1	4	0	0	1
Spent Sulfidic Caustic	2	28	3	4	4
Tank Bottoms	3	25	5	4	7

Table 2—Percent of Facilities in Each NPDES Classification Reporting Each Stream.

	NPDES Permit Classification				
	<u>Topping</u>	<u>Cracking</u>	<u>Petrochemical</u>	<u>Lube</u>	<u>Integrated</u>
<u>Distribution by Residual Stream:</u>					
API Separator Sludge	44%	68%	83%	50%	43%
Biomass	11%	53%	67%	67%	71%
Contaminated Soils	67%	87%	100%	83%	100%
DAF Float	0%	37%	17%	17%	57%
FCC Catalyst	0%	76%	100%	50%	100%
Hydro. Catalyst	22%	84%	83%	67%	71%
Other Spent Catalysts	11%	82%	83%	33%	43%
Pond Sediments	11%	13%	17%	0%	14%
Primary Sludges	56%	84%	100%	83%	86%
Slop Oil Emulsion Solids	0%	32%	67%	67%	43%
Spent Cresylic Caustic	0%	42%	33%	33%	43%
Spent Naphthenic Caustic	11%	11%	0%	0%	14%
Spent Sulfidic Caustic	22%	74%	50%	67%	57%
Tank Bottoms	33%	66%	83%	67%	100%

WASTEWATER MANAGEMENT

Each of the 66 facilities that reported their wastewater plant configurations indicated that their wastewater is treated prior to discharge. They all reported having primary oil-water separation equipment, with 49 indicating that they use an API Separator. The remaining 17 facilities listed various types of equipment for primary separation, with the most frequent mention being a corrugated plate interceptor. The survey asks whether the facility discharges to a publicly-owned treatment works (POTW), a joint treatment facility (i.e., a privately-owned wastewater treatment facility shared by multiple users), or neither. This question allows a determination of whether the onsite treatment is pretreatment prior to additional treatment offsite, or is the complete treatment process for the facility's wastewater. The schematic in Figure 8 (on the following page) illustrates the distribution of equipment in the wastewater treatment facilities, as well as indicating whether effluent discharged prior to advanced treatment is sent to another treatment facility.

Three facilities reported having primary separation only, two of which discharge to a POTW. An additional ten facilities reported discharging after secondary separation, of which eight discharge to a POTW and one to a joint treatment facility. Of the remaining 53 facilities, 50 have some form of biotreatment and the three without biotreatment have some form of advanced treatment. Thus 64 of the 66 facilities (97%) report having biotreatment and/or advanced treatment, or discharging to another facility for further treatment.

The most common equipment configuration (reported by 50% of respondents) includes primary separation, gas flotation, and biotreatment. The following list summarizes the responses.

Primary separation . . .	100% (typically an API Separator)
Secondary separation . .	74% (typically some type of gas flotation)
Secondary	
biological treatment .	76% (typically includes activated sludge)
Advanced treatment . . .	45% of all reporting facilities (filtration is most common), and
	59% of those not subject to posttreatment.

The survey previously sought to differentiate among stormwater, process wastewater, and combined flow by asking for information on holding structures for segregated sewers separately from combined sewers. This question was revised in the 1996 survey to ask what percent of the facility is served by segregated sewers. In addition, the 1996 survey asked whether the effluent parameters were measured at the discharge from the wastewater treatment plant, or for the combined discharge of wastewater and untreated stormwater. The 1997 survey sought to further clarify this question by differentiating between dry and wet weather flow for combined sewers.

Figure 9 illustrates the type of structures used to hold stormwater and wastewater. The predominant type of structure reported for holding wastewater-only was tanks and for stormwater-only was impoundments. Eighteen facilities reported having 100% segregated sewers, and another 25 facilities reported having some segregated sewers and some combined sewers. Three respondents did not report their sewer configurations, and the remaining respondents indicated having 100% combined sewers. These responses are summarized below.

100% Segregated Sewers	18 facilities
Some Segregated/Some Combined .	25 facilities
100% Combined	20 facilities

In that some facilities have both segregated sewers and combined sewers, the total number of responses in Figure 9 exceeds 63.

Figure 8--Wastewater Treatment System Summary. (total number of responses = 66)

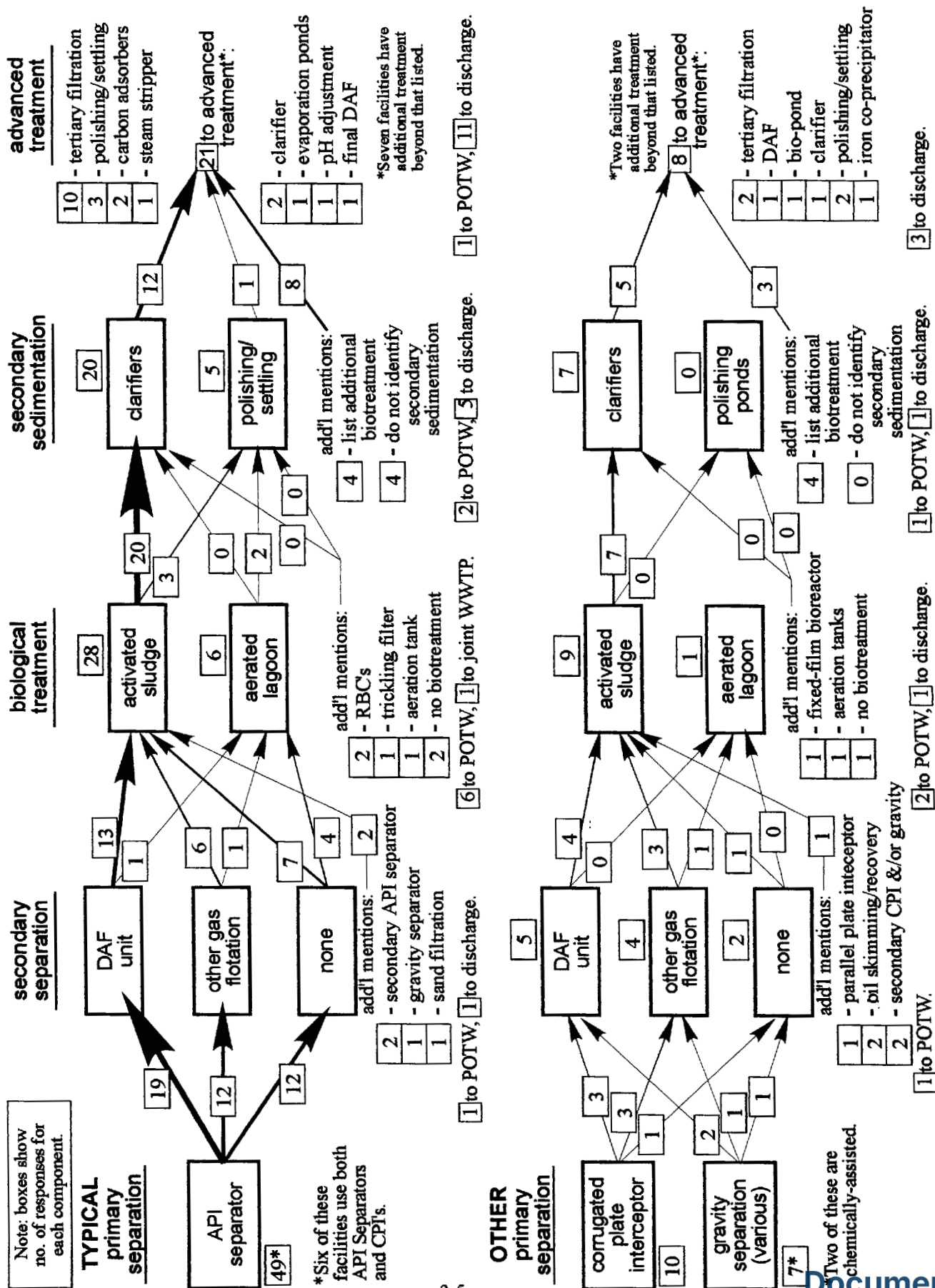
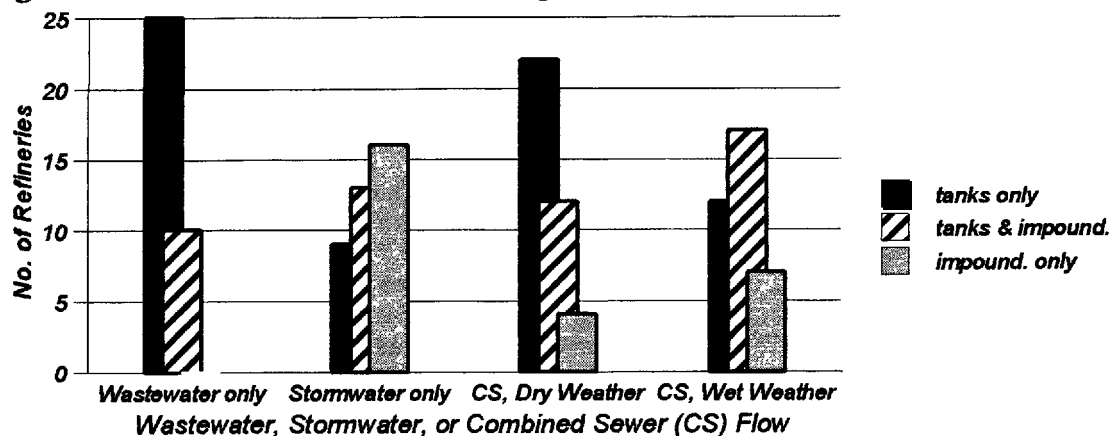


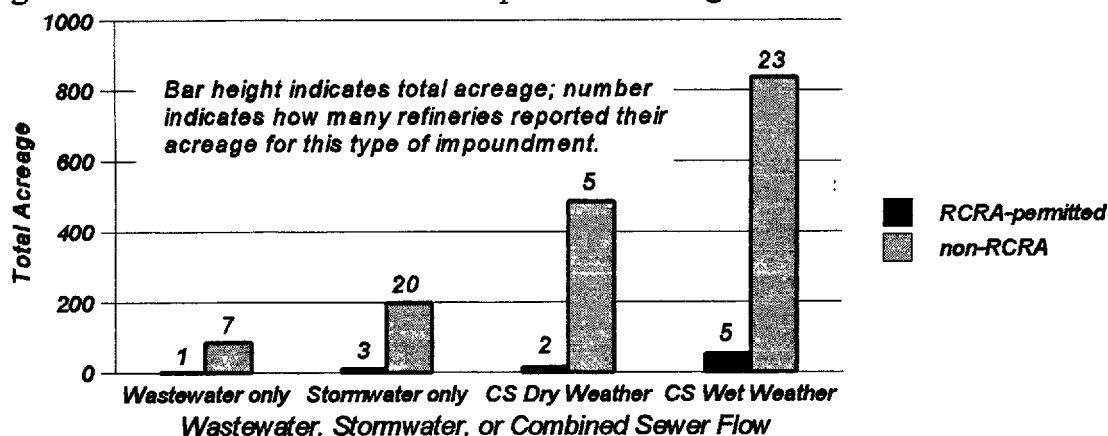
Figure 9—Stormwater and Wastewater Holding Structures.



Most of the facilities that reported using impoundments also reported the estimated acreage, which varied from 0.01 to 350 acres per facility. Figure 10 shows the total acreage having RCRA permits or interim status versus the acreage of impoundments that are not RCRA regulated. The chart also indicates the number of facilities that reported their acreage for each category. The average size of impoundments is summarized in the following list.

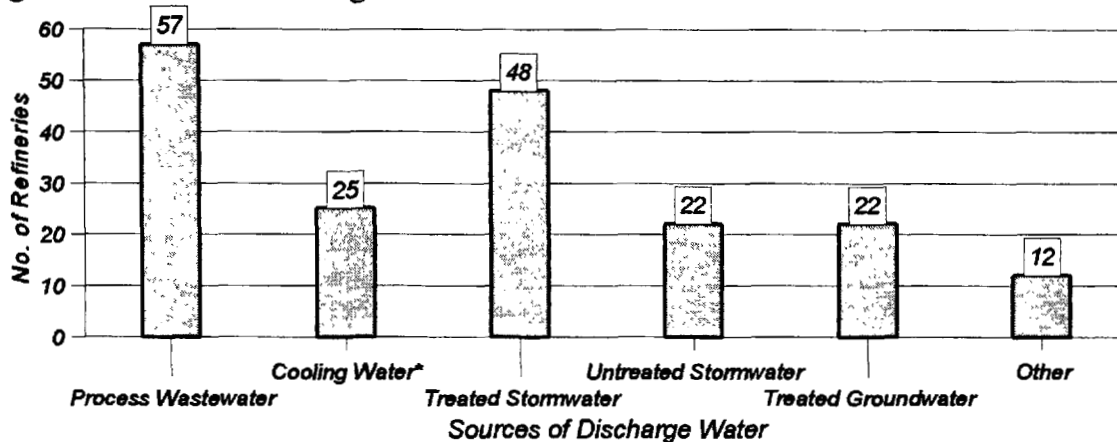
	average of all responses	average without largest & smallest
RCRA-permitted:	6.8 acres	4.3 acres
not RCRA regulated:	29.1 acres	23.6 acres

Figure 10—Stormwater and Wastewater Impoundment Acreage.



Every responding facility listed the quantity of wastewater discharged daily. The average of the reported daily discharge rates was 2.5 million gallons per day (MGD), and the median rate was 1.0 MGD. Two facilities indicated that their wastewater is routed to evaporation ponds, resulting in no offsite discharges. Most of the remaining respondents gave a breakdown of the sources of their discharge water, with all but one reporting some contribution from process wastewater. The number of facilities reporting each source of discharge water is shown in Figure 11. Note that most facilities report more than one source of discharge water. Of those listing 'other' sources, the most frequently mentioned source was blowdown water. Sanitary wastewater was also mentioned in several responses.

Figure 11—Sources of Discharge Water.



*Only includes non-contact once through cooling water that is treated prior to discharge.

Additional detail on the sources of discharge water is provided in Table 3. In this table, the contribution of each source is shown as a percent of total discharge water, for those facilities reporting that source.

Table 3—Sources of Discharge Water as a Percent of Total.

	No. of Respondents reporting this source	Range	Median	Median Flow 1997 (MGD)	Median Flow 1996 (MGD)
Process Wastewater	57	10 – 100 %	70%	0.8	1.0
Noncontact Cooling Water*	25	2 – 80 %	20%	0.3	0.1
Treated Stormwater	48	0.5 – 100 %	9.9%	0.1	0.1
Untreated Stormwater	22	0.01 – 25 %	5%	0.05	0.08
Treated Groundwater	22	0.01 – 80 %	3.1%	0.03	0.04
Other	12	0.1 – 57 %	6.5%	0.2	0.1

* only includes non-contact once through cooling water that is treated prior to discharge.

Levels of eight discharge parameters were requested in the question on effluent quality. The levels are presented as an amount (pounds per year) in Table 4, and as a concentration (pounds per million gallons) in Table 5.

Table 4—Water Quality Discharge Parameters (pounds per year).

	No. of Respondents reporting this parameter	Median-1997	Median-1996
Total Suspended Solids (TSS)	58	84,000 lbs	73,000 lbs
Biochemical Oxygen Demand (BOD)	56	49,000 lbs	49,000 lbs
Chemical Oxygen Demand (COD)	51	435,000 lbs	380,000 lbs
Ammonia	58	9,100 lbs	9,700 lbs
Oil & Grease (O&G)	60	14,000 lbs	13,000 lbs
Chromium	42	22 lbs	26 lbs
Nickel	18	180 lbs	100 lbs
Selenium	22	200 lbs	120 lbs

Table 5—Water Quality Discharge Parameters (pounds per million gallons of wastewater discharge).

	<u>Median-1997</u>	<u>Median-1996</u>
Total Suspended Solids (TSS)	165 lbs/MG	140 lbs/MG
Biochemical Oxygen Demand (BOD)	92 lbs/MG	87 lbs/MG
Chemical Oxygen Demand (COD)	667 lbs/MG	750 lbs/MG
Ammonia	25 lbs/MG	26 lbs/MG
Oil & Grease (O&G)	28 lbs/MG	27 lbs/MG
Chromium	0.07 lbs/MG	0.04 lbs/MG
Nickel	0.16 lbs/MG	0.13 lbs/MG
Selenium	0.32 lbs/MG	0.12 lbs/MG

In addition to the effluent parameters, the survey solicited measurements of certain wastewater parameters at intermediate points in the system. The survey requested the levels of oil and grease after primary separation and again after secondary separation, as an indicator of the effectiveness of secondary oil/water separation. In a similar manner, the survey asked for levels of both BOD and COD before and after biotreatment. Approximately one third of the respondents supplied this information. The average levels of these parameters at the intermediate points indicated, as well as the average effluent levels, are summarized in Table 6. The effluent values do not match those reported in Table 5, in that only those facilities reporting these parameters at all three points were included in Table 6. These, then, comprise a subset of the facilities reported in Table 5.

Table 6—Water Quality Parameters at Intermediate Points (pounds per million gallons of wastewater flow).

	No. of Respondents reporting <u>this parameter</u>	Total Level* (pounds/MG)	1997 Average Level* (pounds/MG)
<u>Oil and Grease (O&G)</u>			
After primary separation	24	49,506	2,250
After secondary separation	24	10,222	465
At effluent	24	2,553	116
<u>Biochemical Oxygen Demand (BOD)</u>			
Before biotreatment	27	45,183	1,807
After biotreatment	27	6,306	252
At effluent	27	5,684	227
<u>Chemical Oxygen Demand (COD)</u>			
Before biotreatment	28	145,934	5,405
After biotreatment	28	31,108	1,152
At effluent	28	28,832	1,068

*Two outliers were deleted from the O&G summary, two outliers were deleted from the BOD summary, and one outlier was deleted from the COD summary.

POLLUTION PREVENTION

The simplified pollution prevention question introduced in the 1995 survey and used again in the 1996 survey was retained in the 1997 survey. Rather than soliciting pollution prevention practices for each residual stream, a single listing was requested for the entire facility. The question asked for a description of those pollution prevention activities undertaken in 1997. Most respondents listed only those projects brought on line in 1997, but it is evident from other portions of the survey that virtually every facility practices certain pollution prevention techniques, such as recycling.

Many of the pollution prevention techniques relate to recognizing that waste streams are often comprised largely of water and dirt that have been contaminated by being combined with process materials.

Accordingly, the pollution prevention techniques include:

- ▶ reducing the amount of dirt that enters the oily wastewater stream,
- ▶ reducing the amount of water that enters the oily wastewater stream,
- ▶ dewatering to reduce the volume of oily sludges, and
- ▶ minimizing the contamination of dirt by reducing spills and leaks.

In addition to reducing the volume of water and dirt in the wastewater residuals, the industry has continued to implement strategies to better manage the process residuals, including:

- ▶ source reduction,
- ▶ waste segregation, and
- ▶ recycling.

Each of these practices is enhanced by education and training. The specific responses from the 1997 survey are listed in Table 7.

Table 7—Pollution Prevention Activities.

<u>General Practice</u>	<u>Survey Response</u>
Reduction of dirt to the oily water sewer.	Improved housekeeping. Improved site drainage. Modify sewer systems to reduce solids entering the sewer.
Reduction of water to the oily water sewer.	Eliminating and/or rerouting drains to reduce the flow of water entering the sewers.
Dewatering of oily sludges.	Installed new dewatering equipment. Replaced or improved existing dewatering equipment. Expanded the use of dewatering equipment.
Education and training.	Raised awareness of the facility's pollution prevention practices. Improved the FCCU waterwash program. Initiated a study of MEK and toluene losses to identify opportunities for reducing losses. Improved operations of the thermal desorption unit. Reviewed operating procedures to reduce the amount of acid soluble oil generated in the Alkylation Unit. Completed an NPDES point source study baseline.

Table 7—Pollution Prevention Activities (continued).

<u>General Practice</u>	<u>Survey Response</u>
Reduction/Containment of spills and leaks.	Improved housekeeping. Tagged and entered components for LDAR program. Installed double bottoms in storage tanks. Improved or expanded leak inspection programs for tanks. Upgraded rim seals on storage tank floating roofs. Installed high level alarms on tanks. Replaced underground piping with either double-walled piping or aboveground piping. Installed hydrocarbon recovery trenches. Replaced leaking seals and gaskets. Replaced/repairs concrete on hydrotreater and dewaxer units. Upgraded and/or relocated sewer lines.
Source reduction/process modification.	Reduced flaring from units through process changes. Upgraded the catalyst separator at the FCCU. Discontinued use of Freon® 12 (replaced with Freon® 134). Phase out of tetraethyllead. Permanently removed methylene chloride from the refinery's obsolete vapor recovery unit. Improved oil/water separations in the process units. Improved sulfur processing. Substituted less toxic chemicals for certain uses. Cleaned or replaced crude heat exchangers and fin fan air-product coolers. Purchased solvent-free parts washer. Replaced heavy atmospheric gas oil (HAGO) seal flush with nitrogen pump seals. Installed a filter to reduce particulate loadings from the intake water. Utilized a dry paint-removal system to reduce the use of hazardous abrasives. Replaced caustic and cresylic treating of crack stock gasoline with mercox treating to meet -RSH specifications. Desalted Amine Solution and Stretford Solution. Changed the configuration of the burner system to increase the destruction efficiency of VOCs from the asphalt operation.
Waste segregation.	Kept nonlisted residuals from combining with listed wastes. Utilized containers and tanks to retain contaminated water and settle out solids prior to discharge to the wastewater treatment plant.

Table 7—Pollution Prevention Activities (continued).

General PracticeSurvey Response

Recycling.

Utilized Delayed Coking unit to recycle DAF flock and tank bottoms.

Recycled recovered oil from the process sewers back to the crude unit.

Converted wastes into products or for use as intermediates.

Installed equipment to inject the emulsion precursor directly into the pipestill crude feed pump suction.

Initiated use of chemical treatment for tank cleaning to dissolve and recycle hydrocarbons from the sludge.

Began a paper recycling program.

Recycled ethylene glycol.

Recycled activated alumina.

Recycled spent catalysts.

Recycled dessicants.

Recycled non-hazardous sandblast abrasives.

Recycled Freon®.

Improved treatment.

Used antifoulants in the heat exchanger systems.

Added odor/emission control equipment to units.

Improved pH control in the ASU.

Upgraded the metering system for treated wastewater effluent.

Enhanced water treatment by the installation of a solvent extraction system upstream of the DAF unit and by the downstream addition of microorganisms.

Installed a unit to treat tail gas from the sulfur recovery unit.

Replaced a flare with a new, taller flare.

Installed more efficient tertiary cyclones to control particulates from the FCC unit stack.

Installed a waste gas chiller.

Installed a vapor recovery system at the NGL loading rack.

Installed a treatment unit to remove benzene from the crude desalter effluent.

Section 3 RESIDUAL STREAM PROFILES

The U.S. refining industry managed an estimated 2.74 million wet tons of material from the 14 residual streams included in the 1997 API Refining Residual Survey. A summary of the total quantity of residuals managed per year is presented in Figure 12. The data for 1987 through 1994 have been adjusted in Figures 12 and 13 by deleting the quantities considered to be recovered oil or water rather than true residuals. Quantities reported as FCC catalyst recycled to a cat cracker have been deleted for the years 1991 through 1996, in that the material was still in use as a catalyst and therefore was not a residual.

Figure 12—Nationwide Estimate of Residual Quantity per Year: 1987-1997.

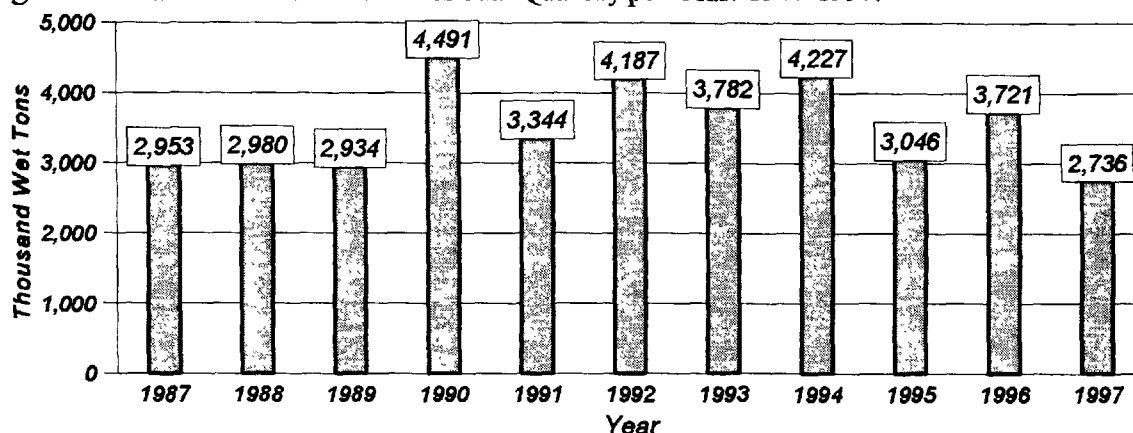
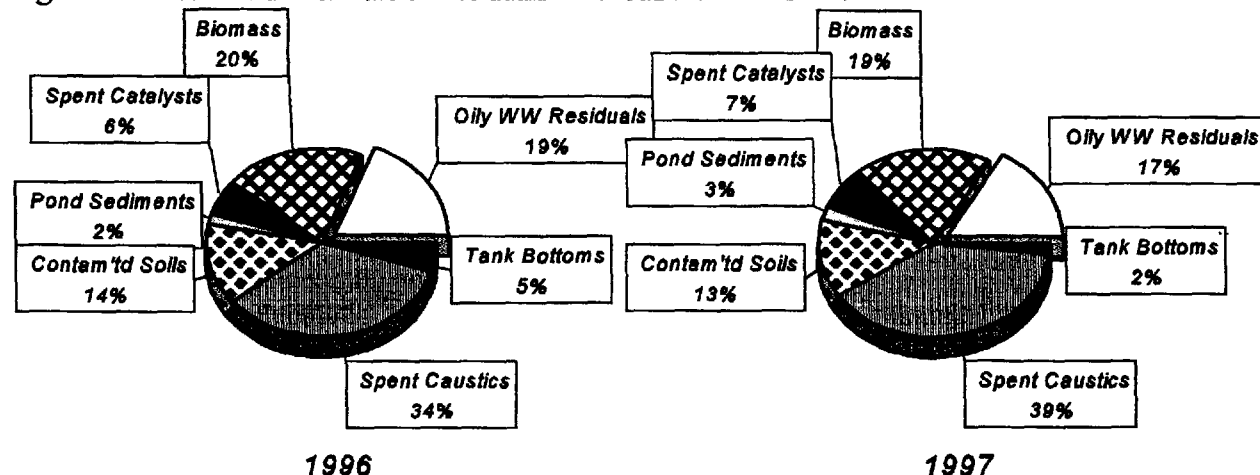


Figure 13 shows the relative contribution of the residual streams, with certain streams grouped together. The FCC catalyst, hydro. catalyst, and other spent catalyst streams are combined into a *spent catalysts* category; and a *spent caustics* category includes spent cresylic caustic, spent naphthenic caustic, and spent sulfidic caustic. The *oily wastewater residuals* (i.e., API separator sludge, DAF float, primary sludges, and slop oil emulsion solids) make up a third grouping. The contribution of each category in 1997 is estimated to be within five percentage points of its contribution to the 1996 data.

Figure 13—Nationwide Estimate of Residuals Distribution: 1996-1997.

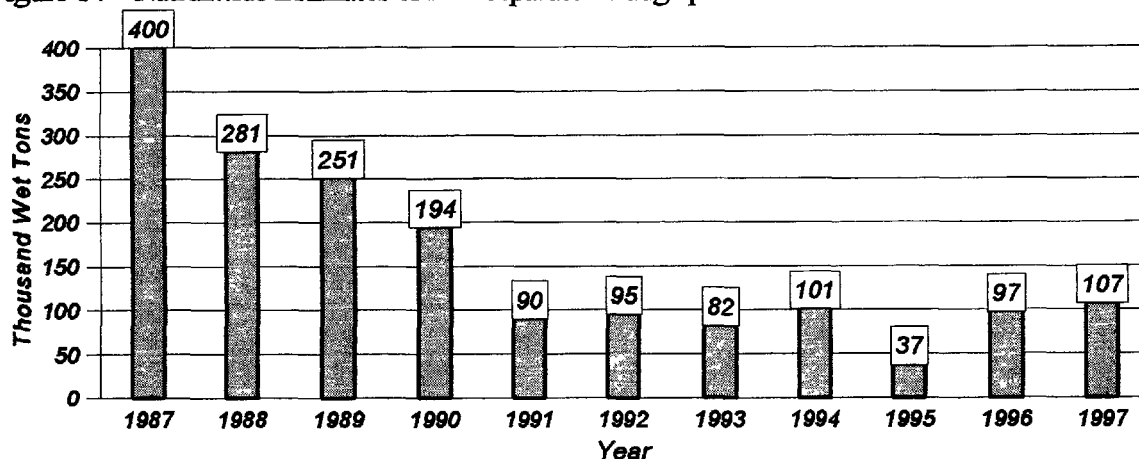


The remainder of this section presents detailed information for the individual streams, with the streams arranged in alphabetical order. The data for this section are summarized in the tables of Appendix C.

API SEPARATOR SLUDGE¹

The U.S. petroleum refining industry managed an estimated 107 thousand wet tons of API Separator Sludge in 1997, which was a 10% increase from 1996. A summary of the quantity of API Separator Sludge managed per year is presented in Figure 14. The data for 1987 through 1994 have been adjusted by deleting the quantities considered to be recovered oil or water rather than true residuals.

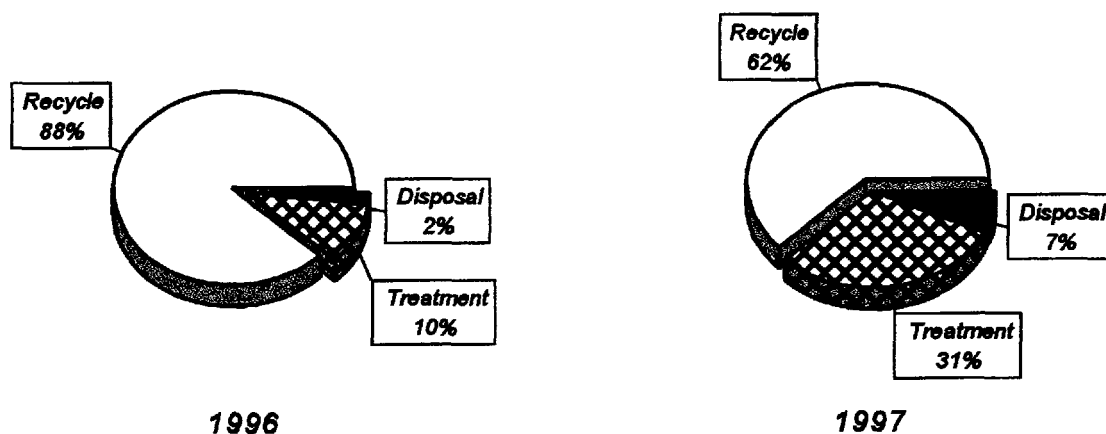
Figure 14—Nationwide Estimates of API Separator Sludge per Year: 1987-1997.



Several facilities combine some or all of the residuals associated with their wastewater treatment facility (i.e., API Separator Sludge, DAF Float, Primary Sludges, and Slop Oil Emulsion Solids). The combined quantities of these oily wastewater streams are summarized in Figure 88, which shows a decrease from 723 thousand wet tons in 1996 to 467 thousand wet tons in 1997, a decrease of 35%.

The portion of the API Separator Sludge stream that is managed by each management practice is shown in Figure 15 for 1996 and 1997. Recycling continues to be the dominant management practice for this stream.

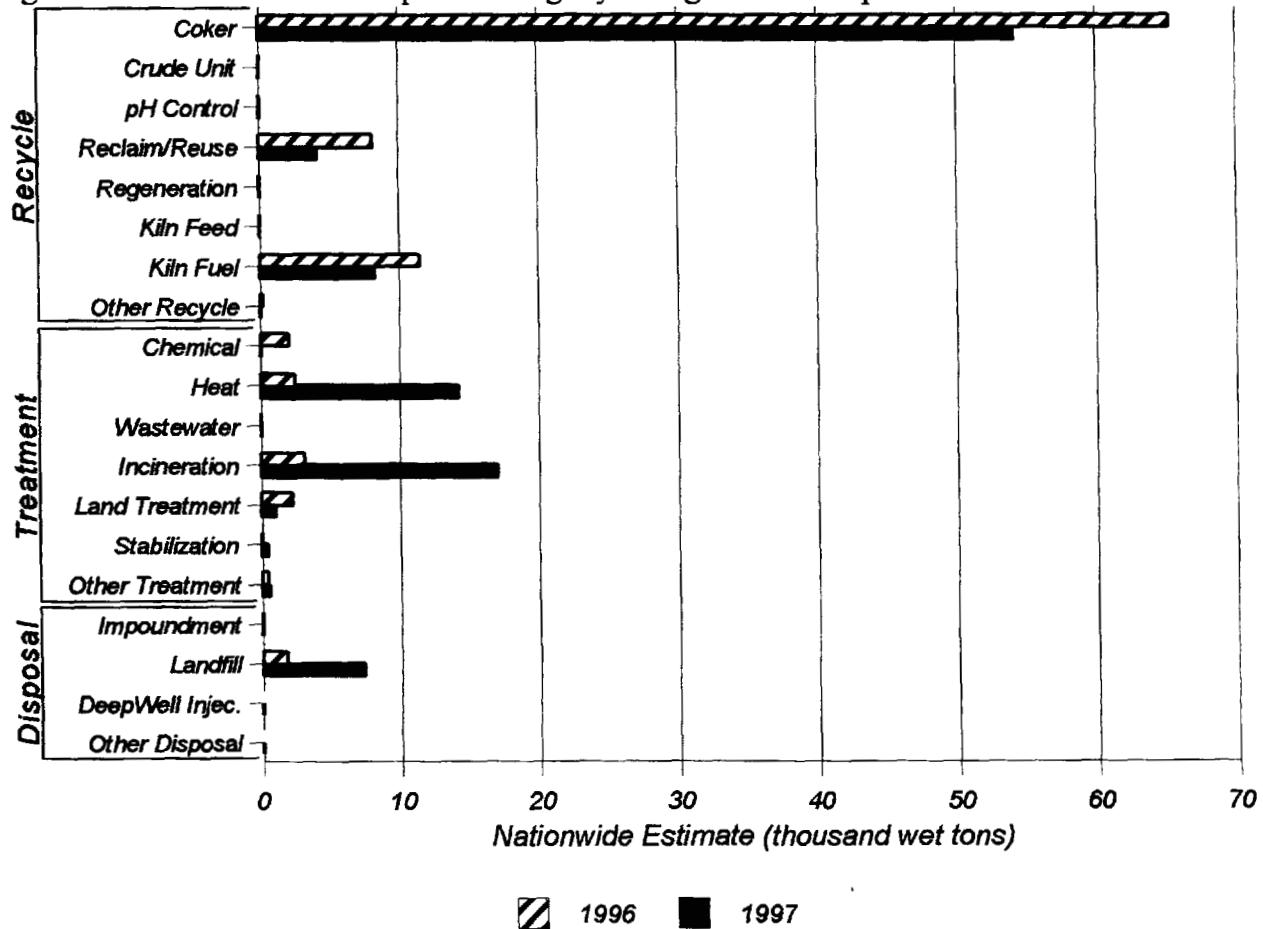
Figure 15—Nationwide Estimates of API Separator Sludge by Management Practice: 1996-1997.



¹Recall that this report uses labels such as API Separator Sludge in the broader context of a *residual stream* which includes materials that are not subject to RCRA regulation.

Figure 16 shows the API Separator Sludge distribution by management technique for 1996 and 1997. This stream is most commonly managed by techniques that recycle the oil content, primarily by routing the stream to a *coker*. When oil is recovered from this stream by thermal desorption, it is reported as *reclamation*. End uses reported for reclaimed or reused material were *oil recovery* and *fuels blending*. The end-use categories are defined in Appendix A.

Figure 16—Distribution of API Separator Sludge by Management Technique: 1996-1997.



The 1997 survey prompted respondents who listed land treating or landfilling this stream to explain the circumstances. Some facilities indicated having exported the residual to Canada for landfilling, others explained that the material in question did not fall within the RCRA definition for this stream, and one facility cited a 'no migration land farm permit' as allowing land treatment of certain RCRA wastes.

Responses in the *other* categories are listed below.

Other Recycle: none.

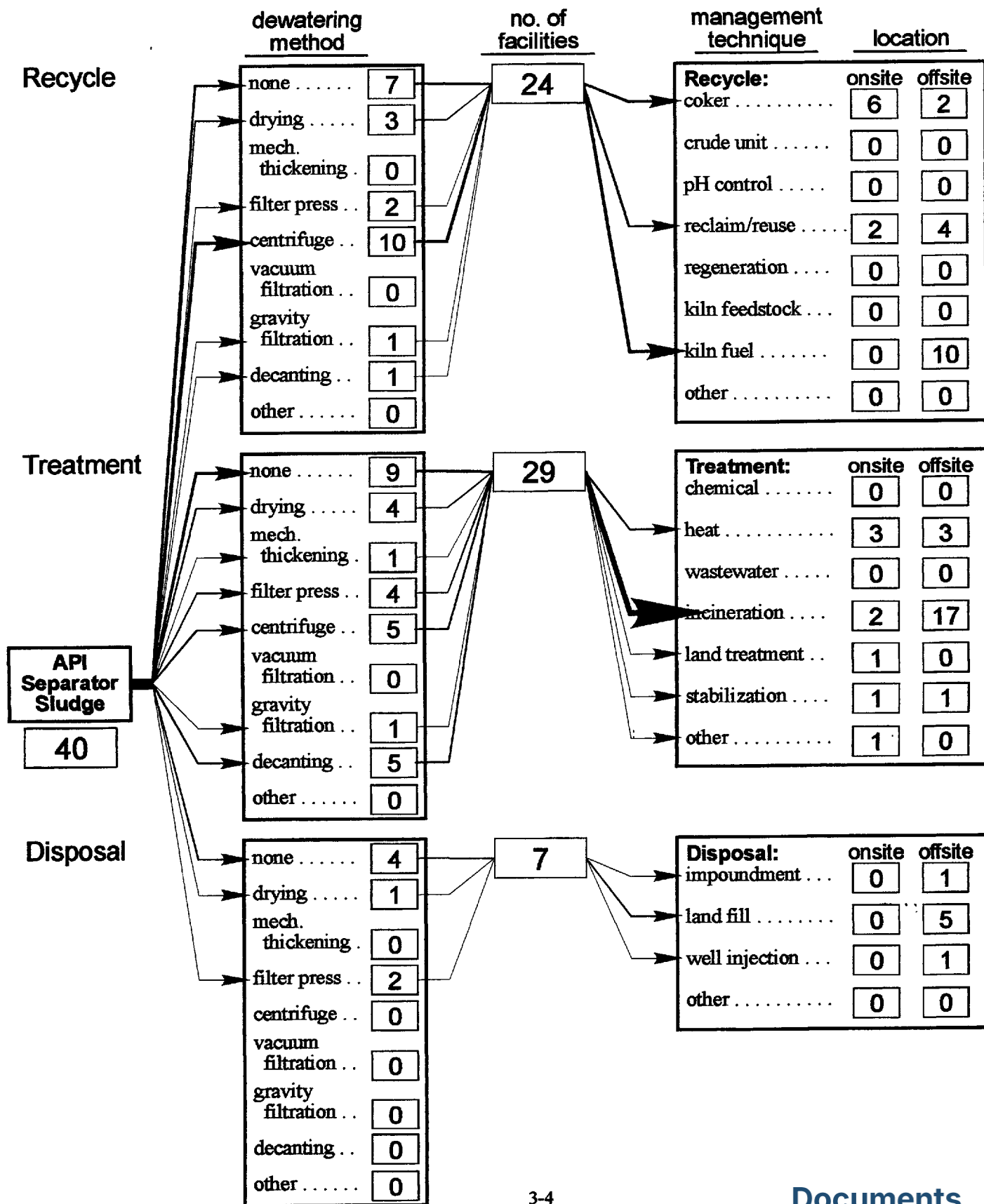
Other Treatment: one facility sends this stream to Permitted Storage.

Other Disposal: none.

The schematic on the next page illustrates the distribution of dewatering techniques and onsite versus offsite management for this stream by number of respondents.

Figure 17 - API Separator Sludge Summary: 1997

Note: Boxes show no. of facilities reporting each option.
Some facilities report multiple options



The following three graphs summarize the cost data reported for API Separator Sludge.

Figure 18—Onsite Management Cost for API Separator Sludge: 1997

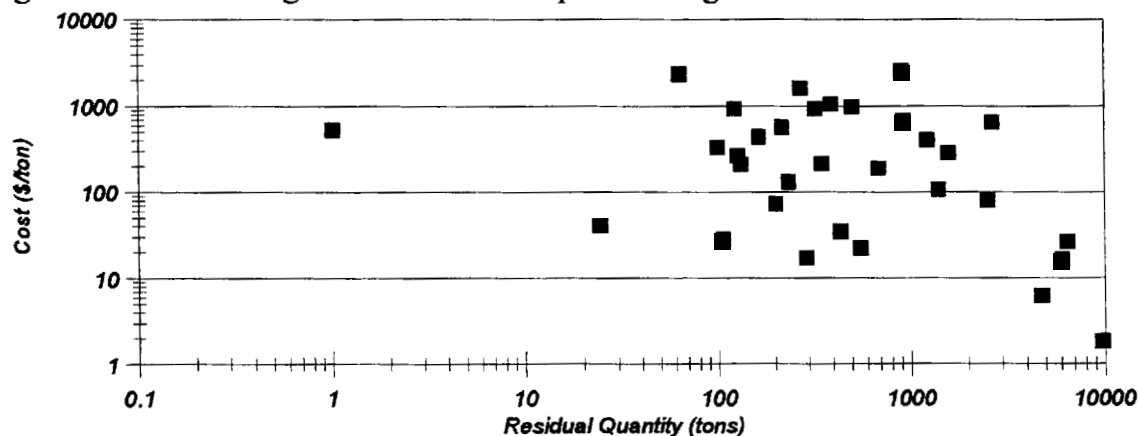


Figure 19—Offsite Management Cost for API Separator Sludge: 1997

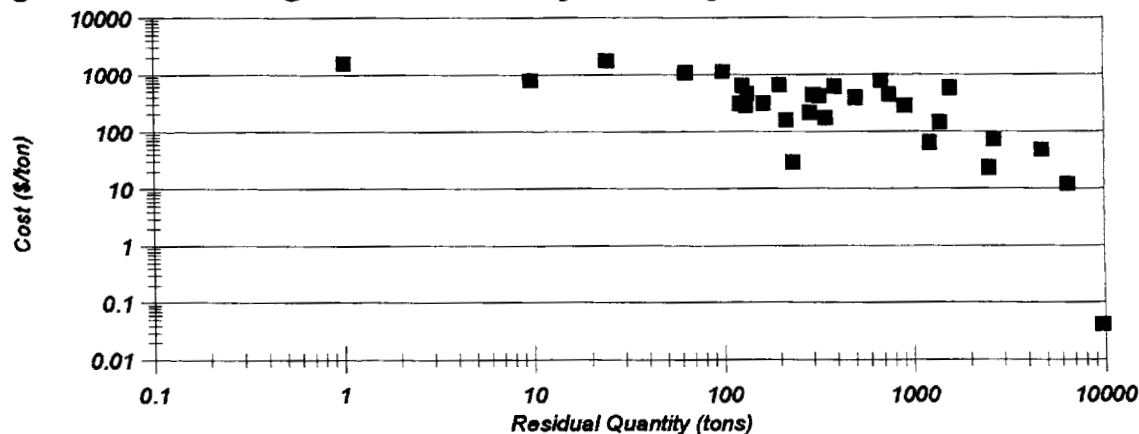


Figure 20—Total Management Cost for API Separator Sludge: 1997

