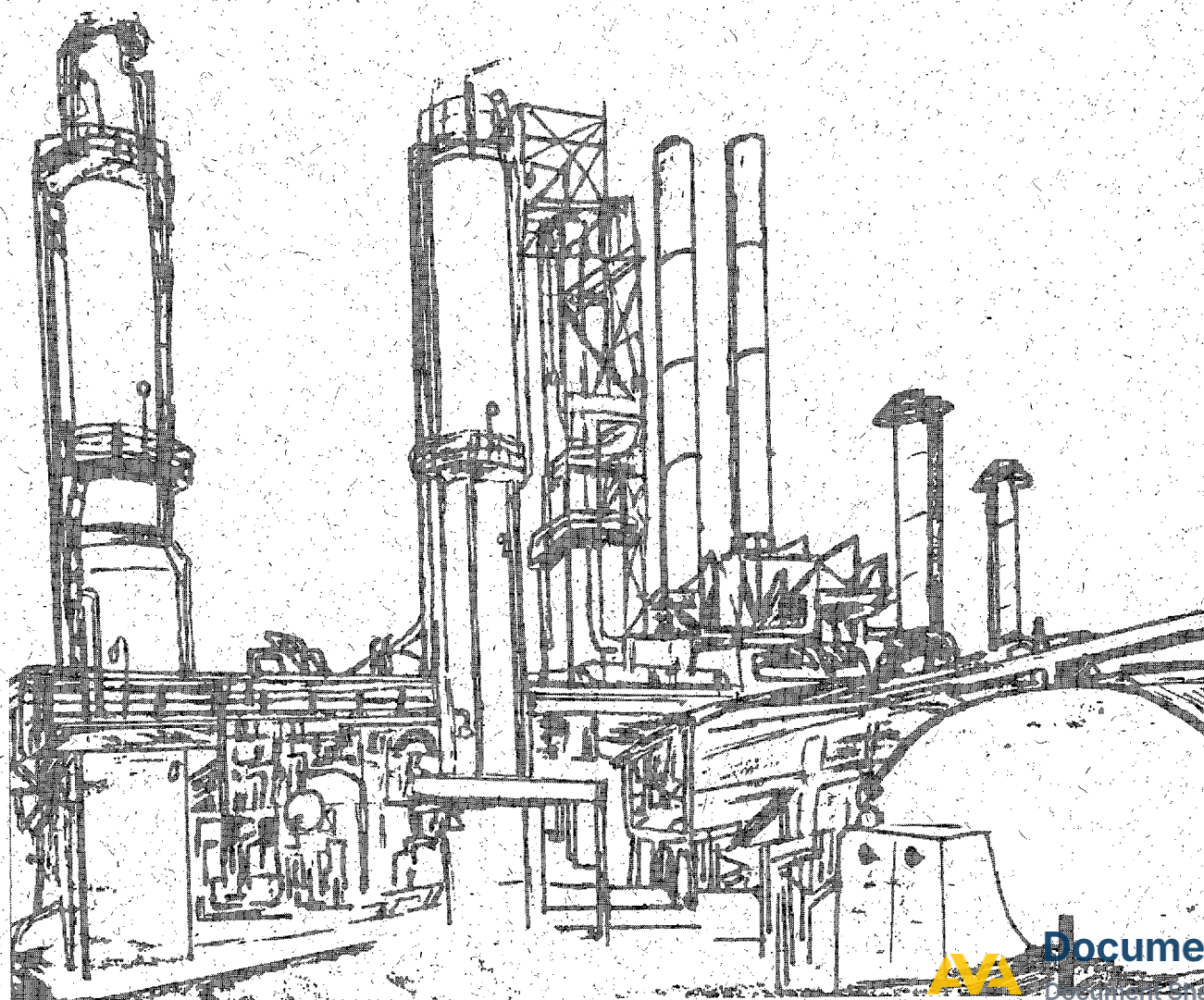


MANAGEMENT OF RESIDUAL MATERIALS: 1996

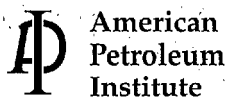
PETROLEUM REFINING PERFORMANCE

HEALTH AND ENVIRONMENTAL AFFAIRS DEPARTMENT
PUBLICATION NUMBER 345
JUNE 1998



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Management of Residual Materials: 1996

Petroleum Refining Performance

Health and Environmental Affairs Department

API PUBLICATION NUMBER 345

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JUNE 1998

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At each refinery participating in the survey, one or more individuals assumed the responsibility to complete the survey questionnaire. Their efforts deserve special recognition and thanks from the industry.

Carol Gosnell (API) is recognized for her contribution to the cover art for this publication.

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EXECUTIVE SUMMARY

The 1996 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).

1996 Refining Residual Survey—Response Level

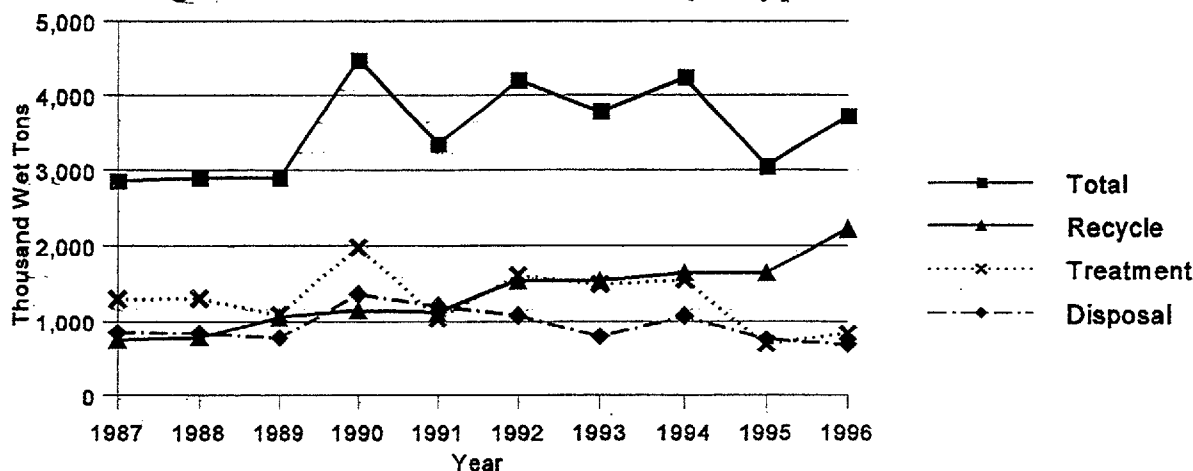
	<u>Estimated U.S. Total</u>	<u>Survey Respondents</u>	<u>Percent</u>
No. of Facilities	152	79	52 %
Refining Capacity	15,534,500 bsd	8,925,800 bsd	57 %
Residual Quantity	3,722,000 wet tons	1,887,000 wet tons	51 %

The 1996 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 through enhanced guidance on the survey form. 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 survey. In the following chart, the data for 1987 through 1994 have been adjusted by deleting the quantities considered to be recovered oil or water rather than true residuals.

Trends in Management Practices—Nationwide Estimates of Quantity per Year



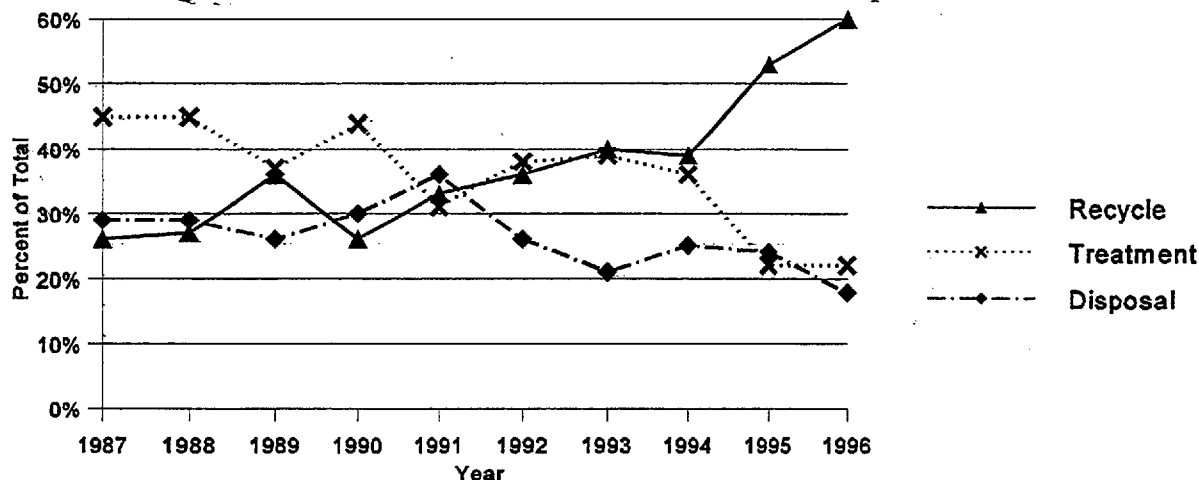
The specific adjustments made to the 1987 through 1994 data were to delete the amounts shown as managed by wastewater treatment from the streams that are reduced by dewatering, which are the *tank bottoms*, *API separator sludge*, *DAF float*, *primary sludges*, *slop oil emulsion solids*, *biomass*, 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 estimated total quantity of residuals managed at U.S. refineries increased from 3,049,000 wet tons in 1995 to 3,722,000 wet tons in 1996, an increase of 673,000 wet tons. The 1996 nationwide estimate, however, is still lower than the annual estimated quantities for 1992 through 1994. 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.

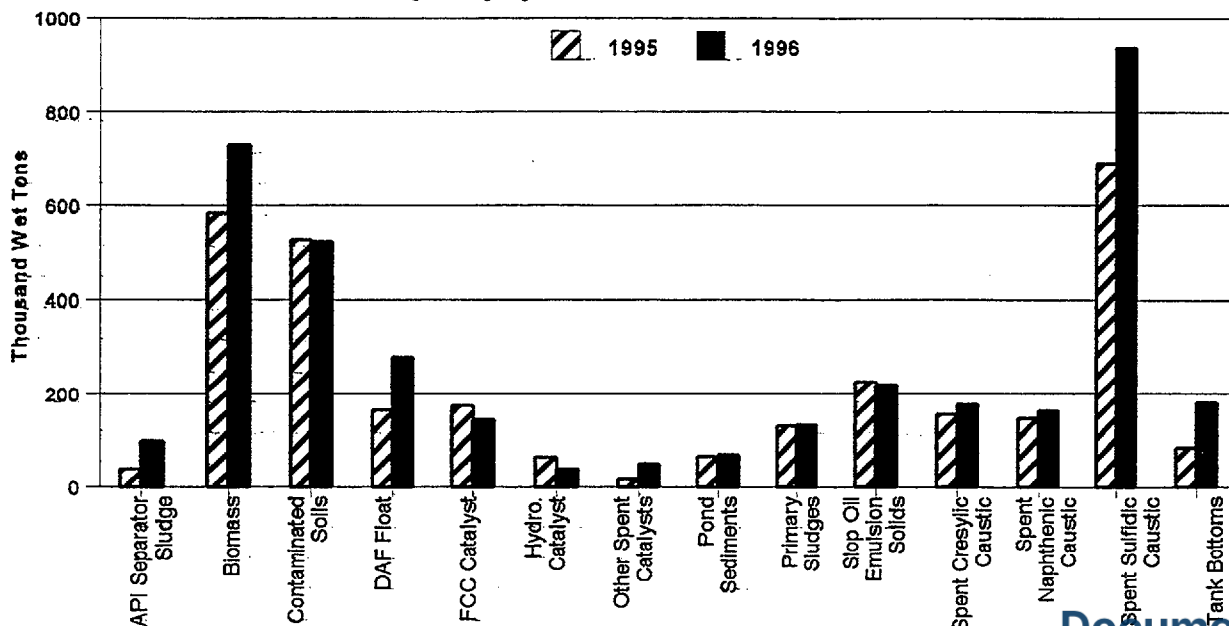
The portion of residual material reported as having been *recycled* continues the strong upward trend of recent years, with well over half of the total quantity managed now shown as *recycled*.

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



The next chart compares residual quantities by stream for 1995 and 1996.

Nationwide Estimates of Residual Quantity by Stream—1995 versus 1996

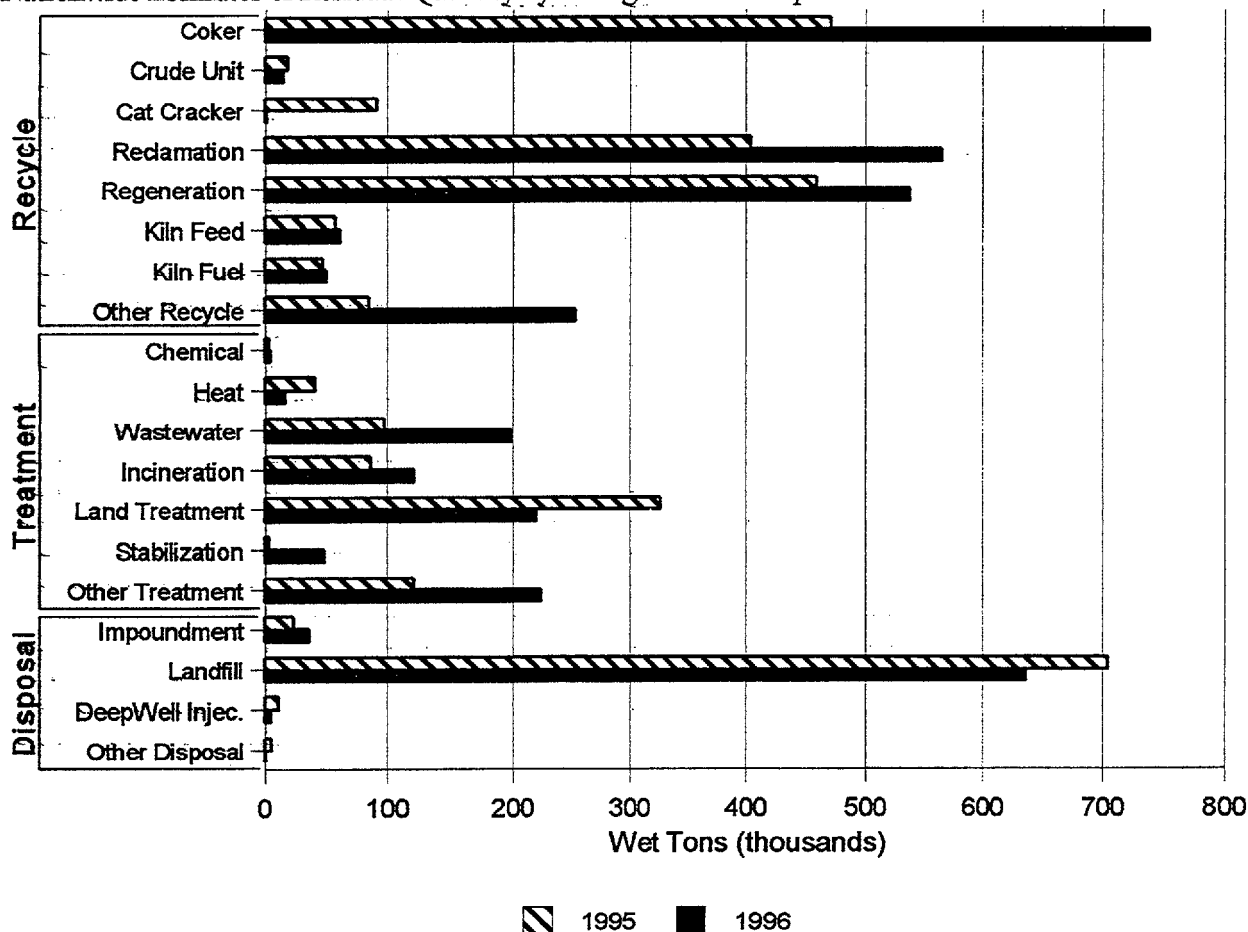


ES-2

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 increased from 554,000 wet tons in 1995 to 726,000 wet tons in 1996.

Another step taken in the 1995 survey to improve reporting consistency was to combine all manner of *land farming* and *land spreading* into a single *land treatment* category. This approach was continued in the 1996 survey. The 1996 survey additionally discontinued the *physical treatment* category. In the following chart, the quantity reported under *physical treatment* in 1995 has been combined with *other treatment* in order to make the data comparable to 1996.

Nationwide Estimates of Residual Quantity by Management Technique—1996 versus 1995



The most significant difference in the quantity per residual stream from 1995 to 1996 is the increase in the quantities of *biomass*, *DAF float*, and *spent sulfidic caustic*. These three streams, in fact, account for 75% of the total increase in estimated quantities from 1995 to 1996.

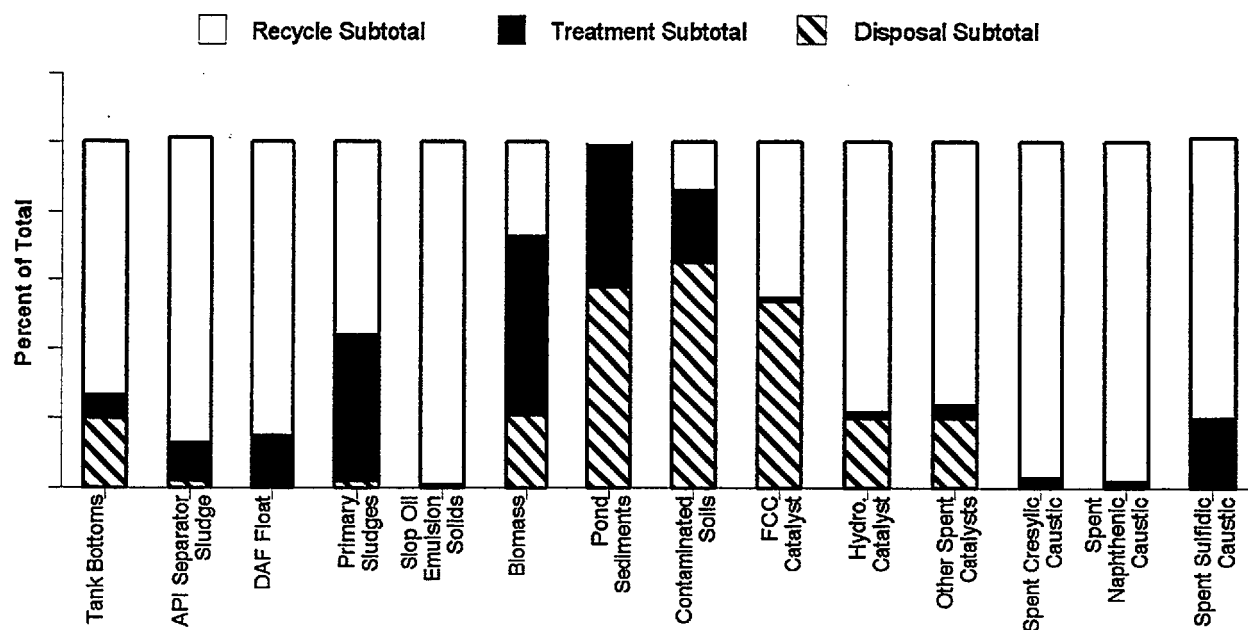
The *biomass*, *DAF float*, and *spent sulfidic caustic* streams often contain very small concentrations of the residual in a relatively large volume of water. Wide variation in the quantities reported for these streams may be due at least in part to differences in how reporting facilities account for the accompanying volume of water. In the 1996 survey, for example, three facilities reported managing *biomass* by *wastewater treatment*, and one facility reported this practice for *DAF float*. Follow up phone calls confirmed this to be

the case, but the streams in questions were less than 5% solids. Other facilities use a continuous flow coker technology that requires large amounts of water. *Spent sulfidic caustic* is increasingly used for pH control in the wastewater plant, and again the quantity reported typically includes large volumes of water. Thus the increase in the *biomass*, *DAF float*, and *spent sulfidic caustic* streams shows up in the management techniques primarily under *coker*, *other recycle* (for pH control), and *wastewater treatment*.

The improved data integrity in the 1996 survey has virtually eliminated routing to the *cat cracker* as a management practice. It was found that most materials reported as being routed to the *cat cracker* were in reality routed to either the *coker* or the *crude unit*, with the exception of *FCC catalyst*. When *FCC catalyst* is routed to a *cat cracker*, however, it is for continued use as a catalyst. If it has been processed in some manner in order to restore its suitability for service, it should be reported as *regenerated*. If, on the other hand, it is cascaded for continued use as a catalyst without any processing to improve its performance, then it is still being used for its intended function, and would not yet be a residual. Thus it appears that U.S. refineries do not process residuals by routing them to the *cat cracker*.

The next chart displays the nationwide distribution by management practice for each stream, as estimated from the 1996 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.

Nationwide Estimates of Distribution by Management Practice-1996



The most evident trend of the last two years in the management of residual material by U.S. refineries is the movement toward *recycling* as the dominant management practice.

Section 1 METHODOLOGY

LISTING OF REFINERIES

The term 'petroleum refinery' is used differently in various contexts. For purposes of the 1996 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 1996 survey was distributed in electronic format (i.e., computer software on diskettes), in a similar manner to the 1995 survey. 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, 1997* published by the Oil & Gas Journal. Excluding those refineries that were found to either not actually process crude or to have been shut down resulted in a final count of 152 refineries. Of these, 79 responded to the survey.

RATIONALE FOR SURVEY CLARIFICATIONS

As was explained in last year's report, 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 survey 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

MANAGEMENT PRACTICES AND TECHNIQUES

The 1996 survey continued to group management techniques into three categories of management practice—recycling, treatment, and disposal. The management techniques from the 1995 and 1996 surveys, with the definitions assigned to them for the 1996 survey, are listed in Appendix A. Note that the *physical treatment* 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 treatment*, to accommodate comparison with the 1996 data. *Each of these management techniques is allowed under certain regulatory scenarios.*

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 1996 survey is

$$\sqrt{R} = 28.0 + 8.88 \times 10^{-4} C$$

with an R^2 measure of correlation equal to 0.70 and a percent error of 7.7%. The statistical analysis is described in more detail in Appendix B.

Section 2 RESULTS

RESPONSE RATE

The 1996 survey response rate is illustrated by several parameters in the following charts.

Figure 2—Response Rate by Refinery Capacity.

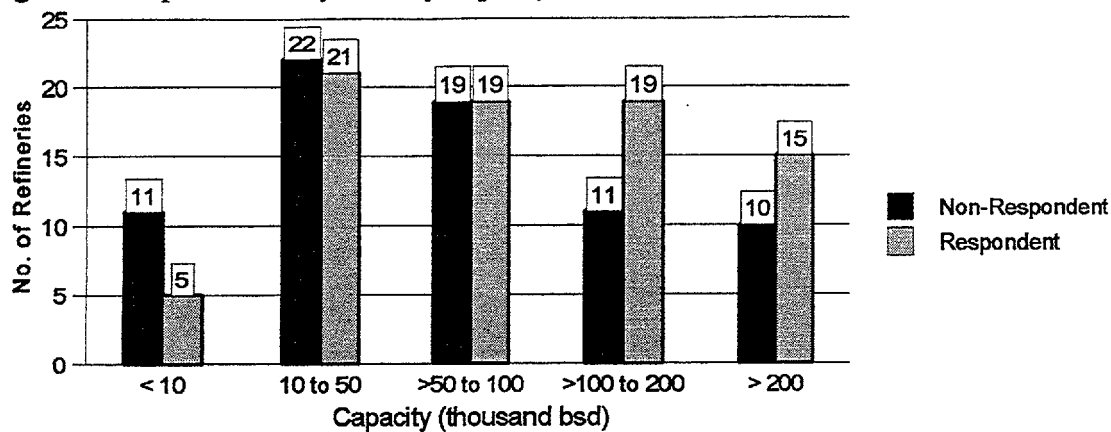


Figure 3—U.S. Department of Energy's Petroleum Administration for Defense (PAD) regions.

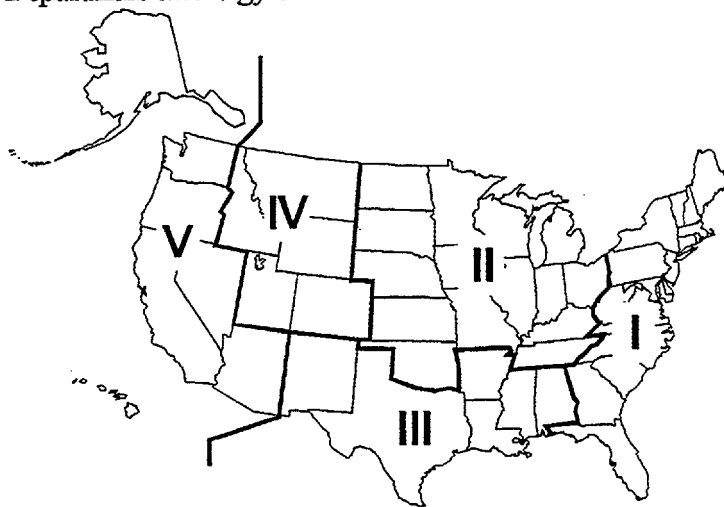


Figure 4—Response Rate by PAD Region.

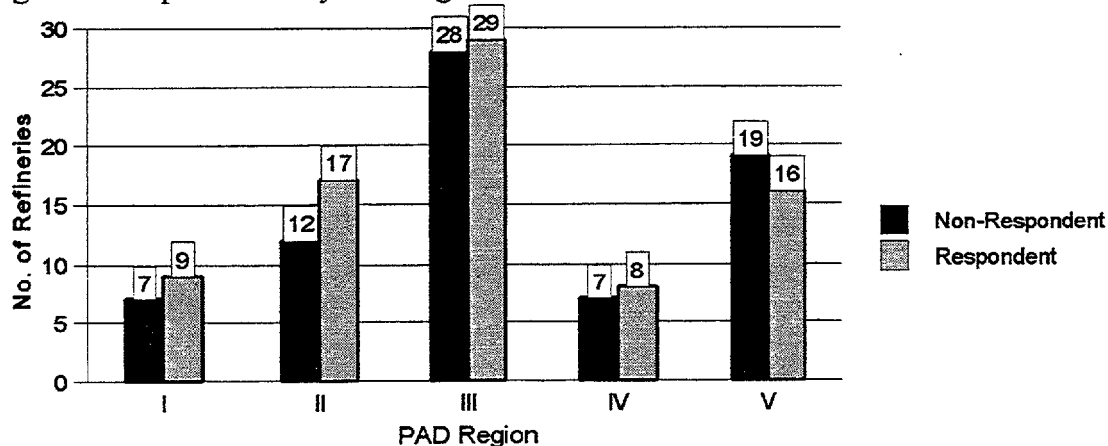


Figure 5—Response Distribution by Complexity of Facility.

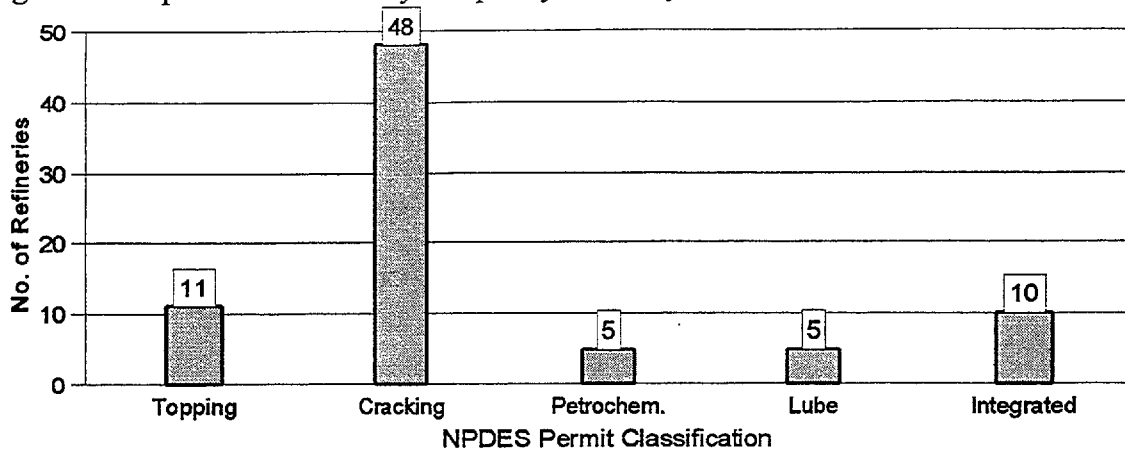


Figure 6—Response Distribution by Age of Facility.

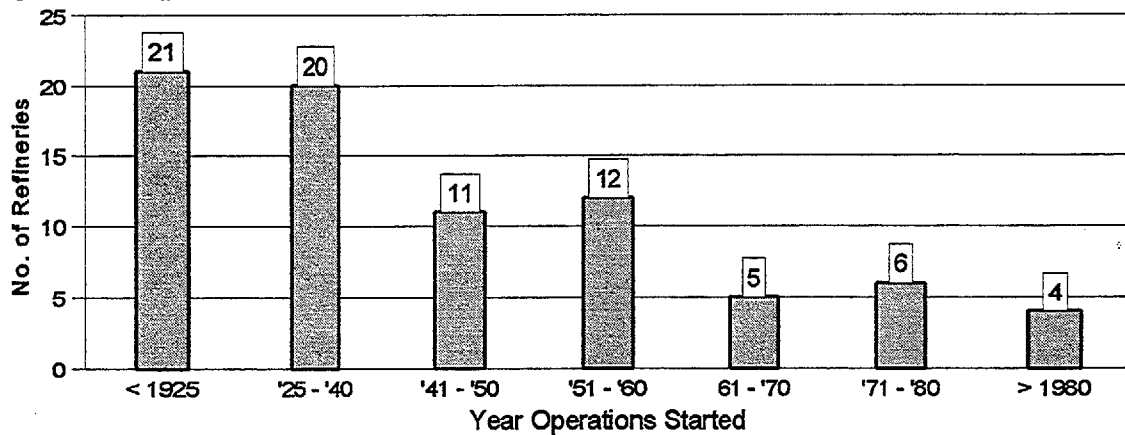
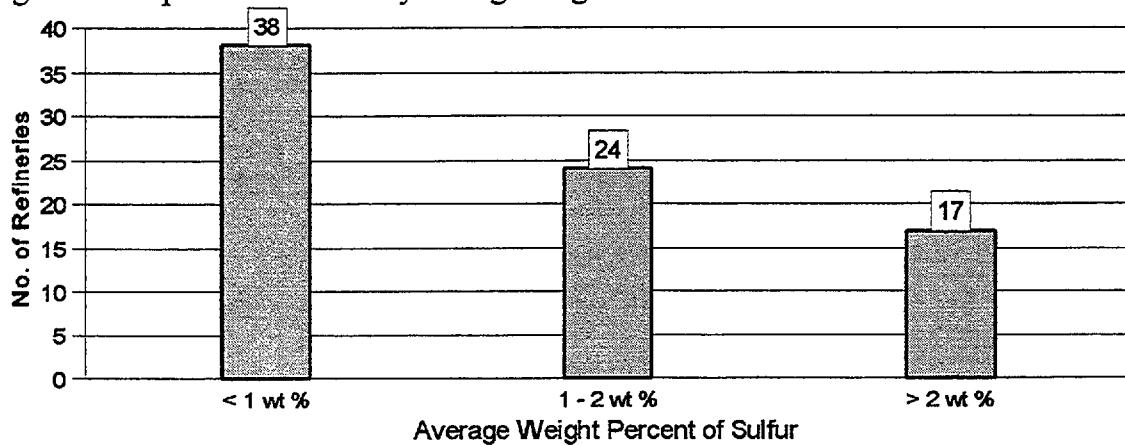


Figure 7—Response Distribution by Average Weight Percent of Sulfur in the Crude Run.



The number of responses from each NPDES Permit Classification for each residual stream are summarized in Table 1, and are 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:	11	48	5	5	10
<u>Distribution by Residual Stream:</u>					
API Separator Sludge	3	35	4	2	4
Biomass	3	29	4	3	8
Contaminated Soils	8	43	5	5	10
DAF Float	0	22	1	2	6
FCC Catalyst	0	30	5	3	9
Hydro. Catalyst	4	35	4	3	9
Other Spent Catalysts	2	31	3	3	7
Pond Sediments	0	3	1	2	2
Primary Sludges	8	42	5	4	10
Slop Oil Emulsion Solids	1	17	3	2	5
Spent Cresylic Caustic	0	19	2	3	7
Spent Naphthenic Caustic	1	2	1	0	3
Spent Sulfidic Caustic	3	31	4	3	9
Tank Bottoms	5	40	4	4	9

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	27%	73%	80%	40%	40%
Biomass	27%	60%	80%	60%	80%
Contaminated Soils	73%	90%	100%	100%	100%
DAF Float	0%	46%	20%	40%	60%
FCC Catalyst	0%	63%	100%	60%	90%
Hydro. Catalyst	36%	73%	80%	60%	90%
Other Spent Catalysts	18%	65%	60%	60%	70%
Pond Sediments	0%	6%	20%	40%	20%
Primary Sludges	73%	88%	100%	80%	100%
Slop Oil Emulsion Solids	9%	35%	60%	40%	50%
Spent Cresylic Caustic	0%	40%	40%	60%	70%
Spent Naphthenic Caustic	9%	4%	20%	0%	30%
Spent Sulfidic Caustic	27%	65%	80%	60%	90%
Tank Bottoms	45%	83%	80%	80%	90%

WASTEWATER MANAGEMENT

Every responding facility indicated that its wastewater is treated prior to discharge. All of the 79 responding facilities reported having primary oil-water separation equipment, with 57 indicating that they use an API Separator. The remaining 22 facilities listed various types of equipment for primary separation, with the most frequent mention being a corrugated plate interceptor. A new question in the 1996 survey asks whether the facility discharges to a publicly-owned treatment works (POTW), a joint treatment facility (i.e., a privately-owned wastewater treatment 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 eight facilities reported discharging after secondary separation, of which six discharge to a POTW and one to a joint treatment facility. Of the remaining 67 facilities, 64 have some form of biotreatment and the three without biotreatment have some form of advanced treatment. Thus 77 of the 79 facilities (97%) report having biotreatment and/or advanced treatment, or discharging to another facility for further treatment.

The most common equipment configuration (reported by 62% of respondents) includes primary separation, gas flotation, and biotreatment. The following list summarizes the responses.

Primary separation . . .	100% (typically an API Separator)
Secondary separation . .	80% (typically some type of gas flotation)
Secondary	
biological treatment .	81% (typically includes activated sludge)
Advanced treatment . .	43% of all reporting facilities (filtration is most common), and 52% of those not subject to posttreatment.

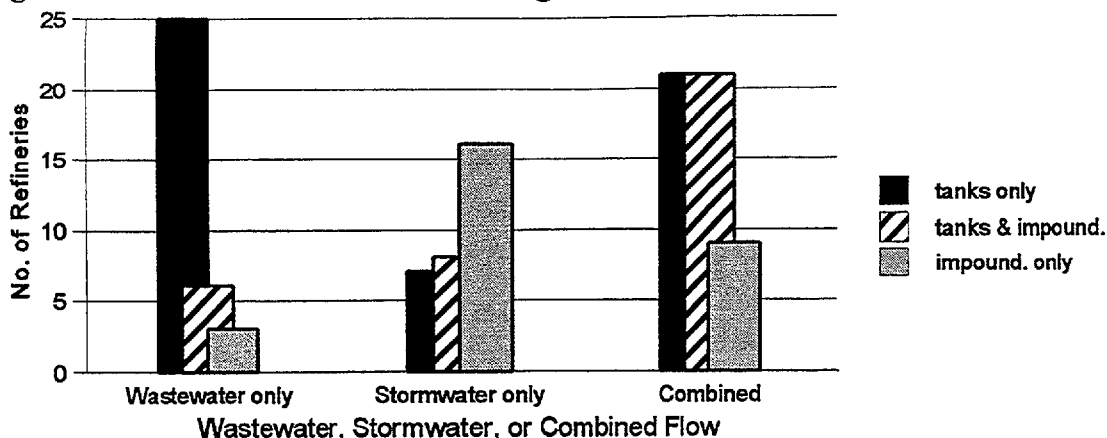
The survey previously sought to differentiate among stormwater, process wastewater, and combined flow by asking for information on holding structures for segregated sewers separately from combined sewers. This question was revised in the 1996 survey to ask what percent of the facility is served by segregated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

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. Twenty one facilities reported having 100% segregated sewers, and another eighteen facilities reported having some segregated sewers and some combined sewers. The remaining half of the respondents indicated having 100% combined sewers. These responses are summarized below.

100% Segregated Sewers	21 facilities
Some Segregated/Some Combined .	18 facilities
100% Combined	40 facilities

In that some facilities have both segregated sewers and combined sewers, the total number of responses in Figure 9 exceeds 79.

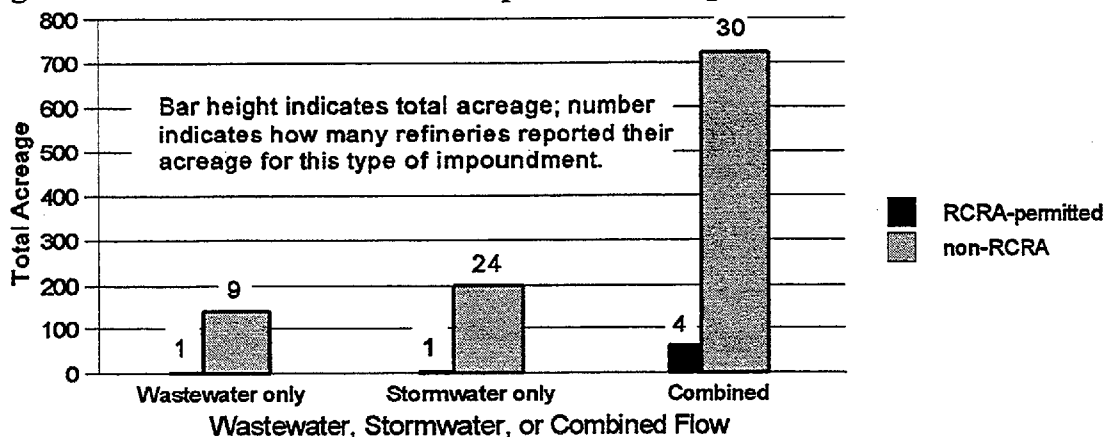
Figure 9—Stormwater and Wastewater Holding Structures.



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.

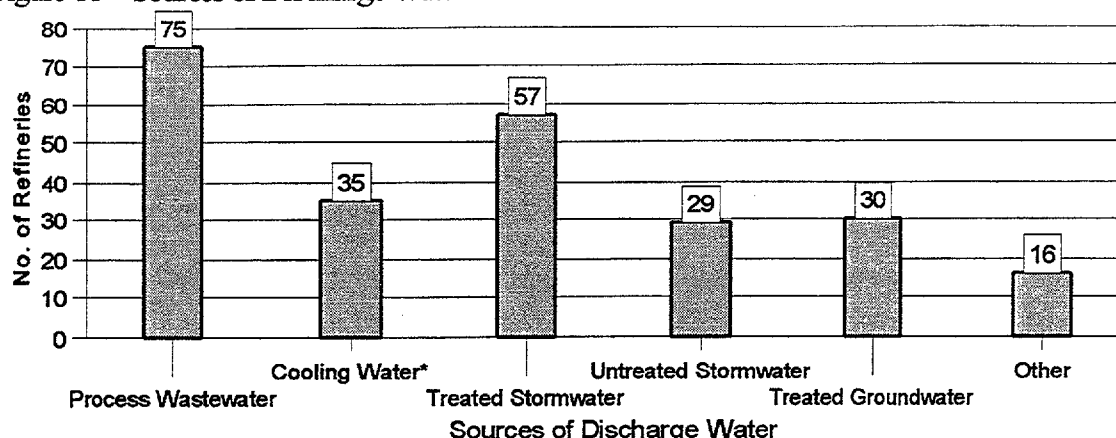
	average of all responses	average without largest & smallest
RCRA-permitted:	10.4 acres	4.3 acres
not RCRA regulated:	16.8 acres	11.6 acres

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 2.7 million gallons per day (MGD), and the median rate was 1.0 MGD. One facility indicated that it practices 100% evaporation, and thus is a zero discharge facility. All but three of the remaining respondents gave a breakdown of the sources of their discharge water, with each 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 1996 (MGD)	Median Flow 1995 (MGD)
Process Wastewater	75	13 – 100 %	73%	1.0	1.0
Noncontact Cooling Water*	35	1 – 70 %	21%	0.1	0.1
Treated Stormwater	57	0.5 – 60 %	7.5%	0.1	0.2
Untreated Stormwater	29	0.1 – 44 %	6.5%	0.08	0.1
Treated Groundwater	30	0.001 – 80 %	1.0%	0.04	0.05
Other	16	0.1 – 100 %	11%	0.1	0.03

* 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-1996	Median-1995
Total Suspended Solids (TSS)	76	73,000 lbs	66,000 lbs
Biochemical Oxygen Demand (BOD)	71	49,000 lbs	40,000 lbs
Chemical Oxygen Demand (COD)	69	380,000 lbs	310,000 lbs
Ammonia	73	9,700 lbs	9,400 lbs
Oil & Grease (O&G)	77	13,000 lbs	17,000 lbs
Chromium	50	26 lbs	29 lbs
Nickel	18	100 lbs	120 lbs
Selenium	25	120 lbs	42 lbs

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

	<u>Median-1996</u>	<u>Median-1995</u>
Total Suspended Solids (TSS)	140 lbs/MG	130 lbs/MG
Biochemical Oxygen Demand (BOD)	87 lbs/MG	77 lbs/MG
Chemical Oxygen Demand (COD)	750 lbs/MG	680 lbs/MG
Ammonia	26 lbs/MG	31 lbs/MG
Oil & Grease (O&G)	27 lbs/MG	26 lbs/MG
Chromium	0.04 lbs/MG	0.08 lbs/MG
Nickel	0.13 lbs/MG	0.20 lbs/MG
Selenium	0.12 lbs/MG	0.15 lbs/MG

In addition to the effluent parameters, the 1996 survey solicited measurements of certain wastewater parameters at intermediate points in the system. The survey requested the level of oil and grease levels 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 half 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.

Table 6—Water Quality Parameters at Intermediate Points (pounds per year).

	<u>No. of Respondents reporting this parameter</u>	<u>Total Level* (pounds/year)</u>	<u>Average Level* (pounds/year)</u>
<u>Oil and Grease (O&G)</u>			
After primary separation	37	45,200,000	1,290,000
After secondary separation	37	11,200,000	319,000
At effluent	37	1,990,000	57,000
<u>Biochemical Oxygen Demand (BOD)</u>			
Before biotreatment	40	57,900,000	1,480,000
After biotreatment	40	4,380,000	112,000
At effluent	40	4,120,000	106,000
<u>Chemical Oxygen Demand (COD)</u>			
Before biotreatment	43	168,000,000	3,990,000
After biotreatment	43	28,100,000	670,000
At effluent	43	26,100,000	622,000

*Two outliers were deleted from the O&G summary, and one each from the BOD and COD summaries.

POLLUTION PREVENTION

The simplified pollution prevention question introduced in the 1995 survey was retained in the 1996 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 1996. Most respondents listed only those projects brought on line in 1996, 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 1996 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. Regularly cleaned stormwater holding basins, catch basins, and drainage systems upstream of the oily sewer. Installed concrete curbing around process units to reduce solids entering the sewer.
Reduction of water to the oily water sewer.	Completed containment projects to better segregate stormwater from units. Installed closed loop pump cooling to minimize wastewater volume. Replaced seal fluid at dewaxing unit from water to neutral oil. Improved drainage and drain system to reduce the flow of water entering the plant from offsite.
Dewatering of oily sludges.	Installed new dewatering equipment. Replaced or improved existing dewatering equipment. Expanded the use of dewatering equipment.

Table 7—Pollution Prevention Activities (continued).

<u>General Practice</u>	<u>Survey Response</u>
Reduction/Containment of spills and leaks.	Improved housekeeping. Improved or expanded leak inspection programs. Installed an HDPE barrier wall twenty feet into the ground to intercept leaks, which are then collected and recovered. Installed covers on API Separators. Installed double bottoms in storage tanks. Upgraded rim seals on storage tank floating roofs. Replaced underground piping with either double-walled piping or aboveground piping. Replaced leaking lines or gaskets. Installed double seals on pumps.
Source reduction/process modification.	Initiated more stringent specifications for solids in the crude and used oil brought into the plant. Installed clarifier to remove solids from river water used for cooling. Process modifications to reduce benzene concentration in the wastewater. Improved sulfur processing, including installation of a NaHS unit. Improved oil/water separations in the process units. Reduced acids, caustics, and solids entering the sewer from process units. Converted loading racks from top loading to bottom loading. Modified combustion units to lower NO_x emissions. Changed barometric pressure in crude to decrease wastewater flow. Eliminated the use of liquid chlorine as a biocide in cooling towers, by substituting a Br/Cl compound. Installed a centrifuge to remove oil from desalter effluent before it enters the sewer. Commissioned a Sats Gas plant to more efficiently process refinery gases. Installed piping and equipment to allow neutralization of Acid Soluble Oil with potassium hydroxide. Changed from high-concentration caustics to mercox for gasoline treating. Installed a new sour water stripper and Claus plant, thereby eliminating a large SO₂ and odor source.
Waste segregation.	Kept nonlisted residuals from combining with listed wastes.

Table 7—Pollution Prevention Activities (continued).

<u>General Practice</u>	<u>Survey Response</u>
Recycling.	Found markets for materials formerly treated or disposed of. Installed a compressor to recover vacuum tail gas. Routed oily sludges to the coker. Designed & constructed a patented spent caustic stripper. Sent oily sludges to fuels blender. Blended contaminated soils into refinery roadbase. Installed vapor recovery for railcar loading of propylene. Recycled ethylene glycol. Mulched used lumber. Recycled employees' used motor oil. Segregated scrap metal and shipped to metals dealer. Used caustic stream for pH adjustment in the wastewater plant. Recycled spent catalysts, dessicants, and caustics. Recycled high mercury content wastes. Regenerated Stretford Solution and Sulfinol Solution by desalting. Recycled spent pleated paper filters for fuels blending. Blended bioremediated biomass and contaminated soils into topsoil. Recovered oil from a thermal desorption unit. Routed an oil-water separator drain to a crude tank for reprocessing. Recycled ceramic packing supports.
Education and training.	Raised awareness of the benefits of pollution prevention. Raised awareness of the facility's pollution prevention practices. Raised awareness of regulatory requirements. Initiated a Permanent Pollution Prevention Program.
Improved treatment.	Installed new and upgraded existing wastewater treatment facilities. Began to use bioremediation. Relocated a wastewater outfall to a larger-flowing stream.

Section 3 RESIDUAL STREAM PROFILES

The U.S. refining industry managed an estimated 3.72 million wet tons of material from the 14 residual streams included in the 1996 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.

Figure 12—Nationwide Estimate of Residual Quantity per Year: 1987-1996.

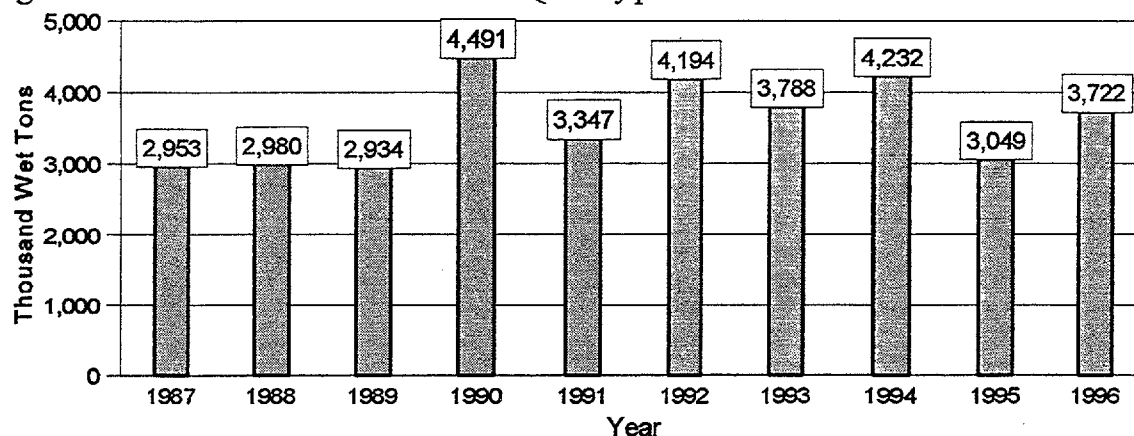
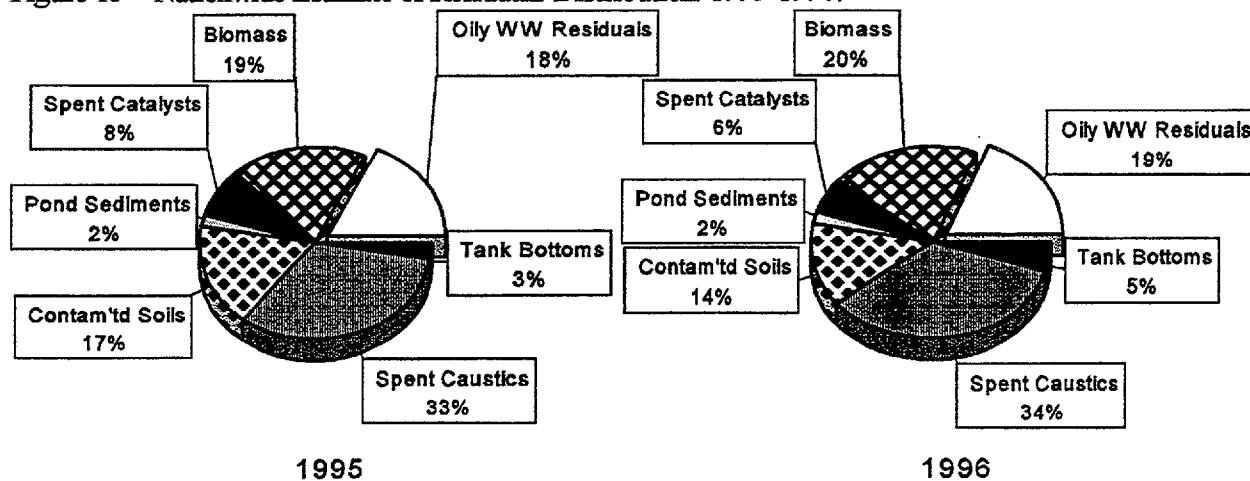


Figure 13 shows the relative contribution of the residual streams, with certain streams grouped together. The FCC catalyst, hydro. catalyst, and other spent catalyst streams are combined into a *spent catalysts* category; and a *spent caustics* category includes spent cresylic caustic, spent naphthenic 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 1996 is estimated to be within three percentage points of its contribution to the 1995 data.

Figure 13—Nationwide Estimate of Residuals Distribution: 1995-1996.

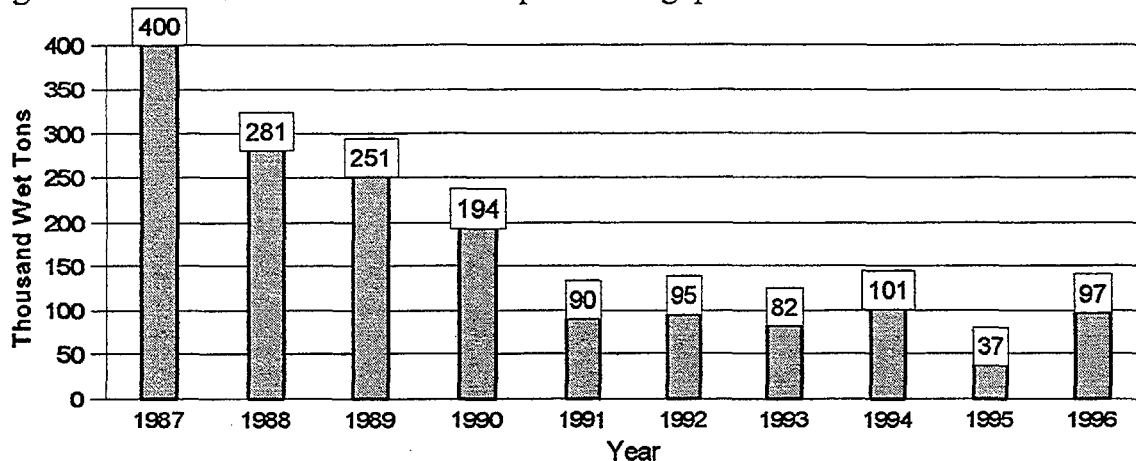


The remainder of this section presents detailed information for the individual streams, with the streams arranged in alphabetical order. The data for this section are summarized in the tables of Appendix C.

API SEPARATOR SLUDGE¹

The U.S. petroleum refining industry managed an estimated 97 thousand wet tons of API Separator Sludge in 1996, which was a 162% increase from 1995. 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.

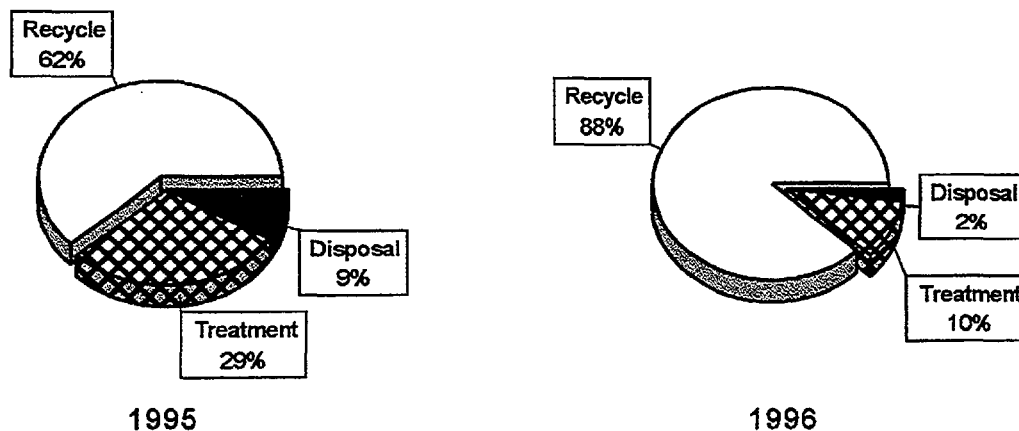
Figure 14—Nationwide Estimates of API Separator Sludge per Year: 1987-1996.



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 an increase from 554 thousand wet tons in 1995 to 723 thousand wet tons in 1996, an increase of 30%.

The portion of the API Separator Sludge stream that is managed by each management practice is shown in Figure 15 for 1995 and 1996. Recycling has become the dominant management practice, and disposal is disappearing as a management practice for this stream.

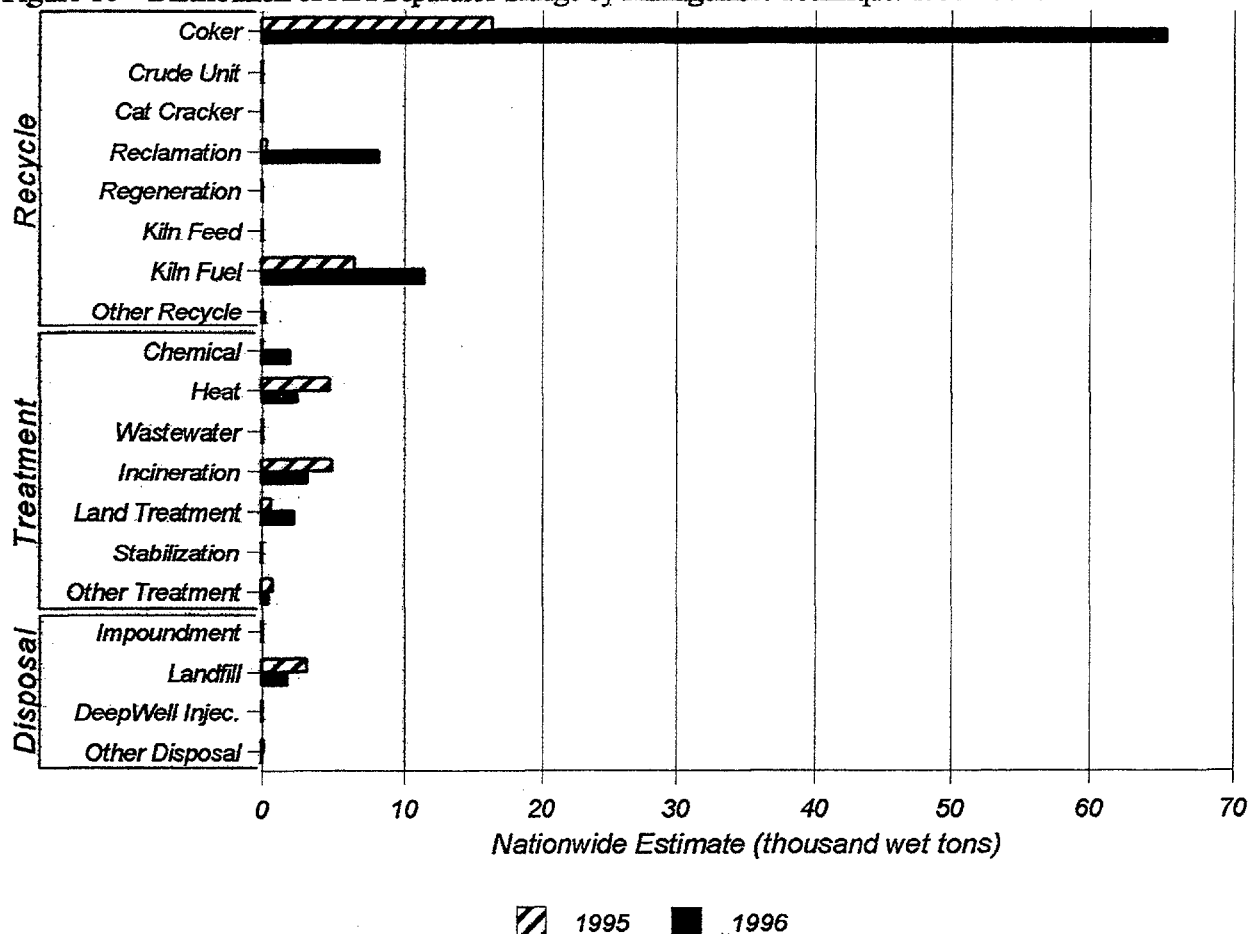
Figure 15—Nationwide Estimates of API Separator Sludge by Management Practice: 1995-1996.



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 1995 and 1996. This stream is primarily managed by techniques that recycle the oil content. This is most commonly accomplished by routing the stream to a *coker*. Another frequently employed technique is to send this stream to a fuels blending unit for incorporation into *kiln fuel*. When oil is recovered from this stream by thermal desorption, it is reported as *reclamation*.

Figure 16—Distribution of API Separator Sludge by Management Technique: 1995-1996.



Responses in the *other* categories are listed below.

Other Recycle: one facility reports recycling for aggregate manufacturing.

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: 1996

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

