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Cost-Effectiveness Analysis For Proposed Effluent Limitations Guidelines And Standards For The Coastal Subcategory Of The Oil And Gas Extraction Point Source Category

COST EFFECTIVENESS ANALYSIS FOR PROPOSED EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS FOR THE COASTAL SUBCATEGORY OF THE OIL AND GAS EXTRACTION POINT SOURCE CATEGORY

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SECTION ONE

INTRODUCTION

This analysis is submitted in support of the effluent limitations guidelines and standards for the Coastal Oil and Gas Industry. The report analyzes the cost-effectiveness of 10 regulatory options organized by three wastestreams. This document compares the total annualized cost incurred for each of the regulatory options within each wastestream to the corresponding effectiveness of that option in reducing the discharge of pollutants. The effectiveness measure used is pounds of pollutant removed weighted by an estimate of the relative toxicity of the pollutant. The rationale for this measure, referred to as "pound equivalents (PE) removed," is described later in this document.

Section Two discusses the cost-effectiveness methodology used and identifies the pollutants included in the analysis, presenting their toxic weighting factors and removal efficiencies. Section Three presents the results of the analysis. In Section Four, the cost-effectiveness values are compared to cost-effectiveness values for other promulgated rules. Appendix A presents data on pollutants, pollutant removals, annualized costs, and other, more detailed information.

SECTION TWO

BACKGROUND METHODOLOGY

Cost-effectiveness (CE) is defined as the incremental annualized cost of a pollution control option in an industry or industry subcategory per incremental pound-equivalent of pollutant (i.e., pound of pollutant adjusted for toxicity) removed by that control option. A cost-effectiveness analysis is used to analyze effluent limitation guidelines to enable various regulatory options to be compared either among options or to other benchmarks such as guidelines for other industries. The cost-effectiveness value derived in the analysis represents the unit cost of removing the next pound-equivalent of pollutant.

A number of steps must be undertaken before a cost-effectiveness analysis can be performed. There are five steps that define the analysis or generate data for use in the cost-effectiveness calculation:

- Determine the wastewater pollutants of concern (priority and other pollutants).
- Estimate the relative toxic weights (the adjustments to pounds of pollutants to reflect toxicity) of the pollutants of concern.
- Define the regulatory pollution control options.
- Calculate pollutant removals for each pollution control option.
- Determine the annualized cost of each pollution control option.

All of these factors are used in the calculation of the cost-effectiveness values, which can then be compared for each of the regulatory options under consideration. The following sections discuss the five preliminary steps and the cost-effectiveness calculation and comparison methodologies.

2.1 POLLUTANTS OF CONCERN

Under the effluent limitation guidelines for the coastal oil and gas industry, 95 priority and other nonconventional pollutants are regulated. Some of the factors considered in selecting pollutants for regulation include toxicity, frequency of occurrence, and amount of pollutant in the wastestream. The list of regulated pollutants is presented in Table 2-1.

2.2 TOXIC WEIGHTING FACTORS

Cost-effectiveness analyses account for differences in toxicity among the pollutants using toxic weighting factors. These factors are necessary because different pollutants have different potential effects on human and aquatic life. For example, a pound of zinc in an effluent stream has a significantly different effect than a pound of PCBs. Toxic weighting factors for pollutants are derived using ambient water quality criteria and toxicity values. For most industries, toxic weighting factors are derived from chronic freshwater aquatic criteria. In cases where a human health criterion has also been established for the consumption of fish, then the sum of both the human and aquatic criteria are used to derive toxic weighting factors. The factors are standardized by relating them to the water quality criterion for copper. Although this criterion has been revised (to 12.0 ug/l), all cost-effectiveness analyses for effluent guideline regulations use the "old" criterion of 5.6 ug/l so that cost-effectiveness values can continue to be compared to those for other effluent guidelines. The revised higher criterion for copper results in a toxic weighting factor for copper of 0.467 rather than 1.0. Table 2-1 presents the toxic weighting factors used for the regulated pollutants in the cost-effectiveness analysis of the coastal oil and gas industry. Where possible, factors are derived for pollutants discharged to saltwater, since most discharges by the industry are to salt or brackish waters. In general, saltwater toxic weighting factors are lower for pollutants in saltwater than in freshwater. Only where no saltwater toxic weighting factors are available are freshwater factors used. Table 2-1 also shows the source of the toxic weighting factor if it is not a saltwater toxic weighting factor and whether the pollutant is a priority pollutant.

Examples of the effects of different aquatic and human health criteria on freshwater toxic weighting factors are presented in Table 2-2. As shown in this table, the toxic weighting factor is

TABLE 2-1

TOXIC WEIGHTING FACTORS AND REMOVAL EFFICIENCIES FOR REGULATED POLLUTANTS

Pollutant Code	Pollutant Name	Toxic Weighting Factor	Removal Efficiency
	Cyanide	1	0.5
3	Acetonitrile	0.00009	0.83
9	Ammonium Hydroxide	0.0933	NA
10	N-Amyl Acetate	0.000862	0.9
11	Amyl Alcohol (1-Pentanol)	0.000155	0.904
12	Aniline	1.41	0.85
15	Benzene	0.0185	0.941
22	Bis(chloromethyl)ether	7.18	0.79
25	2-Butanone(Methyl Ethyl Ketone (MEK))	0.0000316	0.5
26	Butyl acetate,n-	0.00311	0.9
27	N-Butyl Alcohol (1-Butanol)	0.0000782	0.9
29	Tert-Butyl Alcohol (2-Methyl-2-Propanol)	0.0000316	0.904
35	Chlorobenzene	0.00293	0.995
37	Chloroform (Trichloromethane)	0.00208	0.676
39	Chloromethane	0.00205	0.974
43	Cyclohexane	0.009	0.95
48	O-Dichlorobenzene (1,2-Dicholorobenzene)	0.0105	0.918
51	Dichloroethane,1,2-	0.00617	0.554
55	Diethylamine	0.00028	0.79
58	Diethyl ether	0.0000774	0.75
60	Dimethylacetamide,N,N-	0.00000209	0.79
61	Dimethylamine	0.000622	0.9
62	N,N-Dimethylaniline	0.00336	0.85
63	Dimethylcarbamyl chloride		0.554
64	Dimethylformamide, N,N-	0.00000236	0.79
66	Dimethyl sulfoxide	0.00000165	0.75
67	Dioxane,1,4-	0.000228	0.5
70	Ethanol	0.000583	0.5658
71	Ethyl acetate	0.000582	0.9
77	Ethylene glycol	0.0000838	0.5658
79	Formaldehyde	0.00233	0.85
80	Formamide		0.79
82	Furfural	0.0134	0.5
83	Glycol Ethers (Ethylene Glycol Monoethyl Ethe	0.00000717	NA
84	Heptane,n-	0.0615	0.95
87	Hexane,n-	0.0287	0.95
93	Isobutyraldehyde (2-Methyl Propanol)	0.00214	0.85
94	Isopropanol	0.0056	0.904
95	Isopropyl Acetate	0.000069	0.9
96	Isopropyl Ether	0.000611	0.75
97	Methanol	0.00000892	0.95

TABLE 2-1 (cont.)

Pollutant Code	Pollutant Name	Toxic Weighting Factor	Removal Efficiency
99	Methylamine	0.000344	0.8
101	Methyl Cellusolve (2-Methoxyethanol)	0.0000287	NA
102	Methylene Chloride (Dichloromethane)	0.000418	0.87
103	Methyl formate	0.00000891	0.9
105	MIBK (Methyl Isobutyl Ketone)	0.000125	0.5
106	2-Methylpyridine (2-Picoline)	0.000136	0.15
113	Petroleum Naphtha	0.0667	0.95
114	Phenol	0.028	0.967
115	Polyethylene Glycol 600	0.000056	0.5658
117	N-Propanol (1-Propanol)	0.0000273	0.904
118	Acetone	0.0000076	0.944
124	Pyridine	0.00126	0.15
129	Tetrahydrofuran	0.0000404	0.75
130	Toluene	0.00563	0.976
134	Trichlorofluoromethane	0.000958	0.979
136	Triethylamine	0.000147	0.9
139	Xylenes	0.00423	0.87

TABLE 2-2

EXAMPLES OF TOXIC WEIGHTING FACTORS BASED ON COPPER FRESHWATER CHRONIC CRITERIA

Pollutant	Human Health Criteria (μg/l)	Aquatic Chronic Criteria (μg/l)	Weighting Calculation	Toxic Weighting Factor
Copper[a]	---	12.0	5.6/12.0	0.467
Cadmium	84	1.1	5.6/84 + 5.6/1.1	5.16
Naphthalene	41,026	370	5.6/41,026 + 5.6/370	0.015

[a]Although the water quality criterion for copper has been revised (to 12.0 μg/l), the cost effectiveness analysis used the previous criterion (5.6 μg/l) to facilitate comparisons with cost-effectiveness values for other effluent limitations guidelines. The revised higher criteria for copper results in a toxic weighting factor for copper equal to 0.467 instead of 1.0, which was the result of the previous criterion.

Notes: Human health and aquatic chronic criteria are maximum contamination thresholds. Units for criteria are micrograms of pollutant per liter of water.

Sources: Versar, Inc. 1991. Toxic weighting factors for oil and gas extraction industry pollutants. Prepared for U.S. Environmental Protection Agency, Office of Water, October 1992.

the sum of two criteria-weighted ratios: the "old" copper criterion divided by the human health criterion for the particular pollutant and the "old" copper criterion divided by the aquatic chronic criterion. For example, using the values reported in Table 2-2, 11 pounds of copper pose the same relative hazard in freshwater as one pound of cadmium because cadmium has a freshwater toxic weight 11 times as large as the toxic weight of copper (5.16/0.467=11.05).

2.3 POLLUTION CONTROL OPTIONS

This cost-effectiveness analysis was performed on pollution control options proposed for a number of wastestreams, including: produced water; drilling wastes; and treatment, workover, and completion fluids (TWC). Table 2-3 presents a summary of the options proposed by wastestream. In all there are 10 separate options: 5 for produced water, 3 for drilling waste, and 2 for TWC. For all three wastestreams, a zero-discharge option is considered. New Source Performance Standards (NSPS) options are not specifically covered because they are either identical to Best Available Technology (BAT) options or because there are no new sources projected in certain coastal areas. The relative cost-effectiveness for new sources will not be different from that shown for the BAT options. Pretreatment Standards for Existing Sources (PSES) and Pretreatment Standards for New Sources (PSNS) options identical to NSPS options are also proposed. Because no PSES or PSNS projects are anticipated, however, the cost effectiveness of these options is not discussed.

2.4 POLLUTANT REMOVALS

The pollutant loadings have been calculated for each facility under each regulatory option for comparison with baseline (i.e., current, without the regulation) loadings. The postregulatory removals for each wastestream affected under each regulatory option are presented in Appendix A.

Pollutant removals are calculated directly as the difference between current and post-treatment discharges. Removals are then weighted using the toxic weighting factors and are reported in pound-equivalents (see Appendix A for pound-equivalent removals for all pollutants by wastestream and option). Total removals for each option are then calculated by summing the

TABLE 2-3

REGULATORY OPTIONS CONSIDERED IN THE COST-EFFECTIVENESS ANALYSIS

Type of Wastestream	Name	Description
Produced Water	Option #1	Best Practicable Control Technology (BPT)—current regulatory requirement
	Option #2	Gas flotation
	Option #3	Zero discharge/BPT Cook Inlet
	Option #4	Zero discharge/Oil and grease limits based on improved gas flotation Cook Inlet
	Option #5	Zero discharge
Drilling Wastes	Option #1	Zero discharge/offshore limitations Cook Inlet
	Option #2	Zero discharge/offshore limitations plus 1 million ppm toxicity limit Cook Inlet
	Option #3	Zero discharge
TWC	Option #1	BPT
	Option #2	Zero discharge/Oil and grease limits based on improved gas flotation Cook Inlet

removals for each pollutant under each option. Total pollutant removals and pound-equivalent removals estimated to be achieved under each regulatory option, by wastestream, are presented in Table 2-4.

2.5 ANNUALIZED COSTS OF COMPLIANCE

Under each regulatory option, annualized costs of compliance have been developed (see *Economic Impact Analysis of Effluent Guidelines and Limitations on the Coastal Oil and Gas Industry* [EPA, 1995]). The derivation of these costs is summarized briefly below.

For produced water and TWC, the pretax costs (including the state and federal governments' share of compliance costs)[1] of purchasing, installing, and operating injection wells or improved gas flotation systems, or alternatively, transportation and disposal at a commercial facility, depending on size of operation, were derived for each of the treatment facilities determined still to be discharging in 1996 in the Gulf of Mexico and for each of the treatment facilities in Cook Inlet. Where capital costs are incurred, capital costs were annualized at 8 percent[2] over 10 years (the estimated realistic worst-case lifetime of production) and added to the cost of operating the pollution control equipment. Commercial disposal was computed on a barrels per year disposed (i.e., annual) basis.

For drilling wastes (which are only of concern in Cook Inlet), costs of landfilling (in an existing landfill—annual costs only) or using dedicated disposal wells (including the capital costs of installing wells and retrofitting platforms) were determined. A drilling schedule, supplied by Cook Inlet operators, was used to distribute operating costs over time. A net present value of this uneven stream of capital and operating cost outlays was then derived and annualized at 8 percent over a 7-year period of drilling.

The aggregate annual costs by option are presented in Table 2-5.

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[1]Every dollar spent on compliance can be applied against a firm's taxable income. Due to various tax mechanisms such as accelerated depreciation, this reduction means that firms face only about 60 to 70 percent of compliance costs posttax.

[2]Average real cost of capital as estimated from Section 308 survey.

TABLE 2-4

TOTAL POLLUTANT REMOVALS BY REGULATORY OPTIONS[a]

Type of Wastestream	Option Number	Total Pollutant Removals	Pound-Equivalent Removals
Produced Water	Option #1	0	0
	Option #2	12,439,274	610,053
	Option #3,	4,306,800,606[b]	5,000,458
	Option #4	4,308,303,172[c]	5,491,731
	Option #5	5,484,799,119[d]	5,988,082
Drilling Wastes	Option #1	0	0
	Option #2	3,868,896[e]	1,264
	Option #3	22,739,018[f]	7,375
TWC	Option #1	0	0
	Option #2	3,463,013	2,143

[a]Counting all pollutants under total removals and all nonconventional pollutants under pound-equivalent removals.

[b]Includes 2,355,274,655 lb of chlorides from Gulf (95% of total removals).

[c]Includes 2,392,845,231 lb of chlorides from Gulf and Cook Inlet (96%).

[d]Includes 3,471,412,322 lb of chlorides from Gulf and Cook Inlet (95%).

[e]Includes 2,585,260 lb of TSS (93%).

[f]Includes 15,207,413 lb of TSS (94%).

TABLE 2-5

AGGREGATE ANNUAL COSTS BY REGULATORY OPTIONS ($1981)

Type of Wastestream	Option Number	Aggregate Annual Cost
Produced Water	Option #1	0
	Option #2	$8,773,233
	Option #3	$20,291,749
	Option #4	$21,885,327
	Option #5	$35,210,507
Drilling Wastes	Option #1	0
	Option #2	$971,990
	Option #3	$2,758,070
TWC	Option #1	0
	Option #2	$429,479

2.6 CALCULATION OF THE COST-EFFECTIVENESS VALUES

Cost-effectiveness values are calculated separately for each wastestream. This scheme leads to the following three analytical groupings: produced water options, drilling waste options, and TWC options. Within each of these groups, the options are ranked in ascending order of pound-equivalents of pollutants removed. Under each of these analytical groupings, the cost-effectiveness value for a particular control option is calculated as the ratio of incremental annual cost of that option to the incremental pound equivalents removed by that option. The incremental effectiveness may be viewed both in comparison to the baseline scenario and to another regulatory option. Cost-effectiveness values are reported in units of dollars per pound-equivalent of pollutant removed.

For the purpose of comparing cost-effectiveness values of options under review to those of other promulgated rules, compliance costs used in the cost-effectiveness analysis are adjusted to 1981 dollars using *Engineering News Record*'s Construction Cost Index (CCI). This adjustment factor is calculated as follows:

Adjustment factor = 1981 CCI/1992 CCI = 3,535/4,835 = 0.71

The equation to calculate cost-effectiveness is:

$$CE_k = \frac{ATC_k - ATC_{k-1}}{PE_k - PE_{k-1}}$$

where:

CE_k=	Cost-effectiveness of Option k
ATC_k=	Total annualized treatment cost under Option k
PE_k=	Pound-equivalents removed by Option k

The numerator of the equation, ATC_k minus ATC_{k-1}, is simply the incremental annualized treatment cost in going from Option k-1 (an option that removes fewer pound-equivalent pollutants) to Option k (an option that removes more pound-equivalent pollutants). The denominator is similarly the incremental removals achieved in going from Option k-1 to k. Thus, cost-effectiveness measures the incremental unit cost of pollutant removal of Option k (in pound-equivalents) in comparison to Option k-1.

Nonincremental cost-effectiveness values can also be derived by setting ATC_{k-1} to zero and by setting the pollutant loadings (PE_{k-1}) to the current loading. These values are used to compare an option to previously promulgated effluent limitations guidelines.

2.7 COMPARISONS OF COST-EFFECTIVENESS VALUES

Because the options are ranked in ascending order of pound-equivalents of pollutants removed, any option that has higher costs but lower removals than another option immediately can be identified (the cost-effectiveness value for the next option becomes negative). When negative values are computed for Option k, Option k-1 will be noted as "dominated" (having a higher cost and lower removals than Option k). Option k-1 is then removed from the cost-effectiveness calculations, and all cost-effectiveness values within a regulatory grouping are then recalculated without the "dominated" option. This process continues until all "dominated" options are eliminated. The remaining options can then be presented in terms of their incremental cost-effectiveness values and are considered viable options for regulatory consideration.

SECTION THREE

RESULTS

The cost-effectiveness analysis is based on the Agency's estimates of the cost of compliance and wastewater pollution removals associated with 10 BAT options for three wastestreams—produced water, drilling waste, and TWC. NSPS options are also proposed but are not separately investigated because they are the same as BAT options and the relative cost-effectiveness is the same. A total of 10 options organized into three regulatory groupings are analyzed (see Section Two for more details).

The following sections present a brief description of the technologies used in each of the three regulatory groupings, and, for each grouping, cost-effectiveness data and results are presented in a table. Note that the incremental data for the first option in each group is determined against baseline values (i.e., no removals and no cost). Cost-effectiveness results are presented for priority and other nonconventional pollutants combined.

3.1 PRODUCED WATER BAT OPTIONS

Five BAT options were evaluated for produced water. Option #1 is Best Practicable Control Technology (BPT) and is the current regulatory requirement. Option #2 involves oil and grease limits based on the use of gas flotation technology (currently required of all offshore oil and gas operations). Option #3 requires all operations to achieve zero discharge, with the exception of Cook Inlet, where BPT must be achieved. Option #4 requires zero discharge, with the exception of Cook Inlet where oil and grease limits based on improved gas flotation will be needed to achieve the proposed requirements. Finally, Option #5 requires all coastal oil and gas operations to achieve zero discharge, regardless of location.

Table 3-1 presents the cost effectiveness data and results for this group of options. As shown in Table 3-1, the incremental cost-effectiveness values (not including Option #1) range from $3 to $27 per pound equivalent removed.

The selected option is Option #4, zero discharge with improved gas flotation in Cook Inlet. The incremental cost effectiveness of this option is $3 per pound equivalent removed. Average cost effectiveness of this option from current levels of pollutant loadings is $4 per pound equivalent removed.

3.2 DRILLING WASTE BAT OPTIONS

Three BAT options were evaluated for drilling waste. Option #1 specifies zero discharge in all coastal areas and offshore oil and gas industry limitations for Cook Inlet. This option corresponds to current practices. Option #2 requires zero discharge, with the exception of offshore limits plus a more stringent 1 million ppm toxicity limit in Cook Inlet. Finally Option #3 requires zero discharge regardless of location.

Table 3-2 presents the cost-effectiveness data and results for this group of options. As shown in Table 3-2, the incremental cost-effectiveness values (not including Option #1) range from $292 to $769 per pound equivalent removed.

All three options are co-proposed. The most costly option is Option #3, zero discharge. The incremental cost effectiveness of this option is $292 per pound equivalent removed. Average cost effectiveness of this option from current levels of pollutant loadings is $374 per pound equivalent removed.

3.3 TWC BAT OPTIONS

Two BAT options were evaluated for TWC. Option #1 specifies BPT (current regulatory) requirements. Option #2 requires TWC fluids to be disposed of in the same way as produced water

TABLE 3-1

COST EFFECTIVENESS FOR PRODUCED WATER—COOK INLET AND GULF COMBINED
(Including All Pollutants for which Toxic Weighting Factors Are Available)

Option	Total Annual		Incremental		Incremental Cost Effectiveness[1] ($ 1981) ($/lb. eq.)	Average Cost Effectiveness (from BPT)[2] ($ 1981) ($/lb.eq.)
	Pound Equivalents Removed (lbs.)	Cost ($ 1981)	Pound Equivalents Removed (lbs.)	Cost ($ 1981)		
Option #1: BPT	0	$0	0	$0	$0	$0
Option #2: Gas Flotation	610,053	$8,773,233	610,053	$8,773,233	$15	$15
Option #3: Zero Discharge/BPT Cook Inlet	5,000,458	$20,291,749	4,390,405	$11,518,516	$2	$4
Option #4: Zero Discharge/Offshore limits Cook Inlet	5,491,731	$21,885,327	491,273	$1,593,578	$3	$4
Option #5: Zero Discharge	5,988,082	$35,947,923	496,351	$14,064,709	$27	$5

[1]Incremental cost divided by incremental pounds removed.

[2]Total annual cost divided by total pound equivalents removed.

TABLE 3-2

COST EFFECTIVENESS FOR DRILLING WASTE—COOK INLET
(Including All Pollutants for which Toxic Weighting Factors Are Available)

Option	Total Annual		Incremental		Incremental Cost Effectiveness[3] ($ 1981) ($/lb. eq.)	Average Cost Effectiveness (from BPT)[4] ($ 1981) ($/lb.eq.)
	Pound Equivalents Removed (lbs.)	Cost ($ 1981)	Pound Equivalents Removed (lbs.)	Cost ($ 1981)		
Option #1: Zero Discharge Gulf/Offshore Limitations, Cook Inlet	0	$0	0	$0	$0	$0
Option #2: Zero Discharge Gulf/Offshore plus Tox. Limits, Cook Inlet	1,264	$971,990	1,264	$971,990	$769	$769
Option #3: Zero Discharge	7,375	$2,758,070	6,112	$1,786,080	$292	$374

[3]Incremental cost divided by incremental pounds removed.

[4]Total annual cost divided by total pound equivalents removed.

under the preferred produced water regulatory option. Thus Option #2 is zero discharge in the Gulf of Mexico,[3] to be achieved through a combination of injection and commercial disposal. Both options are co-proposed.

Tables 3-3 presents the cost-effectiveness data and results for this group of options. As shown in Table 3-3, the incremental cost-effectiveness values are $0 or $200 per pound equivalent removed.

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[3]In Cook Inlet TWC is not a separate wastestream and gas flotation will be required given the preferred option for that region. A separate cost-effectiveness analysis is not performed for TWC in Cook Inlet.

TABLE 3-3

COST EFFECTIVENESS FOR TREATMENT, WORKOVER, AND COMPLETION (TWC) FLUIDS—GULF OF MEXICO
(Including All Pollutants for which Toxic Weighting Factors Are Available)

Option[a]	Total Annual		Incremental		Incremental Cost Effectiveness[5] ($ 1981) ($/lb. eq.)	Average Cost Effectiveness (from BPT)[6] ($ 1981) ($/lb.eq.)
	Pound Equivalents Removed (lbs.)	Cost ($ 1981)	Pound Equivalents Removed	Cost ($ 1981)		
Option #1: BPT	0	$0	0	$0	$0	$0
Option #2: Zero Discharge	2,143	$429,479	2,143	$429,479	$200	$200

[5]Incremental cost divided by incremental pounds removed.

[6]Total annual cost divided by total pound equivalents removed.

SECTION FOUR

COMPARISON OF COST-EFFECTIVENESS VALUES WITH PROMULGATED RULES

Table 4-1 presents the cost-effectiveness values for effluent limitations guidelines and standards issued for direct dischargers under BAT in other industries. The numbers presented here for this rulemaking are pretax costs, whereas many of the numbers presented for other effluent guidelines are posttax costs—that is, the costs faced by the firms, not the total cost of the equipment. Thus direct comparisons between this rulemaking and others cannot be made easily. An equivalent posttax cost, however, might be at least 60 to 70 percent of pretax costs. The number reported for the Coastal Oil and Gas Industry is for the selected produced water option, the most costly drilling waste option, and the most costly TWC option listed separately. As the table shows, the $3 per pound equivalent removed for produced water is well within the range of cost-effectiveness values seen for other rules. For TWC and drilling waste, the $200 and $292 per pound equivalent removed are also within the range shown.

TABLE 4-1

INDUSTRY COMPARISON OF BAT COST-EFFECTIVENESS FOR DIRECT DISCHARGERS
(Toxic and Nonconventional Pollutants Only; Copper-Based Weights[a]; $ 1981)

Industry	PE Currently Discharged (thousands)	PE Remaining at Selected Option (thousands)	Cost-Effectiveness of Selected Option(s) ($/PE removed)
Aluminum Forming	1,340	90	121
Battery Manufacturing	4,126	5	2
Canmaking	12	0.2	10
Coal Mining	BAT=BPT	BAT=BPT	BAT=BPT
Coastal Oil and Gas			
Produced Water	5,998	506	3
Drilling Waste	7	0	292
TWC[b]	2	0	200
Coil Coating	2,289	9	49
Copper Forming	70	8	27
Electronics I	9	3	404
Electronics II	NA	NA	NA
Foundries	2,308	39	84
Inorganic Chemicals I	32,503	1,290	<1
Inorganic Chemicals II	605	27	6
Iron and Steel	40,746	1,040	2
Leather Tanning	259	112	BAT=BPT
Metal Finishing	3,305	3,268	12
Nonferrous Metals Forming	34	2	69
Nonferrous Metals Manufacturing I	6,653	313	4
Nonferrous Metals Manufacturing II	1,004	12	6
Offshore Oil and Gas	3,628	2,218	34[c]
OCSPSF[d]	54,225	9,735	5
Pesticides	2,461	371	15
Petroleum Refining	BAT=BPT	BAT=BPT	BAT=BPT
Pharmaceuticals			

TABLE 4-1 (continued)

Industry	PE Currently Discharged (thousands)	PE Remaining at Selected Option (thousands)	Cost-Effectiveness of Selected Option(s) ($/PE removed)
Plastics Molding and Forming	44	41	BAT=BPT
Porcelain Enameling	1,086	63	6
Pulp and Paper[e]	1,330	748	18
Textile Mills	BAT=BPT	BAT=BPT	BAT=BPT

[a]Although toxic weighing factors for priority pollutants varied across these rules, this table reflects the cost-effectiveness at the time of regulation.

[b]TWC loadings and reductions are for Gulf of Mexico only. Produced water loadings and reductions include TWC discharges in Cook Inlet.

[c]For produced water only; for produced sand and drilling fluids and drill cuttings under Offshore Oil and Gas, BAT=NSPS.

[d]Reflects costs and removals of both air and water pollutants.

[e]PCB control for Deink subcategory only.

SECTION FIVE

REFERENCES

U.S. EPA. 1995. Economic Impact Analysis of Effluent Guidelines and Limitations on the Coastal Oil and Gas Industry.

Versar, Inc. 1991. Toxic Weighting Factors for Oil and Gas Extraction Industry Pollutants. Prepared for U.S. Environmental Protection Agency, Office of Water, October 1992.

APPENDIX A

SUPPORTING DOCUMENTATION FOR COST-EFFECTIVENESS ANALYSIS: ANALYSIS OF ALL POLLUTANTS

COST-EFFECTIVENESS
PRODUCED WATER
COOK INLET AND GULF OF MEXICO COMBINED

(1) Cost of Disposal

	Option #2 *Gas Flotation Gulf/ Gas Flotation Cook*	Option #3 *Zero-Discharge Gulf*	Option #4 *Zero-Discharge Gulf/ Gas-Flotation Cook*	Option #5 *Zero-Discharge Gulf/ Zero-Discharge Cook*
Captial Cost Gulf ($1992) (a)	$36,783,691	$80,423,518	$80,423,518	$80,423,518
Capital Cost Cook ($1992) (b)	$8,113,475	N/A	$8,113,475	$84,349,749
Total Capital Cost ($1992)	$44,897,166	$80,423,518	$88,536,993	$164,773,267
Annual O&M Cost Gulf ($1992)(a)	$4,642,779	$16,629,622	$16,629,622	$16,629,622
Annual O&M Cost Cook ($1992)(b)	$1,035,110	N/A	$1,035,110	$9,507,483
Total Annual O&M Cost ($1992)	$5,677,889	$16,629,622	$17,664,732	$26,137,105
Total Annualized Capital Cost ($1992)	$6,691,002	$11,985,476	$13,194,623	$24,556,076
Total Annual Cost ($1992)	$12,368,891	$28,615,098	$30,859,355	$50,693,181
Deflator (c)	0.71	0.71	0.71	0.71
Total Cost ($1981)	$8,771,119	$20,291,749	$21,883,213	$35,947,923

(2) **Pounds and Pound-Equivalent (PE) of Pollutants Removed**
See Attached Pages

(3) Cost-Effectiveness

AVERAGE:	BPT to Option #2 *Gas Flotation Gulf/ Gas Flotation Cook*	BPT to Option #3 *Zero-Discharge Gulf*	BPT to Option #4 *Zero-Discharge Gulf/ Gas-Flotation Cook*	BPT to Option #5 *Zero-Discharge Gulf/ Zero-Discharge Cook*
Total Cost ($1981)	$8,771,119	$20,291,749	$21,883,213	$35,947,923
Total Pound-Equivalents (PE)	590,876	5,636,864	6,108,960	6,625,724
Cost per PE ($1981)	$15	$4	$4	$5

INCREMENTAL:	to Option #2	to Option #3	to Option #4	to Option #5
Total Cost ($1981)	$8,771,119	$11,520,630	$1,591,464	$14,064,709
Total Pound-Equivalents (PE)	590,876	5,045,989	472,095	516,764
Cost per PE ($1981)	$15	$2	$3	$27

COST-EFFECTIVENESS
PRODUCED WATER
COOK INLET AND GULF OF MEXICO COMBINED

(4) Notes/Assumptions:

(i) Annualized cost is capital cost at 8% for 10 years, plus annual O&M cost.
(ii) Values for Total Dissolved Solids (Total dis. sol.) and Total Phenols (TP) were reduced to 0 for this analysis.
(iii) (*) indicates pollutants that are in the Gulf of Mexico Produced Water analysis but are not in the Cook Inlet analysis. They have been added using the concentration per liter found in the Gulf, and the produced water volumes of Cook Inlet. Removals for these pollutants could not be determined for the Gas Flotation Option in Cook Inlet because the percentages differ from those used for the similar option for the Gulf.
(iv) The volume of produced water discharged in the Gulf of Mexico was increased since the previous draft CE report. See source (a).
(v) Radium 226 and Radium 228 loadings were calculated per Marta Jordan, US EPA.
(vi) Deflator is based on source (c) below and is equal to 0.71, the ratio of 1981 dollars to 1992 dollars ($3535/$4985)

(5) Sources:

(a) McIntyre, Jamie, SAIC. Memorandum to Allison Wiedeman, EPA-EAD, regarding "Revised Produced Water Discharge Volumes For the Gulf of Mexico," September 27, 1994. See Development Document, Section XI.
(b) Dawley, Joe, SAIC. Memorandum to Allison Wiedeman, EPA, regarding "Preliminary Cost Estimates for Cook Inlet BAT Produced Water Options (Version 2),", June 17, 1994. See Development Document, Section XI.
(c) Engineering News Record, "First Quarterly Cost Report," March 28, 1994.
(d) McIntyre, Jamie, SAIC. Draft fax titled "Worksheet 1. Produced Water Pollutant Loading Characterization for Gulf of Mexico: All Facilities Discharging Using Gas Flotation Option," June 20, 1994. Updated August 22, 1994. See Development Document, Section XI.
(e) Roman, Susan, SAIC. Memorandum to Allison Wiedeman, EPA, regarding "Estimated Produced Water Pollutant Loadings for Cook Inlet, Alaska," June 1, 1994. See Development Document, Section XI.
(f) Avanti Corp. Fax titled "Table 1. Pound Equivalent Removals for Gulf of Mexico Coastal Subcategory," June 8, 1994.
(g) Versar, Inc., "Toxic Weighting Factors for Coastal Subcategory of the Oil and Gas Extraction Industry Proposed Effluent Guidelines", Draft Report, November 2, 1994

COST-EFFECTIVENESS
PRODUCED WATER
COOK INLET AND GULF OF MEXICO COMBINED

(2) **Pounds and Pound-Equivalent (PE) Removed**
(Combined, Produced Water)

CAS	*Pollutant*	**Option #2** *Gas Flotation Gulf/ Gas Flotation Cook (Pounds) (d,e)*	**Option #3** *Zero-Discharge Gulf (Pounds) (f)*	**Option #4** *Zero-Discharge Gulf/ Gas-Flotation Cook (Pounds) (f,e)*	**Option #5** *Zero-Discharge Gulf/ Zero-Discharge Cook (Pounds) (f,e)*
7429905	Aluminum	64,455.95	67,101.30	67,581.30	68,435.30
7664417	* Ammonia	0.00	4,117,027.63	4,117,027.63	5,244,513.35
7440360	* Antimony	0.00	10,390.69	10,390.69	13,236.27
7440382	Arsenic	703.00	676.02	1,379.02	2,629.02
7440393	Barium	1,406,983.17	3,290,780.32	3,632,895.32	4,241,098.32
71432	Benzene	228,429.19	268,217.41	305,164.41	326,131.41
65850	* Benzoic Acid	0.00	238,672.80	238,672.80	304,035.54
100516	* Benzyl alcohol	0.00	3,098.43	3,098.43	3,946.96
7440417	* Beryllium	0.00	348.03	348.03	443.34
117817	* Bis(2-ethylhexyl)phthalate	0.00	2,879.35	2,879.35	3,667.88
7440428	Boron	394,483.26	1,267,162.93	1,425,649.93	1,707,402.93
7440439	Cadmium	660.41	1,427.15	1,566.15	1,814.15
7440702	* Calcium	0.00	156,548,828.65	156,548,828.65	199,421,158.97
75150	* Carbon disulfide	0.00	530.80	530.80	676.17
16887006	* Chlorides	0.00	4,075,590,076.80	4,075,590,076.80	5,191,727,741.66
74873	* Chloromethane	0.00	1,790.20	1,790.20	2,280.47
7440473	* Chromium	0.00	8,012.10	8,012.10	10,206.28
7440484	* Cobalt	0.00	5,232.90	5,232.90	6,665.98
7440508	Copper	2,738.00	11,267.01	14,005.01	18,872.01
84742	Di-n-butylphthalate	2,641.86	2,290.94	2,455.94	2,565.94
100414	Ethylbenzene	4,940.24	7,198.37	8,832.37	9,896.37
na	* Gross alpha (pCi/l)	0.00	0.02	0.02	0.02
na	* Gross beta (pCi/l)	0.00	0.02	0.02	0.02
142621	* Hexanoic acid	0.00	49,449.65	49,449.65	62,991.89
7439896	Iron	803,050.23	969,713.90	999,981.90	1,053,790.90
na	* Lead 210 (pCi/l)	0.00	0.00	0.00	0.00
7439921	Lead	25,621.62	32,236.16	33,437.16	35,573.16
7439954	* Magnesium	0.00	38,539,367.15	38,539,367.15	49,093,725.77
7439965	Manganese	77,506.43	81,435.44	82,148.44	83,417.44
7439976	Mercury	0.00	0.00	0.00	0.00
75092	* Methylene chloride	0.00	10,641.06	10,641.06	13,555.22
7439987	* Molybdenum	0.00	5,439.46	5,439.46	6,929.11
108383	m-Xylene	0.00	8,512.85	8,512.85	8,512.85
91203	Naphthalene	17,646.66	9,013.61	23,406.61	24,980.61
124185	* n-Decane	0.00	8,700.63	8,700.63	11,083.38
629970	* n-Docosane	0.00	2,378.59	2,378.59	3,029.99
112403	* n-Dodecane	0.00	14,083.76	14,083.76	17,940.73
112958	* n-Eicosane	0.00	4,256.43	4,256.43	5,422.09
630013	* n-Hexacosane	0.00	2,259.66	2,259.66	2,878.49
544763	* n-Hexadecane	0.00	17,714.24	17,714.24	22,565.45
630024	* n-Octacosane	0.00	2,203.33	2,203.33	2,806.73
593453	* n-Octadecane	0.00	5,189.08	5,189.08	6,610.16
646311	* n-Tetracosane	0.00	2,391.11	2,391.11	3,045.94
629594	* n-Tetradecane	0.00	7,448.74	7,448.74	9,488.65
638686	* n-Triacontane	0.00	2,190.81	2,190.81	2,790.78
7440020	Nickel	10,501.00	6,822.80	17,323.80	35,991.80
opxylenes	o+p Xylene	0.00	5,389.39	5,389.39	5,389.39
95487	* o-Cresol	0.00	7,573.93	7,573.93	9,648.12
na	Oil and Grease	2,047,674.41	3,314,754.01	3,518,645.01	3,920,570.01
106445	* p-Cresol	0.00	9,326.58	9,326.58	11,880.75
108952	Phenol	1,064.11	34,614.75	34,614.75	41,994.75
13982633	Radium 226 (pCi/l)	0.000E+00	1.076E-02	1.076E-02	1.078E-02
15262201	Radium 228 (pCi/l)	0.000E+00	1.427E-02	1.427E-02	1.432E-02
7782492	* Selenium	0.00	15,648.62	15,648.62	19,934.14
7440224	* Silver	0.00	15,773.81	15,773.81	20,093.62
7440246	* Strontium	0.00	12,863,168.45	12,863,168.45	16,385,864.92

COST-EFFECTIVENESS
PRODUCED WATER
COOK INLET AND GULF OF MEXICO COMBINED

(2) Pounds and Pound-Equivalent (PE) Removed
(Combined, Produced Water)

CAS	Pollutant	Option #2 Gas Flotation Gulf/ Gas Flotation Cook (Pounds) (d,e)	Option #3 Zero-Discharge Gulf (Pounds) (f)	Option #4 Zero-Discharge Gulf/ Gas-Flotation Cook (Pounds) (f,e)	Option #5 Zero-Discharge Gulf/ Zero-Discharge Cook (Pounds) (f,e)
7704349	* Sulfur	0.00	606,102.48	606,102.48	772,089.20
7440280	* Thallium	0.00	11,267.01	11,267.01	14,352.58
7440315	* Tin	0.00	19,091.32	19,091.32	24,319.65
7440326	Titanium	1,790.64	2,028.06	2,071.06	2,148.06
108883	Toluene	170,751.72	210,943.44	222,567.44	236,725.44
TP	* Total phenols (*)	0.00	0.00	0.00	0.00
na	* Total dis. sol. (*)	0.00	0.00	0.00	0.00
na	Total susp. sol.	7,092,546.30	8,329,011.11	8,970,381.11	9,483,476.11
75694	* Trichlorofluoromethane	0.00	18,402.78	18,402.78	23,442.55
7440622	* Vanadium	0.00	6,046.63	6,046.63	7,702.55
108054	* Vinyl acetate	0.00	1,840.28	1,840.28	2,344.26
7440655	* Yttrium	0.00	1,564.86	1,564.86	1,993.41
7440666	Zinc	12,215.32	20,593.59	20,593.59	21,359.59
78933	2-Butanone	10,559.00	7,636.53	18,195.53	25,235.53
591786	* 2-Hexanone	0.00	2,240.88	2,240.88	2,854.57
91576	* 2-Methylnaphthalene	0.00	4,206.35	4,206.35	5,358.30
67641	* 2-Propanone (Acetone)	0.00	57,148.77	57,148.77	72,799.49
105679	2,4-Dimethylphenol	4,527.00	7,323.56	11,850.56	16,126.56
1464535	* 1,2,3,4-Diepoxybutane	0.00	4,450.47	4,450.47	5,669.27
Alkanes	n-Alkanes	44,561.84	0.00	16,845.00	28,075.00
Steranes	Steranes	795.00	0.00	795.00	1,325.00
riterpanes	Triterpanes	800.00	0.00	800.00	1,334.00
xylenes	Total Xylenes	2,813.00	0.00	2,813.00	9,278.00
120127	Anthracene	305.00	0.00	305.00	432.00
108907	Chlorobenzene	4.00	0.00	4.00	138.00
50328	Benzo(a)pyrene	101.00	0.00	101.00	181.00
59507	p-Chloro-m-cresol	259.00	0.00	259.00	432.00
		12,431,128	**4,306,800,606**	**4,308,295,026**	**5,484,799,117**

COST-EFFECTIVENESS
PRODUCED WATER
COOK INLET AND GULF OF MEXICO COMBINED

(2) (Cont.) Pound-Equivalent (PE) Removed
(Combined, Produced Water)

CAS	Pollutant	Toxic Weighting Factor TWF (g)	Option #2 Gas Flotation Gulf/ Gas Flotation Cook (Pound-Equivalents)	Option #3 Zero-Discharge Gulf (Pound-Equivalents)	Option #4 Zero-Discharge Gulf/ Gas-Flotation Cook (Pound-Equivalents)	Option #5 Zero-Discharge Gulf/ Zero-Discharge Cook (Pound-Equivalents)
7429905	Aluminum	6.40E-02	4,125.18	4,294.48	4,325.20	4,379.86
7664417	* Ammonia	8.10E-03	0.00	33,347.92	33,347.92	42,480.56
7440360	* Antimony	1.30E-02	0.00	135.08	135.08	172.07
7440382	Arsenic	4.20E+00	2,952.60	2,839.29	5,791.89	11,041.89
7440393	Barium	2.00E-03	2,813.97	6,581.56	7,265.79	8,482.20
71432	Benzene	1.60E-02	3,654.87	4,291.48	4,882.63	5,218.10
65850	* Benzoic Acid	3.30E-04	0.00	78.76	78.76	100.33
100516	* Benzyl alcohol	5.60E-03	0.00	17.35	17.35	22.10
7440417	* Beryllium	4.20E+00	0.00	1,461.71	1,461.71	1,862.01
117817	* Bis(2-ethylhexyl)phthalate	9.50E-02	0.00	273.54	273.54	348.45
7440428	Boron	1.80E-01	71,006.99	228,089.33	256,616.99	307,332.53
7440439	Cadmium	6.70E-01	442.48	956.19	1,049.32	1,215.48
7440702	* Calcium	2.80E-05	0.00	4,383.37	4,383.37	5,583.79
75150	* Carbon disulfide	6.00E-05	0.00	0.03	0.03	0.04
16887006	* Chlorides	2.40E-05	0.00	97,814.16	97,814.16	124,601.47
74873	* Chloromethane	2.20E-03	0.00	3.94	3.94	5.02
7440473	* Chromium	1.10E-01	0.00	881.33	881.33	1,122.69
7440484	* Cobalt	5.60E-01	0.00	2,930.42	2,930.42	3,732.95
7440508	Copper	1.90E+00	5,202.20	21,407.32	26,609.52	35,856.82
84742	Di-n-butylphthalate	1.60E+00	4,226.98	3,665.51	3,929.51	4,105.51
100414	Ethylbenzene	1.30E-01	642.23	935.79	1,148.21	1,286.53
na	* Gross alpha (pCi/l)	0.00E+00	0.00	0.00	0.00	0.00
na	* Gross beta (pCi/l)	0.00E+00	0.00	0.00	0.00	0.00
142621	* Hexanoic acid	3.40E-04	0.00	16.81	16.81	21.42
7439896	Iron	2.10E-03	1,686.41	2,036.40	2,099.96	2,212.96
na	* Lead 210 (pCi/l)	0.00E+00	0.00	0.00	0.00	0.00
7439921	Lead	6.60E-01	16,910.27	21,275.87	22,068.53	23,478.29
7439954	* Magnesium	8.70E-04	0.00	33,529.25	33,529.25	42,711.54
7439965	Manganese	5.60E-01	43,403.60	45,603.84	46,003.12	46,713.76
7439976	Mercury	2.60E+02	0.00	0.00	0.00	0.00
75092	* Methylene chloride	2.50E-03	0.00	26.60	26.60	33.89
7439987	* Molybdenum	2.00E-01	0.00	1,087.89	1,087.89	1,385.82
108383	m-Xylene	1.70E-02	0.00	144.72	144.72	144.72
91203	Naphthalene	4.70E-02	829.39	423.64	1,100.11	1,174.09
124185	* n-Decane	1.10E-04	0.00	0.96	0.96	1.22
629970	* n-Docosane	1.10E-04	0.00	0.26	0.26	0.33
112403	* n-Dodecane	4.30E-03	0.00	60.56	60.56	77.15
112958	* n-Eicosane	4.30E-03	0.00	18.30	18.30	23.31
630013	* n-Hexacosane	8.20E-05	0.00	0.19	0.19	0.24
544763	* n-Hexadecane	4.30E-03	0.00	76.17	76.17	97.03
630024	* n-Octacosane	8.20E-05	0.00	0.18	0.18	0.23
593453	* n-Octadecane	4.30E-03	0.00	22.31	22.31	28.42
646311	* n-Tetracosane	8.20E-05	0.00	0.20	0.20	0.25
629594	* n-Tetradecane	4.30E-03	0.00	32.03	32.03	40.80
638686	* n-Triacontane	8.20E-05	0.00	0.18	0.18	0.23
7440020	Nickel	6.80E-01	7,140.68	4,639.50	11,780.18	24,474.42
opxylenes	o+p Xylene	3.30E-02	0.00	177.85	177.85	177.85
95487	* o-Cresol	5.70E-03	0.00	43.17	43.17	54.99
na	Oil and Grease	0.00E+00	0.00	0.00	0.00	0.00
106445	* p-Cresol	1.80E-04	0.00	1.68	1.68	2.14
108952	Phenol	2.20E-01	234.10	7,615.25	7,615.25	9,238.85
13982633	Radium 226 (pCi/l)	1.50E+05	0.00	1,614.00	1,614.00	1,617.58
15262201	Radium 228 (pCi/l)	3.50E+08	0.00	4,994,500.00	4,994,500.00	5,013,235.50
7782492	* Selenium	7.90E-02	0.00	1,236.24	1,236.24	1,574.80
7440224	* Silver	6.10E+00	0.00	96,220.26	96,220.26	122,571.05
7440246	* Strontium	5.50E-06	0.00	70.75	70.75	90.12
7704349	* Sulfur	5.60E-06	0.00	3.39	3.39	4.32
7440280	* Thallium	2.60E-02	0.00	292.94	292.94	373.17
7440315	* Tin	3.00E-01	0.00	5,727.40	5,727.40	7,295.90
7440326	Titanium	2.90E-02	51.93	58.81	60.06	62.29

COST-EFFECTIVENESS
PRODUCED WATER
COOK INLET AND GULF OF MEXICO COMBINED

(2) (Cont.) Pound-Equivalent (PE) Removed
(Combined, Produced Water)

CAS	*Pollutant*	Toxic Weighting Factor *TWF (g)*	Option #2 *Gas Flotation Gulf/ Gas Flotation Cook (Pound-Equivalents)*	Option #3 *Zero-Discharge Gulf (Pound-Equivalents)*	Option #4 *Zero-Discharge Gulf/ Gas-Flotation Cook (Pound-Equivalents)*	Option #5 *Zero-Discharge Gulf/ Zero-Discharge Cook (Pound-Equivalents)*
108883	Toluene	1.10E-03	187.83	232.04	244.82	260.40
TP	* Total phenols (*)	2.80E-02	0.00	0.00	0.00	0.00
na	* Total dis. sol. (*)	0.00E+00	0.00	0.00	0.00	0.00
na	Total susp. sol.	0.00E+00	0.00	0.00	0.00	0.00
75694	* Trichlorofluoromethane	9.60E-04	0.00	17.67	17.67	22.50
7440622	* Vanadium	6.20E-01	0.00	3,748.91	3,748.91	4,775.58
108054	* Vinyl acetate	4.00E-03	0.00	7.36	7.36	9.38
7440655	* Yttrium	0.00E+00	0.00	0.00	0.00	0.00
7440666	Zinc	6.50E-02	794.00	1,338.58	1,338.58	1,388.37
78933	2-Butanone	4.50E-04	4.75	3.44	8.19	11.36
591786	* 2-Hexanone	1.30E-04	0.00	0.29	0.29	0.37
91576	* 2-Methylnaphthalene	9.30E-02	0.00	391.19	391.19	498.32
67641	* 2-Propanone (Acetone)	5.60E-04	0.00	32.00	32.00	40.77
105679	2,4-Dimethylphenol	2.40E-03	10.86	17.58	28.44	38.70
1464535	* 1,2,3,4-Diepoxybutane	2.90E-02	0.00	129.06	129.06	164.41
Alkanes	n-Alkanes	4.30E-03	191.62	0.00	72.43	120.72
Steranes	Steranes	4.30E-03	3.42	0.00	3.42	5.70
Triterpanes	Triterpanes	4.30E-03	3.44	0.00	3.44	5.74
xylenes	Total Xylenes	1.70E-02	47.82	0.00	47.82	157.73
120127	Anthracene	3.50E-01	106.75	0.00	106.75	151.20
108907	Chlorobenzene	1.10E-02	0.04	0.00	0.04	1.52
50328	Benzo(a)pyrene	4.20E+03	424,200.00	0.00	424,200.00	760,200.00
59507	p-Chloro-m-cresol	4.30E-03	1.11	0.00	1.11	1.86
		TOTALS:	**590,876**	**5,636,864**	**6,108,960**	**6,625,724**

COST-EFFECTIVENESS
DRILLING WASTES
COOK INLET

(1) Cost of Disposal

	Option #2 *1 Million ppm toxicity*	Option #3 *Zero Discharge*
Annual Cost ($1992) (a)	$1,370,685	$3,889,386
Deflator (b)	0.71	0.71
Cost ($1981)	$971,990	$2,758,070

(2) Pounds and Pound-Equivalents (PE) Removed

CAS	*Pollutant*	Option #2 *1 Million ppm toxicity (c)* *Pounds*	Option #3 *Zero Discharge (d)* *Pounds*	*TWF (e)*	Option #2 *1 Million ppm toxicity* *Pound-Equivalents*	Option #3 *Zero Discharge* *Pound-Equiv.*
7440439	Cadmium	1.33	7.86	6.70E-01	0.89	5.26
7439976	Mercury	0.11	0.71	2.60E+02	29.71	185.71
7429905	Aluminum	11,010.17	64,765.74	6.40E-02	704.65	4,145.01
7440360	Antimony	6.91	40.70	1.30E-02	0.09	0.53
7440382	Arsenic	8.61	50.70	4.20E+00	36.18	212.94
7440393	Barium	145,670.99	856,888.16	2.00E-03	291.34	1,713.78
7440417	Beryllium	0.84	5.00	4.20E+00	3.54	21.00
7440473	Chromium	291.34	1,713.77	1.10E-01	32.05	188.51
7440508	Copper	22.70	133.53	1.90E+00	43.13	253.70
7439896	Iron	18,626.83	109,569.57	2.10E-03	39.12	230.10
7439921	Lead	42.61	250.64	6.60E-01	28.13	165.42
7440020	Nickel	16.39	96.40	6.80E-01	11.14	65.55
7782492	Selenium	1.33	7.86	7.90E-02	0.10	0.62
7440224	Silver	0.84	5.00	6.10E+00	5.14	30.50
7440280	Thallium	1.46	8.57	2.60E-02	0.04	0.22
7440315	Tin	17.73	104.26	3.00E-01	5.32	31.28
7440326	Titanium	106.21	624.81	2.90E-02	3.08	18.12
7440666	Zinc	243.39	1,431.71	6.50E-02	15.82	93.06
91203	Naphthalene	0.23	0.23	4.70E-02	0.01	0.01
86737	Fluorene	3.57	3.57	5.60E-01	2.00	2.00
85018	Phenanthrene	0.53	0.53	1.90E+01	10.04	10.04
AB	Alkylated benzenes	133.10	133.10	5.60E-03	0.75	0.75
AN	Alkylated naphthalenes	2.19	2.19	6.20E-02	0.14	0.14
AF	Alkylated fluorenes	7.71	7.71	8.90E-02	0.69	0.69
AP	Alkylated phenanthrenes	0.90	0.90	1.40E-01	0.13	0.13
TB	Total biphenyls	8.61	8.61	3.70E-02	0.32	0.32
TD	Total dibenzothiophenes	0.03	0.03	4.60E-02	0.00	0.00
na	TSS	3,688,894.81	21,699,381.23	0.00E+00	0.00	0.00
na	Total Oil	3,774.70	3,774.61	0.00E+00	0.00	0.00
	TOTALS:	**3,868,896.18**	**22,739,017.72**		**1,263.54**	**7,375.39**

(3) Cost-Effectiveness

AVERAGE:	Option #2 *1 Million ppm toxicity*	Option #3 *Zero Discharge*	INCREMENTAL:	Option #2 to Option #3
Total Cost ($1981)	$971,990	$2,758,070		$1,786,080
Total Pound-Equivalents (PE)	1,264	7,375		6,112
Cost per PE ($1981)	$769	$374		$292

COST-EFFECTIVENESS
DRILLING WASTES
COOK INLET

(4) Notes/Assumptions:

(i) Option 1 (30,000 ppm toxicity limitation option) has no incremental costs or removals over BPT, so it is not considered here.
(ii) Costs were annualized over the lifetime of drilling (7 years) at 8% real interest rate.
(iii) See EPA, 1995. Economic Impact Analysis of Proposed Effluent Limitations Guidelines and Standards for the Coastal Oil and Gas Industry for more information on the cost annualization methodology based on capital and operating costs.
(iv) Deflator is based on source (b) below and is equal to 0.71, the ratio of 1981 dollars to 1992 dollars ($3535/$4985)

(5) Sources:

(a) Cost for Option 3 calculated from worksheets in Safavi, Behzad, SAIC. Memorandum to Allison Wiedeman, EPA-EAD, regarding "Zero-Discharge and Toxicity Limitation Compliance Cost Estimates for Disposal of Drilling Wastes in Cook Inlet, Alaska, Coastal Oil & Gas Operations," August 30, 1994. See Development Document, Section X.
(b) ENR Deflator from Engineering News Record, "First Quarterly Cost Report," March 28, 1994.
(c) Loadings for Option 2 from Worksheet 11, September 7, 1994, "1,000,000 ppm SPP Toxicity Limitation Option", faxed by Behzad Safavi, SAIC, to ERG on September 7, 1994. See Development Document, Section X.
(d) Loadings for Option 3 from Worksheet 10, September 7, 1994, "Zero Discharge Option," faxed by Behzad Safavi, SAIC, to ERG on Sept. 7, 1994. The loadings in the worksheets are 7-year cumulative loadings. The numbers here have been reduced to annual levels. See Development Document, Section X.
(e) Versar, Inc., "Toxic Weighting Factors for Coastal Subcategory of the Oil and Gas Extraction Industry Proposed Effluent Guidelines", Draft Report, November 2, 1994

COST-EFFECTIVENESS
TREATMENT, WORKOVER, AND COMPLETION (TWC) FLUIDS
GULF OF MEXICO

(1) **Cost of Disposal**

	Option #2a *Gas Flotation*	Option #2b *Zero-Discharge*
Annual Cost ($1992) (a)	$591,538	$605,645
Deflator (b)	0.71	0.71
Cost ($1981)	$419,476	$429,479

(2) **Pounds and Pound-Equivalents (PE) Removed**

CAS	*Pollutant*	Option #2a *Pounds (c)*	Option #2b *Pounds (d)*	*TWF (e)*	Option #2a *Pound-Equiv.*	Option #2b *Pound-Equiv.*
na	Oil & Grease	20,562	22,303	0.00E+00	0.00	0.00
na	Solids, Total Suspended	47,871	50,094	0.00E+00	0.00	0.00
Cyanide	Cyanide, Total		5	1.10E+00	0.00	5.50
7440360	Antimony		3	1.30E-02	0.00	0.04
7440382	Arsenic	11	16	4.20E+00	46.20	67.20
7440417	Beryllium	0	1	4.20E+00	0.00	4.20
7440439	Cadmium	1	3	6.70E-01	0.67	2.01
7440473	Chromium		59	1.10E-01	0.00	6.49
7440508	Copper	7	27	1.90E+00	13.30	51.30
7439921	Lead	123	133	6.60E-01	81.18	87.78
7440020	Nickel	3	11	6.80E-01	2.04	7.48
7782492	Selenium		4	7.90E-02	0.00	0.32
7440224	Silver		0	6.10E+00	0.00	0.00
7440280	Thallium		1	2.60E-02	0.00	0.03
7440666	Zinc	25	35	6.50E-02	1.63	2.28
7429905	Alumimum	619	623	6.40E-02	39.62	39.87
7440393	Barium	11	48	2.00E-03	0.02	0.10
7440428	Boron	333	1,448	1.80E-01	59.94	260.64
7440702	Calcium		990,004	2.80E-05	0.00	27.72
7440484	Cobalt		1	5.60E-01	0.00	0.56
7439896	Iron	36,773	37,006	2.10E-03	77.22	77.71
7439965	Manganese	490	496	5.60E-01	274.40	277.76
7439954	Magnesium		486,365	8.70E-04	0.00	423.14
7439987	Molybdenum		7	2.00E-01	0.00	1.40
7440235	Sodium		1,818,087	5.50E-06	0.00	10.00
7440246	Strontium		13,739	5.50E-06	0.00	0.08
7704349	Sulfur		23,615	5.60E-06	0.00	0.13
7440315	Tin		3	3.00E-01	0.00	0.90
7440326	Titanium	7	7	2.90E-02	0.20	0.20
7440622	Vanadium		111	6.20E-01	0.00	68.82
7440655	Yttrium		4	0.00E+00	0.00	0.00
67641	Acetone		694	5.60E-04	0.00	0.39
71432	Benzene	39	129	1.60E-02	0.62	2.06
100414	Ethylbenzene	106	111	1.30E-01	13.78	14.43
74873	Methyl Chloride		3	2.20E-03	0.00	0.01
78933	Methyl Ethyl Ketone		5	4.50E-04	0.00	0.00
108383	m-Xylene		172	1.70E-02	0.00	2.92
opxylenes	o-, p- Xylene		16,466	3.30E-02	0.00	543.38
108883	Toluene	24	86	1.10E-03	0.03	0.09

COST-EFFECTIVENESS
TREATMENT, WORKOVER, AND COMPLETION (TWC) FLUIDS
GULF OF MEXICO

108101	4-Methyl-2-Pentanone		292	1.20E-04	0.00	0.04
132649	Dibenzofuran		13	2.00E-02	0.00	0.26
132650	Dibenzothiophene		11	4.60E-02	0.00	0.51
86737	Fluorene		6	5.60E-01	0.00	3.36
91203	Naphthalene	44	51	4.70E-02	2.07	2.40
124185	N-Decane (N-C10)		27	1.10E-04	0.00	0.00
629970	N-Docosane (N-C22)		74	1.10E-04	0.00	0.01
112403	N-Dodecane (N-C12)		55	4.30E-03	0.00	0.24
112958	N-Eicosane (N-C20)		22	4.30E-03	0.00	0.09
630013	N-Hexacosane (N-C26)		47	8.20E-05	0.00	0.00
544763	N-Hexadecane (N-C16)		39	4.30E-03	0.00	0.17
630024	N-Octacosane (N-C28)		20	8.20E-05	0.00	0.00
593453	N-Octadecane (N-C18)		103	4.30E-03	0.00	0.44
646311	N-Tetracosane (N-C24)		78	8.20E-05	0.00	0.01
629594	N-Tetradecane (N-C14)		119	4.30E-03	0.00	0.51
99876	P-Cymene		7	4.30E-02	0.00	0.30
700129	Pentamethylbenzene		5	2.90E-01	0.00	1.45
85018	Phenanthrene		7	1.90E+01	0.00	133.00
108952	Phenol	5	25	2.20E-01	1.10	5.50
1730376	1-Methylfluorene		8	8.90E-02	0.00	0.71
91576	2-Methylnaphthalene		79	9.30E-02	0.00	7.35
xylenes	Total Xylenes	229	—	1.70E-02	3.89	0.00
	TOTALS:	**107,283**	**3,463,013**		**617.91**	**2,143.28**

(3) Cost-Effectiveness

AVERAGE (And Incremental):	**Option #2a** *Gas Flotation*	**Option #2b** *Zero-Discharge*
Total Cost ($1981)	$419,476	$429,479
Total Pound-Equivalents (PE)	618	2,143
Cost per PE ($1981)	**$679**	**$200**

(4) Notes/Assumptions:

Costs were annualized over a 10-year lifetime at 8% real interest rate.
Deflator is based on source (b) below and is equal to 0.71, the ratio of 1981 dollars to 1992 dollars ($3535/$4985)

(5) Sources:

(a) McIntyre, Jamie, SAIC. Fax to Anne Jones, ERG, regarding "Summary Results From TWC Costs and Pollutant Removal Analyses, Annual Compliance Cost Estimates." November 2, 1994. See Development Document, Section XII.

(b) Engineering News Record, "First Quarterly Cost Report," March 28, 1994.

(c) McIntyre, Jamie, SAIC. Fax to Anne Jones, ERG, regarding "Total Annual BAT Pollutant Removals for Discharge Option", 11/2/94. Tables XII-?? (BAT Annual Workover/Treatment Fluids and Completion Fluids - Discharge Option) See Development Document, Section XII.

(d) McIntyre, Jamie, SAIC. Fax to Anne Jones, ERG, regarding "Total Annual BAT Pollutant Removals for Zero Discharge Option",11/2/94. Tables XII-?? (BAT Annual Workover/Treatment Fluids and Completion Fluids - Zero Discharge) See Development Document, Section XII.

(e) Versar, Inc., "Toxic Weighting Factors for Coastal Subcategory of the Oil and Gas Extraction Industry Proposed Effluent Guidelines", Draft Report, November 2, 1994