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AN ANALYSIS
OF
CONSTRUCTION COST EXPERIENCE
FOR
WASTEWATER TREATMENT PLANTS

FEBRUARY 1976

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Water Program Operations
Municipal Construction Division
Washington, D.C. 20460

MCD-22

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ABSTRACT

The topics addressed in this report are: an analysis of wastewater treatment plant construction cost experience in the construction grants program; an evaluation of the cost estimating system, as presented in the Technical Report entitled "A Guide to the Selection of Cost Effective Wastewater Treatment Systems," EPA-430/9-75-002; and the development of treatment plant cost curves. A data base consisting of descriptions and bid and grant eligible cost data for over 150 treatment plants constructed in the last four years was obtained from EPA Regional Offices and used in the analysis.

ACKNOWLEDGEMENTS

The preparation of this report was under the direction of Gary F. Otakie of the Municipal Construction Division of EPA.

The contributions and technical assistance of Mr. James Chamblee, Mr. Wen Huang and Mr. Arnold Kuzmack, also of EPA were invaluable in the report's preparation.

Most important, the contributions of the numerous EPA Regional Construction Grants personnel who assisted in obtaining the necessary cost information from the large and complex construction grant files is acknowledged. Without their cooperation this report would not have been possible.

Summary

The emphasis of this study was to gather, categorize and analyze wastewater treatment plant construction bid data available in EPA's Regional Offices. Pages 7-11 explain the categorization of bid data. A linear regression analysis resulted in two cost curves (one for new secondary plants and one for primary to secondary upgrades) formulated directly from the bid data. The new secondary plant curve formed the "anchor curve" for five additional curves for various degrees of tertiary treatment. The tertiary treatment curves were developed utilizing the differential cost from secondary treatment cost in EPA's Cost Guide (see pages 39-43) and adding these differentials to the "anchor curve". Experience in analyzing the bids indicated a need for a secondary deduct curve when upgrading to tertiary treatment; since few existing secondary plants were of equal value to a new secondary treatment plant. Sufficient data was not available to formulate this curve. Engineering judgement resulted in a secondary deduct curve of 75% of the new secondary curve. The resulting cost curves are presented on pages 29 and 30. To determine the accuracy of the curves for tertiary treatment (which are only indirectly derived from the bid data base), a comparison of costs was made between the cost predicted from the new curves and a limited number of new tertiary plants (15). The results indicated that on an average, the curves (see page 31) were 16.4% above bid cost. In recoginiton of the limited number of tertiary bids this was considered sufficiently accurate.

A comparison was made between the bid based cost curve and the adjusted cost presented in the Guide for secondary treatment. Cost in the Guide were adjusted to include 20% for site work and updated from 1973 utilizing the STP index. The comparison establishes that bid costs are 1 to 2.5 times higher (see page 26) than cost predicted utilizing the Guide, at 1 and 60 MGD respectively. This fact indicates much less economy of scale is shown by the bid data than was assumed in preparation of the Guide's unit process capital cost estimates. The analysis indicates the Guide is extremely inaccurate as a basis for estimating construction costs. The Guide's main use is to make rough "comparitive" analyses during the facilities planning phase and it advises readers to exercise extreme caution in utilizing the data to calculate construction cost.

Another important finding of this study is that for any specific wastewater treatment plant, construction costs are not necessarily solely related to the type of unit processes included or required effluent quality. The market place is subject to a considerable number of factors, none of which are amendable to accurate quantification. The factors include:

1. The standard design requirements promulgated by regulatory agencies;

2. Conventions of engineering practice and procedures;

3. The extent to which construction and supplier markets are competitive;

4. The extent to which cost is a controlling parameter in the character of designs, construction techniques and procedures;

5. Timeliness of construction;

6. Site conditions;

7. Influent wastewater characteristics (i.e. strength and peak/average flow);

8. Condition of existing wastewater treatment facilities;

9. Local labor and material costs.

These and other factors serve to obscure the relationship between parameters perceived to dictate cost (i.e. effluent quality, new or upgraded plant and flow) and the actual cost of facilities. Accordingly, the cost curves presented in this report are a best fit of extremely variable data points (caused by some combination of the above factors). Thus, the curves may require adjustment to accurately reflect the cost of a specific project. Appendix C contains adjustment factors to account for regional cost variations. However, additional adjustments may be necessary where factors specific to a project warrant.

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SECTION I

INTRODUCTION

PURPOSE

The general objective of the analysis presented herein was to develop some data based upon "real life" treatment plant construction cost experience, that could be used to estimate the cost of providing the publicly owned treatment facilities necessary to comply with the water quality management programs following from Public Law 92-500 (Federal Water Pollution Control Act Amendments of 1972). The specific purposes of the project were to develop treatment plant construction cost curves based on analysis of actual construction bids, and to use these curves as a basis for evaluating the cost estimating system presented in an EPA recent report entitled "A Guide to the Selection of Cost Effective Wastewater Treatment Systems" (EPA 430/9-75-002). As one outcome of the analysis, it was anticipated that the resultant treatment plant cost curves would be used in the 1976 Needs Survey to be conducted by EPA.

The following information is presented to provide some orientation as to the overall problem of estimating treatment plant construction costs.

BACKGROUND

The needs for wastewater treatment facilities have been identified traditionally in terms of the wastewater flow to be treated, the effluent quality or degree of treatment required, and whether the facility is an expansion or upgrading of an existing facility or a new facility. The preceding parameters are those which can be used reasonably to characterize an existing or needed facility; i.e., to those knowledgeable of wastewater treatment, the preceding parameters convey considerable information about the technical aspects of an existing or needed facility. It would therefore seem rational to move forward on a course of action which would result in cost being expressed as a function of the same parameters. However, the assumptions implicit in such an approach, and which need to be examined rather carefully are: (1) that the actual cost of a wastewater treatment facility is in fact determined by the preceding and related parameters; and, (2) that data exist which permit one to quantify the relationship between cost and the preceding and related parameters.

Given the current state of the art of technology in the field, the unit process is the "backbone" of wastewater treatment facility design and analysis. A wastewater treatment system is comprised of a sequence of unit processes arranged on the basis of either tradition, contribution to effluent quality, or creating an effluent required for a critical downstream unit process, or some combination of the three. For the most part, deterministic or quasi-deterministic expressions exist, which can be used to determine the required basic characteristics of a unit process, after their calibration to a particular situation. Thus, it is possible to predict in a rather refined manner the volume, surface area, or depth required for a unit process to produce a particular effluent quality, the preceding variables or combinations thereof being the basic dependent variables for most wastewater treatment unit processes. Also, it is important to realize that a given effluent quality can be obtained through the use of numerous alternative sequences of similar and different unit processes, i.e., there is no unique relationship between treatment system composition and arrangement and effluent quality.

The above is generally referred to as the "unit process approach" to wastewater treatment design and evaluation. Capital cost estimates for the "unit process approach" are generally based on the direct proportionality between process performance and a basic dimension of the unit process, i.e. volume, surface area, and/or depth, and on an estimated in-place material cost to provide for the critical basic dimension. Equipment cost, also a capital cost element, is usually determined on the basis of the solids handling or mass transfer capacity required to support a particular unit process at a given level of performance, for example, solids removal from clarifiers, oxygen transfer and mixing in an aeration tank, chemical and mixing demands in a chemical reactor, etc. Because the relationships between unit process performance and the basic/critical dimensions of a unit process are a continuous function, capital cost, and for that matter operation and maintenance cost, can be expressed as a continuum of "process performance." Thus, in the "unit process approach" it is possible to define a difference in cost between an activated sludge system producing an effluent with a BOD of 30 mg/l and one producing an effluent of 5 mg/l.

A cost estimating system prepared for EPA (entitled "A Guide to the Selection of Cost Effective Wastewater Treatment Systems, EPA-430/9-75-002, and hereinafter called "Guides") is a reasonable representation of what can be accomplished through the "unit process approach" to dealing with wastewater treatment cost estimation. The preceding is true regardless of how the contractor elected to define unit process performance or the basis of the cost estimates for the individual unit processes. There have been complaints about various aspects of the Guides; nonetheless, the approach used represents one endproduct of the "unit process approach" to developing cost information. The utility of such an approach, although not necessarily the validity, is attested to by the relative ease with which computer programs have been developed to permit rapid use of the information presented in the Guides.

The above discussion of the "unit process approach" and the Guides does not address the validity of either or both relative to the realities of the marketplace for wastewater treatment facility construction. It was realized as the analysis proceeded that although the "unit process approach" and the Guides represent consistent frameworks for estimating costs, neither represents the wastewater treatment marketplace, i.e., the compendium of circumstances that determine how much it costs to provide a wastewater treatment facility.

Unlike the "unit process approach" which can be characterized in terms of essentially objective terms, the marketplace is subject to a considerable number of subjective factors, none of which are particularly amenable to quantification. The subjective factors include:

1. The standard design requirements promulgated by regulatory agencies;
2. Conventions of engineering practice and procedures;
3. The extent to which construction and supplier markets are competitive;
4. The extent to which cost is a controlling parameter in the character of designs, construction techniques and procedures;

5. Timeliness of construction;
6. Site conditions;
7. Influent wastewater characteristics (i.e. strength and peak/average flow);
8. Condition of existing wastewater treatment facilities;
9. Local labor and material costs.

If manifest in a particular manner, each of the preceding factors can serve to negate the relationship between the parameters perceived (i.e. effluent quality, new or upgraded plants and flow) to dictate cost and the actual cost of facilities. Design requirements promulgated by regulatory agencies may preclude a design based on the results of laboratory or pilot plant treatability studies. A 12-mgd plant designed and constructed as a 12-mgd plant may show certain economies of scale, however, a 12 mgd facility which in fact is comprised of four 3 mgd facilities may not show economies of scale. Structural design is a key determinant in the cost of wastewater treatment facilities, however, how many regulatory agencies seriously review or even have the staff to seriously review the efficiency and reasonableness of structural designs? An engineer is much more likely to be challanged over whether he designed for 800 or 1000 gallons per day per square foot overflow rate than for whether he used six or 12 inch concrete walls for the clarifier. Given the mobility of labor forces and the capacity to transport materials and equipment, there is the distinct possibility that local costs are not dictated by local market conditions. It appears that only rarely does a client specify the amount he is willing to pay for a treatment facility having certain performance characteristics; thus, more often than not cost appears to be a consequence of rather than a parameter of design and construction. When designers and contractors are familiar with each other's work, significant economies can occur; when they are not, economic caution is understandably the criteria. And finally, one can only speculate as to the consequence of bidding equipment before, rather than after the design of a facility is completed; the concept is contradictory to tradition but the consequence might be interesting.

To take into consideration the possible factors of the marketplace for this analysis, it was decided to obtain a representative number of bids for the construction of wastewater treatment facilities. The construction bids were obtained from the Regional Offices of EPA and subjected to several levels of classification before the actual analysis was done. The classification was done to take into account the location, size of facility, type of plant (new, expanded upgraded, etc.), and levels of treatment, etc., and several levels of analysis were performed. Two significant results were obtained from the analysis:

1. A set of treatment plant cost/performance level/capacity relationships for the construction of new and expanded or expanded/upgraded plants.

2. A benchmarking of the cost relationships in the Guides against actual treatment plant construction cost experience.

SECTION II

ACQUISITION AND PRESENTATION OF CONSTRUCTION COST DATA BASE

Several basic decisions were made prior to the start of the analysis in relation to the development and analysis of construction cost experience for wastewater treatment plants. The first of these decisions was that the analysis would be directed solely towards publicly - owned waste treatment facilities which are, or have been, eligible for Federal construction grant funds, and the second decision was that actual cost experience as for individual projects, resident in the construction grant files of Regional Offices of EPA, would be used to develop the data base for the cost analysis. The third decision was that the "winning" construction bid for a project would constitute the indicator of construction cost, with no allowances being made for any overruns beyond the usual contingencies.

From these basic decisions were developed the actual procedures used in the acquisition of the construction cost data base.

ACQUISITION OF DATA BASE

The overall objective set forth for the acquisition of the construction cost data base was to obtain a representative sampling of construction cost experience on individual projects that had received Federal construction grant funds under the aegis of either PL 92-500 or earlier funding programs implemented by EPA or its predecessor agencies. The phrase "representative sampling" as used herein means representative with respect to: locations throughout the Nation; type of construction (whether the project related to a new sewage treatment plant, the upgrading of an existing plant, or the expansion and upgrading of an existing plant); the level of treatment afforded by the as-constructed treatment plant; and the types of unit processes used in providing liquid stream and residual solids management. Lastly, to confine the sampling to recent municipal waste treatment plant experience, only projects under bid after late 1971 were accepted for inclusion in the data base.

To develop the data base, a total of ten EPA Regional Offices were contacted, and nine were visited, by personnel of the Municipal Construction Division of EPA. The nine Regional Offices visited were: Region I (Boston); Region II (New York); Region III (Philadelphia); Region IV (Atlanta); Region V (Chicago); Region VII (Kansas City); Region VIII (Denver); Region IX (San Francisco); and Region X (Seattle). From this information on individual grants contained in the construction grant files of each Regional Office, the following types of information were excerpted and recorded (as available) for each selected project:

1. Grant application, location, and EPA Project Number.

2. Types of construction, i.e.: complete new sewage treatment plant; upgrading of an existing plant; or upgrading and expansion of an existing plant.

3. Design flow rates for the new plant and (if applicable) for the plant prior to expansion.

4. Construction bid cost and date of bid.

5. Total grant eligible cost (i.e. construction, architect and engineer fees, and legal, administrative and contingency costs), for the treatment plant.

6. Effluent design criteria (design effluent quality) and influent stream characteristics.

7. Unit process flow diagram for the liquid stream and residual solids treatment trains.

8. Factors which might abnormally affect the bid price were identified (such as unusual site work or influent quality).

9. Backup information such as bid proposals and consultant reports were also obtained.

The implementation of this procedure resulted in the collection of bid information and supporting materials for over 200 individual projects. After initial screening of this data base for completeness of description of the individual projects, a total of 157 projects were selected for the analysis of construction cost experience presented herein.

PRESENTATION OF DATA BASE

Pre-Processing of Bid Information

In order to organize the bid information for the analysis presented subsequently, it was first necessary to: (1) convert bid costs to grant eligible construction costs (in those cases wherein the latter information was not provided); (2) update the grant eligible construction costs from the date of bid to a current time horizon; and, (3) classify each project as to design treatment level (in terms of the design effluent quality), type of construction (new plant, upgraded plant, or upgraded/expanded plant), and the unit processes that were constructed or added.

Ninety five of the 157 bids in the data set contained complete information on the grant eligible construction cost; consequently, it was necessary to convert construction bid costs to grant eligible costs for 62 of the bids. To develop a relationship between construction bid cost and grant eligible cost for use in the conversion, an analysis was made of the difference between the two cost parameters for each of the 95 bids containing both cost parameters. From this analysis, it was found that, the grant eligible construction cost was an average of 17 percent greater than the construction bid cost for the 95 bids analyzed. On this basis, an escalation factor of 20 percent was used to estimate grant eligible costs for the 62 bids for which only bid cost information was provided.

Grant eligible construction costs were updated from the bid date to a current time horizon (Winter 1976) using the EPA Sewage Treatment Plant Construction Cost Index (STP Index). The base value for the STP Index is 100 (1957 - 1959), and it was assumed (unofficially) that the national average value of the STP Index will be 263 in the Winter Quarter of 1976. The updating procedure was done by escalating the grant eligible construction cost for each bid by the ratio of: 263 divided by the national average value of the STP Index at the date of the bid.

The third pre-processing step involved the classification of each bid in terms of type of construction, design treatment level provided, and unit processes constructed. The classifications used to characterize the type of construction in each project are presented in Table 1, the treatment categories used to characterize the design treatment levels of each plant are presented in Table 2, and the unit process classifications are presented in Table 3. Each bid was assigned the applicable code for type of construction (Table 1), the applicable treatment category code from Table 2, and the applicable unit process codes for the types of secondary, tertiary, and residual solids treatment unit processes (from those listed in Table 3). It was recognized that the above characterization procedure may have resulted in the excessive disaggregation of the data base for purposes of the analysis; however, the intent was to maximize the possible distinctions that could be made from bid to bid in the development of the analysis.

As a final preprocessing step, each bid was identified by a three digit bid number. The bid number was designed so that the first digit (i.e. the "hundreds" digit) contain information on the flow rate and type of construction for each plant, as follows:

Bid Number	Design Flow Rate	Type of Construction
1XX	<1 mgd	New Plant
2XX	<1 mgd	Upgraded plant
3XX	<1 mgd	Upgraded/expanded plant
4XX	>1 mgd	New Plant
5XX	>1 mgd	Upgraded Plant
6XX	>1 mgd	Upgraded/expanded plant

The abbreviation "mgd" connotes millions of gallons per day.

Presentation of Pre-Processed Data Base

The bid data base, pre-processed as described above, was compiled in the "Summary of Bid Information" that is presented in Appendix A. The summary of Appendix A is organized in the following format: (one line per bid)

- Column 1 contains a three digit Bid Number assigned uniquely to each bid.
- Column 2 contains the EPA Project Number, a six digit code.
- Column 3 contains the design flow rate in units of mgd.
- Column 4 contains the updated grant eligible construction cost for the plant (adjusted to an STP Index of 263) in units of millions of dollars.

TABLE 1. DESCRIPTION OF CODES FOR TYPE OF CONSTRUCTION IN SUMMARY OF BID INFORMATION

Code	Definition	Ratio of QFINAL/QINITIAL	No. of Plants	% of Total
1	New plant	--	99	63
2	Upgrade; primary to secondary	1	12	8
3	Upgrade; primary to tertiary	1	1	<1
4	Upgrade; secondary to tertiary	1	3	2
5	Upgrade/expansion; primary to second.	>4	0	-
6	Upgrade/expansion; primary to second.	2 to 4	6	4
7	Upgrade/expansion; primary to second.	1.33 to 2	3	2
8	Upgrade/expansion; primary to second.	<1.33	5	3
9	Upgrade/expansion; primary to tertiary	>4	0	-
10	Upgrade/expansion; primary to tertiary	2 to 4	1	<1
11	Upgrade/expansion; primary to tertiary	1.33 to 2	4	3
12	Upgrade/expansion; primary to tertiary	<1.33	2	1
13	Upgrade/expansion; second. to tertiary	>4	1	<1
14	Upgrade/expansion; second. to tertiary	2 to 4	9	6
15	Upgrade/expansion; second. to tertiary	1.33 to 2	5	3
16	Upgrade/expansion; second. to tertiary	<1.33	2	1
17	Expansion at same treatment level	--	4	3

TABLE 2. DESCRIPTION OF CODES FOR TREATMENT CATEGORIES IN SUMMARY OF BID INFORMATION

Code	Treatment Level						No. of Plants	Cum. Percent
	BOD_5 mg/l	SS mg/l	P	NH_3-N	NO_3-N	Post-Aeration		
1	20-30	20-30	--	--	--	--	66	42
2	5-19	5-19	--	--	--	--	49	73
3	5-19	5-19	R	--	--	--	15	83
4	5-19	5-19	R	R	--	--	8	88
5	5-19	5-19	R	R	R	--	2	89
6	<5	<5	R	R	R	--	3	91
7	5-19	5-19	--	R	--	--	6	95
8	5-19	5-19	--	--	--	Yes	4	99
9	5-19	5-19	R	R	R	Yes	0	99
10	<5	<5	R	R	R	Yes	0	99
11	5-19	5-19	--	R	--	Yes	1	99
12	5-19	5-19	--	R	--	Yes	1	99
13	<5	<5	--	--	--	--	2	100

Note: R = Removal

TABLE 3. DESCRIPTION OF CODES FOR UNIT PROCESS TRAINS USED IN SUMMARY OF BID INFORMATION

SECONDARY TREATMENT UNIT PROCESSES

Code	Description
011	Activated sludge
012	Contact stabilization
013	Extended aeration
014	Step aeration
015	Pure oxygen
016	Roughing filter - conventional activated sludge
017	Primary chemical and activated sludge
018	Physical chemical
019	Primary chemical and oxygen activated sludge
021	Trickling filter (std. rate)
022	Trickling filter (high rate)
023	Trickling filter (high rate) - step aeration
031	Lagoon (single)
032	Lagoon (series)
033	Aerated lagoon (single)
034	Aerated lagoon (series)
041	Biodisc
051	Oxidation ditch

TERTIARY TREATMENT UNIT PROCESS

Code	Description
111	Filtration only
112	Filtration - activated carbon
113	Filtration- microscreening
114	Microscreening
115	Activated carbon only
121	Nitrification
122	Nitrification - filtration
123	Nitrification - P removal - filtration
124	Nitrification - P removal - filtration - activated carbon
131	Nitrification - denitrification
132	Nitrification - denitrification - filtration
133	Nitrification - denitrification - P removal - filtration
134	Nitrification - denitrification - P removal - filtration - activated carbon
141	P removal - filtration
142	P removal - filtration - activated carbon

TABLE 3. (CONTINUED)

Code	Description
143	P removal - clarification (no filtration)
144	P removal - clarification - microscreening
151	P removal - ammonia stripping - filtration
152	P removal ammonia stripping - filtration - activated carbon
161	Filtration - ammonium ion exchange
162	Filtration - activated carbon - ammonium ion exchange
163	P removal - filtration - ammonium ion exchange
164	P removal - filtration - activated carbon -ammonium ion exchange
171	Breakpoint Cl_2 filtration - activated carbon
172	P removal - breakpoint Cl_2 - filtration - activated carbon
181	Post aeration
182	Chlorination - dechlorination - post aeration
191	Spray irrigation
192	Lagoons (polishing)
193	Evaporation/percolation pond

RESIDUAL SOLIDS TREATMENT UNIT PROCESSES

Code	Description
211	Thickening - only
212	Thickening - air drying
213	Thickening - dewatering
214	Air drying
215	Sludge lagoon - air drying
216	Dewatering
217	Incineration
218	Anaerobic Digestion
219	Anaerobic Digestion - dewatering
221	Thickening anaerobic digestion
222	Thickening - anaerobic digestion - air drying
223	Thickening - anaeriboc digestion - dewatering
224	Thickening - anaerobic digestion - dewatering - air drying
231	Thickening - dewatering - incineration
232	Thickening - dewatering - recalcination
233	Thickening - dewatering - recalcination - incineration
234	Thickening - heat treatment
235	Thickening - heat treatment - incineration
236	Thickening - heat treatment - filtration
237	Thickening - heat treatment - dewatering - incineration

TABLE 3. (CONTINUED)

Code	Description
241	Aerobic digestion
242	Aerobic digestion - air drying
243	Aerobic digestion dewatering
244	Aerobic digestion - thickening - dewatering
245	Aerobic digestion/anaerobic digestion - air drying
246	Aerobic digestion/anaerobic digestion - thickening - heat treatment dewatering
251	Pump/haul

The abbreviation for this parameter used in Appendix A and subsequently in this report is "UC", for "updated cost."

- Column 5 contains the updated unit cost (or "UUC"), which is equal to the quotient obtained dividing UC by the design flow rate, and is expressed in units of $/gpd (Dollars per gallon per day of capacity).

- Column 6 contains the code for type of construction, based upon the code system of Table 1.

- Column 7 contains the code for the treatment category or level of treatment (from Table 2).

- Column 8 contains the code for the applicable secondary unit process train (from Table 3).

- Columns 9 to 11 contain the code or codes for the applicable tertiary treatment unit processes (from Table 3).

- Columns 12 and 13 contain the code or codes for the applicable residual solids treatment unit processes (from Table 3).

- Columns 14 and 15 contain the EPA Region code and project location.

To exemplify the interpretation of the summary, an example bid listing is presented for Bid Number 134. This entry contains information for a new treatment plant of less than one mgd capacity that is located in Washington Township, PA. The design capacity of this plant is 0.2 mgd, its updated grant eligible construction cost is $0.649 million, and its updated unit cost is $3.25/gpd of capacity. The Treatment Category for this plant is 02, i.e. the plant was designed to produce an effluent containing 5 - 19 mg/l BOD_5 and 5 - 19 mg/l SS (Table 2). Secondary treatment is provided by extended aeration (Code 013; Table 3); tertiary treatment by microscreening (Code 113); and residuals solids treatment by thickening and air-drying (Code 212).

Discussion of Data Base

The bid data base as displayed in Appendix A contains a description of each bid in a number of different dimensions, e.g., in terms of updated cost (UC), updated unit cost (UUC), design flow rate, type of construction, treatment category, location, type of secondary treatment unit process train, etc. In order to present a brief picture of the content of the data base, the distribution of the bids with respect to several of these dimensions is discussed below.

The bid data base contains information on individual projects located within 37 of the 48 contiguous states. The contiguous states which are not represented in the data set are: Connecticut (Region I); Alabama, Georgia, Kentucky, and Mississippi (Region IV); Arkansas, Louisiana, New Mexico, Oklahoma, and Texas (Region VI); and Arizona (Region IX). Thus, from a locational perspective, every sector of the nation with exception of the south-central states is represented to some extent in the sampling.

The distribution of treatment plants by design flow rate is presented in Table 4. The range of design flow rates for all 157 plants in the data set varies from less than 0.1 mgd to 120 mgd, and the range of design flow rates for all new plants varies from less than 0.1 mgd to 64.1 mgd. About 50 percent of the new plants have design flow rates of less than or equal to one mgd, as opposed to only 31 percent of the other plants ("other" connoting existing plants that are either upgraded or expanded and upgraded). Nearly 50 percent of the "other" plants are designed to handle flow rates of equal to or less than two mgd. Additionally, about two thirds of the new plants have design flow rates of less than or equal to two mgd, whereas two thirds of the other plants are designed to handle flow rates less than or equal to five mgd. Based on these observations, the median flow rate for new plants in the data set (about one mgd) is half the median value of two mgd for other plants.

The distribution of treatment plants by type of construction is presented in the right hand columns of Table 1. Sixty three percent of the sampling involves new sewage treatment plants, whereas about 10 percent of the bids pertain to upgraded plants and the remaining 27 percent of the bids relate to plants that have been both upgraded and expanded. The distribution of treatment plants according to treatment category is presented in Table 2, (right hand columns). Forty two percent of the plants were designed to provide Category 1 effluents (Category 1 is assumed to correspond to the minimal national level of secondary treatment) and 73 percent of the plants were designed to meet effluent BOD_5 and SS design criteria but no other effluent criteria. The remaining 27 percent of the plants were designed to meet one or more of the additional effluent criteria of ammonia-nitrogen, nitrate-nitrogen, and phosphorus removals, and post aeration.

The distribution of treatment plants by principal unit processes is described in Table 5. The term principal unit process as used in this context connotes the secondary treatment unit process train. The conventional activated sludge process was specified in fully one third of the plants in the sampling. Extended aeration, contact stabilization, and lagoon systems were specified as the principal unit process in an additional 39 percent of the plants in the sampling. In addition to the "old line" principal unit process trains such as trickling filters and oxidation ditches, the data set also includes plants containing new process developments such as pure oxygen activated sludge systems, biodisc systems, physical chemical systems, and primary chemical systems. It is suggested that the distribution of treatment plants by principal unit process, if not representative of the total "population" of new plants built or under construction in the last four years, does reflect the mixture of tradition and innovation upon which treatment plant design concepts are presently being developed in the nation.

TABLE 4. DISTRIBUTION OF TREATMENT PLANTS BY DESIGN FLOW RATE

Design Q, MGD	% of Plants With Flow Rate ≤ Indicated Flow Rate		
	All Plants	New Plants	Other Plants[1]
0.1	16	24	2
0.4	29	38	12
1.0	44	52	31
2.0	59	68	48
5.0	73	78	66
15.0	85	85	83
64.1	99	100	97
120.0	100	100	100

Note: [1]"Other" connotes existing plants that are either upgraded or expanded/upgraded.

TABLE 5. DISTRIBUTION OF TREATMENT PLANTS BY PRINCIPAL UNIT PROCESSES IN DATA SET

Principal Unit Process Train Involved	No. of Plants	% of Total
Activated sludge (conventional)	52	33
Extended aeration	26	16
Lagoons	20	13
Contact stabilization	16	10
Trickling filters	8	5
Oxidation ditches	8	5
Pure oxygen	7	4
Roughing filters & conventional activated sludge	7	4
Primary chemical and activated sludge	3	2
Biodisc	2	1
Physical-chemical	2	1
Primary chemical and pure oxygen	1	1
Step aeration	1	1
Trickling filter and step aeration	1	1

SECTION III

EVALUATION OF "GUIDES" COST ESTIMATING SYSTEM AND FORMULATION OF TREATMENT PLANT CONSTRUCTION COST CURVES

The four issues of concern in this report are: (1) an analysis of the construction bid cost experience in relation to the development of treatment plant cost curves; (2) the development of the curves; (3) an evaluation of the cost estimating system in the Guides report (EPA 430-9/75-0002); and, (4) a benchmarking of cost estimates derived from this system against the cost curves derived from the construction bid cost experience. The approach used to commence the development of the desired treatment plant cost curves was that of "searching" the bid data base to define subsets that could be subjected to regression analysis. A series of "anchor" cost curves were developed from the bid data base using regression analysis techniques, and used to benchmark the Guides cost estimating system. The anchor cost curves and the benchmarked Guides system were then used in combination to complete the development of the desired treatment plant cost curves.

As discussed in Section I, the Guides system is based upon the unit process approach to wastewater treatment technology, and is structured in a format that renders it readily usable but of somewhat doubtful validity. To explore the question of the validity of the Guides system, it is first appropriate to describe in overview what the system is.

THE GUIDES SYSTEM

The Guides system was developed for the specific purpose of providing a tool for making preliminary cost comparisons, such as are required in the planning, project formulation and preliminary engineering stages of development of wastewater treatment plants. The Guides system was completed in February, 1973, at a time when there existed essentially no prototype experience with the innovative advanced wastewater and residual solids treatment processes then undergoing development and/or demonstration, and the Guides system was presented in published form (March, 1975) with the caveat that periodic revision and update of the cost relationships therein would be required.

The Guides system was developed in a unit process framework wherein: (1) each of over 50 unit processes for liquid stream and residual solids treatment were characterized in terms of flow and material balances and described in flow sheets showing process features; and, (2) nearly 150 treatment system alternatives were formulated by the specification of interlinkages between/among different combinations of the unit processes. The unit processes considered in the Guides system were selected as those most commonly used in treatment plants of capacities between one and 100 mgd. Because a plant size of one mgd was selected as the lower capacity limit for the selection of unit processes, treatment systems such as lagoons, extended aeration and oxidation ditches were not included in the process inventory because these are specified most commonly in plants smaller than one mgd in capacity. At the other extreme, the only generic type of advanced waste treatment unit processes not included in the process inventory are those used for effluent desalination.

The flow and material balances developed for each unit process were based upon conditions expected to prevail for the treatment of a standard domestic wastewater containing 210 mg/l BOD, 230 mg/l TSS, 30 mg/l total nitrogen (as nitrogen), and 11 mg/l total phosphorus (as phosphorus). Each of the nearly 150 treatment system alternatives is assigned to one of 18 levels of performance which are defined in terms of effluent quality. The spectrum of effluent levels included in the 18 treatment categories is bounded at one extreme by the minimum national standard for secondary treatment (25-30 mg/l BOD and TSS respectively), and at the other extreme by "Tahoe type" effluents.

The development of cost estimates for any treatment system alternative is done at the unit process level, for all unit processes within the alternative, when using the Guides system. Relationships are incorporated into this system for estimating four types of cost parameters for each unit process, as a function of design flow rate within a flow rate range of one to 100 mgd. The four cost parameters are base capital cost, land cost, base manhour cost for O/M (operation and maintenance) and base materials cost for O/M. Each of the preceding cost parameters was developed on the basis of information available from all sources as of early 1973, and for each unit process at the specific design flow rates of one, 5, 20 and 100 mgd. From the resultant matrix of costs for each unit process (four cost parameters and four flow rates), cost/capacity expressions were developed for each unit process and each cost parameter. The resultant expressions are presented in the format of mathematical equations, in each case relating the cost parameter as a function of Q, in February 1973 dollars.

The preceding cost equations serve as the basis for estimating the various measures of cost for each unit process, and are specified as applicable in the range of flow rates between one and 100 mgd. Procedurally, the determination of the construction cost, amortized cost, annual O/M cost, or total annual (amortization plus O/M) cost of a treatment plant involves the addition of the costs in each category for all unit processes in the alternative - a process that is readily computerized (as has been demonstrated by personnel in EPA and in several states).

Of immediate interest in this analysis are the accuracy of the base capital cost relationships which are provided in the Guides system for the estimation of construction costs, and how the cost of a treatment plant estimated with the Guides system compares with the grant eligible construction cost for the "same" treatment plant based upon the construction bid cost experience. To assess this relationship, one must first examine what is dealt with in the Guides system for estimating construction costs as well as what constitutes a grant eligible construction cost.

To first address the issue of grant eligible construction cost, it was understood that this cost includes the cost of construction of the treatment plant (as the summation of bid costs plus subsequent change order costs), administrative and legal costs, contingencies, and fees, but does not include land costs. In this context, site work is included as a component of the construction effort. As noted in Section II, it was found from an analysis of the difference between bid costs and grant eligible construction costs (for 95 bids wherein this information was available) that grant eligible construction costs averaged 17 percent greater than bid costs.

The unit process construction cost relationships in the Guides system were keyed to a date of February 1973, and to the then in use EPA Sewage Treatment Plant Construction Cost Index (or simply the STP Index, as used in this report). The relationship between the cost relationships and STP Index is defined in a manner whereby one has the option of either using the STP Index for cost updating, or selecting any other index of one's choosing that has a time horizon dating from Feburary 1973. The unit process construction cost relationships provide for the costs of the structures, equipment, pumps, integral piping, and the appurtenances for each unit process as implied in the flow sheets presented, plus a surcharge of 27 percent on the preceding items of cost for engineering, contingencies, and interest during construction. Specifically, not included in the unit process construction cost relationships are the costs of site work, yard piping, administrative, laboratory and garage buildings, and possibly not included are costs for general electrical and HVAC (heating, ventilation and air conditioning) systems. In light of the intended use of the Guides system, the omission of these cost items is quite reasonable - each item being extremely sensitive to site specific conditions.

As a result, what one obtains with the Guides system is a dollar cost that on the surface should be comparable with (but not necessarily equal to) the grant eligible construction cost, if:

1. The same unit process train is used in developing the estimate with the Guides system as in the grant eligible cost.

2. A cost updating index is used that reflects changes in buying the same "thing" over time.

3. It is assumed that the same "nonstructural" items are included in the Guides estimate as are included in the grant eligible construction cost, e.g., contingencies, legal and engineering fees, etc.

4. A surcharge is imposed on the Guides system treatment plant cost estimate to account for the omitted items of cost as above - identified (A surcharge of 20 percent was used, as discussed below).

The approach used herein to develop cost estimates with the Guides system that could be compared with the grant eligible construction cost experience (as the method of benchmarking the Guides system) was based upon the assumption that the preceding framework is valid, and on the additional assumptions that:

1. The STP Index can be used as the basis of cost update (although the STP Index is not the only basis that could have been used); for purposes of the benchmarking effort, an STP Index of 263 was used with the Bechtel base capital cost relationships to account for inflation of costs between February 1973 (at which time the value of the STP Index was 177.5) and the Winter Quarter of 1976.

2. A surcharge of 20 percent was added to the treatment plant construction cost estimates derived with the Bechtel relationships to account for site work, yard piping, and other omitted costs as above discussed. The value of 20 percent was based upon the subjective judgment of the authors in consideration of their review of the bid data base, and information available in the literature.

In reference to the first assumption above, it should be noted that the use of any index to update cost will at best provide a rough approximation of inflation and changes in the construction field. By specifically updating the Guides cost estimate from February 1973 (STP Index - 177.5) to 1976 (STP Index = 263), the update factor of nearly 1.5 undoubtedly incorporates a large error in any cost estimates calculated with the Guides. In regards the second assumption above, the 20 percent added cost for site work, yard piping and other omitted costs is chosen only as an approximate average. This surcharge could vary greatly with the specific construction site; in particular the use of pile foundations or large amounts of rock excavation would increase the surcharge whereas a minimal problem site would decrease the surcharge.

With the background for evaluation of the Guides system and development of the treatment plant cost curves as described above, the sequence of steps implemented and described in the remainder of this section were as follows:

1. A search was made of the bid data base to establish reference or "anchor" cost/capacity/performance curves based upon the bid experience.

2. The Guides cost estimating system was used to develop cost/capacity curves at performance levels analogous to those associated with the above reference curves, and the cost estimates based upon the reference and the Guides cost curves were compared to benchmark the Guides system.

3. The Guides system was additionally used to define the relative cost escalation between each of the several treatment categories (performance levels) selected for the desired treatment plant construction cost curves.

4. The desired cost curves were developed using the reference cost curves obtained by searching the bid data base, and the cost escalation factors between treatment categories developed using the Guides system.

The first six of the 13 treatment categories defined in Table 2 (Section II) were used as the set of treatment categories upon which to organize both the evaluation of the Guides system and the development of the treatment plant construction cost curves. The effluent limitations associated with each of these six treatment categories are structurally analogous to those used by EPA in the 1974 Needs Survey.

EVALUATION OF GUIDES COST ESTIMATING SYSTEM

Development of Reference Cost Curves

The reference cost curves were developed by a search of the bid data base, with the objective of identifying those series of data within the data set that could be subjected to regression analysis. As a result of this search, two subsets of data were selected for the analysis, as follows: (1) Seventythree new secondary treatment plants in Treatment Categories 1, 2 or 8, as defined in Table 2; (2) Seventeen primary-to-secondary treatment plant upgrades or upgrades/expansions in Treatment Categories 1 or 2 and (Type of Construction Codes 2 and 8 (Table 1)).

Plots showing the log of the data points for each data series used in the regression analyses and the regression lines are presented in Figure 1 (for new secondary plants) and in Figure 2 (for primary-to-secondary plants), and the results of the analyses are presented in Table 6. The coefficients of the regression equations and the correlation coefficients for each data subset are presented in Table 6. The values of the correlation coefficients were .93 for both the analysis of new secondary plant cost data and the primary-to-secondary plant cost data. These correlation coefficients were accepted as reasonable in light of the many "marketplace" circumstances that can affect the cost of wastewater treatment facilities, and for this reason, the regression equations of Table 6 were used for development of two reference cost curves.

The reference cost curve (curve 1) for new secondary treatment plants (shown in Figure 1) was assumed to be applicable only for new plants in Treatment Category 1. This assumption was made even though the data set for the regression analysis include plants in Treatment Categories 1, 2 and 8, simply because preliminary analysis showed that one could not distinguish cost differences among plants in each of the three categories based upon the bid costs contained in the data set.

The second reference curve (Curve 7) was developed to provide appropriate deduction for new plant cost curves where an existing primary plant is in place. The deduction curve was developed by subtracting regression equation 2 (Table C) cost for upgrading primary to secondary plants from regression equation 1 costs for constructing a new secondary plant. The primary deduct curve can be utilized to estimate the cost of upgrading a primary plant to secondary (subtract curve 7 at existing design flow from curve 1 at new design flow) and to estimate the cost of upgrading a primary plant to tertiary plant (subtract curve 7 at existing design flow from curve 2, 3, 4, 5 or 6 at new plant flow). The third reference curve (Curve 8) is provided to allow appropriate deduction from new plant cost where an existing secondary plant is in place (subtract curve 8 at existing design flow from curve 2, 3, 4, 5 or 6 at new plant flow). The curve is based on engineering judgement and not any factual data. The curve represents the value of the existing secondary plant less an allowance for essential adjustments and rehabilitation of the existing secondary plant. Such adjustments include modifications of unit processes, piping and the plant site. It is recognized that the cost of upgrading and/or expanding an existing primary or secondary plant will vary with age of the plant, existing equipment, the plant's configuration and site conditions. Accordingly both the deduction curves should be utilized only in full recognition that conditions at a particular plant could substantially alter the deduct curves.

Cost Estimates with Guides System

In order to develop cost curves with the Guides system for benchmarking against the "new secondary treatment plant cost curve" of Figure 1, construction cost estimates were developed with the Guides equations for a total of nine treatment system alternatives in the Guides treatment category analogous to Treatment Category 1 of Table 2. The Guides base capital cost equations were applied using the conditions described earlier in this section, and the details of the calculations performed are presented in Appendix B, and the results are summarized in Table 9.

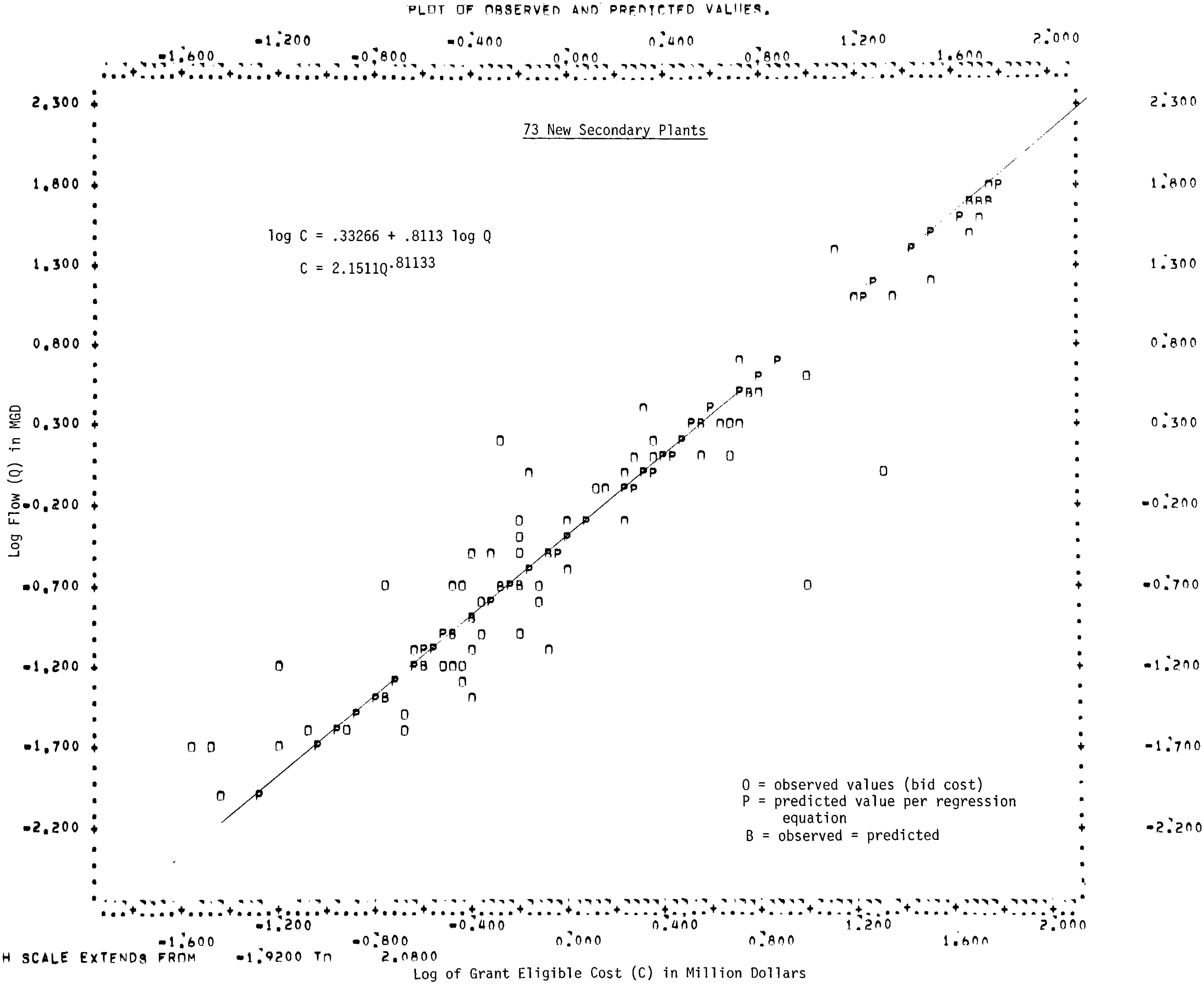


FIGURE 1
REGRESSION ANALYSIS DATA PLOT - ALL NEW SECONDARY TREATMENT PLANTS

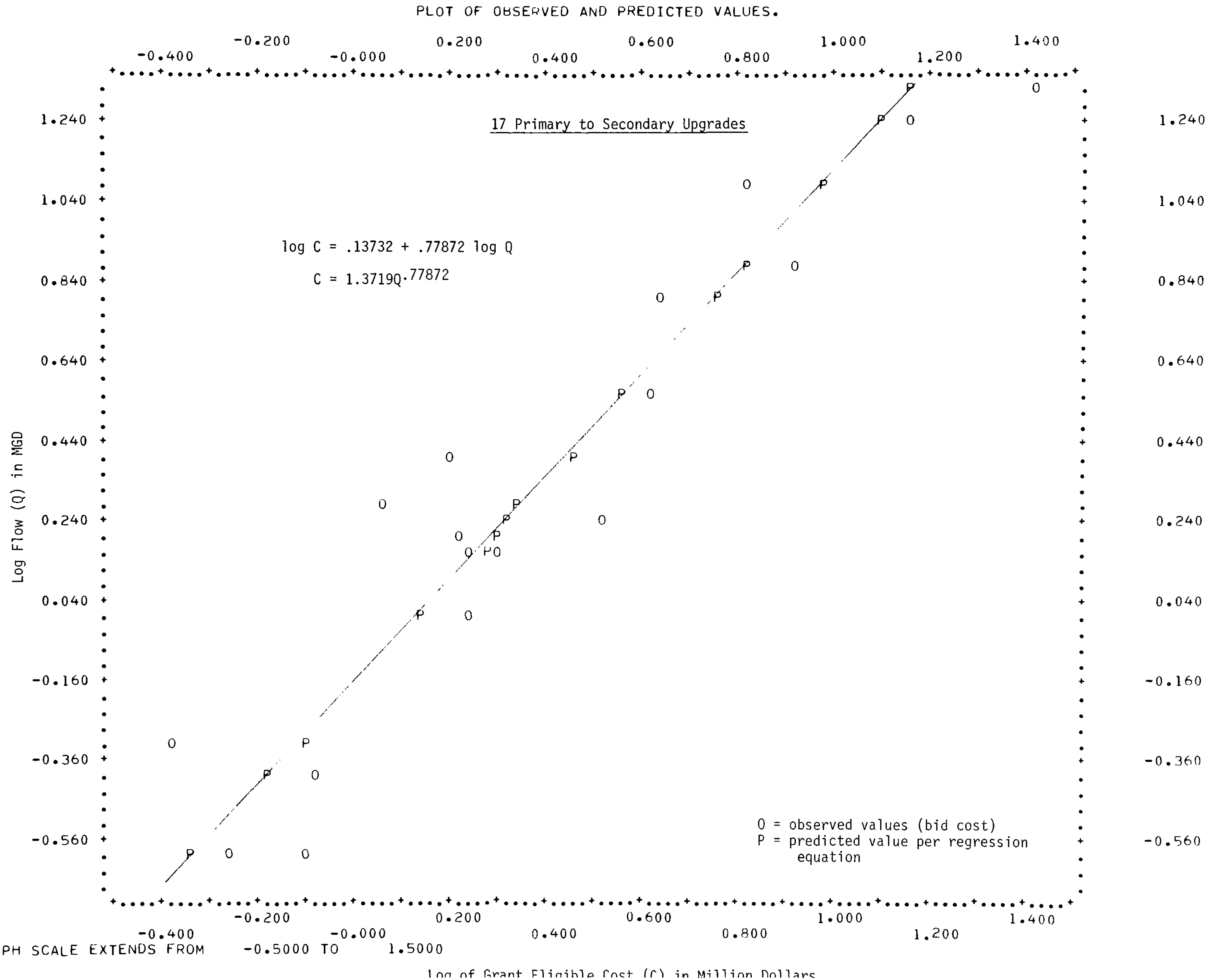


FIGURE 2

REGRESSION ANALYSIS DATA PLOT - PRIMARY TO SECONDARY TREATMENT PLANT UPGRADES OR UPGRADES/EXPANSIONS

TABLE 6. SUMMARY OF REGRESSION ANALYSIS

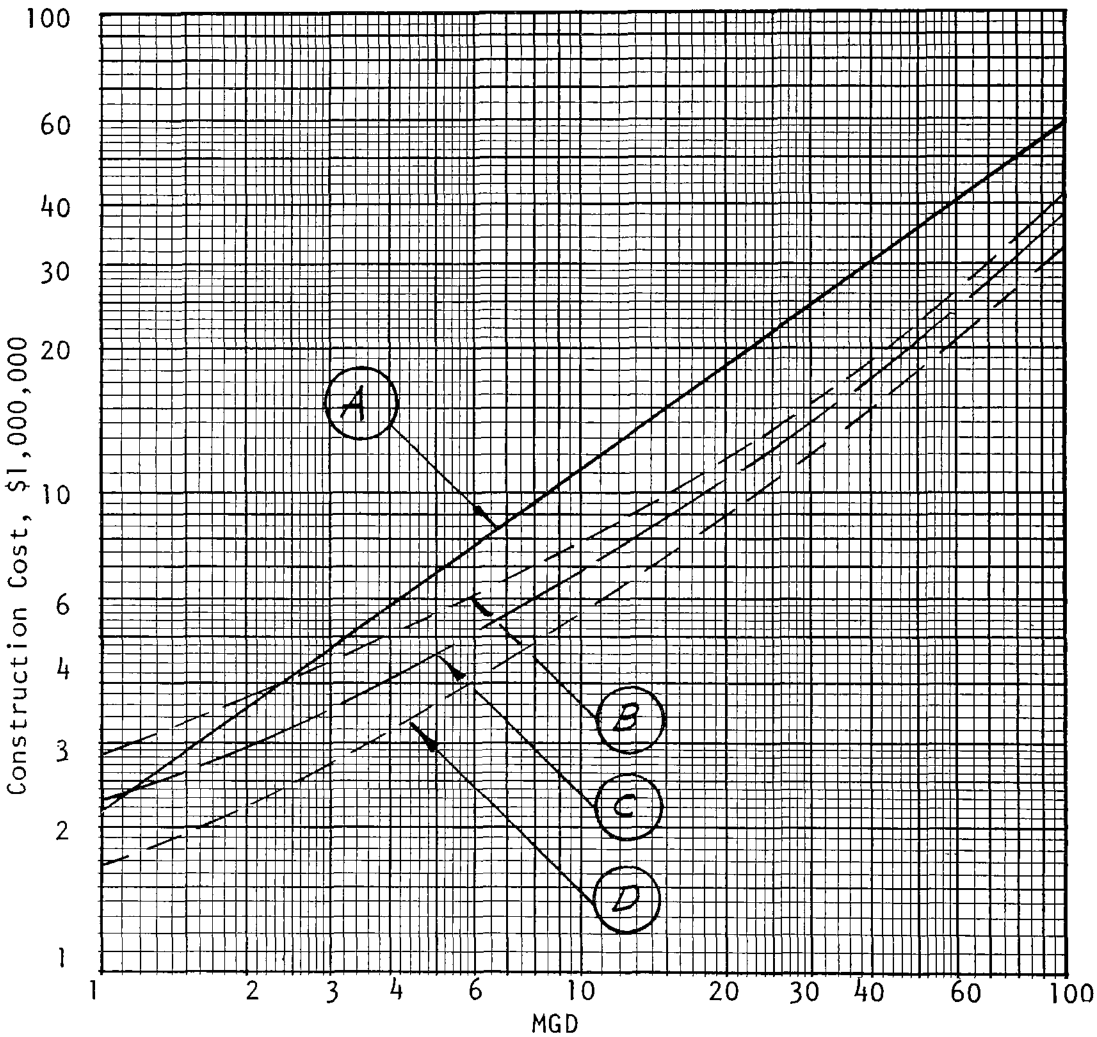
Description of Subsets		Regression Equation	Correlation	No. of
Type of Plant	Treatment Category	$C(\$M) = aQ(mgd)^n$	Coefficient	Plants
New Secondary	1,2,8	a = 2.1511 n = 0.81133	0.935	73
Upgraded or Expanded/Upgraded, Primary to Secondary	1,2	a = 1.3719 n = .77872	0.936	26

The cost estimates for the nine alternatives in Treatment Category 1 (Table 9 of Appendix B) were evaluated to determine the high, low, and nine alternative mean costs of construction of treatment plants for each of the four flow rates (1, 5, 20 and 100 mgd) at which the estimates were developed. These cost data were used to develop a cost curve envelope showing the high, mean, and low construction cost estimates as derived with the Guides system. The resultant high, mean and low cost curves are presented as Curves B, C and D respectively in Figure 3, and the "new plants" cost curve of Figure 1 is presented as Curve A in Figure 3.

Figure 3

COMPARISON BETWEEN BID COST EXPERIENCE AND ESTIMATED CONSTRUCTION COSTS

(Treatment Category 1)



Notes:

1. Curve "A" from regression analysis of construction bid costs for new secondary treatment plants (Figure 1).

2. Curves "B," "C," "D" - high, mean and low estimated construction costs from Table 9.

Benchmarking

The benchmarking of the Guides cost estimating system was done by comparison of the differences between the respective construction cost estimates obtained using Curve A and C in Figure 3. The difference between the bid based and the Guides based costs was defined in terms of an adjustment ratio that was determined by dividing the bid based cost from Curve A by the Guides based cost from Curve C. The adjustment ratios were determined as a function of flow rate over the range of plant capacities between one and 100 mgd, and the results of this determination are presented in Figure 4.

The adjustment ratio relationship of Figure 4 represents the magnitude of the differences between the bid based cost curve and the mean Guides based cost curve when all the conditions and assumptions set forth in this report are taken into account. The trend defined by the adjustment ratio curve is nonlinear and both divergent and convergent depending upon range of flow rates considered. The value of the adjustment ratio is unity at a flow rate of 1.05 mgd. The value of the adjustment ratio increases at a decreasing rate as the flow rate increases from 1.05 mgd, and the maximal value of the adjustment ratio is equal to 2.52 at a flow rate of about 65 mgd. At flow rates greater than 65 mgd, the value of the adjustment ratio decreases at an increasing rate, and is equal to 2.42 at the upper flow rate boundary of 100 mgd.

It is apparent from the preceding that, for the conditions used in the benchmarking, the magnitude in the variation of the estimates obtained is both complex in nature, and not readily quantifiable in mathematical terms - should one be tempted to do so without dealing with the causative factors for the variation, as discussed below.

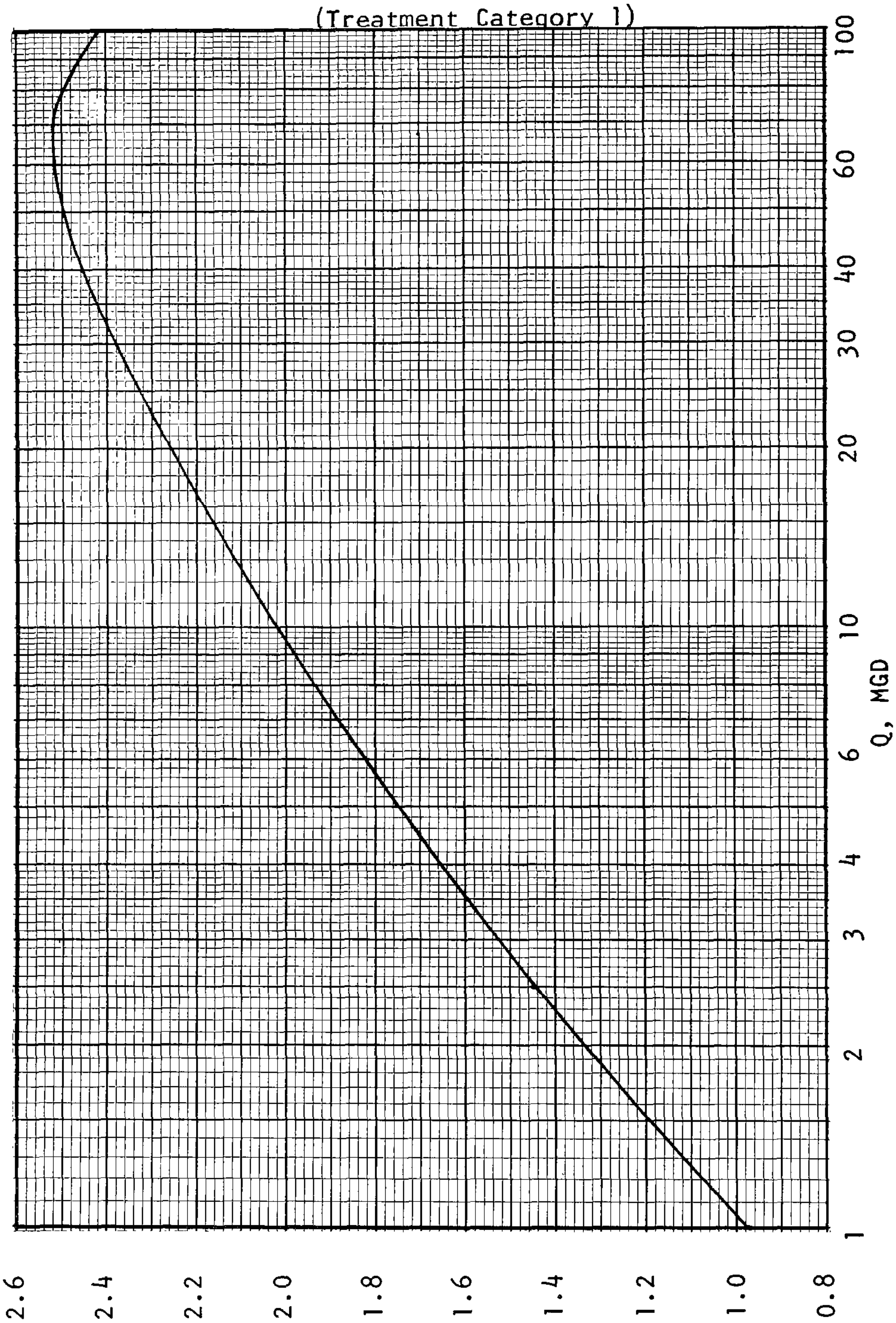
Evaluation of Results

In concert with the precepts of the unit process concept of wastewater treatment technology, the designers of the Guides cost estimating system held fast to two basic distinctions derived from this concept - the first being that distinctions in performance levels can be made as a function of the number and types of unit processes incorporated into a treatment system, and the second being that distinctions in cost can be defined as a function of the unit process "content" of a treatment system. While such an approach is rational, given the intended use of the Guides system, it flies in the face of the reality that the unit process philosophy has gained only marginal application in the design and operation of wastewater treatment facilities, and has no discernible role whatsoever in the wastewater treatment plant marketplace. A second reality at the present time is that there is very limited prototype information on either construction costs or performance levels available in the unit process format. Thus, given the insensitivities of most interests involved in the field of wastewater treatment technology to the unit process format, and the resultant absence of usable cost information at the unit process level, it is noteworthy that the Guides system could have been compiled as it was in the first place.

In examining the possible reasons for the variability of the adjustment ratio of Figure 4 with respect to flow rate, three factors were considered:

Figure 4

ADJUSTMENT RATIO BETWEEN BID COST EXPERIENCE AND MEAN ESTIMATED COST



(1) the unit process base capital cost relationships in the Guides system; (2) the cost updating index selected; and, (3) the 20 percent surcharge added to account for omitted cost items in the base capital cost relationships, such as site work, yard piping and buildings. In reference to the latter two factors, the important point in relation to the variability of the adjustment ratio is not the magnitude of each factor, but rather that each introduced linear adjustments to the magnitudes of the estimates obtained with the Guides system. Additionally these factors were dealt with as external coefficients to the structure of the cost estimating system as opposed to being inherent. Consequently, the nonlinear variation of the adjustment ratio that was exhibited with respect to flow rate cannot be explained in terms of either of these external factors, but rather must be inherent to the system. Thus, the only factor to which the nonlinearity of the adjustment ratio can be attributed is the set of unit process base capital cost relationships in the Guides system.

No attempt was made to ascertain how to distribute the variability defined by the adjustment factors between/among the base capital cost relationships for the unit processes in the nine treatment alternatives involved in the benchmarking - it is an understatement that such an effort would entail the review and updating of the entire Guides cost estimating system. Rather, it was assumed herein that the Guides cost estimating system could be used "as is" to develop estimates of the cost escalation between treatment system alternatives representative of each of the six treatment categories for which treatment system construction costs are presented subsequently.

TREATMENT PLANT CONSTRUCTION COST CURVES

The treatment plant construction cost curves presented subsequently in this section were developed in consideration of the following requirements:

1. To encompass a range of plant capacities varying from 0.01 to 1000 mgd.

2. To incorporate cost curves for up to 6 levels of wastewater treatment.

3. To provide a basis for determining construction costs associated with new plants as well as the upgrading or upgrading and expansion of existing plants.

The development of the desired cost curves was done as follows:

1. New treatment plant cost curves were developed for six levels of treatment, as defined by Treatment Categories 1 to 6 of Table 2.

2. The reference curve for secondary plants presented in Figure 1 was used to obtain a cost curve for new plants in Treatment Category 1 - an application which involved the extrapolation of the "new plants" curve of Figure 1 to cover the flow rate range from 0.01 to 1000 mgd.

3. The cost curves for Treatment Categories 2 to 6 were developed by estimating the escalation in the cost of a new secondary treatment plant (as determined by the above referenced curve) that would be necessary to construct new plants capable of performance in

Treatment Categories 2 to 6.

4. The cost escalation factors were estimated with the Guides system as described in Appendix B, and were as follows:

Treatment Category	Cost Escalation Factor Relative to Treatment Category/Cost
2	Add 20%
3	" 23%
4	" 38%
5	" 56%
6	" 83%

5. The reference curve for determination of the salvage value of primary treatment plants (curve 7 herein called "deduction for existing primary treatment") was developed using the regression equations of Table 6 to determine the difference between the costs of constructing a new secondary plant and upgrading (or upgrading/expanding) a primary plant to secondary status.

6. The reference curve for determination fo the salvage value of secondary treatment plants (curve 8 herein called "deduction for existing secondary treatment") is based on engineering judgement (see page 20).

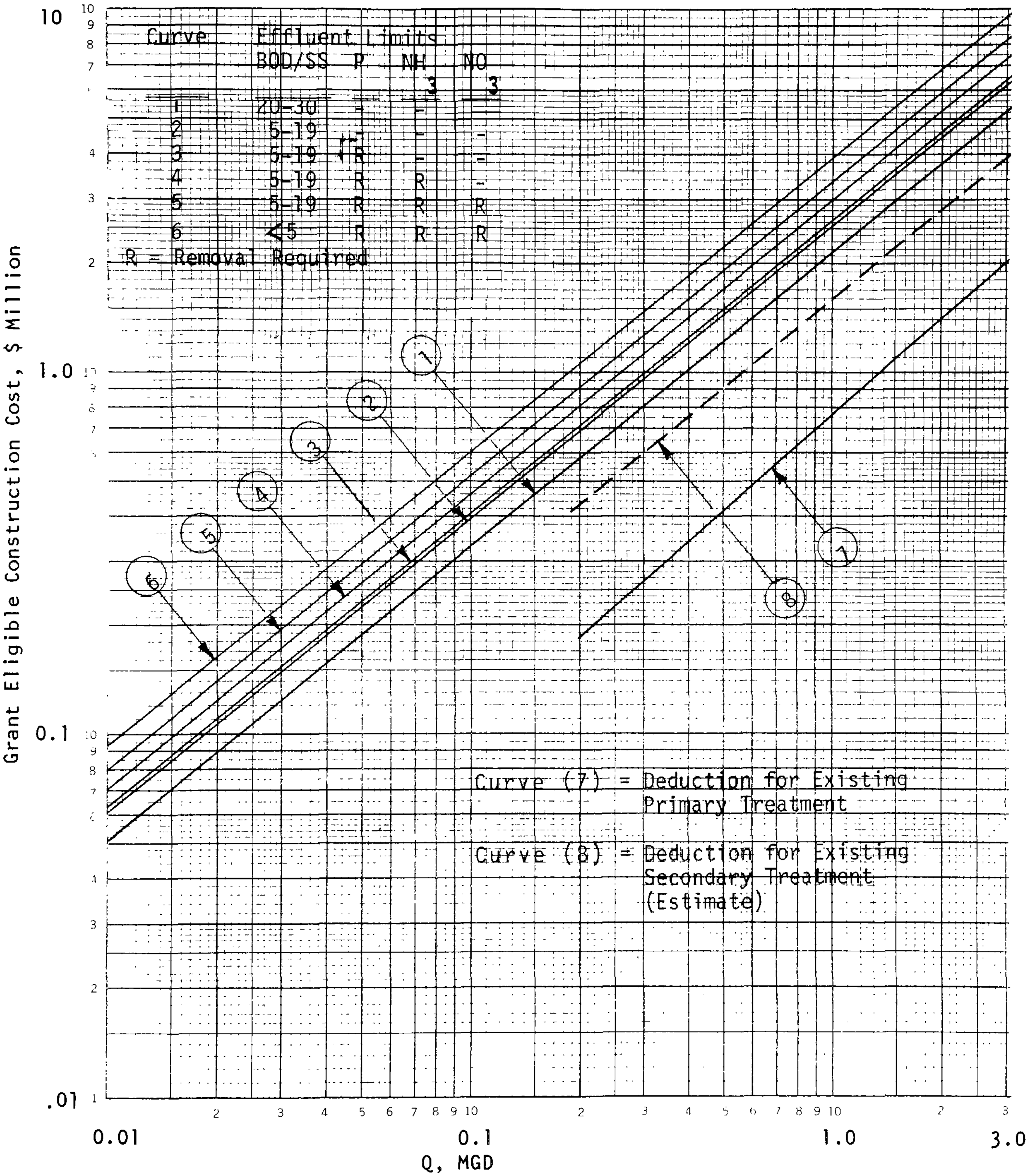
The treatment plant construction cost curves developed by the above process are presented in Figures 5 and 6, which are applicable for plants in the capacity ranges of 0.01 to 3 mgd and 3 to 1,000 mgd, respectively. In each figure, the curves labelled (1) through (6) refer to the construction of new plants associated with the effluent limitations presented in the legends. (The effluent limitations for Curves (1) to (6) are identical with those presented for Treatment Categories 1 to 6 in Table 2). The other curve in each figure can be used to determine the salvage value of an existing primary plant to be deducted from the cost of constructing a new plant, wherein the salvage value is determined as a function of the flow rate of the existing plant. The cost of constructing a new plant in a given treatment category is determined simply as a function of the design flow rate of the new plant, using the appropriate cost curve. In all cases, the cost curves were based upon an STP Index of 263.

In order to provide some perspective for evaluating the cost curves, a comparison was made between bid cost experience and cost estimates derived from the curves of Figure 5 and 6 for fifteen specific plants in the bid data set. The fifteen plants selected for the comparison were classified as advanced waste treatment plants (in Treatment Categories 3 to 6 as defined in Table 2 and in relation to Curves 3 to 6 of Figures 5 and 6). Each of the 15 plants is identified in Table 7 by Bid Number, Treatment Category, design flow rate, and updated and estimated grant eligible construction cost. The Bid Number, design flow and updated cost information were obtained from Table 8 of Appendix A, and the estimated cost for each plant was obtained from the appropriate cost curve in Figure 5 or 6. When each plant is considered individually, the difference between the estimated and updated costs varies from extreme values of -47 percent to 144 percent. However, the average difference between the estimated and updated costs for all 15 bids is 16 percent.

Figure 5

TREATMENT PLANT CONSTRUCTION COST CURVES - DESIGN FLOW RATE 0.01 to 3.0 MGD

(STP Index - 263)



TREATMENT PLANT CONSTRUCTION COST CURVES - DESIGN FLOW RATE 3 TO 1000 MGD

(STP Index - 263)

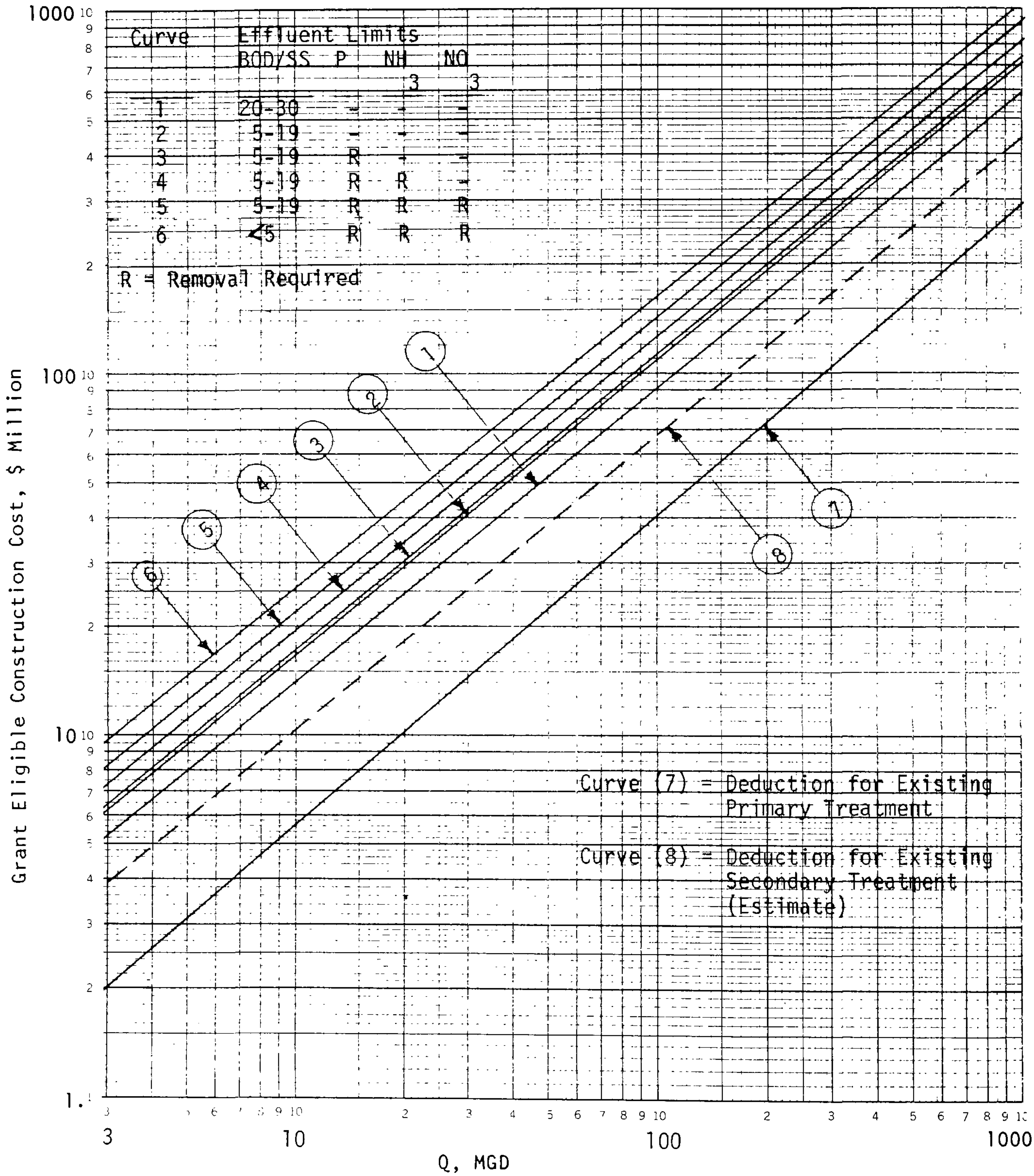


TABLE 7. COMPARISON OF INDIVIDUAL BID COST EXPERIENCE WITH ESTIMATED COSTS FROM COST CURVES - NEW TREATMENT PLANTS IN TREATMENT CATEGORIES 3 TO 6

Bid Number[1]	Treatment Category[2]	Design Flow Rate (mgd)[1]	Grant Elig. Const. Cost, $ Million: Updated Cost[1]	Grant Elig. Const. Cost, $ Million: Estimated Cost[3]	% Difference (Estimated-Updated)/Updated
108	3	0.45	1.08	1.45	34.3
148	3	0.50	1.16	1.60	37.9
405	3	2.00	1.99	4.85	143.7
416	3	2.25	2.99	5.35	78.9
426	3	5.00	15.8	10.0	-36.7
422	3	7.50	22.5	14.0	-37.8
424	3	20.00	32.0	30.8	- 3.8
447	3	43.60	57.7	57.5	0.0
135	4	0.75	2.40	2.83	-0.8
423	4	4.00	17.7	9.35	-47.2
428	4	4.40	9.16	10.2	11.4
443	4	12.4	19.4	23.4	20.6
420	5	48.0	79.9	78.0	-2.4
409	6	20.0	29.4	44.0	49.7
433	6	22.0	46.6	47.5	-1.9
Avg[4]		-	-	-	16.4

Notes: [1]See Appendix A, Table 8
[2]From Table 2
[3]From Figures 6 and 7
[4]Average difference for all 15 bids

SECTION IV

APPENDICES

APPENDIX A

SUMMARY OF BID INFORMATION

A summary of the bid information developed for use in the present report is presented in Table 8. The summary is organized in the following format (one line per bid):

Column	Content
1	Bid number
2	EPA project number
3	Design flow rate, in units of mgd
4	Updated grant eligible construction cost (UC), adjusted to an STP Index of 263, in units of millions of dollars
5	Updated unit cost (UUC), in units of $/gpd
6	Code for type of construction (see Table 1)
7	Code for treatment category (see Table 2)
8	Code for secondary unit process train (Table 3)
9, 10, 11	Code for tertiary unit processes (see Table 3)
12, 13	Code for residual solids treatment unit processes (see Table 3)
14	EPA Region in which project is located
15	Project location

An overview discussion of the development and content of the bid data base is presented in Section II.

TABLE 8 - SUMMARY OF BID INFORMATION

Bid No.	Proj. No.	Design Flow(mgd)	UC ($M)	UUC ($/gpd)			Sec.	Unit Processes Tertiary			Res.Solids		EPA Reg.	Project Location
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
101	060631	000.200	00.546	02.73	01	01	011	000	000	000	218	214	09	DESERT HOT SPRNGS, CA.
102	060766	000.500	01.772	03.55	01	02	051	182	000	000	215	000	09	DUNSMUIR, CA.
103	088803	000.050	00.348	06.96	01	02	013	192	000	000	241	251	08	REDSTONE, CO.
104	080325	000.300	00.405	01.35	01	02	013	000	000	000	214	000	08	EAGLE, CO.
105	120340	000.200	00.370	01.85	01	01	012	191	000	000	241	251	04	NEWBERRY, FL.
106	170470	000.070	00.363	05.19	01	02	013	192	000	000	242	000	05	PARAGON, IN.
107	180354	000.220	00.794	03.61	01	01	012	000	000	000	214	000	05	WILLIAMSPORT, IL.
108	180375	000.450	01.081	02.40	01	03	034	143	000	000	214	000	05	ROME CITY, IN.
109	180376	000.070	00.318	04.54	01	02	013	181	192	000	242	000	05	CROMWELL, IN
110	180459	000.500	00.650	01.30	01	02	013	000	000	000	242	000	05	NEWBURGH, IN.
111	180495	000.130	00.384	02.95	01	02	012	192	181	000	241	251	05	DUGGER, IN.
112	180526	000.090	00.330	03.67	01	02	013	192	000	000	214	000	05	STAUNTON, IN.
113	180638	000.500	00.998	02.00	01	02	011	000	000	000	241	000	05	PICKNELL, IN.
114	190619	000.025	00.201	08.06	01	01	032	000	000	000	000	000	07	HENDERSON, IA.
115	190686	000.033	00.215	06.52	01	01	032	000	000	000	000	000	07	BEAMAN, IA.
116	190703	000.043	00.173	04.02	01	01	032	000	000	000	000	000	07	BARNUM, IA.
117	200428	000.061	00.254	04.17	01	01	031	000	000	000	000	000	07	TIMBERLAKES, KS.
118	230098	000.070	00.289	04.13	01	01	013	000	000	000	251	000	01	BLUE HILL MA.
119	250246	000.410	00.651	01.59	01	01	013	000	000	000	214	251	01	OXFORD, MA.
120	270808	000.075	00.232	02.95	01	01	032	000	000	000	000	000	05	ZIMMERMAN, MN.
121	270970	000.093	00.620	06.67	01	02	051	111	000	000	214	000	05	MADISON LAKE, MN.
122	290602	000.343	00.494	01.44	01	01	012	000	000	000	241	000	07	MONTGOMERY CITY, MO.
123	290675	000.223	00.334	01.50	01	01	051	000	000	000	214	000	07	COLECAMP, MO.
124	290674	000.857	01.367	01.59	01	02	013	000	000	000	215	000	07	WARRENTON, MO.
125	290731	000.083	00.483	05.81	01	08	051	111	000	000	215	000	07	EXETER, MO.
126	300159	000.020	00.062	03.12	01	01	013	000	000	000	241	000	08	HINSDALE, MT.
127	300193	000.025	00.120	04.78	01	02	013	192	000	000	000	000	08	HIGHWOOD, MT.
128	310435	000.165	00.436	02.64	01	01	013	000	000	000	211	251	07	ARLINGTON, NB.
129	310470	000.042	00.389	09.27	01	01	041	000	000	000	218	000	07	MURRAY, NB.
130	360433	000.100	00.720	07.20	01	12	013	131	000	000	211	251	02	SAG HARBOR, NY.
131	420567	000.150	00.791	05.27	01	02	013	000	000	000	212	000	03	WAMPUM, PA.
132	420684	000.800	01.451	01.81	01	01	012	000	000	000	218	214	03	BOSWELL, PA.
133	420699	000.300	00.867	02.89	01	01	034	000	000	000	000	000	03	SUMMERSET TWP, PA.
134	420773	000.200	00.649	03.25	01	02	013	114	000	000	212	000	03	WASH TWP, PA.
135	420778	000.750	02.400	03.20	01	04	011	141	000	000	000	000	03	S. MIDDLETON TWP, PA.
136	460221	000.027	00.082	03.03	01	01	032	093	000	000	000	000	08	HUDSON, SD
137	460225	000.180	00.175	00.97	01	01	032	000	000	000	000	000	08	DESMET, SD.
138	460244	000.070	00.063	00.91	01	01	032	000	000	000	000	000	08	ELKTON, SD.

TABLE 8 - SUMMARY OF BID INFORMATION

Bid No.	Proj. No.	Design Flow(mgd)	UC ($M)	UUC ($/gpd)			Unit Processes Sec.	Tertiary			Res.Solids		EPA Reg.	Project Location
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
139	460257	000.020	00.032	01.61	01	01	032	000	000	000	000	000	08	KRANZBURG, SD
140	460258	000.010	00.037	03.72	01	01	032	000	000	000	000	000	08	TURTON, SD
141	460259	000.020	00.027	01.37	01	01	032	193	000	000	000	000	08	HENRY, SD
142	470355	000.500	00.705	01.41	01	07	012	122	182	000	242	000	04	MCEWEN, TN.
143	500860	000.080	00.400	05.00	01	01	051	000	000	000	214	000	01	PUTNEY, VT.
144	500150	000.080	00.858	10.72	01	01	033	000	000	000	214	000	01	MERRIMACK, NH.
145	510375	000.300	00.655	02.18	01	01	013	000	000	000	214	000	03	PATRICK, VA.
146	540164	000.250	01.016	04.06	01	01	051	000	000	000	214	000	03	DELBARTON, WV.
147	540192	000.100	00.438	04.38	01	01	051	000	000	000	214	000	03	BELMONT, WV.
148	080314	000.500	01.161	02.32	01	03	011	143	192	000	000	000	08	SILVERTHORN, CO.
201	410332	000.500	00.409	00.82	02	01	012	000	000	000	000	000	10	GOLD BEACH OR
202	420578	000.250	00.562	02.25	02	01	021	000	000	000	218	000	03	WILLIAMSTOWN, PA.
203	420689	000.250	00.809	03.24	02	01	011	000	000	000	241	000	03	TUNKHANNOCK, PA.
204	420691	000.650	00.922	01.42	03	07	012	000	000	000	216	000	03	JIM THORPE, PA.
205	420710	000.400	00.820	02.05	02	01	013	000	000	000	000	000	03	REYNOLDSVILLE, PA.
206	170951	001.000	01.047	01.05	04	02	012	111	000	000	216	000	05	TROY. IL
301	060718	000.500	01.080	02.16	14	02	011	000	000	000	242	000	09	WWEAVERVILLE, CA.
302	171196	001.200	01.490	01.24	16	02	012	111	000	000	218	215	05	DUQUOIN, IL.
303	180499	000.900	01.992	02.21	14	02	011	111	000	000	242	000	05	SALEM,, IN.
304	262213	000.400	01.199	03.00	11	03	013	143	000	000	222	000	05	ONTONAGAN, MI.
305	310480	000.500	00.306	00.61	06	01	012	000	000	000	000	000	07	GRETNA, NB.
306	320081	000.400	00.053	00.13	14	02	034	000	000	000	000	000	09	BATTLE MTN, NV
307	420705	000.090	00.732	08.13	16	04	011	000	000	000	218	000	03	MCVEYTOWN, PA.
308	420720	000.600	01.167	01.94	14	02	011	111	000	000	243	000	03	MONTGOMERY, PA.
309	450188	000.360	00.408	01.13	14	02	034	000	000	000	214	000	04	DILLON, SC. (MS)
310	450188	000.800	00.640	00.80	14	02	041	000	000	000	214	000	04	DILLON, SC. (LP)
311	560097	000.800	00.443	00.55	17	01	013	000	000	000	000	000	08	S. CHEYENNE, WY.
401	060664	001.500	03.546	02.36	01	01	034	192	000	000	000	000	09	PETALUMA, CA.
402	060796	005.750	11.804	02.05	01	08	016	181	000	000	224	234	09	ROSEVILLE, CA.
403	060810	010.350	42.129	04.08	01	07	016	111	182	000	242	000	09	FAIRFIELD, CA.
404	061121	004.830	23.517	04.87	01	06	017	172	000	000	223	234	09	TAHOE-TRUCKEE, CA.
405	080239	002.000	01.989	00.99	01	03	011	111	000	000	241	000	08	BRECKENRIDGE, CO.
406	080257	001.000	00.698	00.70	01	01	011	000	000	000	242	000	08	CARBONDALE, CO.
407	080326	001.000	01.720	01.72	01	02	011	111	000	000	213	000	08	EVERGREEN, CO.
408	100088	003.000	05.597	01.87	01	02	011	114	000	000	341	000	03	SUSSEX CO. DL.
409	120428	020.000	29.422	01.47	01	06	015	133	000	000	223	233	04	PENSACOLA, FL.
410	180533	002.000	04.544	02.27	01	02	013	000	000	000	242	000	05	PRINCETON. IN.

TABLE 8 - SUMMARY OF BID INFORMATION

Bid No.	Proj. No.	Design Flow(mgd)	UC ($M)	UUC ($/gpd)			Sec.	Unit Processes Tertiary			Res.Solids		EPA Reg.	Project Location
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
411	200366	006.200	10.378	01.67	01	01	011	000	000	000	241	000	07	MANHATTAN, KS.
412	240311	001.800	05.141	02.85	01	02	011	000	000	000	242	000	03	CARROLL CO., MD.
413	270630	001.330	01.879	01.41	01	02	034	111	000	000	000	000	05	MEDELLA, MN.
414	270711	003.420	06.424	01.88	01	02	017	000	000	000	243	000	05	NEW ULM, MN.
415	270747	013.000	15.339	01.18	01	01	012	000	000	000	221	000	05	ST CLOUD, MN.
416	290539	002.250	02.986	01.33	01	03	051	111	000	000	216	000	07	LEBANON, MO.
417	340371	030.000	46.017	01.53	01	02	011	000	000	000	223	000	02	S. OCEAN CO. NJ.
418	340556	045.000	55.825	01.24	01	02	011	000	000	000	223	000	02	N. OCEAN CO. NJ.
419	360643	013.000	23.679	01.82	01	01	011	000	000	000	234	000	02	SARATOGA, NY.
420	360747	048.000	79.917	01.66	01	05	018	115	000	000	213	000	02	NIAGARA FALLS, NY.
421	370347	001.500	02.200	01.47	01	02	014	000	000	000	243	000	04	JACKSON CO. NC.
422	390683	007.500	22.460	02.99	01	03	011	114	000	000	231	000	05	FRENCH CR., OH
423	390684	004.000	17.682	04.42	01	04	015	121	000	000	233	000	05	MAHONING CO., OH.
424	410371	020.000	32.016	01.60	01	03	011	111	000	000	235	000	10	DURHAM, OR.
425	420600	008.000	10.245	01.28	01	08	011	111	000	000	231	234	03	VALLEY FORGE, PA.
426	420665	005.000	15.817	03.16	01	03	034	112	000	000	232	000	03	DERRY TWP, PA.
427	420675	040.000	53.144	01.33	01	02	011	181	000	000	231	000	03	CHESTER, PA.
428	420679	004.400	09.156	02.08	01	04	011	114	000	000	223	000	03	WESTMORELAND CO. PA.
429	420695	002.000	03.236	01.62	01	07	012	000	000	000	244	000	03	HOLLIDAYSBURG, PA.
430	420701	001.400	03.586	02.39	01	01	012	000	000	000	243	000	03	PHILLIPSBURG, PA.
431	440667	003.900	10.325	02.64	01	01	011	000	000	000	234	000	01	S. KINGSTON, RI.
432	490142	002.260	02.155	00.95	01	02	011	111	000	000	222	000	08	CEDAR CITY , UT.
433	510331	022.000	46.594	02.12	01	06	011	164	000	000	223	000	03	U. OCCUQUAN, VA.
434	510362	024.000	13.315	00.55	01	02	015	000	000	000	216	000	03	DANVILLE, VA.
435	510395	002.000	03.553	01.78	01	02	011	000	000	000	223	000	03	WYTHERVILLE, VA.
436	510435	050.000	50.546	01.01	01	01	011	000	000	000	231	000	03	HOPEWELL, VA.
437	560095	004.500	05.359	01.19	01	01	034	000	000	000	222	000	08	CHEYENNE, WY.
438	540182	001.200	04.704	03.92	01	08	011	000	000	000	213	000	03	BLUEFIELD, WV.
439	420781	002.000	04.618	02.31	01	01	011	000	000	000	218	216	03	SCHUYLKILL HAVEN, PA.
440	100088	003.000	05.698	01.90	01	02	011	114	000	000	242	000	03	BETHANEY BCH, DL
441	230092	001.230	04.999	04.06	01	01	013	141	000	000	216	000	01	HARTLAND, ME.
442	230096	001.210	01.884	01.56	01	01	012	000	000	000	213	000	01	LISBON, ME.
443	250227	012.400	19.421	01.57	01	04	011	121	000	000	231	000	01	FITCHBURG, MA.
444	250753	015.300	33.451	00.60	01	01	018	112	000	000	215	000	01	WORCHESTER, MA.
445	250258	056.000	49.555	00.77	01	01	011	000	000	000	231	000	01	SPRINGFIELD, MA.
446	270748	064.100	57.716	01.32	01	01	011	000	000	000	236	000	01	DULUTH, MN.
447	330104	043.600	05.568	05.30	01	03	015	141	000	000	231	000	05	ALLENTOWN, NH.
448	250234	015.300	15.916	01.04	01	01	018	012	000	000	215	000	01	FITCHBURG, MA. 92% industrial

TABLE 8 - SUMMARY OF BID INFORMATION

Bid No. (1)	Proj. No. (2)	Design Flow(mgd) (3)	UC ($M) (4)	UUC ($/gpd) (5)	(6)	(7)	Unit Processes Sec. (8)	Tertiary (9)	(10)	(11)	Res. (12)	Solids (13)	EPA Reg. (14)	Project Location (15)
501	060621	015.000	21.054	01.40	01	01	013	000	000	000	213	000	09	SANTA ANNA, CA.
502	060681	007.500	01.881	00.25	04	04	000	152	000	000	000	000	09	S. TAHOE, CA.
503	160188	012.000	06.687	00.56	02	01	011	000	000	000	000	000	10	POCADELLO, ID
504	170876	001.200	02.193	01.83	01	02	011	000	000	000	242	000	05	ALGONQUIN, IL.
505	262142	001.500	02.018	01.35	02	03	011	143	000	000	000	000	05	GRAND LEDGE, MI.
506	270720	002.000	02.403	01.20	01	03	013	141	000	000	211	215	05	VIRGINIA, MN.
507	390626	018.500	19.179	01.04	04	04	000	121	143	000	211	215	05	LIMA, OH.
508	420447	002.560	01.586	00.62	02	01	022	000	000	000	216	000	03	AMBRIDGE, PA.
509	420682	001.000	01.704	01.70	02	01	011	000	000	000	000	000	03	HAMBURG, PA.
510	420697	001.750	03.361	01.92	02	02	011	000	000	000	211	216	03	TAMAQUA, PA.
511	460218	001.830	01.157	00.63	02	01	022	000	000	000	000	000	08	YANKTON, SD.
512	530503	001.650	01.627	00.90	02	01	011	000	000	000	222	000	10	DOUGLAS CO, WA
513	540199	017.000	14.661	00.86	02	01	011	000	000	000	211	217	03	HUNTINGTON, WV.
601	060579	003.300	03.948	01.20	12	01	016	191	000	000	222	000	09	SANGER, CA.
602	060591	011.000	09.862	00.90	17	01	011	000	000	000	224	000	09	ESCONDIDO, CA.
603	060603	019.000	20.159	01.06	15	02	011	111	000	000	000	000	09	LOS ANGELES, CA
604	060735	120.000	74.994	00.62	11	02	015	121	115	000	000	000	09	E BAY OAKLAND, CA.
605	080328	012.000	11.159	00.93	06	02	013	000	000	000	242	000	08	FT COLLINS, CO.
606	080329	020.000	26.229	01.31	08	02	015	000	000	000	223	000	08	LITTLETON/ENG, CO.
607	120473	060.000	93.000	01.55	11	05	019	131	000	000	218	000	04	TAMPA, FL.
608	170970	003.000	01.485	00.50	17	02	012	000	000	000	211	251	05	OFALLON, IL.
609	171202	004.500	02.720	01.49	15	13	011	111	000	000	242	000	05	MATTOON, IL.
610	171332	011.100	12.230	01.10	06	01	011	000	000	000	223	000	05	E MOLINE, IL.
611	171397	012.000	11.843	00.99	14	02	011	111	000	000	245	000	05	HINSDALE, IL.
612	180474	001.000	01.900	01.90	14	13	017	111	000	000	221	251	05	SCHERERVILLE, IN.
613	180538	060.000	41.514	00.69	17	02	017	000	000	000	218	000	05	FT WAYNE, IN.
614	190593	007.500	08.376	01.12	08	07	011	000	000	000	221	000	07	CLINTON, IA.
615	200406	004.000	02.587	00.65	06	01	016	000	000	000	218	000	07	GARDEN CITY, KS.
616	250305	002.160	06.140	02.84	10	04	013	111	181	000	223	000	01	MIDDLEBOROUGH, MA.
617	262127	050.000	60.896	01.22	15	02	016	114	182	000	000	000	05	FLINT, MI.
618	270871	003.500	04.119	01.18	08	02	023	181	000	000	218	215	05	FAIRBOLT, MN.
619	290564	024.000	45.671	01.90	14	07	015	121	000	000	223	000	07	SPRINGFIELD, MO.
620	290652	007.000	07.466	01.07	06	01	022	000	000	000	213	217	07	CAPE GIRARDEAU, MO.
621	300163	002.700	01.711	00.64	12	02	022	111	000	000	211	215	08	KALISPELL, MT.
622	310444	001.500	01.763	01.18	08	01	022	000	000	000	218	214	07	LEXINGTON NB.

TABLE 8 - SUMMARY OF BID INFORMATION

Bid No.	Proj. No.	Design Flow(mgd)	UC ($M)	UUC ($/gpd)			Unit Processes Sec.	Tertiary			Res.Solids		EPA Reg.	Project Location
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
623	380321	005.040	04.434	00.88	15	02	013	111	000	000	218	000	08	BISMARK, ND.
624	390593	005.000	04.502	00.90	11	03	011	143	000	000	222	242	05	MT VERNON, OH.
625	390599	003.000	04.241	01.41	07	03	016	000	000	000	242	000	05	URBANA, OH.
626	470027	002.100	04.422	02.11	13	11	011	122	182	000	244	000	04	KNOXVILLE, TN.
627	510329	015.000	04.298	00.29	06	01	011	000	000	000	246	000	03	PETERSBURG, VA.
628	550648	015 .500	20.627	01.33	15	03	022	141	000	000	219	000	05	MANITOWAC, WI.
629	550662	001.900	02.259	01.19	07	01	022	000	000	000	222	251	05	RHEINLANDER, WI.
630	550687	002.000	03.929	01.96	01	03	011	111	000	000	243	000	05	RIPON, WI.
631	550788	011.100	20.189	01.82	07	01	016	000	000	000	236	251	05	FOND DU LAC, WI.
632	560109	006.400	04.334	00.68	08	01	011	000	000	000	222	000	08	CASPER, WY.

APPENDIX B

TREATMENT PLANT COST ESTIMATES

The Guides cost estimating system was used to estimate treatment plant costs for a number of purposes as discussed in Section III. The conditions under which the cost estimates were developed with the unit process base capital cost equations of the Guides system are also discussed in Section III, and the purpose of this Appendix is to describe the specific treatment system alternatives for which estimates were made, and to summarize the estimates.

A summary of each cost estimate prepared with the Guides system is presented in Table 9. Each alternative is defined in terms of unit process content, the treatment category (in Table 2) analogous to the level of performance assigned to the alternative in the Guides system, and the cost estimates developed at each of four flow rates (1, 5, 20 and 100 mgd). The unit processes in each alternative are described in Tables 10 and 11, and all of the estimates were developed using a value of 263 for the STP Index and a surcharge of 20 percent to account for site work, yard piping and other cost items not included in the unit process cost expressions of the Guides system.

A total of nine alternatives were evaluated in Treatment Category 1 and the mean cost for all nine alternatives was determined as a function of the flow rate. The values of the high, mean and low cost estimates at each of the four flow rates as presented in Table 9 were used to compile Curves B, C, and D respectively of Figure 4 (Section III).

In the development of the cost curves presented in Figures 6 and 7, it was necessary to use the Guides system to determine the relative cost differences (or cost escalation factors) between each treatment category as a function of flow rate. The alternatives within the Guides system selected for the cost estimations are identified by unit process content for Treatment Categories 2 to 6 of Table 9. The alternatives specified in each of these categories were selected because of their representativeness in current practice. The cost estimates developed for the first alternative in each treatment category in each case incorporating the activated sludge process were selected for use in developing the cost escalation factors because fully one third of the plants in the bid data base were activated sludge plants (Table 5). The cost estimates for the first alternative of Treatment Categories 2 to 6 were divided by the cost estimates for the first alternative in Treatment Category 1, and the resultant cost escalation factors are presented in Table 12.

It is apparent from inspection of the factors presented in Table 12 that the magnitude of the factors within each category varies nonlinearly with respect to flow rate. As discussed in Section III, the nonlinearity is associated with the structure of the base capital cost relationships in the Guides system. Because of the nonlinearity, an average cost escalation factor was determined for each treatment category, and with one exception the average factors reported in Table 12 were used in developing the curves of Figures 6 and 7. The exception was with respect to Treatment Category 2, wherein the average factor value was 1.28 and the value of the factor used was 1.20, based upon engineering judgement.

TABLE 9. SUMMARY OF TREATMENT PLANT CONSTRUCTION COST ESTIMATES

Treatment Category[1]	Att. No.	Unit Processes by Alternative	Estimated Cost ($ Million) at Design Flow Rate (mgd)[3]			
			1	5	20	100
1	1	AA, AB, A-1, C-1, R, O-5, L-1	2.06	3.73	9.05	34.4
	2	AA, AB, A-1, C-1, R, P-6, O-8,M-1	2.67	5.13	11.7	38.7
	3	AA,AB,A-1,C-1,R,O-1,P-1	2.53	4.97	11.5	38.7
	4	AA,AB,A-1,C-1,R,O-1,P-5	2.36	4.58	10.7	36.7
	5	AA,AB,A-1,B-1,R,L-1,N-1	1.63	3.54	9.79	40.2
	6	AA,AB,A-1,B-1,R,L-1,O-5	1.84	3.50	8.81	34.1
	7	AA,AB,A-1,B-1,R,O-8,P-6	2.42	4.90	11.4	38.4
	8	AA,AB,A-1,B-1,R,O-1,P-1	2.30	4.74	11.3	38.4
	9	AA,AB,A-1,B-1,R,O-1,P-5	2.14	4.35	10.4	36.4
1	-	Mean Cost (Alternatives 1 to 9)	2.22	4.38	10.5	37.3
2	1	AA,AB,A-3,R,C-2,O-4,P-4	2.70	5.32	12.3	35.8
	2	AA,AB,A-3,R,B-2,Q-2,O-4	2.36	4.63	10.7	36.0
	3	AA,AB,A-3,R,B-2,O-4,P-4	2.50	5.10	12.0	35.0
3	1	AA,AB,A-1,C-1,F-2,R,O-5,L-1	2.70	4.61	10.8	41.0
4	1	AA,AB,A-2,G-4,R,O-3,P-3	3.22	5.29	12.1	41.3
5	1	AA,AB,A-2,G-4,H,R,O-3,P-3	3.56	5.90	13.7	48.2
6	1	AA,AB,A-2,G-4,H,O,R,O-3,P-3	3.97	7.09	16.7	56.8

Notes: [1]Treatment categories from Table 2.

[2]For unit process codes, see Tables 10 and 11.

[3]Estimated using cost equations from Table B-1 of "A Guide to the Selection of Cost Effective Wastewater Treatment Systems" (EPA 430/9-75-002), March 1975, an STP Index of 263, and a 20% surcharge for site work and buildings .

TABLE 10. WASTEWATER TREATMENT UNIT PROCESSES

AA. Preliminary Treatment
Influent: Raw wastewater

AB. Raw Wastewater Pumping
Influent: Effluent from AA

A. Primary Sedimentation
Influent: Effluent from AA or AB
- A-1 Conventional
- A-2 Two-Stage Lime Addition
- A-3 Single Stage Lime Addition
- A-4 Alum Addition
- A-5 $FeCl_3$ Addition

B. Trickling Filter
- B-1 Influent: Effluent from A-1
- B-2 Influent: Effluent from A-3
- B-3 Influent: Effluent from A-4 or A-5

C. Activated Sludge
- C-1 Conventional
  Influent: Effluent from A-1
- C-2 Conventional
  Influent: Effluent from A-3
- C-3 Conventional
  Influent: Effluent from A-4 or A-5
- C-4 Alum Addition
  Influent: Effluent from A-1
- C-5 $FeCl_3$ Addition
  Influent: Effluent from A-1
- C-6 High Rate
  Influent: Effluent from A-1
- C-7 High Rate & Alum Addition
  Influent: Effluent from A-1
- C-8 High Rate & $FeCl_3$ Addition
  Influent: Effluent from A-1

D. Filtration
Influent: Effluent from A-2, B-2, B-3, C-2, C-3, C-4, C-5, F-1 or F-2 G-1, G-2, G-3, G-4, H, J, K

E. Activated Carbon
Influent: Effluent from D

F. Two-Stage Tertiary Lime Treatment
- F-1 Influent: Effluent from B-1
- F-2 Influent: Effluent from C-1

G. Biological Nitrification
- G-1 Influent: Effluent from C-6
- G-2 Influent: Effluent from B-1
- G-3 Influent: Effluent from A-3, A-4 or A-5
- G-4 Influent: Effluent from A-2,C-7 or C-8

H. Biological Denitrification
Influent: Effluent from G-1, G-2, G-3 or G-4

I. Ion Exchanges
Associated with A-2, B-2, B-3, C-2, C-3, C-4, C-5, F-1, or F-2

J. Breakpoint Chlorination
Influent: Effluent from A-2, B-1, B-2, B-3, C-1, C-2, C-3, C-4, C-5, F-1 or F-2

K. Ammonia Stripping
Influent: Effluent from F-1 or F-2

R. Disinfection
Influent: Effluent from any treatment process

Source: "A Guide to the Selection of Cost Effective Wastewater Treatment Systems" (EPA 430/9-75-002, March 1975)

TABLE 11. SLUDGE HANDLING UNIT PROCESSES

L. Anaerobic Digestion
- L-1 Sludge Influent: Generated from A-1+B-1, C-1 or C-6
- L-2 Sludge Influent: Generated from A-1+C-4, or C-5, or C-7, or C-8, A-4+B-3 or C-3, A-5+B-3 or C-3

M. Heat Treatment
- M-1 Sludge Influent: Generated from A-1+B-1, C-1 or C-6
- M-2 Sludge Influent: Generated from A-1+C-4 or C-5, or C-7, or C-8, A-4+B-3 or C-3, A-5+B-3 or C-3

N. Air Drying
- N-1 Sludge Influent: Effluent Sludge from L-1
- N-2 Sludge Influent: Effluent Sludge from L-2

O. Dewatering
- O-1 Sludge Influent: Generated from A-1+B-1, C-1 or C-6
- O-2 Sludge Influent: Generated from A-1+C-4 or C-5, or C-7, or C-8, A-4+B-3 or C-3, A-5+B-3 or C-3
- O-3 Sludge Influent: Generated from A-2
- O-4 Sludge Influent: Generated from A-3+B-2 or C-2
- O-5 Sludge Influent: Effluent Sludge from L-1
- O-6 Sludge Influent: Effluent Sludge from L-2
- O-7 Sludge Influent: Generated from F-1 or F-2
- O-8 Sludge Influent: Effluent Sludge from M-1
- O-9 Sludge Influent: Effluent Sludge from M-2

P. Incineration
- P-1 Influent Sludge: Effluent Sludge from O-1
- P-2 Influent Sludge: Effluent Sludge from O-2
- P-3 Influent Sludge: Effluent Sludge from O-3
- P-4 Influent Sludge: Effluent Sludge from O-4
- P-5* Influent Sludge: Effluent Sludge from O-7+O-1
- P-6 Influent Sludge: Effluent Sludge from O-8
- P-7 Influent Sludge: Effluent Sludge from O-9

Q. Recalcination (includes chemical storage & feeding)
- Q-1 Sludge Influent: Effluent Sludge from O-3
- Q-2 Sludge Influent: Effluent Sludge from O-4
- Q-3 Sludge Influent: Effluent Sludge from O-7

Source: "A Guide to the Selection of Cost Effective Wastewater Treatment Systems" (EPA 430/9-75-002, March, 1975)

TABLE 12. COST ESCALATION FACTORS BETWEEN TREATMENT CATEGORY ONE AND SPECIFIED TREATMENT CATEGORY FOR SELECTED ALTERNATIVES

Treatment Category[1]	Selected Alternative[2]	Cost Escalation from Treatment Category One to Specified Category[3]					
		Design Flow Rate (mgd)				Average	Factor Used
		1	5	20	100		
1	1	1.00	1.00	1.00	1.00	1.00	1.00
2	1	1.31	1.43	1.36	1.04	1.28	1.20
3	1	1.31	1.24	1.20	1.19	1.23	1.23
4	1	1.56	1.42	1.34	1.20	1.38	1.38
5	1	1.73	1.58	1.52	1.40	1.56	1.56
6	1	1.92	1.90	1.85	1.65	1.83	1.83

Notes: [1]Treatment categories from Table 2

[2]Alternatives as specified by "Alternative Number" in Table 9

[3]Ratio of estimated construction at specified treatment category to that at Treatment Category 1, at each flow rate

APPENDIX C

TABLE 13

CITY MULTIPLIERS FOR TREATMENT PLANT CONSTRUCTION

LOCATION	TREATMENT PLANT CITY MULTIPLIER
ATLANTA, GEORGIA	.8347
BALTIMORE, MARYLAND	1.0083
BIRMINGHAM, ALABAMA	.8264
BOSTON, MASSACHUSETTS	1.1132
CHARLOTTE, NORTH CAROLINA	.6281
CHICAGO, ILLINOIS	1.1570
CINCINNATI, OHIO	1.0331
CLEVELAND, OHIO	1.0744
DALLAS, TEXAS	.7934
DENVER, COLORADO	.8843
DETROIT, MICHIGAN	1.0083
HOUSTON, TEXAS	.8678
KANSAS CITY, MISSOURI	1.0000
LOS ANGELES, CALIFORNIA	1.0578
MIAMI, FLORIDA	.8843
MILWAUKEE, WISCONSIN	1.0331
MINNEAPOLIS, MINNESOTA	.9091
NEW ORLEANS, LOUISIANA	.9256
NEW YORK, NEW YORK	1.3223
PHILADELPHIA, PENNSYLVANIA	1.1818
PITTSBURGH, PENNSYLVANIA	1.0413
ST. LOUIS, MISSOURI	1.1570
SAN FRANCISCO, CALIFORNIA	1.1157
SEATTLE, WASHINGTON	1.0330
TRENTON, NEW JERSEY	1.0826

NOTE: the treatment plant construction cost presented in Figures 5 and 6 can be multiplied by the above multipliers to account for local labor and material cost variations.

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