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WASTEWATER MANAGEMENT STUDY FOR CLEVELAND - AKRON METROPOLITAN --ETC(U)

DEC 72 DACW49-72-C-0051

UNCLASSIFIED NL

1 OF 2

ADA042152

WASTEWATER MANAGEMENT STUDY

APPENDIX V
LAND TREATMENT

U. S. ARMY ENGINEER DIVISION, NORTH CENTRAL
CORPS OF ENGINEERS
536 SOUTH CLARK STREET
CHICAGO, ILLINOIS - 60605

AUGUST 1973

FOR

CLEVELAND – AKRON METROPOLITAN

AND

THREE RIVERS WATERSHED AREAS

(6) Wastewater Management Study

for CLEVELAND-AKRON METROPOLITAN

AND THREE RIVERS WATERSHED AREAS

~~WASTEWATER MANAGEMENT SURVEY SCOPE~~ STUDY

Appendix V. Land Treatment.

(1)

LAND TREATMENT

PHASE II REPORT

PREPARED

FOR

U. S. ARMY CORPS OF ENGINEERS

BUFFALO DISTRICT

UNDER CONTRACT NO.: DACW49-72-C-0051

(15)

WRIGHT-McLAUGHLIN ENGINEERS

ENGINEERING CONSULTANTS

DENVER, COLORADO

(11) 20 DEC [redacted]72

(12) 126p.

ATTACHMENT A

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND-AKRON METROPOLITAN
AND THREE RIVERS WATERSHED AREA

U N I T C O S T S

DEVELOPED BY LAND TREATMENT CONTRACTOR
PHASE II

PREPARED
FOR
U. S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT

UNDER CONTRACT NO.: DACW49-72-C-0051

WRIGHT-McLAUGHLIN ENGINEERS
ENGINEERING CONSULTANTS
DENVER, COLORADO
SEPTEMBER 22, 1972
REVISED OCTOBER 6, 1972

UNIT COSTS

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Section

1. Abbreviations

2. Costing Sequence Diagrams - Showing the Cost Components of the Formulated Plans - The Numbers Shown are Keyed to Those Used for the Detailed Cost Sheet Component Columns (See Section 4 for Samples of Detailed Cost Sheets)

3. Unit Costs

A. Capital Costs - Details of Unit Cost Determinations

Cost Component	Detailed Cost Sheet Column Number
(Basic Data)	(1-6)
Treatment Facilities (In Plants or Aerated Lagoons) . . .	7-11
Transmission Facilities	
Pump Plant.	13
Force Main) Drop Shaft) . . . . Tunnel)	14
Secondary Pump Plant.	15
Force Main.	16 (See Col. 14)
Storage Reservoir	
Reservoir	17
Aeration	18
Chlorination.	19
Land Treatment Site	
Purchase & Relocation	20
Site Preparation.	22
Irrigation System	
Pump Station.	23
Force Main.	24 (See Col. 14)
Equipment & Distribution Piping .	25
Drainage System	
Tile.	26
Conduits & Canals	27
Sludge Management.	28
Miscellaneous (Monitoring, Admin. Bldgs., Labs.) .	29

CURVES USED FOR COSTING OF COMPONENTS . . .(See Separate List)

CAPITAL COSTS
LIST OF CURVES
USED FOR COSTING

Cost Component	Curve	Detailed Cost Sheet Column Number
Pump Plant (Station)	A	13 & 15
Force Main	D	14, 16, 24
Drop Shaft	C	14
Tunnel (Lined Mole)	B	14
Secondary Pump Plant	E	15
Lift Shaft	C	15
Aerated Lagoons	G	10
Storage Reservoir or Det'n. Pond	F	17
Chlorination	H	19
Irrigation Pump	I	23
Sludge Storage (In Basin)	K	28
Sludge to Strip Mine Areas	L	28
Sewer	J	

UNIT COSTS

Table of Contents (Cont'd.)

Section

3. Unit Costs

B. Operation & Maintenance Costs - Details of Unit Cost Determinations

Cost Component	Detailed Cost Sheet Column Number
(Basic Data)(See A. Capital Costs) .	(1-6)
Treatment Facilities	
(In Plants or Aerated Lagoons) . . .	7-11
Aerated Lagoons - Power	10A
- Maint. & Labor.	10B
- Chlorination. .	10C
Transmission Facilities	
Pump Plant - Power.	13A
- Maint. & Labor . . .	13B
Force Main)	
Drop Shaft)- Maint. & Labor . . .	14
Tunnel)	
Secondary Pump Plant - Power. . . .	15A
- Maint. & Labor	15B
Force Main - Maint. & Labor . . .	16 (See Col. 14)
Storage Reservoir	
Reservoir - Maint. & Labor. . . .	17
Aeration - Power.	18A
- Maint. & Labor	18B
Chlorination - Power.	19A
- Maint. & Labor . .	19B
Land Treatment Site.	No O&M for Cols. 20 & 22
Irrigation System	
Pump Station - Power.	23A
- Maint. & Labor . .	23B
Force Main - Maint. & Labor . . .	24 (See Col. 14)
Equipment & Distribution Piping - Maint. & Labor.	25
Drainage System	
Tile - Maint. & Labor	26
Conduits & Canals - Maint. & Labor	27
Sludge Management - Power.	28A
- Maint. & Labor .	28B
Miscellaneous - Maint. & Labor . . .	29

C. Contingencies - Percentage Applied to Capital Costs
- Percentage Applied to O&M Costs

UNIT COSTS

Table of Contents (Cont'd.)

Section

4. Sample Cost Compilation & Summary Forms Used in Costing
- -Detailed Capital Costs - Sheets A & B
- -Detailed O&M Costs - Sheets A & B
- -Comparable Annual Cost Index - Year 2020 - Sheets A & B (Cost Summaries)

ABBREVIATIONS

ADF = Average Daily Flow

AR = Annual Runoff

MDF = Maximum Daily Flow

MF = Peak Hourly Flow

MGD = Million Gallons Per Day

TDH = Total Dynamic Head

TPD = Tons Per Day

LAND TREATMENT

SEQUENCE OF COST COMPONENTS * OF FORMULATED PLANS

Initial Treatment	In-Basin
Final Treatment	In-Basin

* Circled Numbers Refer To Column Numbers On Detailed Cost Sheets

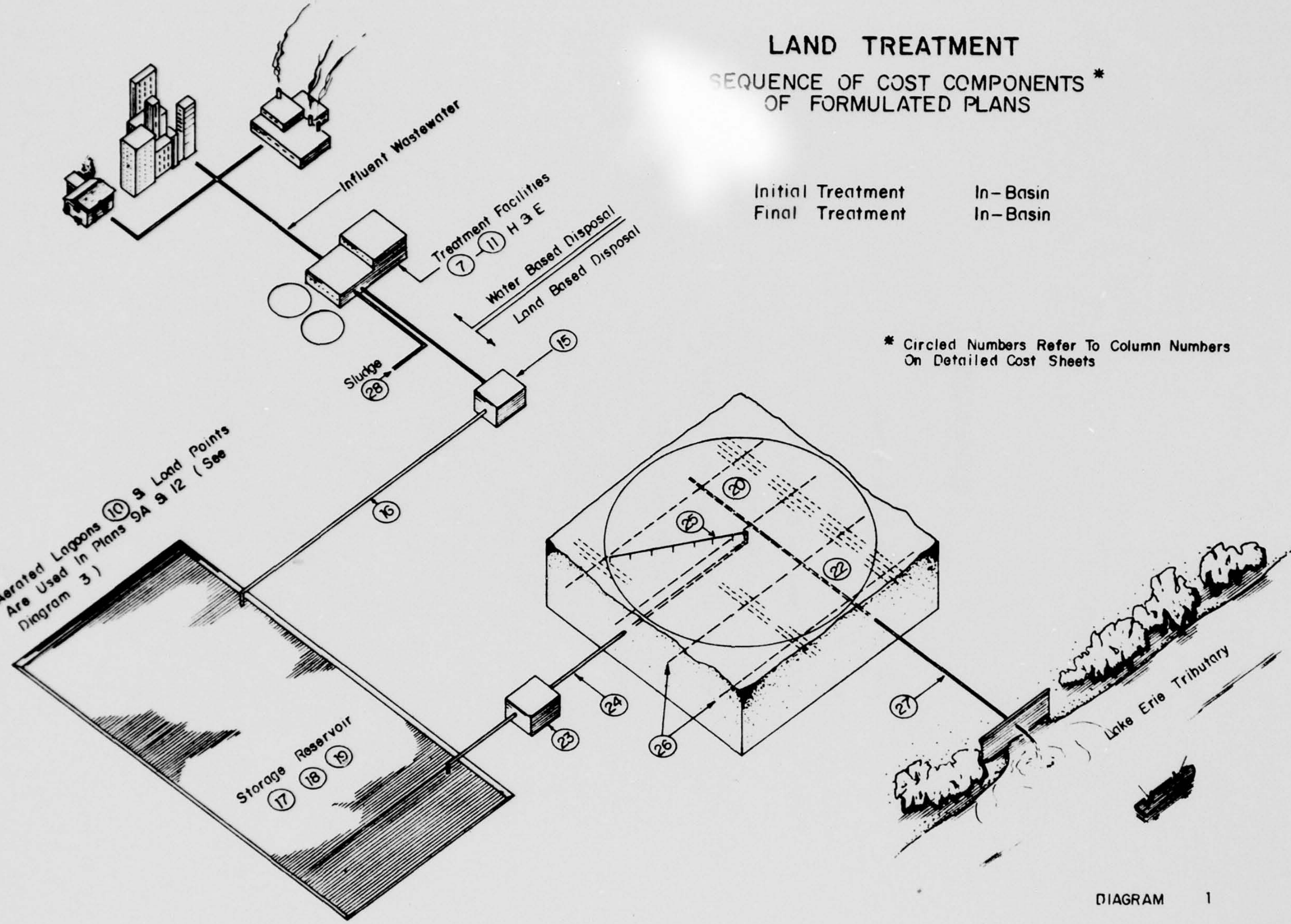


DIAGRAM 1

LAND TREATMENT

SEQUENCE OF COST COMPONENTS *
OF FORMULATED PLANS

Initial Treatment — In-Basin
Final Treatment — Out-of-Basin

* Circled Numbers Refer To Column Numbers On Detailed Cost Sheets

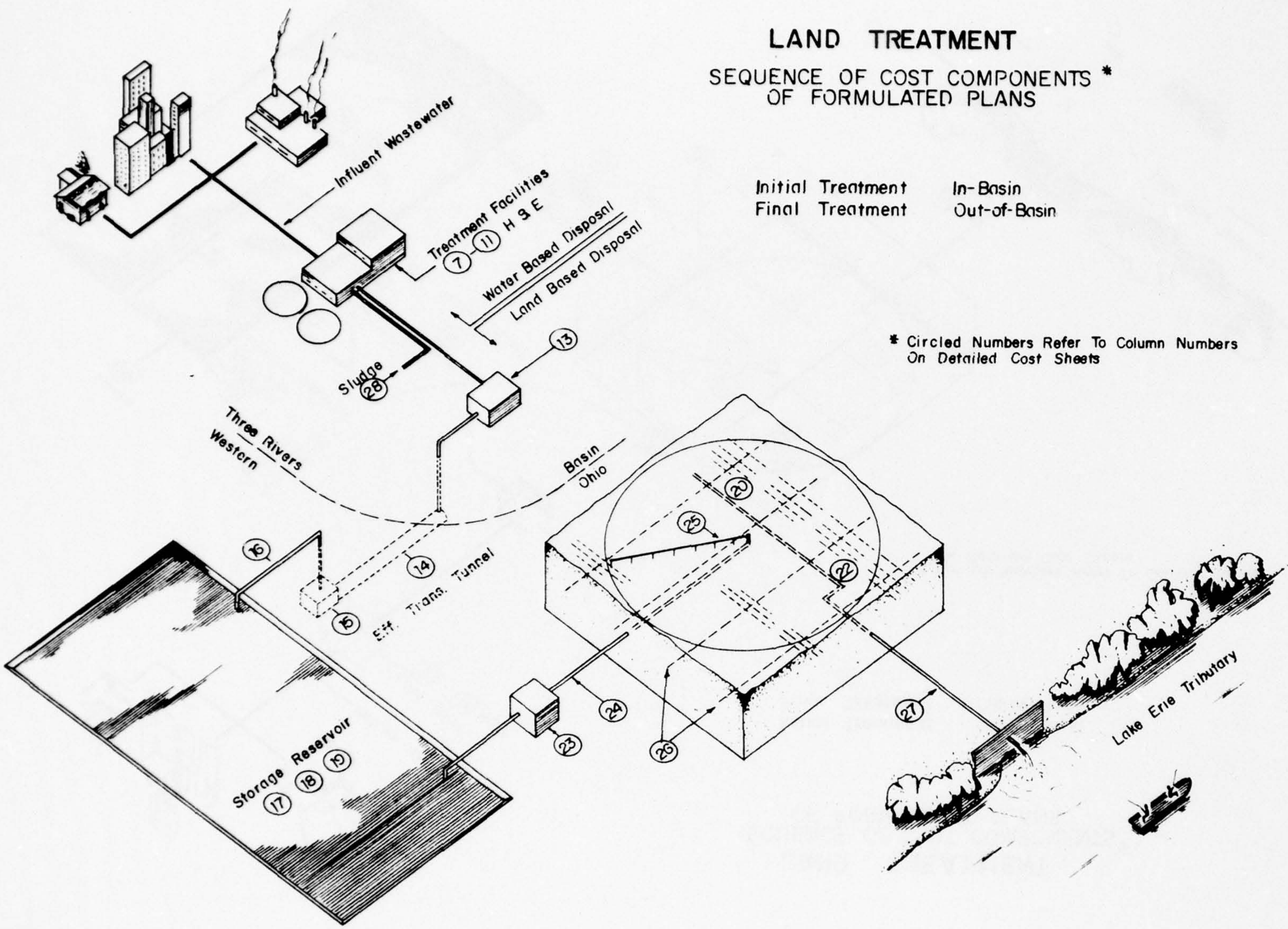


DIAGRAM 2

LAND TREATMENT

SEQUENCE OF COST COMPONENTS* OF FORMULATED PLANS

Initial Treatment	Out-of-Basin
Final Treatment	Out-of-Basin

* Circled Numbers Refer To Column Numbers On Detailed Cost Sheets

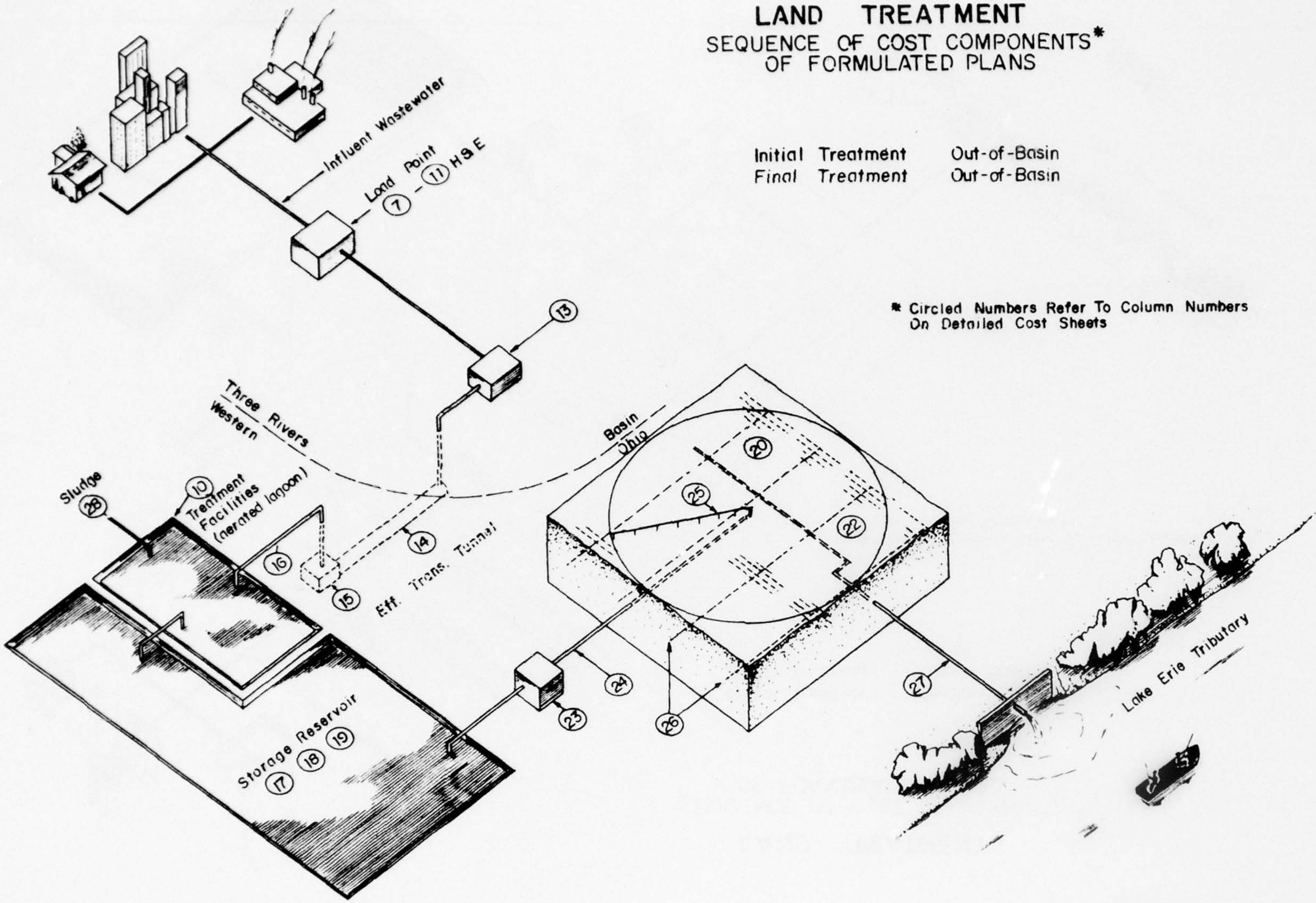


DIAGRAM 3

CAPITAL COSTS

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 1 OF 1
FOR COLUMN #: 1-6   JOB NO. 712 - 70
ITEM: Basic Data   BY W-ME   DATE 9-20-72

A. Cost Type: Capital Cost X   Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ______   Irrigation System ______
Storage Reservoirs ______   Drainage ______
Land Treatment Site ______   Miscellaneous ______

C. Cost Item: Basic Data (Used in Costing)   Column: 1-6
Name

Column No.	Item w/Source of Data and/or Explanation
1	Plant Name
2	Detention Storage (MG) H&E Phase I Report - Part B
3	Plant Capacity (MGD) Wastewater: Municipal Wastewater Flow - H&E Projections Phase I Report, Part A Industrial: AWARE Projections Stormwater: H&E Projections Phase I Report, Part B Conceptualized Plants: W-ME Projections
4	Raw Sludge - H&E (TPD)
5	Winter Storage (MG)
	a. Sanitary Plant No. of Days x (ADF) = MG Storage
	b. Sanitary Plant with Stormwater Sanitary + Stormwater = MG Storage No. of Days x (ADF) + %(AR) = MG Storage
	c. Stormwater Plant (two most widely used %'s are shown as examples) $\frac{155}{365}$ x Annual Runoff = MG Storage or $\frac{85}{365}$ x Annual Runoff = MG Storage
6	Acres Needed for Treatment
	a. Sanitary Plant (ADF) x 365 x 3.07 $\frac{\text{Acre-ft.}}{\text{MG}}$ / App. Rate = Acres
	b. Sanitary Plant with Stormwater Sanitary Acres + Stormwater Acres (ADF) x 365 x 3.07 $\frac{\text{Acre-ft.}}{\text{MG}}$ / App. Rate + AR x 3.07 $\frac{\text{Acre-ft.}}{\text{MG}}$ / App. Rate = Acres
	c. Stormwater Plant AR x 3.07 $\frac{\text{Acre-ft.}}{\text{MG}}$ / App. Rate = Acres

Note: The number of days used to determine the Winter Storage equals 365 days less the number of days of estimated application of wastewater. This can vary depending upon the soil type being used for treatment.

Land Treatment/Formulation Phase: 2 Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1

FOR COLUMN #: 7-11 JOB NO. 712-70

ITEM: Treatment (In Plants) (Aerated Lagoon - Col. 10) BY W-ME DATE 9-20-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____

B. General Component Heading:

Treatment Facilities X Irrigation System ____
Transmission Facilities ____ Drainage ____
Storage Reservoirs ____ Miscellaneous ____
Land Treatment Site ____

C. Cost Item Treatment (In Plants or Aerated Lagoon) Column: 7-11
Name

COMPUTATION:

All costs for sewage treatment plants are supplied by Havens & Emerson. For Plan 9A, 3 plants were costed using aerated lagoons rather than secondary treatment in sewage treatment plants. The costs for these aerated lagoons are included in land treatment costs. For Plan 12 all plants were costed using aerated lagoons.

Column 10 in the detailed cost sheets shows aerated lagoon costs and this component cost is shown under the Land Treatment Site heading rather than under Treatment in Plants on the plan cost summary sheets.

Curve G has been plotted to show the capital cost for a wide range of aerated lagoon treatment capacities. The costs shown in column 10 of the detailed cost sheets were selected from Curve G.

EXPLANATION:

REFERENCES:

Havens & Emerson - Secondary, Tertiary and Advanced Wastewater Treatment Plant Costs.
W-ME - Aerated Lagoon Costs

FINAL UNIT COST USED: All costs supplied by Havens & Emerson except as in Plans 9A & 12.

3

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 1 OF 1
FOR COLUMN #: 13   JOB NO. 712-70
ITEM: Pumping Plant to Tunnel/ Force Main   BY W-HE   DATE 9-20-72

A. Cost Type: Capital Cost X   Operation & Maintenance (O&M) ______
B. General Component Heading:
Transmission Facilities X   Irrigation System ______
Storage Reservoirs ______   Drainage ______
Land Treatment Site ______   Miscellaneous ______

C. Cost Item Pumping Plant (Name)   Column: 13

COMPUTATION:

Curve A plots the costs of various size pumping plants as used in the C-SELM project. The costs are based on actual contract experience as well as designs built up from component labor and material costs.

EXPLANATION:

REFERENCES:

OCE Cost Curve - Figure 21-13 as shown in Bauer, C-SELM Report (Feb. 1972)

FINAL UNIT COST USED: Curve A Used to Determine Individual Plant Costs

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 1 OF 1
FOR COLUMN #: 14, 16 and 24   JOB NO. 712 - 70
ITEM: Force Main   BY W-ME   DATE 9-20-72

A. Cost Type: Capital Cost X   Operation & Maintenance (O&M) ____
B. General Component Heading:
Transmission Facilities X   Irrigation System X
Storage Reservoirs ____   Drainage ____
Land Treatment Site ____   Miscellaneous ____

C. Cost Item: Force Main (Name)   Column: 14, 16 and 24

COMPUTATION:

Curve D was plotted from data in the referenced report. Costs of some sizes smaller as well as larger than those shown in the table were then determined by extrapolation.

EXPLANATION:

REFERENCES:

OCE Cost Table 21-3 as shown in Bauer, C-SELM Report (Feb. 1972)

FINAL UNIT COST USED: Use Curve D to Determine Cost of Various Size Lines

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 1 OF 1
FOR COLUMN #: 14 and 15   JOB NO. 712-70
ITEM: Drop Shaft (Lift Shaft)   BY GGR   DATE 9-14-72

A. Cost Type: Capital Cost X   Operation & Maintenance (O&M) ____
B. General Component Heading:
   Transmission Facilities X   Irrigation System ____
   Storage Reservoirs ____   Drainage ____
   Land Treatment Site ____   Miscellaneous ____

C. Cost Item: Drop Shaft (Lift Shaft)   Column: 14 and 15
   Name

COMPUTATION:

Curve C, which is Figure 21-14 from the OCE publication (Task No. 21) of the unit costs developed in the C-SELM, Bauer Engineering Study, is the source of drop shaft and lift shaft unit costs.

EXPLANATION:

REFERENCES:

OCE Cost Figure 21-14 as shown in
Bauer, C-SELM Report
(Feb. 1972)

FINAL UNIT COST USED: Use Curve C to Determine Costs of Various Diameter Shafts

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1

FOR COLUMN #: 14 JOB NO. 712-70

ITEM: Tunnel BY GGR DATE 9-14-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ______

B. General Component Heading:

Transmission Facilities X Irrigation System ______

Storage Reservoirs ______ Drainage ______

Land Treatment Site ______ Miscellaneous ______

C. Cost Item Tunnel (Name) Column: 14

COMPUTATION: COST PER LINEAL FOOT (Constr. Cost Only)

Finish Dia.	Adjusted '72 (Cleve) (Rpt) D-D&L	'72 (Ltr) W-C	'72 (C-Selm Rpt) BAUER	AVERAGE	ADJUSTED
8'	280	400	310	330	350
10'	360	450	380	400	400
12'	460	500	440	470	500
14'	570	600	530	570	600
16'	660	650	640	650	650
18'	780	800	750	780	750

The ENR Sept. 1970 Engr. Construction Cost Index = 1752 (Cleveland) (used by Dalton-Dalton-Little) On 6-72 the Index = 2025 (Cleveland)

$\frac{2025}{1752} = 1.16$ (Used to adjust D-D&L costs from 1970 - 1972)

All tunnels are lined:

EXPLANATION:

Based on above average costs, it is felt that tunnel costs in "adjusted" column are reasonable to use. This means W-C costs as used before can be reduced $50/ft for the 8', 10', and 18' tunnels. (The 18' tunnel is adjusted to a slightly below the average figure since the original $800 cost was not in the W-C letter and was subsequently extrapolated at what is now felt to be the more on the high side - $750 probably would have been a more reasonable extrapolation).

REFERENCES: September 1970 - Dalton, Dalton & Little Cleveland Tunnel Report
February 1972 - C-Selm (Bauer) costs as Published by Corps
June 1972 - Woodward-Clevenger & Assoc. Inc. letter to W-ME

FINAL UNIT COST USED: See "Adjusted" column. (Curve B was plotted from the costs shown above)
(Revision as of 9-14-72)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 1 OF 1
FOR COLUMN #: 15   JOB NO. 712 - 70
ITEM: Secondary Pump Plant   BY W-ME   DATE 9-20-72

A. Cost Type: Capital Cost X   Operation & Maintenance (O&M) ______
B. General Component Heading:
Transmission Facilities ______   Irrigation System ______
Storage Reservoirs ______   Drainage ______
Land Treatment Site ______   Miscellaneous ______

C. Cost Item: Secondary Pump Plant   Column: 15
Name

COMPUTATION:

Curves A and E both plot the costs of various size pumping plants as used in the C-SELM project. The costs are based on actual contract experience as well as designs built up for specific applications.

Use Curve A for pumping into tunnel or pumping from plant to storage reservoirs.

Use Curve E for pumping out of tunnel.

EXPLANATION:

REFERENCES:

Pumping Station Construction Cost as shown in Cost Data Annex to Technical Appendix C-SELM, Bauer Engineering Report (March, 1972)

Wright-McLaughlin Engineers

FINAL UNIT COST USED: Use Curves A and E to Determine Individual Plant Costs

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 1 OF 1
FOR COLUMN #: 17   JOB NO. 712-70
ITEM: Storage Reservoirs   BY GGR   DATE 9-15-72

A. Cost Type: Capital Cost X   Operation & Maintenance (O&M) ______
B. General Component Heading:
Transmission Facilities ______   Irrigation System ______
Storage Reservoirs X   Drainage ______
Land Treatment Site ______   Miscellaneous ______

C. Cost Item Storage Reservoirs (Name)   Column: 17

COMPUTATION:

	STORAGE VOLUME	COST/MG	ADJUSTED COST/MG (25% contingency Removed)	
Based on sample designs and costing	10 MG	$8,200 x 0.8 =	$6,560	
	540 MG	4,000 x 0.8 =	3,200	
	12,500 MG	1,275 x 0.8 =	1,020	use $1,000/MG min
	50,000 MG (4 cells)	1,230 x 0.8 =	985	
	100,000 (8 cells)		700	) Estimated based on Bauer cost experience
	150,000 (12 cells)		500	)

Land costs and site preparation included in above. Tight soils should not require lining.

EXPLANATION: NOTE: Costing is to be done so that any contingency factor which is applied is added at the very end and to the total cost rather than to individual items comprising the composite estimate.

Storage reservoirs had a 25% contingency added in as used in previous estimates -- this 25% is now removed!

Chicago-Selm Reservoir cost of $363/MG based on adjusted bidding experience at Muskegon (C-Selm Res. is 369,000 MG) (In 8 cells @ 46,000 MG per cell)

REFERENCES: Wright-McLaughlin Engineers - cost comps.
Bauer Engr'g-costs based on Muskegon and other data.

FINAL UNIT COST USED: As shown in adjusted col. above and as plotted for W-ME curve titled "Storage Reservoirs & Det'n Ponds - Capital Costs".

(Revision as of ?-14-72)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1

FOR COLUMN #: 18 JOB NO. 712 - 70

ITEM: AERATION BY RMcL DATE 8-11-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M)

B. General Component Heading:

Transmission Facilities Irrigation System

Storage Reservoirs X Drainage

Land Treatment Site Miscellaneous

C. Cost Item: Aeration Column: 18

Name

COMPUTATION:

For emergency - supplemental storage aeration. Prototype 5 MG module @ 20' Depth (avg)
Area = 31,400 s.f. or R = 100' (ok for area of influence)

Avg BOD_5 = 12 mg/l or BOD_u = 20 mg/l

Say satisfy by feed @ 2 mg/l/day maximum rate

#/day for 5 MG = 40 #/day/unit =<2.0 $\#O_2$/hr

Way low: Mixing intensity will govern. Normal for D. O. mix = 6-8 HP/MG
With small units, reasonable D.O. mix (at surface only) can be done
w/about 1.0 HP/MG.
5 HP unit w/cables & elect. = $3,500
$3,500/5 MG = $700/MG

EXPLANATION:

REFERENCES:

Wright-McLaughlin Engineers

FINAL UNIT COST USED: $700/MG

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ________

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 1 OF 1
FOR COLUMN #: 19   JOB NO. 712 - 70
ITEM: Chlorination   BY W-ME   DATE 9-20-72

A. Cost Type: Capital Cost X   Operation & Maintenance (O&M) ____
B. General Component Heading:
   Transmission Facilities ____   Irrigation System ____
   Storage Reservoirs X   Drainage ____
   Land Treatment Site ____   Miscellaneous ____

C. Cost Item Chlorination   Column: 19
   Name

COMPUTATION:

Curve H is as supplied by Havens and Emerson.

EXPLANATION:

REFERENCES:

Havens & Emerson

FINAL UNIT COST USED: Use Curve H to determine Chlorination cost for Various Plant Sizes.

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 1 OF 1

FOR COLUMN #: 20   JOB NO. 712 - 70

ITEM: Purchase & Relocation   BY KRW   DATE 9-14-72

A. Cost Type: Capital Cost X   Operation & Maintenance (O&M) ______

B. General Component Heading:

Transmission Facilities ______   Irrigation System ______

Storage Reservoirs ______   Drainage ______

Land Treatment Site X   Miscellaneous ______

C. Cost Item: Purchase & Relocation (Name)   Column: 20

COMPUTATION:

Purchase Land Cost - Average $334.00/Acre (page 3 of letter from Dept. of Army - see reference below)

Family Relocation Cost:

Average Farm = 80 acres - based on listed averages
Cost for 1 unit of farm buildings = $16,000
Relocation Cost - $5,000

Total Relocation Cost for One Family	Relocation Cost Per Acre	Total Purchase & Relocation Cost Per Acre:
$16,000	= $21,000/80 acres	$334/Ac. Raw purchase
5,000	= $262.50/Ac.	$262/Ac. Relocation
$21,000		$596/Ac.

EXPLANATION:

Method: Each County priced by township ($/acre)
Cost ($/acre) averaged for each county
Average cost ($/acre) for all counties = $334/acre - See resume, page 3 of letter
Average relocation cost = $262.50/acre - see above or page 4 of letter
Total Estimated Cost Per Acre = $600/acre
(With 15% variation allowance = $700/acre - page 4 of letter)

REFERENCES: Dept. of The Army
North Central Division, Corps of Engineers
536 S. Clark Street
Chicago, Illinois 60605
By letter - July 24, 1972/Management & Disposal Branch, Real Estate Div.

FINAL UNIT COST USED: $600/Acre (does not include any contingency)

Revision as of 9-14-72

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 1 OF 1
FOR COLUMN #: 21   JOB NO. 712 - 70
ITEM: Revision - Farm Equipment   BY W-ME DATE 9-14-72

A. Cost Type: Capital Cost X   Operation & Maintenance (O&M) ____
B. General Component Heading:
Transmission Facilities ____   Irrigation System ____
Storage Reservoirs ____   Drainage ____
Land Treatment Site X   Miscellaneous ____

C. Cost Item Farm Equipment (Name)   Column: 21

COMPUTATION:

Do not include this in cost summary. This item originally estimated at $100/ac. is a cost of doing business. It more appropriately should be considered as a deduct from farm income, along with labor, chemicals, gas, oil, and vehicles.

Net farm income estimates can be more readily referenced to by leaving out of estimate.

EXPLANATION:

Land management has been investigated in detail with regard to specific crops, type of application, type of drainage, etc. Costs of irrigation equipment and drainage reflect land management techniques required initially such as surface preparation and specialized deep plowing.

REFERENCES: Wright McLaughlin Engineers

FINAL UNIT COST USED: Drop Farm Equipment Cost (Revision as of 9-14-72)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation — Phase: 2 — Sub-Item: ____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS — SHEET NO. 1 OF 1
FOR COLUMN #: 22 — JOB NO. 712-70
ITEM: Site Preparation (Revised) — BY W-ME — DATE 9-14-72

A. Cost Type: Capital Cost X — Operation & Maintenance (O&M) ____
B. General Component Heading:
Transmission Facilities ____ — Irrigation System ____
Storage Reservoirs ____ — Drainage ____
Land Treatment Site X — Miscellaneous ____

C. Cost Item: Site Preparation (Name) — Column: 22

COMPUTATION:

1)	Woodland clearing	$35/acre
2)	Miscellaneous site preparation such as fences, removals, site work	20/acre
3)	Access roads	5/acre
4)	Miscellaneous grading for operation	5/acre
		$65/acre

$65/acre is basic site preparation. Specialized site preparation to be included in irrigation equipment.

Note: Relocation costs and purchase of farm buildings included in cost of land at $700/acre (includes 15% contingency factor included by Chicago Division). Thus, use $600/acre in computations for land purchase and relocation. Families not moved from site would tend to lower land costs.

EXPLANATION:

1) Woodland clearing computed at 10% of total area at $350/acre. Much of woodland will not be cleared, however.
2) Includes removal of buildings which would conflict with operations.
3) Access roads would be in addition to existing roads, for access to operational points of irrigation and drainage facilities.
4) This includes grading for irrigation facilities, access roads, etc.. For specialized irrigation and application techniques, additional site preparation will be included under irrigation equipment.

REFERENCES: Reservoir clearing experience in Colorado - Wright - McLaughlin Engineers
"Cost Summary for Land Treatment" ($82/acre)
"Muskegon Contract No. 1"
C - SE&M Report - Technical Appendix (Cost Data Annex)
March, 1972

FINAL UNIT COST USED: $65/acre
(Revision as of 9-14-72)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS

FOR COLUMN #: 23   SHEET NO. 1 OF 1
JOB NO. 712-70
ITEM: Pump Station   BY W-ME DATE 9-20-72

A. Cost Type: Capital Cost X   Operation & Maintenance (O&M) ______

B. General Component Heading:

Transmission Facilities ______   Irrigation System X
Storage Reservoirs ______   Drainage ______
Land Treatment Site ______   Miscellaneous ______

C. Cost Item Name: Pump Station   Column: 23

COMPUTATION:

Curve I is based on construction cost experience.

EXPLANATION:

REFERENCES:

U. S. Bureau of Reclamation
Wright-McLaughlin Engineers

FINAL UNIT COST USED: Use Curve I to Determine Individual Plant Costs

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 1 OF 6
FOR COLUMN #: 25   JOB NO. 72 - 70
ITEM: EQUIPMENT & DISTRIBUTION PIPING - MAHONING SOILS MINI-BORDER SYSTEM   BY W-ME   DATE 9/18/72

A. Cost Type: Capital Cost X   Operation & Maintenance (O&M) ____
B. General Component Heading:
Transmission Facilities ____   Irrigation System X
Storage Reservoirs ____   Drainage ____
Land Treatment Site ____   Miscellaneous ____

C. Cost Item: EQUIPMENT & DISTRIBUTION PIPING (Name)   Column: 25

COMPUTATION: MAHONING SOILS - MINI-BORDER SYSTEM

For application rates of 90 inches/year (municipal effluent) or 150 inches/year (separate storm runoff).

Automated farm distribution equipment (25-year life) . . $150/acre

Site Preparation:

Forming . . . . $ 10/acre

Soil preparation and seeding . . . . $ 15/acre

Deep plowing on contour . . . . $ 40/acre

$215/acre

EXPLANATION:

REFERENCES: Donald L. Miles, Irrigation Specialist, Agricultural Engineering Dept. Colorado State University
Wright-McLaughlin Engineers
Valmont Industries, Inc., Valley, Nebraska
IRECO Industries, Inc., Eugene, Oregon
ENRESCO, Colorado Springs, Colorado
Rain Bird Sprinkler Manufacturing Corp., Glendora, California

FINAL UNIT COST USED: $215/acre

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 2 OF 6
FOR COLUMN #: 25   JOB NO. 712 - 70
ITEM: EQUIPMENT DISTRIBUTION PIPING-CHILI & RELATED SOILS IN-BASIN   BY W-ME   DATE 9/18/72

A. Cost Type: Capital Cost X   Operation & Maintenance (O&M) ______
B. General Component Heading:
   Transmission Facilities ______   Irrigation System X
   Storage Reservoirs ______   Drainage ______
   Land Treatment Site ______   Miscellaneous ______

C. Cost Item: EQUIPMENT & DISTRIBUTION PIPING (Name)   Column: 25

COMPUTATION: CHILI AND RELATED SOILS IN-BASIN

For application rate of 60 inches/year.

Use solid-set system.

Sprinklers	\$ 300/acre
Distribution System	\$ 175/acre
	\$475/acre

EXPLANATION:

REFERENCES: Donald L. Miles, Irrigation Specialist, Agricultural Engineering Dept. Colorado State University
Wright-McLaughlin Engineers
Valmont Industries, Inc., Valley, Nebraska
IRECO Industries, Inc., Eugene, Oregon
ENRESCO, Colorado Springs, Colorado
Rain Bird Sprinkler Manufacturing Corp., Glendora, California

FINAL UNIT COST USED: \$ 475/acre

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation — Phase: 2 — Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS — SHEET NO. 3 OF 6
FOR COLUMN #: 25 — JOB NO 712 - 70
ITEM: EQUIPMENT & DISTRIBUTION PIPING - CARDINGTON-BENNINGTON SOILS (COMPOSITE) — BY W-ME — DATE 9/18/72

A. Cost Type: Capital Cost X — Operation & Maintenance (O&M) ______

B. General Component Heading:

Transmission Facilities ______	Irrigation System X
Storage Reservoirs ______	Drainage ______
Land Treatment Site ______	Miscellaneous ______

C. Cost Item: EQUIPMENT & DISTRIBUTION PIPING (Name) — Column: 25

COMPUTATION: CARDINGTON - BENNINGTON SOILS
(COMPOSITE OF WESTERN AREAS)

Mini-Border	5%	0.05	(175) =	9
Hay & Pasture	30%	0.30	(475) =	142
Corn (Pivot Rigs)	65%	0.65	(320) =	208
				359

USE $360/Acre

EXPLANATION:

REFERENCES:
Donald L. Miles, Irrigation Specialist, Agricultural Engineering Dept. Colorado State University
Wright-McLaughlin Engineers
Valmont Industries, Inc., Valley, Nebraska
IRECO Industries, Inc., Eugene, Oregon
ENRESCO, Colorado Springs, Colorado
Rain Bird Sprinkler Manufacturing Corp., Glendora, California

FINAL UNIT COST USED: $360/Acre

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 4 OF 6
FOR COLUMN #: 25   JOB NO. 712-70
ITEM: EQUIPMENT & DISTRIBUTION PIPING - CARDINGTON-BENNINGTON SOILS   BY RLT   DATE 9/18/72

A. Cost Type: Capital Cost X   Operation & Maintenance (O&M) ______
B. General Component Heading:
Transmission Facilities ______   Irrigation System X
Storage Reservoirs ______   Drainage ______
Land Treatment Site ______   Miscellaneous ______

C. Cost Item: EQUIPMENT & DISTRIBUTION PIPING   Column: 25
Name

COMPUTATION: CARDINGTON-BENNINGTON SOILS

For application rate of 75 inches/year on corn with drip tubes on rigs. On 160 acres one large rig irrigates 122 acres.

Cost of Pivot Rig: $23,000

Cost per acre: $23,000/122 acres = $190/acre Use: $200/acre

Cost of Piping $100/acre

Circular Plowing with roads and gully crossing . . . $ 20/acre

$320/acre

EXPLANATION:

REFERENCES: Donald L. Miles, Irrigation Specialist, Agricultural Engineering Dept., Colorado State University
Wright-McLaughlin Engineers
Valmont Industries, Inc., Valley, Nebraska
IRECO Industries, Inc., Eugene, Oregon
ENRESCO, Colorado Springs, Colorado
Rain Bird Sprinkler Manufacturing Corp., Glendora, California

FINAL UNIT COST USED: $320/acre

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation — Phase: 2 Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS — SHEET NO. 5 OF 6
FOR COLUMN #: 25 — JOB NO. 712 - 70
ITEM: EQUIPMENT & DISTRIBUTION PIPING - CARDINGTON-BENNINGTON SOILS — BY RLT — DATE 9/18/72

A. Cost Type: Capital Cost X — Operation & Maintenance (O&M) ______
B. General Component Heading:
Transmission Facilities ______ — Irrigation System X
Storage Reservoirs ______ — Drainage ______
Land Treatment Site ______ — Miscellaneous ______

C. Cost Item: EQUIPMENT & DISTRIBUTION PIPING (Name) — Column: 25

COMPUTATION: CARDINGTON-BENNINGTON SOILS

For application rate of 50 inches/year using solid-set system.

Cost of Sprinklers $300/acre
Cost of Distribution System. $175/acre
$475/acre

EXPLANATION:

REFERENCES: Donald L. Miles, Irrigation Specialist, Agricultural Engineering Dept., Colorado State University
Wright-McLaughlin Engineers
Valmont Industries, Inc., Valley, Nebraska
IRECO Industries, Inc., Eugene, Oregon
ENRESCO, Colorado Springs, Colorado
Rain Bird Sprinkler Manufacturing Corp., Glendora, California

FINAL UNIT COST USED: $475/acre

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item: ____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 6 OF 6
FOR COLUMN #: 25 JOB NO. 71 2 - 70
ITEM: EQUIPMENT & DISTRIBUTION PIPING - CARDINGTON-BENNINGTON SOILS - MINI BORDER BY RLT DATE 9/18/72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____
B. General Component Heading:
Transmission Facilities ____ Irrigation System X
Storage Reservoirs ____ Drainage ____
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: EQUIPMENT & DISTRIBUTION PIPING (Name) Column: 25

COMPUTATION:

CARDINGTON-BENNINGTON SOILS - MINI-BORDER SYSTEM

Automated Farm Distribution. $150/acre

Site Preparation

Forming . . . . $ 10/acre

Soil Preparation and Seeding. . . . . $ 15/acre

$175/acre

EXPLANATION:

REFERENCES: Donald L. Miles, Irrigation Specialist, Agricultural Engineering Dept., Colorado State University
Wright-McLaughlin Engineers
Valmont Industries, Inc., Valley, Nebraska
IRECO Industries, Inc., Eugene, Oregon
ENRESCO, Colorado Springs, Colorado
Rain Bird Sprinkler Manufacturing Corp., Glendora, California

FINAL UNIT COST USED: $175/acre

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 6
FOR COLUMN #: 26 JOB NO. 712-70
ITEM: Tile - Mahoning Soils - Mini-Border BY RLT DATE 9-18-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M)
B. General Component Heading:
Transmission Facilities Irrigation System
Storage Reservoirs Drainage X
Land Treatment Site Miscellaneous

C. Cost Item: Tile - Mahoning Soils Column: 26
Name

COMPUTATION:

MAHONING SOILS: MINI-BORDER SYSTEM

For stormwater use 150"/yr. application rate.
For sanitary sewage use 90"/yr. application rate.

Spacing = 20'
Total length = 2180'

Total cost of tile (2180') = $328/acre
Collectors and structures = $ 95/acre
$423/acre

Use $425/acre

EXPLANATION:

See above: Tile costs are based on agricultural costs in 1972 as determined by survey and major checking w/Agricultural Engineers, including several at Ohio State University.

REFERENCES:

Donald L. Miles - Agricultural Extension Agent for Colorado
Wright-McLaughlin Engineers

FINAL UNIT COST USED: $425/acre (MAHONING SOILS: MINI-BORDER SYSTEM)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 2 OF 6
FOR COLUMN #: 26 JOB NO. 712-70
ITEM: Tile - Cardington-Bennington Soils BY RLT DATE 9-18-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M)
B. General Component Heading:
Transmission Facilities Irrigation System
Storage Reservoirs Drainage X
Land Treatment Site Miscellaneous

C. Cost Item: Tile - Cardington-Bennington Soils (Name) Column: 26

COMPUTATION:

CARDINGTON-BENNINGTON SOILS -- CORN

Use application rate of 75"/yr.

Spacing = 20'

Total length = $\frac{209}{20}$ (209) = 2180 l.f.

Total cost of tile (2180') = $480/acre
Add $70/acre for collectors, structures, etc. = $ 70/acre
$550/acre
Deduct 10% for existing tiles= - 55/acre
$495/acre

Net cost/acre = $495/acre

EXPLANATION:

See above: Tile costs are based on agricultural costs in 1972 as determined by survey and major checking w/Agricultural Engineers, including several at Ohio State University.

REFERENCES:

Donald L. Miles - Agricultural Extension Agent for Colorado
Wright-McLaughlin Engineers

FINAL UNIT COST USED: $495/acre (CARDINGTON-BENNINGTON SOILS--CORN)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 3 OF 6
FOR COLUMN #: 26   JOB NO. 712 - 70
ITEM: Tile - Cardington-Bennington Soils--Hay & Pasture   BY RLT DATE 9-18-72

A. Cost Type: Capital Cost X   Operation & Maintenance (O&M) ______
B. General Component Heading:
Transmission Facilities ______   Irrigation System ______
Storage Reservoirs ______   Drainage X
Land Treatment Site ______   Miscellaneous ______

C. Cost Item: Tile - Cardington-Bennington Soils   Column: 26
Name

COMPUTATION:

CARDINGTON-BENNINGTON SOILS--HAY & PASTURE

Use application rate of 50"/yr.

Spacing = 30'

Length = $\frac{209}{30}$ (209) = 1450 l.f.

Total cost of tile (1450')	=	$320/acre
Add $70/acre for collectors, structures, etc.	=	$ 70/acre
		$390/acre
Deduct 10% for existing tiles	=	- 40/acre
Net cost/acre	=	$350/acre

EXPLANATION:

See above: Tile costs are based on agricultural costs in 1972 as determined by survey and major checking w/Agricultural Engineers, including several at Ohio State University.

REFERENCES:

Donald L. Miles - Agricultural Extension Agent for Colorado
Wright-McLaughlin Engineers

FINAL UNIT COST USED: $350/acre (CARDINGTON-BENNINGTON SOILS--HAY & PASTURE)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 4 OF 6
FOR COLUMN #: 26   JOB NO. 712-70
ITEM: Tile - Cardington-Bennington Soils--Composite Cut-of-Basin   BY RLT   DATE 9-18-72

A. Cost Type: Capital Cost X   Operation & Maintenance (O&M) ______
B. General Component Heading:
Transmission Facilities ______   Irrigation System ______
Storage Reservoirs ______   Drainage X
Land Treatment Site ______   Miscellaneous ______

C. Cost Item: Tile - Cardington-Bennington Soils (Name)   Column: 26

COMPUTATION:

CARDINGTON-BENNINGTON SOILS--COMPOSITE OF WESTERN LAND AREAS

Mini-border	5%	=	.05(350)	=	$ 18/acre
Hay & Pasture	30%	=	.30(350)	=	$105/acre
Corn (pivot rigs)	65%	=	.65(495)	=	$322/acre
				TOTAL	$445/acre

EXPLANATION:

See above: Tile costs are based on agricultural costs in 1972 as determined by survey and major checking w/Agricultural Engineers, including several at Ohio State University.

REFERENCES:

Donald L. Miles - Agricultural Extension Agent for Colorado
Wright-McLaughlin Engineers

FINAL UNIT COST USED: $445/acre (CARDINGTON-BENNINGTON SOILS--COMPOSITE)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item: ____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 5 OF 6
FOR COLUMN #: 26 JOB NO. 712-70
ITEM: Tile - Cardington-Bennington Soils--Mini-Border System BY RLT DATE 9-18-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____
B. General Component Heading:
Transmission Facilities ____ Irrigation System ____
Storage Reservoirs ____ Drainage X
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Tile - Cardington-Bennington Soils Column: 26
Name

COMPUTATION:

CARDINGTON-BENNINGTON SOILS--MINI-BORDER CONCEPT

Use 30' spacing.
Same as Hay & Pasture.

EXPLANATION:

See above: Tile costs are based on agricultural costs in 1972 as determined by survey and major checking w/Agricultural Engineers, including several at Ohio State University.

REFERENCES:

Donald L. Miles - Agricultural Extension Agent for Colorado
Wright-McLaughlin Engineers

FINAL UNIT COST USED: $350/acre (CARDINGTON-BENNINGTON SOILS--MINI-BORDER CONCEPT)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation — Phase: 2 — Sub - Item: ____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS — SHEET NO. 6 OF 6
FOR COLUMN #: 26 — JOB NO. 712-70
ITEM: Tile - Chili Soils — BY RLT DATE 9-18-72

A. Cost Type: Capital Cost X — Operation & Maintenance (O&M) ____
B. General Component Heading:
Transmission Facilities ____ — Irrigation System ____
Storage Reservoirs ____ — Drainage X
Land Treatment Site ____ — Miscellaneous ____

C. Cost Item: Tile - Chili Soils (Name) — Column: 26

COMPUTATION:

CHILI SOILS

Use application rate of 60"/yr.

Use spacing of 60' @ $5\frac{1}{2}$-foot depth

Length = $\frac{43,560}{60}$ = 726 ft.

Cost of 4" Tile (726') = \$290/acre
Add \$90/acre for collectors, structures, etc. = \$ 90/acre
TOTAL \$380/acre

EXPLANATION:

All of the Chili soils may not require tile drainage, depending on the topography. For example, on steep terrain tile drainage may be limited to the low-lying lands.

REFERENCES:

Table III, Practical Installation of Clay, Concrete and Corrugated Plastic Subsurface Drains, by Lyman S. Willardson. Also conversation with Dr. Willardson.

FINAL UNIT COST USED: \$380/acre (CHILI SOILS)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1

FOR COLUMN #: 27 JOB NO. 71- -70

ITEM: Conduits and Canals BY KRW DATE 9-16-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____

B. General Component Heading:

Transmission Facilities ____ Irrigation System ____

Storage Reservoirs ____ Drainage X

Land Treatment Site ____ Miscellaneous ____

C. Cost Item Conduits and Canals (Name) Column: 27

COMPUTATION:

Cost of construction will be an average of $25/acre over and above drainage unit costs.

EXPLANATION:

Conduits will be required to convey return flow to suitable discharge points. Canals will be used where volumes are large. Hydrological studies in western Ohio show stream regimes to be generally suitable.

REFERENCES:

Based on evaluation of typical units and topographical maps, and on hydrological study of streams.

FINAL UNIT COST USED CAPITAL COST: $25/acre

(Revision as of 9-14-72)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY

CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS

FOR COLUMN #: 28 SHEET NO. 1 OF 2

ITEM: JOB NO. 712 - 70

Sludge Management (In-Basin) BY LAL DATE 9-21-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ______

B. General Component Heading:

Transmission Facilities ______ Irrigation System ______

Storage Reservoirs ______ Drainage ______

Land Treatment Site ______ Miscellaneous ______

C. Cost Item Sludge Management (In-Basin) Column: 28

Name

COMPUTATION:

Costs based upon the storage capacity needed for winter months. (No costs were included for land or equipment as they are included under land acquisition and treatment costs.)

EXPLANATION:

Sludge produced was converted to gallonage. Use Curve K to obtain cost at that volume.

REFERENCES:

Wright-McLaughlin Engineers

FINAL UNIT COST USED: Use Curve K to Determine Costs of Sludge Management Facilities In-Basin.

Land Treatment/Formulation Phase: 2 Sub - Item: ____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS

FOR COLUMN #: 28 SHEET NO. 2 OF 2

ITEM: Sludge Management (Strip Mined Areas) JOB NO. 712-70

BY LAL DATE 9-21-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____

B. General Component Heading:

Transmission Facilities ____ Irrigation System ____

Storage Reservoirs ____ Drainage ____

Land Treatment Site ____ Miscellaneous ____

C. Cost Item Sludge Management (Strip M. Areas) Column: 28
Name

COMPUTATION:

EXPLANATION:

Capital Cost for sludge management to STRIP MINED AREAS based on:

1. Pipeline Easement
2. Pipeline
3. Pump Stations
4. Storage Reservoirs
5. Distribution Piping
6. Trucks
7. Application Equipment

REFERENCES:

"Bulk Transport of Waste Slurries to Inland and Ocean Disposal Sites," Bechtel Corporation, Sept. 1969
Wright-McLaughlin Engineers

FINAL UNIT COST USED: Use Curve L to Determine Cost of Facilities for Sending Sludge to Strip Mined Areas.

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item: ____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS

FOR COLUMN #: 29 SHEET NO. 1 OF 1

ITEM: Miscellaneous JOB NO. 712 - 70

BY KRW DATE 9-16-72

A. Cost Type: *Capital Cost* X *Operation & Maintenance (O&M)* ____

B. General Component Heading:

Transmission Facilities ____ Irrigation System ____

Storage Reservoirs ____ Drainage ____

Land Treatment Site ____ Miscellaneous X

C. Cost Item Miscellaneous (Name) Column: 29

COMPUTATION:

Computed at 5 percent of irrigation & drainage capital costs. (Cols. 23 thru 27)

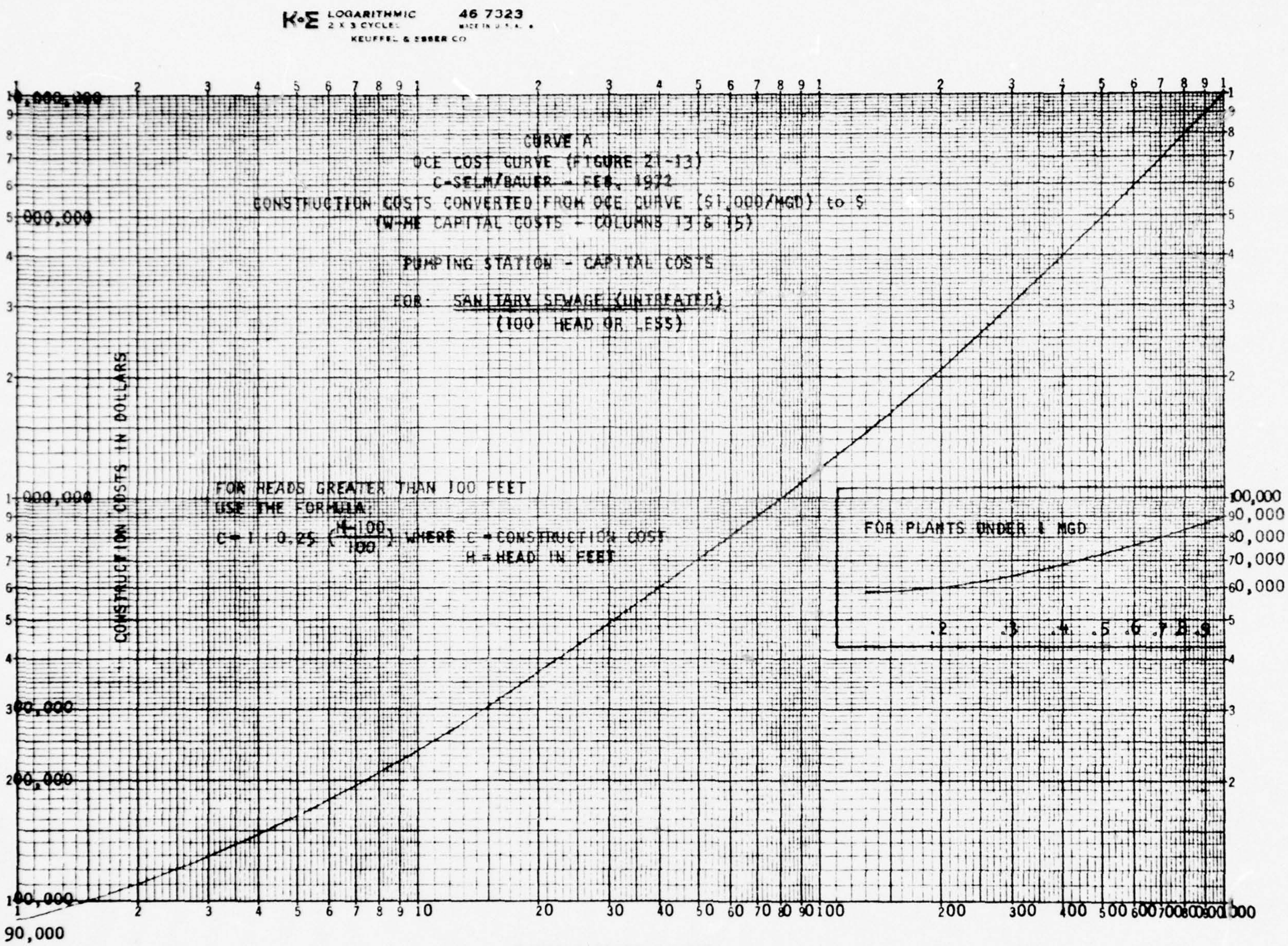
EXPLANATION:

Miscellaneous includes capital cost for administration building, monitoring holes for ground water, also outside electrical costs not already included in other major components and laboratories.

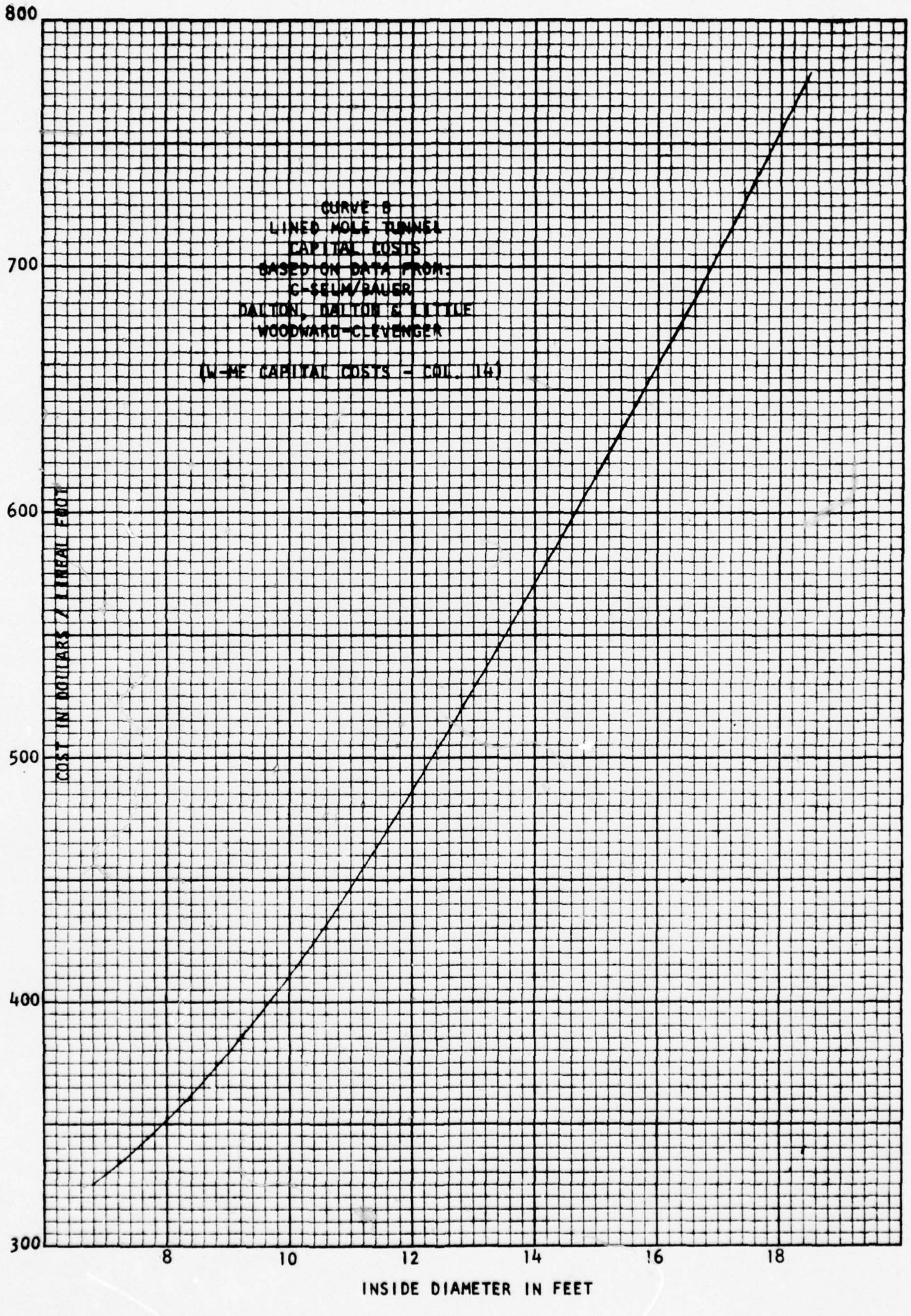
REFERENCES:

Wright-McLaughlin Engineers
Bauer Engineering

FINAL UNIT COST USED: 5 percent of Irrigation & Drainage Cost (Cols. 23 thru 27)

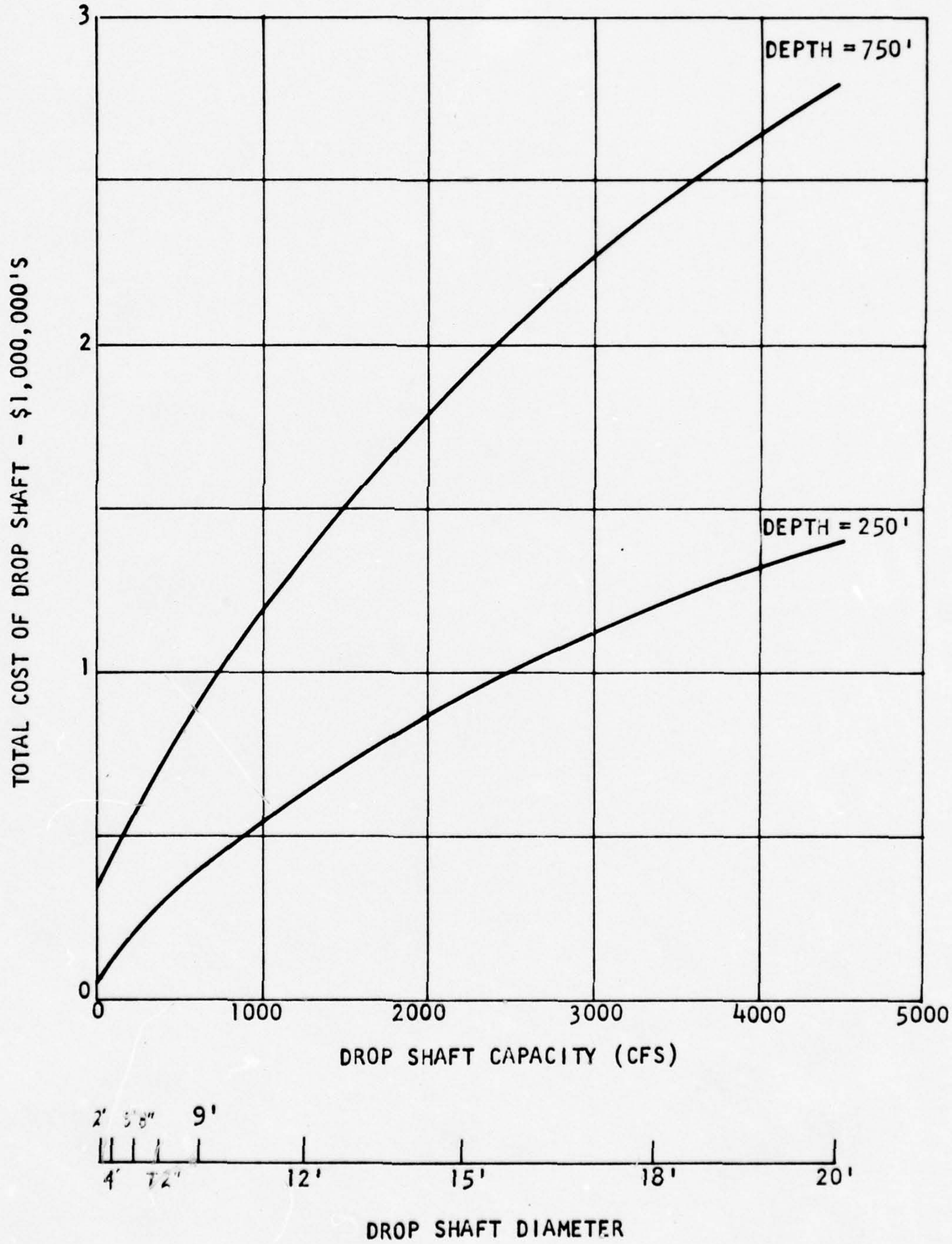

K·E LOGARITHMIC 2 X 3 CYCLES KEUFFEL & ESSER CO.
46 7323
CURVE A
OCE COST CURVE (FIGURE 21-13)
C-SELM/BAUER - FEB. 1972
CONSTRUCTION COSTS CONVERTED FROM OCE CURVE ($1,000/MGD) to $
(W-HE CAPITAL COSTS - COLUMNS 13 & 15)
PUMPING STATION - CAPITAL COSTS
FOR: SANITARY SEWAGE (UNTREATED)
(100' HEAD OR LESS)
FOR HEADS GREATER THAN 100 FEET
USE THE FORMULA:
C = 1 + 0.25 (H-100 / 100) WHERE C = CONSTRUCTION COST
H = HEAD IN FEET
FOR PLANTS UNDER 1 MGD
CONSTRUCTION COSTS IN DOLLARS
1,000,000
500,000
100,000
300,000
200,000
90,000
60,000
70,000
80,000
PUMPING PLANT IN MGD

CURVE A


CURVE B
LINED MOLE TUNNEL
CAPITAL COSTS
BASED ON DATA FROM:
C-SELM/BAUER
DALTON, DALTON & LITTLE
WOODWARD-CLEVENGER
(W-ME CAPITAL COSTS - COL. 14)
COST IN DOLLARS / LINEAL FOOT
800
700
600
500
400
300
8
10
12
14
16
18
INSIDE DIAMETER IN FEET

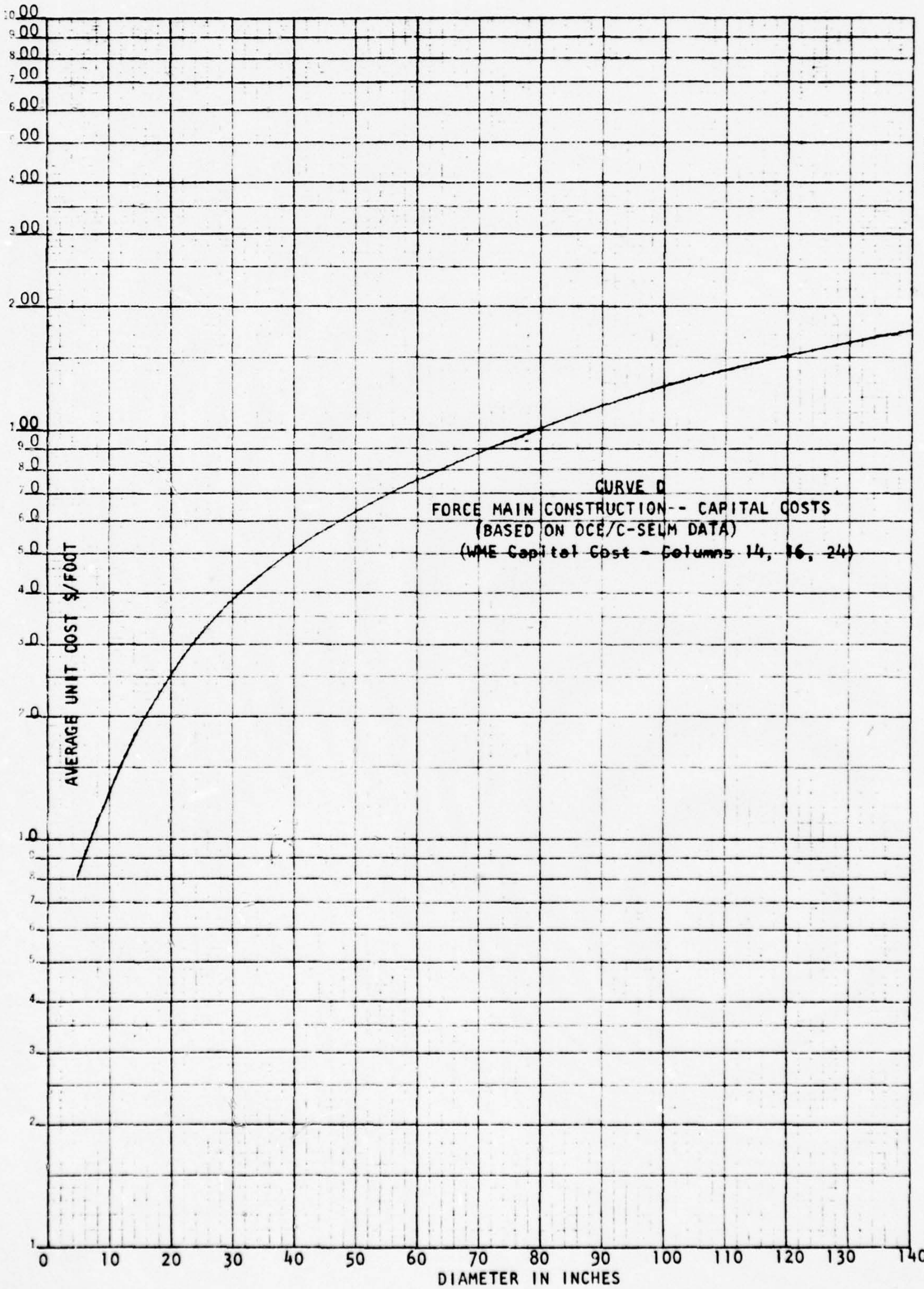
CURVE B

CURVE C
OCE, FIGURE 21-14
C-SELM, BAUER
(WME CAPITAL COSTS - COLS. 14 & 15)

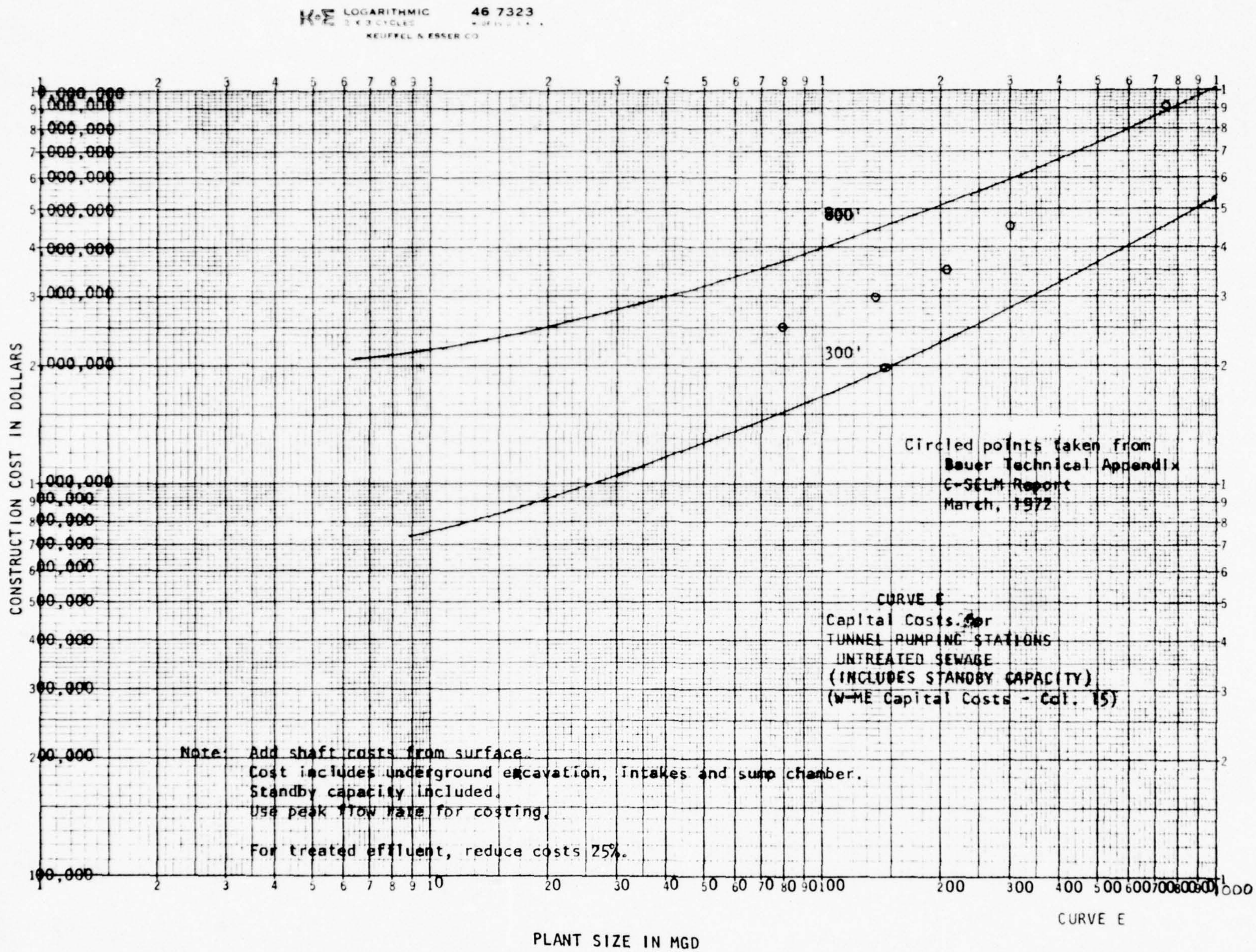


CURVE C

CURVE D



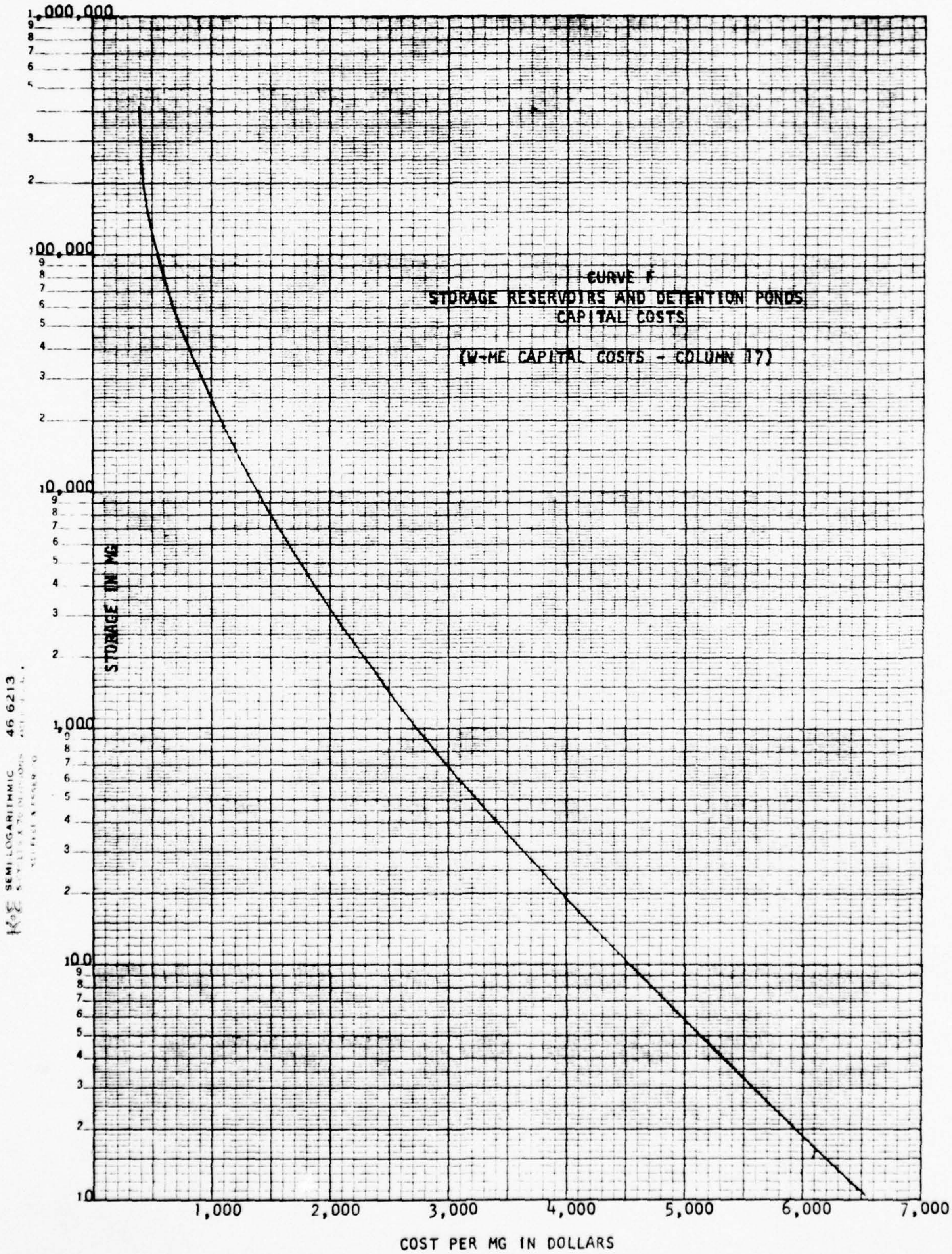
CURVE D
FORCE MAIN CONSTRUCTION-- CAPITAL COSTS
(BASED ON OCE/C-SELM DATA)
(WME Capital Cost - Columns 14, 16, 24)
AVERAGE UNIT COST $/FOOT
DIAMETER IN INCHES
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00

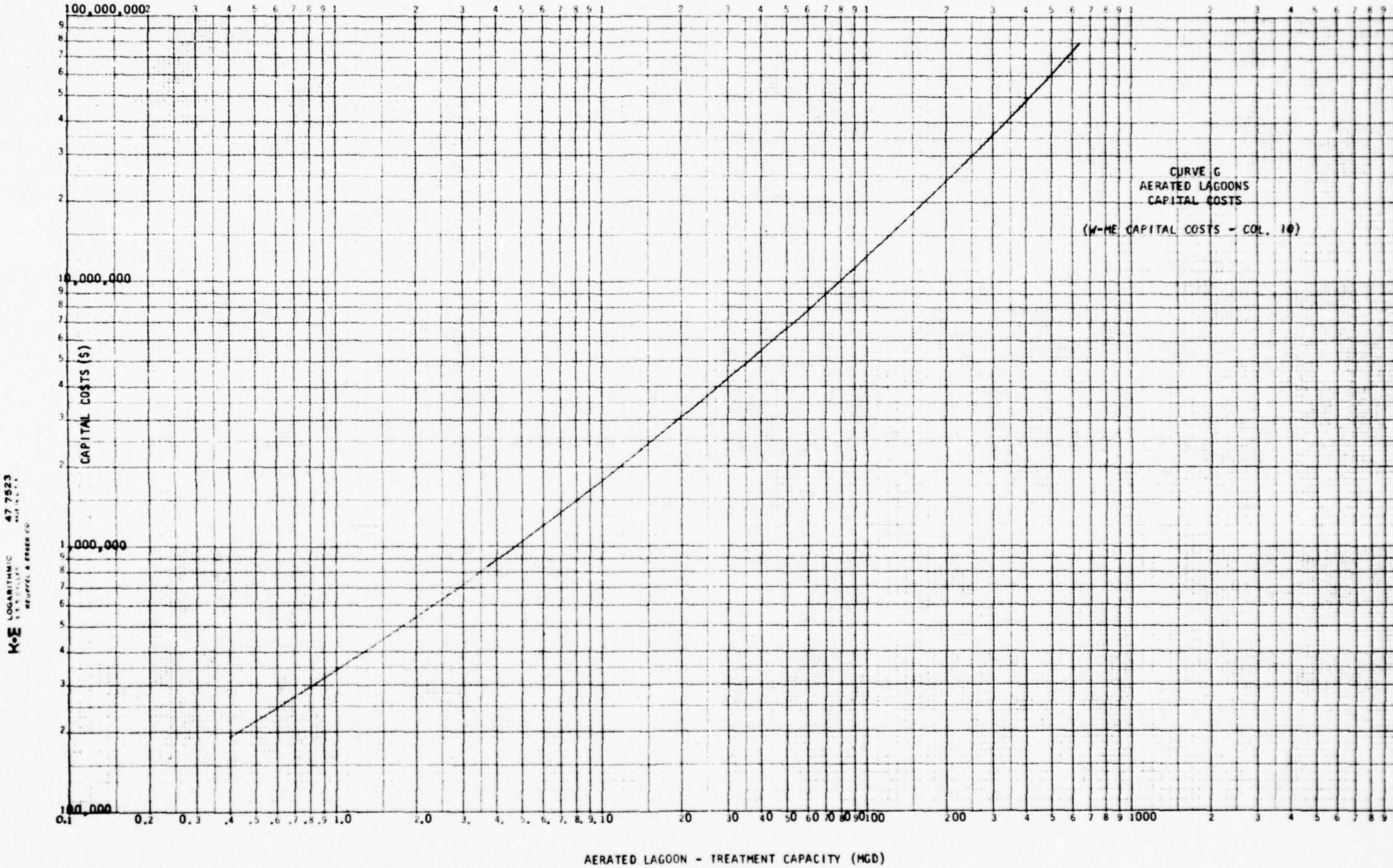


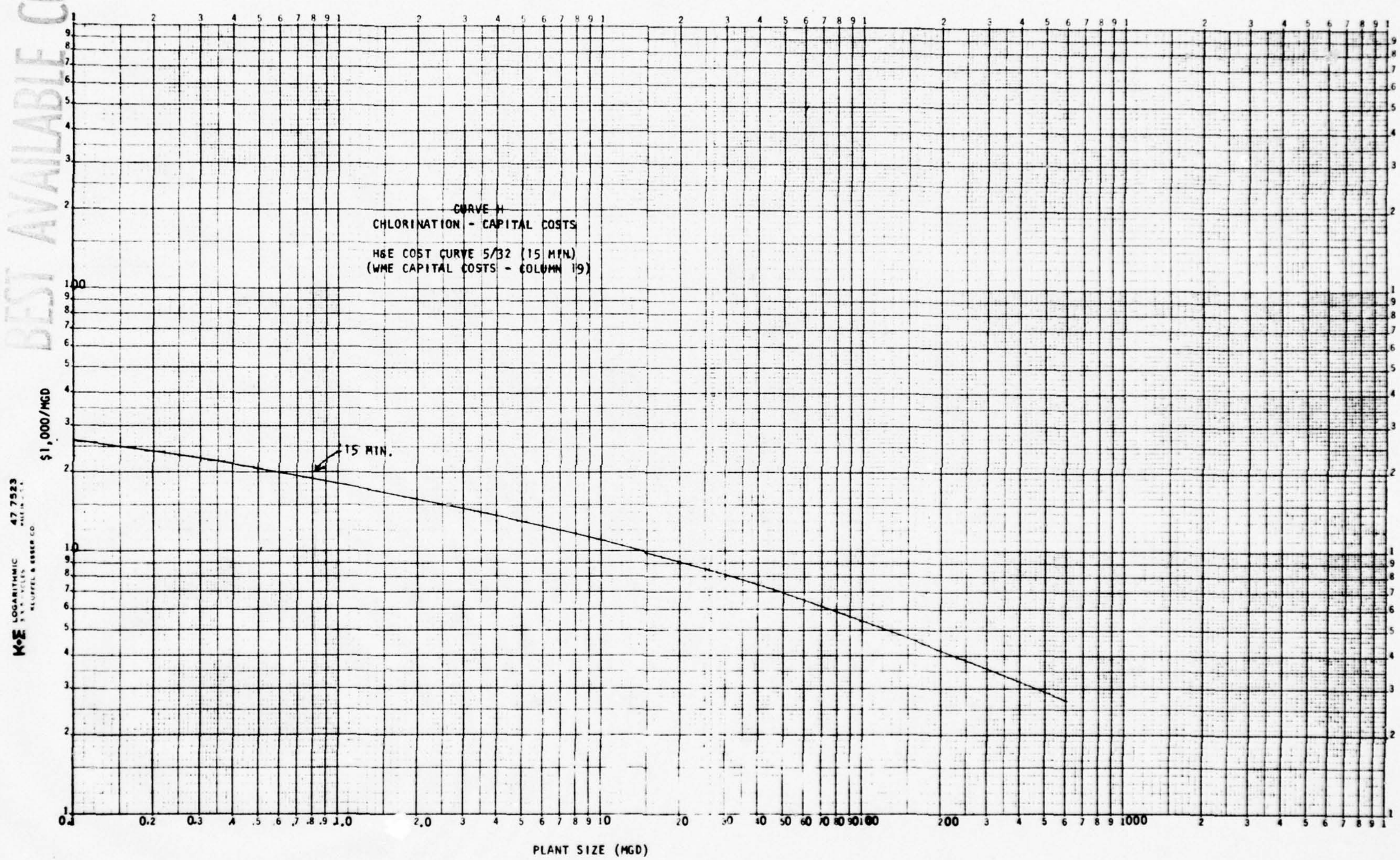
K+E LOGARITHMIC 46 7323
KEUFFEL & ESSER CO.
CONSTRUCTION COST IN DOLLARS
10,000,000
9,000,000
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
800'
300'
Circled points taken from
Bauer Technical Appendix
C-SELM Report
March, 1972
CURVE E
Capital Costs for
TUNNEL PUMPING STATIONS
UNTREATED SEWAGE
(INCLUDES STANDBY CAPACITY)
(W-ME Capital Costs - Col. 15)
Note: Add shaft costs from surface.
Cost includes underground excavation, intakes and sump chamber.
Standby capacity included.
Use peak flow rate for costing.
For treated effluent, reduce costs 25%.
1
10
20
30
40
50
60
70
80
90
100
200
300
400
500
600
700
800
900
1000
PLANT SIZE IN MGD

CURVE E

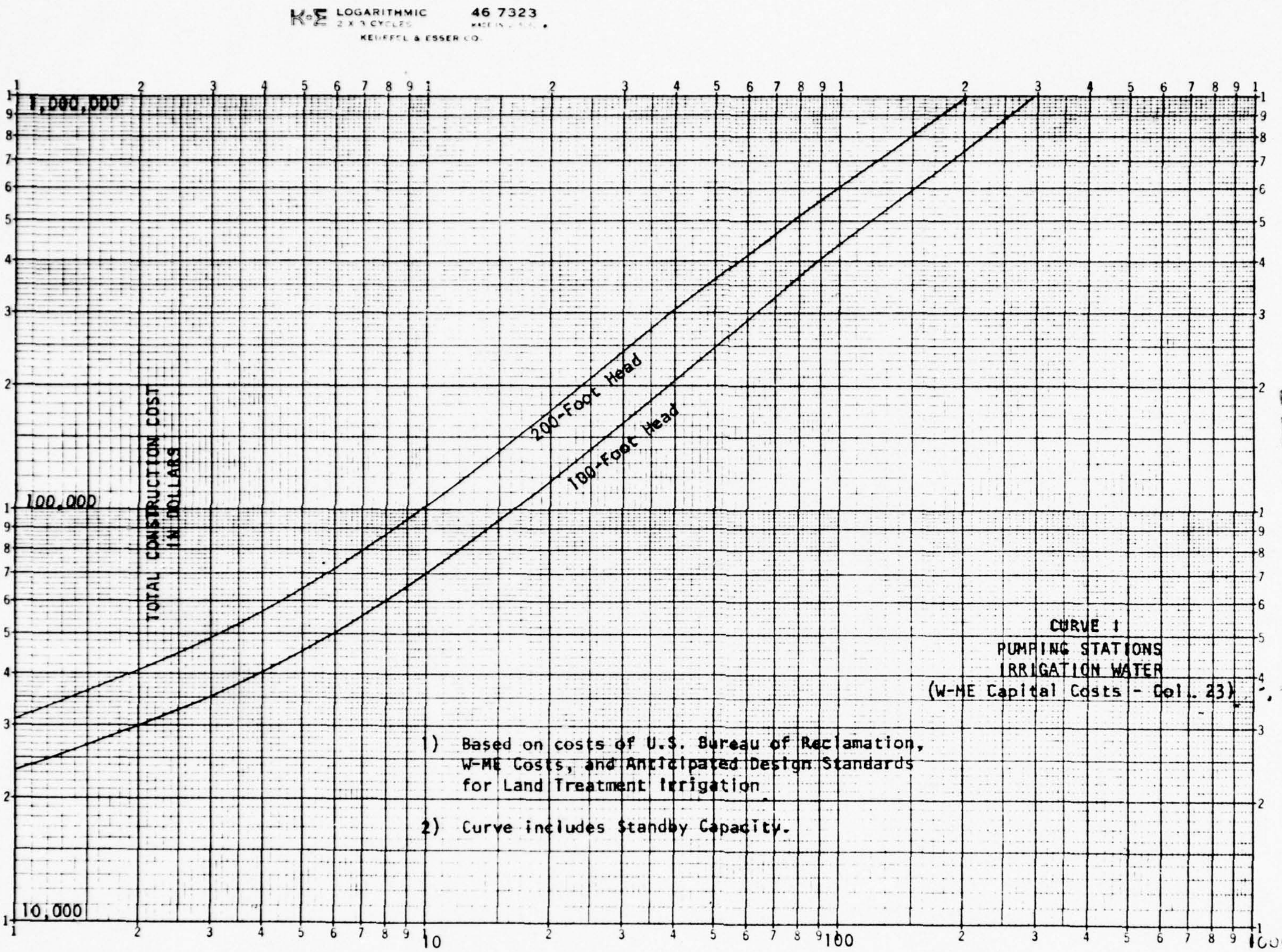
CURVE F


CURVE F
STORAGE RESERVOIRS AND DETENTION PONDS
CAPITAL COSTS
(W-ME CAPITAL COSTS - COLUMN 17)
STORAGE IN MG
COST PER MG IN DOLLARS
1,000,000
100,000
10,000
1,000
100
10
1,000
2,000
3,000
4,000
5,000
6,000
7,000
SEMI-LOGARITHMIC 46 6213


CURVE G
AERATED LAGOONS
CAPITAL COSTS
(W-ME CAPITAL COSTS - COL. 10)
CAPITAL COSTS ($)
100,000,000
10,000,000
1,000,000
100,000
AERATED LAGOON - TREATMENT CAPACITY (MGD)
0.1
0.2
0.3
1.0
2.0
10
20
30
40
50
60
100
200
1000

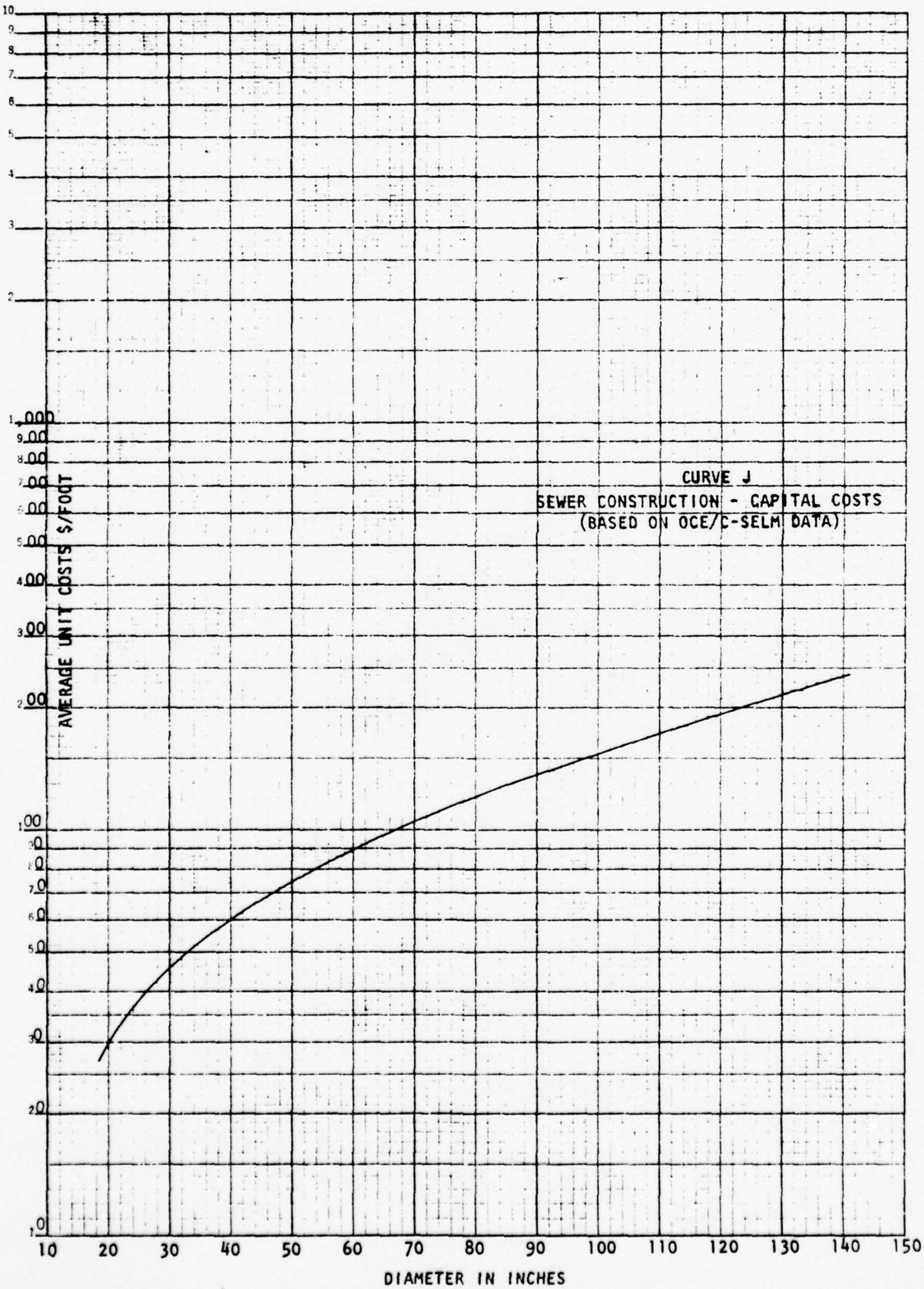

CURVE H
CHLORINATION - CAPITAL COSTS
H&E COST CURVE 5/32 (15 MIN.)
(WME CAPITAL COSTS - COLUMN 19)
15 MIN.
$1,000/MGD
PLANT SIZE (MGD)
K+E LOGARITHMIC 47 7523
KEUFFEL & ESSER CO.

CURVE H


K+E LOGARITHMIC 2 X 3 CYCLES KEUFFEL & ESSER CO. 46 7323
1,000,000
100,000
10,000
TOTAL CONSTRUCTION COST IN DOLLARS
200-Foot Head
100-Foot Head
CURVE I
PUMPING STATIONS
IRRIGATION WATER
(W-ME Capital Costs - Col. 23)
1) Based on costs of U.S. Bureau of Reclamation, W-ME Costs, and Anticipated Design Standards for Land Treatment Irrigation
2) Curve includes Standby Capacity.
10
100
1000
PUMPING CAPACITY IN MGD

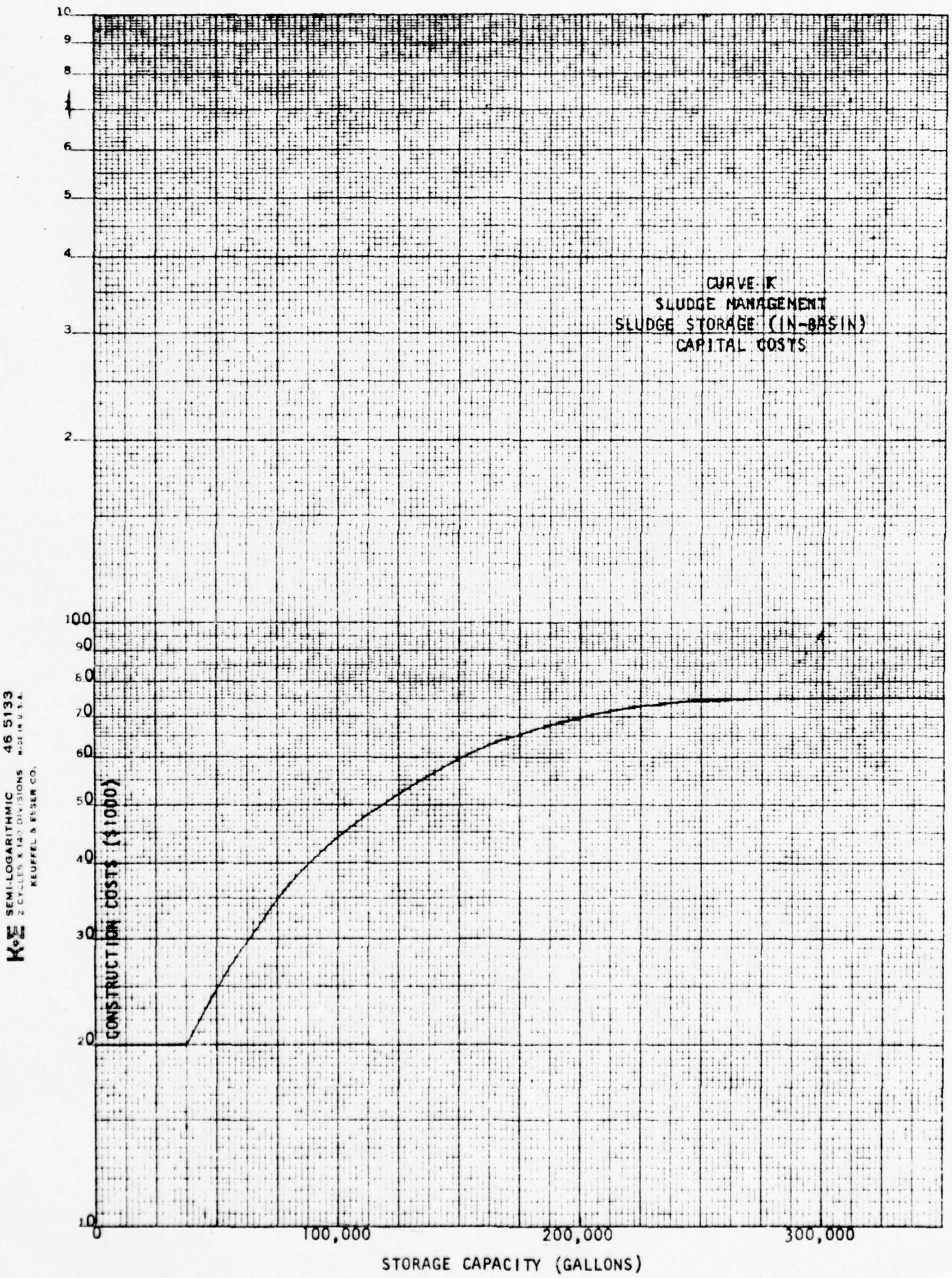
CURVE I

CURVE J

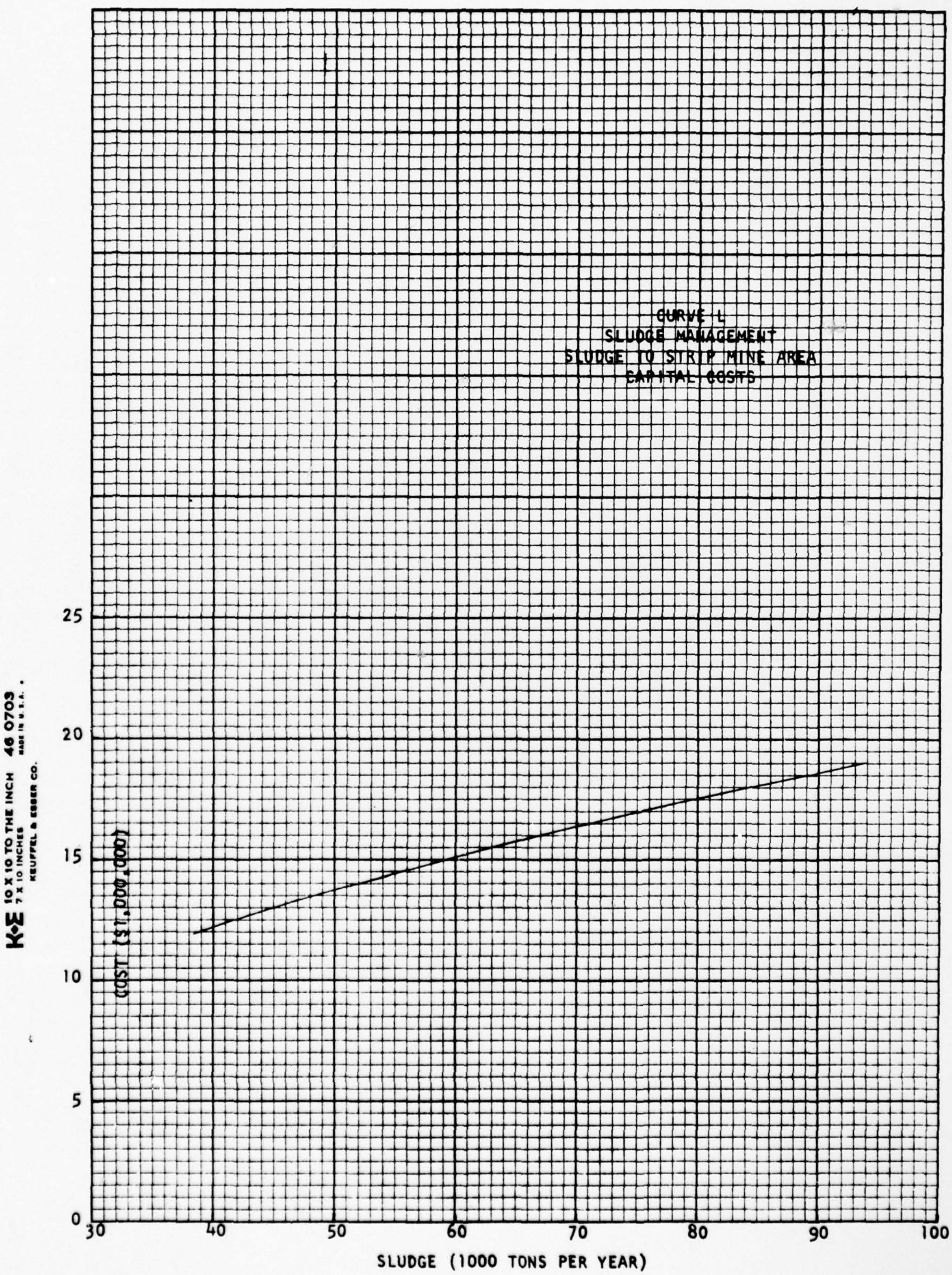


CURVE J
SEWER CONSTRUCTION - CAPITAL COSTS
(BASED ON OCE/C-SELM DATA)
AVERAGE UNIT COSTS $/FOOT
1,000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
DIAMETER IN INCHES

CURVE K


CURVE K
SLUDGE MANAGEMENT
SLUDGE STORAGE (IN-BASIN)
CAPITAL COSTS
CONSTRUCTION COSTS ($1000)
STORAGE CAPACITY (GALLONS)
0
100,000
200,000
300,000
10
20
30
40
50
60
70
80
90
100
2
3
4
5
6
8
9
10
K&E SEMI-LOGARITHMIC 46 5133
2 CYCLES X 140 DIVISIONS
KEUFFEL & ESSER CO.

CURVE L


CURVE L
SLUDGE MANAGEMENT
SLUDGE TO STRIP MINE AREA
CAPITAL COSTS
COST ($1,000,000)
0
5
10
15
20
25
30
40
50
60
70
80
90
100
SLUDGE (1000 TONS PER YEAR)
K+E 10 X 10 TO THE INCH 46 0703
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

OPERATION & MAINTENANCE COSTS

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 1 OF 1
FOR COLUMN #: 1-6   JOB NO. 712-70
ITEM: Basic Data   BY GGR   DATE 9-20-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ____ Irrigation System ____
Storage Reservoirs ____ Drainage ____
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Basic Data (Used in Costing) Column: 1-6
Name

The basic data shown in columns 1-6, as well as the costs compiled under the Capital Costs Section contained herein, were used to determine the various Operation and Maintenance unit costs which follow in this O&M Costs Section.

(See Capital Cost Sheet covering columns 1-6 for explanation of individual column items.)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 1 OF 1
FOR COLUMN #: 7-11   JOB NO. 712 - 70
ITEM: Treatment (In Plants or Aerated Lagoons)   BY GGR   DATE 9-20-72

A. Cost Type   Capital Cost ____   Operation & Maintenance (O&M) X

B. General Component Heading:
Treatment Facilities X   Irrigation System ____
Transmission Facilities ____   Drainage ____
Storage Reservoirs ____   Miscellaneous ____
Land Treatment Site ____

C. Cost Item: Treatment (In Plants or Aerated Lagoons)   Column: 7-11
Name

COMPUTATION:

All O&M costs for sewage treatment plants are supplied by Havens & Emerson except those for Aerated Lagoons. (See the computation sheets for Column 10 - Aerated Lagoons, which follow.)

Aerated Lagoons were used for 3 plants in Plan 9A and all plants in Plan 12.

EXPLANATION:

REFERENCES:

Havens & Emerson - Secondary, Tertiary and Advanced Wastewater Treatment Plant Costs
Wright-McLaughlin Engineers - Aerated Lagoon Costs

FINAL UNIT COST USED: All costs supplied by Havens and Emerson except as in Plans 9A & 12

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation — Phase: 2 — Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS — SHEET NO. 1 OF 3
FOR COLUMN #: 10A (Treatment) — JOB NO. 72 - 70
ITEM: Aerated Lagoons - Power — BY HAB — DATE 9-20-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ____ Irrigation System ____
Storage Reservoirs ____ Drainage ____
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Aerated Lagoons - Power (Name) Column: 10A

COMPUTATION:

For both IN-BASIN and OUT-OF-BASIN:

$7,550 x Total ADF (MGD)

Note: For Plan 9A, 3 plants which were costed individually have aerated lagoons; these costs were included in land treatment costs. In Plan 12 all plants were costed with aerated lagoons.

EXPLANATION:

Power costs for aeration include mixing and oxygen transfer. W-ME computed detailed horsepower requirements.

REFERENCES:

Wright-McLaughlin Engineers

FINAL UNIT COST USED: $7,550 x Total ADF (MGD)

NOTE: For Plans 9A and 12 only.

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/~~Formulation~~ Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS — SHEET NO. 2 OF 3
FOR COLUMN #: 10B (Treatment) — JOB NO. 712 - 70
ITEM: Aerated Lagoons - Maintenance and Labor — BY HAB DATE 9-20-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ____ Irrigation System ____
Storage Reservoirs ____ Drainage ____
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Aerated Lagoons - Maint. & Labor (Name) Column: 10B

COMPUTATION:

3% of Capital Cost

Note: For Plan 9A, 3 plants which were costed individually have aerated lagoons; these costs were included in land treatment costs. In Plan 12 all plants were costed with aerated lagoons.

EXPLANATION:

Typical maintenance and labor figures based on W-ME experience were also used for comparison.

REFERENCES:

Wright-McLaughlin Engineers

FINAL UNIT COST USED: 3% of Capital Cost

NOTE: For Plans 9A and 12 only.

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ____________

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 3 OF 3
FOR COLUMN #: 10C (Treatment)   JOB NO. 712 - 70
ITEM: Chlorination - Aerated Lagoons - Maint. & Labor (Power Negligible)   BY HAB   DATE 9-20-72

A. Cost Type: Capital Cost ____   Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ____   Irrigation System ____
Storage Reservoirs ____   Drainage ____
Land Treatment Site ____   Miscellaneous ____

C. Cost Item: Chlorination - Aerated Lagoons   Column: 10C
Name

COMPUTATION:

In-Basin	$3,650 x Total ADF (MGD)
Out-of-Basin	$2,500 x Total ADF (MGD)

Note: For Plan 9A, 3 plants which were costed individually have aerated lagoons; these costs were included in land treatment costs. In Plan 12 all plants were costed with aerated lagoons.

EXPLANATION:

OCE and H&E curves for O&M were used to arrive at these two conversions. The Out-of-Basin unit costs are less because larger systems are used.

REFERENCES:
Havens and Emerson
OCE

FINAL UNIT COST USED: $3,650 x Total ADF (MGD), In-Basin
$2,500 x Total ADF (MGD), Out-of-Basin
NOTE: For Plans 9A and 12 only.

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation — Phase: 2 — Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS — SHEET NO. 1 OF 2
FOR COLUMN #: 13A — JOB NO. 712-70
ITEM: Pump Station -- Power — BY HAB DATE 9-21-72

A. Cost Type: Capital Cost ______ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities X — Irrigation System ______
Storage Reservoirs ______ — Drainage ______
Land Treatment Site ______ — Miscellaneous ______

C. Cost Item: Pump Station -- Power (Name) — Column: 13A

COMPUTATION:

No In-Basin facilities

Out-of-Basin = $2,100 x Total ADF (MGD)

EXPLANATION:

Cost is based upon TDH of 100'.

Basic data ($.0121/kwhr and 65% wire to water efficiency used to provide costs consistent and comparable to costs provided by H&E.)

As a check, the maintenance and labor was added to the power and compared to annual O&M costs for pumping stations as provided by H&E. The total W-ME O&M costs were also checked against OCE curves.

REFERENCES:

$.0121/kwhr and 65% wire to water efficiency -- Havens & Emerson
Curve for Annual Power Costs by Wright-McLaughlin Engineers
ADF - computed by W-ME and H&E
TDH - W-ME computations for individual plans

FINAL UNIT COST USED: $2,100 x total ADF (MGD)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 2 OF 2
FOR COLUMN #: 13B   JOB NO. 712 - 70
ITEM: PUMP STATION - MAINTENANCE AND LABOR   BY HAB   DATE 9/21/72

A. Cost Type: Capital Cost ____   Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities X   Irrigation System ____
Storage Reservoirs ____   Drainage ____
Land Treatment Site ____   Miscellaneous ____
C. Cost Item MAINTENANCE AND LABOR EXCLUDING POWER (Name)   Column: 13B

COMPUTATION: FOR OUT-OF-BASIN PUMP STATIONS . . . . . . 5% of Capital Cost

EXPLANATION: For annual maintenance and labor costs of pump stations, excluding power, 5% of the capital cost was used. This was obtained from expenses for given sized plants in Colorado based on past experience. As a check, maintenance and labor costs were added to power costs and compared to annual total O&M costs for pumping stations as defined by Havens and Emerson.

REFERENCES: See Sheet 1 of 2.

FINAL UNIT COST USED: 5 Percent of Capital Cost

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS

FOR COLUMN #: 14, 16 and 24 SHEET NO. 1 OF 1

JOB NO. 712-70

ITEM: Force Main, Drop Shaft, Tunnel - Maintenance & Labor BY HAB DATE 8-20-72

A. Cost Type: Capital Cost ______ Operation & Maintenance (O&M) X

B. General Component Heading:
Transmission Facilities X
Storage Reservoirs ______
Land Treatment Site ______
Irrigation System X
Drainage ______
Miscellaneous ______

C. Cost Item: Force Main, Drop Shaft, Tunnel (Name) Column: 14, 16 and 24

COMPUTATION:

1/2% of Capital Cost

EXPLANATION:

The 1/2% rate was obtained from Havens & Emerson. This percentage was used for force mains, drop shafts, and tunnel costs in order to provide costs consistent and comparable to costs by Havens & Emerson.

REFERENCES:

Havens & Emerson

FINAL UNIT COST USED: 1/2% of Capital Cost

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation — Phase: 2 — Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS — SHEET NO. 1 OF 2
FOR COLUMN #: 15A — JOB NO. 712-70
ITEM: Secondary Pump Plant - Power — BY HAB — DATE 9-21-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities X — Irrigation System ____
Storage Reservoirs ____ — Drainage ____
Land Treatment Site ____ — Miscellaneous ____

C. Cost Item: Secondary Pump Plant - Power (Name) — Column: 15A

COMPUTATION:

In-Basin = $5,550 x Total ADF (MGD)

Out-of-Basin = $15,000 x Total ADF (MGD)

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EXPLANATION:

In-Basin TDH = 265'
Out-of-Basin TDH = 720'

Basic data ($.0121/kwhr and 65% wire to water efficiency) used to provide costs consistent and comparable to costs provided by H&E.

As a check, the maintenance and labor was added to the power and compared to annual O&M costs for pumping stations as provided by H&E. The total W-ME O&M costs were also checked against OCE curves.

REFERENCES:

$.0121/kwhr and 65% wire to water efficiency -- Havens & Emerson
Curve for Annual Power Costs by Wright-McLaughlin Engineers
ADF - computed by Wright-McLaughlin Engineers and Havens & Emerson
TDH - Wright-McLaughlin Engineers computations for individual plans

FINAL UNIT COST USED: $5,550 x Total ADF (MGD), In-Basin
$15,000 x Total ADF (MGD), Out-of-Basin

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 2 OF 2
FOR COLUMN #: 15B JOB NO. 712-70
ITEM: Secondary Pump Plant - Maintenance and Labor BY HAB DATE 9-21-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities X
Storage Reservoirs ____
Land Treatment Site ____
Irrigation System ____
Drainage ____
Miscellaneous ____

C. Cost Item: Secondary Pump Plant - Maint. & Labor (Name) Column: 15B

COMPUTATION:

For In-Basin Pump Stations . . . . . . 5% of Capital Cost

For Out-of-Basin Pump Stations . . . . 3% of Capital Cost

EXPLANATION:

For annual maintenance and labor costs of pump stations, excluding power, 5% of the capital cost was used for in-basin stations and 3% of the capital cost for stations out-of-basin. This was obtained from expenses for given sized plants in Colorado based on past experience. As a check, maintenance and labor costs were added to power costs and compared to total annual O&M costs for pumping stations as defined by Havens and Emerson. Out-of-Basin costs are less because the pump station capital costs included shafts and other related items which would have an O&M of approximately 1/2% x capital.

REFERENCES:

See Sheet 1 of 2.

FINAL UNIT COST USED: 5% of Capital Cost, In-Basin
3% of Capital Cost, Out-of-Basin

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 17 JOB NO. 712-70
ITEM: Reservoir - Maintenance & Labor BY HAB DATE 9-20-72

A. Cost Type: Capital Cost ______ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ______ Irrigation System ______
Storage Reservoirs X Drainage ______
Land Treatment Site ______ Miscellaneous ______

C. Cost Item: Reservoir - Maintenance & Labor Column: 17
Name

COMPUTATION:

1/2% of Capital Cost

EXPLANATION:

Based on O&M cost for force mains and shafts plus general experience with similar type reservoirs.

REFERENCES:

Wright-McLaughlin Engineers

FINAL UNIT COST USED: 1/2% of Capital Cost

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation — Phase: 2 Sub - Item: ____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS — SHEET NO. 1 OF 1
FOR COLUMN #: 18A - Power; 18B - Maintenance & Labor — JOB NO. 712-70
ITEM: Aeration — BY HAB DATE 9-21-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X

B. General Component Heading:

Transmission Facilities ____	Irrigation System ____
Storage Reservoirs X	Drainage ____
Land Treatment Site ____	Miscellaneous ____

C. Cost Item: Aeration - Power/Maint.& Labor (Name) Column: 18A and 18B

COMPUTATION:

For Plans 9A and 12
In-Basin
Power = $20 x Storage Reservoir Volume in MG

Maintenance and Labor:

$20 x Storage Reservoir Volume in MG

Out-of-Basin and in reservoirs for stormwater runoff in-basin there is no aeration of storage reservoirs.

EXPLANATION:

In-Basin, Plans 9A and 12 -- Power was determined by W-ME.

REFERENCES:

Wright-McLaughlin Engineers

FINAL UNIT COST USED: $20 x Storage Reservoir Volume in MG for Power and
$20 x Storage Reservoir Volume in MG for Maintenance & Labor

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 19B JOB NO. 712 - 70
ITEM: Chlorination - Maint. & Labor (Assumes Power Cost Negligible) BY HAB DATE 9-21-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ____ Irrigation System ____
Storage Reservoirs X Drainage ____
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Chlorination (Name) Column: 19B

COMPUTATION:

Effluent to storage reservoirs to land site treatment:
$1,825 x Total ADF (MGD)

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EXPLANATION:

This is 1/2 of the H&E and OCE chlorination O&M costs as the chlorine treatment concentration is less than 1/2 required for secondary treated sewage. This cost is equivalent to that used by Bauer Engineering.

REFERENCES:

OCE
Bauer Engineering

FINAL UNIT COST USED: $1,825 x Total ADF (MGD)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 1 OF 1
FOR COLUMN #: 20 and 22 (Col. 21 Cost was dropped)   JOB NO. 712 - 70
ITEM: Purchase & Relocation; Site Preparation   BY W-ME   DATE 9-22-72

A. Cost Type: Capital Cost ____   Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ____   Irrigation System ____
Storage Reservoirs ____   Drainage ____
Land Treatment Site X   Miscellaneous ____

C. Cost Item: Purchase & Relocation; Site Prep.   Column: 20 and 22
Name

THERE ARE NO OPERATION AND MAINTENANCE COSTS FOR THE FOLLOWING:

Component	Column
Land Treatment Site	
Purchase and Relocation	20
Site Preparation	22

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation — Phase: 2 — Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS — SHEET NO. 1 OF 2
FOR COLUMN #: 23A — JOB NO. 712-70
ITEM: Pump Station - Power — BY HAB — DATE 9-21-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ____ Irrigation System X
Storage Reservoirs ____ Drainage ____
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Pump Station - Power (Name) Column: 23A

COMPUTATION:

In-Basin = Wastewater: \$18 x acres
Separate Stormwater: \$36 x acres

Out-of-Basin = \$16 x acres

EXPLANATION: In-Basin
Wastewater - TDH = 150'
Average application rate = 75"
Stormwater - TDH = 150'
Average application rate = 150"
Out-of-Basin
TDH = 150'
Average application rate = 66"

Basic data (\$.0121/kwhr and 65% wire to water efficiency) used to provide costs consistent and comparable to costs provided by H&E. The total W-ME O&M costs were also checked against OCE curves.

REFERENCES:

\$.0121/kwhr and 65% wire to water efficiency - Havens & Emerson
ADF computed by Wright-McLaughlin Engineers and Havens & Emerson
TDH - Wright-McLaughlin Engineers computations for individual plans

FINAL UNIT COST USED: In-Basin Wastewater - \$18 x acres
In-Basin Separate Stormwater - \$36 x acres
Out-of-Basin - \$16 x acres

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY

CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item: ________

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 2 OF 2

FOR COLUMN #: 23B JOB NO. 712-70

ITEM: Pump Station - Maintenance and Labor BY W-ME DATE 9-21-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X

B. General Component Heading:

Transmission Facilities ____ Irrigation System X

Storage Reservoirs ____ Drainage ____

Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Pump Station - Maintenance & Labor (Name) Column: 23B

COMPUTATION:

For In-Basin Pump Stations . . . . . 5% of Capital Cost

For Out-of-Basin Pump Stations . . . 3% of Capital Cost

EXPLANATION:

For annual maintenance and labor costs of pump stations, excluding power, 5% of the capital cost was used for in-basin stations and 3% of the capital cost for stations out-of-basin. This was obtained from expenses for given sized plants in Colorado based on past experience. As a check, maintenance and labor costs were added to power costs and compared to total annual O&M costs for pumping stations as defined by Havens and Emerson.

REFERENCES:

See Sheet 1 of 2.

FINAL UNIT COST USED: 5% of Capital Cost In-Basin

3% of Capital Cost Out-of-Basin

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation — Phase: 2 — Sub - Item: ____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS — SHEET NO. 1 OF 1
FOR COLUMN #: 25 — JOB NO. 712 - 70
ITEM: Equipment and Distribution Piping - Maint. & Labor — BY HAB — DATE 9-21-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ____ Irrigation System X
Storage Reservoirs ____ Drainage ____
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Equipment and Distribution Piping (Name) — Column: 25

COMPUTATION:

In-Basin = \$4/acre

Out-of-Basin = \$10/acre

EXPLANATION:

Mini-border system used in-basin and some solid set system. Both would have same maintenance and labor costs. The \$10 rate reflects an increase due to higher labor and maintenance on pivot sprinklers.

REFERENCES:

Donald L. Miles - Agricultural Extension Agent for Colorado
Wright-McLaughlin Engineers

FINAL UNIT COST USED: \$4/acre In-Basin
\$10/acre Out-of-Basin

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item: ____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 26 JOB NO. 712 - 70
ITEM: Tile - Maintenance and Labor BY HAB DATE 9-21-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ____ Irrigation System ____
Storage Reservoirs ____ Drainage X
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Tile - Maintenance and Labor Column: 26
Name

COMPUTATION:

In-Basin = $4/acre

Out-of-Basin = $4.50/acre

EXPLANATION:

Maintenance is approximately 1% of Capital Cost.

REFERENCES:

Donald L. Miles - Agricultural Extension Agent for Colorado
Wright-McLaughlin Engineers

FINAL UNIT COST USED: In-Basin - $4/acre
Out-of-Basin - $4.50/acre

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 27 JOB NO. 712 - 70
ITEM: Conduits and Canals - Maintenance & Labor BY KRW DATE 9-16-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ____ Irrigation System ____
Storage Reservoirs ____ Drainage X
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Conduits and Canals (Name) Column: 27

COMPUTATION:

Cost of construction will be an average of $25/acre over and above drainage unit costs.

Maintenance and Labor cost for conduits and canals will be $2/acre.

EXPLANATION:

Conduits will be required to convey return flow to suitable discharge points. Canals will be used where volumes are large. Hydrological studies in western Ohio show stream regimes to be generally suitable. Based on evaluation of typical units and topographical maps, and on hydrological study of streams.

REFERENCES:

Wright-McLaughlin Engineers

FINAL UNIT COST USED: $2/acre
(Revision as of 9-14-72)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 28 JOB NO. 712-70
ITEM: Sludge Management (Includes Power Cost) BY HAB DATE 9-21-72

A. Cost Type: Capital Cost ______ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ______ Irrigation System ______
Storage Reservoirs ______ Drainage ______
Land Treatment Site ______ Miscellaneous ______

C. Cost Item: Sludge Management (Includes Power Cost) Column: 28
Name

COMPUTATION:

In-Basin
No O&M cost for separate stormwater derived sludge.
Plans 9A & 12 = \$750 x Total ADF (MGD)
All other plans = \$1200 x Total ADF (MGD)

Out-of-Basin
Plans 9A and 12 = \$750 x Total ADF (MGD)
All other plans = \$480 x Total ADF (MGD)

EXPLANATION:

The \$750/MGD is equivalent to \$25/ton for aerated lagoons. This was determined by W-ME based upon the required equipment and sludge disposal on land within approximately 6 miles.

The \$480/MGD rate is equivalent to \$16/ton which was obtained from the Bechtel Report on pipeline sludge disposal to strip mine areas.

The \$1200/MGD is equivalent to \$40/ton for In-Basin combined sludge disposal.

REFERENCES:

Wright-McLaughlin Engineers
Bechtel Corporation

FINAL UNIT COST USED: In-Basin - \$1200 x Total ADF (MGD)
In-Basin Plans 9A and 12 - \$750 x Total ADF (MGD)
Out-of-Basin - \$480 x Total ADF (MGD)
Out-of-Basin Plans 9A and 12 - \$750 x Total ADF (MGD)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation — Phase: 2 — Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS — SHEET NO. 1 OF 1
FOR COLUMN #: 29 — JOB NO. 712 - 70
ITEM: Miscellaneous - Maintenance & Labor — BY KRW DATE 9-16-72

A. Cost Type: Capital Cost ______ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ______ Irrigation System ______
Storage Reservoirs ______ Drainage ______
Land Treatment Site ______ Miscellaneous X

C. Cost Item: Miscellaneous - Maint. & Labor (Name) Column: 29

COMPUTATION:

Compute O&M as 10% of capital cost of this item.

EXPLANATION:

Miscellaneous includes capital cost for administration building, monitoring holes for ground water, also outside electrical costs not already included in other major components and laboratories.

REFERENCES:

Wright-McLaughlin Engineers

FINAL UNIT COST USED: 10% of Capital Cost as computed for Miscellaneous in Column 29

CONTINGENCIES

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation | Phase: 2 | Sub - Item: ____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS | SHEET NO. 1 OF 1
FOR COLUMN #: | JOB NO. 712 - 70
ITEM: Contingency | BY KRW DATE 9-16-72

A. Cost Type: Capital Cost X | Operation & Maintenance (O&M) ____
B. General Component Heading:
- Transmission Facilities ____
- Storage Reservoirs ____
- Land Treatment Site ____
- Irrigation System ____
- Drainage ____
- Miscellaneous ____

C. Cost Item Contingency (Name) | Column: ----

COMPUTATION:

1. A 20-percent contingency allowance will be added to the total cost estimate to allow for uncertainties.
2. An additional 5-percent will be added for engineering and design.
3. An additional 5-percent will be added for supervision and administration.

Total contingency added is 30 percent to capital costs.

EXPLANATION:

REFERENCES: Wastewater Management Program, "Study Procedure" by O.C.E. dated May 1, 1972.

FINAL UNIT COST USED: CAPITAL COSTS - 30%

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation   Phase: 2   Sub - Item: ______

UNIT COST CONTAINED IN DETAILED COSTING SHEETS   SHEET NO. 1 OF 1

FOR COLUMN #: --   JOB NO. 712 - 70

ITEM: Contingency   BY KRW   DATE 9-16-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X

B. General Component Heading:
- Transmission Facilities ____
- Storage Reservoirs ____
- Land Treatment Site ____
- Irrigation System ____
- Drainage ____
- Miscellaneous ____

C. Cost Item Contingency (Name)   Column: --

COMPUTATION:

1. For O&M, a 20% contingency will be added for uncertainties and overhead/administration, and control operations. (No E&D or S&A added to O&M)

EXPLANATION:

REFERENCES: Wastewater Management Program, "Study Procedure," by OCE dated May 1, 1972

FINAL UNIT COST USED: O&M Costs - 20%

SHEET A

DETAILED CAPITAL COSTS FOR PLAN ____

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. ____
Separately Treated S.R.O. Only . . . . ____

PERCENT OF GRAND TOTAL FOR CAPITAL COSTS: Municipal and Industrial. . . . . . . ____%
Combined and Separately-Sewered S.R.O. ____%

All costs in $1,000

	BASIC DESIGN DATA					TREATMENT FACILITIES						TRANSMISSION FACILITIES			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PLANT NAME	Detention Storage (MG)	Plant Capacity (MGD)	Raw Sludge (TPD)	Winter Storage (MG)	Acres	Detention Storage	Sewers	Pump Station	Plant	Sludge	Total Columns 7-11	Pump Plant	Force Main Drop Shaft Tunnel	Secondary Pump Plant	Force Main

DETAILED CAPITAL COSTS FOR PLAN ____

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. ____
Separately Treated S.R.O. Only . . . . ____

All costs in $1,000

	STORAGE RESERVOIR			LAND TREATMENT SITE			IRRIGATION SYSTEM			DRAINAGE SYSTEM			MISC.	
	17	18	19	20	21	22	23	24	25	26	27	28	29	30
PLAN NAME	Reservoir	Aeration	Chlorination	Purchase and Relocation		Site Preparation	Pump Station	Force Main	Equipment and Distribution Piping	Tile	Conduits and Canals	Sludge Management	Monitoring, Admin. & Labs., Elec.	Total Columns 7-29

Sheet A

D E T A I L E D   O P E R A T I O N   A N D   M A I N T E N A N C E   C O S T S   F O R   P L A N ____

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. ____
Separately Treated S.R.O. Only. . . . . ____

PERCENT OF GRAND TOTAL FOR O. & M. COSTS: Municipal and Industrial . . . . ____%
Combined and Separately-Sewered S.R.O. ____%

All costs in $1,000

	ASIC DESIGN DATA					TREATMENT FACILITIES						TRANSMISSION FACILITIES					
1	2	3	4	5	6	7	8	9	10	11	12	13		14	15		16
PLANT NAME	Detention Storage (MG)	Plant Capacity (MGD)	Raw Sludge (TPD)	Winter Storage (MG)	Acres	Detention Storage	Sewers	Pump Station	Plant	Sludge	Total Columns 7-11	Pump Plant		Force Main Drop Shaft Tunnel	Secondary Pump Plant		Force Main
												13A	13B	14	15A	15B	16
												Power	Maint & Labor	Maintenance & Labor	Power	Maint & Labor	Maintenance & Labor

DETAILED OPERATION AND MAINTENANCE COSTS FOR PLAN ____

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. ____
Separately Treated S.R.O. Only . . . . ____

All Costs in $1,000

	STORAGE RESERVOIR					LAND TREATMENT SITE			IRRIGATION SYSTEM				DRAINAGE SYSTEM				MISC.	
	17	18		19		20	21	22	23		24	25	26	27	28		29	30
	Reservoir	Aeration		Chlorination		Purchase and Relocation		Site Preparation	Pump Station		Force Main	Equipment & Distribution Piping	Tile	Conduits & Canals	Sludge Management		Monitoring, Admin. & Labs., Elec.	Total Columns 7-29
	17	18A	18B	19A	19B				23A	23B					28A	28B		
	Maintenance & Labor	Power	Maint. & Labor	Power	Maint. & Labor	No O & M		No O & M	Power	Maint. & Labor	Maintenance & Labor	Maint. & Labor	Maintenance & Labor	Maint. & Labor	Power	Maint. & Labor	Maint. & Labor	

SHEET (SAME FORM FOR A & B)

COMPARABLE ANNUAL COST INDEX — YEAR 2020
COST IN $ 1000

FORMULATION PLAN ____
LEVEL ____

WASTEWATER TOTAL SHEET A
COMBINED FLOW (SEE SHEET B FOR DETAILS)*
STORMWATER TOTAL SHEET B
* STORMWATER COST SEPARATE

ITEM	1 CAPITAL COST	2 EXISTING FACILITIES DEPO VALUE	3 NET CAPITAL INVESTMENT	4 CAPITAL RECOVERY FACTOR	5 ESTIMATED USEFUL LIFE	6 REPLACEABLE PORTION	7 ANNUAL CAPITAL COST	8 ANNUAL MAINT. LABOR AND MATERIAL	9 ANNUAL POWER	10 ANNUAL O&M (8+9)	11 ANNUAL COMPAR. VALUE (7+10)	12 COST PER MG	
TREATMENT IN PLANT													
DETENTION STORAGE													
SEWERS													
PUMP STATION													
PLANT													
SLUDGE													
SUB-TOTAL													
TRANSMISSION FACILITIES													
PUMP PLANT													
FORCE MAIN-SHAFT-TUNNEL													
SECONDARY PUMP PLANT													
FORCE MAIN													
SUB-TOTAL													
STORAGE RESERVOIRS													
RESERVOIRS													
AERATION													
CHLORINATION													
SUB-TOTAL													
LAND TREATMENT SITE													
PURCHASE & RELOCATION													
AERATED LAGOONS													
SITE PREPARATION													
SUB-TOTAL													
IRRIGATION SYSTEM													
PUMP STATION													
FORCE MAIN													
EQUIPMENT & DISTR'N PIPE													
SUB-TOTAL													
DRAINAGE SYSTEM													
TILE													
CONDUITS & CA[illegible]													
SUB-[illegible]													
SLUDGE MANAGEMENT													
[illegible]													
[illegible]													
[illegible]													
GRAND TOTAL													

BEST AVAILABLE COPY

CLEVELAND-AKRON METROPOLITAN
AND THREE RIVERS WATERSHED AREA
WASTEWATER MANAGEMENT SURVEY SCOPE STUDY

LAND TREATMENT

PHASE III REPORT

PREPARED
FOR
U. S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT

UNDER CONTRACT NO.: DACW49-72-C-0051

WRIGHT-McLAUGHLIN ENGINEERS
ENGINEERING CONSULTANTS
DENVER, COLORADO

APRIL 19, 1973

SECTION III

FARM MANAGEMENT TECHNIQUES

OPERATION AND PERFORMANCE OF LAND TREATMENT SYSTEMS

Farm management varies from soil to soil. For optimum performance the management techniques must be specifically designed and operated to meet the physical and environmental constraints peculiar to each location.

Farm management for the Mahoning-Ellsworth soil association would utilize the overland-flow/infiltration method for both municipal/industrial wastewater and separate storm runoff.

On Chili soils, spray irrigation would be employed with center-pivot rigs and solid-set sprinklers.

The Western Land Treatment Area, which accounts for the major portion of irrigated lands in Plan C, is located on Cardington-Bennington soils, where center-pivot rigs and solid-set sprinklers would be used. The Western Land Treatment Area is shown in Figure II-2.

WESTERN LAND TREATMENT AREA CROPS AND APPLICATION RATES

To enable farmers to maintain the current practice of growing 30 to 40 percent corn, farming would be done in circular strips whenever the center-pivot irrigation rigs were used. Alternate strips of Reed Canary grass and corn would form concentric rings approximately 14 feet wide. This width would accommodate modern machinery and allow six rows of corn at 30-inch spacing, although the row spacing is not critical.

Within the irregular areas between the center-pivot irrigation rigs, solid-set irrigation systems would be used. It is contemplated that Reed Canary grass would be grown in these smaller irregular areas.

Several patterns of corn-to-grass crop rotation would be possible under the center-pivot irrigation rigs.

For example, the grass strips could be maintained for three to ten years, after which they would be plowed under and planted in corn. The old corn strips would be planted in grass during the preceding autumn. This method would require lower than average irrigation rates until approximately the first cutting, to allow new grass to become established. The reduction, however, would not significantly diminish the annual capacity of the land treatment area, since the alternation between corn and grass would be made for only 10% to 30% of the irrigation rigs each year.

Another method of crop rotation would be to plant Reed Canary grass over the entire area using a desiccant to retard growth of the grass in the corn strips from spring to early fall. The grass would reassert itself in the fall and become the grass strips in the following year. Corn would be planted in the spring, on the preceding year's grass strips after the desiccant was applied, resulting in a no-tillage type of farming.

One of the desiccants used would be Paraquat, which is non-selective when applied at very high rates. At lower rates it kills annual weeds and grasses while preventing growth of perennial grasses until later in the season by acting as a contact desiccant.

Paraquat is subject to very rapid and complete inactivation by the soil. Therefore, there is no danger of its moving with the drainage water. (Herbicide Handbook of the Weed Society of America, Second Edition, 1970). Low concentrations which might occur in runoff have very little effect on plant and animal life on land or in water. (Ecological Effects of Pesticides on Non-Target Species, published by the Executive Office of the President, June 1971).

Regrowth of the grass before harvest time could be advantageous in a wet fall, since heavy corn-harvesting equipment could operate in the fields. During the fall of 1972, some of the corn crop was lost due to the problem of soft ground making fields impassable.

Center-pivot irrigation rigs would apply the treated wastewater directly only on the grass strips at twice the average application rate, For the Cardington-Bennington soils in western Ohio on which an average application rate of 75 inches per year is proposed, the grass strips would receive 150 inches per year. The spray nozzles would produce droplets having low kinetic energy, which would limit the dispersion of soil aggregates upon impact. Grass cover would also prevent soil dispersion on these silty soils.

The center-pivot rigs would make three to four revolutions daily applying approximately 0.18 inches of water on each pass. This water would infiltrate long before the next rotation of the sprinkler.

On the area irrigated by the solid-set sprinklers, 75 inches of water per year would be applied uniformly over the surface. Applications can be scheduled as desired at a rate of approximately 0.25 inches per hour. Applications of 2.5 inches per week would require ten total hours of sprinkling at this rate. Applications on these lands could readily be increased to 120 inches per year or more, which provides a safety factor of significant proportions.

APPLICATION RATES FOR THE THREE SELECTED SOILS

The selection of an application rate for each soil was based on the parameters of infiltration rate, permeability, nutrient balance, and renovative capacity of the soil.

Infiltration Rate

Details of soil infiltration capacity are given in the Land Treatment Phase I Technical Appendix. This parameter may become the limiting condition for soils with a high silt content in the upper horizon, which is characteristic of both the Chili and Cardington-Bennington soils. Large drops of water on the bare soil have a tendency to disperse the soil structure, which reduces the infiltration capacity and forms a thin crust upon drying.

a. Chili soils have a silt content of approximately 60 percent in the upper two feet. Below this depth, the soil generally changes drastically to a sand and gravel layer where the silt content drops to about 18 percent as shown in Table II-I of the Land Treatment Technical Appendix. Deep plowing to a depth of 30 to 36 inches could overturn the soil profile, depositing the coarser soil on top. Considerable mixing would be likely to occur under these circumstances.

b. Cardington-Bennington soils in western Ohio have relatively high silt contents in the top layer, which gradually diminish with depth. Reed Canary grass used in conjunction with a solid-set irrigation system would avoid the soil dispersion effect of large droplets on bare soil. Similarly, the center-pivot irrigation rigs can be used successfully with alternate strips of corn and grass, as discussed above. The infiltration capacity of the Cardington-Bennington soil was the single most important constraint governing the selection of the farm management method. With a total grass crop, the average application rates could be increased to about 120 inches per year for optimum nitrogen balance.

c. Mahoning-Ellsworth soils have a lower silt content than the Chili or Cardington-Bennington soil associations, so that the infiltration rate is dependent not on surface conditions, but on the sub-surface permeability of the soil. The overland-flow/infiltration method of irrigation is proposed for the Mahoning-Ellsworth soils.

Permeability.

The permeability of a soil controls the rate at which percolating water can reach the tile drain system and the degree of aeration in the root zone. Detailed drainage analyses have indicated suitable tile spacings greater than those selected in this study. The analyses were based upon computations using standard agricultural engineering methods, and upon recent Ohio field tests made on similar soils.

The drain tile spacing in the Western Land Treatment Area is satisfactory for root aeration of both the corn and the Reed Canary grass proposed. See Land Treatment Phase II Appendix.

The permeability of the Cardington-Bennington soils varies from 0.63 to 2.0 inches per hour in the plow layer. Beneath this zone, the permeability decreases to 0.2 to 0.63 inches per hour.

For the Mahoning soils the overland-flow/infiltration method on Reed Canary grass was chosen. This method simulates the border method (overland flow) of releasing the water at the upper end of a ten-foot wide strip and allowing the water to flow by gravity towards the lower end. Any water remaining at the lower end is collected and released to the next lower battery of borders. For this method, 90 inches per year for municipal/industrial effluent and 150 inches for storm water were selected. The higher rate for storm water was used because of the considerably lower concentration of nutrients and BOD. Permeability of these soils will permit complete infiltration of the wastewater through the soil zone, which will result in a double treatment.

The Chili soils are sufficiently permeable so that this parameter does not limit any reasonable application rate. For the upper two feet, the permeability varies from 2.0 to 6.3 inches per hour and increases to more than 12.0 inches per hour below the C-horizon. The rate of 60 inches per year was selected on the basis of nitrate leaching potential. This application rate is considered conservative, and higher application rates may be found reasonable after testing.

Nutrient Balance

The subject of nutrient balance is discussed in a separate subsection beginning on page III-13. Generally, the application rate is selected to provide enough nitrogen for optimum crop yields without losing excessive nitrates by leaching. An allowance should also be made for up to 40 to 50 percent nitrogen loss before plant uptake of nitrogen. Much of this nitrogen is volatilized. The percentage lost to the atmosphere will depend on the soil texture, temperature, moisture conditions and acidity.

Renovative Capacity

The renovative capacity is dependent upon the soil and plants. Too high an application rate would cause an excess of nitrogen to be carried into the drainage water. The amount would depend on the type of crop, soil texture, organic matter in the soil, and other factors. The selection of application rates equal to 60, 90 and 75 inches per year on the Chili, Mahoning and Cardington-Bennington soils, respectively, was based primarily on providing enough nitrogen to the crops for satisfactory yields while meeting the maximum O.C.E. levels for nitrogen as N of 4 mg/l.

Renovation of wastewater for other pollutants such as phosphorous and heavy metals is related more to the soil's capacity to store these elements, although plant uptake is important for phosphorous removal, especially that which is in the soluble forms.

The renovation of the wastewater for each of the farm management methods is discussed in detail in the Land Treatment Phase II Appendix. The return flow will be renovated to a degree meeting the 1985 effluent goals.

DRAINAGE

Drainage, both surface and subsurface, is of paramount importance to farmers in Ohio. Artificial drainage helps the farmer to get into the fields early in the spring and at harvest time during a wet fall and lessens the possibility of depressed yields resulting from a prolonged rainy period.

The Chili Association

This soil is relatively coarse having a permeability range from 2.0 to 6.3 inches per hour in the A and B horizons. Below this, the soil has sand and gravel texture with permeabilities in excess of 12 inches per hour. For an application rate of 60 inches per year, subsurface drainage would not be required on high ground, but could be limited to the low areas where the water table is high in the spring. For cost purposes, drains were assumed to be constructed at a depth of five and one-half feet and spaced 60 feet apart. Shallow wells may be preferable to subsurface drains, especially for reuse of the renovated effluent.

Cardington-Bennington Association in Western Ohio

This soil association requires subsurface drainage under present conditions. The drains are placed approximately 36 inches deep at the top of the glacial till. The drain spacing recommended by the 1965 Ohio Drainage Guide is 50 to 75 feet for general crops. The permeability of the "A" horizon is from 0.63 to 2.0 inches per hour and diminishes to 0.2 to 0.63 inches per hour in the "B" and "C" horizons.

Two types of irrigation, the center-pivot and the solid-set systems, have been proposed for these soils. The large center-pivot irrigation rigs would be suitable for about 75 percent of the area, and the irregular areas remaining would be irrigated by the solid-set system. All of the irrigation would take place on Reed Canary grass.

Irrigation will cease during wet periods, corn planting and during harvesting periods. When irrigation is interrupted during the planting and harvesting seasons, the water table will tend to drop to the level of the drains at about 36 inches. When the irrigation rigs are operating full time, the phreatic line will fluctuate within a relatively narrow range between the ground surface and the drains.

The best estimate of the drain system flow-through rate comes from Schwab and Fouss. Their experimental data for soils with characteristics similar to the Mahoning soils, documented the performance of a system with a drain spacing of 40 feet. This drain system discharged, from a saturated profile, two inches per day. For a 20-foot spacing, as proposed for the Cardington-Bennington soils, the discharge from the drains should approximately double. Since the water is to be applied on only one-half of the surface area, eight inches per day, including rainfalls, would be the theoretical maximum application rate for the hydraulic capacity of the soil zone-drain tile system under saturated conditions. The proposed irrigation rate is approximately five inches per week on the grass strips. A drainage analysis is presented in the Land Treatment Phase II Technical Appendix.

Mahoning Soils

The method of irrigation proposed for these soils is similar to the border system still used in the western states. The borders would be ten feet wide. Water would be released at the upper end and allowed to run overland through a grass coverto the lower end. All of the water will infiltrate through the soil column so that there will be no excess at the lower end.

The permeability of these soils is lower than that of the Cardington-Bennington soils, ranging from 0.2 to 0.63 inches per hour in the upper foot, and from 0.063 to 0.2 inches per hour in the next 18 to 24 inches. These permeabilities are identical to the Fulton soils on which Schwab and Fouss conducted their experiemnts. In this case, however, the water will be applied once a week at the rate of about two and one-half inches per week (90 inches per year) for municipal and industrial effluent, and about four inches per week (150 inches per year) for storm water. The application time will be governed by the infiltration rate and length of run.

CROPPING AND PROJECTED PRODUCTION

The crops currently grown in northern and western Ohio include corn, soybeans, wheat, oats and hay. In 1970 these crops represented approximately 32%, 33%, 13%, 7% and 15% of the harvest, respectively. On the Cardington-Bennington soils, by use of alternating strips of grass and corn, half of the area under the center-pivot system would be planted in corn. It is estimated that 75 percent of the area in the western Ohio land treatment site can be put under a center-pivot system which allows approximately 35 to 40 percent of the land to be planted in corn. The remainder would be in Reed Canary grass.

The overland-flow/infiltration method recommended for the Mahoning-Ellsworth soil association requires grass for the entire site. For convenience in estimating crop production, it has been assumed that the Chili soils will be 70 percent corn and 30 percent grass. With the above assumptions the values of the crops from the land treatment areas are shown in Table III-1.

TABLE III-1

SUMMARY OF CROPS, YIELDS AND ANNUAL GROSS INCOME
FOR 2020 FLOWS IN PLAN C

Soil Association	Crop	Acres(1)	Yield Amount	Yield Unit	Unit Price ($)	Gross Value ($/Acre)	Gross Total Value ($1000)
Chili	Corn	9,284	160	Bu/Ac	1.50	240.00	2,228
	Reed Canary-grass	4,000	4	T/Ac	50.00	200.00	800
Mahoning	Reed Canary-grass	6,280	4	T/Ac	50.00	200.00	1,256
Cardington-Bennington	Corn	41,300	200	Bu/Ac	1.50	300.00	12,390
	Reed Canary-grass	76,727	5	T/Ac	50.00	250.00	19,182
	TOTALS	137,591					35,856

(1) Does not include land irrigated by separate storm runoff treatment systems.

The yields for the crops shown above are based on recommended farm management practices. Nutrients will be provided by the wastewater. The unit prices are based on current (April, 1973) quotes which are now in an upward trend and higher than the depressed prices received by the farmers a year ago. The gross annual return per acre amounts to $262, resulting in a net profit of about $200 per acre to the farmer, disregarding costs of land treatment components. The net profit also includes the fertilizer value in the wastewater effluent which is provided at no cost to the farmer, but has a value of approximately $60 per acre. Without the amount of nutrients provided in the sewage effluent, the yields would generally be lower since most Ohio farmers would not spend more than $40 per acre on commercial fertilizer. Furthermore, commercial fertilizers in Ohio are applied once or twice a year, rather than in steady daily or weekly doses, which would not provide the nutrients as efficiently as would the steady applications. Sewage effluent also contains other nutrients in readily available form which are not generally provided in commercial fertilizers unless a critical deficiency has been indicated by a county extension agent.

In the future, wastewater renovation ponds and reservoirs may provide a direct source of cattle feed. The University of California at Davis has developed and tested a pilot plant which removes algae from these basins and converts it to a high-protein cattle food. Analyses have shown that the protein content is comparable to mature alfalfa hay and high quality oat hay.

SALINITY CONTROL

In arid areas of the world, a hazard of irrigation is the salinization or alkalization of the soil. This hazard is related to the quality of irrigation water and to subsurface drainage.

Water quality for irrigation depends on (1) total dissolved solids concentration, (2) the proportion of sodium to other cations, and (3) the presence of special toxic ions such as borate or, for some crops, possibly chloride, sodium, or bicarbonate. Unfortunately, usual chemical analyses of the Cleveland shoreline plants' effluent does not include information on elements such as sodium, potassium, calcium and magnesium. On February 23, 1973, a sample of the Cleveland Southerly plant was analyzed for the pertinent elements with the following results:

AD-A042 152 WRIGHT-MCLAUGHLIN ENGINEERS DENVER COLO F/G 13/2
WASTEWATER MANAGEMENT STUDY FOR CLEVELAND - AKRON METROPOLITAN --ETC(U)
DEC 72 DACW49-72-C-0051
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Calcium	92 mg/l
Sodium	150 mg/l
Magnesium	4.1 mg/l
Potassium	82 mg/l
Total Dissolved Solids	752 mg/liter

Sodium chloride and calcium chloride are used on the streets to melt the snow and ice in Cleveland. The snow was melting on February 23, 1973. The calcium, sodium and total dissolved solids in this sample are higher than would be normal.

The U.S. Salinity Laboratory uses the sodium adsorption ratio (SAR) and the electrical conductivity of the water as criteria to evaluate the sodium hazards of irrigation water. For this particular sample, the electrical conductivity and sodium adsorption ratio is equal to 1175 micromhos/cm x 10^6 and 4.2, respectively. A diagram used by the U.S. Salinity Laboratory for classifying irrigation water based on the above two parameters would place this sample into the better quality side of Class C3-S1. As far as sodium is concerned, the water could be used on almost all soils with little danger of accumulation of harmful amounts of exchangeable sodium. In an arid climate, where conservation of water is necessary, there would be little surplus water applied which would leach excess salts downward. With such practices in mind, the U. S. Salinity Laboratory classified this water as a medium salinity water, which can be used on soils of medium permeability. They also recommend that plants of moderate salt tolerance should be selected and that special salinity control management should be used. At the proposed irrigation application rates of 60 to 90 inches per year, however, salts would be leached to the drainage system, so that they would not tend to accumulate. In the moderately humid climate of Ohio, at high application rates and with the proposed drainage tile spacing of 20 feet the leaching would constitute a special management control.

It has been concluded that the Cleveland area wastewater is quite suitable for irrigation from the standpoint of salinity and the SAR of the soil.

An advantageous aspect of the land treatment system in Plan C relative to total dissolved solids is the fact that combining storm runoff with municipal and industrial wastewater in the Western Land Treatment Area will reduce the TDS concentration of the municipal/industrial wastewater and of the effluent discharged to natural watercourses.

NUTRIENTS

Sewage effluent from an activated sludge plant, or an aerated lagoon, is rich in nutrients required for plant growth. Typical sewage effluent in the Study Area contains macro-nutrients such as nitrogen, phosphorous, potassium, calcium, magnesium and sulphur; and micro-nutrients such as iron, copper and zinc.

When sewage effluent is utilized in a land treatment program and applied at a rate of 60 inches or more a year, most of these nutrients (with the possible exception of nitrogen) exceed plant requirements. This excess is usually captured by soil adsorption onto clays, cation exchange or attachment to organic matter. In areas with heavy rainfall and good soil drainage, some calcium, magnesium and potassium will migrate with the soil solution into the ground water aquifer or into subsurface drains.

The nutrients, nitrogen, phosphorous, and potassium are considered primary nutrients for plant growth and are discussed below.

Nitrogen

More laboratory and field work has been done on nitrogen than on any other plant nutrient. Despite this research, conclusive statements about the behavior of nitrogen in the soil are scarce. Nitrogen is mobile and can be transformed from the solid to the liquid or the gaseous state under the proper conditions. The soil's acidity, temperature, and moisture content, and the availablility of oxygen, are the most important variables which influence the behaviour of the element.

The concentration of nitrogen in effluent from a standard activated sludge plant is approximately 20 mg/l. Typically, 80 to 90 percent of this nitrogen is in the form of ammonium ions. Most of the remainder is in the organic form with a small amount of nitrate and nitrite ions. Wastewater which has received treatment in an aerated lagoon system may contain more nitrogen in the form of nitrates than wastewater treated in an activated sludge plant.

Nitrogen uptake by plants reaches a peak during the growing season. In warm, moist weather nitrification of the ammonium ion also proceeds rapidly. Most plants require some of the nitrogen to be in the form of nitrates, although the roots can readily accept the ammonium ion and sometimes prefer it.

When the soil temperature is below $50^{\circ}F$, nitrification takes place much more slowly. Nitrogen is then stored in the form of ammonia and held by the soil colloids. Experiments have been conducted in which anhydrous ammonia fertilizer is applied to agricultural land for several years. After this period, succeeding applications do not increase the crop yields, as large amounts of nitrogen, stored in the form of the ammonium ion, are available in the soil profile.

In a sandy, coarse-textured soil, excess nitrates will eventually migrate with the ground water into the subsurface drainage system and pass into the creeks and rivers.

Nitrate leaching may occur in fine-textured soils but the extent of the leaching is limited by the soil's basic properties. The abundant clay colloids tend to store the nitrogen as ammonia and to release it according to the plant demand. In addition, the nitrates migrate more slowly through a fine-textured soil, giving root fibers more time to absorb these ions. When sewage effluent is applied to fine-textured soils at a rate of two to four inches per week, alternating aerobic and anaerobic conditions result in a nitrification-denitrification process. During these reversals, nitrogen will be lost to the atmosphere in the form of nitrogen gas (N_2). This loss may equal up to fifty percent of the nitrogen applied.

Application Rates and Nitrogen Balance

To ensure the proper nitrogen balance in soils receiving applications of sewage effluent, the application rates were calculated separately for each soil type. In the coarse-textured soils of the Cuyahoga Basin where there is some risk of nitrate leaching to the ground water, application rates have been limited to 60 inches per year. On the tighter Cardington-Bennington and Mahoning-Ellsworth soils, the application rates have been set at 75 and 90 inches per year, respectively.

The effluent applied on the Cardington-Bennington soils in western Ohio will be a mixture of municipal/industrial wastewater and storm runoff, with nitrogen concentrations of 19.7 and 2.2 mg/l respectively, The mixture of 83 percent M & I wastewater, and 17 percent storm runoff will result in an effluent containing nitrogen at approximately 16.4 mg/l, as stated in the Phase II Land Treatment Report. At an average application rate of 75 inches per year, the average nitrogen application would amount to 278 lbs/acre/year. The direct application rate of 150 inches per year on one-half of the area irrigated by center-pivot rigs would result in a nitrogen application of 556 lbs/acre/year to the grass strips only. Volatilization losses of nitrogen will range up to 50 percent of the total amount applied. Assuming a 40% volatilization loss of 225 lbs/acre/year from the Cardington-Bennington soils planted in strips of Reed Canary grass, 331 pounds of nitrogen would be available for crop uptake annually. Assuming a harvest of 4.5 tons of Reed Canary grass per acre per year and a nitrogen content of 62 lbs. per ton, the crop uptake would be 279 lbs/acre/year leaving a balance of 52 lbs/acre/year.

There are three possibilities for the disposition of the balance: leaching, uptake by the adjacent corn rows and storage in the soil. It is estimated that the adjacent corn rows would utilize at least 30 pounds of the excess nitrogen from the irrigated grass strips. Neglecting storage of nitrogen in the soil, approximately 22 lbs. of nitrogen per acre per year would migrate through the soil zone to be carried in the return flow. However, this represents an average migration of 11 lbs/acre/year from the gross acreage under irrigation by the center-pivot rigs.

Based upon the effluent criterion for nitrogen of 4.0 mg/l for Level II Standards, the permissible leaching of nitrogen with the return flow should be limited to the range of 50 - 70 lbs/acre/year or approximately 120 lbs/acre/year from the directly-irrigated grass portion of the center-pivot rig acreage.

If only Reed Canary grass were grown, as described in the Phase II Report, average application rates should be raised to 120 inches/year for optimum balance between high-protein grass and nitrogen application.

That portion of the Cardington-Bennington soil irrigated by solid-set sprinklers (25 percent) would receive a nitrogen application of only 278 lbs/acre/year. The optimum nitrogen application for Reed Canary grass is approximately 445 lbs/acre/year. Therefore, a substantial safety factor exists for readjusting the application rates between areas irrigated by the center-pivot rigs and the solid-set equipment. The amount of water applied by the solid-set equipment might be increased to 120 inches per year, permitting a reduction in the application rate of the center-pivot rigs.

On Chili soils within the Three Rivers Watershed, where an irrigation rate of 60 inches/year of municipal/industrial effluent has been proposed, the annual nitrogen application would be 268 lbs/acre. Volatilization from this relatively coarse-grained soil would account for a lower percentage of the nitrogen than would volatilization from the Cardington-Bennington soils. Assuming a nitrogen loss of 25 percent of 67 lbs/acre/year through volatilization from the Chili soils, an annual balance of 201 lbs/acre would be available for crop uptake or leaching. The rate of nitrogen uptake would be 160 lbs/acre/year for corn and significantly more for Reed Canary grass, leaving a maxiumum of 41 lbs/acre/year for leaching and storage in the soil.

The application of 90 inches/year to the fine-grained Mahoning soils, using the overland-flow/infiltration method would result in a nitrogen application of 400 lbs/acre/year. It is anticipated that crop uptake by the Reed Canary grass and the volatilization of nitrogen would account for essentially the full amount of nitrogen applied.

Phosphorous Loading

According to the Phase I Report by Havens & Emerson, the phosphate contents of municipal/industrial wastewater and storm runoff are 10.2 mg/l and 2.2 mg/l, respectively. At the Western Land Treatment Area, the combination of municipal/industrial wastewater and storm runoff would result in an approximate phosphorous concentration of 8.3 mg/l, as stated in the Phase II Land Treatment Report. With an application rate of 75 inches per year the phosphorous loading would amount to 145 pounds per acre per year. This represents approximately three times as much phosphorous as would normally be applied in commercial fertilizers for good yields on typical soils. The excess phosphorous would react chemically with the aluminum and iron ions abundant in the Cardington-Bennington soils. This process would proceed rapidly and the phosphorous would not easily be released. Calcium ions, provided by lime applications, would combine chemically with phosphorous to form a tightly held precipitate.

These processes would provide a high level of removal at the Western Land Treatment Area. The treatment will meet the Level II Standards easily and may satisfy the more stringent O.C.E. Goals of 0.10 mg/l for phosphorous as PO_4. Treatment on the Mahoning-Ellsworth soils utilizing the overland-flow/infiltration method should achieve a similar level of removal. On the more coarsely textured Chili soils, the application rates have been limited to 60 inches per year to meet the Level II Standards.

Potassium Application

Potassium is a primary crop nutrient. The Ohio Agronomy Guide suggests an application rate of 250 pounds/acre of potassium as K for best crop yields. This crop requirement would be satisfied by a concentration of 15 mg/l in effluent applied at a rate of 75 inches per year. The potassium content of wastewater from the Study Area has not been documented by this study, but certainly exceeds the crop requirement. Excess potassium would be leached to the drainage system. The Level II water quality standards do not set a limitation on the concentration of potassium in treated effluent, since it is not considered a harmful pollutant.

RECYCLED NUTRIENTS

Nutrients contained in wastewater from the Cleveland-Akron Metropolitan and Three Rivers Watershed Area represent a substantial resource, which will become more valuable as the elements become scarce and the cost and energy required to process them escalate. Table III-2 presents the amounts of nitrogen, phosphorous and potassium contained in Study Area wastewater, storm runoff and sludge, summarized according to treatment facilities proposed in Plan C for the year 2020. The value of these nutrients was based on 1972 unit costs of 15 cents per pound for nitrogen, ten cents per pound for phosphorous, and five cents per pound for the amount of potassium recommended for crops. The net totals for the value of phosphorous were halved, since the total amount applied to the land would be twice that required for top yields.

The estimated value of the reclaimable nutrients is $9,450,000 for the year 2020. (Approximately $705,000 worth of nutrients from the water-based Akron plant are not included.) The additional value of the secondary nutrients sulfur, calcium and magnesium, and the mirco-nutrients contained in the effluent and sludge has not been estimated. However, the value of these nutrients may increase considerably as the costs to process similar fertilizers escalate.

TABLE III-2

SUMMARY OF NUTRIENTS IN SEWAGE EFFLUENT, STORMWATER AND SLUDGE
(Based on 2020 Flows in Plan C)

	NITROGEN		PHOSPHOROUS		POTASSIUM	
	Million Lbs.	$1000	Million Lbs.	$1000	Million Lbs.	$1000
WESTERN OHIO LAND TREATMENT AREA						
Sewage Effluent	32.9	$4800	17.3	$ 860	24.4	$1220
Storm Runoff	.2	30	.1	5	.2	10
Sludge	2.9	435	1.7	85	.9	45
Subtotal	36.0	$5265	19.1	$ 950	34.5	$1275
IN-BASIN TREATMENT						
Sewage Effluent	5.6	$ 840	2.9	$ 145	4.3	$ 215
Storm Runoff	1.5	225	.3	15	1.3	65
Sludge	0.5	75	0.3	15	0.1	5
Subtotal	7.6	$1140	3.5	$ 175	7.1	$ 285
AKRON TREATMENT PLANT						
Sewage Effluent *	9.0	$ 135	4.6	$ 230	6.8	$ 340
Sludge	1.6	240	1.6	80	0.8	40
Subtotal	10.6	$ 375	6.2	$ 310	9.9	$ 380
TOTAL	54.2	$6780	28.8	$1435	51.5	$1940

* These nutrients would be discharged to the Cuyahoga River and would not be reclaimable.

HEAVY METALS

Sources of Heavy Metals

The metals in urban wastewater are generated by industry, domestic wastes and storm runoff. The industrial sources have been studied by AWARE and are discussed in detail in their Industrial Wastes Phase I Report. Five possible levels of industrial pretreatment were defined and costed by AWARE. These alternatives varied substantially in cost, depending upon their removal criteria. Alternative 3 provided for the most complete in-house industrial treatment and was the most expensive alternative, with a present worth cost, at seven percent interest, of $1,013.8 million. Alternative 5A, which called for a lower degree of industrial pretreatment with removal completed by land treatment, had a present worth of $518.7 million (at seven percent interest), or a present worth approximately half that of Alternative 3. The cost of industrial pretreatment is thus in the same general range as that of the total municipal/industrial treatment system, which is approximately $1,400 million.

The U.S. Army Corps of Engineers has directed that all three wastewater management plans include Alternative 3, with a high removal of heavy metals; therefore, the discussion of confined disposal of heavy metals from industry in the soil zone using land treatment is intended for general information purposes only.

Section X of the Land Treatment Phase I Report provides a discussion concerning the potential load of heavy metals from industry and their accumulation in the soil. Specific reference is made to Table X-8 which tabulated long-term concentrations of some typical heavy metals, assuming no industrial pretreatment to remove them. Furthermore, these metal loadings assume no major future change in the present philosophy of use and conservation of natural resources by industry.

Stormwater contributes heavy metals to the total treatment load as it cleanses the streets, parking lots, lawns, driveways, raw material stockpiles, and open industrial areas. The stormwater carries litter, particulate exhaust emissions, hydrocarbons, heavy metals, toxic compounds, fertilizers, and pesticides.*

The heavy metals washed into receiving waters during a 0.5 inch/hour rainstorm from a typical urban area of one (1) million people were estimated by Condon:

TABLE III-3.

STORM RUNOFF FLUSHING OF HEAVY METALS

Elements	Runoff Load in Lbs/Hours
Zinc	2,600
Copper	800
Lead	2,300
Nickel	200
Mercury	290

The domestic contribution of heavy metals is not well known because nearly all municipal effluent contains industrial wastes to some extent. However, a review of the lables of typical household products such as cleaners, breakfast foods, vitamin pills, toothpaste and common medicines indicates that a steady stream of heavy metals is contributed by domestic sewage.

Heavy Metal Uptake by Crops

Typical quantities of some heavy metals found in common crop plants are presented in Table III-4. Since general agricultural conditions cause tremendous variability in uptake, the figures given represent values near the middle of the range reported. (Allaway, 1968, and Chapman, 1966). The average values given in the final column were used to calculate the amounts of heavy metals removed from the soil by typical plant growth, as shown in Table III-5. The annual heavy metals uptake was calculated based upon an average removal of

* Condon, Francis J. "Treatment of Urban Runoff", APWA Reporter.

TABLE III-4

CONTENT OF SOME HEAVY METALS IN TYPICAL CROPS*

(Ppm in dry plant material)

Element	Alfalfa	Barley	Beans	Cabbage	Carrot	Clover	Coffee	Corn	Soybean	Tomatoes	Plant Matter Typical Values
Cadmium											0.5
Chromium		1						0.5			0.8
Copper		10				10	10	9		20	10
Iron								100	120	107	110
Lead	5	1	2	0.5	2.6	6				5	5
Nickel	2	4		3	1	1	0.4	0.14	4		2
Silver	0.3					0.5	0.02				0.3
Zinc	30					39	7	50		13	30

*Values near the middle of the range reported by Allaway (1968) and Chapman (1966). See references No. 1 and 2.

TABLE III-5

REMOVAL OF TYPICAL HEAVY METALS BY PLANTS

Element	Annual Loading Rate (Lbs/Acre) (1)	Additional Annual Concentration in Soil from Irrigation Water (ppm/Acre-foot Slice)	Concentration of Elements After 100 Years (ppm/Acre-foot Slice) (2)	Normal Plant Content (ppm) (3)	Annual Plant Removal (Lbs/Acre) (4)	Percent of Annual Addition Removed By Plant	Normal Soil Content (ppm)
Cadmium	0.075	0.019	1.9	0.5	0.003	4.0	.01 - 7
Chromium	3.41	0.85	85	0.8	0.0048	1.4	5 - 3,000
Copper	2.12	0.53	53	10	0.06	2.8	2 - 180
Iron	16.4	4.1	410	110	0.66	4.0	50,000
Lead	0.066	0.016	1.6	5	0.03	45	2 - 200
Nickel	2.12	0.53	53	2	0.012	0.57	10 - 1,000
Silver	0.0115	0.0029	0.29	0.3	0.0018	15.6	1 - 5
Zinc	2.63	0.66	66	30	0.18	6.8	10 - 300

(1) Values taken from Table X-8, Wright-McLaughlin Land Treatment Phase I Report.
(2) These values are based on an irrigation rate of 75 inches per year.
(3) Values derived from preceding Table III-4.
(4) These values are based on removal of 6,000 pounds of dry plant material per acre, and the normal plant content.

three tons of dry plant material per acre. This removal figure is too high for some plants and too low for others, but it is sufficiently accurate to illustrate the point that a fairly low percentage of the heavy metals added each year would be removed with the crops. As indicated in Column 6 of Table III-5, the percentage removal would range from less than 1 to about 16 percent.

The capacity of soil to adsorb heavy metal ions varies widely, but is at least 20,000 lbs/acre-foot slice. Of the elements treated in this report, exclusive of iron, soils contain about 2,000 - 2,500 lbs/acre-foot slice. The amount of these elements added each year with 75 inches of effluent, would be about 20 - 40 lbs/acre-foot slice (exclusive of iron). This is a fairly insignificant amount compared to the total adsorption capacity of the soil. It also represents a small percentage of the natural "background" concentration of these elements in soils.

The total amount of a particular heavy metal present in the soil may not be very meaningful in terms of plant growth, plant toxicity or leaching. It is the solubility of the element that is most critical and this information is difficult to isolate due to the many factors, such as soil pH, degree of soil aeration, texture and kind of clay mineral, organic matter, temperature and moisture, which cause variations. The most critical factor is soil pH, because the solubility of heavy metals is closely dependent upon it. Generally, as pH increases, solubility decreases.

A brief discussion of some important heavy metals is given below:

<u>Cadmium</u>. The chemistry of cadmium is somewhat similar to zinc. It would take more than 100 years of adding .075 lbs/acre/year to reach the upper limit of the normal range of cadmium in soils. John et al. (1972) showed that 90 lbs/acre of cadmium added to the soil surface over several years did not move below

the 4-inch level in the soil profile. They also showed little increase in cadmium uptake in oats. Traynor and Knezek (1972) found some increase in uptake in corn with cadmium application to the soil. Unless soluble and mobile complexes with low molecular weight organic compounds are formed, there should be little danger of leaching in high pH soils (Murrmann and Koutz, 1972).

Chromium. Although the three pounds of chromium per acre per year to be added to soil through land treatment of effluent is relatively high compared to some of the other heavy metals, it has a low solubility and for several years this addition should be well within the normal range in soils. Knezek (1973) indicated that soils have a high capacity to fix chromium. Pratt (1966) found no appreciable accumulation of chromium in plants in cases where chromium toxicity has been thought to exist. However, Turner and Rust (1971) found a chromium toxicity in soybeans when 10 lbs. chromium per acre was added, although the concentration of chromium in the plants was not reported. Soane and Saunder (1959) showed that chromium added to sand cultures at concentrations of 10 ppm caused toxicity to tobacco plants; however, they did not prove that a high chromium content in the serpentine soils was the cause of infertility.

Copper. Ellis and Knezek (1972) showed that copper would be bound to organic and clay complexes near the soil surface. Reuther and Labanauskas (1966) reviewed the chemistry and toxicity of copper and indicated that it should cause no plant toxicity problems. Mitchell (1964) showed that there would be a minimal leaching of organic complexes containing copper into drainage waters. With the small amount of copper added each year in effluent there should be few if any problems for many years, as long as the pH of the soil is maintained near 7.0.

Iron. Relatively large quantities of iron compared to other heavy metals will be added in the effluent, but compared to the total of 50 tons or more per acre-foot slice in soil already, it is a minute amount. Since the added iron will be fixed rapidly (Mitchell, 1962), and since iron is seldom toxic to plants grown in natural soils (Wallahan, 1966), little if any problem should result from the effluent addition to soils of high pH. The major potential problem could be interaction with the uptake of zinc and manganese, if the pH of the soil were to drop. (Mitchell, 1964; Sauchelli, 1969; Wallahan, 1966).

Lead. Plants can accumulate high concentrations of lead (64 - 196 lbs/ acre, according to Cox and Rains, 1972) although it is not known to be essential for animal or plant growth. Much of the lead from sewage treatment plants remains with the sludge, so that the effluent has a low concentration of this element. (Lead solubility is low at pH of 7.0, so leaching should present little problem.) Plants will die of lead toxicity before the concentration reaches levels high enough to be toxic to animals (Allaway, 1968). Solution culture with lead concentrations up to 200 ppm had no depressing effect on apples and grapes (Childers, 1941). Similar results with orange seedlings were found in California (Vanselow and Bradford, 1960). However, Wilkins (1957) found that lead concentrations of 10, 30, and 100 ppm in solution cultures, measureably retarded, markedly retarded and stopped growth respectively of fescue plants.

Nickel. Nickel is not known to be essential for plant growth but is taken up by plants in concentrations of 0.5 to 150 ppm. Two ppm of nickel is quite normal. A middle-of-the-range concentration in soils would be 100 ppm (Swaine, 1955), most of which is not soluble at any given time. The amount of soluble nickel approaches 1 ppm (Vanselow, 1966). In all but serpentine and basic igneous rock-derived soils, nickel toxicity should not be a serious problem.

Silver. Little is known about silver in soils, except that it occurs almost universally but only in minute amounts. Seldom does it exceed 1 ppm (Vanselow, 1966; Rogers et al., 1939; Swaine, 1951). It has been reported in plant tissue in amounts of less than 0.01 and no higher than 1.3 ppm in the dry matter. The occurrence of toxic amounts of silver is quite unlikely because of its extremely low solubility. Little leaching and movement through the soil profile should occur.

Zinc. Although zinc additions may be high from some effluents, comparable quantities are added as a fertilizer on field beans and corn in Michigan (Virande et al., 1967) with beneficial effects. Melton, et al. (1970) indicates that there is little danger of leaching or toxicity from zinc added with effluent, unless a zinc-sensitive plant is grown. Allaway (1968) indicated that some animal feeds are deficient in zinc, so additional zinc could be beneficial to animals. Zinc is needed at a concentration of 8 - 15 ppm in the forage dry matter. Animals require about 10 - 40 ppm zinc in the diet. At 200 ppm of the dry matter zinc is toxic.

An unpublished work of Sabey and Hart (1973) indicated that there was a build-up of extractable zinc, copper, iron and manganese on an irrigated sandy loam in the zone of incorporation of sewage sludge. No downward movement of these elements occurred during the first year after application.

The elements in Table III-IV should pose no serious threat to the groundwater or to plants growing on medium to fine-textured soils if the pH of the soil is maintained near 7.0. If however, the pH of the soil decreased to below 6.0, there is a possibility of increasing solubility of several of the elements, therefore increasing the likelihood of groundwater pollution and plant toxicity.

Heavy Metal Management

Maintenance of a sufficiently high pH (equal to 6.0 or more) in soils receiving heavy metals would be an important part of land management unless monitoring demonstrated that somewhat increased solubilization of the heavy metals at lower pH values was not a hazard. Maintaining the pH at this level should pose no problem for agriculturalists, as good farm management generally dictates the use of lime to raise the pH to approximately 6.5. Lime applications are common on Ohio soils.

The Ohio 1972-1973 Agronomy Guide, Bulletin 472, published by the Cooperative Extension Service of Ohio State University, reported that lime applications on acid soils often return $6.00 to $9.00 for every dollar invested. According to this bulletin, approximately ten tons per acre would be required to increase the present soil pH of about 5.5 to a level of 6.5. Subsequent annual lime applications of about three tons per acre per year may be required to maintain the pH at about the 6.5 level.

It is clear that the possibility of toxicity to plants is greatest with an acid soil (pH less than approximately 6.0).

Field tests conducted at the University of Illinois have shown the feasibility of managing heavy metals on agricultural land. Should monitoring indicate an undesirable rate of accumulation for a particular heavy metal, management steps might include reduction of that metal at the source, incorporation of special removal processes at the secondary treatment stage, recycling of the element by industry, and rotation or substitution of crops.

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

FAIRMOUNT ROAD PLANT SIZE: 3.40(MGD) SOIL-TYPE:CHILI APPLICATION RATE: 60 IN/YR FAIRMOUNT ROAD PLANT

- - - - - BASIC DESIGN DATA - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
POPULATION																									
DOMESTIC AND INDUSTRIAL Q				0.31	0.35	0.40	0.45	0.49	0.54	0.64	0.74	0.84	0.94	1.05	1.15	1.25	1.35	1.45	1.55	1.85	2.14	2.47	2.80	3.10	3.40
TREATMENT PLANT CAPACITY (MGD)					1.85						1.55								2.14	2.47	2.80	3.10	3.40	3.40	3.40
SLUDGE DISCHARGED (TPD)						0.08	0.10	0.10	0.11	0.13	0.16	0.18	0.20	0.22	0.24	0.26	0.28	0.31	0.33	0.35	0.45	0.52	0.59	0.65	0.71
WINTER STORAGE (MG)												95	106	119	130	141	153	164	175	209	242	279	316	350	384
LAND AREA (ACRE)												188	211	235	258	280	302	325	347	414	479	553	627	694	762

PLAN C PLANT 13

- - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
PLANTS	35	0	0	0	56	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	720	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	39	0	0	0	0	520	0	0	0	0	0	0	0	0	0	0	0	0	0
SECONDARY PUMPING	33	0	0	0	0	0	0	0	0	0	0	139	0	0	0	0	0	0	0
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	385	0	0	0	0	0	0	0
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	715	0	0	0	0	0	0	0
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	162	0	0	0	0	0	0	0
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	173	0	0	0	57	0	0	0
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	161	0	0	0	45	0	0	0
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	104	0	0	0	36	0	0	0
SLUDGE MANAGEMENT	39	0	0	0	0	95	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	33	0	0	0	0	52	0	0	0	0	0	28	0	0	0	9	0	0	0
TOTAL		0	0	0	776	667	0	0	0	0	0	1867	0	0	0	147	0	0	0
PW (1/72) 5 3/8%		0	0	0	663	540	0	0	0	0	0	1105	0	0	0	70	0	0	0
PW (1/72) 7 %		0	0	0	633	509	0	0	0	0	0	948	0	0	0	57	0	0	0
PW (1/72) 10 %		0	0	0	582	455	0	0	0	0	0	720	0	0	0	38	0	0	0

	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	RESID	NET	PRESENT WORTH AT 7% EXPEND	RESID	NET	PRESENT WORTH AT 10% EXPEND	RESID	NET
PLANTS	0	0	0	0	56	0	0	112	39	55	3	52	49	1	48	43	0	43
EXPAND TO LEVEL 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	0	0	0	0	0	0	0	720	72	615	5	609	587	2	584	540	0	540
SEWER EXPANSION	498	0	0	0	0	0	0	498	199	194	16	178	147	7	139	89	1	87
DETENTION BASINS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	0	405	0	0	0	520	0	1445	539	597	43	554	510	21	489	409	5	403
SECONDARY PUMPING	139	0	0	0	0	139	0	417	139	151	11	139	119	5	113	81	1	79
FORCE MAINS	0	0	0	0	0	0	0	385	92	227	7	220	195	3	191	148	0	147
STORAGE RESERVOIRS	295	0	335	0	325	0	0	1670	1124	660	91	569	525	43	481	360	11	349
RESERVOIR AER & CL	218	0	282	0	340	0	340	1342	340	320	27	292	228	13	214	133	3	130
LAND PURCHASE & PREP	44	44	48	48	45	45	0	0	504	190	40	149	150	19	130	101	5	96
IRRIGATION SYSTEMS	49	48	37	36	33	195	45	649	280	194	22	171	148	10	137	96	2	94
DRAINAGE SYSTEMS	27	26	30	29	28	27	0	307	109	115	8	107	91	4	87	61	1	60
SLUDGE MANAGEMENT	0	49	0	0	0	95	0	239	93	101	7	94	88	3	84	71	0	71
MISCELLANEOUS	7	48	7	7	7	67	2	234	0	91	0	91	75	0	75	57	0	57
TOTAL	1277	620	739	120	834	1088	387	8018	3530	3516	285	3230	2918	137	2780	2197	35	2162
PW (1/72) 5 3/8%	498	186	170	21	114	114	31	0	0	3516	285	3230	0	0	0	0	0	0
PW (1/72) 7 %	377	130	110	12	63	59	15	0	0	0	0	0	2918	137	2780	0	0	0
PW (1/72) 10 %	229	65	50	5	22	18	3	0	0	0	0	0	0	0	0	2197	35	2162

- - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
PLANTS	35	9	19	29	40	50	1	1	1	1	1	1	1	1	3	3	3	3	3
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	39	0	0	0	0	0	20	20	21	22	22	23	24	26	27	29	30	31	32
SECONDARY PUMPING	33	0	0	0	0	0	0	0	0	0	0	0	12	12	13	13	14	14	15
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	4	4
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	9	9	9	9	9	9	10
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	10	10	10	11	11	11	11
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2	2
SLUDGE MANAGEMENT	39	0	0	0	0	0	1	1	1	1	1	1	2	2	2	2	2	2	2
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		9	19	29	43	53	27	27	28	29	29	30	70	72	77	81	83	84	87
PW (BEGIN PER) 5 3/8%		9	18	27	40	50	25	25	26	27	27	28	66	68	73	76	78	79	82
PW (1/72) 5 3/8%		9	17	24	34	40	19	18	18	18	17	17	37	36	36	36	36	34	33
PW (BEGIN PER) 7%		9	17	27	40	49	25	25	26	27	27	28	65	67	71	75	77	78	81
PW (1/72) 7%		9	16	23	32	37	17	16	16	15	14	14	31	29	29	29	28	26	25
PW (BEGIN PER) 10%		9	17	26	39	48	24	24	25	26	26	27	63	65	69	73	75	76	79
PW (1/72) 10%		9	15	21	29	32	15	13	13	12	11	10	22	20	20	19	18	16	15

	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	RESID	NET	PRESENT WORTH AT 7% EXPEND	RESID	NET	PRESENT WORTH AT 10% EXPEND	RESID	NET
PLANTS	5	6	7	8	9	10	11	395	0	171	0	171	148	0	148	121	0	121
SLUDGE FACILITIES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	6	6	6	6	6	6	6	225	0	60	0	60	44	0	44	27	0	27
TEMPORARY PUMPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	33	38	53	58	61	64	67	1932	0	453	0	453	319	0	319	182	0	182
SECONDARY PUMPING	22	24	25	27	29	31	33	909	0	190	0	190	127	0	127	64	0	64
FORCE MAINS	2	2	2	2	2	2	2	74	0	17	0	17	12	0	12	6	0	6
STORAGE RESERVOIRS	5	5	7	7	7	7	7	223	0	48	0	48	32	0	32	16	0	16
RESERVOIR AER & CL	13	13	13	19	19	20	21	584	0	122	0	122	82	0	82	41	0	41
LAND PURCHASE & PREP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	13	14	14	18	19	19	19	575	0	124	0	124	84	0	84	43	0	43
DRAINAGE SYSTEMS	3	3	3	4	4	4	5	116	0	23	0	23	15	0	15	7	0	7
SLUDGE MANAGEMENT	2	2	3	3	4	4	6	108	0	24	0	24	17	0	17	9	0	9
MISCELLANEOUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	107	116	144	157	165	172	0	5144	0	1238	0	0	883	0	0	522	0	0
PW (BEGIN PER) 5 3/8%	475	556	642	687	717	741	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 5 3/8%	185	167	148	122	98	77	0	0	0	1286	0	0	0	0	0	0	0	0
PW (BEGIN PER) 7%	455	532	615	662	656	707	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 7%	134	112	92	70	52	38	0	0	0	0	0	0	918	0	0	0	0	0
PW (BEGIN PER) 10%	419	493	576	617	622	661	5	168	0	0	0	0	0	0	0	0	0	0
PW (1/72) 10%	75	55	39	26	16	11	0	0	0	0	0	0	0	0	0	542	0	0

- - - - - ANNUAL CAPITAL COSTS AT 7% IN $1000 - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
PLANTS	35	0	0	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	39	0	0	0	0	39	39	39	39	39	39	39	39	39	39	39	39	39	39
SECONDARY PUMPING	33	0	0	0	0	0	0	0	0	0	0	10	10	10	10	10	10	10	10
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	27	27	27	27	27	27	27	27
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	51	51	51	51	51	51	51	51
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	27	27	27	27	27	27	27	27
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	12	12	12	12	16	16	16	16
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	12	12	12	12	16	16	16	16
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	7	7	7	7	10	10	10	10
SLUDGE MANAGEMENT	39	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7	7	7
MISCELLANEOUS	33	0	0	0	0	4	4	4	4	4	4	6	6	6	6	6	6	6	6
5 3/8% CRF		0	0	0	45	86	86	86	86	86	86	213	213	213	213	222	222	222	222
7 % CRF		0	0	0	56	106	106	106	106	106	106	258	258	258	258	269	269	269	269
10 % CRF		0	0	0	78	146	146	146	146	146	146	350	350	350	350	365	365	365	365

	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	RESID	NET	PRESENT WORTH AT 7% EXPEND	RESID	NET	PRESENT WORTH AT 10% EXPEND	RESID	NET
PLANTS	4	4	4	4	4	4	4											
EXPAND TO LEVEL 1	0	0	0	0	0	0	0											
EXPAND TO LEVEL 2	0	0	0	0	0	0	0											
SLUDGE FACILITIES	0	0	0	0	0	0	0											
SLUDGE FAC. EXP.	0	0	0	0	0	0	0											
SEWERS	51	51	51	51	51	51	51											
SEWER EXPANSION	35	35	35	35	35	35	35											
DETENTION BASINS	0	0	0	0	0	0	0											
BASIN EXPANSION	0	0	0	0	0	0	0											
TEMPORARY PUMPS	0	0	0	0	0	0	0											
SHAFTS & TUNNELS	0	0	0	0	0	0	0											
AERATED LAGOONS	39	69	69	69	69	69	69											
SECONDARY PUMPING	21	21	21	21	21	21	21											
FORCE MAINS	27	27	27	27	27	27	27											
STORAGE RESERVOIRS	72	72	96	96	120	120	120											
RESERVOIR AER & CL	36	36	47	47	56	56	56											
LAND PURCHASE & PREP	19	22	26	29	33	36	36											
IRRIGATION SYSTEMS	19	23	26	29	31	34	34											
DRAINAGE SYSTEMS	12	13	16	18	20	22	22											
SLUDGE MANAGEMENT	7	10	10	10	10	10	10											
MISCELLANEOUS	7	11	11	12	8	11	11											
5 3/8% CRF	293	332	369	376	407	416	416											
7 % CRF	355	402	446	455	492	503	502											
10 % CRF	483	546	604	617	666	681	680											

- - - - - TOTAL ANNUAL CAPITAL COSTS IN $1000 - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
CAPITAL RECOVERY FACTOR AT 5 3/8%																									
TOTAL ANNUAL CAPITAL	0	0	0	45	86	86	86	86	86	86	213	213	213	213	222	222	222	222	293	332	369	376	407	416	416
TOTAL ANNUAL O&M	9	19	29	43	53	27	27	28	29	29	30	70	72	77	81	83	84	87	107	116	144	157	165	172	175
TOTAL ANNUAL COSTS	9	19	29	88	139	113	113	114	115	115	243	283	285	290	303	305	306	309	400	448	513	533	572	588	591
CAPITAL RECOVERY FACTOR AT 7 %																									
TOTAL ANNUAL CAPITAL	0	0	0	56	106	106	106	106	106	106	258	258	258	258	269	269	269	269	355	402	446	455	492	503	502
TOTAL ANNUAL O&M	9	19	29	43	53	27	27	28	29	29	30	70	72	77	81	83	84	87	107	116	144	157	165	172	175
TOTAL ANNUAL COSTS	9	19	29	99	159	133	133	134	135	135	288	328	330	335	350	352	353	356	462	519	590	612	657	675	677
CAPITAL RECOVERY FACTOR AT 10 %																									
TOTAL ANNUAL CAPITAL	0	0	0	78	146	146	146	146	146	146	350	350	350	350	365	365	365	365	483	546	604	617	666	681	680
TOTAL ANNUAL O&M	9	19	29	43	53	27	27	28	29	29	30	70	72	77	81	83	84	87	107	116	144	157	165	172	175
TOTAL ANNUAL COSTS	9	19	29	121	199	173	173	174	175	175	380	420	422	427	446	448	449	452	590	662	748	774	831	853	855

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

FOWLER'S MILL PLANT   SIZE: 1.98(MGD)   SOIL-T YPE(CHILI   APPLICATION RATE: 60 IN/YR   FOWLER'S MILL PLANT

- - - - - BASIC DESIGN DATA - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
POPULATION																									
DOMESTIC AND INDUSTRIAL Q				0.53	0.55	0.57	0.59	0.62	0.64	0.67	0.69	0.73	0.75	0.78	0.80	0.82	0.84	0.86	0.88	1.01	1.14	1.34	1.54	1.76	1.98
TREATMENT PLANT CAPACITY (MGD)					1.01						0.98								1.14	1.34	1.54	1.76	1.98	1.98	1.98
SLUDGE DISCHARGED (TPD)						0.12	0.12	0.13	0.13	0.14	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.18	0.19	0.21	0.24	0.28	0.32	0.37	0.42
WINTER STORAGE (MG)												82	85	88	90	93	95	97	99	114	129	151	174	199	224
LAND AREA (ACRE)												164	168	175	179	184	189	193	197	226	255	300	345	394	444

PLAN C PLANT 14

- - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
PLANTS	35	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TC LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TC LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	979	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	35	0	0	0	0	345	0	0	0	0	0	0	0	0	0	0	0	0	0
SECONDARY PUMPING	33	0	0	0	0	0	0	0	0	0	0	84	0	0	0	0	0	0	0
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	105	0	0	0	0	0	0	0
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	460	0	0	0	0	0	0	0
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0
LAND PURCHASE & PREP	50	20	0	0	0	0	0	0	0	0	0	128	0	0	0	12	0	0	0
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	116	0	0	0	12	0	0	0
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	73	0	0	0	7	0	0	0
SLUDGE MANAGEMENT	35	0	0	0	0	80	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	33	0	0	0	0	34	0	0	0	0	0	20	0	0	0	2	0	0	0
TOTAL		20	0	0	1019	459	0	0	0	0	0	1086	0	0	0	33	0	0	0
PW (1/72) 5 3/8%		20	0	0	871	372	0	0	0	0	0	642	0	0	0	15	0	0	0
PW (1/72) 7 %		20	0	0	931	350	0	0	0	0	0	551	0	0	0	12	0	0	0
PW (1/72) 10 %		20	0	0	765	313	0	0	0	0	0	419	0	0	0	8	0	0	0

ITEM	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	RESID	NET	PRESENT WORTH AT 7% EXPEND	RESID	NET	PRESENT WORTH AT 10% EXPEND	RESID	NET
PLANTS	0	0	0	0	40	0	0	80	28	39	2	37	35	1	34	31	0	30
EXPAND TC LEVEL 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TC LEVEL 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	0	0	0	0	0	0	0	979	97	837	7	829	798	3	795	735	0	734
SEWER EXPANSION	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	0	335	0	0	0	345	0	1025	427	416	34	381	352	16	336	279	4	274
SECONDARY PUMPING	84	0	0	0	0	84	0	252	84	91	6	84	72	3	68	48	0	48
FORCE MAINS	0	0	0	0	0	0	0	105	29	62	2	60	53	0	52	40	0	40
STORAGE RESERVOIRS	165	0	240	0	295	0	0	1140	301	434	24	410	343	11	332	234	3	231
RESERVOIR AER & CL	127	0	170	0	215	0	215	827	215	194	17	177	138	8	130	81	2	78
LAND PURCHASE & PREP	19	19	30	30	33	33	0	[illegible]	304	134	24	110	111	11	95	82	3	79
IRRIGATION SYSTEMS	15	15	23	23	25	141	12	382	176	113	14	99	87	6	80	58	1	56
DRAINAGE SYSTEMS	12	12	19	18	20	20	0	181	69	67	5	61	53	2	50	36	0	35
SLUDGE MANAGEMENT	0	40	0	0	0	80	0	200	78	85	6	78	73	3	70	60	0	59
MISCELLANEOUS	3	34	4	4	5	45	0	153	0	59	0	59	49	0	49	37	0	37
TOTAL	445	497	406	75	593	748	227	5324	1004	2536	146	2390	2170	70	2099	1725	18	1707
PW (1/72) 5 3/8%	173	137	112	13	81	78	10	0	0	2536	146	2390	0	0	0	0	0	0
PW (1/72) 7 %	131	96	72	8	45	41	6	0	0	0	0	0	2170	70	2099	0	0	0
PW (1/72) 10 %	80	51	33	3	16	12	2	0	0	0	0	0	0	0	0	1725	18	1707

- - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
PLANTS	35	61	66	71	77	82	2	2	2	2	2	2	2	2	3	3	3	3	3
SLUDGE FACILITIES	35	4	4	4	5	6	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	35	0	0	0	0	0	16	16	16	16	16	17	17	17	18	18	19	19	20
SECONDARY PUMPING	33	0	0	0	0	0	0	0	0	0	0	0	9	9	10	10	10	10	10
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	6	6	6
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	6	6	6	6	6	6	6
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
SLUDGE MANAGEMENT	35	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		65	70	75	86	92	24	24	24	24	24	25	50	50	53	53	55	55	56
PW (BEGIN PER) 5 3/8		61	66	71	81	87	22	22	22	22	22	23	47	47	50	50	52	52	53
PW (1/72) 5 3/8%		61	63	64	69	70	17	16	15	14	14	14	26	25	25	24	23	22	21
PW (BEGIN PER) 7%		60	65	70	80	85	22	22	22	22	22	23	46	46	49	49	51	51	52
PW (1/72) 7%		60	61	61	65	65	15	14	13	13	12	11	22	20	20	19	18	17	16
PW (BEGIN PER) 10%		59	63	68	78	83	21	21	21	21	21	22	45	45	48	48	50	49	50
PW (1/72) 10%		59	57	56	58	57	13	12	11	10	9	8	15	14	13	12	11	10	10

ITEM	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	RESID	NET	PRESENT WORTH AT 7% EXPEND	RESID	NET	PRESENT WORTH AT 10% EXPEND	RESID	NET
PLANTS	3	3	4	5	6	7	8	528	0	343	0	343	317	0	317	202	0	202
SLUDGE FACILITIES	0	0	0	0	0	0	0	23	0	19	0	19	18	0	18	17	0	17
SEWERS	4	4	4	4	4	4	4	180	0	57	0	57	44	0	44	29	0	29
TEMPORARY PUMPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	20	32	34	36	38	40	42	1288	0	310	0	310	220	0	220	128	0	128
SECONDARY PUMPING	13	14	15	16	17	18	19	533	0	115	0	115	78	0	78	48	0	48
FORCE MAINS	1	1	1	1	1	1	1	37	0	8	0	8	6	0	6	3	0	3
STORAGE RESERVOIRS	3	3	4	4	5	6	6	139	0	27	0	27	18	0	18	9	0	9
RESERVOIR AER & CL	7	8	9	10	12	12	12	333	0	68	0	68	46	0	46	23	0	23
LAND PURCHASE & PREP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	7	7	9	9	10	11	12	312	0	67	0	67	45	0	45	23	0	23
DRAINAGE SYSTEMS	2	2	2	2	3	3	3	77	0	15	0	15	10	0	10	5	0	5
SLUDGE MANAGEMENT	1	1	2	2	2	2	3	63	0	15	0	15	11	0	11	6	0	6
MISCELLANEOUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	63	77	87	92	101	107	0	3505	0	1091	0	0	818	0	0	570	0	0
PW (BEGIN PER) 5 3/8	299	351	381	409	444	462	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 5 3/8%	116	105	88	72	60	48	0	0	0	1085	0	0	0	0	0	0	0	0
PW (BEGIN PER) 7%	287	336	364	394	431	441	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 7%	85	70	54	42	32	24	0	0	0	0	0	0	841	0	0	0	0	0
PW (BEGIN PER) 10%	264	311	341	368	385	412	3	10C	0	0	0	0	0	0	0	0	0	0
PW (1/72) 10%	47	34	23	15	10	7	0	0	0	0	0	0	0	0	0	583	0	0

- - - - - ANNUAL CAPITAL COSTS AT 7% IN $1000 - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
PLANTS	35	0	0	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
EXPAND TC LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	35	0	0	0	0	25	25	25	25	25	25	25	25	25	25	25	25	25	25
SECONDARY PUMPING	33	0	0	0	0	0	0	0	0	0	0	6	6	6	6	6	6	6	6
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	7	7	7	7	7	7	7	7
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	33	33	33	33	33	33	33	33
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	16	16	16	16	16	16	16	16
LAND PURCHASE & PREP	50	1	1	1	1	1	1	1	1	1	1	10	10	10	10	11	11	11	11
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	9	9	9	9	9	9	9	9
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5	5
SLUDGE MANAGEMENT	35	0	0	0	0	6	6	6	6	6	6	6	6	6	6	6	6	6	6
MISCELLANEOUS	33	0	0	0	0	2	2	2	2	2	2	4	4	4	4	4	4	4	4
5 3/8% CRF		1	1	1	60	89	89	89	89	89	89	163	163	163	163	165	165	165	165
7 % CRF		1	1	1	75	109	109	109	109	109	109	198	198	198	198	201	201	201	201
10 % CRF		2	2	2	105	151	151	151	151	151	151	270	270	270	270	274	274	274	274

ITEM	1990	1995	2000	2005	2010	2015	2020
PLANTS	3	3	3	3	3	3	3
EXPAND TC LEVEL 1	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	0	0	0	0	0	0	0
SLUDGE FACILITIES	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	0	0	0	0	0	0	0
SEWERS	70	70	70	70	70	70	70
SEWER EXPANSION	0	0	0	0	0	0	0
DETENTION BASINS	0	0	0	0	0	0	0
BASIN EXPANSION	0	0	0	0	0	0	0
TEMPORARY PUMPS	0	0	0	0	0	0	0
SHAFTS & TUNNELS	0	0	0	0	0	0	0
AERATED LAGOONS	25	51	51	51	51	51	51
SECONDARY PUMPING	13	13	13	13	13	13	13
FORCE MAINS	7	7	7	7	7	7	7
STORAGE RESERVOIRS	46	46	63	63	82	82	82
RESERVOIR AER & CL	21	21	28	28	35	35	35
LAND PURCHASE & PREP	12	14	16	18	20	23	23
IRRIGATION SYSTEMS	11	12	14	15	17	19	19
DRAINAGE SYSTEMS	6	7	8	10	11	13	13
SLUDGE MANAGEMENT	6	5	9	9	9	9	9
MISCELLANEOUS	4	7	7	8	5	7	7
5 3/8% CRF	188	217	242	247	271	278	277
7 % CRF	229	263	293	299	328	336	335
10 % CRF	311	358	398	406	445	455	455

- - - - - TOTAL ANNUAL CAPITAL COSTS IN $1000 - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
CAPITAL RECOVERY FACTOR AT 5 3/8%																									
TOTAL ANNUAL CAPITAL	1	1	1	60	89	89	89	89	89	89	163	163	163	163	165	165	165	165	188	217	242	247	271	278	277
TOTAL ANNUAL O&M	65	70	75	86	92	24	24	24	24	24	25	50	50	53	53	55	55	56	63	77	87	92	101	107	110
TOTAL ANNUAL COSTS	66	71	76	146	181	113	113	113	113	113	188	213	213	216	218	220	220	221	251	294	329	339	372	385	387
CAPITAL RECOVERY FACTOR AT 7 %																									
TOTAL ANNUAL CAPITAL	1	1	1	75	109	109	109	109	109	109	198	198	198	198	201	201	201	201	229	263	293	299	328	336	335
TOTAL ANNUAL O&M	65	70	75	86	92	24	24	24	24	24	25	50	50	53	53	55	55	56	63	77	87	92	101	107	110
TOTAL ANNUAL COSTS	66	71	76	161	201	133	133	133	133	133	223	248	248	251	254	256	256	257	292	340	380	391	429	443	445
CAPITAL RECOVERY FACTOR AT 10 %																									
TOTAL ANNUAL CAPITAL	2	2	2	105	151	151	151	151	151	151	270	270	270	270	274	274	274	274	311	358	398	406	445	455	455
TOTAL ANNUAL O&M	65	70	75	86	92	24	24	24	24	24	25	50	50	53	53	55	55	56	63	77	87	92	101	107	110
TOTAL ANNUAL COSTS	67	72	77	191	243	175	175	175	175	175	295	320	320	323	327	329	329	330	374	435	485	498	546	562	565

TOTAL WASTEWATER AND STORMWATER FOR PLAN C

PLAN C

CAPITAL COSTS IN $1000 FOR WASTEWATER

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
PLANTS	35	0	0	0	78306	2780	2788	2796	2804	44093	3075	2927	2779	2631	98980	3323	2826	2629	2432
EXPAND TO LEVEL 1	25	0	0	0	82445	45	45	45	45	1159	109	109	109	109	168	163	158	153	148
EXPAND TO LEVEL 2	25	0	0	0	113	113	113	113	113	115	115	115	115	115	22251	251	251	251	251
SLUDGE FACILITIES	35	0	0	0	48093	0	0	0	0	2617	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	11500	0	0	0	0
SEWERS	50	0	0	0	131447	0	0	0	0	63756	0	0	0	0	72479	0	0	0	0
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	29369	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	94930	0	0	0	0	63410	0	0	0	0	67005	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	2768	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	69814	0	0	0	191930	208930	0	0	0	0	0
AERATED LAGOONS	39	0	0	0	0	12429	0	0	0	0	0	0	0	0	0	0	0	0	0
SECONDARY PUMPING	33	0	0	0	0	494	0	0	12	0	0	4425	0	24000	0	0	0	0	0
FORCE MAINS	50	0	0	0	0	587	0	0	68	0	0	9002	0	240	0	0	0	0	0
STORAGE RESERVOIRS	50	0	0	0	0	2287	0	0	0	0	0	18604	0	41145	0	0	0	0	0
RESERVOIR AER & CL	10	0	0	0	0	532	0	0	0	0	0	4139	0	3654	0	0	0	0	0
LAND PURCHASE & PREP	50	9636	0	0	0	794	0	0	0	0	0	5886	0	62889	0	517	0	0	0
IRRIGATION SYSTEMS	33	0	0	0	0	513	0	0	3	0	0	5264	0	56260	0	442	0	0	0
DRAINAGE SYSTEMS	50	0	0	0	0	537	0	0	0	0	0	3611	0	49170	0	378	0	0	0
SLUDGE MANAGEMENT	39	0	3004	0	9200	2452	0	1185	0	2700	0	0	0	8885	342	0	0	0	0
MISCELLANEOUS	33	0	0	0	0	1363	0	0	0	0	0	961	0	10926	0	79	0	0	0
TOTAL		9686	3004	0	444734	24917	2946	4139	75627	207219	3299	55043	194933	468954	272724	4852	3235	3033	2831
PW (1/72) 5 3/8		9686	2850	0	380247	20207	2268	3021	52409	136350	2058	32585	109552	250421	137998	2329	1475	1313	1163
PW (1/72) 7 %		9686	2808	0	362902	19011	2100	2756	47115	120601	1794	27961	92593	208215	113180	1662	1171	1028	897
PW (1/72) 10 %		9686	2730	0	333995	17014	1829	2334	38796	96771	1398	21246	68226	149596	79089	1276	773	661	560

ITEM	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	RESID	NET	PRESENT WORTH AT 7% EXPEND	RESID	NET	PRESENT WORTH AT 10% EXPEND	RESID	NET
PLANTS	123825	1886	25830	1462	17950	32594	97141	555558	161726	234765	13099	221665	195887	6307	189579	147874	1617	146257
EXPAND TO LEVEL 1	126	103	95	87	6093	94	98	93695	5711	77244	462	72781	69283	222	69060	63182	57	63125
EXPAND TO LEVEL 2	252	256	261	261	22261	261	261	48238	13230	15863	1069	14794	12197	514	11682	7972	132	7840
SLUDGE FACILITIES	0	0	0	0	10263	0	0	61003	8354	44251	676	43574	41549	325	41223	37617	83	37534
SLUDGE FAC. EXP.	0	0	0	0	0	0	11500	23030	11500	6750	931	5819	5221	448	4772	3450	115	3335
SEWERS	41429	0	52113	0	0	0	0	361423	95450	219378	7733	211645	194698	3723	190964	160712	954	159757
SEWER EXPANSION	23588	0	720	0	0	0	0	53677	15733	28690	1274	27416	24182	613	23569	18010	157	17853
DETENTION BASINS	9349	0	9406	0	0	0	0	244130	51606	162612	4180	158432	146352	2012	144340	122668	516	122152
BASIN EXPANSION	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	0	0	0	0	0	0	0	2768	0	1918	0	1918	1724	0	1724	1419	0	1419
SHAFTS & TUNNELS	0	0	0	0	0	0	0	470674	120967	267814	9798	258016	227425	4717	222708	169638	1209	168429
AERATED LAGOONS	72940	10600	10000	25	0	12425	0	118410	36314	45318	2941	42376	35489	1416	34073	23701	363	23338
SECONDARY PUMPING	11015	0	3205	0	506	4484	24000	72141	32166	23364	2605	20759	18250	1254	16996	12241	321	11919
FORCE MAINS	904	0	1826	0	0	0	0	12627	3745	6756	303	6451	5711	146	5565	4275	37	4238
STORAGE RESERVOIRS	20806	0	22101	0	14456	0	0	119339	46649	50039	3778	46261	40036	1819	38217	27528	466	27062
RESERVOIR AER & CL	10243	0	12368	0	13862	0	13896	58694	13908	14709	1126	13582	10613	542	10071	6337	139	6197
LAND PURCHASE & PREP	4955	3544	4935	3243	3513	2783	0	89778	92992	53098	7532	45556	45101	3626	41474	34593	929	33663
IRRIGATION SYSTEMS	5704	2888	4452	2619	3226	7377	56703	145451	70390	44184	5701	38482	34326	2745	31581	22996	703	22292
DRAINAGE SYSTEMS	3993	2656	3972	2405	2553	2040	0	71355	24781	33280	2007	31273	27127	966	26160	19043	247	18795
SLUDGE MANAGEMENT	2668	1139	11233	0	3868	11652	2700	61025	23797	26213	1927	24286	22389	928	21461	17889	237	17651
MISCELLANEOUS	8164	1661	1851	535	597	1952	10941	39029	14316	12924	1159	11764	10090	558	9532	6772	143	6629
TOTAL	335862	24753	164358	10637	101218	75662	217240	2702015	843335	1365178	68310	1296868	1167648	32890	1134758	907928	8433	899494
PW (1/72) 5 3/8	132546	7425	37966	1893	13866	7944	17596	0	0	1365178	68310	1296868	0	0	0	0	0	0
PW (1/72) 7 %	100599	5222	24653	1138	7652	4161	6472	0	0	0	0	0	1167648	32890	1134758	0	0	0
PW (1/72) 10 %	61175	2772	11340	457	2732	1286	2172	0	0	0	0	0	0	0	0	907928	8433	899494

O & M COSTS IN $1000 FOR WASTEWATER

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
PLANTS	35	27407	28522	29638	31160	31922	30208	30773	31338	32520	32162	31804	31446	31088	25673	26465	27257	28049	28841
SLUDGE FACILITIES	35	3416	3522	3627	3751	3805	3763	3810	3857	4322	4357	4392	4427	4462	3393	3411	3429	3447	3465
SEWERS	50	0	0	0	535	561	587	613	639	976	976	976	976	976	1184	1213	1242	1271	1300
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	244	349	349	349	1119	1889	2772	2374	2346	2398	2409	[illegible]
AERATED LAGOONS	39	0	0	0	0	0	676	694	712	733	747	767	821	838	857	1145	1432	1720	2011
SECONDARY PUMPING	33	0	0	0	0	0	40	41	45	46	48	49	472	482	8346	8586	8826	9063	9303
FORCE MAINS	50	0	0	0	0	0	4	4	4	4	4	4	4	58	58	59	59	59	59
STORAGE RESERVOIRS	50	0	0	0	0	0	11	11	11	11	11	11	104	104	310	315	321	326	331
RESERVOIR AER & CL	10	0	0	0	0	0	34	35	35	436	438	438	687	689	1594	1661	1728	1796	1865
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	33	0	0	0	0	0	31	31	32	32	33	33	293	297	2953	3021	3089	3155	3221
DRAINAGE SYSTEMS	50	0	0	0	0	0	8	8	8	8	8	8	64	66	684	687	690	691	692
SLUDGE MANAGEMENT	39	0	791	840	1291	1346	1442	1500	1559	1616	1656	1695	1736	1774	2274	2193	2236	2280	2329
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	9	9	103	116	129	142	155
TOTAL		30823	32835	34105	36737	37634	36861	37577	38541	41110	40846	40583	42309	42829	50845	51889	53468	55041	56621
PW (BEGIN PER) 5 3/8		29238	31159	32349	34932	35715	34930	35659	36579	38970	38735	38509	40182	40569	48217	49278	50755	52230	53712
PW (1/72) 5 3/8%		29251	29584	29159	29793	28578	26508	26040	25359	25652	24180	22807	22593	21671	24405	23561	23151	22621	22082
PW (BEGIN PER) 7%		28805	30643	31865	34333	35148	34416	35134	35988	38410	38126	37929	39531	40013	47516	48334	50054	51449	52953
PW (1/72) 7%		28819	26664	27829	29030	26833	24549	23410	22430	22363	20749	19276	18785	17774	19727	18783	18125	17447	16759
PW (BEGIN PER) 10%		28003	29820	30994	33396	34202	33462	34164	35068	37307	37170	36782	38542	38918	46093	47138	48749	49973	51458
PW (1/72) 10%		28018	27121	25612	25091	23370	20789	19277	17998	17430	15766	14204	13496	12420	13372	12401	11656	10898	10191

ITEM	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	RESID	NET	PRESENT WORTH AT 7% EXPEND	RESID	NET	PRESENT WORTH AT 10% EXPEND	RESID	NET
PLANTS	26586	27239	17165	17996	18946	20133	21372	1162393	0	465161	0	465161	382573	0	382573	284150	0	284150
SLUDGE FACILITIES	3295	3583	1605	1714	1874	1572	2107	135246	0	57337	0	57337	47521	0	47521	35560	0	35560
SEWERS	1488	1592	1716	1716	1716	1716	1716	64235	0	17053	0	17053	12426	0	12426	7512	0	7512
TEMPORARY PUMPS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	3037	3074	3114	3147	3181	3205	3228	110893	0	25600	0	25600	17606	0	17606	9420	0	9420
AERATED LAGOONS	8573	9328	9599	10347	10705	10941	11174	318518	0	63390	0	63390	41522	0	41522	20373	0	20373
SECONDARY PUMPING	5615	10035	10711	11123	11533	11832	12129	375672	0	81111	0	81111	54489	0	54489	27840	0	27840
FORCE MAINS	62	62	73	73	73	73	73	2535	0	596	0	596	413	0	413	224	0	224
STORAGE RESERVOIRS	411	414	516	522	582	585	590	17377	0	3653	0	3653	2441	0	2441	1242	0	1242
RESERVOIR AER & CL	1970	2051	2159	2280	2401	2451	2504	79331	0	17885	0	17885	12238	0	12238	6507	0	6507
LAND PURCHASE & PREP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	3225	3369	3605	3730	3873	3555	3964	126721	0	27670	0	27670	18661	0	18661	9607	0	9607
DRAINAGE SYSTEMS	737	773	823	855	888	911	914	28907	0	6294	0	6294	4241	0	4241	2181	0	2181
SLUDGE MANAGEMENT	1419	1510	1849	1944	2056	2129	2208	86554	0	26483	0	26483	20413	0	20413	13664	0	13664
MISCELLANEOUS	175	183	203	203	210	210	210	6653	0	1408	0	1408	937	0	937	470	0	470
TOTAL	61245	64260	54635	56852	59262	61338	0	2513835	0	793647	0	0	615488	0	0	418755	0	0
PW (BEGIN PER) 5 3/8	266651	254590	238856	247828	257443	264652	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 5 3/8%	104782	76381	55178	44116	35271	27790	0	0	0	801426	0	0	0	0	0	0	0	0
PW (BEGIN PER) 7%	257529	243657	228502	238685	249886	252621	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 7%	76233	51416	34277	25541	18592	13855	0	0	0	0	0	0	620720	0	0	0	0	0
PW (BEGIN PER) 10%	237018	225539	214041	222726	223293	236111	1225	37455	0	0	0	0	0	0	0	0	0	0
PW (1/72) 10%	42665	25262	14770	9577	6029	4014	0	0	0	0	0	0	0	0	0	421637	0	0

ANNUAL CAPITAL COSTS AT 7% IN $1000

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
PLANTS	35	0	0	0	4029	6263	6458	6673	6889	10284	10521	10746	10960	11163	18794	19017	19235	19437	19624
EXPAND TO LEVEL 1	25	0	0	0	6523	6527	6531	6534	6538	6638	6647	6657	6666	6675	6690	6704	6717	6731	6743
EXPAND TO LEVEL 2	25	0	0	0	9	19	29	39	49	59	69	79	88	98	2011	2033	2054	2076	2097
SLUDGE FACILITIES	35	0	0	0	3703	3703	3703	3703	3703	3904	3904	3904	3904	3904	3904	3904	3904	3904	3904
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	885	885	885	885	885
SEWERS	50	0	0	0	9478	9478	9478	9478	9478	14069	14069	14069	14069	14069	19287	19287	19287	19287	19287
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114
DETENTION BASINS	50	0	0	0	6834	6834	6834	6834	6834	11400	11400	11400	11400	11400	16224	16224	16224	16224	16224
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	816	816	816	816	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	5026	5026	5026	5026	18845	33888	33888	33888	33888	33888	33888
AERATED LAGOONS	39	0	0	0	0	931	931	931	931	931	931	931	931	931	931	931	931	931	931
SECONDARY PUMPING	33	0	0	0	0	38	38	38	39	39	39	39	384	384	2256	2256	2256	2256	2256
FORCE MAINS	50	0	0	0	0	42	42	42	47	47	47	695	695	712	712	712	712	712	712
STORAGE RESERVOIRS	50	0	0	0	0	166	166	166	166	166	166	1504	1504	4466	4466	4466	4466	4466	4466
RESERVOIR AER & CL	10	0	0	0	0	60	60	60	60	60	60	751	751	1362	1362	1362	1362	1362	1362
LAND PURCHASE & PREP	50	697	697	697	697	754	754	754	754	754	754	1178	1178	5706	5706	5743	5743	5743	5743
IRRIGATION SYSTEMS	33	0	0	0	0	40	40	40	40	40	40	450	450	4829	4829	4873	4873	4873	4873
DRAINAGE SYSTEMS	50	0	0	0	0	39	38	38	38	38	38	298	298	3838	3338	3866	3866	3866	3866
SLUDGE MANAGEMENT	39	0	225	225	915	1099	1099	1188	1188	1390	1390	1390	1390	1390	2056	2082	2082	2082	2082
MISCELLANEOUS	33	0	0	0	0	106	106	106	106	106	106	181	181	1033	1033	1039	1039	1039	1039
5 3/8% CRF		561	748	748	28028	29593	29783	30047	35078	47408	47622	51320	61860	90114	106955	107265	107476	107674	107860
7 % CRF		697	922	922	34191	36093	36311	36629	42709	57887	59143	62591	75816	110518	131022	131395	131649	131885	132107
10 % CRF		978	1284	1284	46956	45523	49830	50259	58500	79583	79928	85886	104712	152683	180762	181266	181605	181923	182220

ITEM	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	RESID	NET	PRESENT WORTH AT 7% EXPEND	RESID	NET	PRESENT WORTH AT 10% EXPEND	RESID	NET
PLANTS	25159	29304	31243	31406	26758	25013	23593											
EXPAND TO LEVEL 1	6754	6763	5098	4990	711	655	655											
EXPAND TO LEVEL 2	2119	2141	2156	2128	2389	2003	2004											
SLUDGE FACILITIES	3904	3904	3904	3904	3904	792	792											
SLUDGE FAC. EXP.	885	885	885	885	885	885	885											
SEWERS	22270	22270	26022	26022	26022	26022	26022											
SEWER EXPANSION	3912	3912	3964	3964	3964	3964	3964											
DETENTION BASINS	16857	16897	17575	17575	17575	17575	17575											
BASIN EXPANSION	0	0	0	0	0	0	0											
TEMPORARY PUMPS	0	0	0	0	0	0	0											
SHAFTS & TUNNELS	33888	33888	33888	33888	33888	33888	33888											
AERATED LAGOONS	6402	7167	7647	7564	7644	7640	7640											
SECONDARY PUMPING	3115	3115	3365	3365	3366	3370	3370											
FORCE MAINS	777	777	905	909	905	909	909											
STORAGE RESERVOIRS	5964	5964	7555	7555	8596	8596	8596											
RESERVOIR AER & CL	2263	1673	2098	2017	2362	2260	2382											
LAND PURCHASE & PREP	6093	6349	6705	6538	7291	7391	7391											
IRRIGATION SYSTEMS	5318	5543	5891	6095	6306	6471	6471											
DRAINAGE SYSTEMS	4153	4344	4630	4803	4990	5137	5137											
SLUDGE MANAGEMENT	2292	2368	3210	3210	3500	3275	3196											
MISCELLANEOUS	1676	1805	1950	1992	1932	2009	2004											
5 3/8% CRF	125068	130026	138102	138542	130545	129014	128199											
7 % CRF	157761	155010	160951	165504	155956	158073	157081											
10 % CRF	217070	218921	232734	233520	220556	213121	216771											

TOTAL ANNUAL CAPITAL COSTS IN $1000

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
CAPITAL RECOVERY FACTOR AT 5 3/8%																									
TOTAL ANNUAL CAPITAL	561	748	748	28028	29593	29793	30047	35078	47408	47622	51320	61860	90114	106955	107265	107475	107674	107860	129068	130026	138102	138542	130549	129014	128199
TOTAL ANNUAL O&M	30923	32835	34105	36737	37634	36361	37577	38541	41110	40846	40583	42309	42829	50845	51889	53468	55041	56621	61245	64260	54635	56852	59262	61338	62189
TOTAL ANNUAL COSTS	31384	33583	34853	64765	67227	66644	67624	73619	88518	88468	91903	104169	132943	157800	159154	160944	162715	164481	190313	194286	192737	195394	189811	190352	190388
CAPITAL RECOVERY FACTOR AT 7 %																									
TOTAL ANNUAL CAPITAL	697	922	922	34191	36093	36311	36629	42709	57887	59143	62581	75516	110519	131022	131395	131644	131885	132107	157761	155010	160951	165504	159956	158073	157081
TOTAL ANNUAL O&M	30823	32835	34105	36737	37634	36861	37577	38541	41110	40846	40593	42309	42829	50845	51989	53468	55041	56621	61245	64260	54635	56852	59262	61338	62189
TOTAL ANNUAL COSTS	31520	33757	35027	70928	73717	73172	74206	81249	98997	98989	103164	118125	153347	181867	183284	185116	186926	188728	219006	223270	223586	226356	219158	219411	219270
CAPITAL RECOVERY FACTOR AT 10 %																									
TOTAL ANNUAL CAPITAL	978	1284	1284	46956	45523	49830	50259	58500	79583	79928	85886	104712	152683	180762	181265	181605	181923	182220	217070	218921	232734	233520	220556	213121	216771
TOTAL ANNUAL O&M	30823	32835	34105	36737	37634	36861	37577	38541	41110	40846	40583	42309	42829	50845	51889	53468	55041	56621	61245	64260	54635	56852	59262	61338	62189
TOTAL ANNUAL COSTS	31801	34119	35389	83693	87157	86651	87836	97041	120693	120774	126469	147021	195512	231607	233155	235073	236964	238841	278315	283181	287369	290372	279818	274459	278960

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