UPPER LEON RIVER
MUNICIPAL WATER DISTRICT
REGIONAL WASTEWATER STUDY
VOLUME IV
POINT-SOURCE POLLUTION CONTROL EVALUATION

SEPTEMBER, 1991

STATE OF TEXAS
GREGORY J. LEWIS
58261
REGISTERED
PROFESSIONAL ENGINEER

D910172
JN040404

JONES AND NEUSE, INC.
Environmental and Engineering Services

TABLE OF CONTENTS
UPPER LEON RIVER MUNICIPAL WATER DISTRICT
REGIONAL WASTEWATER STUDY

TABLE OF CONTENTS

VOLUME IV

POINT SOURCE POLLUTION CONTROL EVALUATION

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

LIST OF TABLES

TABLE OF CONTENTS
(Continued)

PAGE

LIST OF TABLES (Continued)

LIST OF FIGURES

TABLE OF CONTENTS
(Continued)

PAGE

LIST OF FIGURES (Continued)

LIST OF APPENDICES

LIST OF REFERENCES

SECTION 1.0
EXECUTIVE SUMMARY

1.0 EXECUTIVE SUMMARY

This report has been written for the Upper Leon River Municipal Water District (ULRMWD) under a grant from the Texas Water Development Board (TWDB). It is Volume 4 of a 5 Volume study of the water quality of Lake Proctor, and deals with point source pollution, primary sources being wastewater treatment systems. The report first assesses the existing conditions of wastewater facilities in the watershed, then goes on to estimate the amount of wastewater flow which will be generated in the future, through the 30-year planning period. Next, the report considers two alternatives for treatment of future wastewater flow: upgrading existing facilities to handle anticipated needs, and the construction of a regional facility (or one or more subregional facilities).

The following conclusions have been made by this report:

- The conditions of the individual treatment plants vary considerably: several will be adequate throughout the planning period, and at least one is under an enforcement order from the Texas Water Commission (TWC).

- The population of the watershed is not expected to increase dramatically during the design period.

- Rural large-lot septic systems are not a threat to lake water quality, but the unsewered and improperly sewered areas near the lake may threaten both lake quality and public health.

- There are no indications that communities with existing 30 mg/l BOD5 and 90 mg/l TSS (30/90) permits will not be allowed to obtain such permits in the future. It is likely that any regional or subregional treatment facility would be required to have a 10/15 permit.

- The relatively low population density of the Lake Proctor watershed would lead to a high cost of collection to be shared by the residents.

- The goal of the water conservation measures identified in Volume 5 of this document is to reduce the water consumption in the watershed by 5 percent. Some correlation in the reduction of wastewater flows will occur.

This report recommends the following:

- Cities in the watershed should continue to treat their wastewater individually, however future permit requirements may necessitate reevaluation of a regional or subregional collection and treatment system.

- Wastewater collection and treatment should be provided for the unsewered areas immediately adjacent to Lake Proctor, as these are immediate threats to water quality and possibly to public health. Ideally these systems would have no-discharge permits with effluent being used for irrigation. Until wastewater treatment is provided, existing rules on septic systems near the lake should be strongly enforced. These include the Buffalo Springs area, the High Point area, and potentially the Proctor area.

SECTION 2.0
INTRODUCTION

2.0 INTRODUCTION

2.1 Purpose of Study

This is Volume 4 of the regional wastewater management plan which has been performed for the ULRMWD with assistance from the TWDB. This volume is intended to fulfill the requirements of Tasks 4 and 5 of the contract between the ULRMWD and the TWDB. Task 4 is to evaluate the need for point source pollution controls. This task requires assessment of existing wastewater facilities, an estimate of present wastewater flow, a projection of future wastewater flow, and the identification of existing unsewered areas. Task 5 requires evaluation and identification of alternatives for regional centralized wastewater collection and treatment.

2.2 Scope of Study

The planning period of this study is from the present to 2022. The most current TWDB population projections have been used, with adjustments for 1990 census data. The geographic scope of this study is the watershed of Lake Proctor, which includes parts of Comanche, Eastland, Erath and Hamilton counties. The watershed of Lake Leon has been included in this study because the outflow from Lake Leon flows directly into Lake Proctor, and because the communities located in the Lake Leon watershed were considered likely candidates for inclusion in any proposed regional wastewater collection and treatment plan. The study area includes the cities of Gorman, Ranger, Cisco, Eastland, Rising Star, Comanche, Dublin and DeLeon. The permitted wastewater facilities of these cities have been assessed, as well as the small wastewater facility operated by the ULRMWD. Unsewered communities and non-conforming developments adjacent to Lake Proctor are a source of concern, and an assessment of these areas has been made as well.

SECTION 3.0

ASSESSMENT OF EXISTING CONDITIONS

3.0 ASSESSMENT OF EXISTING CONDITIONS

3.1 Evaluation of Existing Sewered Communities

The process of evaluating existing wastewater facilities was pursued in three steps. First, all available data was acquired from the TWC on the individual plants, including copies of permits, and printouts of plant self-reporting data. Second, a request for information was sent to each community, in the form of a letter informing the appropriate city official about the purpose of the ULRMWD study, a summary of information which we already had obtained, and a form requesting additional information. The final step was to inspect each facility and meet the person responsible for operation of the wastewater facility. A copy of the request letter and the information form from each of the permitted facilities is included in Appendix A. Existing population and flow records are shown in Table 1. A map of the Lake Proctor watershed showing permitted wastewater treatment facilities is shown in Figure 1.

- City of Cisco

  Cisco is a city of 4,223 located in northwest Eastland county. The average wastewater flow is 324,000 gallons per day (GPD) and the current TWC permit limits the wastewater discharge to 30 milligrams per liter (mg/l) of five day biochemical oxygen demand (BOD5) and 90 mg/l of total suspended solids (TSS). The treatment facilities consist of a facultative lagoon with two stabilization ponds, constructed in June, 1987. The City has exceeded its permitted flow several times last year, but has submitted a waiver request to the TWC maintaining that the excessive flows were caused by unusually heavy rainfall and inflow and infiltration (I&I) problems which the city is currently attempting to correct.

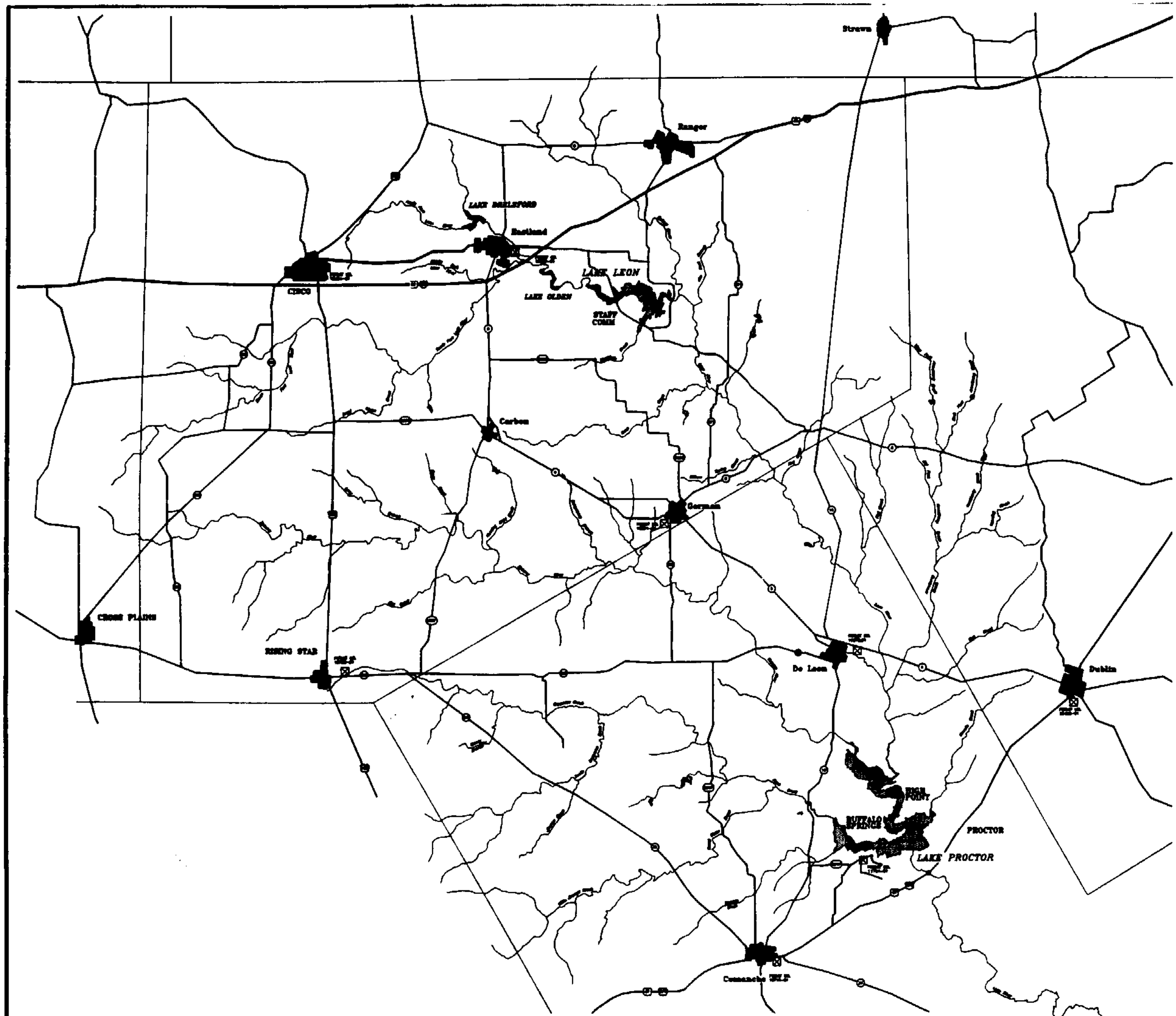
- City of Comanche

  Comanche is a city of 4,807 people located in the center of Comanche county and just southwest of Lake Proctor. The current daily average wastewater flow is 369,100 GPD. TWC permitted effluent limits are 20 mg/l BOD5, and 20 mg/l TSS (20/20). The

TABLE 1

EXISTING FACILITIES AND DESIGN YEAR REQUIREMENTS

Station	1990 Population	1987-1989 Max. Mo. Flow (GPD)	1987-1989 Max. Mo. Flow (GPCD)	1987-1989 Avg. Flow (GPD)	1987-1989 Avg. Flow (GPCD)	Design Yr. (2022) Population	Req'd. Max Mo. Plant Capacity (GPD)	Design Year Flow (GPCD)	Permitted Plant Capacity (GPD)	Modifications Req'd. to Meet Capacity Needs	Modifications Req'd to Meet Performance Needs
Cisco	3813	544,300	142.7	324,600	85.1	4052	567,380	140	440,000	Expand Pond System	
Comanche	4087	617,000	128.4	369,100	76.8	5208	729,120	140	740,000		
DeLeon	2190	150,000	68.5	119,600	54.6	2873	402,220	140	166,000	Expand Pond System	Same
Dublin	3190	345,900	108.4	176,900	55.5	3873	542,220	140	250,000	Expand Pond System	Same
Eastland	3690	528,100	143.1	348,800	94.5	4029	564,060	140	400,000	Add Oxidation Ditch	
Gorman	1290	974,800	755.7	103,900	80.5	1304	182,560	140	120,000	Expand Pond System	Same
Proctor	362	NA			0.0	499	69,860	140	NA	Build Pkg. Plant	Same
Ranger	2803	900,900	321.4	271,000	96.7	2974	416,360	140	430,000	New Plant	New Plant/red. I&I
Rising Star	859	134,000	156.0	76,800	89.4	884	123,760	140	140,000	None	Reduce I & I
ULRMWD	175	NA	0.0	11,000	62.9	241	33,740	140	60,000	None	
Buffalo Springs	350	NA	NA	NA	NA	482	67,500	140	NA	Build Pkg. Plant w/Pressure Collection System	
High Point	525	NA	NA	NA	NA	723	101,200	140	NA	Build Pkg. Plant w/Pressure Collection System	
Staff Community	350	NA	NA	NA	NA	580	81,200	140	NA	Build Pkg. Plant w/Pressure Collection System	



LEGEND

SCALE IN FEET

SCALE IN MILES

7/10/91

FIGURE 1
UPPER LEON
EXISTING COMMUNITIES & EXISTING
WASTEWATER DISCHARGE LOCATIONS

JN JONES AND NEUSE, INC.
Environmental and Engineering Services

wastewater plant is a contact stabilization plant built in 1966, and expanded in 1982 with the addition of a new sludge thickener, screw lift pumps, bar screen and air blowers. Replacement of the chlorination system and flow recorder is planned for this summer. The plant is currently experiencing no problems meeting its permit limits. Operators report some problems with filamentous bacteria, and some shock loadings believed to be due to illegal dumping by septic cleaning services.

- City of DeLeon

The City of Deleon has a population of 2,190 and is located in the northeast corner of Comanche county, just to the north of Lake Proctor. DeLeon has an average daily wastewater flow of 119,600 GPD with TWC permit limits of 30 mg/l BOD5 and 90 mg/l TSS (30/90). The treatment facility was built in 1958 and consists of an Imhof tank followed by two stabilization ponds. The second pond was added in 1986. The plant has been exceeding its permit discharge limits and is under an enforcement order from the TWC. Todd Engineering of Abilene is preparing plans for updating the plant.

- City of Dublin

The City of Dublin is located in western Erath county, just east of Lake Proctor and has a population of 3,190. The average discharge is 176,900 GPD, and the facility is permitted for discharge limits of 30/90. Treatment is by an Imhof tank, built in 1949, followed by four lagoons. The collection system is experiencing serious I&I problems, which the city hopes to reduce and continue to operate the present facilities for 4-5 more years. The Imhof tank is beginning to leak, and the operator believes that the lift station pumps may be undersized.

- City of Eastland

The City of Eastland has a population of 3,690 and is located in the center of Eastland county northwest of Lake Leon. The average flow is 348,800 GPD and effluent discharge limits are 20/20. The wastewater treatment facility consists of an oxidation ditch, a final clarifier and chlorine disinfection and was built in 1977. The city plans to add another oxidation ditch and clarifier and ultra-violet disinfection. The operator reports some problem with I&I.

- City of Gorman

The City of Gorman has a population of 1,290 and is located on the southern edge of Eastland county. Average wastewater flow is 103,900 GPD and permitted effluent limits are 30/90. Treatment consists of an Imhof tank built in 1920 and two lagoons. The first lagoon was dredged and deepened in 1990. An engineering report prepared by Jacobs and Martin Consulting Engineers of Abilene, recommends abandoning the Imhof tank, converting the first pond to a facultative lagoon, enlargement of the second pond, construction of a third stabilization pond and the addition of a rock-reed filter.

- City of Ranger

The City of Ranger is located in northeastern Eastland county and has a population of 2,803. The City has an average wastewater flow of 271,000 GPD, and is permitted to discharge an effluent with 10/15 limits. Treatment consists of an Imhof tank built around 1920 and stationary trickling filters. Discharges are exceeding permitted flow and BOD5. Both the collection system and the treatment facility require extensive repair and/or replacement. The City is currently under TWC enforcement provisions.

- City of Rising Star

The City of Rising Star has a population of 859, and is located in southwestern Eastland county. The wastewater facility is permitted for 20/20 and has an average flow of 76,800 GPD. Treatment is accomplished by an extended aeration activated sludge plant, built in 1964. The plant is in good general condition and is capable of meeting the needs of the City throughout the planning period.

- ULRMWD

The ULRMWD operates a small package treatment plant near the golf course along the southern edge of Lake Proctor which serves 150 to 200 people. The facility has a no discharge permit with treated effluent going to a holding pond, where it used for irrigation. The TWC permit limits the BOD5 of the effluent to 100 mg/l. Average flow is 10,000 GPD, and the plant can treat 60,000 GPD. Five lift stations pump wastewater up to the plant. The plant was built in 1975 and is in excellent condition.

3.2 Evaluation of Unsewered Communities

For purposes of this report, unsewered communities have been divided into two types: those in the immediate vicinity of one of the lakes, and those in outlying areas of the region.

3.2.1 Lakeside Communities

The lakeside communities are a particular source of concern with respect to the water quality of area lakes. Development in these areas has been poorly regulated, and rules on septic and other wastewater systems have not been stringently enforced. The high permeability of the soil may allow migration of leaking septic or holding tank waste into the lakes. Three areas have been identified as areas of concern; two are near Lake Proctor, and one is near Lake Leon.

- Buffalo Springs

Buffalo Springs refers to the area just northwest of the main pool of Lake Proctor, and between the two arms. An estimated 350 permanent residents live in dwellings or mobile homes in the area. There is a recreational vehicle development called Promontory Point with spaces for about 400 trailers. These lots are approximately 1,000 square feet and have no wastewater service provided, except a holding tank for RV wastes. The park management is out of business, and it is not known who, if anyone, is responsible for wastes. Some of the owners have built permanent structures and some have installed permitted septic systems on two or more lots, but there is some evidence that some of the owners may have installed illegal septic tanks on single lots, and in the restricted zone near the lake.

About 40 mobile homes near the lake were flooded in 1990 and are now abandoned. A small septic system was installed in the early 1970's by the ULRMWD to serve this area.

- High Point

High Point refers to a developed area northeast of the main pool of Lake Proctor. The current population in this area has been estimated at 525. The area has one subdivision with lots too small for septic tanks and drainfields, as well as a convenience store with laundromat and car wash.

- Staff Community

Staff Community refers to the developed area southwest of Lake Leon. Approximately 350 people live in this area. The residents are on septic systems, and there are a number of small stores and bait stands in the area.

3.2.2 Remote Communities

A significant number of the study area inhabitants live in unincorporated areas. Some of these live in small "crossroad" communities, and the rest live on farms or ranches. These residences are almost invariably on individual septic systems. In Comanche county 75 percent of the population falls in to this category, as well as 33% of Eastland county and 39 percent of Erath county. Although these percentages are substantial, these septics are not considered to be a major threat to the water quality of Lake Proctor for two reasons: the discharges are not concentrated in any one area or tributary, and the BOD of the discharges is reduced by biological metabolism and dilution as the wastewater moves through the watershed. For small discharges as would be expected from septic systems found in the Lake Proctor area one-half mile or more above the lake, the assimilative capacity of the receiving stream should result in a reduction of BOD concentrations to near background levels before reaching the reservoir.

However, total nutrient loadings would not be expected to be reduced significantly. There are no major industrial discharges in these areas, and agricultural chemical runoff is addressed in Volume III of this report.

SECTION 4.0
POPULATION PROJECTIONS

4.0 POPULATION PROJECTIONS

Population projections for the planning period have been made using 1990 census records, TWDB projections, information from ULRMWD personnel and from site visits. Current population data and projections are summarized in Table 2.

4.1 Census Data and Lot Counts

Population data for this report is from the 1990 census, obtained through the Texas Natural Resources Information System (TNRIS). Total county populations are available, as well as totals for cities with populations greater than 1,000. Estimates have been made for the lakeside communities through site visits and information from ULRMWD personnel. Where population estimates were made from estimated number of residences, a factor of 3.5 persons per house was used. Conservative assumptions have been made, and more thorough population counts of these areas should be made prior to actual design of treatment facilities.

4.2 TWDB Projections

Population projections have been made using the TWDB high-range projections dated October, 1989. These are the most current projections available from the TWDB. New projections incorporating data from the 1990 census are expected out this fall. It is common practice to use the TWDB high-range projections for water and wastewater development.

4.3 Growth Trend Evaluation and Projections for 30-Year Planning Period

Since the TWDB projections were produced, the 1990 census figures have been released. The TWDB projections have been adjusted to reflect the 1990 census data using the following method: first, a value for the 2022 population was calculated by interpolating between the TWDB values for the years 2020 and 2030; next, the growth factor between the TWDB values for 1990 and 2022 was calculated; finally, this growth factor was used to project an adjusted 2022 population beginning from the 1990 census population.

TABLE 2

UPPER LEON RIVER MUNICIPAL WATER DISTRICT

POPULATION PROJECTIONS

Station	Actual 1980	Actual 1986	TWDB 1990	Actual 1990	TWDB 2022	Adjusted 2022	Projected Growth 1990 - 2022 TWDB (%)
COMANCHE COUNTY							
Comanche	4075	4140	4223	4087	5381	5208	27.42
DeLeon	2478	2600	2696	2190	3537	2873	31.19
Other	6064	6060	5617	7104	7739	9788	37.78
TOTAL	12,617	12,800	12,536	13,381	16,657	17,869	32.29
EASTLAND COUNTY							
Cisco	4517	4370	4359	3813	4632	4052	6.26
Eastland	3747	4280	4356	3690	4756	4029	9.18
Gorman	1258	1250	1285	1290	1299	1304	1.09
Ranger	3142	3380	3349	2803	3553	2974	6.09
Rising Star	1204	1150	1181	859	1216	884	2.96
Other	5612	5770	5773	6033	9575	10,006	65.86
TOTAL	19,480	20,200	20,303	18,488	25,031	23,249	25.75
ERATH COUNTY							
Dublin	2723	2730	2798	3190	3397	3873	21.41
Stephenville	11,881	12,790	13,309	13,817	17,870	18,552	34.27
Other	7956	9380	10,580	10,984	13,426	13,938	26.90
TOTAL	22,560	24,900	26,687	27,991	34,693	36,363	30.00

As an example, for the City of Comanche, TWDB populations for 1990, 2020, and 2030 are 4,223, 5,285, and 5,768 respectively. Using the first formula, the population for 2,022 should be:

$$P_{2022} = 5285 + \left(\frac{5768 - 5285}{10}\right) \times 2 = 5382$$

The growth factor is then:

$$GF = \frac{5382 - 4223}{4223} = 0.2774$$

Applying this factor to the 1990 census population for gives:

$$P_{2022adj} = 4087 \times (1 + 0.2744) = 5209$$

This method was used to project the population of the study area to determine future wastewater flows. This method has been reviewed by TWDB staff, and is sufficient for the design purposes of this report.

Where populations have been estimated, population projections were made by using the "other" category from the TWDB projections. (The "other" category consists of all people within the county not living in a city of 1,000 or more people.) For example, the 1990 population for the Buffalo Springs area was estimated at 350 people. The 2022 design population for the area was obtained by dividing the adjusted 2022 population (as calculated in the preceding paragraph) for the "other" population of Comanche County by the "other" 1990 census population and multiplying this times the estimated 1990 population.

SECTION 5.0

PROJECTED WASTEWATER LOADINGS FOR COMMUNITIES REQUIRING SERVICE AND CRITERIA FOR EVALUATION

5.0 PROJECTED WASTEWATER LOADINGS FOR COMMUNITIES REQUIRING SERVICE AND CRITERIA FOR EVALUATION

5.1 Planning Basis

In order to evaluate existing wastewater facilities in the watershed, TWC permits and self-reporting data for the permitted wastewater facilities were obtained. The self-reporting data is assembled from the monthly reports that the wastewater plant operators submit to the TWC. It contains measurements of the daily effluent flow, the BOD5 and TSS of the treated effluent, and any other effluent characteristic which the TWC permit requires the plant to monitor. Using this data, the maximum daily flow is determined by dividing the highest monthly flow reported by the number of days in the month. These are given in column two of Table 1. The maximum month daily flow was then used to estimate per capita wastewater flow for design purposes.

5.2 Flow Projections

Wastewater flow is a combination of true wastewater discharged into the sewer collection system, and water entering the collection system from other sources such as leaking sewer lines, roof drains, or storm drains improperly connected to the sewer system. In column three of Table 1, the present per capita wastewater flow has been calculated by dividing the maximum daily flow for each city by the present population. There is a wide variability in these values for three reasons: some cities are experiencing severe I&I problems; flow measurement devices at some of the treatment facilities are inaccurate; and the area experienced unusually high rainfall during the 1987-1989 time period. A design value of 140 gallons per capita per day (GPCD) has been used for projecting future wastewater flow. This figure is higher than is usually used to allow for I&I in aging collection systems found in the area. To estimate design year wastewater flow, the projected 2022 population has been multiplied by 140 GPCD.

The Water Conservation Plan (WCP) contained in Volume 5 of this report is intended to conserve drinking water as well as potentially reduce wastewater flow. The stated goal of reducing water use by 5 percent may serve to reduce wastewater flows by some amount; however, it will not be the full 5 percent. For the purposes of this study, the potential flow reductions have not been included making these projections somewhat conservative. A clear benefit to the operators/owners of the wastewater facilities exists as a result of conserving water including, lower O&M costs and an extension of a facility life as it relates to capacity. For design and projections purposes however, this study considers the effects of water conservation on wastewater flows to be minimal.

5.3 Permit Restrictions

Cost projections for future wastewater treatment needs have been calculated using two scenarios: For the first case, it is assumed that cities will be issued permits for expansion which are of the same stringency that they now hold. For example, if a city currently holds a 30/90 effluent permit for a stabilization pond system, it was assumed that a 30/90 permit will be issued to expand pond facilities for future capacity, and costs were calculated for facilities to handle the incremental amount of wastewater, that is the difference between present treatment capacity and projected wastewater flow. In the second case, it was assumed that the TWC would require 10/15 permits of all future facilities, in which case pond systems would have to be abandoned for activated sludge facilities. Costs were thus calculated assuming all of the design flow would have to be handled by an activated sludge facility.

5.4 Design Criteria

Where facilities would be required to meet 30/90 permits, costs were calculated for facultative lagoons. Since land costs are low in the study area, facultative lagoons are good design responses where permitted. When 10/15 permit limits were assumed, costs have been calculated for conventional activated sludge treatment with aerobic sludge digestion, chlorine disinfection, sulfur dioxide dechlorination and sludge drying beds.

SECTION 6.0

NEEDS ASSESSMENT AND EVALUATION OF ALTERNATIVES FOR INDIVIDUAL TREATMENT SYSTEMS

6.0 NEEDS ASSESSMENT AND EVALUATION OF ALTERNATIVES FOR INDIVIDUAL TREATMENT SYSTEMS

6.1 Capacity Needs

Future capacity needs have been determined by comparing permitted plant capacity to design year flow. Where projected flow exceeds permitted plant capacity, the difference is the expansion requirement, the amount of additional capacity which must be built to handle design year flows. When permitted flow exceeds projected flow, and present facilities are in reasonably good shape as in the case of Rising Star, no additional expansion has been recommended. Similarly, as in the case of Ranger, even though permitted capacity exceeds projected wastewater flow, the present facilities are in such poor condition that a new activated sludge plant has been assumed for purposes of this report.

6.2 Performance Needs

Performance needs are closely linked to capacity needs. Where plants are having trouble meeting their permit limits and capacity expansion is anticipated, it is assumed that plant performance will be addressed by the designer to meet permit limits. This would be the case for DeLeon, Dublin, and Gorman where expansion of the existing pond system will solve both capacity and performance needs simultaneously. Several area cities are currently pursuing I&I reduction, and in the case of Rising Star, even though additional capacity will not be required, reduction of I&I will increase the efficiency of the existing plant, and reduce operating costs. It is likely that all of the area cities will need major collection system repair/replacement during the design period due to neglect of collection facilities. Modifications required to meet current performance needs are presented in column 11 of Table 1.

6.3 Other Needs

The City of Ranger will need extensive replacement/repair of its collection system in addition to a new treatment plant. The City is currently under an enforcement order from the TWC, and is in the planning stage for new facilities.

6.4 Needs of Unsewered Communities

The unsewered communities will need facilities for both collection systems and treatment of wastewater. Because the outlying areas (that is those a mile or more away from the lakes) do not threaten lake water quality, are adequately served by individual septic systems, and do not have the population density to make collection and treatment economically feasible, no additional facilities are anticipated. The lakeside communities (those less than one mile from the lake) will require collection and treatment to protect lake water quality. Though population densities in these areas are low, collection systems can be designed to serve the residences in this area. Many of these residences will be on a lower grade than sites available for wastewater treatment facilities and lift stations will increase collection costs.

Wastewater for the unsewered areas will be treated by several small package plants, preferably with effluent being land applied well away from the lake, as is currently being done by the ULRMWD package plant near the golf course, just south of Lake Proctor. Discharges into the lake would undoubtedly be vigorously opposed, and if allowed, would likely have very stringent permit limits, increasing the cost of the treatment facilities.

6.5 Estimated Costs of Recommended Individual Treatment Systems

The estimated costs to upgrade each individual treatment facility through the design period presented in Table 3, have been calculated using two assumptions. First in Section 6.5.1, it has been assumed that dischargers would be allowed to expand their facilities under the same permit restrictions which they now hold. For example, if a city currently holds a 30/90 permit and is treating with a pond system, it is assumed that the city will be allowed to expand the pond system to account for future flow. In Section 6.5.2, it is assumed that future expansions will be required to meet 10/15 permit limits, and new activated sludge facilities will be required to handle both present and future flow.

TABLE 3
COST TO UPGRADE EXISTING FACILITIES
TO MEET DESIGN YEAR REQUIREMENTS,
MAINTAINING EXISTING PERMITS

System	*Capital Cost*	*O & M Cost*	*Total Annual Cost*
Cisco	372,000	62,100	97,500
Comanche			
DeLeon	525,000	84,300	134,300
Dublin	579,485	85,300	140,500
Eastland	785,335	90,490	165,242
Gorman	400,000	461,000	72,400
Proctor	318,000	28,950	59,220
Ranger	929,000	72,600	161,027
Rising Star			
Buffalo Springs	308,420	12,400	41,760
High Point	396,870	18,600	56,380
Staff Community	289,500	15,000	42,600
TOTAL	*$4,903,610*	*$930,740*	*$970,930*

6.5.1 Costs to Upgrade Existing Facilities Assuming Current Permits will be Extended for Future Flow

Estimated costs for each project have been calculated and are shown in detail in Appendix B. Table 3 summarizes the costs to upgrade existing facilities to meet design year requirements. Detailed cost calculations are shown in Appendix B. A 15% contingency has been added to both the estimated capital costs and to the O&M costs.

- Capital Costs

  For activated sludge and lagoon type facilities capital costs have been estimated using the Innovative and Alternative Technology Assessment Manual (EPA 430/9-78-009). Costs were updated using the March, 1991 Engineering News Record (ENR) Construction Cost Index (4774).

  For pre-engineered or package treatment plants, a current survey was done of three manufacturers of this type of equipment to estimate costs. Data points were plotted on a graph of installed cost versus wastewater flow. This graph was then used to estimate costs for various size package plants.

- Operation and Maintenance (O&M) Costs

  For activated sludge and pond systems, O&M costs were estimated and updated using the EPA manual as described above. Power costs were estimated using $0.05 per KwH. O&M costs for package treatment plants were estimated using $0.15 per GPD of flow treated.

- Total Annual Costs

  The total annual cost is the sum of the yearly O&M cost and the annualized cost of the capital cost. Annual capital cost of each project has been calculated assuming financing at 8.75 percent for 30 years.

6.5.2 Costs to Upgrade Facilities Assuming that Future Permit Requirements will be 10/15

For this alternative, it is assumed that all existing pond systems will be abandoned when permit renewal is required at some time during the planning period, and facilities built to meet 10/15 discharge permit limits. The cities which would require this upgrade are Cisco, DeLeon, Dublin, and Gorman. The City of Ranger will be building new facilities in either case. To meet 10/15 limits, it has been assumed that the treatment process required would include an activated sludge system, secondary clarification, aerobic digestion, sludge drying beds, chlorine disinfection, and dechlorination. Costs for each of these processes have been estimated using the EPA publication "Innovative and Alternative Technology Assessment Manual". As previously described, these costs have been adjusted to present-day costs, and a 15 percent contingency added. Totals for capital costs, O&M costs, and annual costs are shown in Table 4. Costs broken down by city are shown in Appendix D.

TABLE 4

COST TO UPGRADE EXISTING FACILITIES

TO 10/15 PERMITS

System	*Capital Cost*	*O & M Cost*	*Total Annual Cost*
Cisco	1,083,200	88,200	191,300
Comanche			
DeLeon	913,400	75,100	162,000
Dublin	1,037,600	86,300	185,000
Eastland	785,335	90,490	165,242
Gorman	601,000	53,600	110,800
Proctor	318,000	28,950	59,220
Ranger	929,000	72,600	161,027
Rising Star			
Buffalo Springs	308,420	12,400	41,760
High Point	396,870	18,600	56,380
Staff Community	289,500	15,000	42,600
TOTAL	*$6,662,325*	*$541,240*	*$1,175,330*

SECTION 7.0
REGIONAL ALTERNATIVES

7.0 REGIONAL ALTERNATIVES

7.1 Regional vs. Sub-Regional Systems

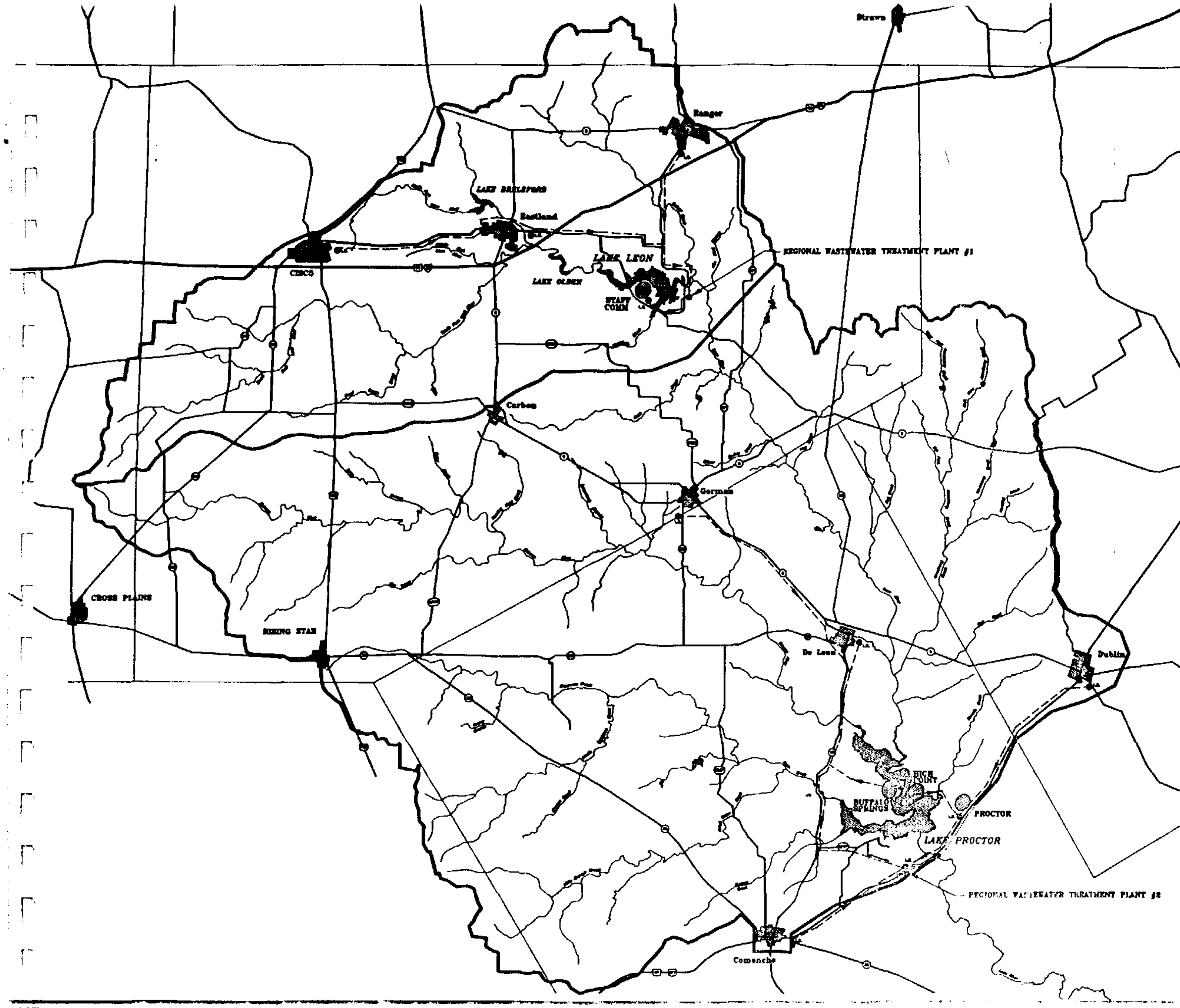
The greatest cost benefit of scale is achieved if one regional wastewater facility handles all the waste from the Lake Proctor watershed. However, design of just one plant cannot be justified economically due to the topographic diversity of the watershed, the relatively low population density, and the large area to be covered. With the population of the watershed generally clustered around Lake Proctor and Lake Leon, an obvious possibility is to serve the area with two subregional wastewater plants, one located just downstream of Lake Leon, and one located just downstream of Lake Proctor. The subregional plant at Lake Leon would serve the communities of Eastland, Cisco, Ranger and the Staff community around the lake. The subregional plant at Lake Proctor would serve the communities of Comanche, DeLeon, Dublin, Gorman, Proctor, High Point, and Buffalo Springs. Because of its remoteness from the possible subregional treatment plant sites, and because its plant should be adequate throughout the planning period, the City of Rising Star is not included in the subregional alternative. Placement of the plants below the lakes maximizes the economic benefit of utilizing gravity collection to the greatest extent possible, while keeping plant sizes large. Figure 2 shows the arrangement of the subregional treatment system.

7.2 Feasible Sub-Regional Alternatives

Consideration of more than two subregional wastewater plants only leads to a greater decrease in benefits of scale with respect to plant size, with minimal corresponding reduction of collection system complexity and cost.

7.3 Feasible Sub-Regional Process Alternatives

Although low land costs would reduce the capital cost of a subregional treatment plant using stabilization ponds and/or facultative lagoons, it is unlikely that a 30/90 permit would be issued for treatment plants of this size. A large plant with a 30/90 permit would likely generate considerable opposition by landowners downstream of the facility. For purposes of this report,



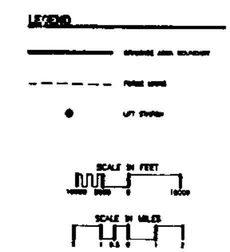


FIGURE 2
UPPER LEON
ALTERNATIVE SUB-REGIONAL
WASTEWATER SYSTEM FACILITI

JN JONES AND NEUSE, INC.
Environmental and Engineering Services

it is assumed that any regional or subregional wastewater facility would have a 10/15 discharge permit, necessitating an activated sludge type plant.

7.4 Pumping and Transportation Systems

It has been assumed that wastewater interceptor lines would follow existing highway right of ways, and no easement or land acquisition costs have been added. It is possible that some cost savings may be possible by taking lines cross-country, but such allowances have not been made in this report. Each city served by the subregional system will have a lift station to collect and pump its wastewater into the subregional interceptor, where wastewater will flow to the subregional plant. Additional collection systems with lift stations will be required for the unsewered lakeside communities, and other areas considered critical to water quality of the lakes.

The design data used to estimate costs of the subregional collection system is shown in Table 5. To estimate peak flow, the average flow in gpd was multiplied by three and converted to GPM. Static head was determined using topographic maps of the watershed area to compare the difference in elevation of the location of the proposed lift station and the proposed subregional treatment plant to which it would pump. A negative static head indicates a downhill run to the treatment plant. Pipe size was chosen to maintain a velocity of 2-4 FPS in the pipe, using standard hydraulic tables with the assumed peak flows. Plastic pipe has been assumed for the force mains. The friction head was also determined from standard hydraulic tables, using the pipe diameter and its length measured along highway right of ways. The total design head is the sum of the static head and the static head.

7.5 Estimated Costs of Feasible Sub-Regional Systems

Complete cost calculations are shown in Appendix C. Table 6 summarizes costs for force mains and lift stations and Table 7 shows costs for regional treatment systems, including the costs of collection systems for the unsewered areas. Detailed cost calculations are shown in Appendix C. A 15 percent contingency has been added to the estimated capital costs and to the O&M costs.

TABLE 5

TRANSFER LIFT STATIONS

DESIGN SUMMARY [1]

Station		Average Capacity (gpd)	Peak Capacity (gpm)	Approx. Static Head	Velocity (fps)	Approx. Friction Head	Approx. TDH	Force Main Diameter (in.)	Force Main Length (ft.)	Friction Loss ft/1000 ft.
1600	Cisco	567,300	1182	-200	3.25	304	104	12	124,088	2.45
1420	Eastland	564,100	1175	-20	3.23	135	115	12	55,440	2.44
1410	Ranger	416,400	867	-10	3.56	157	147	10	47,250	3.3
1380	Staff Community	81,200	169	+20	1.9	60	80	6	15,840	3.8
1400	Gorman	182,600	380	-200	2.62	307	107	8	139,920	2.2
1350	Comanche	729,100	1519	-150	4.35	191	41	12	44,880	4.25
1250	De Leon	402,200	838	-50	2.4	112	62	12	84,480	1.32
1430	Dublin	542,200	1130	-230	2.8	391	161	10	73,920	5.3
1210	Proctor	69,900	146	-10	3.8	153	143	4	18,400	8.3
1230	Buffalo Springs	67,500	141	-30	1.6	150	120	6	73,920	2.0
1250	High Point	101,200	211	-50	2.4	118	68	6	36,960	3.2
1200	ULRMWD	33,740	70	0	1.8	42	42	4	10,000	4.2

Peak Capacity (gpm) = 3 × Maximum Monthly Flow (MGD) × 694.4
Force Main Diameter Based on V_{max} = 5 fps (4 min. except where grinder pumps are utilized)
[1]Force Main Lengths Are Based on Following Existing Roads

7.5.1 Capital Costs

Capital costs for the subregional treatment systems have been calculated using the Innovative and Alternative Technology Assessment Manual, EPA 430/9-78-009. Costs have been adjusted using the March, 1991 ENR Construction Cost Index of 4774. It has been assumed that both subregional facilities will consist of activated sludge treatment, secondary clarification, aerobic sludge digestion, sludge drying beds, chlorine disinfection and sulfur dioxide dechlorination.

Capital costs for the transfer lift stations have been taken from the EPA manual and adjusted to current costs as above. Costs for the transfer force mains have been estimated using recent contractor data.

FORCE MAIN UNIT COSTS	
Diameter (inches)	***Installed Cost ($/foot)***
4	5
8	10
10	12.5
12	15

7.5.2 O & M Costs

O&M costs for the subregional treatment facilities have been estimated using the EPA manual, and adjusted to current prices. A cost of $11,600, based on an $6000 adjusted to current prices, has been assumed for all lift stations pumping less than 800,000 GPD. Power costs for lift stations have been calculated using the following formula:

$$PowerCost = \frac{\$0.05/Kwh \times Q_{avg}(MGD) \times TDH \times 1140}{Efficiency\ (assume .67)}$$

TABLE 6

COST SUMMARY FOR TRANSFER LIFT STATIONS AND FORCE MAINS

Station	*Pump Station Capital Cost*	*Force Main Capital Cost*	*Total Capital Cost*	*Pump Station Power Cost*	*Pump Station O & M*	*Total Annual Cost[1]*
Cisco	288,190	2,140,400	2,428,590	5,019	16,619	247,787
Eastland	287,500	956,300	1,243,800	5,532	17,132	135,524
Ranger	243,915	683,100	927,015	5,201	16,801	105,040
Staff Community	144,100	136,600	280,700	764	12,364	39,083
Gorman	166,290	200,100	366,390	1,675	13,275	48,150
Comanche	421,245	774,200	1,195,445	2,527	14,127	127,917
DeLeon	210,680	1,457,280	1,667,960	2,105	13,705	172,473
Dublin	354,775	1,062,600	1,417,375	8,144	19,744	154,659
Proctor	130,870	105,800	236,670	849	12,449	34,976
Buffalo Springs	144,100	637,600	781,700	505	13,991	88,397
High Point	155,200	318,800	474,000	3,168	14,768	59,886
ULRMWD	99,800	57,500	157,300	121	11,721	26,693

[1]Total Annual Cost = Annualized Total Capital Cost + Pump Station O & M Cost + Pump Station Power Cost

TABLE 7
COSTS OF REGIONAL TREATMENT SYSTEM

System	*Capital Cost*	*O & M Cost*	*Total Annual Cost*
SUBREGIONAL PLANT NO 1	1,994,238	185,900	375,700
Cisco	2,428,590	16,619	247,787
Eastland	1,243,800	17,132	135,524
Ranger	927,015	16,801	105,040
Staff Community	280,700	12,364	39,083
SUBTOTAL, SUBREGIONAL NO. 1	6,874,343	248,816	903,134
SUBREGIONAL PLANT NO. 2	2,711,700	200,400	458,500
Gorman	366,390	13,275	48,150
Comanche	1,195,445	14,127	127,917
DeLeon	1,667,980	13,705	172,473
Dublin	1,417,375	19,744	154,659
Proctor	236,670	12,449	34,976
Buffalo Springs	781,700	13,991	88,397
High Point	474,000	14,768	59,886
ULRMWD	157,300	11,721	26,693
SUBTOTAL, SUBREGIONAL NO. 2	9,008,560	314,180	1,171,651
TOTAL	*15,882,903*	*562,996*	*2,074,785*

Note: Costs shown for individual cities or unsewered areas include costs for collection systems and lift stations.

7.5.3 Total Annual Costs

Annual costs consist of the sum of the annualized capital cost and the yearly O&M cost. Annual capital cost has been calculated assuming 8.75 percent interest for a 30 year period.

SECTION 8.0
CONCLUSIONS AND RECOMMENDATIONS

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

The evaluation of the existing wastewater treatment and discharge facilities in the study area revealed that conditions varied significantly among the communities. Some communities had recently completed collection system and treatment system rehabilitations or expansions and had sufficient capacity for future growth. Some communities were currently in the process of system evaluation or expansion. Some communities were in need of significant upgrades or expansions.

Population growth for most of the communities in the study area was not projected to be large. Therefore those communities now meeting their permit requirements with any significant amount of excess capacity are not likely to require systen expansions in the near future.

The evaluation of unsewered communities revealed that large lot rural communities were not adversely impacted by the use of on-site systems as far as water quality issues are concerned. However, the more densely developed lakeside communities showed signs of inadequately designed and constructed systems, drainfields, bypasses to drainage ditches and other factors which would pose a significant threat to water quality and possibly to public health.

Many of the communities have discharge permits which allow the use of oxidation ponds as the treatment methodology. There are no indications that these permits will be revised to require higher technology. This significantly affects the comparison of individual treatment alternatives with regional treatment alternatives. It is anticipated that any regional or subregional system would require more advanced treatment technology, likely being required to treat to levels of 10/15.

The geographic distance between the communities in the study area would result in substantial construction costs for transportation of wastewater to a regional system. (See Table 8)

A regional wastewater treatment system would provide economy of scale in manpower and other operational aspects. It would enable centralized control and monitoring of point source

TABLE 8

COST COMPARISON OF ALTERNATIVES

	Capital Cost	*O & M Cost*	*Total Annual Cost*
SUBREGIONAL SYSTEM NO. 1	6,874,343	248,816	903,134
Sum of Individual Plants w. Existing Permit Limits	2,375,835	240,190	466,369
Sum of Individual Plants w. 10/15 Permits	3,087,035	266,290	560,169
SUBREGIONAL SYSTEM NO. 2	9,008,560	314,180	1,171,651
Sum of Individual Plants w. Existing Permits	2,527,775	690,550	504,561
Sum of Individual Plants w. 10/15 Permits	3,575,290	274,950	657,761

discharges and make it easier to measure and minimize impacts on water quality in the area. However, because of the difference in probable treatment technologies between individual and regional treatment alternatives and because of the high cost of transporting flow from distant communities, this study concluded that it was not cost-effective at this time to implement a regional or subregional wastewater treatment system.

If state or federal permit requirements are revised to require more stringent treatment levels for communities in the study area, or if the water quality monitoring program indicates that current treatment standards are insufficient to provide a reasonable level of protection to Lake Proctor or its tributaries, the cost-effectiveness analysis of regional alternatives should be re-evaluated.

8.2 Recommendations

It is recommended that wastewater collection and treatment on an individual basis be continued. However, if permit limits are revised, or if the water quality monitoring program indicates the need for higher levels of treatment, the regional system alternative should be reevaluated.

The unsewered developments in close proximity to Lake Proctor should be provided with centralized wastewater collection and treatment systems. A preliminary design of facilities for the Buffalo Springs and High Point communities is included in Appendix E. These facilities will be extended aeration activated sludge prefabricated package plants, with gravity collection to a lift station adjacent to the plant. A similar facility is operated by the ULRMWD at Par Village just west of the Lake Proctor Dam.

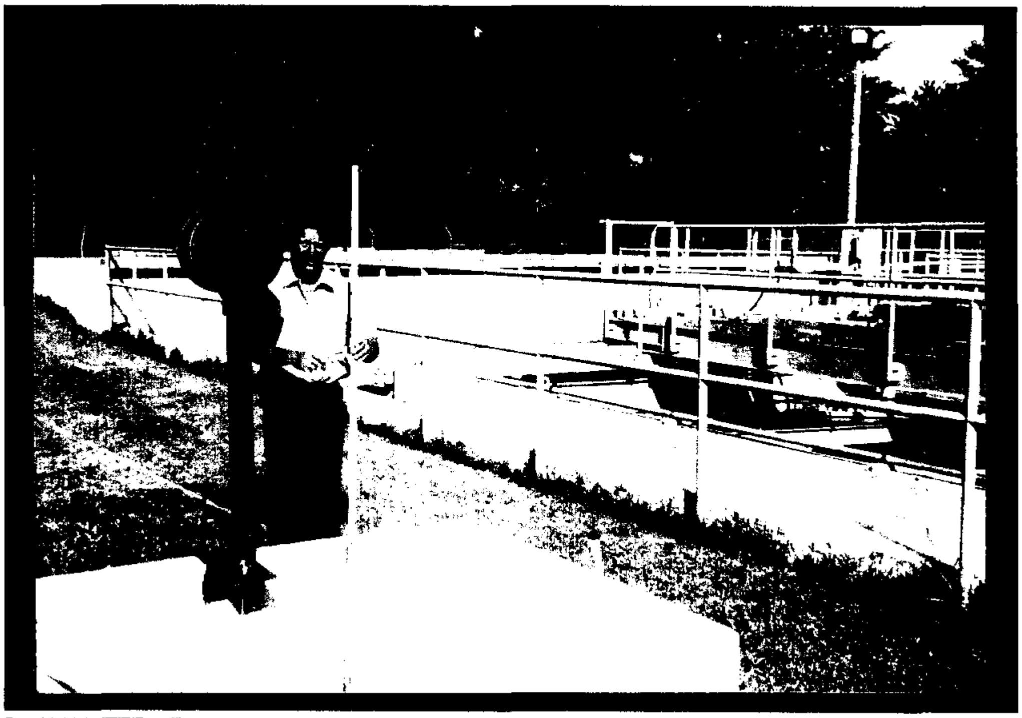
It is recommended that these plants operate under a seasonal discharge permit, which would allow irrigation during the growing season, and discharge of effluent during the winter. A number of agricultural activities in the area require irrigation, and it is anticipated that storage/irrigation ponds can be built on private land where the irrigation is to take place. The ponds would be sized to provide storage of effluent for 45 days. Recommended irrigation acreages and pond sizes are included in Appendix E.

Sludge drying beds should be built to handle sludge from these facilities. It is recommended that initially sludge beds be built only at one plant, and sludge trucked to the beds for drying. This should be done because sludge production will be small, especially early in the design life of the plants, and the district can build drying beds only as they are needed. Dried sludge may be sold to licensed sludge applicators, or sent to the landfill. Sizes of sludge beds are shown in Appendix E.

FIGURES

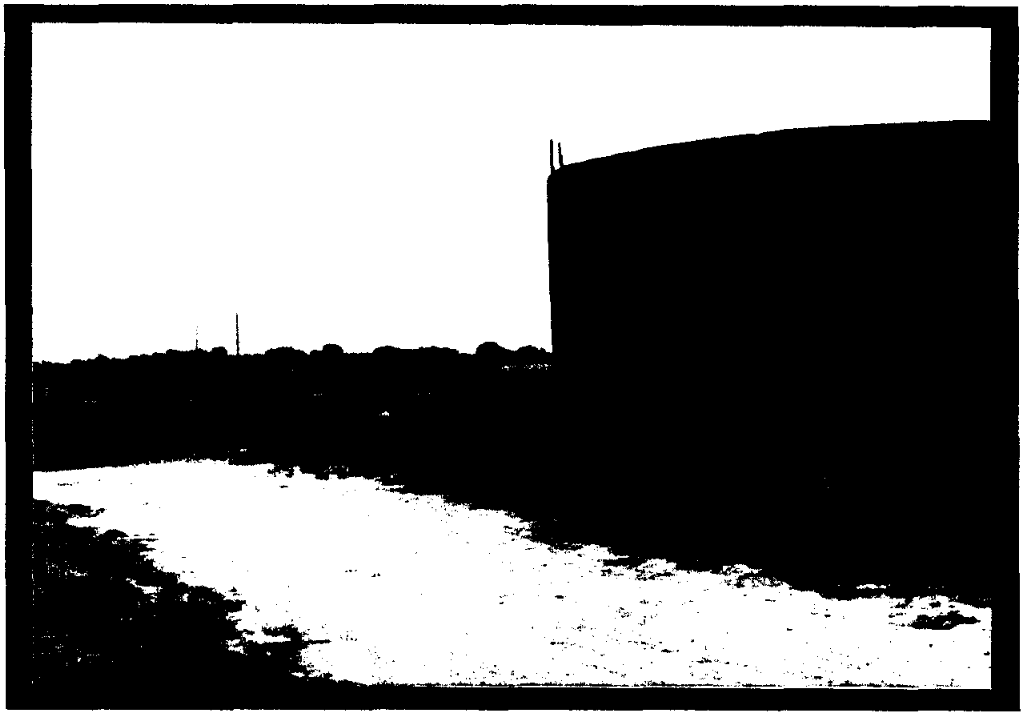
Old Cisco Activated Sludge Plant

New Cisco Facultative/Aerobic Pond System

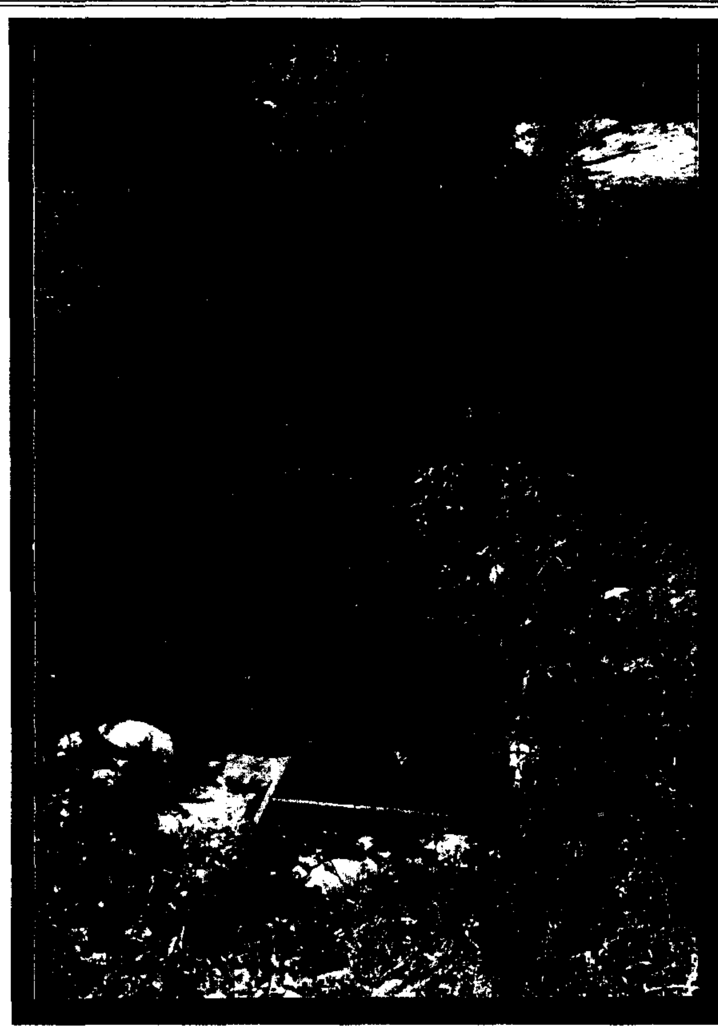


City of Comanche Wastewater Treatment Plant

Comanche Effluent Weir

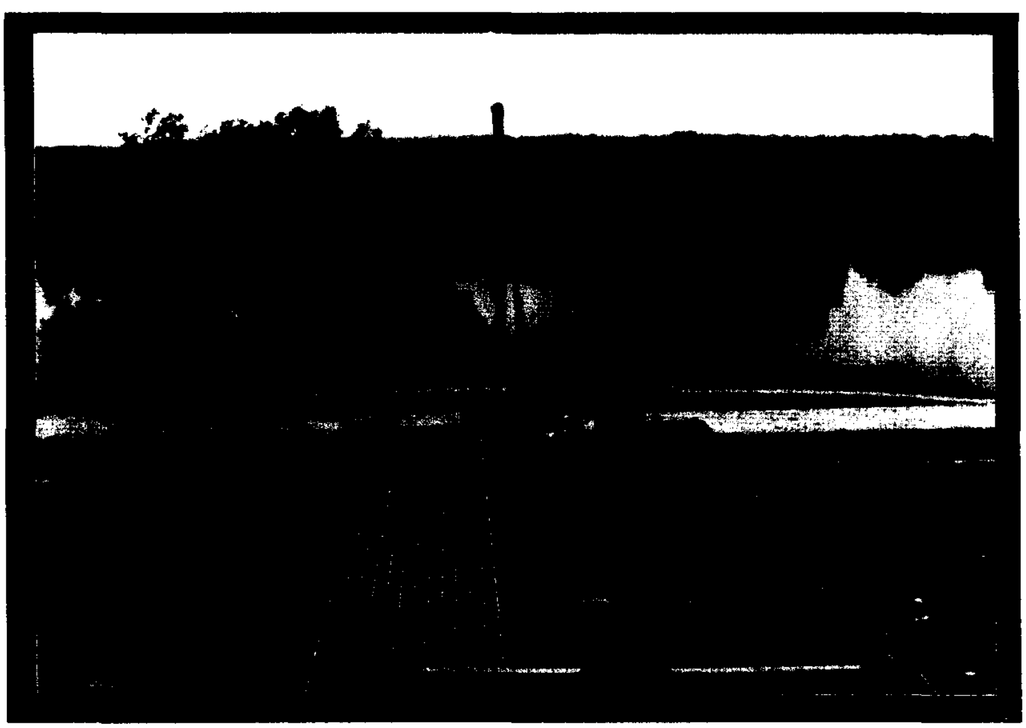


City of DeLeon, Imhof Tank and Sludge Beds
and Lift Station



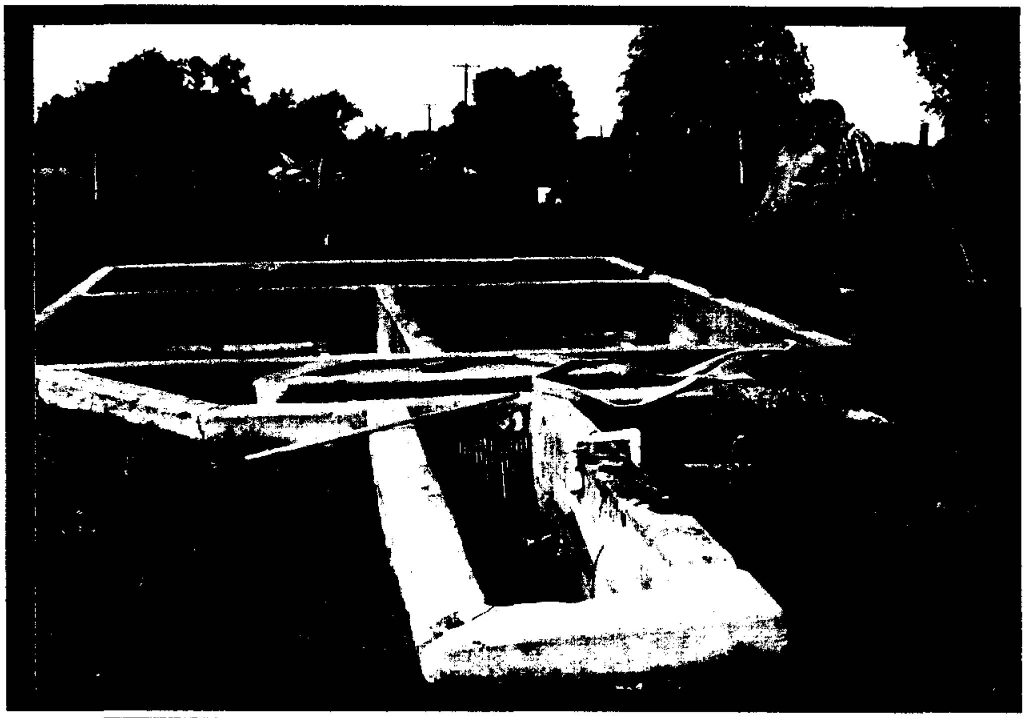
DeLeon Effluent Weir

City of Dublin, Imhof Tank and
Sludge Drying Beds

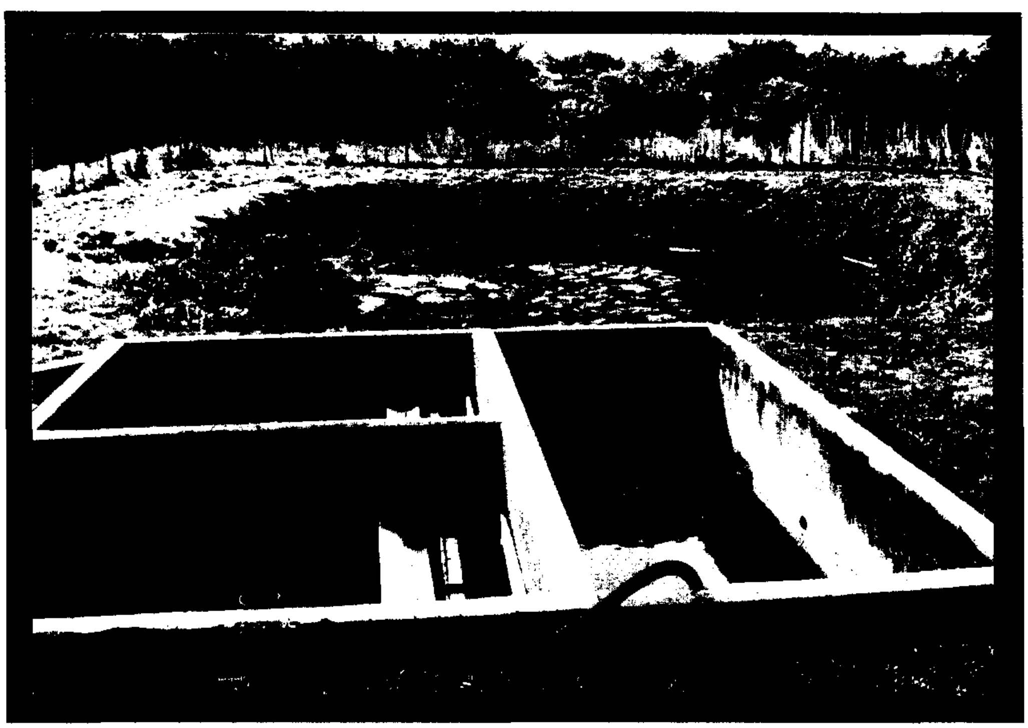


Dublin Stabilization Pond

Eastland Oxidation Ditch Plant

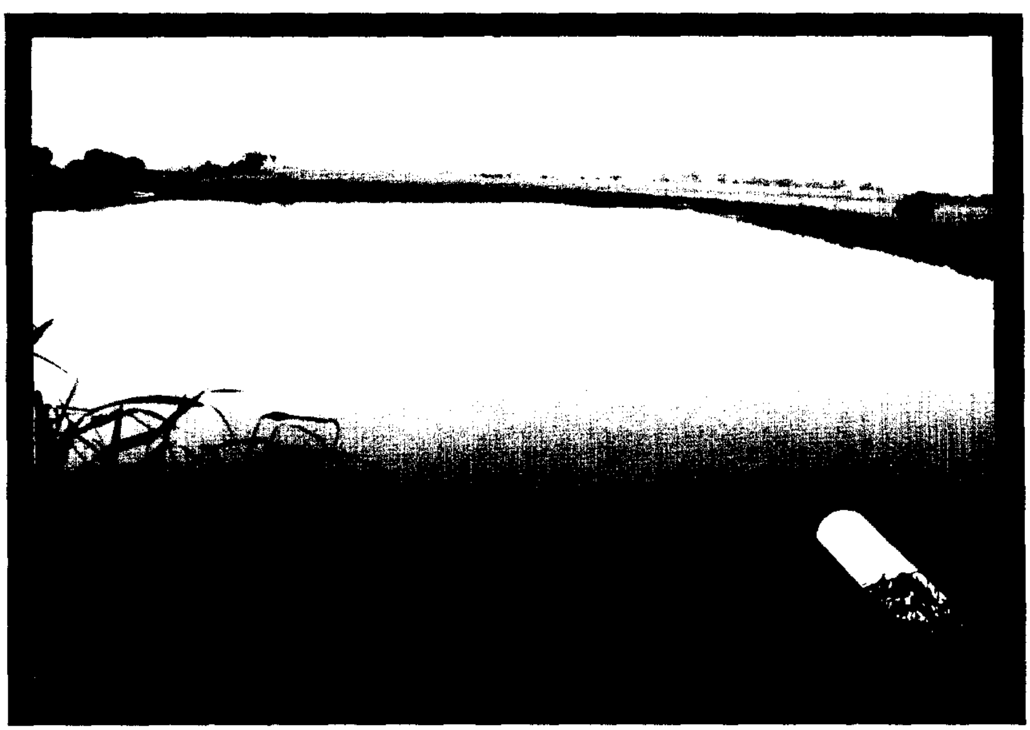


Gorman Primary Treatment Facilities

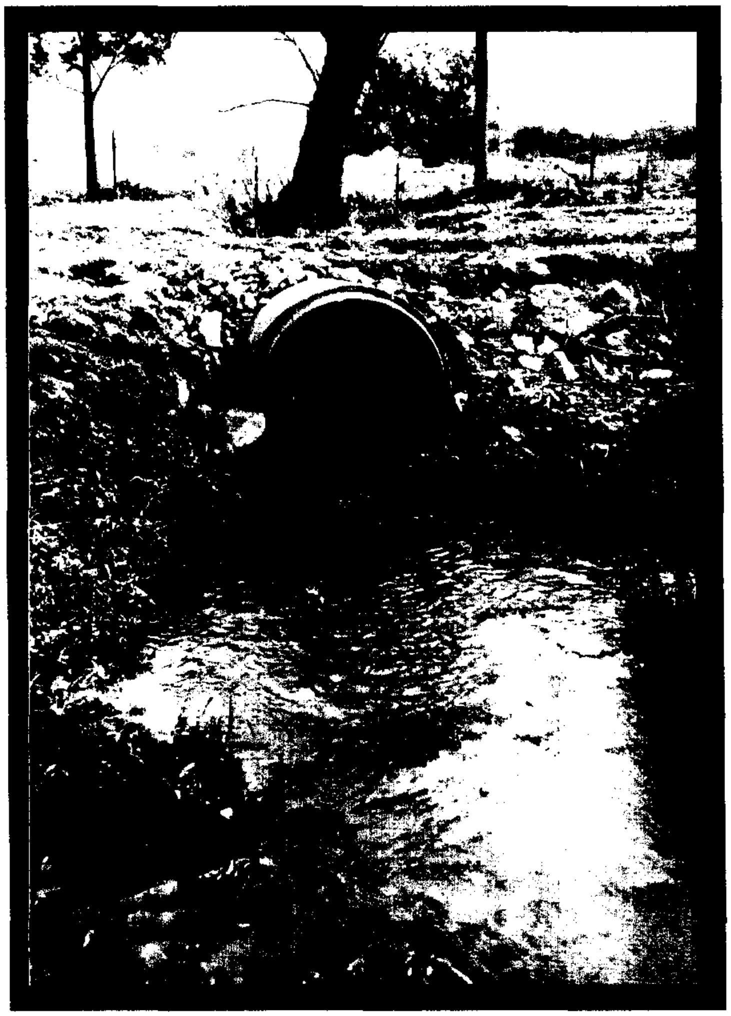


Gorman Primary Sludge Disposal

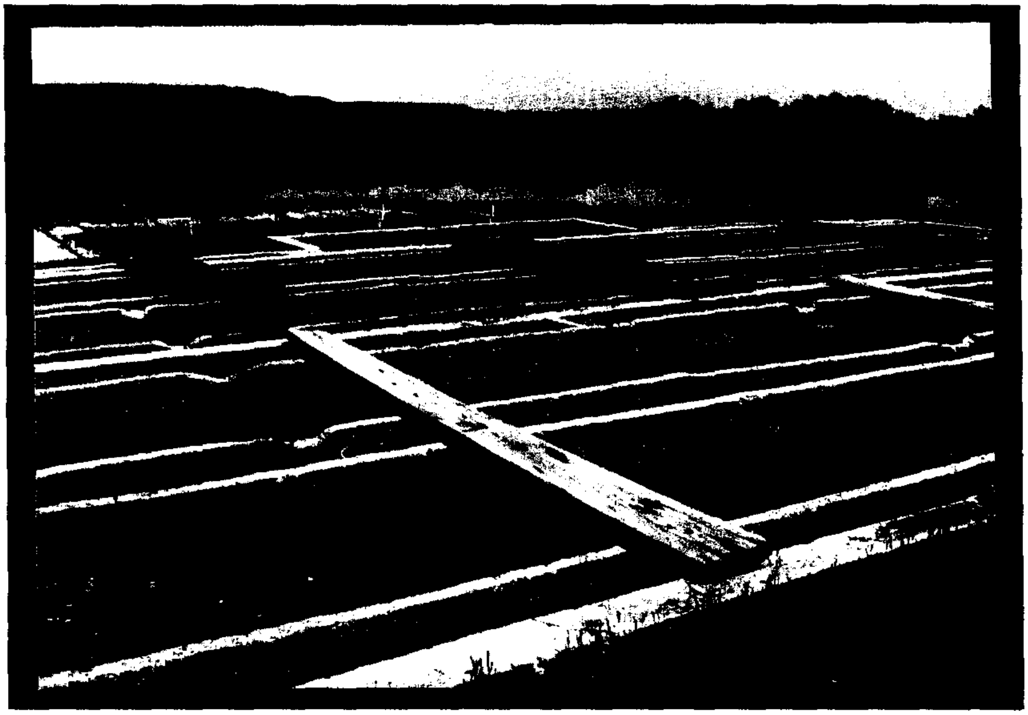
Gorman Pond Effluent



Gorman Oxidation Pond

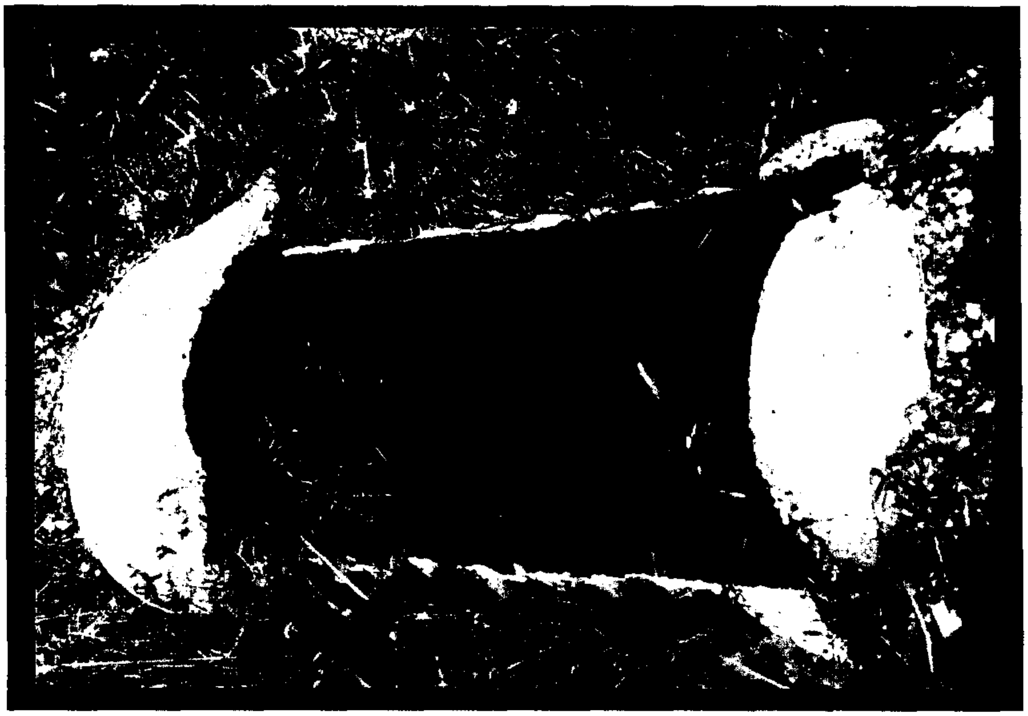


Tributary Downstream of Gorman Pond



Ranger Primary Treatment Facilities

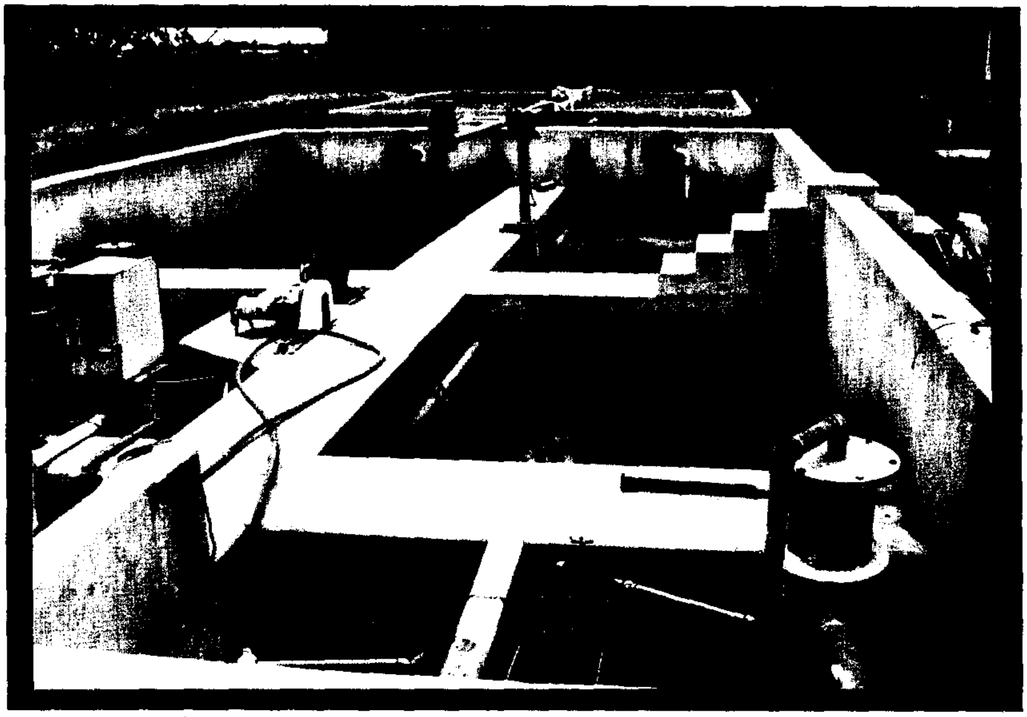
Ranger Fixed Filter and Pond System



Ranger Influent Line - Septic Conditions and Hydrogen Sulfide Corrosion

Hydrogen Sulfide Corrosion of Primary Basins

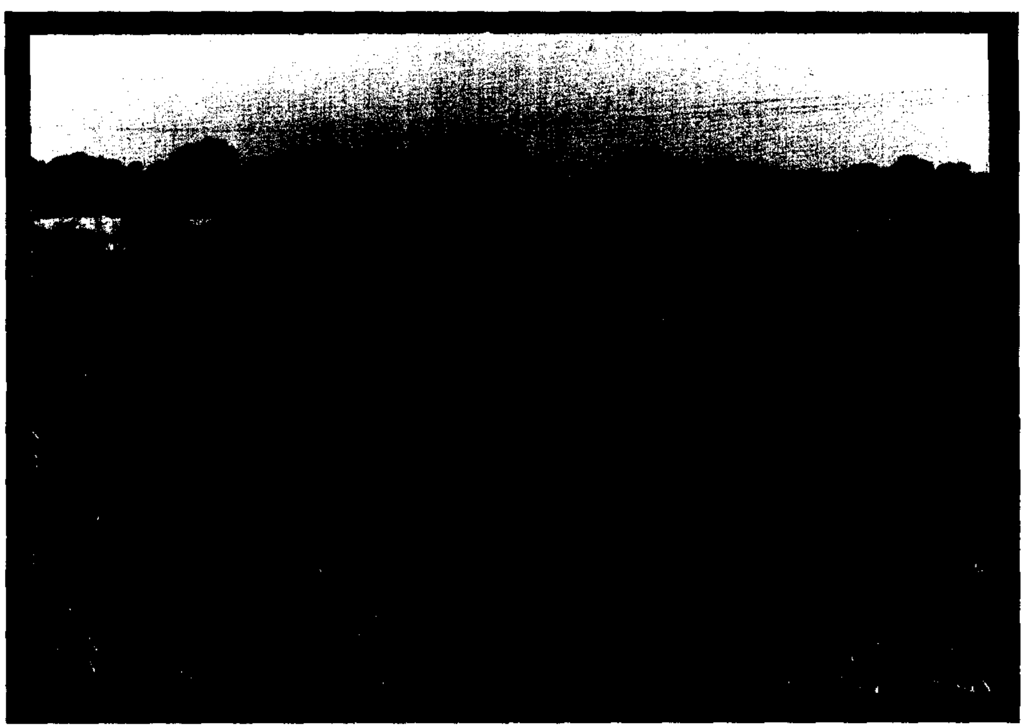
Ranger Sludge Disposal



Rising Star Activated Sludge Plant

Rising Star Sludge Drying Beds

Package Treatment Plant Operated By The
Upper Leon River Municipal Water District



ULRMWD Effluent - Irrigation Pond

Promontory Point RV Park With
Lake Proctor in Background

Typical Lot With Structure at
Promontory Point

Non-permitted Septic System in Promontory Point
Note Lake in Background

Trailer at Promontory Point

APPENDIX A
INFORMATION LETTERS

FACILITY SUMMARY
FACT SHEET

Owner: City of Cisco	
Permit No.: 10424-01	Expiration Date: 11/28/94
Address: P.O. Box 110 Cisco, Texas 76437	
County: Eastland	
Lat.: Long:	

Parameters	Permit Limits	Current Average*
Flow (mgd)	0.44 MGD Daily Average	0.29 MGD Outfall 1 0.03 MGD Outfall 2
BOD	30 mg/l Daily Average	24 mg/l Outfall 1
TSS	90 mg/l Daily Average	55.8 mg/l Outfall 1 10.2 mg/l Outfall 2
Other		

Type of Treatment Process:

Facultative Lagoon, three (3) stabilization ponds

Number of Connections:	1527
Date of Construction:	June, 1987
Date of Last Expansion:	None
Type of Expansion:	N/A
Recorded Operational Problems:	Heavy rains in 1989-90 caused facility to exceed 90% of design daily average capacity

* **1987-1989**

FACILITY SUMMARY
FACT SHEET
-Continued-

Recorded Maintenance Problems: None	
Expansion or Rehabilitation Needs: None at this time	
Method of Sludge Disposal: N/A	
Additional Comments:	Sewer collection system smoke tested in late 1990 - early 1991 to reduce infiltration and inflow (I&I) problem. City has submitted a waiver request to the Water Commission to avoid building new facilities. It maintaines that unusually heavy rainfall and I&I problems caused permit limitations to be exceeded and not extra demand on the system due to population growth. City has two outfalls. Cisco outfall is not in Lake Proctor watershed.

FACILITY SUMMARY
FACT SHEET

Owner: City of Comanche	
Permit No.: 10719-01	Expiration Date: 09/12/94
Address: 114 West Central Comanche, Texas 76442	
County: Comanche	
Lat.: 31/53/36 Long: 48/35/36	

Parameters	Permit Limits	Current Average*
Flow (mgd)	0.74 MGD Daily Average 1520 GPM 2-Hour Peak	0.37 MGD 0.52 MGD
BOD	20 mg/l Daily Average	4.4 mg/l
TSS	20 mg/l Daily Average	4.7 mg/l
Other	Between 1.0 - 4.0 mg/l	

Type of Treatment Process:

Contact Stabilization

Number of Connections:	1660
Date of Construction:	1966
Date of Last Expansion:	1982
Type of Expansion:	Construction of sludge thickener, screw lift pumps, bar screen; Replace air compressors.
Recorded Operational Problems:	April, 1991 - Enzymes added to the system because of build-up filamentation. Some shock loads believed to be caused by illegal septic tank dumping.

* 1987-1989

FACILITY SUMMARY
FACT SHEET
-Continued-

Recorded Maintenance Problems: No major problems reported.
Expansion or Rehabilitation Needs: Replace current chlorination system and replace flow meter chart system this summer.
Method of Sludge Disposal: Pump into drying beds and BFI hauls to landfill near Abilene.
Additional Comments:

FACILITY SUMMARY
FACT SHEET

Owner: City of DeLeon	
Permit No.: 10078-01	Expiration Date: 3/29/93
Address: 105 South Texas Street DeLeon, Texas 76444	
County: Comanche	
Lat.: Long:	

Parameters	Permit Limits	Current Average *
Flow (mgd)	0.166 MGD Daily Average	0.12 MGD
BOD	30 mg/l	45 mg/l
TSS	90 mg/l	40 mg/l
Other		

Type of Treatment Process:

Imhoff tank and two (2) aeration ponds.

Number of Connections:	1039
Date of Construction:	1958
Date of Last Expansion:	1986
Type of Expansion:	1 new aeration pond

Recorded Operational Problems:

BOD has been above average in the past and the City has been placed under an Order by the Texas Water Commission.

* 1987-1989

FACILITY SUMMARY
FACT SHEET
-continue-

Recorded Maintenance Problems: Lack of daily maintenance
Expansion or Rehabilitation Needs:
Method of Sludge Disposal: Drying beds and sludge disposed of at approved land application site.
Additional Comments: The City has received a grant from the Texas Department of Commerce for updating the plant. Todd Engineering, Abilene, has presented the proposed plans to the necessary agencies. Operator believes first pond needs to be dredged.

DWN/adh:67.FactSht.dwn

FACILITY SUMMARY
FACT SHEET

Owner: City of Dublin	
Permit No.: 10405-01	Expiration Date: 06/24/91
Address: 213 East Blackjack Dublin, Texas 76446	
County: Erath	
Lat.: Long:	

Parameters	Permit Limits	Current Average*
Flow (mgd)	0.25 MGD Monthly Average 0.50 MGD Daily Average	0.18 MGD 0.28 MGD
BOD	30 mg/l Daily Average	24.1 mg/l
TSS	90 mg/l Daily Average	54.2 mg/l
Other		

Type of Treatment Process:

Imhof tanks with four (4) lagoons

Number of Connections:	1200
Date of Construction:	1949
Date of Last Expansion:	
Type of Expansion:	
Recorded Operational Problems:	Lift station pumps may be undersized.

* 1987-1989

FACILITY SUMMARY
FACT SHEET
-Continued-

Recorded Maintenance Problems: Severe I & I
Expansion or Rehabilitation Needs: Imhoff tanks are leaking; lift station needs upgrading.
Method of Sludge Disposal: Landfill
Additional Comments: Beginning smoke testing soon; hope to repair I & I and gain 4-5 more years on system.

FACILITY SUMMARY
FACT SHEET

Owner: City of Eastland	
Permit No.: 10637-01	Expiration Date: 10/21/91
Address: P.O. Box 749 Eastland, Texas 76448	
County: Eastland	
Lat.: Long:	

Parameters	Permit Limits	Current Average
Flow (mgd)	0.40 MGD 0.94 MGD Max 1-Day	0.35 MGD 0.52 MGD
BOD	20 mg/l	7.5 mg/l
TSS	20 mg/l	7.6 mg/l
Chlorination	1.0 mg/l	

Type of Treatment Process: Oxidation ditch with final clarifier

Number of Connections:	1700
Date of Construction:	Approx. 14 Years ago
Date of Last Expansion:	
Type of Expansion:	
Recorded Operational Problems:	Some I & I problems
Recorded Maintenance Problems:	None

FACILITY SUMMARY
FACT SHEET
-continue-

Expansion or Rehabilitation Needs:	None
Method of Sludge Disposal:	Landfill
Additional Comments:	Will eventually have another oxidation ditch and clarifier. Have applied for loan from FHA. Planning on adding UV disinfection.

DWN/adh:67.FactSht.dwn

FACILITY SUMMARY
FACT SHEET

Owner: City of Gorman	
Permit No.: 10091-01	Expiration Date: 04/11/95
Address: P.O. Box 236 Gorman, Texas 76454	
County: Eastman	
Lat.: Long:	

Parameters	Permit Limits	Current Average*
Flow (mgd)	0.12 MGD Daily Average 250 GPM 2-Hour Peak	0.10 MGD 0.14 MGD
BOD	30 mg/l Daily Average	45 mg/l
TSS	90 mg/l Daily Average	107 mg/l
Other		

Type of Treatment Process: Imhof tanks with two lagoons.

Number of Connections:	650
Date of Construction:	1920
Date of Last Expansion:	1990
Type of Expansion:	first lagoon was dredged and deepened.
Recorded Operational Problems:	Corrected some I & I problems last year. Also has moved to eliminate high BOD_5 waste from an agricultural testing lab.

* 1987-1989

FACILITY SUMMARY
FACT SHEET
-Continued-

Recorded Maintenance Problems:
Expansion or Rehabilitation Needs: Imhoff tanks are undersized, as are ponds.
Method of Sludge Disposal: Dried on site and removed to landfill.
Additional Comments: TSS problems due to low storage of lagoons due to sludge buildup.

FACILITY SUMMARY
FACT SHEET

Owner: City of Ranger	
Permit No.: 11557-01	Expiration Date:
Address: 314 West Main Street Ranger, Texas 76470	
County: Eastland	
Lat.: Long:	

Parameters	Permit Limits	Current Average *
Flow (mgd)	0.43 MGD Daily Average 743 GPM, 2-Hour Peak	0.27 MGD 1.64 MGD
BOD	10 mg/l	20.0 mg/l
TSS	15 mg/l	15.0 mg/l
Chlorination	To between 1.0 - 4.0 mg/l	

Type of Treatment Process: Imhoff tanks with trickling filters

Number of Connections:	1300
Date of Construction:	1920's
Date of Last Expansion:	
Type of Expansion:	
Recorded Operational Problems:	Exceeding permitted BOD and flow limits.

* 1987-1989

FACILITY SUMMARY
FACT SHEET
-continue-

Recorded Maintenance Problems:	Severe I & I
Expansion or Rehabilitation Needs:	Extensive repairs to collection system needed; treatment plant needs to be upgraded.
Method of Sludge Disposal:	Landfill
Additional Comments:	City is under TWC enforcement provisions at this time.

DWN/adh:67.FactSht.dwn

FACILITY SUMMARY
FACT SHEET

Owner: Upper Leon River Municipal Water District	
Permit No.: 11764-01	Expiration Date: 10/18/93
Address: P.O. Box 67 Comanche, Texas 76442	
County: Comanche	
Lat.: Long:	

Parameters	Permit Limits	Current Average*
Flow (mgd)	0.06 MGD	0.01 MGD
BOD	100 mg/l	
TSS		
Other	6-9	

Type of Treatment Process: Package extended aeration plant

Number of Connections:	50
Date of Construction:	1975
Date of Last Expansion:	None
Type of Expansion:	
Recorded Operational Problems:	None

* 1987-1989

FACILITY SUMMARY
FACT SHEET
-Continued-

Recorded Maintenance Problems: None
Expansion or Rehabilitation Needs: None
Method of Sludge Disposal: Sold to registered applicator.
Additional Comments: ULRMWD has a no discharge permit. Effluent is pumped to a holding pond and is used for irrigation. Five lift stations pump to plant.

APPENDIX B

COSTS TO EXPAND TREATMENT FACILITIES UNDER CURRENT PERMIT LIMITS FOR PROJECTED WASTEWATER FLOW

APPENDIX B

COSTS TO EXPAND TREATMENT FACILITIES UNDER CURRENT PERMIT LIMITS FOR PROJECTED WASTEWATER FLOW

CITY OF CISCO

The calculated expansion requirement throughout the planning period is 130,000 gpd. The most feasible alternative would be to add to the existing pond system. The factor 1.928 used below is the ratio of the current (March, 1991) Engineering News Record (ENR) Construction Cost Index to that given in the EPA publication "Innovative and Alternative Technology Assessment Manual". The capital costs were obtained from this manual, and then converted to present day costs. A 15% contingency has been added to the capital and O&M costs.

Additional Lift Capacity

Capital Cost	=	70,000 × 1.928	=	$134,966
O & M Cost	=	6,000 × 1.928	=	$ 11,568

Additional Pond Capacity

Capital Cost	=	95,000 × 1.928	=	$183,167

Land acquisition costs have been calculated using 140 GPCD of wastewater production, a loading of 0.17 lb BOD5/capita/day and allowing 1 acre per pound of BOD5 per day (TWC Design Criteria).

$$\frac{130{,}000\ gpd}{140\ gpcd} \times \frac{0.17\ lb.}{capita\text{-}day} \times \frac{1ac.\text{-}day}{35\ lb.BOD5} = 4.5\ acres$$

Multiply acres by two to allow for dikes and roads.

		9 Ac. × $600/ac.	=	$ 5,400
O & M Cost	=	$22,000 × 1.928	=	$42,418

Total Estimated Costs

Total Expansion Capital Cost	=	$323,533
	=	$372,100(w/cont)

Total Expansion O & M Cost	=	$ 53,986
		$ 62,100(w/cont)

The total annual cost is calculated using the following formula to obtain a factor which is multiplied by the total capital cost to give the annual cost of debt service. The total annual cost consists of the sum of the annual capital cost and the annual O&M cost. An interest rate of 8.75% over a 30 year loan period has been assumed.

$$CRF\ (A/P) = \frac{(0.875)\times(1.0875)^{30}}{(1.0875)^{30}-1} = 0.095186$$

Total Annual Cost = $97,500

<u>CITY OF DE LEON</u>

The calculated expansion increment is 240,000 gpd. The most feasible alternative would be to add to the existing pond system. The influent to the existing De Leon plant must be lifted at the plant site so the expansion would include an expansion to the influent lift station.

Additional Lift Station Capacity

Capital Cost	=	82,000 × 1.928	=	$158,100
O & M Cost	=	6,000 × 1.928	=	11,600

Additional Pond Capacity

Capital Cost	=	150,000 × 1.928	=	$289,212

Land Acquisition:

$$\frac{240{,}000\ gpd}{140\ gpcd} \times \frac{0.17\ lb.}{capita} \times \frac{1ac.}{35\ lb.} = 8.33\ ac.$$

Use 16 Ac.

16 Ac. × $600/ac. = $9,600

O & M Cost	=	$32,000 × 1.928	=	$ 61,699

Total Estimated Costs (w/Contingencies)

Total Capital Cost	=	$525,500
Total O & M Cost	=	84,300
Total Annual Cost	=	$134,300

CITY OF DUBLIN

The calculated expansion increment is 295,000 gpd. The most feasible alternative would be to expand the existing pond system. The influent to the existing plant is lifted to the treatment facilities, so an expansion to the influent lift station would be required.

Additional Lift Station Capacity

Capital Cost	=	91,000 × 1.928	=	$175,400
O & M Cost	=	6,200 × 1.928	=	12,000

Additional Pond Capacity

Capital Cost	=	160,000 × 1.928	=	$308,500

Land Acquisition:

$$\frac{295,000\ gpd}{140\ gpcd} \times \frac{0.17\ lb.}{capita\text{-}day} \times \frac{1ac.\text{-}day}{35\ lb.} = 10.12\ ac.$$

Use 20 Ac.

20 Ac. × $600/ac. = $20,000

O & M Cost	=	$38,000 × 1.928	=	$ 73,300

Total Estimated Costs (w/Contingencies)

Total Capital Cost	=	$579,485
Total O & M Cost	=	85,300
Total Annual Cost	=	$140,500

CITY OF EASTLAND

The calculated expansion increment is 164,000 gpd. The most feasible alternative would be to add another oxidation ditch of similar design to the existing ditch. It is anticipated that plant expansion would require enlargement of the influent lift station, sludge drying beds and disinfection facilities.

Additional Lift Station Capacity

Capital Cost	=	72,000 × 1.928	=	$138,800
O & M Cost	=	6,000 × 1.928	=	11,600

Additional Oxidation Ditch Capacity

$$\mathit{CapitalCosts} = 220{,}000 \times \frac{4772}{2445} = \$429{,}400$$

$$\mathit{O/M\ Costs} = 28{,}000 \times \frac{4772}{2445} = \$53{,}986$$

4772 is the current ENR Construction Cost Index and 2445 is the index used at the time of preparation of the EPA manual.

Additional Sludge Drying Beds

Capital Cost	=	22,000 × 1.928	=	$ 42,400
O & M Cost	=	4,400 × 1.928	=	8,500

Additional Disinfection Facilities

Capital Cost	=	28,000 × 1.928	=	$ 54,000
O & M Cost	=	5,500 × 1.928	=	10,604

De-chlorination Facilities

Capital Cost	=	9,500 × 1.928	=	$ 18,300

O & M Cost	=	3,000 × 1.928	=	$ 5,804

Total Estimated Costs (w/Contingencies)

Total Capital Cost	=	$785,335
Total O & M Cost	=	90,490
Total Annual Cost	=	$165,242

CITY OF GORMAN

An engineering study was completed for the City of Gorman in August, 1990. It recommends demolishing the existing Imhof tank and converting one of the existing stabilization ponds to a facultative lagoon, and adding a rock-reed filter. Figures are from this engineering report.

Additional Pond Capacity

Capital Cost (includes contingencies) = $377,200

Land Acquisition 38 acres @ $600/acre = $22,800

O&M Cost = $72,400

Total Estimated Costs

Total Capital Cost = $400,000

Total O&M Cost = $46,000

Total Annual Cost = $72,400

CITY OF RANGER

The existing plant has little salvageable value and is incapable of meeting the existing permit limits. Although it is possible a 30/90 discharge permit may be obtainable, for the purpose of this report it is assumed that a new activated sludge plant capable of meeting the existing 10/15 permit limits at the projected future capacity of 420,000 gpd will be required. The relief of the existing plant site is such that it is anticipated that gravity flow can continue to be utilized and that an influent lift station will not be required.

Activated Sludge Facilities				
Capital Cost	=	$140,000 × 1.928	=	$269,920
O & M Cost	=	8,000 × 1.928	=	15,400
Power Cost	=	$0.05 × 10,000	=	500
Aerobic Sludge Digestion				
Capital Cost	=	$71,000 × 1.928	=	$136,900
O & M Cost	=	$18,000 × 1.928	=	$34,704
Sludge Drying Beds				
Capital Cost	=	32,000 × 1.928	=	$ 61,700
O & M Cost	=	5,600 × 1.928	=	10,800
Disinfection Facilities				
Capital Cost	=	38,000 × 1.928	=	$ 73,300
O & M Cost	=	8,200 × 1.928	=	15,800
De-Chlorination Facilities				
Capital Cost	=	13,000 × 1.928	=	$ 25,300
O & M Cost	=	4,800 × 1.928	=	9,300
Total Estimated Costs (w/Contingencies)				
Total Capital Cost			=	$928,993
Total O & M Cost			=	72,600
Total Annual Cost			=	$161,027

PROCTOR

The estimated capacity requirement is 70,000 gpd. A package plant with a total unit plant cost of $3.00 per gpd is estimated. Since the community is completely unsewered at this time, a gravity collection system averaging 35 feet per connection, with 6-8-inch diameter lines, and manholes spaced at 500 feet intervals is assumed. Recent Contractor's Data Reports were used for construction cost estimates.

Treatment Plant Costs

Capital Cost	=	70,000 × \$3	=	\$210,000
O & M Cost	=	\$0.10/gpd × 70,000 gpd	=	7,000
Plant Operator		@ \$10/hr	=	\$21,600

Collection System Costs

Collection Line Costs =

$$\frac{499\ persons}{3.5\ persons\ per\ connection}\ x\ \frac{35\ ft}{connection}\ x\ \$12/ft = \$59,880$$

$$ManholeCost = \frac{499\ x\ 35}{3.5\ x\ 500}\ x\ \$1,000 = \$10,000$$

O & M Costs = (EPA)

$\$0.07/ft \times 499/3.5 \times 35 = \$350$

Total Estimated Costs (w/Contingencies)

Total Capital Cost	=	\$318,000
Total O & M Cost	=	28,950
Total Annual Cost	=	\$ 59,220

<u>BUFFALO SPRINGS</u>

Buffalo Springs is a partially developed, unincorporated area just to the north of the main pool of Lake Proctor. There are approximately 350 full-time residents in the area, and there is a development with 400 lots for trailers or recreational vehicles, which is occupied seasonally. A design population of 482 has been assumed. The permanent residences have septic tanks, and the trailer development has only holding tanks. The management is out of business, and it is not known what is being done with wastes deposited in this facility. It is assumed that a package activated sludge plant with treatment capabilities of 10/15 would be the most cost effective individual treatment alternative. Recent cost information for package treatment units of similar size from several suppliers indicates typical installed costs of $2.30/GPD of capacity. It is assumed that this plant would be staffed part time by existing ULRMWD personnel.

Design Flow = 482 persons x 140GPCD = 67,500 GPD
Capital Costs= 67,500 x 2.30 = $155,250 ✓
O&M Cost = 67,500 x 0.15 = $10,125
Collection System = (482people/3.5 people/connection) x 35 ft/unit x $12/ft = $57,800
Manhole Cost = (482/3.5) x 35ft/conn. x 1m.h./500ft x $1000/m.h. = $9,640
Collection System O&M Cost = $0.07 x (482/3.5) x 35 x 1.928 = $650
Total Estimated Cost (+15% contingency)
Total Capital Cost = $308,420
Total O&M Cost = $12,400
Total Annual Cost = $41,760

HIGH POINT

High Point is an unincorporated area northeast of Lake Proctor. The current population has been estimated at 525, and a design population of 723 has been assumed. The area is currently unsewered, with some lots too small for septic tanks and drainfields. It is assumed that this area would be served by a package activated sludge plant with 10/15 treatment capability. The anticipated design flow would be 101,200 GPD, and a package plant of this size would cost approximately $1.90/GPD of capacity. Again, it is anticipated that ULRMWD personnel would staff this plant.

Capital Cost 101,200 x $1.90 = $192,280
O&M Cost 101,200 x $0.15 = $15,200

Collection System Cost = (723/3.5) x 35 ft/unit x $12/ft = $86,800

Manhole Cost = (723/3.5) x 35 ft/conn. x 1 m.h./500 ft x $1000 ea = $14,500

Collection O&M = $0.07/ft x (723/3.5) x 35 x 1.928 = $1000

Total Estimated Costs (+15% contingency)

Total Capital Cost = $345,105

Total O&M Cost = $18,600

Total Annual Cost = $56,400

LAKE LEON STAFF COMMUNITY

An estimated 350 people now live in unincorporated areas of Lake Leon. A design population of 580 people and a design flow of 81,200 GPD has been assumed. The cost for a package plant to serve this area is estimated at $2.10 per gpd of capacity.

Design Flow = 580 persons x 140GPCD = 81,200 GPD

Capital Costs= 81,200 x $2.10 = $170,500

O&M Cost = 81,200 x $0.15 = $12,200

Collection System = (580people/3.5 people/connection) x 35 ft/unit x $12/ft = $69,600

Manhole Cost = (580/3.5) x 35 ft/conn. x 1m.h./500ft x $1000/m.h. = $11,600

Collection System O&M Cost = $0.07 x (580/3.5) x 35 x 1.928 = $800

Total Estimated Cost (+15% contingency)

Total Capital Cost = $289,500

Total O&M Cost = $15,000

Total Annual Cost = $42,600

APPENDIX C
COSTS OF SUB-REGIONAL SYSTEMS

SUBREGIONAL WASTEWATER TREATMENT PLANT NO. 1

This plant would serve the Cities of Ranger, Eastland, Cisco and include an allowance for present development around Lake Leon, and a moderate amount of future lakeside developments.

Total Required Plant Capacity

Cisco	=	567,300
Eastland	=	564,100
Ranger	=	416,400
Lakeside Developments(1)	=	81,200
	Total	1,629,000 gpd

(1) Allowance for future population of 580.

This facility would be anticipated to be permitted at 10/15, suggesting an activated sludge treatment facility. Influent pumping would not be anticipated since all contributing communities would be required to pump into this facility.

Activated Sludge Facilities

Capital Cost	=	320,000 × 1.928	=	$616,960
O & M Cost	=	18,000 × 1.928	=	34,700
Power Cost	=	$0.05 × $330,000	=	16,500

Secondary Clarifier

Capital Cost	=	270,000 × 1.928	=	$520,560
O & M Cost	=	9,000 × 1.928	=	17,350
Power Cost	=	$0.05 × $40,000	=	2,000

Aerobic Sludge Digestion

Capital Cost	=	155,000 × 1.928	=	$298,800
O & M Cost	=	10,500 × 1.928	=	20,200

Sludge Drying Beds

Capital Cost	=	72,000 × 1.928	=	$138,800
O & M Cost	=	10,500 × 1.928	=	21,200

Disinfection Facilities

Capital Cost	=	67,000 × 1.928	=	$119,500
O & M Cost	=	16,000 × 1.928	=	30,800

De-Chlorination Facilities

Capital Cost	=	20,500 × 1.928	=	$ 39,500
O & M Cost	=	9,000 × 1.928	=	17,400

Total Estimated Costs (w/Contingencies)

Total Capital Cost	=	$1,994,238
Total O & M Cost	=	185,900
Total Annual Cost	=	375,700

SUBREGIONAL WASTEWATER TREATMENT PLANT NO. 2

This plant would serve the cities of Gorman, DeLeon, Comanche, Dublin, Proctor, the lakeside communities of Buffalo Springs and High Point, and a moderate amount of future lakeside development.

Total Required Plant Capacity

Comanche	=	729,100	
De Leon	=	402,200	
Dublin	=	542,200	
Gorman	=	182,600	
Proctor	=	69,900	
Lakeside Developments	=	168,700	
	Total	2,024,800	gpd

As with the determination for Subregional Wastewater Treatment Plant No. 1, it is anticipated that this facility would be permitted at 10/15, suggesting an activated sludge treatment facility. Influent pumping would not be anticipated.

Activated Sludge Facilities

Capital Cost	=	380,000 × 1.928	=	$732,600
O & M Cost	=	21,000 × 1.928	=	40,500
Power Cost	=	$0.05 × $430,000	=	21,500

Secondary Clarifier

Capital Cost	=	290,000 × 1.928	=	$559,100
O & M Cost	=	9,800 × 1.928	=	18,900
Power Cost	=	$0.05 × $40,000	=	2,000

Aerobic Sludge Digestion

Capital Cost	=	170,000 × 1.928	=	$327,800
O & M Cost	=	13,000 × 1.928	=	25,100

Sludge Drying Beds

Capital Cost	=	82,000 × 1.928	=	$158,100
O & M Cost	=	12,500 × 1.928	=	24,100

Disinfection Facilities

Capital Cost	=	70,000 × 1.928	=	$134,960
O & M Cost	=	18,000 × 1.928	=	34,700

De-Chlorination Facilities

Capital Cost	=	21,000 × 1.928	=	$ 40,500
O & M Cost	=	9,500 × 1.928	=	18,300

Total Estimated Costs (w/Contingencies)

Total Capital Cost	=	$2,711,700
Total O & M Cost	=	200,400
Total Annual Cost	=	458,500

APPENDIX D
COSTS TO UPGRADE EXISTING FACILITIES TO 10/15 PERMITS

COSTS TO UPGRADE EXISTING FACILITIES TO 10/15 PERMITS								
City	*2022 Required Maximum Monthly Cap. (GPD)*	*Activated Sludge*	*Secondary Clarifier*	*Aerobic Digestion*	*Sludge Beds*	*Chlorination*	*Dechlorination*	*Totals*
Cisco								
- Cap. Cost	$567,380	$327,800	$269,900	$163,900	$73,300	$79,000	$28,000	$941,900
- O&M Cost		$ 17,300	$ 8,700	$ 10,200	$11,800	$18,300	$10,400	$ 76,700
- Power		$ 7,000	$ 600					$ 7,600
DeLeon								
- Cap. Cost	$402,220	$269,900	$231,400	$135,000	$63,600	$69,400	$25,000	$794,300
- O&M Cost		$ 14,500	$ 7,500	$ 8,400	$10,600	$15,400	$ 8,900	$ 65,300
- Power		$ 4,500	$ 500					$ 5,000
Dublin								
- Cap. Cost	$542,220	$308,500	$260,300	$160,000	$69,400	$77,100	$27,000	$902,300
- O&M Cost		$ 17,000	$ 8,500	$ 10,000	$11,600	$17,700	$10,200	$ 75,000
- Power		$ 6,500	$ 600					$ 7,1000
Gorman								
- Cap. Cost	$182,560	$173,500	$142,700	$ 86,800	$46,300	$54,000	$19,300	$522,600
- O&M Cost		$ 9,400	$ 7,500	$ 5,600	$ 8,700	$11,200	$ 4,200	$ 46,600
- Power		$ 2,100	$ 300					$ 2,400
Ranger								
- Cap. Cost	$416,360	$279,600	$241,000	$138,800	$65,500	$71,300	$26,000	$822,200
- O&M Cost		$ 14,900	$ 7,700	$ 8,700	$10,800	$15,600	$ 9,000	$ 66,700
- Power		$ 5,000	$ 500					$ 5,500

APPENDIX E
PRELIMINARY ENGINEERING FOR RECOMMENDED TREATMENT FACILITIES

PRELIMINARY ENGINEERING FOR RECOMMENDED TREATMENT FACILITIES

BUFFALO SPRINGS

Design flow is 67,500 GPD (47 GPM); Peak flow is estimated at four times the design flow or 270,000 GPD (190 GPM). Assuming 200 mg BOD/l, there will be a BOD loading of 113 pounds BOD/day at design flow.

Influent Pump Station

Three pumps each with a capacity of 95 GPM at 20 feet of head, and underground pump station.

Aeration Basin

Maximum organic loading = 15 lb BOD/1000 cu ft/day
Minimum aeration capacity = 2850 SCF /lb BOD

Basin volume should be 7533 cubic feet or 56,350 gallons. Blowers should provide a total air volume of 224 SCFM.

Clarifier

Maximum surface loading at peak flow = 1,000 gpd/sq ft
Maximum surface loading at peak flow = 500 gpd/sq ft

Required surface area at peak flow is 270 sq ft
Required surface area at design flow is 135 sq ft

Design surface area should be 270 sq ft

Sludge Beds

Sludge beds should be 848 sq ft

Chlorine Contact Basin

Minimum detention time at peak flow = 20 min

Chamber volume should be 508 cu ft

Effluent Pumps

Two pumps each with a capacity of 190 GPM at 100 feet of head.

Force Main

Use 3 inch PVC pipe.

Land

Provide 1 acre of land for facilities.

Irrigation

An effluent application rate of 3.0 ac-ft/ac/yr has been assumed. For pond size, a depth of 10 feet and storage capacity of 45 days has been assumed.

Land required for irrigation = 25.2 acres
Pond size = 0.93 acres

HIGH POINT

Design flow is 101,200 GPD (71 GPM); Peak flow is estimated at four times the design flow or 404,800 GPD (280 GPM). Assuming 200 mg BOD/l, there will be a BOD loading of 170 pounds BOD/day at design flow.

Influent Pump Station

Three pumps each with a capacity of 190 GPM at 20 feet of head, and underground pump station.

Aeration Basin

Maximum organic loading = 15 lb BOD/1000 cu ft/day
Minimum aeration capacity = 2850 SCF /lb BOD

Basin volume should be 11,259 cubic feet or 84,200 gallons. Blowers should provide a total air volume of 336 SCFM.

Clarifier

Maximum surface loading at peak flow = 1,000 gpd/sq ft
Maximum surface loading at peak flow = 500 gpd/sq ft

Required surface area at peak flow is 405 sq ft
Required surface area at design flow is 202 sq ft

Design surface area should be 405 sq ft

Sludge Beds

Sludge beds should be 1275 sq ft

Chlorine Contact Basin

Minimum detention time at peak flow = 20 min

Chamber volume should be 749 cu ft

Effluent Pumps

Two pumps each with a capacity of 280 GPM at 100 feet of head.

Force Main

Use 4 inch PVC pipe.

Land

Provide 2 acres for facilities.

Irrigation

An effluent application rate of 3.0 ac-ft/ac/yr has been assumed. For pond size, a depth of 10 feet and storage capacity of 45 days has been assumed.

Land required for irrigation = 37.8 acres
Pond size = 1.40 acres.

REFERENCES

1. Gary Lacy, ULRMWD, personal communication.

2. TWDB, Population Projections for Comanche, Eastland, Erath and Hamilton Counties, October, 1989.

3. Butch Bloodworth, TWDB, personal communication.

4. Garry Godfrey, ULRMWD, personal communication.

5. "Innovative and Alternative Technology Assessment Manual", EPA 430/9-78-009.

6. "Cameron Hydraulic Data", published by Ingersoll-Rand, Woodcliff Lake, NJ 07675.

7. 31 TAC 317.1-317.13, "Design Criteria for Sewerage Systems", 1989.

8. 1990-1991 Texas Almanac, published by the Dallas Morning News.

9. "An Engineering Report on Wastewater Facilities Study for the City of Gorman, Texas", prepared by Jacob & Martin, Inc., Consulting Engineers, Abilene, Texas, August 1990.

10. "Engineering News Record", March, 1991.

11. "Contractor's Data Report", by Contractor's Tabulating Service, Plymouth, MI 48170.