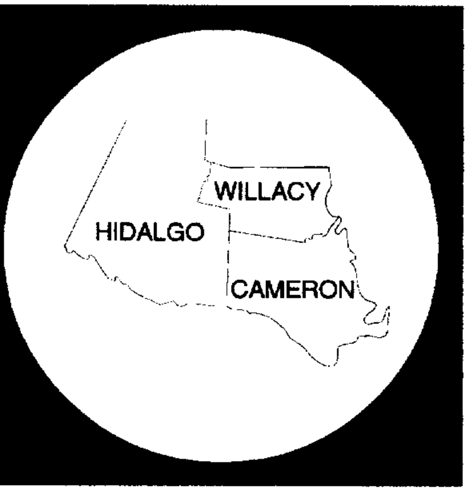
LOWER RIO GRANDE VALLEY
DEVELOPMENT COUNCIL



McAllen/Edinburg Reuse Feasibility Study

Final Report

Prepared for

Lower Rio Grande Valley Development Council
The City of Edinburg, Texas
The City of McAllen, Texas
Texas Water Development Board

Prepared by
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in association with
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January 1997

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Executive Summary

Project Findings

This study is to investigate the technical and economic feasibility of wastewater reclamation to augment limited water supply sources in the lower Rio Grande Valley. The primary focus of the project is on the potential for indirect potable reuse, since the practice of nonpotable reuse is well-established in Texas. This project is a joint effort of the Lower Rio Grande Valley Development Council, the City of Edinburg, the City of McAllen, and the Texas Water Development Board. While the evaluations performed are specific to the cities of Edinburg and McAllen, it is believed this study will provide useful information for other cities in the lower Rio Grande Valley and elsewhere in Texas or beyond.

With respect to the the feasibility of indirect potable reuse for the cities of Edinburg and McAllen the following is demonstrated in this report:

There is a serious need for more water.

This is likely already understood by all residents of the Lower Rio Grande Valley. This report quantifies the projected shortage based on current water rights and the projected demands. For Edinburg it is projected that demand could exceed supply by 2003. For McAllen it is projected that demand could exceed supply in 1997.

There are several options available to the Lower Rio Grande Valley water providers to meet demands, one of which is indirect potable reuse.

Several alternatives are available to Edinburg and McAllen, including construction of a new reservoir, treatment and use of groundwater, seawater desalination, purchase of additional Rio Grande rights from irrigators, and wastewater reuse. Indirect potable reuse is the alternative explored in this report. It was demonstrated that indirect potable reuse could extend the water supply more than 20 years for both Edinburg and McAllen.

The Cities have the legal rights to the reclaim the water.

No water rights downstream of the Edinburg and McAllen wastewater discharges exist to exert a claim to the treated effluent. Although water rights policies relating to effluent discharges are being reviewed by the TNRCC, no changes are expected which would apply to the reuse projects proposed for Edinburg and McAllen.

Public health can be protected by present day technology.

Currently available technology is capable of reclaiming the water and protecting public health. This report presents treatment processes that are compatible with the existing facilities in the two cities, and that are in used in other facilities throughout the United States for reclaiming water. One of the recommended processes, Reverse Osmosis, has the capability of also reducing the TDS levels in the potable water supplied to the water customers.

No significant adverse environmental impacts are expected by the reuse of wastewater.

The water bodies receiving the Edinburg and McAllen wastewater discharges have limited aquatic life with the exception of the Laguna Madre. These discharges represent a small portion of the inflow to the Laguna and a preliminary opinion from a TWDB biologist indicates a reduction in effluent discharges may have a beneficial impact.

Indirect Potable Reuse is affordable.

Economic evaluation of the proposed projects indicates increasing water supplies through reuse is likely to cost about twice the cost of obtaining additional Rio Grande water through purchase and conversion of irrigation rights. Although this cost difference is substantial, it is expected to narrow with time, and reuse offers several benefits which should be weighed against the additional cost. The principal benefit is the reliability of this source of water during drought conditions.

Indirect Potable Reuse is believed to be socially and politically acceptable.

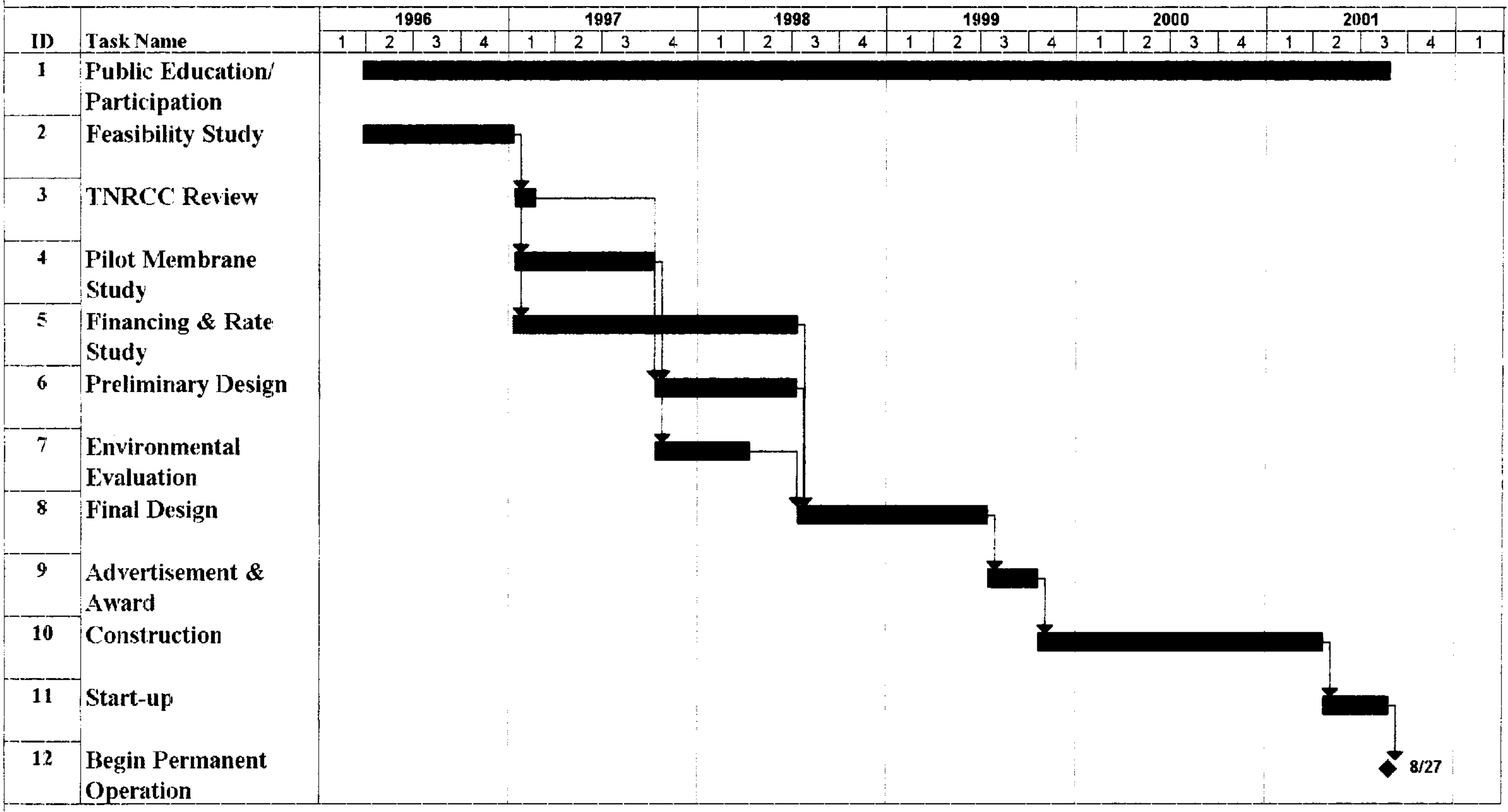
A citizen advisory committee was established in each City to begin the process of identifying local concerns and gaining public acceptance for potential reuse projects. Each of the committees met three times (once jointly) during the study to review the information as it became available and to voice opinions on the general concept of potable reuse and on specific aspects of the potential projects identified. The response received from the committees was generally favorable, indicating a properly developed project could likely gain substantial public acceptance. It is recognized that public education and outreach should be a continuing effort if reuse is to be pursued.

Recommendations

We recommend each city include indirect potable reuse as a potential source of increased water supply. To allow timely implementation of reuse as additional supplies are needed we recommend proceeding with additional studies to further develop the treatment requirements, and to continue a long-term sampling and testing program to establish the water quality parameters of both the wastewater effluent and the existing raw water supply. Specifically, a pilot study of membrane treatment of effluent is recommended to identify treatability and to refine the probable cost of treatment. A recommended implementation schedule is included on the following page.

We also recommend the cities pursue arrangements to provide treated wastewater effluent to agricultural interests in exchange for additional rights to Rio Grande water. Such arrangements should factor in the higher reliability of effluent yield compared to irrigation rights.

Proposed Implementation Schedule



Lower Rio Grande Valley Development Council
Edinburg/McAllen Reuse Feasibility Study

Task ▬ Milestone ◆

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1. Introduction

1.1. Project Overview

This study is to investigate the technical and economic feasibility of wastewater reclamation to augment limited water supply sources in the lower Rio Grande Valley. The primary focus of the project is on the potential for indirect potable reuse, since the practice of nonpotable reuse is well-established in Texas. This project is a joint effort of the Lower Rio Grande Valley Development Council, the City of Edinburg, the City of McAllen, and the Texas Water Development Board. While the evaluations performed are specific to the cities of Edinburg and McAllen, it is believed this study will provide useful information for other cities in the lower Rio Grande Valley and elsewhere in Texas or beyond.

This report is a summary of the study's findings. Detailed information has been published in three technical memoranda. *Technical Memorandum No. 1 (TM1) Baseline Data* contains an inventory of available water quality data, information on the existing water and wastewater facilities for each of the two cities, and population and water demand projections. *Technical Memorandum No. 2 (TM2) Treatment Process Evaluation and Selection* contains a discussion of potential health concerns from the use of reclaimed wastewater for public water supplies and a description of available water and wastewater treatment techniques applicable to wastewater reuse. *Technical Memorandum No. 3 (TM3) Feasibility Evaluation* presents four candidate treatment alternatives and a comparison of their cost and ability to achieve water quality goals. *TM3* also proposes four potential reuse system configurations and contains an economic evaluation of these as well. The technical memoranda are included as appendices to this report.

1.2 Public Participation

Public acceptance is a crucial consideration in the ultimate determination of the suitability of reuse for potable water supply. A public advisory committee for each of the cities was established to begin the process of identifying public concerns regarding reuse and educating water consumers. Membership lists for the committees and summaries of the meeting discussions are included in Appendix A. The committees met three times during this study. The first meeting was held at the beginning of the study to introduce the project and solicit pre-existing concerns. The second meeting was conducted near the middle of the study and focused on the potential health issues involved with potable reuse and the treatment methods available to remove waterborne contaminants. The second meeting also included an introduction of the system configurations being considered. The third meeting was conducted at the completion of the feasibility evaluation, but prior to preparation of the final report. The third meeting was for the presentation of the proposed facilities and associated costs, and conclusions regarding feasibility. If implementation of a reuse program is desired, a more extensive program of public participation will need to be developed for subsequent phases. A recommended approach to public acceptance programs is included in Appendix A.

1.3. Report Organization

This document is structured to answer several questions relating to the feasibility of potable reuse of treated wastewater effluent. *Section 2, Water Supply Considerations,* begins with a presentation of population and water demand projections for the cities of Edinburg and McAllen, and compares the projected demand to available water supplies. The section concludes with a presentation of the potential impact of reuse. *Section 3, Water Quality and Public Health Safeguards,* describes the concept of indirect potable reuse and summarizes the water quality concerns which must be addressed in a reuse project, including public health issues and potential environmental impacts. *Section 4, Water Treatment Requirements,* describes how available treatment processes can be used to provide multiple barriers to the identified contaminants of concern.

Section 5, Reuse System Configurations, describes alternative system configurations which could be used by the Cities of Edinburg and/or McAllen to implement potable reuse. *Section 6, Feasibility Evaluation,* compares the recommended alternative for each city to the conventional practice of securing additional surface water rights. Both economic and non-economic considerations are evaluated. *Section 7, Implementation,* describes the additional steps recommended to bring a reuse project to a successful conclusion.

2. Water Supply Considerations

2.1. Population

Historical and projected populations obtained from the Texas Water Development Board (TWDB) for the Cities of Edinburg and McAllen are described below. The projections shown are from the TWDB's "Most Likely Growth Scenario." Both cities are expected to have a continuation of the rapid growth which has been characteristic of the lower Rio Grande Valley area. It should be noted that both cities are subject to an influx of retired winter visitors during the months of October through March. These visitors are not reflected in the population projections, but are not expected to have a significant impact on this study, since their impact has been included in the historical water usage. This assumes the fraction of water usage attributable to these "Winter Texans" will remain approximately constant.

City of Edinburg. The City of Edinburg population is projected to increase at an annual rate of 2.3% for the period 1990-2000 and at a slightly lower rate thereafter. This growth is illustrated in Figure 2.1. It can be seen from the graph that growth in the past five years is on a pace to exceed the projected population in the year 2000. The population is expected to grow from the existing estimate of about 36,000 to about 92,000 by the year 2050.

City of McAllen. The City of McAllen population is projected to grow from the existing estimate of about 98,300 to about 190,700 by the year 2050, as illustrated in Figure 2.2. The projected annual growth rate is 2.5% to the year 2000 and somewhat lower thereafter.

2.2. Water Demand Projections

Annual municipal water demand projections were also obtained from the TWDB as contained here after. The projections assume a modest reduction in per capita water use due to gradual replacement of plumbing fixtures and other water conservation measures. TWDB terms this series "Expected Conservation" and has a second series (not shown) for "Advanced Conservation" which assumes more aggressive efforts at water conservation. The "Expected Conservation" series is shown as the baseline for this study, since it is more conservative and is more likely to occur unless a comprehensive program of conservation is established. TWDB also differentiates between the water use to be expected during a period of normal rainfall and the higher use expected due to increased landscape irrigation during "below normal rainfall" (drought) conditions. Both values are included in the figures presented here. The TWDB values do not include irrigation, livestock, mining, power or industrial uses, so an industrial allowance is added to the municipal projections for each City, based on recent industrial usage. The projections for Edinburg and McAllen shown in Figures 2.1 and 2.2 include the projected industrial use.

The projections suggest a dramatic change in demand growth around the year 2000, especially for McAllen. This is an artifact of the method used to project these demands; the actual trend should be more gradual. The actual population and water demand must be closly monitored to determinethe accuracy of assumptions regarding conservation and to allow adequate planning for water supply.

City of Edinburg. The City of Edinburg has averaged 152 gallons per capita per day (gpcd) for the years 1980 through 1993, and had a total raw water usage of 6,456 acre-feet in 1995. This corresponds to an average usage of 5.76 million gallons per day (mgd). This is expected to increase to 14,197 acre-feet (12.67 mgd) by 2050, with up to 15,640 acre-feet (13.96 mgd) in a drought year. The City currently holds 7,981 acre-feet of municipal water rights.

City of McAllen. The City of McAllen has averaged 200 gpcd for the period 1980 through 1993, and had a total water usage of 19,506 acre-feet (17.41 mgd average) in 1995. The higher per capita use compared with Edinburg is presumed to be the result of a greater proportion of commercial activity in McAllen. Normal year demand is expected to increase to 36,320 acre-feet (32.42 mgd) by 2050, and drought conditions would be expected to generate a demand of 45,302 acre-feet (40.44 mgd) by 2050. McAllen currently has authorized water rights totaling 25,799 acre-feet.

2.3. Water Rights Assessment

Water rights are a complicated issue in general, and are further complicated by the international status of the Rio Grande. Water in Falcon Lake is allocated to the United States and Mexico by treaty, and is released to meet the requirements of authorized users downstream. Water rights are held by cities, water supply corporations, irrigation districts and other entities with various levels of priority status. Although municipal rights have the highest priority and have historically been dependable, the current low levels in Falcon Lake and Amistad Reservoir upstream have caused public concern even for municipal allotments. This is a result of the current drought situation and unauthorized diversions of river water on both sides of the border.

Quantity and Availability

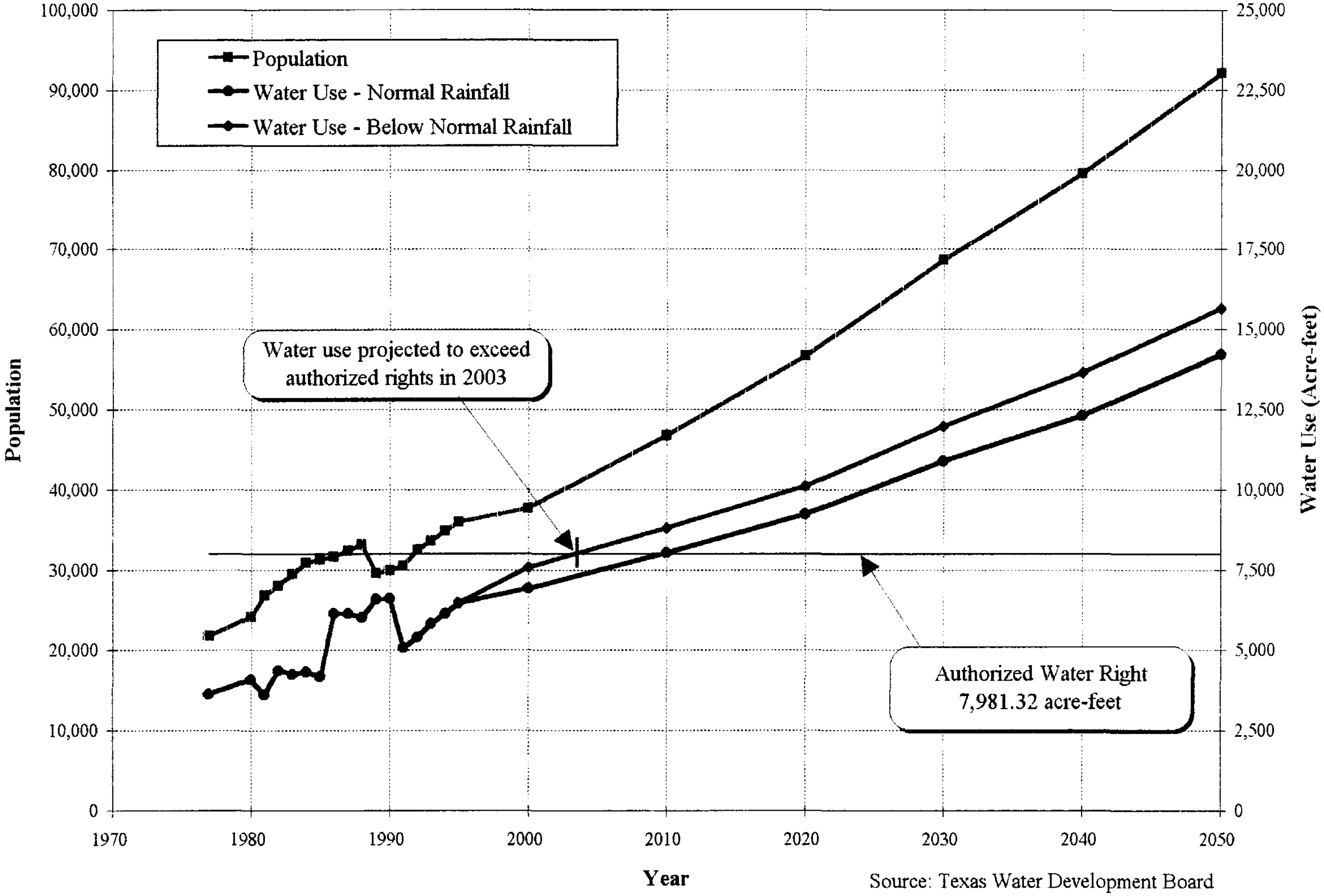
City of Edinburg. The City of Edinburg currently holds municipal water rights totaling 7,981 acre-feet/year. This provides a theoretical supply sufficient to meet the projected needs until the year 2003, assuming the growth and conservation projections are reasonably accurate.

City of McAllen. The City of McAllen currently holds a total of 25,798 acre-feet/year of municipal water rights, with options allowing them to purchase up to 5,000 acre-feet/year as needed. This provides a theoretical supply sufficient to meet projected needs until the year 1997, assuming the growth and conservation projections are reasonably accurate. If the water rights options currently held by the City are exercised, the rights are projected to be adequate until the year 2012.

Effluent Rights

Water rights are often a consideration in evaluations of potential wastewater reuse. Some fraction of wastewater return is often assumed in calculations of reservoir yields or downstream water rights, and in some cases downstream users may have a claim on some portion of the water to be returned. In the cases of McAllen and Edinburg, wastewater is not returned to the Rio Grande, but is discharged to drainage canals which eventually flow into the Laguna Madre.

Figure 2.1
Population and Water Use Projections
City of Edinburg



Source: Texas Water Development Board

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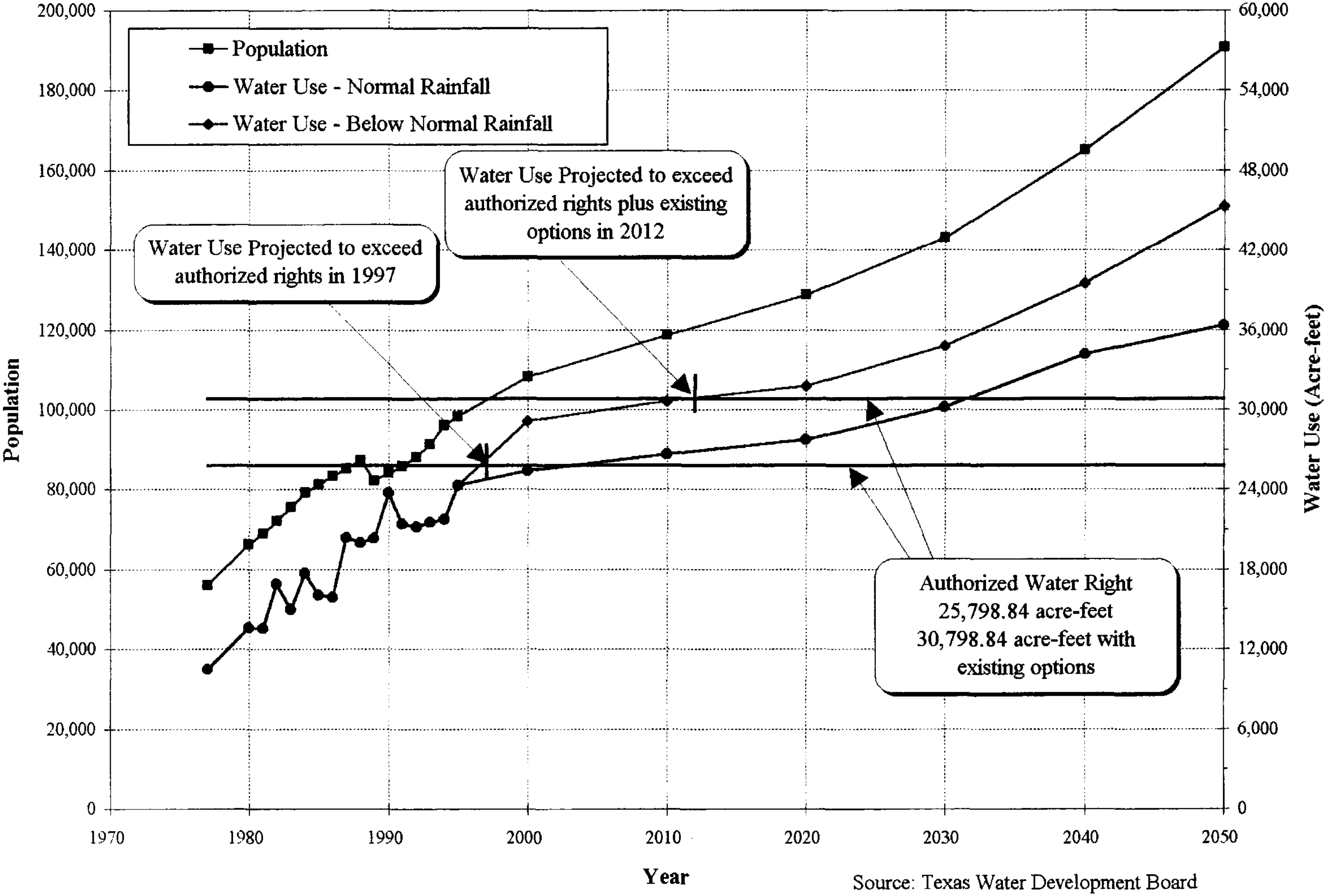
Figure 2.2
Population and Water Use Projections
City of McAllen



Water Use Projected to exceed authorized rights plus existing options in 2012

Water Use Projected to exceed authorized rights in 1997

Authorized Water Right
25,798.84 acre-feet
30,798.84 acre-feet with existing options

Source: Texas Water Development Board

The McAllen City Attorney has provided a legal opinion, indicating there should be no valid legal claim which would limit the City's use of reclaimed effluent prior to discharge. This opinion should apply similarly to Edinburg, although a separate legal opinion should still be obtained. Another issue which should be considered is the potential impact on aquatic life in the receiving streams and the Laguna Madre from removing or reducing the discharge of effluent. This issue is discussed in section 3.5.

2.4. Potential for Nonpotable Reuse

The focus of this study is the feasibility of potable reuse. However, the opportunities for nonpotable reuse, like conservation, represent another way to bring potable demands in line with available supplies. Nonpotable reuse lessens some of the obstacles to potable reuse, such as public health and public opinion, and normally requires less treatment and hence less cost than potable reuse.

Major Water Customers

Some of the major water customers in McAllen and Edinburg, as identified by the Cities, are Coca Cola Bottling Co., Delicious Valley Frozen Food, Rio Grande Regional Hospital, Palmview Condos, McAllen Medical Center, University of Texas Pan American, and Azteca Milling. A cursory review of the major water users suggests that most of the customers are not good candidates for nonpotable reuse. Most are institutional or residential in nature and irrigation or other nonpotable uses would not represent a sufficient portion of their usage to justify the cost of providing a separate source. Similarly, urban irrigation with reclaimed water would require a large investment in a separate distribution system, with limited impact on overall water supply. TWDB records indicate seasonal water use to represent only 17% of total use in Edinburg and 20% in McAllen. There are a few businesses which may be candidates for reuse if they are located near a wastewater treatment plant, and these should be explored further by the Cities. However, the water savings, while important, are not likely to significantly alter the long range water supply situation for either City.

Agricultural Use

From a technical standpoint, agricultural reuse may represent the most feasible opportunity to take advantage of reclaimed wastewater as a water resource. There is a concern that the high dissolved salts may be detrimental to crops; this would have to be examined on a case-by-case basis. If measures are taken to reduce dissolved solids in drinking water, the improvement would benefit the wastewater characteristics as well. For crops intended for human consumption, the fate of pathogens would also be an important consideration. Both these obstacles appear manageable. The greater difficulty may lie in obtaining support and cooperation of various entities with a stake in water supply and agriculture. There is also a concern that the cities may not get the full benefit of the available effluent quantities in a trading scenario. The evaluation of this situation is beyond the scope of this study, but agricultural reuse should be considered as one of the region's preferred alternatives for water management.

2.5. Impact of Indirect Potable Reuse

Wastewater flow records have been reviewed to assess the quantity of effluent which could be expected on a continuous basis from each of the existing plants. The Edinburg WWTP currently receives average flows between 2.5 and 3.0 million gallons per day (mgd). By the time a reuse project would be implemented, it is expected the average flows would typically be above 3.0 mgd, and a net yield of 2.6 mgd should be available after reverse osmosis treatment. Implementing a project of this size in the year 2002 is projected to increase Edinburg's water supply sufficiently to meet the city's needs through approximately 2024, as illustrated in Figure 2.3.

McAllen is currently using its entire appropriation of Rio Grande water, as shown previously in Figure 2.2. Since a reuse project (or other water supply development) would take several years to implement, it is assumed McAllen will need to implement one of their existing options for an additional 5000 acre-feet/year of Rio Grande water. This would meet the projected water demand until about 2002. The McAllen WWTP No. 2 typically treats 6-8 mgd. A 6 mgd project, with a net yield of 5.1 mgd, is projected to extend the available supply to the year 2032. A second project on the north side of town could extend the supply for several additional years. The McAllen WWTP No. 3 currently receives about 2 mgd, but as this area grows these flows will steadily increase. It is expected that a 4 mgd project (3.4 mgd yield) could eventually be supported on the north side of McAllen. Figure 2.4 illustrates the potential impact of these projects on the McAllen water supply.

Figure 2.3
Water Use Projections with Reuse
City of Edinburg

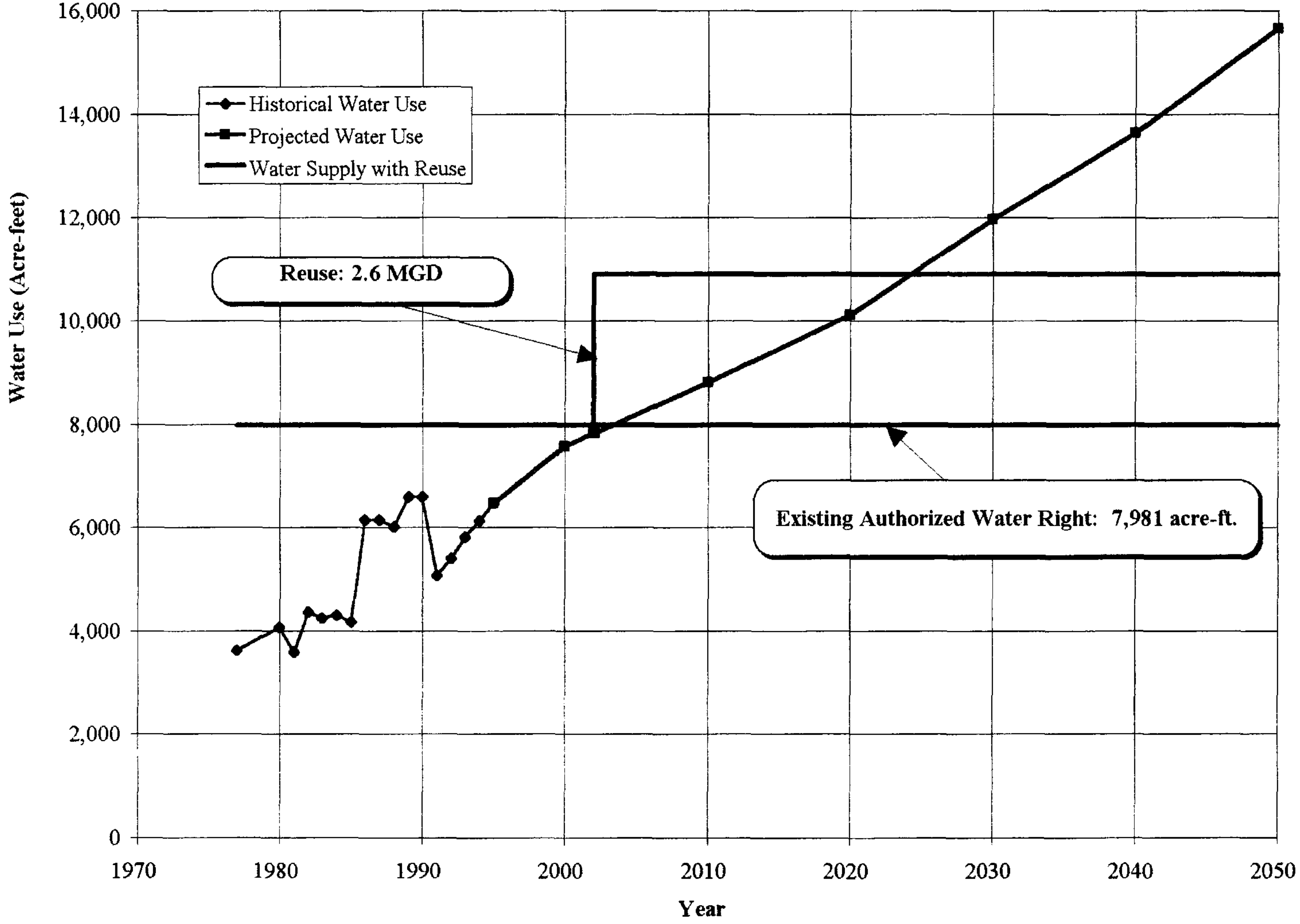
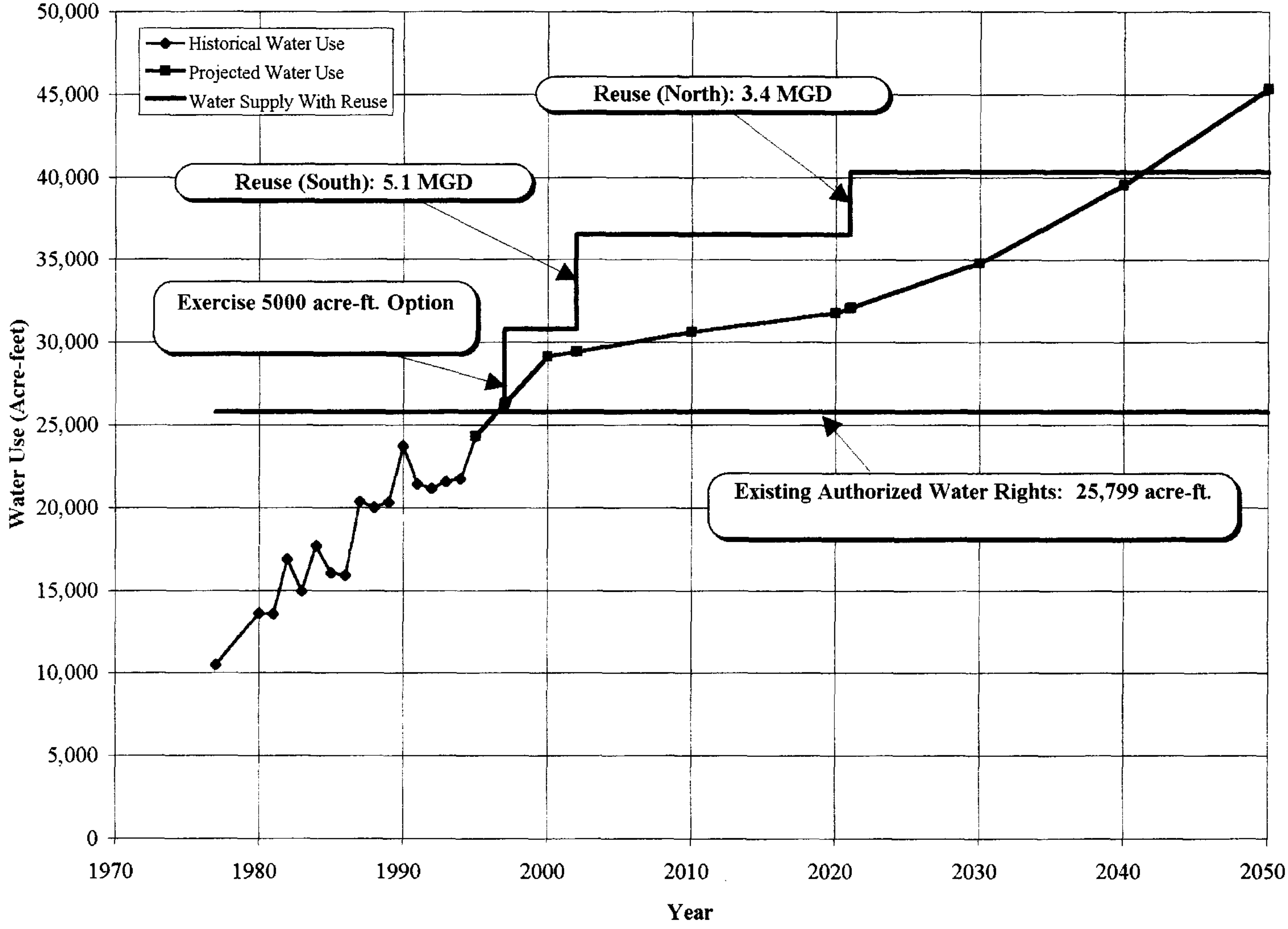


Figure 2.4
Water Use Projections with Reuse
City of McAllen



3. Water Quality and Public Health Safeguards

The purpose of this chapter is to present the state-of-the-art of indirect potable reuse. Indirect potable reuse is the recovery of water from wastewater for the purposeful reintroduction into either a surface water or groundwater body that ultimately serves as a drinking water supply. The following topics are covered in this chapter:

- What is indirect potable reuse?
- History of indirect potable reuse.
- Existing Raw Water Quality
- Water quality and public health safeguards.

3.1 Concept of Indirect Potable Reuse

The concept of indirect potable reuse can be described by what it is, as well as by what it is not. Unplanned or incidental, indirect potable reuse occurs whenever a water supply is withdrawn for potable purposes from a natural surface or underground water source that is fed in part by the discharge of a wastewater effluent. The wastewater is discharged to the water source as a means of disposal and therefore subsequent reuse is an unplanned or incidental byproduct of the wastewater disposal practice.

To gain a better understanding of the prevalence of unplanned, indirect potable reuse in our nation's surface water supplies, the U.S. EPA conducted a study and published a report in 1980 called *Wastewater in Receiving Waters at Water Supply Abstraction Points*. The purpose of the project was to determine how much wastewater and wastewater-derived material from discharges are present in the surface water supplies of U.S. cities with populations greater than 25,000. The study identified 1,246 municipal water supply utilities using surface water from 194 basins serving 525 cities with populations greater than 25,000.

From the nearly 80 million users of surface water included in this study, about 33 percent of this population withdrew their water supplies from sources that contain from 5 to 100 percent wastewater during low flow periods. Clearly, unplanned indirect potable reuse is relatively common in the United States.

Planned, indirect potable reuse is the purposeful augmentation of a surface water source or recharge of an underground water source with a water recovered from wastewater with the intent of reusing the water resource. It is often similar to unplanned or incidental potable reuse, except the time and distance from the point of wastewater discharge to the water treatment plant intake is often shorter.

3.2 U. S. History Of Indirect Potable Reuse

Unplanned indirect potable reuse has been in practice since man first began disposing of wastewaters into watersheds that are hydrologically connected to raw water supplies. As populations have increased, so too has the quantity of wastewater and the technology to manage these increased volumes of wastewater. Indirect potable reuse is one of the developing strategies to both manage wastewater and recover and reuse water resources.

Several projects in the U.S. and elsewhere have demonstrated the viability of planned indirect potable reuse. Appendix B contains a summary of some of the historical milestones marking the development of planned potable reuse as a viable component of a water resource management plan. The following projects are highlighted in the appendix:

- Whittier Narrows Groundwater Replenishment Project, California (1962)
- Orange County, California Water District (1976)
- Upper Occoquan Sewage Authority Water Reclamation Plant, Virginia (1978)
- Potomac Estuary Experimental Water Treatment Plant (1981-1983)
- San Diego Total Resource Recovery Project, California (1983)
- El Paso, Texas Fred Hervey Water Reclamation Plant (1985)
- Tampa, Florida Water Resource Recovery Project (1986)
- West Basin Water Recycling Program, California (1990-1995)

3.3 Water Quality And Public Health Safeguards

In typical drinking water supply systems, state and federal drinking water standards are used as a measure to determine if a given supply has been adequately treated prior to distribution to the community. However, the existing standards were not originally developed with the goal of regulating drinking water derived from a wastewater origin. Therefore, extra care must be incorporated into a water supply system that serves a water of wastewater origin.

Due to the lack of specific standards covering indirect potable reuse applications, the concept of "multiple barriers" has been adopted by the water supply industry to achieve the appropriate level of safety and reliability. In this concept, multiple unit processes and other mechanisms are relied upon to remove or inactivate various water quality parameters that are of concern, primarily pathogenic organisms. For example, an indirect potable reuse application may include two or three unit treatment processes designed to remove or inactivate viruses and parasites that may be present in the supply. Should one process fail at the task, backup mechanisms are available to do the job. Although this multiple barrier approach is particularly necessary for pathogenic organisms, the approach also can be used to provide protection against trace organics or metals.

3.4 Public Health Parameters

In general, reclaimed water should be treated to a level where its quality exceeds that of the historical water supply. The key parameters most often used to measure and assess the quality of the reclaimed water from a public health perspective are listed below.

Microbial Constituents

Microbial pathogens in municipal wastewater originate from human and animal feces. These pathogens can be broadly classified into four groups of organisms and, in an ascending size order, include viruses, bacteria, protozoans, and helminths. Factors that influence the presence and concentration of these agents include:

- Population size
- Population health
- Wastewater collection system sources
- Treatment levels
- Survival rates of the organisms

The public health risk depends on several factors, such as:

- Degree of exposure
- Infective dose
- Organism pathogenicity
- Host susceptibility

It is known that there are bacterial pathogens (as measured by coliform), viruses and other pathogens in the untreated Rio Grande water currently supplied to the McAllen and Edinburg water treatment plants, and in the treated secondary wastewater effluents. The concentration of microbial pathogens is generally greater in wastewater, and blending of the supply will increase the associated risk unless the risk is mitigated by disinfection or additional treatment of both the reclaimed water and the drinking water.

Nitrate

The current drinking water standard for nitrogen is 10 mg/L. This standard is intended to protect children less than 6 months of age from acute methemoglobinemia, also known as "blue baby syndrome". Nitrogen may be removed from water by ion exchange, membrane filtration (reverse osmosis) or biological de-nitrification. Nitrate may also be reduced by blending with lower nitrate sources.

Total Organic Carbon

Total organic carbon (TOC) can be either a naturally occurring compound or man made compounds such as hydrocarbons. Naturally occurring TOC is a problem due to the formation of disinfection by-products, such as trihalomethanes (THMs), when chlorine is used for disinfection. Drinking water standards limit the concentration of THMs and some man made compounds, such as benzene, because of the potential chronic health risk from long term exposure to the compounds.

Untreated water with TOC levels greater than 4 mg/L should receive additional treatment to minimize the health risk. TOC can be reduced by additional coagulation, filtration with granular activated carbon, membrane filtration, and biological treatment.

Other Chemicals

Trace metals and inorganic constituents naturally occur in water from processes such as physical and chemical weathering of rock formations and soil erosion. Inorganics also enter water as a result of domestic and industrial activities. Organic compounds synthesized by man, such as herbicides, pesticides, and plastics, also find their way into water through mechanisms such as surface runoff, industrial discharges, and domestic use.

When considering reuse of municipal wastewater, the sources contributing to wastewater flow should be evaluated to determine if strategies are available to reduce the pollutant load to the reclamation process. Strategies include measures such as water shed protection, industrial pretreatment, and reduction of contaminated infiltration and inflow into the sewer system.

Total dissolved solids (TDS) is a measure of chemicals that are dissolved in water. TDS consists of a variety of salts, such as calcium, magnesium, sodium, potassium, carbonate, bicarbonate, chloride, sulfate, nitrate, and phosphate. An elevated TDS usually results in an undesirable or salty taste. It is desirable for drinking water to have a TDS less than 500 mg/L. The Texas drinking water standards require TDS be less than 1,000 mg/L, unless special approval is obtained.

3.5 Existing Raw Water Quality

Both cities take water indirectly from the lower Rio Grande River (Segment 2302). Hidalgo County Irrigation Districts 1, 2, and 3 pump water into irrigation canals which transport water to various users including the cities. The cities divert water from the Districts' canals to raw water storage reservoirs, and pump water from the reservoirs to their water treatment plants. Regular monitoring of the river is conducted by the Texas Natural Resource Conservation Commission at a station adjacent to the U.S. Highway 281 International Bridge. A sampling program by each City to measure important parameters in the raw water reservoirs and treated wastewater effluent was initiated at the start of this study. This program should be continued to provide a long term database of water quality for each of these sources. It is assumed that water quality in the raw water storage reservoirs is similar to that in the river, although the reservoirs should act to reduce variations in quality. The recommended testing in the reservoirs should determine what differences exist between the reservoirs and the river.

Table 3.1 contains a summary of the TNRCC data on several parameters of primary interest and effluent quality from the WWTPs in McAllen and Edinburg. Rio Grande River water in the vicinity of Hidalgo County is usually high in dissolved salts, especially sulfate, causing exceedence of secondary drinking water standards. Sulfate is typically between 200 and 400 mg/L and total dissolved solids are typically between 700 and 1,000 mg/L, although they have been measured above 1,000 mg/L on numerous occasions. This segment of the river is also subject to periodic contamination from inadequate wastewater treatment upstream. Contamination is indicated by occasional instances of high fecal coliform counts (up to 6,000 per 100 mL). Dissolved oxygen is usually high, between 6 and 11 mg/L, even with summer water temperatures commonly between 25 and 30°C. Data for concentrations of pesticides and other toxics, although limited, do not indicate excessive values. Virtually all of these substances were below detection limits.

The prevalence of pathogenic organisms will be another key measure for comparison of wastewater effluent with existing raw water supplies. The recommended testing program will measure several important water-borne pathogens as well as other constituents.

Table 3.1
Rio Grande River Water and WWTPs Effluent Quality

Parameter	Rio Grande River Water Quality [1]			WWTP Effluent Quality
	Average	Maximum	Minimum	
Temperature, °C	23.3	31.0	11.6	
Average Flow, CFS	1,533	7,513	61.2	15.5[2], 6.2[3], 7.0[4]
Average Conductivity, μmhos/cm	1,357	2,820	100	1350 [2],1580 [3]
pH	N/A	10.10	6.55	7 [2&3]
Alkalinity, mg/L as $CaCO_3$	130	192	101	140 [2], 59 [3]
Chlorides, mg/L	181	460	71	338 [2]
Sulfates, mg/L	271	499	110	375 [2]
Total Dissolved Solids, mg/L	863	1,650	300	977 [2], 1240 [3]
Dissolved Oxygen, mg/L	8.8	13.0	3.85	7.5 [2], 4.5 [4]
Total Suspended Solids, mg/L	79	932	6.0	15 [2], 20 [3], 15 [4]
Total Organic Carbon, mg/L	5.28	36	1.0	
Fecal Coliform, CFU/100 mL	1,172	100,000	1.0	
Chlorophyl "a", μg/L	12.05	40.80	1.0	

Source:
[1] Texas Natural Resource Conservation Commission US 281 International Bridge at Hidalgo
[2] McAllen WWTP No. 2
[3] McAllen WWTP No. 3
[4] Edinburg WWTP

3.6 Recommended Public Health Safeguards

In order for wastewater effluent to be safely used to augment Edinburg's and McAllen's existing surface water supply, additional treatment will be required. The primary purpose of this additional treatment is to remove microbiological contaminants, reduce nitrate and TOC in the effluent, and prevent TDS levels from getting higher. It is also desirable for the treatment system to reduce nutrients in the effluent that encourage algae growth in the raw water reservoirs since this could have a negative impact on taste and odor of the drinking water. Existing sampling data do not indicate the presence of any toxic chemical compounds (trace metals, pesticides, etc.) that will negatively impact public health. However, additional data is required and that is one of the reasons the expanded monitoring program is being performed.

Edinburg and McAllen will have the opportunity to improve their current drinking water quality above what is currently achieved. Rather than apply all or a portion of the barriers at the wastewater treatment plant, they could be applied at the water treatment plant and be used to treat the blended supply. Chapter 4 discusses water treatment processes and the different ways they can be applied.

3.7 Additional Safeguards Through Best Management Practices

Using an existing raw water supply as a recycle conduit and buffer between the reclaimed water and drinking water offers system reliability, redundancy, and psychological satisfaction. In addition, it offers the opportunity to manage the combined water supply such that additional safeguards and protections are provided as described below. These safeguards are the primary reason unplanned or incidental reuse has not resulted in significant health problems. They are effective safeguards and should be part of any indirect potable reuse program.

Blending and Dilution

One of the primary safeguards that, by definition, is inherent in all planned indirect potable reuse projects is the blending and dilution provided to the reclaimed water from the conventional raw water supply. The appropriate level of blending and dilution remains largely a site specific exercise. Generally, it is recommended that the blending ratio be limited to no more than 50-percent. For this study, it is recommended that 50% or less of the water treatment plant inflow be water reclaimed from the Edinburg or McAllen wastewater treatment plants.

Retention Time

Retention time is the time that elapses from the time reclaimed water enters the raw water supply to the time it is withdrawn for potable water treatment and redistribution. Retention time provides time for blending and dilution, time for natural treatment processes to occur, and time for water quality monitoring and potential corrective actions. Provision of retention time generally requires geographic separation between the point of reclaimed water augmentation and withdrawal. This geographic separation in turn provides a psychological comfort that a "natural" barrier is present. Like blending and dilution, retention time provisions are site specific.

Retention time in a surface water reservoir is dependent on the reservoir geometry, inflow location, outflow location, water temperature, density currents, and wind currents. Preliminary guidelines in some locations recommend an average hydraulic retention time of 12 months. The Upper Occoquan project includes about 1 month of average retention time in the Occoquan Reservoir.

Retention time for potential projects in the valley will be relatively short (days or weeks versus months). Thus, methods should be determined for the introduction and withdrawal of reclaimed water from the reservoirs to minimize short circuiting (immediate travel of reclaimed water from the release point to the water supply intake structure). During times the reservoirs are stratified, reuse water should not be introduced above the thermocline, and withdrawals should be from below the thermocline.

Natural Treatment

Beyond dilution and retention, the receiving raw water supply also can provide natural treatment. Typically, in planned indirect potable reuse, this natural treatment is viewed as a redundant system, above and beyond the engineered treatment systems. Surface waters offer nutrient removal, metals removal, organics removal, and pathogen removal via aeration, biological degradation, photodecomposition, adsorption, and sedimentation.

Open Loop Systems

The treatment processes normally employed in a reclaimed water treatment system do a poor job of removing refractory contaminants and TDS; consequently, their concentration increases with each use cycle. Pesticides such as lindane, and some non-polar organic compounds, and inorganic ions are examples of refractory contaminants.

It is important to allow the discharge of a sufficient quantity of wastewater so contaminants do not build up in the water. Generally, no more than 50% of the wastewater should be reclaimed unless specific processes are employed to address the contaminant build-up issue. This percentage can be relaxed when reverse osmosis treatment is used in the reclamation process due to its superior contaminant rejection characteristics.

Management Commitment

Another best management practice important to the overall reuse program is the proper funding, staffing, and operation of treatment and conveyance facilities. No system can be effective if the people involved fail to properly execute their tasks and maintain the reuse components and safeguards.

One method that has been used to measure management commitment is the Composite Correction Program (CCP). Under the CCP, a Comprehensive Performance Evaluation (CPE) is conducted. The CPE is a systematic step-by-step evaluation of an existing treatment plant resulting in a comprehensive assessment of the existing unit treatment process capabilities and the impact of the operation, maintenance and administrative practices on performance of the plant.

3.8 Environmental Considerations

The primary focus of this study is the evaluation of the potential impact of wastewater reuse on water quality and appropriate treatment processes to protect public health and maintain production of high quality drinking water. An additional area of concern is the potential for environmental impacts due to changes in the quantity of wastewater effluent discharged. A preliminary investigation of this issue indicates a probable beneficial impact from a reduction in effluent discharged. The McAllen Wastewater Treatment Plant (WWTP) No. 2 discharges to the Arroyo Colorado, and the Edinburg WWTP and McAllen WWTP No. 3 discharge to the North Floodway. Both the Arroyo Colorado and the North Floodway discharge to the Laguna Madre, a marine lagoon historically characterized by low freshwater inflows and high salinity.

According to an opinion issued on this subject by a staff biologist at the Texas Water Development Board, the Arroyo Colorado and the Laguna Madre are both experiencing eutrophic conditions related to high nutrient loadings. Elevated nutrient loadings result in excessive plankton blooms which prevent sunlight from reaching the bottom grasses native to the marine lagoon. Since municipal wastewater discharges are high in the nutrients nitrogen and phosphorus, these flows are considered a detriment to the health of the Arroyo Colorado and Laguna Madre and the reduction or elimination of such discharges is expected to have a net positive effect on these water bodies. A copy of the referenced opinion is provided in Appendix C.

4. Water Treatment Requirements

4.1. Processes Considered

A variety of treatment processes are currently available for the reclamation of wastewater effluent. All of the treatment combinations presented have been developed to address contaminants of concern. The specific concerns, as discussed before, include:

- Pathogenic microorganisms
- Excessive nutrients (nitrogen and phosphorus)
- Total Organic Carbon (TOC) and the resulting formation of THMs and other disinfection byproducts (DBPs)
- Toxins
- Aesthetic contaminants, especially Total Dissolved Solids (TDS)

Current water quality characteristics have also been considered in order to maintain a raw water quality equal to or better than currently exists. The following is a discussion which highlights critical aspects of the recommended treatment processes and compares them to other processes. Any of the proposed treatment processes could be incorporated into either city's current treatment systems.

Biological Nutrient Removal

Wastewater effluent is typically high in nutrients such as nitrogen and phosphorus which encourage algae growth (eutrophication) in large bodies of water. Excessive algae will diminish the clarity of the water and affect its taste and odor, and may lead the public to mistrust the raw water supply. For these reasons, in addition to others, it is necessary that excessive nitrogen and phosphorus be removed from the wastewater effluent prior to blending in a raw water reservoir. Biological nutrient removal (BNR) describes a group of processes which remove nitrogen and phosphorus through natural means.

One form of nitrogen present in wastewater is ammonia-nitrogen. The removal of ammonia-nitrogen is of primary concern because of the oxygen demand exerted when the compound is released to the environment. Both cities currently address the ammonia-nitrogen issue through partial nitrification. Nitrification is the biological conversion of ammonia to nitrate. BNR could complete this process by simultaneously removing nitrate and phosphorus.

The removal of nitrogen by this process occurs in two steps. In the first, ammonia is converted aerobically to nitrate, and in the second step nitrates are converted to nitrogen gas and released to the atmosphere. Treatment systems which can accomplish this most efficiently include various combinations of anaerobic, anoxic, and aerobic components. BNR systems have been demonstrated to be cost effective for nutrient removal in many municipal wastewater treatment plants, both in new facilities and as retrofit projects. It appears to be feasible to modify the existing aeration basins in the Edinburg and McAllen wastewater treatment plants for some type of anoxic/oxic treatment system. Hence, a BNR system appears to be a cost effective type of biological treatment to address nutrient removal.

Other methods which could be used for nitrogen removal include denitrifying filters, fixed film systems and selective ion exchange. Wetland systems were described in *TM 2*, located in Appendix E, but are not considered a viable treatment alternative and are not included in any of the proposed treatment scenarios. Wetland systems cannot provide the level of reliability needed and do not handle variations in flow very well.

Chemical Treatment

Chemical treatment can aid not only in the removal of phosphorus, but also heavy metals, other suspended organic and inorganic materials, and oxygen demanding substances. The chemical treatment system most commonly applied and proven in water reclamation applications is high lime treatment with two-stage recarbonation. The addition of sufficient lime to water raises the pH and converts bicarbonates and carbonates to hydroxides. This conversion results in the precipitation of phosphorus, calcium, magnesium and heavy metals. As the precipitates thus formed settle from the water, suspended organic and inorganic materials are enmeshed with the falling particles and removed as well. The high pH is also an effective method of virus/bacterial inactivation. Recarbonation is a term applied to the addition of carbon dioxide to the high pH, lime treated water so the pH is lowered and the hydroxides are reconverted to carbonates and bicarbonates. Recarbonation protects downstream process units from scaling and improves their effectiveness.

Metal salts have also been used for phosphorus and particulate removal, but are not included in the proposed treatment scenarios because BNR can be implemented at a lower overall cost.

Disinfection

This is usually the final barrier that prevents pathogenic microorganisms from becoming a public health threat. There are four primary methods of disinfection: chlorine, chlorine dioxide, ultraviolet irradiation and ozonation. Chlorination systems are reliable and flexible and the equipment is relatively easy to control and operate. However, the properties which make it an excellent disinfectant, strong oxidizing properties, also make it hazardous to handle. Chlorine gas is becoming more tightly regulated, and its use as a primary disinfectant is known to cause formation of undesirable byproducts. However, chlorine is used almost universally for providing a disinfection residual in water distribution systems to prevent recontamination of potable water.

The recommended disinfection process for the wastewater treatment plants is ultraviolet (UV) irradiation. UV disinfection offers safety advantages over chlorination and has not shown any toxic effect on receiving waters. Also, this process is more effective than chlorine for the inactivation of Cryptosporidium in wastewater. UV disinfection could effectively replace chlorination/dechlorination of effluent whether reclaimed or discharged.

Ozone is recommended for primary disinfection of blended water at the water treatment plants. It is relatively safe and possesses excellent viricidal and bactericidal properties. It is effective for disinfecting water known to contain protozoa. It is the most effective method known to inactive Cryptosporidium other than heat treatment. One other advantage to ozone is its excellent ability to elevate dissolved oxygen levels in water, often to saturation levels.

Filtration

The two methods considered were conventional and the NSF (natural soil filtration) system. However the NSF system was determined not to meet the level of reliability required and was not included in the evaluated alternatives. Filtration is typically used for achieving supplemental removals of suspended solids (including particulate BOD) from wastewater effluents of biological and chemical treatment processes. Filtration can also aid in the removal of chemically precipitated phosphorus. Conventional filtration at wastewater treatment plants usually is comprised of single media but can be designed to contain multiple filtration media with different specific gravities. The proposed treatment scenarios include multi-media filtration to provide adequate removal of suspended solids. This will allow effective application of UV for disinfection.

Granular Activated Carbon

Even after conventional treatment including coagulation, sedimentation and filtration, soluble organic materials that are resistant to biological breakdown will persist in the effluent. These remaining materials are often referred to as refractory organics. The largest contribution of GAC filtration to the treated water quality will be the reduction in refractory organics and overall TOC. Other benefits which will be realized are the removal of taste, odor and color constituents. This process is included in the treatment scenarios requiring additional organic removal.

Microfiltration

Microfiltration (MF) removes suspended particles, some bacteria, and viruses that accumulate on particles. Its main purpose in the proposed scenarios is as a pretreatment to RO, where it could be a cost effective replacement of flocculation and sedimentation.

Reverse Osmosis

RO is a high or low pressure membrane process which removes a variety of contaminants: chloride, nitrogen, sodium, sulfate, TDS, TSS, TOC, virus and bacteria. Since dissolved salts in both cities' drinking water are already above desirable concentrations, RO or another membrane process should be used for at least of a portion of the flow to prevent increases in salinity. EPA-funded studies have also demonstrated that, on a pilot scale level, RO is effective for removing specific synthetic organic contaminants such as herbicides and pesticides from contaminated groundwater.

4.2. Alternative Process Combinations

Four treatment scenarios have been developed for consideration in this study. Each of the scenarios provides multiple contaminant barriers against pathogens to protect public health and each is expected to provide a finished water quality equal or superior to existing water quality. The scenarios are primarily aimed at determining technical and economic feasibility of potable reuse of wastewater effluent. Accomplishment of additional goals such as dissolved solids reduction or nonpotable reuse may dictate other process combinations which are more efficient for multiple objectives.

Alternative 1

This treatment alternative addresses water quality concerns with a more conventional approach. Improvements to both the current WWTP and the WTP are included. Flows would first be treated with a BNR system at the WWTP for nutrient reduction. It is anticipated that modifications to the existing facilities would allow a retrofit system to be installed. This would be of significant cost savings as compared to constructing an entirely new BNR system. After BNR, the reclaimed water would be treated with conventional filtration and UV disinfection before discharge into the raw water resevoir. Any unused flow would be diverted to the Laguna Madre or used for nonpotable reuse.

At the WTP the combined raw water will be treated using high lime treatment followed by recarbonation, then GAC filtration and finally ozone disinfection. Although some reduction in TDS may be accomplished by the high lime treatment, a side stream RO treatment step will be required for 15-20% of the flow to maintain TDS levels equivalent to raw water levels. Chlorination of the finished water (as currently practiced) will be required so a residual is maintained in the distribution system.

Alternative 2

The changes at the WWTP will be identical to those described in Alternative 1. At the WTP, the use of an RO system will improve water quality appreciably over any current treatment technologies. To make the RO system operate efficiently, it is essential that adequate pretreatment be provided. In this case microfiltration is the recommended process. Once the water has gone through the membrane treatment systems it will be treated with ozone before final chlorination.

Alternative 3

Alternative 3 differs considerably from the first two alternatives in that most of the treatment is provided at the WWTP. The BNR recommendation is similar to that in the first two alternatives. After that a combined MF, RO membrane treatment process is applied followed by UV disinfection. This will enhance the overall effluent quality in comparison to previous alternatives. The WTP side of the system includes relatively minor improvements in the existing flocculation, sedimentation, and filtration processes. The only new process is the addition of ozone disinfection prior to final chlorination.

Alternative 4

Alternative 4 is similar to Alternative 3, except that a high lime, filtration, and GAC system replaces the MF and RO treatment units. Like Alternative 3, most of the treatment is provided at the WWTP. This alternative enhances the overall effluent quality in comparison to alternatives 1 and 2. The WTP side of the system has limited improvements, as discussed under Alternative 3.

Since this alternative would result in an increase in TDS, a side stream TDS removal process is required. For the purpose of this analysis, 15 to 20% of the WTP flow is assumed to be treated by RO. It is estimated that this level of treatment will produce a finished water with a TDS similar to that of the Rio Grande. If a lower TDS is desired, a larger volume of the water could receive RO treatment.

4.3. Recommended Treatment Alternative

The four alternative potable reuse approaches can be compared and judged using four criteria: cost, quality of water produced, waste residuals generated, and land requirements. Alternative 2 is clearly the most expensive, while the other alternatives have similar costs. A sensitivity analysis of the different cost factors was made to determine how variations in the estimates impact the selection of treatment systems. The sensitivity analysis showed no changes in the preferred alternatives over the range of probable variations in the cost estimates. This analysis was presented in *TM 3*, which is included in this report as Appendix F.

Based on the analysis, Alternative 3 is the preferred option. It produces a high quality water at a reasonable cost. It has a waste sidestream that must be managed, but it is less than for the others. Alternative 3 is represented in Figure 4.1.

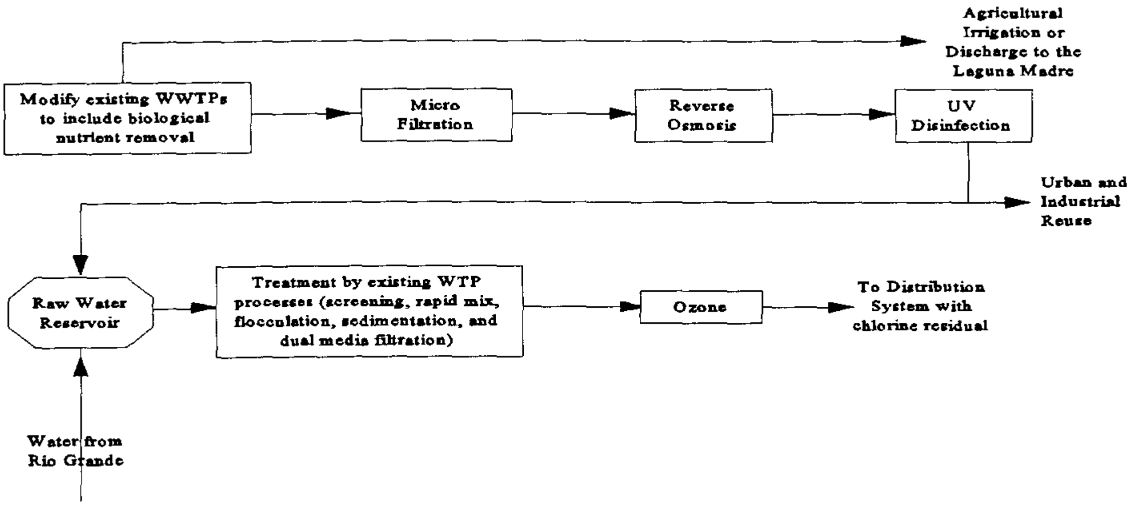


Figure 4.1 - Recommended Treatment Schematic (Alternative 3)

5. Reuse System Configurations

Four system configurations have been developed for application of potable reuse in the McAllen - Edinburg area. The proposed treatment alternatives can be applied to each configuration for an overall plan of implementation. Each of the configurations is described in the following paragraphs, and preliminary cost estimates have been prepared for the conveyance facilities to allow an overall assessment of reuse feasibility. A general location map of the water and wastewater treatment facilities is shown in Figure 5.1.

5.1. Edinburg System

The City of Edinburg is expanding its WWTP to 5.9 mgd and upgrading the plant to provide improved effluent quality. This project will also result in the redirection of effluent to the San Juan Holding Pond. For this study it is assumed effluent will be withdrawn from the San Juan Holding Pond to make use of the natural detention time offered by this arrangement. A reclaimed water flow of 3 mgd is assumed for sizing purposes. A 3 mgd pump station and pipeline would convey the reclaimed water to the existing Edinburg Reservoir as shown in Figure 5.2. Due to space restrictions at the Edinburg WTP, some of the treatment alternatives may not be feasible at the existing plant. It may be preferable to construct the additional treatment facilities as part of the WTP No. 2 proposed for construction adjacent to the Edinburg Reservoir.

5.2. Edinburg/McAllen Regional System

Due to the close proximity of the McAllen WWTP No. 3 to the Edinburg Reservoir, a regional water treatment plant located near the Edinburg Reservoir could accept suitable effluent from both cities, along with raw water from the Rio Grande, and treated blended water to provide an additional source of supply to both cities. Assuming a flow of 4 mgd from McAllen, as discussed in section 2.5, combined with the 3 mgd assumed available from Edinburg, 7 mgd of effluent would be available. To maintain the 50% limit on effluent in the raw water, a plant size of at least 14 mgd would be needed. To provide detention of the raw water, a new reservoir is assumed, located near the Edinburg Reservoir. The facilities proposed for this system are shown in Figure 5.3.

5.3. McAllen North System

Due to the relative locations of WWTP No. 3 and the main water treatment facility (WTP No. 2), it does not appear practical to use effluent from WWTP No. 3 to supplement raw water to the existing water treatment facilities. However, there are plans to locate an additional water treatment plant in the northwest part of the City of McAllen (See Figure 5.4) to provide additional capacity in this rapidly developing area. This plant could readily accommodate supplemental flows from WWTP No. 3. Assuming a 4 mgd effluent contribution, a minimum water treatment capacity of 8 mgd would be recommended. Similar to the regional system, a new reservoir is proposed.

5.4. McAllen South System

As shown in Figure 5.5, the McAllen WWTP No. 2 is located relatively near Boeye Reservoir which provides raw water storage for WTP No. 2. Conveyance of 6 mgd of effluent from the 10 mgd plant is proposed. Since Boeye Reservoir does not provide the duration of storage recommended for potable reuse, an effluent storage reservoir near WWTP No. 2 is proposed.

5.5. Evaluation of Alternatives

The costs for the four systems were compared in *TM3* (Appendix F). The projects considered the easiest to implement are the Edinburg system and the McAllen South system. The regional plant system appears likely to have similar costs per gallon of water reclaimed, but would require establishment of a new utility entity without any obvious benefits. The McAllen North system appears favorable when the planned water treatment plant in this part of McAllen is determined to be needed. Therefore, the Edinburg and McAllen South projects, using Treatment Alternative 3, are recommended for further consideration. The probable costs for these projects are summarized in Tables 5.1 and 5.2.

Table 5.1
Reuse Project Cost Summary - Edinburg

Item	Capacity (mgd)	Capital Cost (millions)	Operating Cost (millions/yr)
Wastewater Treatment Plant Improvements			
Biological Nutrient Removal	6	$1.80	$0.00 [1]
Microfiltration	3	$2.91	$0.22
Reverse Osmosis	3	$3.26	$0.85
UV Disinfection	2.6	$0.23	$0.01
Subtotal WWTP Improvements [2]		$8.20	$1.08
Conveyance Facilities [3]	2.6	$1.25	$0.07
Water Treatment Plant Improvements			
Ozonation [4]	10	$2.00	$0.16
Total		**$11.45**	**$1.30**

[1] Reduction in oxygen requirement is expected to offset cost of additional pumping, resulting in no net increase in operating cost for BNR.

[2] Projected additional cost for wastewater treatment is $ 1.72 per 1000 gallons of effluent reclaimed.

[3] Projected reclaimed water conveyance cost is $ 0.16 per 1000 gallons.

[4] Projected additional cost for water treatment is $ 0.21 per 1000 gallons treated.

Table 5.2
Reuse Project Cost Summary - McAllen

	Capacity (mgd)	**Capital Cost (millions)**	**Operating Cost (millions/yr)**
Wastewater Treatment Plant Improvements			
Biological Nutrient Removal	10	$3.00	$0.00 [1]
Microfiltration	6	$4.42	$0.43
Reverse Osmosis	6	$6.00	$1.58
UV Disinfection	5.1	$0.35	$0.01
Subtotal WWTP Improvements [2]		$13.76	$2.02
Conveyance Facilities [3]	5.1	$0.97	$0.06
Water Treatment Plant Improvements			
Ozonation [4]	38	$5.44	$0.31
Total		**$20.17**	**$2.40**

[1] Reduction in oxygen requirement is expected to offset cost of additional pumping, resulting in no net increase in operating cost for BNR.

[2] Projected additional cost for wastewater treatment is $ 1.58 per 1000 gallons of effluent reclaimed.

[3] Projected reclaimed water conveyance cost is $ 0.07 per 1000 gallons.

[4] Projected additional cost for water treatment is $ 0.12 per 1000 gallons treated.

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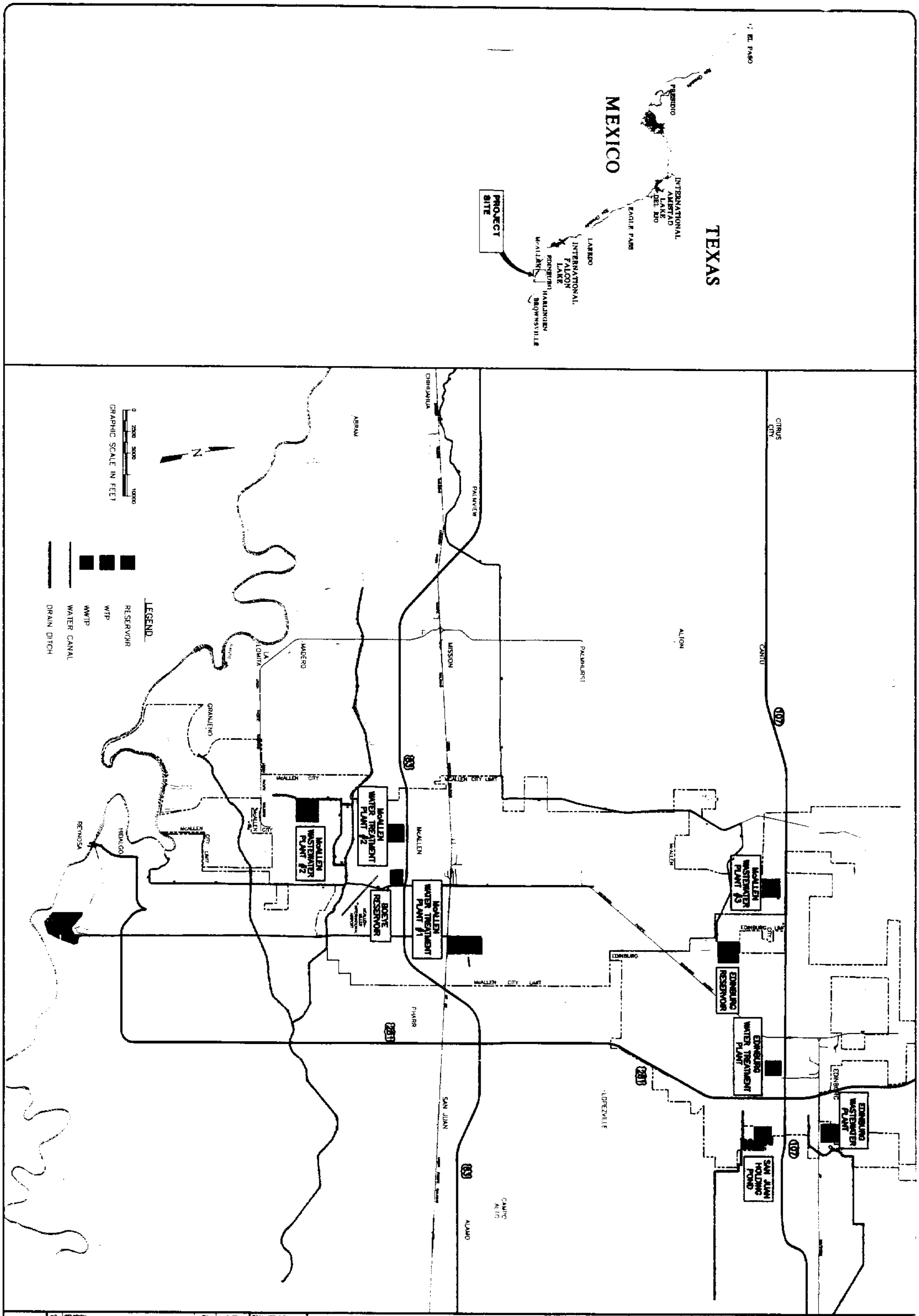

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EDINGBURG AND McALLEN, TEXAS

PROJECT SITE LAYOUT

LOWER RIO GRANDE VALLEY
DEVELOPMENT COUNCIL

REUSE FEASIBILITY STUDY

PEREZ/FREESE AND NICHOLS, L.L.C.
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PEREZ/FREESE AND NICHOLS, L.L.C.

FIGURE
5.1

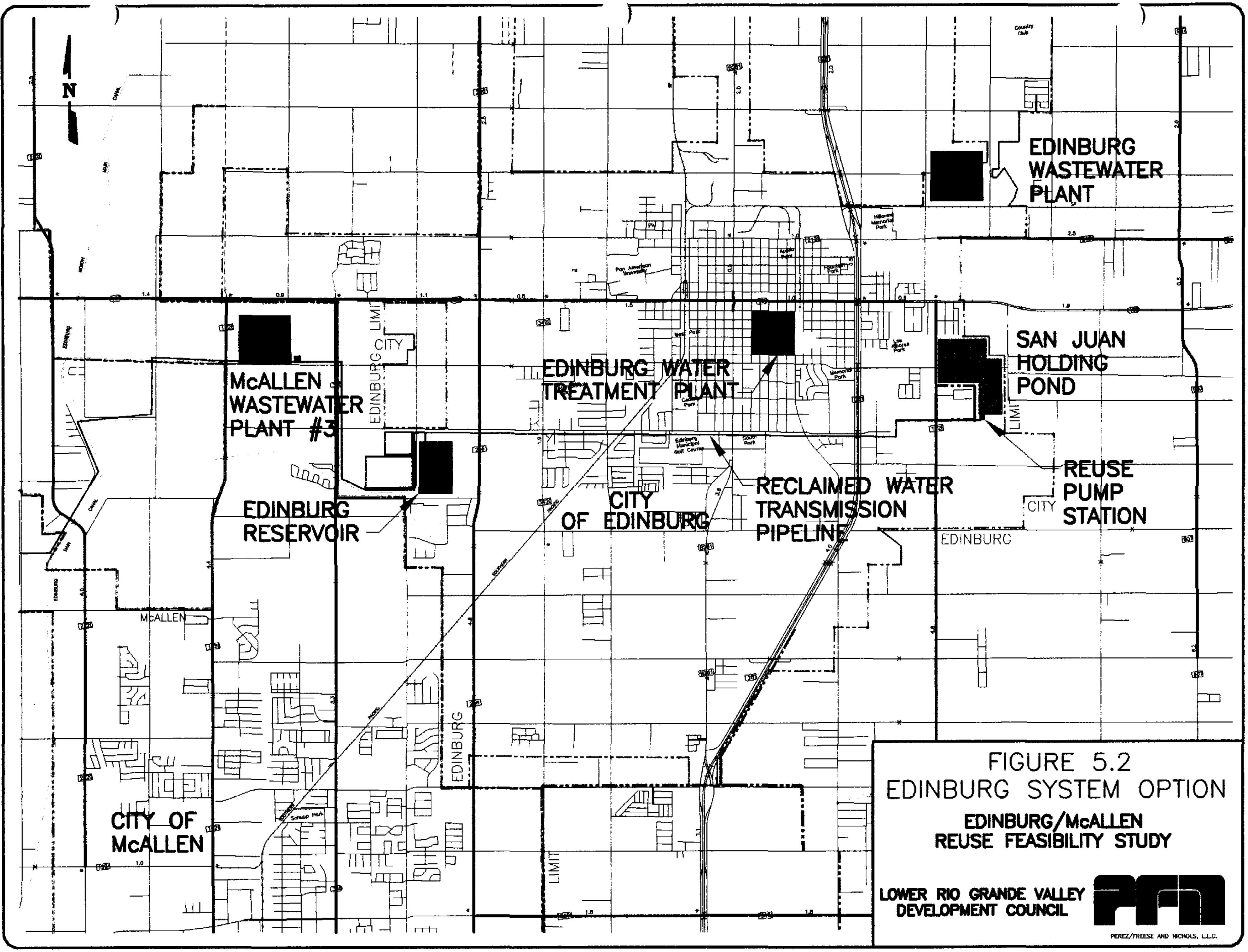


FIGURE 5.2
EDINBURG SYSTEM OPTION

EDINBURG/McALLEN REUSE FEASIBILITY STUDY

LOWER RIO GRANDE VALLEY DEVELOPMENT COUNCIL

PEREZ/FREESE AND NICHOLS, L.L.C.

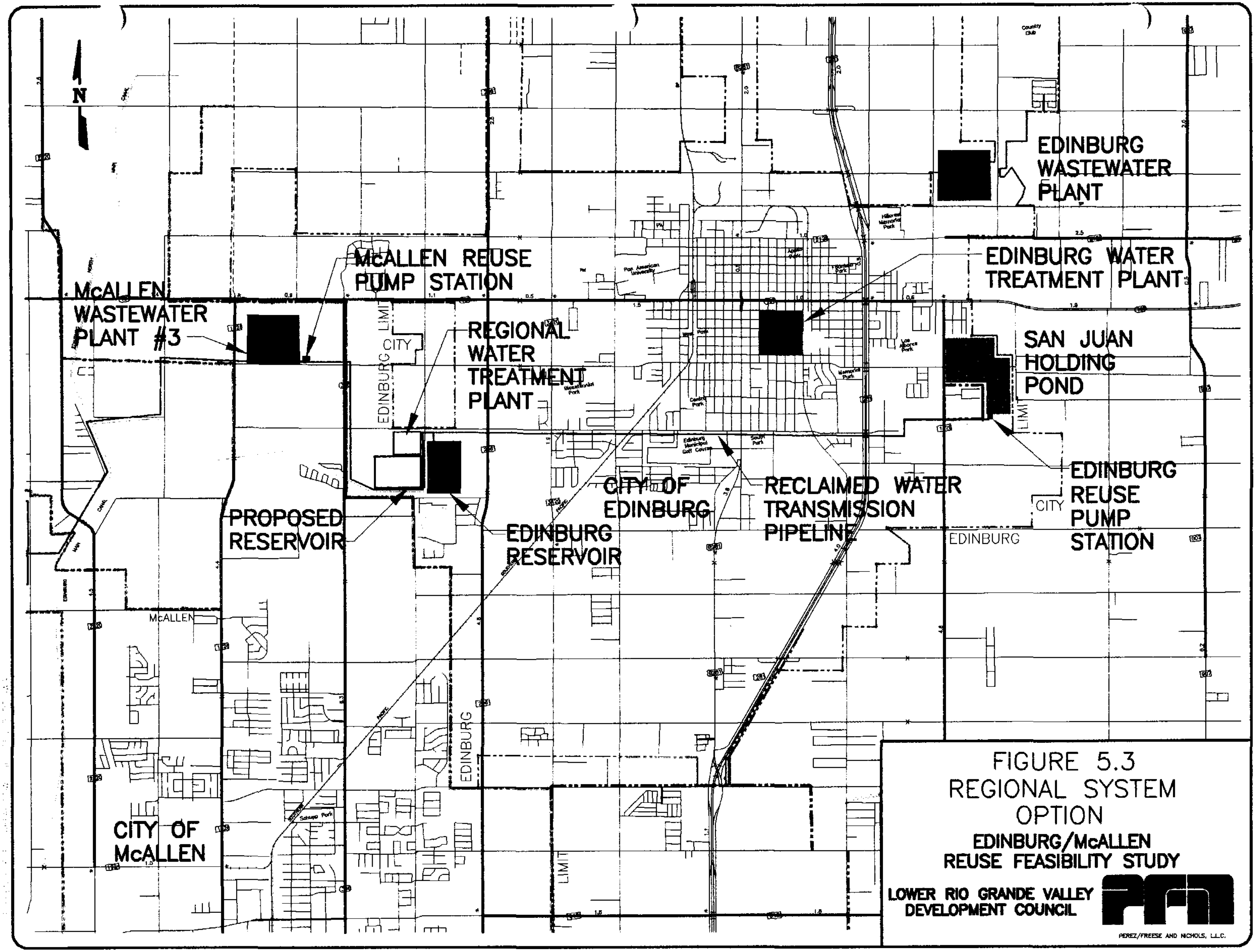


FIGURE 5.3
REGIONAL SYSTEM
OPTION

**EDINBURG/McALLEN
REUSE FEASIBILITY STUDY**

**LOWER RIO GRANDE VALLEY
DEVELOPMENT COUNCIL**

PEREZ/FREESE AND NICHOLS, L.L.C.

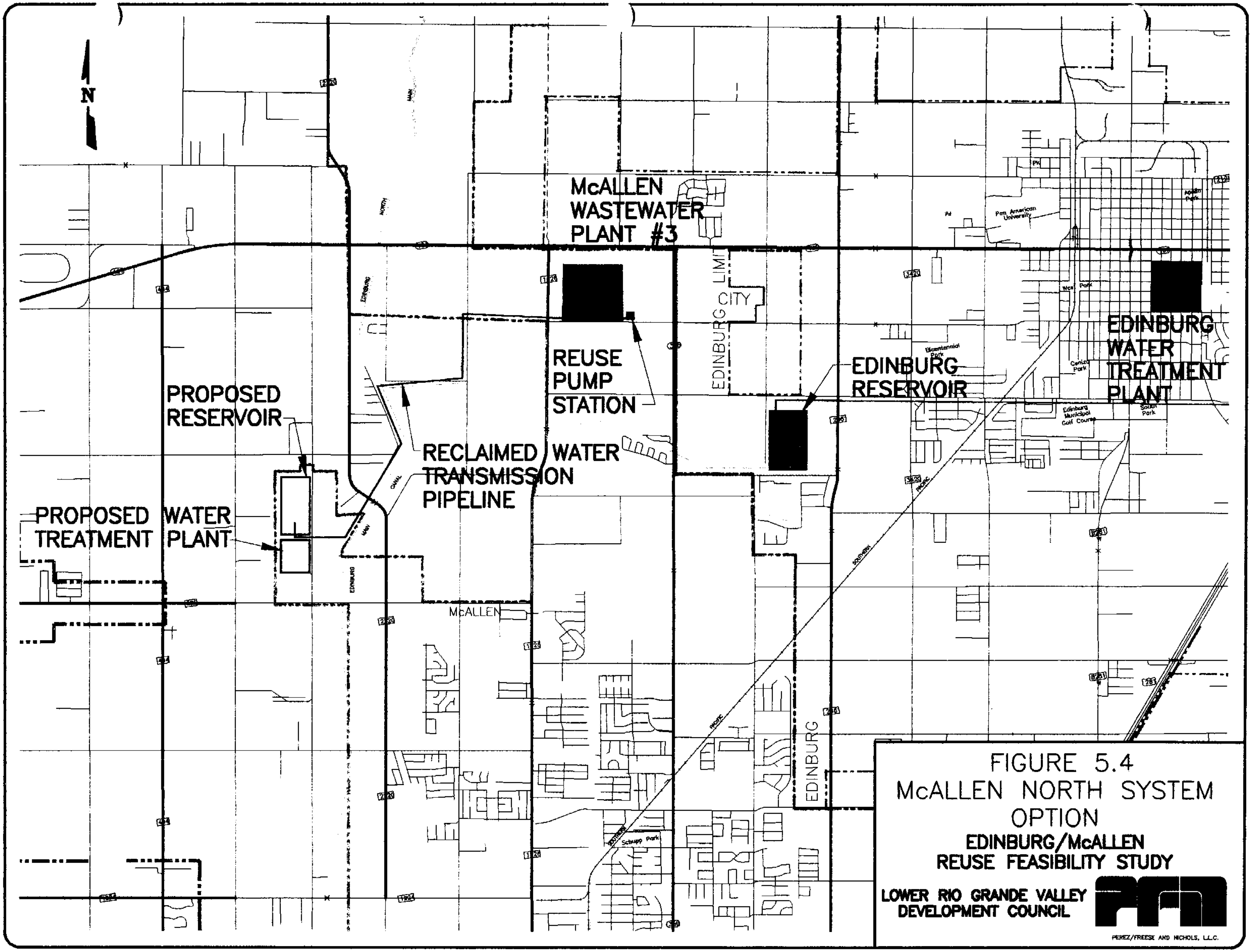


FIGURE 5.4
McALLEN NORTH SYSTEM OPTION

EDINBURG/McALLEN REUSE FEASIBILITY STUDY

LOWER RIO GRANDE VALLEY DEVELOPMENT COUNCIL

PEREZ/FREESE AND NICHOLS, L.L.C.

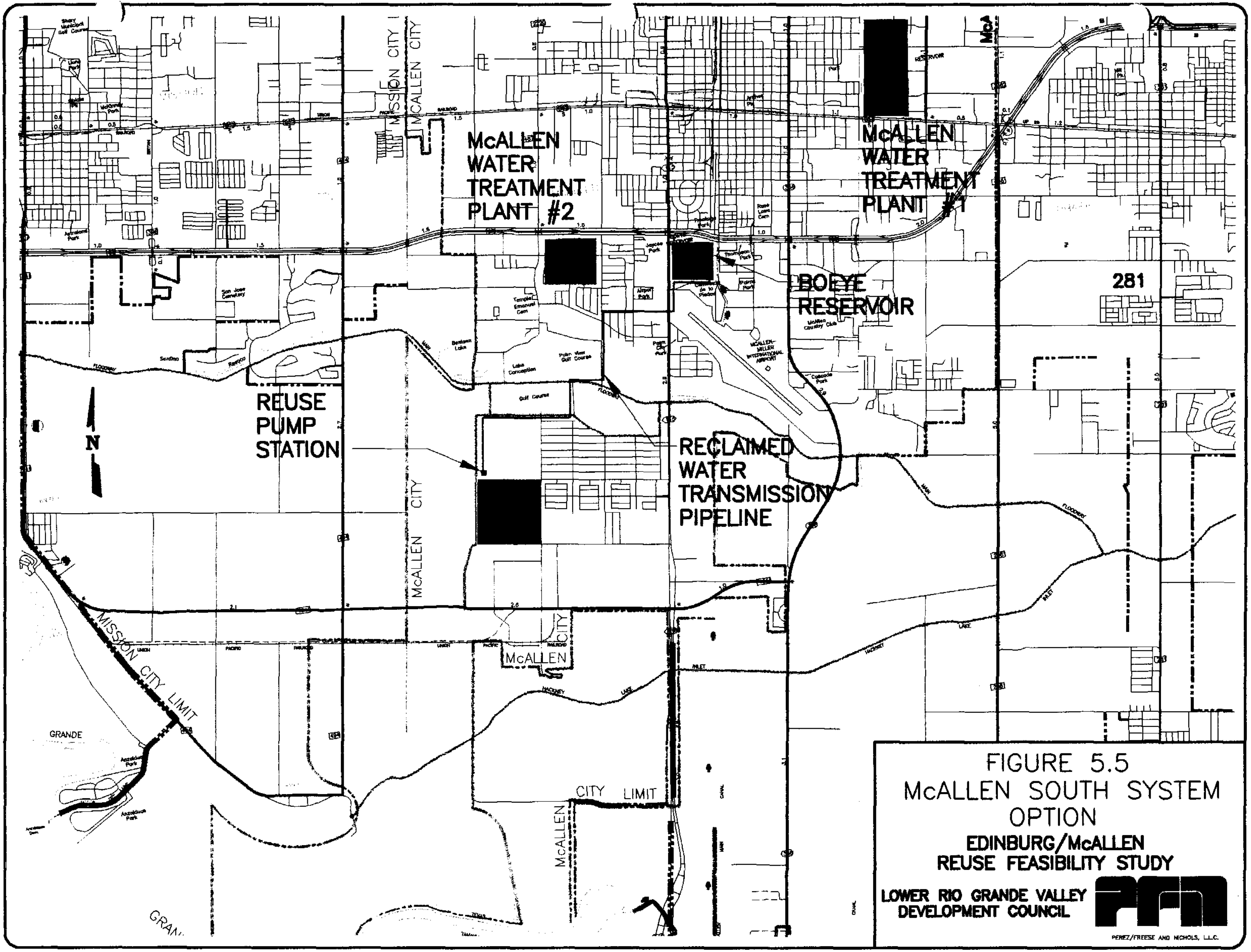


FIGURE 5.5
McALLEN SOUTH SYSTEM OPTION

EDINBURG/McALLEN REUSE FEASIBILITY STUDY

LOWER RIO GRANDE VALLEY DEVELOPMENT COUNCIL

6. Feasibility Evaluation

To determine the feasibility of implementing potable reuse, several factors must be considered, including public health, technical reliability, cost and public acceptance. The development of alternatives which protect public health, using proven technology has been an integral part of this study. Preliminary indications from the Citizens Advisory Committees are that a properly executed reuse project can obtain public acceptance in Edinburg and McAllen. One of the primary objectives of this study is to evaluate the economics of reuse.

6.1. Economic Evaluation

The previous sections detail the basis for projected reuse costs. These costs can be compared to the cost of obtaining additional water supply from a more conventional source. In the lower Rio Grande Valley, the conventional water supply is the Rio Grande River. The costs associated with this source are treatment to a comparable quality as the reclaimed water and the intial acquisition of water rights. All available rights to Rio Grande water are already allocated, so increases can only be obtained by purchasing rights from other users, typically from holders of irrigation rights. Each acre-foot of Class A irrigation rights may be converted to one-half acre-foot of municipal irrigation rights due to the higher priority accorded municipal rights. Since the irrigation districts which manage the raw water deduct evaporation and seepage losses, additional rights must be purchased beyond the water required. Pumping charges are also assessed by the districts, resulting in an annual cost for raw water.

To have the costs for the two alternatives be more comparable certain assumptions were made. The first is that the cost for providing conventional water treatment, that is treatment to meet the current regulations, should not be considered. Since both cities currently have available capacity at the water treatment plants. The second assumption relates to anticipated water treatment regulations which will require additional facilities for each city, regardless if reuse is to be implemented. Facilities that would meet these regulations are already included in the proposed reuse treatment, so a cost for additional facilities (ozonation and filtration using biologically active carbon) has been projected for the conventional supplies to provide an appropriate comparison.

The net costs for purchasing additional rights equivalent to the reclaimed water and providing the additional treatment are summarized in Table 6.1. For Edinburg, the projected reuse cost is about 2-1/2 times the cost of additional irrigation rights. For McAllen, the projected cost for reclaimed water is approximately twice the cost for conventional supply.

It is apparent from the above comparison that the Cities of Edinburg and McAllen may purchase additional Rio Grande water at the assumed current rate of $800 per acre-foot/year more economically than they can treat wastewater effluent using the scenarios prepared for this study. If water rights continue to increase in cost as expected, the option of reuse will become more attractive from an economic standpoint.

Table 6.1
Comparison of Reuse and Conventional Supply Costs

	Capital Costs	Annual Operation & Maintenance Costs	Total Present Worth Cost	Cost per 1000 gallons
Edinburg - Conventional Supply				
Purchase 3883 acre-feet of water rights[1]	$3.11 M[3]		$3.11 M	
Pumping Charges		$0.16 M	$2.39 M	
WTP Improvements	$3.22 M	$0.19 M	$6.00 M	
Total	**$6.33 M**	**$0.35 M**	**$11.50 M**	**$0.81**
Edinburg - Reclaimed Water	**$11.45 M**	**$1.31 M**	**$30.86 M**	**$2.19**
McAllen - Conventional Supply				
Purchase 6721 acre-feet of water rights[2]	$5.38 M[3]		$5.38 M	
Pumping Charges		$0.31 M	$4.56 M	
WTP Improvements	$8.47 M	$0.63 M	$17.90 M	
Total	**$13.85M**	**$0.94 M**	**$27.84 M**	**$1.01**
McAllen - Reclaimed Water	**$20.17 M**	**$2.40 M**	**$55.82 M**	**$2.02**

[1] Equates to 3.47 mgd. Subtract 25% evaporation and seepage losses to yield 2.6 mgd.

[2] Equates to 6 mgd. Subtract 15% evaporation and seepage losses to yield 5.1 mgd.

[3] Assumed cost is $800 per acre-ft. of municipal water rights (=2 acre-ft. of Class A irrigation rights)

6.2. Non-economic Considerations

Other non-economic issues should also be given consideration. For the analysis above, it is assumed that sufficient additional water rights are available at the stated cost to meet the needs of each city. However, recent water shortages have brought this assumption into question. Water rights can only be exercised when sufficient water is available for allocation to the intended users. Low storage levels at Falcon Lake have already resulted in curtailment of irrigation allotments this year. If water supplies continue to decrease, rationing of water supplies would eventually be extended to municipal users as well. However, the additional supply provided by reclaiming wastewater effluent is relatively drought resistant.

Another consideration is that of local control. Many consumers depend on the Rio Grande for water, and its allocation is by the State of Texas and subject to international agreement. Wastewater effluent is the property of the city until its discharge. It should also be noted the economy in the Lower Rio Grande Valley is highly dependent on agriculture. Excessive conversion of irrigation rights to municipal water supply could eventually affect the area's economy.

6.3. Conclusions

It appears potable reuse is a feasible alternative for augmenting potable water supplies for the cities of Edinburg and McAllen. Although reuse currently does not appear to be the lowest cost option, the value of a water source independent of the Rio Grande River makes this option worthy of further study.

7. Implementation

Given the long-term pressures on water supplies in the lower Rio Grande Valley, it is prudent to continue investigation of wastewater reuse as a component of the future water supplies of Edinburg and McAllen. To fully implement a potable reuse project, several steps are recommended. These are summarized in a proposed schedule in Figure 7.1, and are discussed below. The schedule shown represents a "fast track" approach to achieve reuse quickly. If a more conventional approach is followed, the implementation time will be lengthened.

Pilot Testing

Pilot testing is recommended to determine the treatability of the water using one or more of the recommended treatment processes. This is particularly important with the membrane techniques proposed. Pilot testing will demonstrate the applicability of newly available membranes which operate at lower pressures, and will allow better estimates to be made of chemical requirements, water loss with the rejected brine, and the quality of the treated product. This information will in turn allow better estimates of the probable capital and operating costs.

TNRCC Review

One meeting was held with representatives of the TNRCC Public Drinking Water Section during this study to assess the regulatory requirements for a planned indirect potable reuse project. They expressed qualified support for a project of this type, provided the treated effluent could be demonstrated to be of equal or better quality to the existing raw water supply. There are no specific treatment techniques required by state or federal regulations, but regulatory support for this type of project will be important to its success. It is therefore recommended that the proposed projects be presented to representatives of TNRCC for additional discussions prior to the preliminary design phase.

Financing and Rate Study

The proposed projects involve substantial investments by each city, and it will be important to review available funding options and select a suitable financing plan. The possibility of state or federal cost-sharing should also be investigated. The innovative nature of the projects, plus the location near the U.S.-Mexico Border may create opportunities for grant funding for portions of the proposed facilities. A rate study is recommended to determine appropriate utility rates to repay funds borrowed for reuse projects and other capital improvements. The rate study should be conducted near the completion of the preliminary design phase to allow updated estimates of project costs to be considered.

Environmental Review

A cursory environmental review has been conducted in this study, and it does not appear there are major environmental impacts which would preclude implementation of a reuse project. However, a more complete environmental review should be conducted in the next phase to address the specific projects proposed.

Preliminary Design

Following additional discussion of proposed treatment with TNRCC representatives, and completion of the membrane pilot testing, preliminary engineering of each proposed project can be performed. This phase would establish the specific layout and sizing of treatment units at each facility and determination of the desired route for required pipelines. The preliminary design report would include a refined estimate of project cost for use in the rate study and arranging project financing. Following completion of the preliminary design report, a final decision can be made to continue with detailed design and construction or to pursue other water supply alternatives.

Final Design, Award and Construction

The final design phase would consist of the preparation of detailed plans and specifications based on the accepted preliminary design. The plans and specifications would allow one or more construction projects to be bid and awarded to contractors for construction. Careful coordination of construction sequencing will be required to maintain operation of essential facilities.

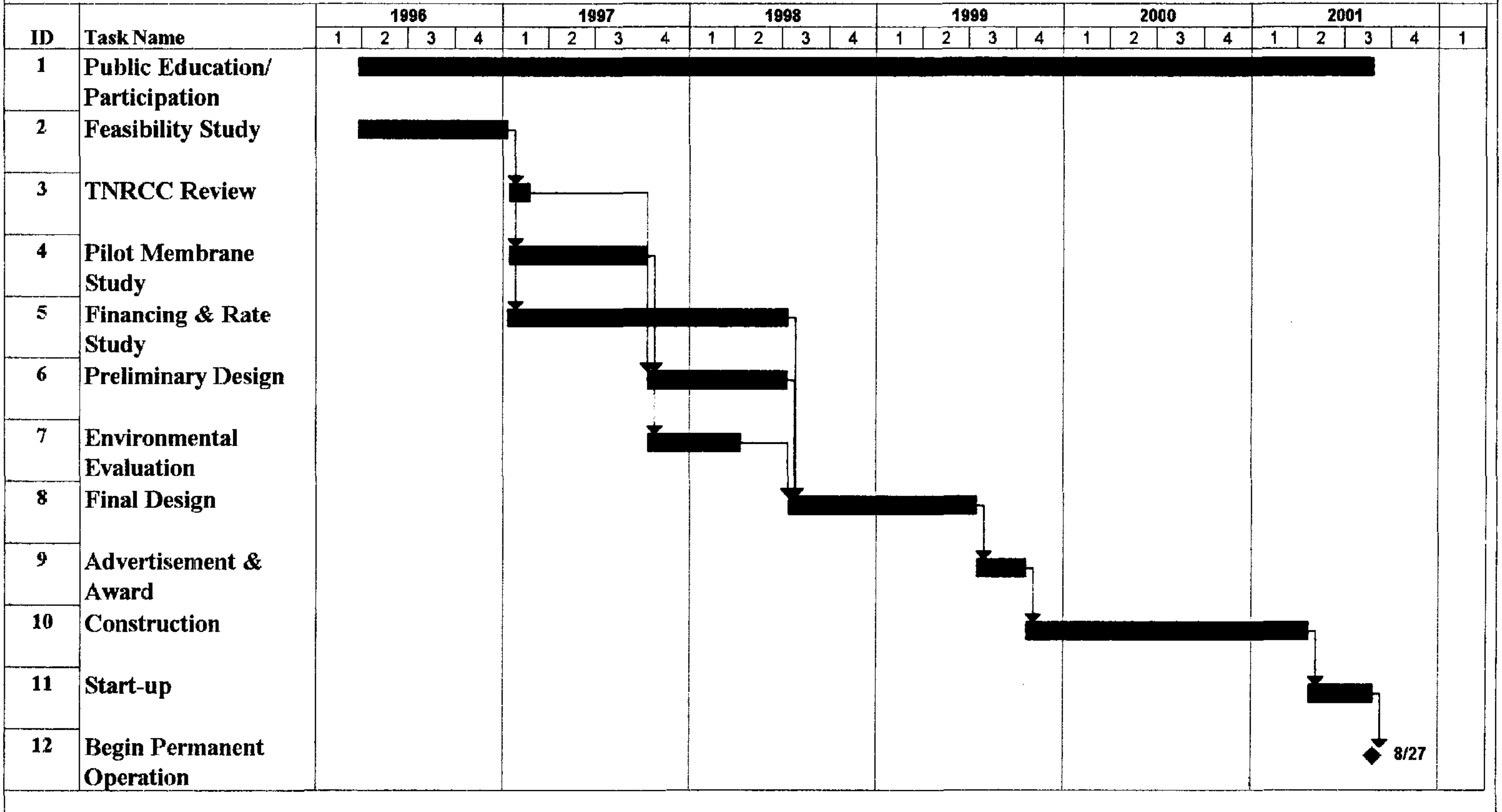
Start-up and Permanent Operation

Project start-up will be particularly important for a potable reuse system. Each component of the system must be adequately tested to confirm its ability to accomplish the treatment goals established for it. When each of the unit processes is performing satisfactorily, effluent can gradually be introduced to the raw water reservoir. As rigorous testing confirms the quality of the water produced, the amount of effluent blended can be increased up to the design capacity of the reclamation facilities.

Public Education/Participation

A key objective of a water utility is to maintain or strengthen public confidence in the drinking water supply. A continuing effort to educate the public and address local concerns should be an integral part of a potable reuse project. Each city has taken an important first step by inclding the citizens advisory committees in this study. If either city proceeds with implementation of a project, the public outreach should be expanded to include a larger audience with each step. It is hoped that a proactive public education program will not only allay fears from the proposed reuse, but will actually boost consumer confidence in the safety of their water supply.

Figure 7.1
Proposed Implementation Schedule



Lower Rio Grande Valley Development Council
Edinburg/McAllen Reuse Feasibility Study

Task ▬ Milestone ◆

APPENDIX A

PUBLIC ADVISORY COMMITTEES

City of Edinburg

Pearl Mathis
Elias A Zuniga
Francisco Martinez
Mateo Solis
Steve Pickering
Minerva Gomez
Linda Gardner
Norma Hodge
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Harlan Bentzincer
Francis Luna
John Mappes
Ms. Candy Sams
Andy Sanchez
Dianca Chapa
Joe Zamora
Cynthia Acevedo
Art Garcia
Ceasar Villareal

City of McAllen

Mr. Danny Boultinghouse, A.I.A.
Mr. Ronnie Cruz, P.E.
Mr. Paul Moffitt
Mr. Jaime Enriquez, P.E.
Mr. Tony Aguirre
Mr. Cayetano Barrera, M.D.

LOWER RIO GRANDE VALLEY DEVELOPMENT COUNCIL
McALLEN/EDINBURG REUSE FEASIBILITY STUDY
CITIZEN ADVISORY COMMITTEE MEETING NO. 1
PROJECT DEFINITION

AGENDA

APRIL 11, 1996
5:30 p.m. - Edinburg
8:00 p.m. - McAllen

Welcome & Introductions - Richard Hinojosa, LRGVDC
- LRGVDC
- City
- Texas Water Development Board
- Perez/Freese & Nichols
- Freese and Nichols
- CH2M Hill

Project Background & History - Jorge Perez, Perez/Freese & Nichols
Ray Longoria, Freese & Nichols
- Lower Rio Grande Valley Growth
- Water Supply Considerations

History and Status of Wastewater Reuse - Scott Ahlstrom, CH2M-Hill
- Types of Reuse
- Typical Projects
- History of Potable Reuse
  - Indirect
  - Direct

Common Questions Regarding Potable Reuse - Ray Longoria
- Is it needed?
- Is it safe?
- Is it economically feasible?

Proposed Approach and Schedule - Ray Longoria

Questions & Answers

LOWER RIO GRANDE VALLEY DEVELOPMENT COUNCIL
EDINBURG/McALLEN REUSE FEASIBILITY STUDY
CITIZEN ADVISORY COMMITTEE MEETING NO. 2
ALTERNATIVE DEVELOPMENT

AGENDA

July 15, 1996, 7:00 p.m.
McAllen Airport East Conference Room

Introduction of committees & presentation of meeting objectives	Richard Hinojosa LRGVDC
Review of previous meeting and project objectives/purpose	Ray Longoria Freese & Nichols
Review of effluent reuse and public health issues	Scott Ahlstrom CH2M-Hill
Presentation and discussion of potential reuse scenarios	David Sloan Freese & Nichols
TWDB Comments	Bill Hoffman TWDB
Discussion	Ray Longoria Freese & Nichols
Adjourn	

LOWER RIO GRANDE VALLEY DEVELOPMENT COUNCIL
EDINBURG/McALLEN REUSE FEASIBILITY STUDY
CITIZEN ADVISORY COMMITTEE MEETING NO. 3
FEASIBILITY EVALUATION

AGENDA

October 17, 1996, 5:00 p.m.
Edinburg Recycling Center

Introduction & presentation of meeting objectives	Richard Hinojosa LRGVDC
Review of previous meetings and project objectives/purpose	Ray Longoria Freese & Nichols
Proposed Treatment Scenario & Comparison with current practice	Scott Ahlstrom CH2M-Hill
Proposed System Configuration and Determination of Feasibility	David Sloan Freese & Nichols
Discussion of Advantages & Disadvantages of Reuse and Project Implementation and Financing	Ray Longoria Freese & Nichols
City Comments	Ernesto Alanis
TWDB Comments	Bill Hoffman TWDB
Discussion	Ray Longoria Freese & Nichols
Adjourn	

LOWER RIO GRANDE VALLEY DEVELOPMENT COUNCIL
EDINBURG/McALLEN REUSE FEASIBILITY STUDY
CITIZEN ADVISORY COMMITTEE MEETING NO. 3
FEASIBILITY EVALUATION

AGENDA

October 17, 1996, 7:00 p.m.
McAllen Airport East Conference Room

Introduction & presentation of meeting objectives	Richard Hinojosa LRGVDC
Review of previous meetings and project objectives/purpose	Ray Longoria Freese & Nichols
Proposed Treatment Scenarios & Comparison with current practice	Scott Ahlstrom CH2M-Hill
Proposed System Configurations and Determination of Feasibility	David Sloan Freese & Nichols
Discussion of Advantages & Disadvantages of Reuse and Project Implementation and Financing	Ray Longoria Freese & Nichols
City Comments	Bart Hines
TWDB Comments	Bill Hoffman TWDB
Discussion	Ray Longoria Freese & Nichols
Adjourn	

LOWER RIO GRANDE VALLEY DEVELOPMENT COUNCIL
McALLEN/EDINBURG REUSE FEASIBILITY STUDY
CITIZEN ADVISORY COMMITTEE MEETING SUMMARIES

Meeting No. 1 - April 11, 1996
5:30 p.m. - Edinburg
8:00 p.m. - McAllen

The project team and the CAC members were introduced and the purpose of the study was explained. Population and water use projections were discussed and compared to available water supplies. It was noted that additional water supplies could potentially be provided by reservoir construction, groundwater pumping and treatment, purchase of irrigation water rights, and water reclamation, but this study is focused on augmentation of potable water supplies through reuse.

Scott Ahlstrom explained some basic concepts of water reuse and described some different types of reuse projects. He also presented case histories of some representative projects which have been completed in the U.S. He then explained that the type of reuse under study for Edinburg and McAllen was indirect potable reuse, where highly treated wastewater effluent would be blended with Rio Grande water and treated for public distribution.

Ray Longoria then posed some basic questions regarding potable reuse for the Rio Grande Valley:

Is it needed? - The rapid growth and limited water supply create a need for additional water supplies, and reuse is one possible source.

Is it safe? - Other potable reuse projects have been implemented without incidence of adverse health effects and adequate technology exists to implement such a project in Edinburg and/or McAllen.

Is it economically feasible? - Experience with other projects indicates reuse to be feasible in some cases and the feasibility in the Rio Grande Valley will be the primary emphasis of the study.

Ray Longoria went on to describe the approach to the study and the proposed schedule. Questions were then solicited from the committee members. One question dealt with the environmental impact of removing existing effluent flows from the drain canals which flow to the Laguna Madre. It was noted there would be a cursory evaluation of environmental impacts which would include such considerations. Other comments involved consideration of household greywater systems and water conservation measures. It was noted that conservation would be an important part of long range water management, but was not a part of this study. Similarly, grey water systems could potentially relieve the demand for potable water but would not be studied in this project. It was noted that such systems required a much greater involvement by the consumer and did not offer the same opportunity as potable reuse for large increases in supply.

Meeting No. 2 - July 15, 1996
7:00 p.m. - Edinburg and McAllen

Ray Longoria briefly reviewed the points presented at the previous meeting and reiterated the project objectives. Scott Ahlstrom described the health issues which could be associated with potable use of reclaimed wastewater. He explained the concept of multiple contaminant barriers where natural (dilution, detention time, sunlight) or engineered (redundant treatment processes) barriers are employed to decrease the opportunity for pathogenic organisms to reach the water distribution system.

David Sloan showed how various treatment processes might be combined in a real system. He explained that some processes could be located at the wastewater plant to improve the quality of effluent prior to blending with river water, or processes could be located at the water treatment plant to improve the quality and safety of the entire supply, but at greater cost. He also showed system configuration options which included separate wastewater and water treatment plant pairings for each city (one for Edinburg and two for McAllen) and a possible regional system which could serve Edinburg and northern McAllen.

During the discussion period following the presentations, there was apprehension that CAC members were being asked to make a decision about something they did not have the background to understand. Most members seemed to accept the ability of treatment technology to remove contaminants but felt process selection should be left to the professionals. There appeared to be a sense of frustration that cost information was not yet available and the information covered was confusing to lay people.

Meeting No. 3 - October 17, 1996
5:00 p.m. - Edinburg
7:00 p.m. - McAllen

Ray Longoria reviewed the material covered at the previous meetings, including the water supply options identified for the lower Rio Grande Valley and the basic questions to be addressed by the study:

Is reuse needed? The existing water supplies and projected future water demands were reviewed, along with the additional supply which could reasonably be achieved through potable reuse. It was shown that reuse could extend water supply sufficiency for several years in each city.

Is it safe? The material presented in Meeting No. 2 demonstrated a safe potable reuse system could be constructed using existing technology.

Is it technically feasible? There do not appear to be any major technical obstacles to implementation of a reuse system.

Is it financially feasible? Potable reuse is not the least cost source of water for the lower Rio Grande Valley, but is in the range of costs expected for most water supply projects. The Rio Grande River continues to be a low cost source of supply for communities in the Edinburg/McAllen area.

Scott Ahlstrom described the reuse treatment system recommended and compared it to projects which have been implemented elsewhere. The recommended system would include the addition of biological nutrient removal, microfiltration, reverse osmosis and ultraviolet disinfection at the wastewater treatment plants and addition of ozonation at the water treatment plants. David Sloan then showed how the system could be implemented in each city with the addition of facilities to convey the treated effluent from selected wastewater treatment plants to the raw water reservoirs.

Ray Longoria presented the main advantages and disadvantages associated with the proposed indirect potable reuse projects. The advantages included independence from the Rio Grande, drought resistance, and the avoidance of competition with agriculture for water supplies. The disadvantages included the greater cost, the use of different technologies, the anticipated effort to obtain public acceptance and the generation of new treatment byproducts for disposal.

Bill Hoffman presented the opinion of a TWDB staff biologist that a reduction in wastewater effluent flows to the Laguna Madre would be a net benefit to the laguna. He explained that the life adapted to the hypersaline conditions did not require large freshwater inflows, and were currently being harmed by the high nutrient load associated with municipal wastewater discharges.

In the discussion which followed, CAC members were generally supportive of the proposed plan, although the higher cost compared to existing supplies was a concern. Members were also concerned about the difficulty of gaining widespread acceptance from the water consumers. There appeared to be a consensus in each city to retain reuse as a viable alternative to be considered for water supply expansion.

RECOMMENDED PUBLIC ACCEPTANCE PROGRAM

The following 10-step approach to public involvement is reprinted from the November 1995 issue of the American Water Works Association publication *Opflow*. This is a summary of a handbook published by the AWWA Research Foundation, *Public Involvement Strategies: A Manager's Handbook.*

Step 1: Frame the problem.

"Framing" sets boundaries that help you focus on the actual problem. Boundaries clarify the issues that need to be solved and those that do not. Effectively framing a problem means describing the project need and the facts that will be useful for making decisions.

Step 2: Identify constraints.

Identifying constraints helps determine which issues can be negotiated with the public and which cannot. There are internal and external constraints. Internal constraints may include scheduling, regulatory or political mandates, or spending limits. An external constraint may be a lack of credibility with the public.

Step 3: Identify and describe decision steps and project milestones.

Public involvement means that you, as a utility manager, will benefit by talking with people about a project's tradeoffs, costs, and impacts. If you identify a project's decision steps early, you will improve your ability to see where public input can be included in project decisions. You can also identify the information that members of the public need so they, in turn, can provide meaningful input.

Step 4: Identify and understand potentially affected stakeholders.

Your public probably consists of various interest groups who have different values. These interest groups are called "potentially affected stakeholders" because they have a "stake" in the outcome of the decision. Using a proven method to clarify stakeholder interests early in your process, means that you'll probably avoid strong controversy or lawsuits.

Step 5: Determine vulnerability and must-resolve issues.

How vulnerable are you to external pressures? The level of vulnerability may differ from one project or utility to the next. The objective of planning for public involvement is to focus on "must-resolve" issues that involve stakeholders who really want to be involved. Those who are not interested should be provided with enough information to feel that they are invited and that the decision to participate is theirs, not yours.

Step 6: Determine the appropriate level of public involvement.

All public involvement processes are not created equal. As a manager, you can do a variety of things to help build public consensus. One-way communication is at one end of the range while two-way communication, where stakeholders may have the ability not only to influence the project but also to help craft and guide the outcomes, is at the other end.

Step 7: Select processes and techniques.

The techniques available for public involvement vary in purpose, cost and ease of use. You can save money, time, and unnecessary frustration by completing the first six steps before selecting the appropriate techniques. (The handbook provides a catalog of useful public involvement techniques.)

Step 8: Develop a public involvement work plan.

A work plan for public involvement clarifies the roles and expectations of staff, serves as a reference point for the duration of the project, and can be reviewed by senior mangers, elected officials, and project stakeholders to obtain support for the consensus-building efforts.

Step 9: Implement and monitor the work plan.

Public involvement plans, once implemented, must be monitored periodically to ensure that

- The frame of the problem has not changed (it often does).
- The issues and stakeholders remain valid.
- The techniques used are effective.

Step 10: Manage change.

Changes, which include project schedules, the political landscape, staff, regulatory requirements, and technical assumptions, influence your public involvement process. Adapting to fit new circumstances while still maintaining your credibility with the stakeholders is a key to maintaining the effectiveness of your problem-solving process.

APPENDIX B

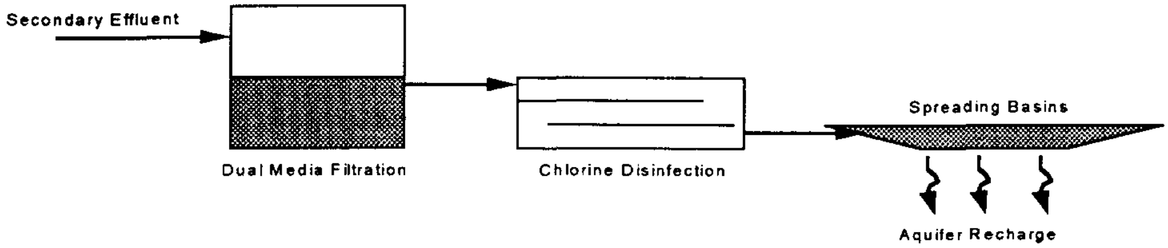
U. S. History Of Indirect Potable Reuse

Unplanned, indirect, potable reuse has been in practice since man first began disposing of wastewaters into watersheds that are hydrologically connected to raw water supplies. As populations have increased, so too has the quantity of wastewater and the technology to manage these increased volumes of wastewater. Indirect potable reuse is one of the developing strategies to both manage wastewater and recover and reuse water resources.

The following is a summary of some of the historical milestones marking the development of planned potable reuse as a viable component of a water resource management plan.

1962: Whittier Narrows Groundwater Replenishment Project, California

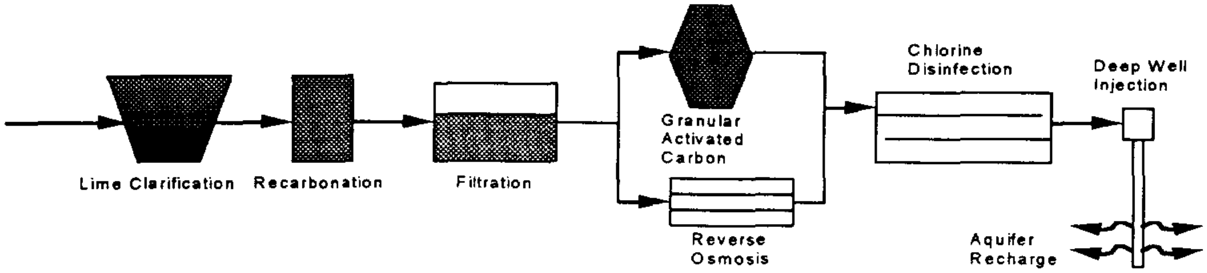
- Since 1962 (34 years of operation)
- 10 mgd
- Reclaimed Water Percentage of Total Aquifer Recharge = 16% Average
- Scientific Advisory Panel concluded the practice is as safe as commonly used surface water supplies



Since 1962, the County Sanitation Districts of Los Angeles County have been surface spreading disinfected secondary effluent (dual media filtration was added later in 1978) from a 10-million-gallon-per-day (mgd) water reclamation plant for infiltration to an underground potable water supply. This operation continues and the amount of reclaimed water recharged annually averages 16 percent of the total inflow to the groundwater basin. Depending on the physical characteristics, location, and pumping history of a given well, the population drawing potable water from the groundwater basin is estimated to be exposed to a reclaimed water percentage ranging from 0 to 23 percent. After extensive data acquisition, evaluation, and statistical analysis by an independent scientific advisory panel to the state of California, the panel concluded that the Whittier Narrows groundwater replenishment project was as safe as commonly used surface water supplies.

1976: Orange County, California Water District

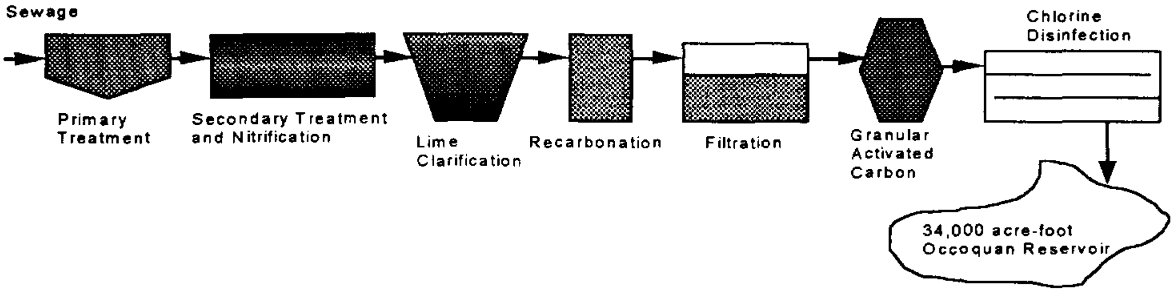
- Since 1976 (20 years of operation)
- 15 mgd
- No more than 5% of the reclaimed water actually comprises the domestic supply
- No observed water quality degradation that constitutes a public health concern



In 1976, the Orange County California Water District's Water Factory 21 began operation. The 15-mgd facility reclaims unchlorinated secondary effluent to drinking water quality and recharges it into a heavily used groundwater to prevent salt water intrusion. The water recovery treatment includes lime clarification, air stripping, recarbonation, filtration, carbon adsorption, slip-stream reverse osmosis, and disinfection. Estimates project that no more than 5 percent of the recovered water actually comprises the domestic supply. The Orange County Water District has found no evidence that indicates that this indirect potable reuse practice poses a significant risk to users of the groundwater.

1978: UOSA Water Reclamation Plant

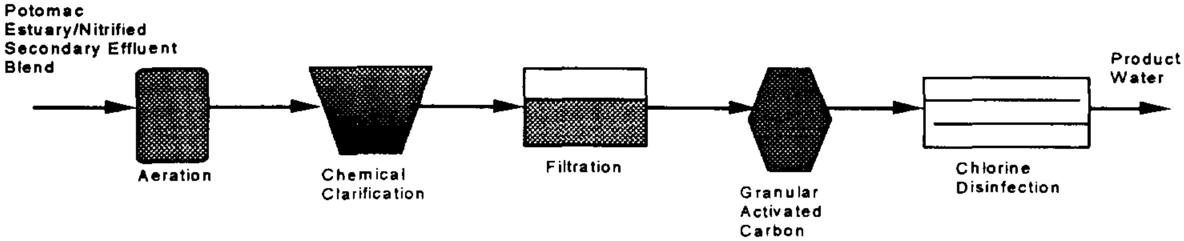
- Since 1978 (18 years of operation)
- 15 mgd expanded to 27 mgd in 1987, & expanded to 54 mgd by 2000
- Typically, 10-15% recovered water comprises reservoir volume
- The Fairfax County Water Authority considers the UOSA product water their most reliable source of water supply



In 1978, the 15-mgd Upper Occoquan Sewage Authority (UOSA) Water Reclamation Plant began reclaiming wastewater for subsequent discharge to the 11 billion gallon Occoquan Reservoir. The Occoquan Reservoir is a critical source of drinking water for about 1 million people in Northern Virginia. During extended droughts, the plant discharge has accounted for as much as 90 percent of the flow into the reservoir. The reclamation treatment includes primary treatment, secondary treatment, biological nitrification, lime clarification and recarbonation, filtration, activated carbon adsorption, and disinfection. Due to the positive reservoir response to the reclaimed water inflow, the plant was expanded to 27 mgd and will be further expanded to 54 mgd by the year 2000. No negative health effects attributable to the plant or effluent discharges have been reported since the plant has been in operation.

1981-1983: Potomac Estuary Experimental Water Treatment Plant

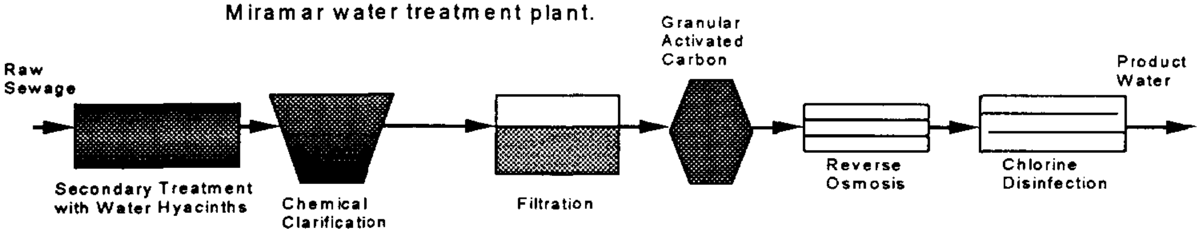
- Objective: Determine the feasibility of using the Potomac estuary waters as a source of water supply (Potomac estuary is 50% treated wastewater during drought conditions).
- Result: Toxicological quality of the reclaimed water compared favorably with finished water from three WTPs in the Washington D.C. area.



From 1981 to 1983, the 1-mgd Potomac Estuary Experimental Water Treatment Plant was operated with a plant influent blend of Potomac Estuary water and nitrified secondary effluent to simulate the influent water quality expected during drought conditions when as much as 50 percent of the estuary flow would comprise treated wastewater. Treatment included aeration, coagulation, clarification, predisinfection, filtration, carbon adsorption, and post disinfection. An independent National Academy of Science/National Academy of Engineering panel reviewed the extensive testing performed by the Army Corps of Engineers. The panel concluded that the advanced treatment could recover water from a highly contaminated source that is similar in quality to three major water supplies for the Washington, D.C. metropolitan area.

1983: San Diego Total Resource Recovery Project, California

- Objective: Determine the feasibility of reliably converting raw sewage to a quality commensurate with existing raw drinking water supplies.
- Result: The health risk associated with using reclaimed water as a raw water supply is less than or equal to that of the existing City raw water entering the Miramar water treatment plant.

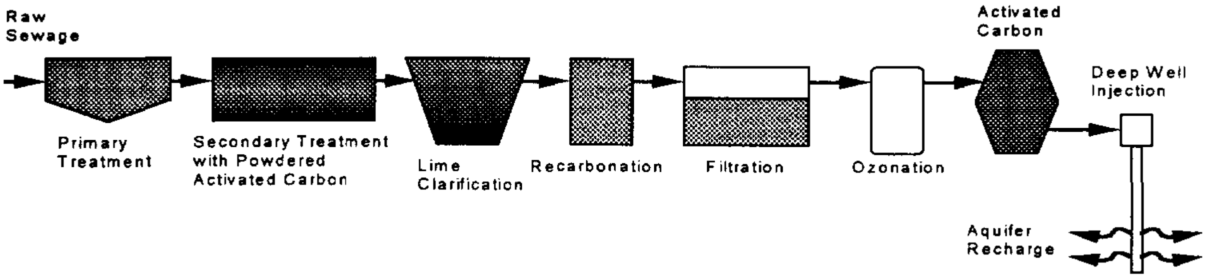


Also in 1983, the San Diego, California 1-mgd potable water recovery demonstration facility was commissioned as part of a total resource recovery program established in San Diego. The treatment system included: primary treatment, a water hyacinth aquaculture system, coagulation, clarification, filtration, ultraviolet disinfection, reverse osmosis, aeration, carbon adsorption, and disinfection to reclaim raw water from raw sewage. The program included an extensive chronic toxicity risk analysis to determine the potential health effects resulting from reuse of the recovered water and to compare the recovered water to current raw water supplies used by the City of San Diego. Results of the health effects showed that the risk associated with use of the recovered water as a raw water supply is less than or equal to that of the existing raw water entering the City's Miramar Water Treatment Plant. Based in large part on these positive results, the City is planning on reclaiming up to 20 mgd of secondary effluent for augmentation of their 90,000 acre foot San Vicente Reservoir where it will blend with imported water prior to passage through the City's Alvarado Water Treatment Plant and on to customers.

1985: El Paso, Texas Fred Hervey Water Reclamation Plant

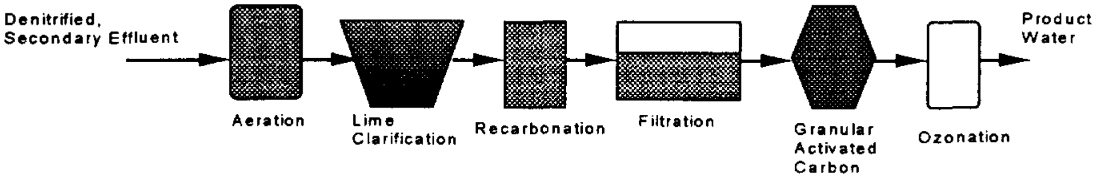
In 1985, the 10-mgd Fred Hervey Water Reclamation Plant began operation in El Paso, Texas. Recovered water is recharged to the Hueco Bolson drinking water aquifer where over a 2-year period, the water travels to one of El Paso's potable water well fields to become part of the potable water supply. The treatment of raw wastewater includes: primary treatment, activated sludge/powdered activated carbon treatment, lime treatment, recarbonation, filtration, ozonation, and granular activated carbon adsorption. No negative health effects have been correlated with this practice, however, some increase in the total dissolved solids content of the aquifer has occurred. Future plant expansions will include slip-stream demineralization to address this concern.

- Since 1985 (11 years of operation)
- 10 mgd
- 2-year travel time through aquifer from injection to withdrawal
- No negative health effects correlated with practice



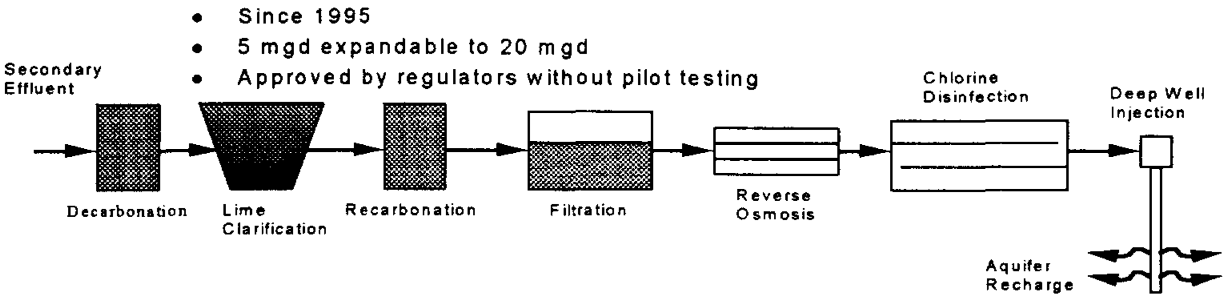
1986: Tampa Water Resource Recovery Project, Florida

- Objective: Determine the feasibility of reliably converting denitrified, secondary effluent to a quality suitable for blending with existing surface water and groundwater sources.
- Result: The results of a $2 million health effects testing program were uniformly negative for the reclaimed water, and therefore within the capability, limits, and statistical power of the assays, provide convincing evidence of the product water safety for raw water augmentation.



In 1986, the City of Tampa, Florida's Water Resource Recovery Pilot Plant began operation. The pilot project was designed to evaluate the feasibility of reclaiming denitrified secondary effluent to a quality suitable for blending with existing surface water and groundwater sources for indirect potable reuse. Several alternative treatments were evaluated and one was selected for health effects testing after 2 years of evaluation. The treatment selected included: aeration, high pH lime clarification, recarbonation, filtration, granular activated carbon adsorption, and ozonation. Final results of the study were documented in 1993. The results of the $1.5 million whole animal health effects testing coupled with the microbiological and chemical analyses performed revealed that the quality of the reuse product water is equivalent to or exceeds the quality of the Hillsborough River raw water supply. The City of Tampa is planning on implementation of a 20 to 50 mgd Water Resource Recovery Plant in the near future.

1990 - 1995: West Basin Water Recycling Program



- Since 1995
- 5 mgd expandable to 20 mgd
- Approved by regulators without pilot testing

From 1990 through 1995, the West Basin Municipal Water District conceived, designed, constructed, and began operation of their West Basin Water Recycling Program, which includes reclaiming 5 mgd expandable to 20 mgd of secondary effluent from the City of Los Angeles's Hyperion Treatment Plant for injection into the West Coast Basin Barrier Project. The West Coast Basin Barrier Project was constructed in the 1950's and 1960's to inject imported water into the coastal reaches of local South Bay aquifers for mitigation of saltwater intrusion. The Barrier has historically received an average of about 20 mgd of potable water. Substitution of reclaimed water for potable water provides substantially greater water use efficiency in southeast Los Angeles county. Reclamation treatment includes pre-decarbonation, lime clarification, recarbonation, filtration, reverse osmosis, post-decarbonation, and final disinfection. A baseline groundwater monitoring program was conducted in advance of the recycling project to allow assessment of reclaimed water impacts on the aquifer water quality. Based on hydrogeologic investigation and modeling of the West Coast Basin, it is anticipated that the reclaimed water will improve groundwater quality along the Barrier due to the high quality of the reclaimed water relative to the imported water and native groundwater.

APPENDIX C

TEXAS WATER DEVELOPMENT BOARD

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October 1, 1996

WATER MANAGEMENT STRATEGIES FOR THE CITIES OF MCALLEN AND EDINBURG, HIDALGO COUNTY, TEXAS

Introduction

The majority of municipalities and communities in the lower Rio Grande Valley obtain their water supply from the Rio Grande under water supply contracts. Water supply distribution in the region is rather unique because the Rio Grande's streamflows are shared with Mexico through the International Boundary and Water Commission (IBWC), while the local share is regulated and adjudicated by the Texas Natural Resource Conservation Commission (TNRCC). Rapid growth in the region, coupled with the current drought conditions, have focused attention on the existing water supplies, their beneficial use, and finally, on wastewater management and re-use.

The Problem

Sustainable economic growth and development requires a reliable water supply. However, existing supplies in the region are quite limited and developing new water supplies would require overcoming major regulatory and legal hurdles, as well as making large financial investments.

Although not immediately obvious, two other problems may be related to the solution of the water supply problem. First, both the 26 miles of the lower Arroyo Colorado (Tidal Segment #2201) and the 63 miles of the upper Arroyo Colorado (Above-Tidal Segment #2202) are characterized by high levels of nutrients, algae, and turbidity, and low levels of dissolved oxygen (D.O.) and desirable conditions for aquatic life. Indeed, eutrophic conditions (i.e., nutrient over-enrichment) were observed even during years when point-source discharges were 85% less than permitted today. Because of the numerous and persistent violations of the state's water quality standards, the TNRCC has classified both segments of the Arroyo Colorado as "water quality limited" and in need of advanced waste treatment.

Secondly, the 56.51 mgd of domestic and municipal sewage from the 26 major outfalls in the upper segment and the 200.02 mgd of wastewaters from the 4 major industrial outfalls in the tidal segment are capable of affecting more than just the Arroyo Colorado, where aquatic life is only partially supported, since it discharges directly to the Laguna Madre of Texas. Marine lagoons typically have low freshwater inflows, high salinities, and clear, oligotrophic (i.e., low nutrient concentration) conditions that promote the penetration of sunlight and the growth of seagrass beds, providing essential food and cover for inhabiting species like the valuable coastal fishes. Although seagrasses can absorb nutrients across the surface of the leaves, bottom sediments are normally the principal source because of the high rates of nitrogen fixation by bacteria in the root zone. However, as the receiving water body, the Laguna Madre suffers from the turbid, nutrient-rich discharges of the Arroyo Colorado. The ecological expectation is for the reduction and loss of seagrass communities (i.e., plant and animal species associates) in the area, as well as the potential for over-dominance of undesirable organisms (e.g., noxious plankton blooms). In this case, the expectation is also the observation of recent years, wherein the high nutrient levels of the Arroyo Colorado cause freshwater plankton blooms that are discharged and assimilated into the lower Laguna Madre, which in turn promotes marine plankton blooms and the growth of epiphytes on the blades of the seagrasses that can reduce light penetration, increase plant stress, and ultimately destroy the seagrass communities in the affected area.

The Solution

Because the lower Rio Grande Basin and South Texas are considered semi-arid, it is not surprising that the existing freshwater supplies and wastewater return flows are part of the same water management strategy. While the problems given above are quite serious, they appear potentially manageable if some innovative approaches are employed. First among these is the beneficial use of wastewaters, rather than their rejection and discharge into the surface drainage. Based on information about the discharges of the municipal sewage treatment plants in question, these wastewater outflows are often of higher quality than the raw intake waters from the Rio Grande. Thus, the augmentation of local water supplies by re-use of the treated wastewaters seems to be viable. As a result, the Lower Rio Grande Valley Development Council (LRGVDC) has proposed a feasibility study that focuses initially on the Cities of McAllen and Edinburg in Hidalgo County, Texas.

These two cities have permitted discharges of 19.5 mgd (21,843 acre-feet/year), but are currently discharging ~15 mgd (16,802 acre-feet/year). If the treated wastewaters are combined, filtered through activated carbon, and run through a reverse osmosis (R.O.) process, then ~85% of the wastewaters can be re-used by blending the flows into the raw water intake at one or more water treatment plants that have additional capacity. Furthermore, if the Year 2000 *per capita* water use in these two cities averages 214 gallons per day per person (40,680 people at 167 gpd in Edinburg and 116,891 people at 231 gpd in McAllen), then the wastewater reuse project could supply over 70,000 people!

The portion (~15%) of wastewaters which remains after the R.O. process will contain slightly elevated total dissolved solids (TDS = ~5,000-6,000 ppm = ~5-6 ppt, where seawater is 35 ppt salt) and approximately 90% of the nutrients (i.e., carbon, nitrogen, and phosphorus) in the original wastestream. Therefore, additional waste treatment is in order if the Arroyo Colorado and Laguna Madre are to also benefit from this wastewater re-use project. Since the upper Arroyo Colorado has an average TDS concentration of 2,836 ppm (= 2.8 ppt), and the lower tidal portion has an average of 9,864 ppm (=9.9 ppt), the TDS of the remaining low-volume wastestream does not appear to be a problem. However, the nutrient concentrations need to be reduced by advanced waste treatment (i.e., send the wastestream back to the sewage treatment plant for further treatment), biological nutrient removal (B.N.R.), or both. Biological nutrient removal is frequently accomplished with artificial wetlands, such as rock-reed filters, but it may also involve natural wetlands downstream, which may be managed for migratory waterfowl or other beneficial purposes. Biological nutrient removal has the advantage of being a low-technology solution with high biological benefits. In this particular case, the benefits will accrue to the Arroyo Colorado, as well as the Laguna Madre, by way of reducing the freshwater and nutrient inflows to this unique estuarine environment.

Conclusion

The beneficial re-use of treated wastewaters is recommended to provide additional potable water supplies in times of need, while simultaneously reducing nutrient loading and turbidity that threatens the aquatic life of the Arroyo Colorado and Laguna Madre.

APPENDIX D

LOWER RIO GRANDE VALLEY
DEVELOPMENT COUNCIL

EDINBURG/McALLEN REUSE FEASIBILITY STUDY

TECHNICAL MEMORANDUM NO. 1
BASELINE DATA

MAY 29, 1996

Prepared For:

Lower Rio Grande Valley
Development Council
City of Edinburg
City of McAllen
Texas Water Development Board

Prepared By:

Perez/Freese and Nichols, L.L.C.
Freese and Nichols, Inc.
CH2M Hill

PEREZ / FREESE • NICHOLS, L.L.C.

LRV96107
PFN96196

LOWER RIO GRANDE VALLEY
DEVELOPMENT COUNCIL

EDINBURG/McALLEN REUSE FEASIBILITY STUDY

TECHNICAL MEMORANDUM NO. 1
BASELINE DATA

STATE OF TEXAS
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REGISTERED PROFESSIONAL ENGINEER
30 MAY 96

MAY 29, 1996

STATE OF TEXAS
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Prepared For:

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LRV96107
PFN96196

TECHNICAL MEMORANDUM NO. 1
BASELINE DATA

LIST OF TABLES

LIST OF FIGURES

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1. EXECUTIVE SUMMARY

1.1 Project Outline

This is the first of three planned technical memoranda for the Edinburg/McAllen Reuse Feasibility Study. This study is an investigation of the technical and economic feasibility of using treated municipal wastewater effluent to augment the available supply of fresh water for potable use in the Edinburg/McAllen area. The project is a cooperative effort between the Lower Rio Grande Valley Development Council, the Cities of Edinburg and McAllen, and the Texas Water Development Board. The participating cities, like many others in the Lower Rio Grande Valley, are experiencing rapid population growth in an area with limited water availability. The local conditions have prompted the participants to view their treated wastewater as a resource and as a potential component of the long-range water supply.

The goal of this study is to determine suitable treatment methods and infrastructure requirements for potable reuse and to determine conceptual-level costs for such use. The study will also result in an implementation plan which outlines the additional testing, permitting, public education, design and construction required to proceed with the recommended alternative. After completion of this study, the cost and feasibility of reuse will have to be compared to other water supply options to determine if reuse is in the best interest of the communities.

This document, Technical Memorandum (TM) No. 1, presents the available data which will form the basis of the study. The second TM will present information on available treatment processes to be considered as part of potential potable reuse projects. The third TM will present the results of feasibility analyses for specific alternatives for potable reuse in the McAllen/Edinburg service areas. A final report will be prepared to summarize the information in the memoranda and present the results in a suitable format for public distribution.

1.2 Public Participation

Public acceptance will be a crucial consideration in the ultimate determination of the suitability of reuse for potable water supply. A public advisory committee for each of the cities has been established to begin the process of identifying public concerns regarding reuse and educating water consumers. Membership lists for the committees are included in Appendix A. The committees will meet a total of three times during this study. The first meeting, to introduce the project and solicit pre-existing concerns, was held on April 11, 1996. The second meeting is tentatively scheduled for July 15, 1996, and will include presentation of preliminary alternative configurations as well as a general status report and discussion. The third meeting, scheduled for November, 1996, will be for the presentation of the final report and conclusions regarding feasibility. If implementation of a reuse program is desired, a more extensive program of public participation will need to be developed for subsequent phases.

1.3 Baseline Data

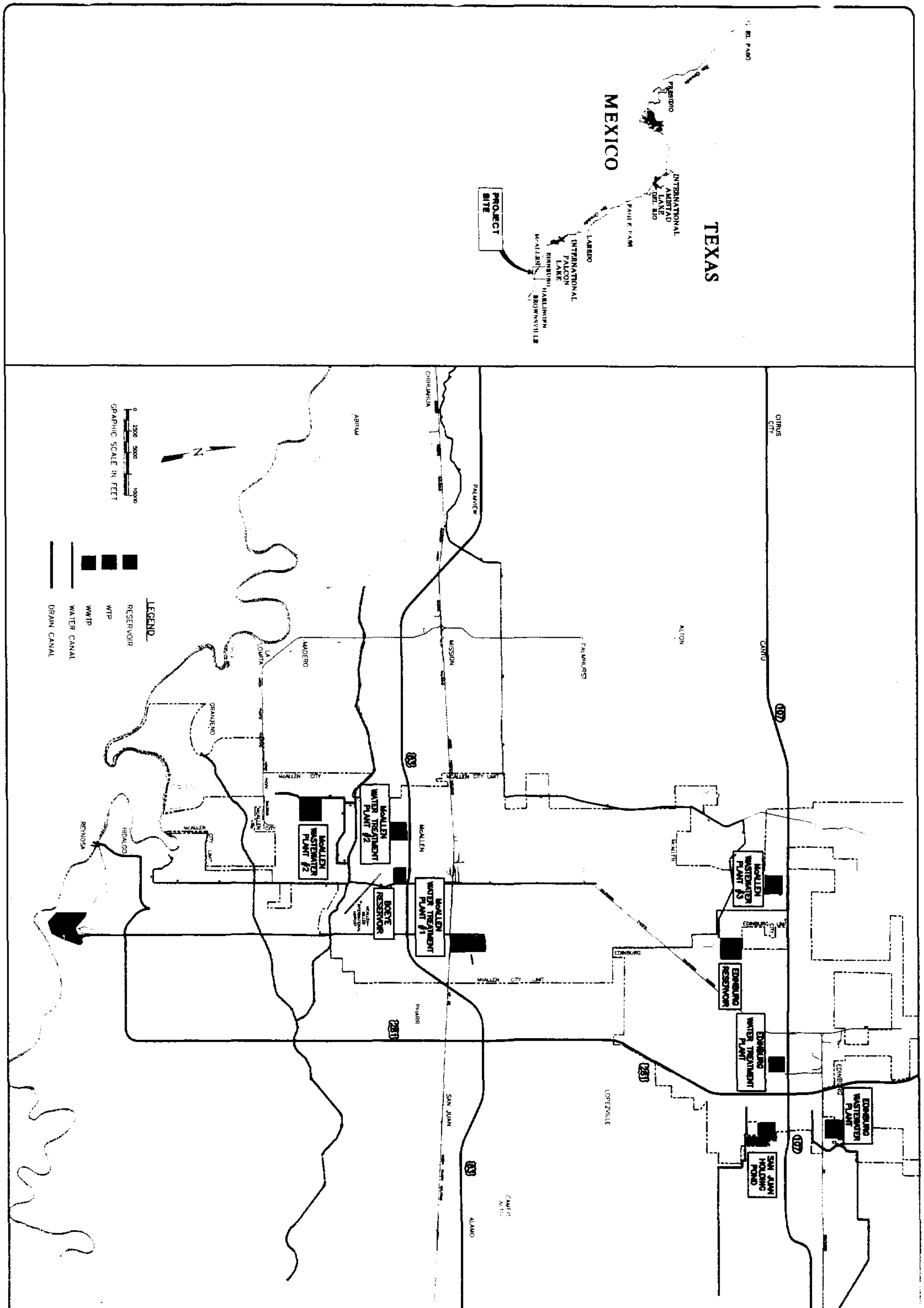
The following information is documented in this TM for use in the remainder of the study:

> Population and Water Use. Suitable projections of population and water use are provided by the Texas Water Development Board to establish the magnitude of future water supply needs.
>
> Water Quality Data. The chemical quality of the Rio Grande River water has been documented by the Texas Natural Resources Conservation Commission's sampling program. Additional information is needed on the variability of water quality between the river and the raw water storage reservoirs, and on the levels of various pathogenic organisms which may or may not be present in the raw water supply. Additional testing of wastewater will be necessary to allow appropriate comparisons with the raw water supply. Recommended supplemental testing is included as Appendix B.
>
> Both Edinburg and McAllen produce water which consistently meets primary standards for drinking water, from a raw water source which is seasonally variable and vulnerable to contamination. Both the variability and the susceptibility of the raw water to episodes of poor quality increase the challenge of consistently producing a high quality finished water, and both cities experience periodic exceedence of secondary and aesthetic standards.
>
> Existing Treatment Facilities. The information detailing the existing water and wastewater treatment facilities is almost complete, although there are still a few treatment units for which additional data are desirable. The locations of the facilities are indicated in Figure 1.1.
>
> Water Rights. It does not appear that effluent rights will be a significant issue, provided reuse occurs prior to discharge. Specific scenarios will require review by the TNRCC to confirm retention of water rights. Environmental impacts must also be considered in the evaluation of reuse alternatives.

Potable Reuse Status. There is substantial precedent for augmenting potable water supplies with treated wastewater effluent, although experience is limited in the state of Texas. Potable reuse projects have emphasized providing multiple treatment barriers against potential disease causing organisms. Balancing cost and risk in a manner acceptable to the public will be of primary importance for a successful reuse project.

Non-Potable Reuse. Although not the primary focus of this study, non-potable reuse for irrigation is an option which holds great promise if institutional obstacles can be overcome.

MAY 31 1998
REFERENCE FILES: ORD.DWG and RIO-G.DWG



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F&N JOB NO. PFN96195
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DATE 5/30/98
DESIGNED
DRAWN JAD
REVISED
CHECKED

VERIFY SCALE
Bar is one inch on original drawing. If not one inch on this sheet, adjust scale

EDINGBURG AND McALLEN, TEXAS

PROJECT SITE LAYOUT

LOWER RIO GRANDE VALLEY
DEVELOPMENT COUNCIL

REUSE FEASIBILITY STUDY

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FIGURE 1.1

2. FUTURE NEEDS

2.1 Population

Historical and projected populations obtained from the Texas Water Development Board (TWDB) for the Cities of Edinburg and McAllen are listed in Tables 2.1 and 2.2. The projections shown are from the TWDB's "Most Likely Growth Scenario". Both cities are expected to have a continuation of the rapid growth which has been characteristic of the lower Rio Grande Valley area. It should be noted that both cities are subject to an influx of retired winter visitors during the months of October through March. These visitors are not reflected in the population projections, but are not expected to have a significant impact on this study, since their impact has been included in the historical water usage. This assumes the fraction of water usage attributable to these "Winter Texans" will remain approximately constant.

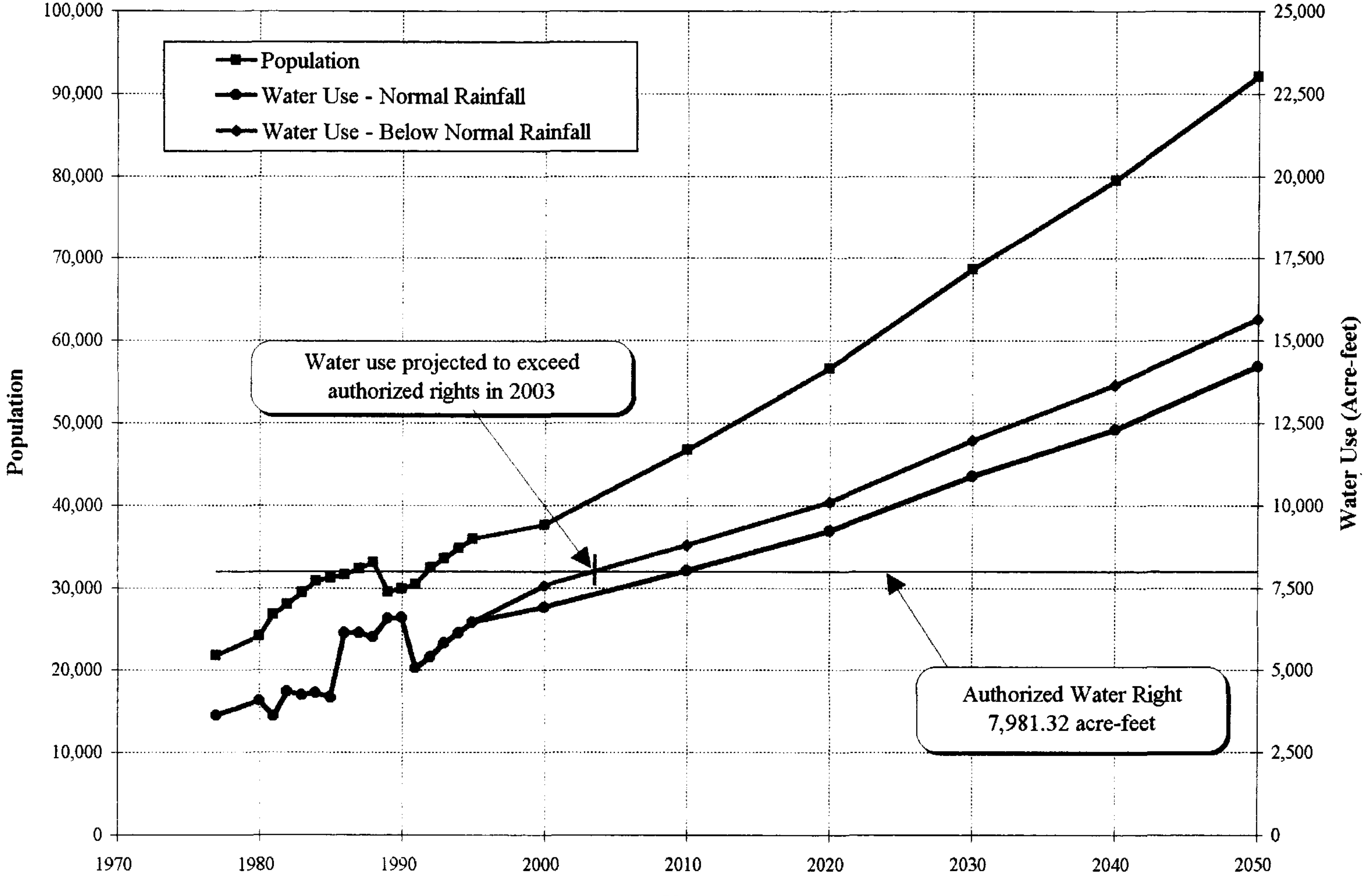
City of Edinburg. The City of Edinburg population is projected to increase at an annual rate of 2.3% for the period 1990-2000 and at a somewhat lower rate thereafter. This growth is illustrated in Figure 2.1. The population is expected to grow from the existing estimate of about 36,000 to about 92,000 by the year 2050.

City of McAllen. The City of McAllen population is projected to grow from the existing estimate of about 98,300 to about 190,700 by the year 2050, as illustrated in Figure 2.2. The projected annual growth rate is 2.5% to the year 2000 and somewhat lower thereafter.

2.2 Water Demand Projections

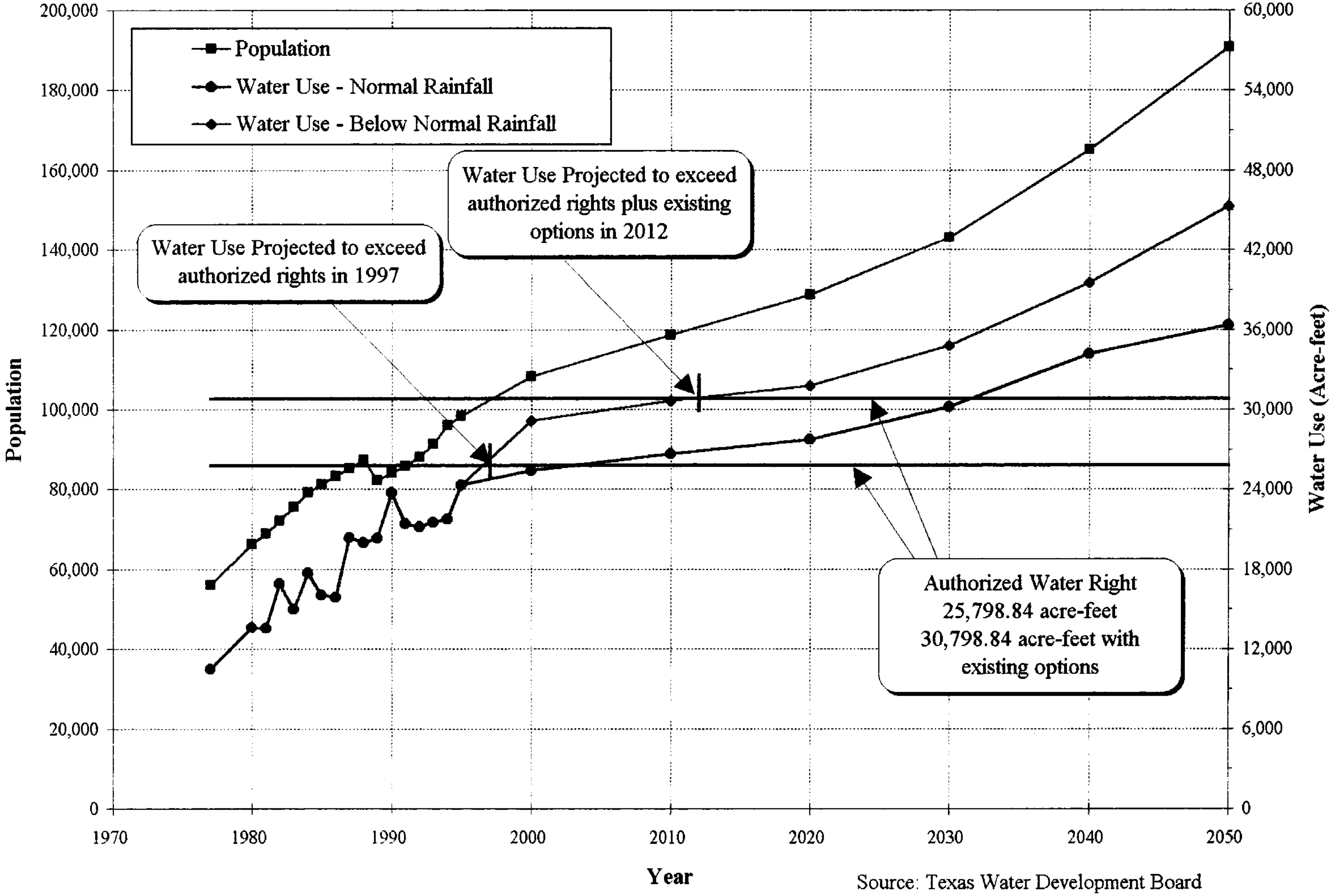
Annual municipal water demand projections were also obtained from the TWDB as contained in Tables 2.1 and 2.2. The projections assume a modest reduction in per capita water use due to gradual replacement of plumbing fixtures and other water conservation measures. TWDB terms this series "Expected Conservation" and has a second series (not shown) for "Advanced Conservation" which assumes more aggressive efforts at water conservation. The "Expected Conservation" series is shown as the baseline for this study, since it is more conservative and is more likely to occur unless a comprehensive program of conservation is established. TWDB also differentiates between the water use to be expected during a period of normal rainfall and the higher use expected due to increased landscape irrigation during "below normal rainfall" (drought) conditions. Both values are included in the tables and figures presented here. The TWDB values do not include irrigation, livestock, mining, power or industrial uses, so an industrial allowance is added to the municipal projections for each City, based on recent industrial usage. The projections for Edinburg and McAllen shown in Figures 2.1 and 2.2 include the projected industrial use.

Figure 2.1
Population and Water Use Projections
City of Edinburg



Source: Texas Water Development Board

Figure 2.2
Population and Water Use Projections
City of McAllen



Water Use Projected to exceed authorized rights plus existing options in 2012

Water Use Projected to exceed authorized rights in 1997

Authorized Water Right
25,798.84 acre-feet
30,798.84 acre-feet with existing options

Source: Texas Water Development Board

Table 2.1
City of Edinburg
Population and Water Use

Year	Population	Historical Water Use (Acre-feet)	Projected Industrial Use (c) (Acre-feet)	Water Use Assuming Normal Rainfall		Water Use Assuming Below Normal Rainfall	
				Municipal (d) (Acre-feet)	Total (Acre-feet)	Municipal (d) (Acre-feet)	Total (Acre-feet)
1977	21,750	3,614					
1980	24,075	4,056					
1981	26,725	3,580					
1982	27,961	4,355					
1983	29,354	4,241					
1984	30,818	4,292					
1985	31,187	4,167					
1986	31,560	6,129					
1987	32,311	6,130					
1988	33,080	5,996					
1989	29,490	6,579					
1990	29,885	6,581					
1991	30,393	5,062					
1992	32,381	5,399					
1993	33,562	5,802					
1994	34,741 (a)	6,120					
1995	35,953 (a)	6,456					
2000	37,610 (b)		485	6,404	6,889	7,078	7,563
2010	46,658 (b)		536	7,474	8,010	8,258	8,794
2020	56,589 (b)		592	8,621	9,213	9,508	10,100
2030	68,637 (b)		653	10,225	10,878	11,302	11,955
2040	79,473 (b)		722	11,573	12,295	12,908	13,630
2050	92,020 (b)		797	13,400	14,197	14,843	15,640

(a) 1994 & 1995 Population from LRGVDC Regional Solid Waste Management Plan
(b) Projected Populations from TWDB 1996 Consensus Water Planning "Most Likely Growth Scenario"
(c) Industrial Use Projected by Freese & Nichols, based on 1989-1993 average, with 2% annual growth to 2000, and 1% annual growth thereafter
(d) Municipal use projections from TWBD 1996 Consensus Water Planning "Expected Conservation" Scenario

Table 2.2
City of McAllen
Population and Water Use

Year	Population	Historical Water Use (Acre-feet)	Projected Industrial Use (c) (Acre-feet)	Water Use Assuming Normal Rainfall		Water Use Assuming Below Normal Rainfall	
				Municipal (d) (Acre-feet)	Total (Acre-feet)	Municipal (d (Acre-feet)	Total (Acre-feet)
1977	55,931	10,485					
1980	66,281	13,586					
1981	68,878	13,572					
1982	72,063	16,883					
1983	75,490	14,947					
1984	79,082	17,701					
1985	81,164	16,033					
1986	83,300	15,904					
1987	85,262	20,372					
1988	87,270	20,004					
1989	82,167	20,309					
1990	84,021	23,720					
1991	85,701	21,408					
1992	88,076	21,158					
1993	91,184	21,544					
1994	95,963 (a)	21,741					
1995	98,302 (a)	24,300					
2000	108,070 (b)		1,155	24,211	25,366	27,963	29,118
2010	118,597 (b)		1,252	25,374	26,626	29,354	30,606
2020	128,575 (b)		1,356	26,356	27,712	30,389	31,745
2030	143,015 (b)		1,468	28,675	30,143	33,321	34,789
2040	165,151 (b)		1,590	32,559	34,149	37,924	39,514
2050	190,713 (b)		1,722	34,598	36,320	43,580	45,302

(a) 1994 & 1995 Population from City of McAllen Planning Department

(b) Projected Populations from TWDB 1996 Consensus Water Planning "Most Likely Growth Scenario"

(c) Industrial Use Projected by Freese & Nichols, based on 1989-1993 average, with 2% annual growth to 2000, and 0.8% annual growth thereafter

(d) Municipal use projections are from TWBD 1996 Consensus Water Planning "Expected Conservation" Scenario

City of Edinburg. The City of Edinburg has averaged 152 gallons per capita per day (gpcd) for the years 1980 through 1993, and had a total raw water usage of 6,456 acre-feet in 1995. This corresponds to an average usage of 5.76 million gallons per day (mgd). This is expected to increase to 14,197 acre-feet (12.67 mgd) by 2050, with up to 15,640 acre-feet (13.96 mgd) in a drought year. The City currently holds 7,981 acre-feet of municipal water rights, as discussed in Section 5.

City of McAllen. The City of McAllen has averaged 200 gpcd for the period 1980 through 1993, and had a total water usage of 19,506 acre-feet (17.41 mgd average) in 1995. The higher per capita use compared with Edinburg is presumed to be the result of a greater proportion of commercial activity in McAllen. Normal year demand is expected to increase to 36,320 acre-feet (32.42 mgd) by 2050, and drought conditions would be expected to generate a demand of 45,302 acre-feet (40.44 mgd) by 2050. McAllen currently has authorized water rights totalling 25,799 acre-feet.

2.3 Identified Additional Water Supply Alternatives

This project is aimed toward studying the feasibility of reusing the effluent from the wastewater treatment plants. This alternative should be considered and evaluated against more conventional water supply alternatives that are available to meet the increasing water demands of the area. Several of the identified conventional alternatives are briefly described below.

Purchase of Additional Water Rights. The traditional means of increasing water supply for the Cities of Edinburg and McAllen has been the purchase of water rights currently held by local irrigators. This allows the Cities to continue operating in the current mode and utilize their existing facilities. However, the cost for additional rights is increasing, and the authorized rights are still subject to water availability in Amistad and Falcon Reservoirs.

Groundwater. Groundwater is often an inexpensive source requiring little treatment due to natural filtration occurring as water moves underground. However, the groundwater availability in Hidalgo County is uncertain and the quality is poor due to elevated levels of Total Dissolved Solids, or dissolved salts. The City of Hidalgo currently meets its water needs from groundwater supplies, but it is questionable what contribution groundwater can make for larger cities such as McAllen and Edinburg. Deeper, higher yield aquifers may be an option, but suspected high levels of dissolved salts will require expensive treatment prior to use.

Desalination. Advances in membrane treatment equipment have significantly reduced the cost of desalination. The City of Brownsville is currently studying this option to increase its water supply. However, removing salt from seawater is still a very expensive process, and for Hidalgo County, there is the additional cost of transporting the water and disposing of the resulting brine waste. Desalination of groundwater may be a more attractive option.

Reservoir Development. Reservoir development is a traditional water supply option for many cities and may be viable for the Rio Grande Valley. However, favorable dam sites are becoming increasingly difficult and expensive to acquire and permit. Another alternative may be to increase the usable supply from Falcon Reservoir by constructing a pipeline to convey the water to the municipalities without evaporation and seepage losses and losses from unauthorized diversions. The raw water pipeline would have the added advantage of protecting the water supply from contamination in the river.

Conservation. Water conservation, while not a supply alternative, is another tool to manage the supply/demand relationship. Due to the widespread limitations on water supply, conservation is likely to play an important role in the Lower Rio Grande Valley, regardless of the supply alternatives ultimately selected.

3. WATER QUALITY DATA

Water quality comparisons are critical to the evaluation of wastewater reuse, especially for potable purposes. Both chemical and microbiological parameters must be considered. Unfortunately, there are limited data available on many constituents of concern. This section summarizes the information which has been gathered to date and lists additional data needs.

3.1 Raw Water

Both cities take water indirectly from the lower Rio Grande River (Segment 2302). Hidalgo County Irrigation Districts 1, 2, and 3 pump water into irrigation canals which transport water to various users including the cities. The cities divert water from the Districts' canals to raw water storage reservoirs, and pump water from the reservoirs to their water treatment plants. Regular monitoring of the river is conducted by the Texas Natural Resource Conservation Commission at a station adjacent to the U.S. Highway 281 International Bridge. It is assumed that water quality in the raw water storage reservoirs is similar to that in the river, although the reservoirs should act to reduce variations in quality. It is recommended both Cities begin testing in the reservoirs to determine what differences exist between the reservoirs and the river.

Table 3.1 contains a summary of the TNRCC data on several parameters of primary interest. Rio Grande River water in the vicinity of Hidalgo County is usually high in dissolved salts, especially sulfate, causing exceedence of secondary drinking water standards, as discussed below. Sulfate is typically between 200 and 400 mg/L and total dissolved solids are typically between 700 and 1,000 mg/L, although they have been measured above 1,000 mg/L on numerous occasions. This segment of the river is also subject to periodic contamination from inadequate wastewater treatment upstream. Contamination is indicated by occasional instances of high fecal coliform counts (up to 6,000 per 100 mL). Dissolved oxygen is usually high, between 6 and 11 mg/L, even with summer water temperatures commonly between 25 and 30°C. Data for concentrations of pesticides and other toxics, although limited, do not indicate excessive values. Virtually all of these substances were below detection limits.

The prevalence of pathogenic organisms will be another key measure for comparison of wastewater effluent with existing raw water supplies. The proposed testing program will measure several important water-borne pathogens as well as other constituents.

3.2 Treated Water

Drinking water is subject to federal and state standards, or maximum contaminant levels, for over 100 potential constituents. Most limits are primary standards, established to protect public health. Additional limits have been issued as secondary standards, established as

Table 3.1
Rio Grande River Water Quality

Parameter	Average	Maximum	Minimum	Period of Record
Temperature, °C	23.3	31.0	11.6	1986-1995
Average Flow, CFS	1,533	7,513	61.2	1974-1995
Average Conductivity, μmhos/cm	1,357	2,820	100	1970-1995
pH	N/A	10.10	6.55	1986-1995
Alkalinity, mg/L as $CaCO_3$	130	192	101	1977-1995
Cl, mg/L	181	460	71	1970-1995
SO_4, mg/L	271	499	110	1970-1995
TDS, mg/L	863	1,650	300	1986-1995
Dissolved Oxygen, mg/L	8.8	13.0	3.85	1986-1995
TSS, mg/L	79	932	6.0	1986-1995
TOC, mg/L	5.28	36	1.0	1986-1995
Fecal Coliform, CFU/100 mL	1,172	100,000	1.0	1975-1995
Chlorophyl "a" μg/L	12.05	40.80	1.0	1986-1995

Source: Texas Natural Resource Conservation Commission
US 281 International Bridge at Hidalgo

Table 3.2
Finished Water Quality Data

Chemical Constituents

Parameter	Edinburg			McAllen	TNRCC
	09/21/93	12/21/94	06/07/95	12/15/94	MCL
Calcium, mg/L	72	79	75	80	
Chloride, mg/L	152	196	184	194	* 300
Fluoride, mg/L	0.8	1.0	0.8	1.0	* 2.0
Magnesium, mg/L	20	33	27	27	
Nitrate (as N), mg/L	0.03	0.09	0.02	0.18	10
Sodium, mg/L	146	190	178	187	
Sulfate, mg/L	266	314	313	311	* 300
Tot. Hardness, mg/L as $CaCO_3$	265	334	296	309	
pH	6.8	8.1	8.0	8.0	* >=7.0
Dil. Conduct. (μmhos/cm)	1,395	1,738	1,620	1,727	
Tot. Alk., mg/L as $CaCO_3$	90	128	96	105	
Bicarbonate, mg/L	110	156	117	128	
Carbonate, mg/L	0.0	0.0	0.0	0.0	
Dissolved Solids, mg/L	715	896	843	870	1,000
P. Alkalinity, mg/L as $CaCO_3$	0.0	0.0	0.0	0.0	

Metals

Parameter	Edinburg			McAllen	TNRCC
	09/17/93	12/21/94	06/07/95	16/19/95	MCL
Aluminum, μg/L	319	327	480	200	* 50-200
Arsenic, μg/L	3.2	2.7	< 2.0	2.5	50.0
Barium, μg/L	109	101	111	133	2,000
Cadmium, μg/L	< 0.1	< 0.1	< 0.2	< 0.2	5.0
Chromium, μg/L	< 4.0	< 4.0	< 8.0	< 8.0	100.0
Copper, μg/L	16.8	12.1	43.0	10.0	* 1,000
Iron, μg/L	10.5	< 4.0	< 6.0	12.0	* 300
Manganese, μg/L	1.8	0.8	2.0	6.0	* 50
Mercury, μg/L	< 0.1	< 0.1	0.2	< 0.1	2.0
Nickel, μg/L	< 5	< 20	< 20	< 20	100
Selenium, μg/L	3.7	< 4.0	< 4.0	< 4.0	50.0
Silver, μg/L	< 10	< 10	< 6	< 6	** 100
Antimony, μg/L	< 3.0	< 2.0	< 2.0	< 2.0	6.0
Beryllium, μg/L	< 0.3	< 0.8	< 1.0	< 1.0	4.0
Zinc, μg/L	7.1	< 5.0	< 5.0	< 5.0	* 5,000

*** Secondary Standard** **** USEPA**

goals for aesthetic reasons or for avoidance of minor health effects. Limited data are available on most parameters in the treated water from the two cities. Table 3.2 contains a summary of recent testing, with the corresponding standards listed for comparison. Both cities are rated "Superior" by the TNRCC and produce water well below the maximum contaminant levels with the exception of sulfate, aluminum and total dissolved solids. The TNRCC has a secondary standard of 300 mg/l for sulfate, and this value is exceeded on some occasions. Available data for aluminum concentrations were consistently at or above the secondary standard of 50-200 μg/L. While none of the samples referenced in Table 3.2 exceeded the total dissolved solids limit of 1000 mg/l, this value could be easily exceeded due to the high levels noted in the river water quality data.

3.3 Treated Wastewater Effluent

The wastewater treatment plants are required to meet pollutant limits established in discharge permits issued by the TNRCC and U.S. Environmental Protection Agency. Most information on the quality of treated effluent is limited to conventional permitted pollutant parameters such as biochemical oxygen demand (BOD), total suspended solids (TSS), and ammonia nitrogen. However, the City of McAllen has begun a testing program to track dissolved solids in their wastewater effluent and in the local irrigation canals which supply the City's water.

> Edinburg. The Edinburg plant was consistently meeting its permit limits until they were changed in September 1994, from 20 mg/l BOD and TSS to 10 mg/l BOD, 15 mg/l TSS and 3 mg/l ammonia nitrogen. Construction is about to begin on a major plant upgrade which should allow it to meet the more stringent limits.
>
> McAllen. Plant No. 2 has permitted limits of 10 mg/l BOD, 15 mg/l TSS and 3 mg/l ammonia nitrogen, while Plant No. 3 has permitted limits of 20 mg/l BOD and TSS. Both plants have excellent records of compliance for BOD and TSS. Plant No. 2 has occasionally been out of compliance with respect to ammonia in the first half of 1995, but has been meeting all permit limits since that time.

4. EXISTING TREATMENT FACILITIES

4.1 Water Treatment Plants

The City of Edinburg has a single and the City of McAllen has two surface water treatment plants. All three use conventional surface water treatment processes. A brief description of the plants follows, and Table 4.1 contains a summary of the facilities at each of the plants.

Edinburg Water Treatment Plant. The City of Edinburg Water Treatment Plant is located near the center of town and is comprised of three treatment trains (two 4-mgd and one 2-mgd) with a total capacity of 10 mgd. Raw water is obtained from the Edinburg Reservoir located at Freddy Gonzalez and Mon Mack. This is a 180 million-gallon reservoir which receives pumped Rio Grande River water from Hidalgo County Water District No. 1 in Benitez. From the reservoir, the raw water flows by gravity to the influent pump station about 2 miles from the water treatment plant.

Chlorine dioxide is injected at the influent pump station for pre-disinfection. Chloramine for secondary disinfection and liquid alum for coagulation are added at the flow splitter at the head of the water treatment plant. From the splitter, the water flows to one of the three treatment trains. Each train consists of rapid mix, flocculation, sedimentation, and dual-media filtration.

There are two clearwells at the water treatment plant. A common transfer pump feeds the water from the clearwells to a ground storage tank and high service pump station located across the street from the plant.

McAllen Water Treatment Plant No. 1. Water Treatment Plant No. 1, located east of the central business district, is the older of the two plants in McAllen. This plant was constructed in 1927 and is not used on a regular basis. It is used occasionally to keep the facilities in working order and to help alleviate peak demands at Water Treatment Plant No. 2. The facilities are old but are still in good working condition.

Raw water is obtained from a reservoir adjacent to the treatment plant site. This reservoir receives water from the Rio Grande River pumped by Hidalgo County Irrigation District No. 2. The reservoir has a capacity of 13.1 million gallons.

The plant uses conventional surface water treatment processes consisting of rapid mix, flocculation, sedimentation, and rapid-sand filtration. Chlorine dioxide for pre-disinfection and liquid alum for coagulation are added at the rapid mix basin. Chloramine is added prior to sedimentation for secondary disinfection.

Table 4.1
Water Treatment Facility Summary

Treatment Process	McAllen WTP No. 1	McAllen WTP No. 2	Edinburg WTP
Raw Water Source	WTP No. 1 Reservoir	Boeye Reservoir	Edinburg Reservoir
Raw Water Lines		30- & 54-inch dia.	36-inch dia.
Raw Water Pump Stations		one 4-mgd, one 8-mgd, & two 12-mgd pumps	Pump Station No. 1: one 2.8-mgd, two 4.8-mgd, & one 7.8-mgd pumps Pump Station No. 2: two 1.2-mgd pumps
Flocculators	40 min. detention	30 min. detention	
Sedimentation Basins	5 hr. detention	6 hr. detention	
Filters	2 gpm/ft^2	5 gpm/ft^2	

Sources: "City of McAllen 8.0 MGD Expansion at Water Treatment Plant No. 2 Engineering Report Summary," July, 1994, other water treatment plant data sheets, and discussions with plant personnel; City of Edinburg Utilities Fact Sheet, April 10, 1996 and discussions with plant personnel.

There are three clearwells for the finished water. A series of high service pumps draws from these clearwells to supply the water distribution system.

<u>McAllen Water Treatment Plant No. 2</u>. McAllen's Water Treatment Plant No. 2 is actually two water treatment plants on the same site on the south end of the city. One is a 30 mgd facility and the other is an 8 mgd facility currently under construction, with an ultimate capacity of 16 mgd. Raw water is supplied to both plants from Boeye Reservoir via two approximately 3,000-foot raw water lines of 30- and 54-inches in diameter. Boeye Reservoir receives water from the Rio Grande River by gravity from Hidalgo County Irrigation District No. 2 and by pumping from Hidalgo County Irrigation District No. 3.

The treatment processes at this plant are the same as those at Water Treatment Plant No. 1 except the filters are dual-media filters (anthracite coal and sand) rather than rapid sand filters (sand only). Chemicals are added in the same locations as described for Plant No. 1.

The finished water from the 30 mgd facility is transferred to one of two clearwells. A transfer pump station then delivers the water to one of three ground storage tanks. The finished water from the 8 mgd facility is transferred directly to one of the three ground storage tanks. A high service pump station then delivers the finished water to the distribution system.

4.2 Wastewater Treatment Plants

The City of McAllen has two activated sludge wastewater treatment plants (WWTP # 2 and WWTP # 3). Currently, the City of Edinburg has one wastewater treatment plant with a combination activated sludge and trickling filter treatment process. A brief description of the plants follows, and Table 4.2 summarizes the facilities at each of the plants.

Edinburg Wastewater Treatment Plant. The City of Edinburg Wastewater Treatment Plant is comprised of one abandoned and two active trickling filters (0.9-mgd and 1.5-mgd) and one oxidation ditch (1.4-mgd) for a total treatment capacity of 3.8 mgd. Construction will begin later this year for a new 4-mgd activated sludge wastewater treatment facility adjacent to this plant and for renovation (and derating to 1.9 mgd) of the existing plant. The two treatment facilities, located northeast of the central business district, will be separate but the effluent will be combined into a common discharge line.

As part of the renovation at the existing plant, an aeration basin has already been constructed which will provide activated sludge treatment for the proposed capacity of 1.9 mgd. When the aeration basin is put on line, the two active trickling filters will be abandoned and the existing oxidation ditch will be used as a backup treatment process. The three trickling filter basins will be demolished but three existing primary clarifiers will be abandoned and could be available for additional treatment processes, if needed, for this reuse project.

The treatment trains at the two facilities will be similar, but with some key differences. At the 4-mgd facility, raw wastewater will be received at the influent lift station. From there, the flow will be pumped to a fine screening and grit removal facility. At the 1.9-mgd facility, the raw water will continue to flow through an existing mechanical bar screen prior to entering the influent lift station. At both plants, aeration basins will provide activated sludge treatment and will be followed by final clarification. The effluent from the proposed 4-mgd and renovated 1.9-mgd treatment trains will then be combined at a common effluent lift station. The force main from the lift station will act as the chlorine contact chamber for the effluent. Sulfur dioxide will be injected just upstream of the outfall structure to dechlorinate the effluent. The discharge point will have a cascade aeration structure over which the effluent will fall prior to entering the San Juan holding pond.

Solids from both the wastewater treatment plants will be sent to one of three existing aerobic digesters. From there, the solids will be removed and spread on sludge drying beds.

Table 4.2
Wastewater Treatment Facility Summary

Treatment Process	**McAllen WWTP No. 2**	**McAllen WWTP No. 3**	**Edinburg WWTP**
Design Flow	10 mgd	4 mgd	Existing: 4.5 mgd Proposed: 5.9 mgd
Grit Removal	Aerated	Aerated	Aerated for 4 mgd None for 1.9 mgd
Aeration Basins	2 - 4.5 MG	2 - 2 MG	1.5 MG for 4 mgd 0.9 MG for 1.9 mgd
Final Clarifiers	2 - 145' dia, 1.4 MG basins	2 - 92' dia, 0.5 MG basins	2 - 80' dia, 0.49 MG basins for 4 mgd 1 - 60' dia, 0.21 MG 1 - 50' dia, 0.14 MG basins for 1.9 mgd
Chlorine Contact	70' dia, 0.36 MG	40' dia, 0.11 MG	Effluent Force Main

Sources: "Design Analysis Proposed 4.0 MGD Sewage Treatment Plant, City of McAllen, Texas," other wastewater treatment plant data sheets, and discussions with plant personnel; City of Edinburg Utilities Fact Sheet, April 10, 1996, and discussions with plant personnel.

McAllen Wastewater Treatment Plant No. 2. Wastewater Treatment Plant No. 2 is the older of the two plants in McAllen. (Plant No. 1 is no longer in use.) This plant is located at the southwest edge of the city and has a treatment capacity of 10 mgd.

The raw wastewater enters an influent structure which includes screening and an aerated grit removal chamber. From there the wastewater is pumped to aeration basins for activated sludge treatment, followed by final clarification and chlorine contact. The final effluent is discharged into the Mission Floodway Channel which flows into the Arroyo Colorado.

Solids from the wastewater treatment plant are removed to an aerobic digester. From there, the solids are spread on sludge drying beds.

There are two abandoned primary clarifier tanks and two anaerobic digester tanks at the plant which are available for use in additional treatment, if needed for this reuse project.

<u>McAllen Wastewater Treatment Plant No. 3</u>. McAllen's Wastewater Treatment Plant No. 3, at the north end of town, currently has a treatment capacity of 4 mgd. Construction for one of two planned 2-mgd expansions of the plant is scheduled to begin later this year. Final effluent is discharged to a drainage ditch within Hidalgo County Drainage District No. 1.

WWTP No. 3 is similar to WWTP No. 2 except that WWTP No. 3 contains 10 acres of holding ponds which are available for temporary storage when the treatment facilities are down for maintenance or repair. Also, WWTP No. 3 has a gravity thickener following aerobic digestion, from which the sludge is removed prior to being spread on sludge drying beds.

5. WATER RIGHTS ASSESSMENT

Water rights are a complicated issue in general, and are further complicated by the international status of the Rio Grande. Water in Falcon Lake is allocated to the United States and Mexico by treaty, and is released to meet the requirements of authorized users downstream. Water rights are held by cities, water supply corporations, irrigation districts and other entities with various levels of priority status. Although municipal rights have the highest priority and have historically been dependable, the current low levels in Falcon Lake and Amistad Reservoir upstream have caused public concern even for municipal allotments. This is a result of the current drought situation and unauthorized diversions of river water on both sides of the border.

5.1 Quantity and Availability

City of Edinburg. The City of Edinburg currently holds municipal water rights totalling 7,981 acre-feet/year. This provides a theoretical supply sufficient to meet the projected needs until the year 2003, assuming the growth and conservation projections are reasonably accurate.

City of McAllen. The City of McAllen currently holds a total of 25,798 acre-feet/year of municipal water rights, with options allowing them to purchase up to 5,000 acre-feet/year as needed. This provides a theoretical supply sufficient to meet projected needs until the year 1997, assuming the growth and conservation projections are reasonably accurate. If the options currently held by the City are exercised, the rights are projected to be adequate until the year 2012.

5.2 Effluent Rights

Water rights are often a consideration in evaluations of potential wastewater reuse. Some fraction of wastewater return is often assumed in calculations of reservoir yield or downstream water rights, and in some cases downstream users may have a claim on some portion of the water to be returned. In the cases of McAllen and Edinburg, wastewater is not returned to the Rio Grande, but is discharged to drainage canals which eventually flow into the Laguna Madre. The McAllen City Attorney has provided a legal opinion indicating there should be no valid legal claim which would limit the City's use of reclaimed effluent prior to discharge. This opinion is included in Appendix C, and should apply similarly to Edinburg, although a separate legal opinion should still be obtained. Another issue which should be considered is the potential impact on aquatic life in the receiving streams and the Laguna Madre from removing or reducing the discharge of effluent. This issue will be examined as specific alternatives are evaluated.

6. STATE OF REUSE TECHNOLOGY

6.1 Wastewater Reuse Status

Wastewater reuse has become an important source of water in various areas where population is concentrated and fresh water is scarce. As development of conventional supplies has become more difficult and costly, and as quality requirements for wastewater effluent have grown more stringent, treated wastewater effluent has become an economical option for certain types of water needs. In the United States, major reuse projects have been concentrated in the states of California, Florida, Texas, and Arizona.

6.2 Types of Reuse

Effluent reuse has been practiced for numerous uses, but the most common have been irrigation (agricultural and landscape), industrial (cooling and process), and municipal supply protection or augmentation. Each is discussed briefly in the following paragraphs.

<u>Irrigation</u>. Agricultural water use accounts for over half of water use nationally, according to the Water Environment Federation's *Water Reuse* Manual of Practice. Since this use is typically concentrated in areas of limited water supply, the use of effluent for irrigation has been an obvious opportunity for conserving potable supplies, and many projects have been developed of this type. Most projects have been for fodder, fiber or seed crops, due to the lesser impacts on public health, but highly treated wastewater has also been successfully used for irrigation of human food crops. Landscape irrigation with treated effluent at parks and golf courses has also been practiced extensively, but typically involves much smaller quantities and therefore is limited in its impact on water supplies.

<u>Industrial</u>. Another common use of wastewater effluent substitution is for cooling water in power generation and other industries. This can be a very economical use since large volumes are often used at a single location, and human contact is generally not an issue. Some industries are also able to use municipal effluents in manufacturing processes, although such use is highly dependent on case-specific considerations.

<u>Municipal Water Supply</u>. A limited number of municipal water suppliers have used highly treated effluent to protect groundwater supplies from saltwater intrusion or other contamination and to augment water supplies. These uses, which have the potential for human consumption, are the subject of the following section.

6.3 Summary of U.S. Potable Reuse Projects

Unplanned, indirect potable reuse has been in practice since man first began disposing of wastewaters into watersheds that are hydrologically connected to raw water supplies. As populations have increased, so too has the quantity of wastewater and the complexity of the technology to manage these increased volumes of wastewater. Potable reuse is one of the developing strategies to manage wastewater and to recover and reuse water resources.

Table 6.1
Potable Reuse Project Summary

Name or Location	Type of Use	Years of Operation	Maximum Percent of Supply	Design Flow (mgd)
Whittier Narrows, CA	Groundwater Infiltration	1962-present	16	10
Water Factory 21 Orange County, CA	Saltwater Intrusion Barrier	1975-present	5	15
Upper Occoquan Sewage Authority, VA	Surface Water Augmentation	1977-present	90	27
Tahoe-Truckee, NV	Surface Water Augmentation			4.83
Denver, CO	Direct Potable Demonstration	1984-1993	100	1.0
Fred Hervey Plant El Paso, TX	Groundwater Recharge	1985-present		10
Tampa, FL	Indirect Potable Pilot Plant	1991-1993		
Phoenix, AZ	Potable Reuse Feasibility Study			
West Basin Barrier Project, L.A., CA	Saltwater Intrusion Barrier			5
San Diego, CA	Surface Water Augmentation	Scheduled 1997	50	20

Table 6.1 is a summary of some of the planned potable reuse projects currently in use and selected studies that helped lead to the acceptance of potable reuse as a viable component of water resource management plans.

Descriptions of these projects are included in Appendix D. It should be noted that several surface water augmentation projects have been developed which are comparable in concept to the potable reuse alternatives to be explored in this study.

6.4 Positions of Professional Organizations

The Water Environment Federation (WEF) and American Water Works Association (AWWA) are the premier professional organizations dealing with water and wastewater issues. Both have long recognized the important role that water reuse plays in water resource planning and have issued policy statements as presented below.

> WEF Reuse Policy Statement (Approved by the WEF Executive Committee on January 18, 1990). WEF considers reclaimed water to be a legitimate and important fresh water resource. Additionally, WEF feels that reclaimed water should be considered a viable alternative to supplement a potable water source in situations or areas where water sources are insufficient to meet projected potable water demands. WEF's official policy statement is as follows:
>
> *Wastewater is an important element of our total fresh water resource. Treated wastewaters already comprise an unplanned, but significant component of our nation's freshwater supplies through discharge to streams, lakes and groundwater basins used to supply domestic, industrial and agricultural water demands. Wastewaters must be treated by appropriate technologies to assure that potentially harmful contaminants are reduced to levels which will not impair the use of the receiving water.*
>
> *The development of advanced wastewater treatment processes and sophisticated control and monitoring systems has permitted reclaimed water to be used directly in planned projects for industrial purposes as well as irrigation including food crops, golf courses, parks and playgrounds and, to supply recreational lakes used for boating, fishing and swimming. Treated wastewater is also used to provide some artificial recharge to potable groundwater basins. In some water-short areas, available surface and groundwater resources will be unable to supply projected demands within the foreseeable future.*
>
> *The Federation strongly supports the use of reclaimed water for non-potable purposes as a means of conserving limited quantities of high quality potable water supplies.*

Furthermore, the Federation recognizes that surface and groundwaters often contain the same contaminants found in wastewater, and that selected treatment processes are capable of reliably eliminating pathogens in reclaimed waters; and treatment processes are also capable of reducing organic and inorganic contaminants to levels equivalent to those in many current potable water supplies.

Therefore, in those situations where water sources are insufficient to meet projected potable water demands, the Federation finds reclaimed water derived from municipal wastewater should be considered a viable alternative to supplement a potable water resource.

The Federation urges that owners and operators of wastewater treatment systems adopt the attitude that they are performing resource recovery rather than wastewater disposal, and that their efforts toward reclamation of wastewater for reuse should parallel their efforts to make beneficial use of residual solids through composting and other means. The Federation also urges that owners and operators of wastewater treatment systems use public information programs to plan and develop their reclamation projects.

AWWA Reuse Policy Statement (Approved by the AWWA Board of Directors on January 22, 1995). AWWA strongly believes that only the best available quality water should be used as a potable water source. However, AWWA does not oppose the indirect use of reclaimed water that is of equal or superior quality to other raw water supplies in areas where raw water sources are limited. AWWA's official policy statement is as follows:

First and foremost, AWWA believes that sources of water with best available quality should be used for potable purposes. The use of reclaimed water can significantly reduce the demands placed on limited conventional supplies of potable water. Accordingly, AWWA encourages responsible use of reclaimed water in lieu of potable water for non-potable uses. Furthermore, when raw water supply sources to an area are limited and reclaimed water is generally of equal or superior quality to other raw water supplies, AWWA does not oppose indirect use of reclaimed water as a supplement to existing raw water sources receiving appropriate subsequent treatment. These sources must be acceptable to health authorities and water users.

AWWA urges continued research to improve treatment technology, monitoring techniques, and the development of health-based drinking water standards, thereby assuring the safe use of reclaimed water.

6.5 Regulatory Requirements for Potable Reuse

The U.S. Environmental Protection Agency (EPA) does not explicitly regulate the practice of potable reuse. However, the Clean Water Act and Safe Drinking Water Act do establish laws that govern the operation of facilities that treat wastewater and drinking water, respectively. In addition, the EPA does have a manual regarding guidelines for water reuse that can be of assistance. Outside of these constraints, the EPA delegates permitting of specific wastewater reuse operations to the states.

Currently, the State of Texas does not prohibit potable reuse. Chapter 310 of Title 30 of the Texas Administrative Code provides guidelines for use of reclaimed water. There are no specific guidelines for direct or indirect potable reuse other than all reuse projects must receive approval from the executive director of the TNRCC. Therefore, potable reuse projects will be evaluated on a case-by-case basis. It is essential to involve TNRCC early in this potable reuse assessment. Similarly, it is important to involve concerned local agencies. Agencies should be identified that have specified responsibility in the following areas:

- Public health
- Water quality standards
- Development of reclamation policy and/or requirements
- Water ownership issues
- Permit requirements
- Potential funding sources

Close involvement with such agencies is paramount to development of a potable reuse implementation program that: encourages objective consideration of each project, serves as a catalyst for the development of potable reuse regulations, and/or informs responsible agencies of the benefits and safety of the potable reuse project.

6.6 Public Acceptance

Public acceptance is generally the most crucial element in determining the success or failure of a potable reuse project--particularly because regulatory agencies often have political ties susceptible to public sentiment. A potable reuse project could be technically viable, the recovered water proven safe by the best scientific procedures available, and regulatory agencies poised for acceptance, but the project could still fail due to lack of public acceptance. A public education program covering the following subjects is vital to the success of a potable reuse program:

- The need for additional water supplies
- The availability of additional water supplies
- The cost of additional water supplies

- The environmental impact of developing additional water supplies
- The status of potable water recovery technology
- The safeguards incorporated in potable water recovery and reuse processes such as multiple barriers, extensive monitoring, and possible blending of the recovered water with another water source

Independent surveys conducted by the Denver Water Department (1982) and City of Colorado Springs Utilities Department (1994) to assess public sentiment regarding potable reuse both demonstrated wide support for potable reuse, so long as the issues noted above were competently addressed and explained. The public overview/input of the current phase of the Edinburg/McAllen Reuse Feasibility Study involves the three meetings with the CAC as described in Section 1.2 Public Participation. The public acceptance program for subsequent phases of the project would be more rigorous. A suggested public acceptance program for the subsequent phase is attached as Appendix E.

7. POTENTIAL FOR NONPOTABLE REUSE

The focus of this study is the feasibility of potable reuse. However, the opportunities for nonpotable reuse, like conservation, represent another way to bring potable demands in line with available supplies. Nonpotable reuse lessens some of the obstacles to potable reuse, such as public health and public opinion, and normally requires less treatment and hence less cost than potable reuse.

7.1 Major Water Customers

Major water customers in McAllen and Edinburg, as identified by the Cities, are listed in Table 7.1. A cursory review of these lists suggests most of the customers are not good candidates for non-potable reuse. Most are institutional or residential in nature and irrigation or other nonpotable uses would not represent a sufficient portion of their usage to justify the cost of providing a separate source. There are a few businesses which may be candidates for reuse if they are located near a wastewater treatment plant, and these should be explored further by the respective Cities. However, the water savings, while important, are not likely to significantly alter the long range water supply situation for either City.

7.2 Agricultural Use

From a technical standpoint, agricultural reuse may represent the most feasible opportunity to take advantage of reclaimed wastewater as a water resource. There is a concern that the high dissolved salts may be detrimental to crops; this would have to be examined on a case-by-case basis. For crops intended for human consumption, the fate of pathogens would be an important consideration. Both these obstacles appear manageable. The greater difficulty may lie in obtaining support and cooperation of various entities with a stake in water supply and agriculture. The evaluation of this situation is beyond the scope of this study, but agricultural reuse should be considered as one of region's alternatives for water management.

Table 7.1
Major Water Customers

	Total Use (MG)		
McAllen	**1993**	**1994**	**1995**
Coca Cola Bottling Co.		61.72	57.54
Delicious Valley Frozen Food 1		60.41	42.77
Rio Grande Regional Hospital			39.65
Palmview Condos		36.87	
Delicious Valley Frozen Food 2		32.44	21.32
McAllen Medical Center 1		25.43	25.37
Aviall Services Inc.		20.67	15.60
McAllen Medical Center 2		20.11	21.36
Roc Properties Inc.		16.10	10.49
I Kunick Co.		14.17	10.80
City of McAllen Baseball Co.		14.10	20.62
Paradise Park		13.67	14.15
Mid Valley Ind.			13.63
Twin Palms Association		12.46	10.57
Calmac Suites LTD.		11.87	11.86
Loop Cold Storage Co.		11.20	14.93
La Vista Mobile Park		11.05	12.49
W. H. Hammonds		10.16	9.67
Las Palmas Apartment			10.06
City of McAllen Parks & Rec.		9.65	11.41

	Total Use (MG)		
Edinburg	**1993**	**1994**	**1995**
University of Texas Pan American	92.31	86.49	85.63
Azteca Milling	91.84	75.41	107.00
Edinburg Consolidated Ind. School District	53.51	63.30	79.62
City of Edinburg	45.34	26.08	29.19
Hidalgo County	38.05	45.04	38.60
Rio Grande Bible Institute	15.76	15.02	14.67
Edinburg Hospital	15.24	15.76	16.94
Citrus Mobile Home Park	11.49	21.25	13.01
Edinburg Manufacturing Company	10.82	8.38	15.27
International Paper	7.76	6.82	8.23
Sharyland Water Supply Corporation		61.12	72.46
Texas Department of Criminal Justice			22.04
Live Oak Mobile Home Park			12.70
Edinburg Village			12.00
Inland Containers Company			11.50

APPENDIX A
PUBLIC ADVISORY COMMITTEES

City of Edinburg

Pearl Mathis
Elias A Zuniga
Francisco Martinez
Mateo Solis
Steve Pickering
Minerva Gomez
Linda Gardner
Norma Hodge
J. Castillo
Graciela Sepulveda
Martha Noelle
Harlan Bentzincer
Francis Luna
John Mappes
Ms. Candy Sams
Andy Sanchez
Dianca Chapa
Joe Zamora
Cynthia Acevedo
Art Garcia
Ceasar Villareal

City of McAllen

Mr. Danny Boultinghouse, A.I.A.
Mr. Ronny Cruz, P.E.
Mr. Paul Moffitt
Mr. Jaime Enriquez, P.E.
Mr. Tony Aguirre

APPENDIX B
WATER QUALITY SAMPLING PROGRAM
LOWER RIO GRANDE VALLEY DEVELOPMENT COUNCIL
EDINBURG/McALLEN REUSE FEASIBILITY STUDY

	City of McAllen						City of Edinburg		
	Raw Water Reservoirs		Finished Water		Wastewater Effluent		Raw Water Reservoir	WTP Finished Water	Waste–water Effluent
Parameter	No. 1	No. 2	WTP No. 1	WTP No. 2	WWTP No. 2	WWTP No. 3			
Primary									
Nitrate	Q	Q	SA	SA	Q	Q	Q	SA	Q
Sodium	Q	Q	SA	SA	Q	Q	Q	SA	Q
Pesticides	Q	Q	SA	SA	Q	Q	Q	SA	Q
Secondary									
Total Organic Carbon	Q	Q	SA	SA	Q	Q	Q	SA	Q
Total Dissolved Solids	Q	Q	SA	SA	Q	Q	Q	SA	Q
Sulfate	Q	Q	SA	SA	Q	Q	Q	SA	Q
Other									
Alkalinity	Q	Q	SA	SA	Q	Q	Q	SA	Q
Ammonia–N	Q	Q	SA	SA	Q	Q	Q	SA	Q
Nitrite–N	Q	Q	SA	SA	Q	Q	Q	SA	Q
Bromide	Q	Q	SA	SA	Q	Q	Q	SA	Q
Conductivity	Q	Q	SA	SA	Q	Q	Q	SA	Q
Phosphorus	Q	Q	SA	SA	Q	Q	Q	SA	Q
Giardia lamblia	SA	SA			SA	SA	SA		SA
Cryptosporidium	SA	SA			SA	SA	SA		SA

M = Monthly   Q = Quarterly   SA = Semi–Annually   SUM = June, Aug

APPENDIX C
CITY OF McALLEN LEGAL OPINION ON EFFLUENT RIGHTS

CITY OF McALLEN
MEMORANDUM

MAY 1996
Public Utilities

TO: Wm. Bart Hines, P.E., Utility Manager

FROM: James E. Darling, City Attorney

SUBJECT: Request for Legal Opinion from Freese-Nichols Relating to Water Discharge Under Existing Statutes, City Water Rights, and City Discharge Permits

DATE: May 3, 1996

COMMENT

You have asked the City Attorney's Office to issue a legal opinion at the request of Freese-Nichols relating to the water re-use program. The questions, as contained in the Freese-Nichols request, are as follows:

1. "Do any of the City's water rights require discharge of water after use?"

The City receives its water under the Certificates of Adjudication which were issued to Water District Number 2, 3, and United Irrigation District. These certificates of adjudication do not mention or have any specifications relating to return of water. The certificates of adjudication deal strictly with the amount of water available, the point of diversion, and the type of water usage. The Water Code, which deals with the application for permits and the use of State waters, does not require a return of water to the water shed. The Water Commission rules and regulations deal with the appropriation and diversion of water, and not return of water to the water shed.

We have reviewed the City's discharge permits which are issued by the EPA and find no restrictions as to the requirement of discharge. The only restrictions relate to the quality of a discharge, if and when discharged. Therefore, it our opinion that there are no restrictions requiring the City's discharge of the water after the use. The water could be 100% consumed.

2. "Can the use of treated wastewater effluent be construed as additional use of water, and counted against the City's water rights?"

The Water Code does not provide for the re-use of water as counting against water usage. The water rights usage are measured as a result of diversion from the water source, which is the Rio Grande River. The reuse of water out of the City's water plant would not be considered an appropriation of water as it would not be returned to a tributary or stream constituting State water. In a similar situation in Laredo, the City of Laredo try to receive a credit for the discharge of its sewer water into the Rio Grande River. The Water Commission took the position that they could not receive credit for return of water as they had the right to use 100% and the discharge point was below the diversion point. Under the same analogy, since the water is not being returned to the river and then subsequently discharged or diverted from the river, there would be no credit and/or charge back to the City. The City's certificates of adjudication and the District's certificates of adjudication do not provide for a charge back against the diverter for reuse of the water.

3. "What restrictions are imposed by the water rights permits/agreements on the types of water use/reuse?"

The City's and District's certificates of adjudication limit the water use to municipal purposes. Therefore, if the reused water is used for the same purposes by which the water was originated to the sewage treatment plant, there would be not restriction on the reuse of the water under the certificates of adjudication. The City's EPA discharge permit obviously has restrictions relating to quality, but not specifically on the ability to use the water from a restriction on the source, or the right to reuse water from the standpoint of the "ownership" of the water.

4. "Does anyone downstream of the wastewater effluent discharges have a legally enforceable interest in the continued flow of effluent?"

No downstream user has a permitted right to use the City's effluent discharge from the sewage treatment plant. The City does have an agreement with an irrigation district to use the district's drainage facilities for the conveyance of the water via the Water District No. 1 to the County's outfall. However, there is no appropriative rights either by the two governmental entities issuing drainage permits or any property owner to require the flow by the City of McAllen into the discharge system. Therefore, it is our opinion that no one has any legal right to legal enforceable interest in the continued flow of the effluent.

If you have any other questions or comments, please do not hesitate to contact me.

JED/vp

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APPENDIX D
POTABLE REUSE PROJECT DESCRIPTIONS

The following descriptions are provided to augment the information in Table 6.1:

Whittier Narrows. At Whittier Narrows, near Los Angeles, California, disinfected tertiary effluent (dual media filtration) from a 10-million-gallon-per-day (mgd) water reclamation plant is spread on the ground for infiltration to an underground potable water supply. This operation provides an average of 16 percent of the total inflow to the groundwater basin. Depending on the physical characteristics, location, and pumping history of a given well, the population drawing potable water from the groundwater basin is estimated to be exposed to a reclaimed wastewater percentage ranging from 0 to 23 percent. After extensive data acquisition, evaluation, and statistical analysis, no measurable adverse health effects have been correlated to the use of the groundwater replenished with recovered water.

Water Factory 21. The 15-mgd Orange County California Water District's Water Factory 21 facility reclaims unchlorinated secondary effluent to drinking water quality and recharges it into a heavily used groundwater aquifer to prevent salt water intrusion. The water recovery treatment includes lime clarification, air stripping, recarbonation, filtration, carbon adsorption, slip-stream reverse osmosis, and disinfection. Estimates project that no more than 5 percent of the recovered water actually enters the domestic supply. The Orange County Water District has found no evidence that indicates that this indirect potable reuse practice poses a significant risk to users of the groundwater.

Upper Occoquan Sewage Authority. The recently expanded 27-mgd Upper Occoquan Sewage Authority (UOSA) Water Reclamation Plant reclaims wastewater for discharge to the 11 billion gallon Occoquan Reservoir. The Occoquan Reservoir is a critical source of drinking water for about 1 million people in Northern Virginia. During extended droughts, the plant discharge has accounted for as much as 90 percent of the flow into the reservoir. The reclamation treatment includes primary treatment, secondary treatment, biological nitrification, lime clarification and recarbonation, filtration, activated carbon adsorption, and disinfection. Due to the positive reservoir response to the reclaimed water inflow, the plant will be further expanded to 54 mgd over the next several years. No negative health effects attributable to the plant or effluent discharges have been reported since the plant has been in operation.

Tahoe-Truckee. The 4.83-mgd Tahoe-Truckee Sanitation Agency Water Reclamation Plant also uses advanced wastewater reclamation processes to recover water suitable for release to the Truckee River that is used as a water supply by the City of Reno, Nevada.

Denver Potable Reuse Demonstration. Although not currently in use, the 1-mgd Potable Reuse Demonstration Plant in Denver, Colorado was designed to evaluate the feasibility of direct potable reuse of secondary treated municipal wastewater. After seven years of testing and evaluating alternative treatments, a conventional plant potable water recovery system comprised of lime clarification, recarbonation, filtration, ultraviolet light intermediate disinfection, carbon adsorption, reverse osmosis, air stripping, ozone primary disinfection, and chloramine secondary disinfection was selected for comprehensive health effects testing. The findings of this extensive research effort, issued in 1993 by the Denver Water Board, unequivocally verified the ability of advanced water treatment processes to reliably remove a broad spectrum of pollutants and render a product which satisfies every currently known measure of drinking water safety.

Fred Hervey Plant. The 10-mgd Fred Hervey Water Reclamation Plant in El Paso, Texas reclaims water which is recharged to a drinking water aquifer where over a 2-year period, the water travels to one of El Paso's potable water well fields to become part of the potable water supply. The treatment of raw wastewater to recharge quality water includes: primary treatment, activated sludge/powdered activated carbon treatment, lime treatment, recarbonation, filtration, ozonation, and granular activated carbon adsorption. No negative health effects have been correlated with this practice, but some increase in the total dissolved solids content of the aquifer has occurred. Future plant expansions will include slip-stream demineralization to address this concern.

Tampa Pilot Plant. The City of Tampa, Florida's Water Resource Recovery Pilot Plant project was designed to evaluate the feasibility of reclaiming denitrified secondary effluent to a quality suitable for blending with existing surface water and groundwater sources for indirect potable reuse. Several alternative treatments were evaluated and one was selected for health effects testing after 2 years of evaluation. The treatment selected included: aeration, high pH lime clarification, recarbonation, filtration, granular activated carbon adsorption, and ozonation. Final results of the study were documented in 1993. The results of the whole animal health effects testing coupled with the microbiological and chemical analyses performed revealed that the quality of the reuse product water is equivalent to or exceeds the quality of the Hillsborough River raw water supply. The City of Tampa is planning on implementation of a 20 to 50 mgd Water Resource Recovery Plant in the near future.

Phoenix Feasibility Study. The City of Phoenix, Arizona conducted a potable reuse feasibility study to evaluate the cost-effectiveness, institutional constraints, and social constraints associated with direct potable reuse. The feasibility study results suggested that potable reuse is cost competitive with other alternative water supply development projects for this desert city. The state, county, and local health departments participated in project workshops to develop the most desirable potable reclamation approach. Consequently, the concept of potable reuse gained regulatory favor. Phoenix now recognizes potable reuse among other alternatives as a viable future water source. Neighboring Scotsdale, Arizona is planning to implement indirect potable reuse via groundwater recharge in the near future.

West Basin Barrier Project. The West Basin Municipal Water District's Water Recycling Program includes reclaiming 5 mgd expandable to 20 mgd of secondary effluent from the City of Los Angeles' Hyperion Treatment Plant for injection into the West Coast Basin Barrier Project. The West Coast Basin Barrier Project was constructed in the 1950's and 1960's to inject imported water into the coastal reaches of local South Bay aquifers for mitigation of saltwater intrusion. The Barrier has historically received an average of about 20 mgd of potable water. Substitution of reclaimed water for potable water provides substantially greater water use efficiency in southeast Los Angeles County. Reclamation treatment includes pre-decarbonation, lime clarification, recarbonation, filtration, reverse osmosis, post-decarbonation, and final disinfection. A baseline groundwater monitoring program was conducted in advance of the recycling project to allow assessment of reclaimed water impacts on the aquifer water quality. Based on hydrogeologic investigation and modeling of the West Coast Basin, it is anticipated that the reclaimed water will improve groundwater quality along the Barrier due to the high quality of the reclaimed water relative to the imported water and native groundwater. The system meets California Department of Health Services (CDHS) proposed regulations for groundwater recharge.

<u>San Diego</u>. The CDHS has given conceptual approval to the City of San Diego's indirect potable reuse project. The City plans to reclaim up to 20 mgd of secondary effluent for augmentation of their 90,000 acre-foot San Vicente Reservoir where it will blend with imported water prior to passage through the City's Alvarado Water Treatment Plant. The North City Water Reclamation Plant is currently under construction and is scheduled to go on line in 1997. As part of their approval of the City's indirect potable reuse project, CDHS included a series of reservoir storage requirements which include:

- Repurified water shall comprise no more than 50 percent of the reservoir water withdrawn over any 36-month period.
- Methods for introducing and withdrawing repurified water from the reservoir shall be designed to minimize short circuiting.
- A 12-month mean theoretical detention time shall be maintained at all times.
- During times the reservoir is stratified, repurified water shall be introduced above the thermocline, and withdrawals shall be from below the thermocline.

This conceptual approval expands existing CDHS policy to allow repurified water to supplement drinking water supplies stored in local reservoirs. Currently, repurified water for drinking and other domestic purposes may be stored only in groundwater basins. Based on this action, it is anticipated that the CDHS will ultimately have regulations in place to govern indirect potable reuse via both groundwater recharge and surface water augmentation. In the past, indirect potable reuse projects have been evaluated on a case-by-case basis. Regulations will foster more expeditious evaluation and approval of indirect potable reuse in California which will set a standard for other states to consider.

APPENDIX E

APPENDIX E
RECOMMENDED PUBLIC ACCEPTANCE PROGRAM

The following 10-step approach to public involvement is reprinted from the November 1995 issue of the American Water Works Association publication *Opflow*. This is a summary of a handbook published by the AWWA Research Foundation, *Public Involvement Strategies: A Manager's Handbook.*

Step 1: Frame the problem.

"Framing" sets boundaries that help you focus on the actual problem. Boundaries clarify the issues that need to be solved and those that do not. Effectively framing a problem means describing the project need and the facts that will be useful for making decisions.

Step 2: Identify constraints.

Identifying constraints helps determine which issues can be negotiated with the public and which cannot. There are internal and external constraints. Internal constraints may include scheduling, regulatory or political mandates, or spending limits. An external constraint may be a lack of credibility with the public.

Step 3: Identify and describe decision steps and project milestones.

Public involvement means that you, as a utility manager, will benefit by talking with people about a project's tradeoffs, costs, and impacts. If you identify a project's decision steps early, you will improve your ability to see where public input can be included in project decisions. You can also identify the information that members of the public need so they, in turn, can provide meaningful input.

Step 4: Identify and understand potentially affected stakeholders.

Your public probably consists of various interest groups who have different values. These interest groups are called "potentially affected stakeholders" because they have a "stake" in the outcome of the decision. Using a proven method to clarify stakeholder interests early in your process, means that you'll probably avoid strong controversy or lawsuits.

Step 5: Determine vulnerability and must-resolve issues.

How vulnerable are you to external pressures? The level of vulnerability may differ from one project or utility to the next. The objective of planning for public involvement is to focus on "must-resolve" issues that involve stakeholders who really want to be involved. Those who are not interested should be provided with enough information to feel that they are invited and that the decision to participate is theirs, not yours.

Step 6: Determine the appropriate level of public involvement.

All public involvement processes are not created equal. As a manager, you can do a variety of things to help build public consensus. One-way communication is at one end of the range while two-way communication, where stakeholders may have the ability not only to influence the project but also to help craft and guide the outcomes, is at the other end.

Step 7: Select processes and techniques.

The techniques available for public involvement vary in purpose, cost and ease of use. You can save money, time, and unnecessary frustration by completing the first six steps before selecting the appropriate techniques. (The handbook provides a catalog of useful public involvement techniques.)

Step 8: Develop a public involvement work plan.

A work plan for public involvement clarifies the roles and expectations of staff, serves as a reference point for the duration of the project, and can be reviewed by senior mangers, elected officials, and project stakeholders to obtain support for the consensus-building efforts.

Step 9: Implement and monitor the work plan.

Public involvement plans, once implemented, must be monitored periodically to ensure that

- The frame of the problem has not changed (it often does).
- The issues and stakeholders remain valid.
- The techniques used are effective.

Step 10: Manage change.

Changes, which include project schedules, the political landscape, staff, regulatory requirements, and technical assumptions, influence your public involvement process. Adapting to fit new circumstances while still maintaining your credibility with the stakeholders is a key to maintaining the effectiveness of your problem-solving process.

LOWER RIO GRANDE VALLEY
DEVELOPMENT COUNCIL

EDINBURG/McALLEN REUSE FEASIBILITY STUDY

TECHNICAL MEMORANDUM NO. 2
TREATMENT PROCESS EVALUATION & SELECTION

AUGUST 1, 1996

Prepared For:

Lower Rio Grande Valley
Development Council
City of Edinburg
City of McAllen
Texas Water Development Board

Prepared By:

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CH2M Hill
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LRV96107
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TECHNICAL MEMORANDUM NO. 2
TREATMENT PROCESS EVALUATION AND SELECTION

LIST OF TABLES

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1. EXECUTIVE SUMMARY

1.1 Introduction

This Technical Memorandum (TM) addresses the water quality and public health issues involved with the proposed reuse of reclaimed water for planned, indirect potable reuse in the Edinburg and McAllen domestic water systems. This memorandum is to aid in the treatment process evaluation and the selection of a suitable treatment scenario. The treatment scenarios proposed employ multiple contaminant barriers, providing more than one unit process capable of treating the physical, chemical, and microbiological contaminants of concern. Multiple contaminant barriers provide treatment reliability. When additional contaminant barriers are available, the failure of one unit process to effectively remove a contaminant does not preclude effective overall treatment.

Several states[1] have developed regulations to control the reuse or reclamation of treated wastewater and provide public health protection. While the original regulations sought to control microbial organisms and the acute threat of infectious disease, now the primary focus is on man-made organic chemicals and metals that may present a long-term threat to human health. From a microbial standpoint, the threat of disease transmission from organisms in untreated wastewater is real. Despite this threat and the limitations of epidemiological investigations, properly operated and controlled water reuse in the United States has not been implicated as the cause of any infectious disease outbreaks. Although there have been isolated instances where improperly treated wastewater was implicated with sickness, none were associated with reuse operations complying with all regulatory requirements. The challenge to both the public health community and the water reuse industry is to continue to develop treatment technology and reuse criteria that will eliminate or minimize disease risk and still permit the "beneficial direct use" of treated wastewater. This may be done by either separating the population at risk from the reclaimed water or eliminating the threat via appropriate treatment.

Generally, the regulations attempt to match the appropriate treatment with the degree of exposure and the population at risk.

---

[1] Regulations and/or guidelines for broad scale wastewater reuse are known to be in place in 20 states including Arizona, California, Colorado, Florida, Georgia, Hawaii, Oregon, Texas, Utah, Virginia, and Washington.

In terms of the population at risk:

- Very young, elderly, and sick are at higher risk than the normal population which are at a higher risk than healthy workers

In terms of exposure the risk varies from high to low:

- Complete immersion or ingestion is more risky than being exposed to aerosol or spray contact which is more risky than secondary contact.

In terms of the duration of exposure:

- Constant exposure creates a higher risk than periodic worker contact which is a higher risk than casual exposure

Appropriate treatment will eliminate or minimize the risk in the reuse operations identified, and these safeguards, used in conjunction with monitoring and process redundancy and control, will ensure a project that adequately protects the public health. The four elements that must be observed are appropriate treatment, system monitoring, periodic sampling, and system redundancy.

1.2 Environmental Effects

The primary focus of this memorandum is the evaluation of the potential impact of wastewater reuse on water quality and appropriate treatment processes to protect public health and maintain production of high quality drinking water. An additional area of concern is the potential for environmental impacts due to changes in the quantity of wastewater effluent discharged. A preliminary investigation of this issue indicates little impact from the reduction in these flows. Available data indicates the discharge from the McAllen Wastewater Treatment Plant (WWTP) No. 2 represents a small portion of flow in the Arroyo Colorado, and even a total elimination of this flow would likely have little environmental impact. The Edinburg WWTP and McAllen WWTP No. 3 discharge to the North Floodway, which has only intermittent flow, and limited aquatic life. It is therefore unlikely that a reduction in wastewater discharges will adversely affect this stream segment, which is undesignated by TNRCC.

Both the Arroyo Colorado and the North Floodway discharge to the Laguna Madre, and thus a reduction in wastewater discharge would reduce flows to the Laguna Madre. However, similar to the Arroyo Colorado, the inflow to the Laguna Madre is not expected to be significantly affected by a reduction in wastewater flows from Edinburg and McAllen. It should also be noted that current wastewater discharges are derived from Rio Grande River diversions and are therefore supplementing historical flows to the Arroyo Colorado and Laguna Madre. A more detailed memorandum discussing the impact of effluent discharge reduction is included as Appendix A.

2. WATER QUALITY ISSUES

In general, one should be concerned with maintaining compliance with the primary (health effects) drinking water standards, and to the maximum extent possible, the secondary (aesthetic) drinking water standards. Primary drinking water standards dictate microbial water quality (bacteria, viruses and other pathogens), nitrogen as nitrate, total organic carbon as represented by disinfection by-products, and any acutely toxic compounds or elements that may compromise public health. From a secondary standpoint, one is concerned with total dissolved solids (TDS), chloride (Cl), sulfate (SO_4), and any other compound that may create an adverse taste or odor in the treated water.

The Texas Administrative Code [Chapter 310] contains criteria for controlling public exposure [Section 310.6], for microbiological water quality [Sections 310.8, 310.9, 310.10, and 310.11], and for sampling and analysis of the reclaimed water [Section 310.12]. These criteria are designed to protect public health for various types of non-potable reuse. The microbiological quality requirements vary from 75 to 800 fecal coliform Colony Forming Units per 100 milliliters (CFU/100mL) depending upon the non-potable use.

Texas currently has no specific criteria for potable reuse, but the end product is subject to drinking water standards which are more stringent than the reclaimed water criteria. The Safe Drinking Water Act (SDWA) sets out to regulate organics, inorganics, radionuclides and microbial limits in the form of MCLs. A more detailed list of the USEPA limits and intentions can be found in the March 1996 issue of *AWWA Journal*. The article is included as Appendix B. The Drinking Water Standards do not allow measurable concentrations of fecal coliform, and require water utilities to demonstrate an absence of Total Coliform in at least 95 percent of the samples. An additional constituent which must be monitored is nitrate (or total nitrogen) in the effluent. Other constituents of concern are the minerals which may impact plant life.

2.1 Viruses

More than 100 different types of human enteric viruses may appear in wastewater. Viruses are unable to replicate outside a living host and eventually lose their infectivity with exposure to the outside environment.

Health effects from these viruses range from gastroenteritis to diseases involving the central nervous system. Other organs, such as the skin and the heart, may also be affected. Most of the evidence relating waterborne viruses to public health effects comes from epidemiological studies correlating reported localized outbreaks of infection with water treatment.

The effective oral dose is not known for most viruses. The poliovirus infection, however, has received considerable attention. At the cellular level, the infection appears to be initiated by as few as one nondefective particle if the cellular tissue environment is a suitable host for the virus. Ineffective doses for tissue cultures have not been shown to be analogous to effective doses for oral ingestion by humans. Studies of poliovirus suggest that a 10^5 tissue-culture dose is an average minimal reliable dose to cause infection by the oral route; however, much remains to be learned about viral etiology.

Consequently, a no-effect concentration of viral contamination has no valid basis at this time. Also, viral recovery and identification are time-consuming and are currently ineffective monitors of water quality for the timely protection of public health. Bacteriological monitoring methods (coliform count and standard plate count) remain the most time-effective tools for evaluating the presence of intestinal pathogens in water, although bacterial indicators have a limited correlation with viral contaminants.

G. Berg defines the suggested water quality criteria for viruses in *Reassessment of the Virus Problem in Sewage and in Surface and Renovated Waters* (1973). He suggests that reclaimed wastewater for potable reuse should be treated to remove and/or inactivate 12 logarithmic units of a reference virus at 5°C and that the finished water should contain no more than 1 plaque forming unit (PFU) in a 100-gallon sample. However, finished waters have been shown to have greater than 1 PFU per 100 gallons, with no outbreak of human illness having been established. Hence, drinking water safety, from a viral standpoint, cannot currently be quantitatively defined.

Unit operations in water treatment are effective for removing and/or inactivating viruses. The following processes provide examples of performance efficiency:

- Coagulation and Settling - 1 to 2 logarithmic units of removal
- Water Softening - 2 to 4 logarithmic units of removal and/or inactivation at a pH near 11
- Filtration - 1 to 2 logarithmic units of removal following proper coagulation
- Disinfection - Remaining virus can be inactivated by chemical disinfection.

Treatment to provide a zero concentration of viruses is impractical. Testing increasingly larger samples of treated finished water will, in some instances, result in virus detection. In general, current treatment technology, when conscientiously applied, can consistently produce reclaimed water that is not likely to pose a public health threat.

2.2 Bacteria

The primary bacterial agents that have been shown to cause human intestinal disease associated with drinking water include the *salmonella* species, the *shigella* species, *vibrio cholerae*, the *leptospira* species, *yersinia enterocolitica, francisella tularenis, escherichia coli* (specific pathogenic strains), and *pseudomonas aeruginosa*.

Unlike viruses, bacteria can replicate outside a living host and have varying resistance to environmental stresses. Like viruses, the results of epidemiological studies comprise most of the evidence relating waterborne bacteria to public health effects. The effective oral dose of enteric bacterial pathogens is about 100 viable cells for the *shigella* species, 10^5 viable cells for the salmonella species, and 10^8 viable cells for *pathogenic escherichia coli*. Isolation and identification of specific pathogenic bacteria are difficult because:

- No single test can be used to identify all the types of bacteria.
- Many of the methods have limited accuracy.
- None of the available procedures are suitable for quantifying small numbers of bacteria in water.
- The procedures require considerable lab technician expertise.

The old drinking water standard of 1 coliform per 100 mL sample did not exclude the possibility of an individual acquiring an infection. However, when combined with responsible water treatment and supply, it has been an effective standard for adequately protecting public health. The new standard of zero coliforms per 100 mL sample of drinking water will provide increased public health protection. Because bacteria are more sensitive to disinfection than viruses are, treatment for removing viruses will, in general, provide adequate removal and inactivation of bacteria. Fortunately, treatment technology is now available to adequately protect public health not only from bacterial pathogens, but also viral pathogens.

2.3 Protozoan

The protozoan parasites associated with major public health concerns are *entamoeba histolytica, giardia lamblia,* and *cryptosporidium*. These organisms only replicate inside a live host, usually the human large intestine, and are excreted in feces. *Entamoeba histolytica* has been found to be responsible for dysentery, and *giardia lamblia* and *cryptosporidium* have been found to be responsible for waterborne outbreaks of gastroenteritis.

The median protozoan effective dose ranges from 10 to 100 viable cysts, and could be as low as 1 cyst. Although the cysts of these organisms are not completely inactivated by usual chlorine disinfection, most cysts will be removed by sedimentation and filtration with proper coagulation pretreatment.

The new surface water treatment rule requires the filtration of surface water supply sources and maintenance of a filtered water turbidity of less than 0.5 NTU in 95 percent of the monthly measurements. This rule is largely based on the control of protozoan parasites and helminths in drinking water sources increasingly subject to pollution.

2.4 Helminths

The most important helminths, or intestinal parasitic worms, transmitted in water in the United States include *ascaris lumbricoides* (stomach worm), *trichuris trichiura* (whipworm), *ancylostoma duodenale* and *necator americanus* (hookworms), and *strongyloides stercoralis* (threadworm).

Stomach worms and whipworms are transmitted directly from one host to another by ingesting their eggs, which harbor infective larva. Hookworms and thread worms produce infective larva that generally gain entry into their new host by penetrating the skin and then maturing in the intestinal tract.

All of these parasites are soil-transmitted parasites and can enter the water supply system from surface runoff during heavy rains. Their large size practically ensures that they will be removed by conventional water clarification and filtration processes. Because none of these worms can replicate in the host, the likelihood that a serious worm infection will occur in humans from ingesting properly clarified and filtered water is very low. Consequently, helminthic infections are not likely to be transmitted through reclaimed water systems.

2.5 Water System Overview

The following paragraphs describe the constituents most likely to determine the suitability of the Edinburg and McAllen effluents to supplement the municipal water supplies.

> Microbial Contamination. It is known that there are bacterial pathogens (as measured by coliform), viruses and other pathogens in the raw (untreated) source water currently supplied to the McAllen and Edinburg water treatment plants, and in the treated secondary wastewater effluents. The concentration of microbial pathogens is generally greater in wastewater, and blending of the supply will increase the risk associated with drinking water. This increased risk may be mitigated by disinfection or additional treatment of both the reclaimed water and the drinking water. Infectious disease caused by microbial pathogens is an acute risk, and the drinking water standard for coliform bacteria is basically "zero".
>
> Nitrogen. The current drinking water standard for nitrogen, as represented as nitrate (NO_3), is 45 milligrams per liter (mg/L), or 10 mg/L as N. This standard is intended to protect children less than 6 months of age from acute methemoglobinemia, also known as "blue baby syndrome". For the purposes of assessing the impacts of nitrate, it is assumed that all nitrogen compounds are capable of being converted to nitrate. Nitrogen may be removed from reclaimed water by ion exchange, membrane

filtration (reverse osmosis) or biological de-nitrification. Nitrate may also be reduced by blending with lower nitrate sources.

Total Organic Carbon. Total organic carbon (TOC) can be either a naturally occurring compound or man made compounds such as hydrocarbon compounds. Naturally occurring TOC is a problem due to the formation of disinfection by-products, such as trihalomethanes (THMs), when chlorine is used for disinfection. The current drinking water standard for THM, 100 parts per billion (ppb), will be lowered to 80 ppb under a proposal currently being developed by USEPA. Drinking water standards for some man made compounds, such as benzene, are in place, and TOC levels greater than 4 mg/L in untreated drinking water will require additional treatment by water utilities. TOC can be reduced by additional coagulation, filtration with granular activated carbon, membrane filtration, and biological treatment. All of the TOC related drinking water standards are based on long-term chronic exposure, rather than acute risk.

Acute Toxicity. From a preliminary inspection of the data, there do not appear to be any acutely toxic compounds identified in the reclaimed water, but additional data is required to complete this analysis.

Secondary Compounds. The SDWA also provides for secondary standards in addition to the primary standards. These standards prescribe maximum limits for those contaminants that tend to make water disagreeable to consumers, but do not have adverse health effects for the general public. Preliminary inspection of the data indicates that the secondary standards for TDS and sulfate are exceeded at this time in the McAllen and Edinburg water supply. These constituents and other dissolved salts are increased in the wastewater, and limited data indicate additional parameters of concern in the treated effluent. Effluent chloride exceeds the SDWA standard, and sodium exceeds the USEPA recommended value for individuals with acute hypertension. The only practical way to reduce dissolved salts is via a membrane process such as RO or EDR.

3. IMPACT OF REUSE ON RAW WATER QUALITY

3.1 Criteria Comparison

This section discusses the unit processes commonly included in potable water recovery plants to provide multiple contaminant barriers.

The removal of a contaminant is considered a relative measure of the ability of a unit process to act as a barrier to that contaminant. Potable water recovery systems should contain considerably more contaminant barriers than a conventional water treatment plant, because wastewater is typically of poorer quality than a conventional surface water or groundwater supply.

Unit processes traditionally included in a potable reuse facility include:

- Biological treatment (with or without nutrient removal)
- High lime treatment with recarbonation
- Filtration
- Granular activated carbon
- Demineralization (membrane treatment)
- Disinfection

Under the Safe Drinking Water Act, every state is granted Program Primacy in approving water sources for public water supply. It is the designated agency's call as to whether or not a given source is of acceptable quality and of acceptable risk. The TNRCC has indicated that all potential effluent to be reclaimed for potable reuse must be treated to meet or exceed the level of current Rio Grande River water quality. Table 3.1 compares current water quality at McAllen WWTP #2 and #3, Edinburg WWTP, and Rio Grande raw water, and lists acceptable minimum standards prior to effluent discharge into any existing or proposed reservoirs. Data currently available for the Rio Grande raw water source and the three wastewater treatment plants are incomplete. Other considerations to be addressed include enteric viruses, Cryptosporidium, Giardia lamblia, protozoa, coliphage, E-coli, fecal coliforms, heterotrophic bacteria and Legionella.

Table 3.1
Water Quality Comparison

Constituent	McAllen WWTP #2, #3	Edinburg WWTP	Rio Grande Raw Water	Acceptable Requirements
Alkalinity as $CaCO_3$, mg/L			**[5]130**	
Ammonia Nitrogen, mg/L	***3, *1**	***3**	**[4]0.08**	**1-5**
BOD, mg/L	*10, *20	*10	2.5	5-15
Bromide, mg/L				
Calcium, mg/L	78			
Chloride, mg/L	338		[5]181	[1] 300, [3] 100
Chlorophyl, µg/L			[5]12.05	
Conductivity µhos/cm			**[5]1,357**	
Cryptosporidium				
DO, mg/L	*4 (7.5 Avg.)	*4 (4.5 Avg)	[5]8.8	
Fecal Coliform, CFU/100 mL			[5]1,172	[1]0
Giardia lamblia				
Hardness, mg/L as $CaCO_3$			300	100-500
Nitrate as N, mg/L	**11**		**[4]0.07**	**[1]10**
Nitrite as N, mg/L	**3**		**[4]3.08**	**[1]1**
pH	7		[5]8	6-8
Phosphorus, mg/L	**3**		**[4]0.1**	**2**
Magnesium, mg/L	26			
Pesticides, µg/L				
Potassium, mg/L	14			
Sodium, mg/L	**243**			**[1]20, Recommended**
Sulfate, mg/L	**375**		**[5]271**	**[1]300**
TDS, mg/L	**1,900**		**[6]1,500**	**[1]500, [2]1000**
THM, µg/L				[1]100
TOC, mg/L			**[5]5.28**	**[5]4.0**
TSS, mg/L	*15, *20	*15	[5]79	10-25
Temperature, °C			[5]23.3	
Turbidity, NTU	2.0		43	

* Permit Limits
[1] USEPA
[2] TNRCC
[3] Local Requirements
[4] TNRCC River Data below Falcon Reservoir
[5] TM-1
[6] HCD #3

Note: Shaded constituents are to be measured in the supplemental water quality sampling program as indicated in appendix B of TM-1

3.2 Management Practices to Maintain Raw Water Quality

The use of best management practices are important to guarding safety of the water supply. For example, water from a reclaimed water source is often limited to a maximum of 50 percent of the total water supply because information on the removal of refractory contaminants has been inadequate. The treatment processes normally employed in a reclaimed water treatment process do a poor job of removing refractory contaminants; consequently, their concentration increases with each use cycle. Pesticides such as lindane, and some non-polar organic compounds, and inorganic ions are examples of refractory contaminants. A percentage of wastewater will always need to be discharged to minimize concentration effects.

This percentage can be relaxed somewhat when a full stream (in contrast to slip-stream) reverse osmosis treatment is used in the reclamation process due to its superior contaminant rejection characteristics. The upper percentage limit of reclaimed water has not been established because its use as the primary source of raw water has not been developed on a community-wide basis. Rather, it is generally considered as the augmenting water source.

From the above discussion the use of reservoir storage requirements should be outlined to ensure that effluent flows do not hamper the quality of any reservoir. Methods should be determined for the introduction and withdrawal of water from the reservoirs to minimize short circuiting (immediate travel of effluent from the release point to the water supply intake structure). During different times the reservoirs are stratified, reuse water should not be introduced above the thermocline, and withdrawals should be from below the thermocline. Field studies must be performed to assess the potential for short-circuiting under non-stratified conditions. In doing this an additional level of treatment will be accomplished. There are no instances of public water supplies with a direct pipe to pipe connection between treated wastewater effluent and finished water.

A key consideration here is viral contamination. The best detection techniques for viruses today are at best 25% efficient. Thus it is entirely probable that a non-detect indication for viruses could be missing a significant population in sewage effluents. The best remedy for this dilemma is time and distance, since viruses cannot live or reproduce outside the host. Therefore, given impoundment in a reservoir for a sufficient period of time (a mean time of about 9 months to 1 year is a common goal) assurance is given of a complete die-off of any discharged virus. Time and distance also tends to launder the identity of the treated effluent and instills faith that it does indeed become a safe drinking water supply. Further, disinfection byproducts tend to go away in a reservoir through a number of phenomena in the natural environment. The only real concern over using reservoirs and streams for impoundment of sewage discharges prior to reuse is the effect of increased nutrient loading on the water quality. Excessive nutrients (Nitrogen and phosphorus) will increase algae growth and would be aesthetically displeasing. If substantial nutrient removal is practiced, this concern will also be alleviated.

The desirable reservoir detention time will be a challenge for the Cities of Edinburg and McAllen. The existing 180 MG Edinburg Reservoir provides a theoretical detention time of 18 days at the WTP design peak flow of 10 MGD. (Residence Time = volume of the reservoir / flow rate = 180 MG / 10 MGD = 18 days.) The McAllen reservoirs provide even less: 3.1 days at WTP No. 1, (13.1 MG) and 4.9 days at WTP No. 2 (Boeye Reservoir, 188 MG), based on the respective design flows of 4.2 MGD and 38 MGD.

Due to the issue of refractory contaminants addressed above, it is recommended that effluent be blended with fresh water. The blended raw water quality will vary as the amount of effluent in the blend varies. For this analysis, 30% and 50% blend scenarios were compared. Where data was unavailable for the wastewater treatment plant in Edinburg it was assumed that the effluent water quality was similar to that of McAllen. The predicted qualities are compared in Table 3.2.

Another best management practice important to the overall reuse program is the proper funding, staffing, and operations of treatment facilities. Regulators will need to be assured that both cities are dedicated to the successful execution and maintenance of any reuse system. One method which has been used to ensure this is the Composite Correction Program (CCP) as described in the EPA document by the same name. The CCP approach consists of a Comprehensive Performance Evaluation (CPE) and a Composite Correction Program (CCP). The CPE is a systematic step-by-step evaluation of an existing treatment plant resulting in a comprehensive assessment of the existing or proposed unit treatment process capabilities and the impact of the operation, maintenance and administrative practices on performance of the plant. Experience has shown the commitment of city administration to proper maintenance and operations activities is critical to the permitting of a potable reuse project.

3.3 Additional Data Needs

Additional information about treated reclaimed water quality parameters, including microbial concentrations and nitrogen series, is required. Existing soil profiles in the vicinities of the treatment plants and holding reservoirs are required to allow assessment of the soil filtration proposal, and a complete analysis of the treated drinking water is necessary to assess existing conditions.

Table 3.2
Predicted Blended Raw Water Quality

Constituent	**McAllen 30% Effluent Mix**	**McAllen 50% Effluent Mix**	**Edinburg 30% Effluent Mix**	**Edinburg 50% Effluent Mix**
Alkalinity as $CaCO_3$, mg/L				
Ammonia Nitrogen, mg/L	0.6	1.04	0.6	1.04
BOD, mg/L	6.25	8.75	4.75	6.25
Calcium, mg/L				
Chloride, mg/L	228	260	228	260
Chlorophyl, ug/L				
Conductivity umhos/cm				
DO, mg/L	8.41	8.15	7.5	6.65
Fecal Coliform, CFU/100 mL				
Hardness as $CaCO_3$, mg/L				
Nitrate as N, mg/L	3.35	5.5	3.35	5.5
Nitrite as N, mg/L	3.0	3.0	3.0	3.0
pH	7.5	7.5	7.5	7.5
Phosphorus, mg/L	1.0	1.6	1.0	1.6
Magnesium, mg/L				
Potassium, mg/L				
Sodium, m/L				
Sulfate, mg/L	302	323	302	323
TDS, mg/L	1,620	1,700	1,620	1,700
THM, ug/L				
TOC, mg/L				
TSS, mg/L	60	50	60	50
Temperature, °C				
Turbidity, NTU	31	23	31	23

Note: A mass balance method was used to calculate the blended raw water quality. The blended percentage indicates the amount of plant water used in the blend. The rest of the percentage will be made up by the raw water from the river. The following illustrates the calculation:

Edinburg BOD at 30% mix: [(30% * 10.0 mg/L) + (70% * 2.5 mg/L)] / 100% = **4.75 mg/L**

4. POTENTIAL TREATMENT TECHNOLOGIES

The current effluent at all the WWTPs will need some type of treatment to address the above mentioned water quality issues. These processes will not only address primary concerns but will also help to increase the aesthetic quality of the water. The following is a summary of candidate technologies and their potential application at McAllen and Edinburg.

4.1 Chemical Treatment

Chemical treatment involves the addition of chemicals to alter the physical state of dissolved and suspended solids and to facilitate their removal by sedimentation. In some cases the alteration is slight, and removal is effected by entrapment within a voluminous precipitate consisting primarily of coagulant itself. Chemical processes, in conjunction with various physical operations, have been developed for the complete secondary treatment of untreated wastewater, including the removal of nitrogen and/or phosphorus.

Chemical treatment can aid in the removal of phosphorus and virus/bacterial inactivation. A high lime treatment with two-stage recarbonation is one example of chemical treatment that can provide a number of barriers including the reduction of pathogen concentrations by coagulation and precipitation, and destruction of pathogens as a result of elevated pH. The precipitation of heavy metals, radionuclides, and phosphorus is also accomplished. High lime treatment is the usual method of reducing the concentrations of nearly all heavy metals to less than Safe Drinking Water Act (SDWA) limits.

4.2 Biological Treatment

Biological treatment with nutrient (nitrogen and phosphorus) removal, using carbon sources indigenous to the wastewater, can reduce total nitrogen levels to 5 mg/L or less and can reduce total phosphorus levels to about 1 mg/L or less. It also removes some suspended solids, volatile organic chemicals, heavy metals, and an additional 1-log removal of pathogens.

A biological nutrient removal process would potentially involve modification to the existing activated sludge process at the plants. Due to this, it may be advantageous to also consider denitrification filters, which can be added in a separate, much smaller treatment facility.

- Biological nutrient removal - A modification to the activated sludge process in which aeration basins are subdivided into anaerobic, anoxic, and aerobic zones to promote nitrification and denitrification reactions. Phosphorus is removed here primarily in the anoxic zone.

- Denitrification filters - An anaerobic process in which nitrate is converted to nitrogen gas. The addition of a carbon source such as methanol may be required.

4.3 Demineralization

Reverse osmosis membrane treatment will produce a 3-4 log reduction in pathogenic organisms and also removes organic chemicals, heavy metals, radionuclides, and nutrients - both phosphorus and nitrogen, as well as most of the dissolved solids. This level of dissolved solids removal allows part of the system to be by-passed to form a blended water that meets defined standards and minimizes costs. Current research is being done in analyzing appropriate membrane technologies by the City of McAllen. This information will be useful in determining an appropriate membrane for this application.

Pressure driven membrane processes include reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF), and microfiltration (MF). The processes are distinct on the basis of several factors, including relative membrane pore size, method by which separation is effected (permselectivity), and the type of components removed. Typical operating pressures required to effect separation vary from 150-1,200 psi for RO, 50-150 for NF, 20-75 for UF and 10-30 for MF.

Separation of contaminants from water is controlled by different mechanisms within the pressure driven processes. For RO and NF, the solubility and diffusion rate of water in the membrane is much greater than for salts and other components in the feed stream. For UF and MF, separation is achieved through simple membrane sieving and in some cases, more complex interactions with rejected substances that accumulate at the membrane surface.

Ion exchange is a process in which water is passed through a filter bed of exchange material known as zeolite. Ions in the insoluble exchange material are displaced by ions in the water. When the zeolite is spent, it is regenerated with a rejuvenating solution. This process produces zero hardness, a level that is obviously unnecessary. Therefore a certain percentage of feed water can bypass this system.

Electrodialysis removes salts and minerals from a stream of saline water through special plastic membranes by the action of a direct electrical current. These salts and minerals pass through the membrane in the form of positively and negatively charged ions. The water from which these ions have been removed flows between the membranes and is collected as a partially demineralized product by manifolds cut through the membranes. The salts and minerals removed from the product stream pass through the membranes into another stream of water which continuously washes the other side of each membrane and emerges through manifolds as a more concentrated waste stream.

4.4 Disinfection

Typically this is the final barrier to microbial organisms. It is most effective at the end of the treatment process where very little suspended matter remains in the water and oxidant demand has been greatly reduced. Currently all the wastewater treatment plants at both cities employ chlorination for disinfection. When determining a viable process, the process must improve disinfection and reduce disinfection by-products, even without reuse. In water treatment, Cryptosporidium and Giardia are two of the most difficult organisms to inactivate and/or remove from treated water. ClO_2 has been shown to be ineffective in the removal of Cryptosporidium at 5°C. Chlorine has limited effectiveness for Cryptosporidium inactivation. In one of the options a pipeline would transport effluent to the water treatment plant. In this case, increased contact time would be realized which may improve the viability of using chlorine. The addition of chemicals or other disinfection techniques will interact with pathogens and ensure their inactivity. Under SDWA and ICR it is anticipated that improvements in the drinking water standards will be required. Improvements in the current system to aid in the reuse process will also help in meeting anticipated new drinking water requirements.

Another method that can be used is ozone. Ozone is relatively safe, possesses excellent viricidal and bactericidal properties, and is especially effective for disinfecting water known to contain protozoa, and particularly for the removal of giardia and cryptosporidium. Ozone also enhances the quality of receiving water as a result of high dissolved oxygen (DO), presents no increase in TDS and has aided in effluent polishing effects (color removal). Ozonation may be accomplished by mechanical mixing, countercurrent or concurrent flow columns, diffusers, or injectors.

Ultraviolet irradiation, as its name implies uses ultraviolet or short-wavelength radiation to kill bacteria. It acts as a germicide through alteration of organic molecular components essential for the functioning of biological cells. It is not particularly effective on unfiltered wastewater, and is best used on low turbidity waters.

4.5 Filtration

Granular media filtration will remove the majority of suspended matter remaining after biological treatment or after coagulation and precipitation. Following biological treatment, filtration produces turbidity levels of 1-2 NTU. Following coagulation, filtration reduces the turbidity to less than 0.5 NTU. The removal of suspended matter also results in a reduction of the microbial contamination. Trace organics can be removed with granular activated carbon filtration. The type of carbon will need to evaluated in detail for proper application.

4.6 Natural Soil Filtration

This technology uses the existing soil profile to filter the reclaimed water. The filtered water is then recovered by extraction wells or another collection process. This process will reduce or eliminate microbial concentrations, reduce TOC and disinfection by-products, and may reduce nitrate through biological action. Depending on the existing soil profile and infiltration capacity, it may be the least costly.

There are generally three types of groundwater recharge that utilize reclaimed water; surface spreading or percolation, direct injection, and river bank or stream bed infiltration as a result of stream flow augmentation. The NSF technique of specific interest here is the percolation type. In this method treated wastewater percolates from spreading basins through the unsaturated zone to an existing permeable layer. Infiltration and percolation of reclaimed water takes advantage of the subsoils' natural ability for biodegradation and filtration, thus providing in situ treatment of the wastewater. Once the filtered water has reached the permeable layer, it can be recovered by a series of wells down gradient of the spreading area.

This operation is not "mining" of water. It is not intended that the amount of water withdrawn will ever exceed the amount applied in the spreading basins. In all probability a net positive recharge will occur due to the unrecoverability of some water.

4.7 Wetlands

Wetlands have been defined as land where the water surface is at or above the ground surface for a long enough period each year to maintain saturated soil conditions and the growth of related vegetation. A variety of naturally occurring wetlands has been used for wastewater treatment.

Constructed wetlands may take many forms. Most employ herbaceous plant species rather than trees or shrubs, making them more similar to a marsh in species composition. Constructed wetlands are generally divided in two general categories: free water surface (FWS) wetlands, in which the majority of water flow is over the sediment and through the above ground plant zone and vegetated submerged bed (VSB) wetlands designed to conduct waste through the bed of the system to make contact with the plant roots. Wetland systems can be designed to effectively remove TSS, organic matter, nitrogen and phosphorus.

4.8 Evaluation of Processes

Table 4.1 illustrates the barriers to various contaminants for each of the candidate treatment processes discussed in the preceding sections. Table 4.2 lists the principal pros and cons for each process. It also indicates issues which may arise in the use of that particular technology. An attempt was made to give ball park costs for a 10 MGD operation. These costs have been updated to reflect 1996 dollars (ENR index of 5617) and adjusted for local construction labor costs. Data was compiled from EPA documents and similar construction projects recently done. The costs include construction and operation and maintenance (O&M) costs.

Table 4.1
Unit Process Contaminant Barrier

Gross Contaminant Category	Biological Treatment	Biological Treatment w/Nutrient Removal	Biological Nitrogen Removal	High Lime w/Recar-bonation	Filtration	Granular Activated Carbon	Membrane Demineral-ization	Wetland System	Membrane Particle Removal
Suspended Solids		X	X	X	X		X	X	X
Dissolved Solids							X		
Biological Oxygen Demand	X	X	X	X		X	X	X	X
Total Organic Carbon	X	X				X	X	X	
Heavy Metals	X	X		X			X	X	
Nutrients		X	X	X			X	X	X
Microbial Factors	X	X		X	X		X	X	X

Table 4.2
Process Evaluation Considerations

Treatment Process	Advantage	Disadvantage	Costs (10 MGD) Capital/O&M
Chemical Treatment	Low Capital Cost	Potentially high chemical costs, increase in solids disposal, sludge disposal	[1] minimal/$6.9M
Biological Nutrient Removal	Reduction in chemical treatment costs	High capital costs	New: $10M/$22M, Modify existing: $3M/$2.2M
Electrodialysis Reversal	High removal efficiencies	High capital and O & M Costs. Not broadly used technology	$9M/$0.5M
Filtration	Easy operation, high removal efficiencies	High O & M requirements	[2]$1.1M/$0.7M
Ion Exchange	High removal efficiencies	High capital and O & M costs	[1]$6.9M/$0.8M
Microfiltration	High removal efficiencies	High capital costs	$6M/$0.7M
Natural Soil Filtration	Low cost	Potential for high electrical costs, Permitting, Right of Capture, Well Head Protection	[1]$2.6M/$0.24M
Ozone	Superior in ability to inactivate viruses	High capital costs, lack of residual protection	[1]$2.9M/$0.4M
Reverse Osmosis	Best overall treatment process	High capital and O&M costs, Brine disposal	[1]$9.4M/$2.5M
Ultrafiltration	High removal efficiencies	High capital and O&M costs	$6M/$1.5M
Ultraviolet Disinfection	Requires no chemicals, low O&M costs	Lack of residual protection, high capital costs	$1.3M/$0.1M
Wetlands	Low maintenance	Land constraints, Permitting	$7.6M/$0.15M

[1] *Innovative and Alternative Technology Assessment Manual*
[2] *Estimating Water Treatment Costs Vol. 2*

5. SUGGESTED TREATMENT SCENARIOS

This section describes three treatment scenarios to illustrate how various processes can be used in combination to address the contaminants of concern for this project. These scenarios will be refined and evaluated in Technical Memorandum No. 3. Table 5.1 illustrates how the various contaminants are to be removed in each scenario.

5.1 Scenario 1

A biological nutrient removal system installed at the wastewater treatment plant would help address the current ammonia, nitrogen and phosphorus requirements, serve as an additional barrier to pathogens and provide suspended solids removal. Further issues could be addressed with reverse osmosis. When using a reverse osmosis system a major factor which comes into play is brine disposal. In the South Texas area there are many deep well injection systems currently in operation. This may be a viable alternative for brine disposal. Due to the nature of this process it is essential that filtration be used upstream to minimize the fouling or clogging of the membrane. The reverse osmosis process would help reduce the chloride, nitrogen, sodium, sulfate, TDS, TSS, TOC, virus, bacteria and protozoan concerns. The filtration process would also serve as a multiple barrier to virus, bacteria and protozoan concerns. Some degree of chemical treatment could be used to serve as a multiple barrier to ammonia, phosphorus, TOC and viruses.

5.2 Scenario 2

Reverse osmosis or electrodialysis could be used to a lesser degree in the second scenario, primarily to address chloride, sodium and TDS, with a chemical treatment to treat for ammonia, phosphorus, TOC, virus bacteria, and protozoan. An ion exchange or microfiltration system could be used to treat nitrogen, sulfate and TSS. Microfiltration would also help in creating a multiple barrier to TOC, virus, bacteria and protozoa.

5.3 Scenario 3

If the soil system in the areas of the existing treatment facilities is appropriate, it may be possible to design and implement a low cost soil filtration scheme to reduce microbial concentrations, reduce nitrate and TOC, and provide public health protection. In this scenario, the existing secondary effluent would be recharged into the shallow groundwater either in existing or constructed surface spreading recharge facilities. This water would then be extracted and used to augment the existing surface water supply. Use of a soil filtration technology would also eliminate the need for filtration backwash facilities and brine or reject disposal. In a similar project developed in San Bernardino County, California, 40 acres of

Table 5.1
Contaminant Barriers for Proposed Treatment Scenarios

	Ammonia	**D.O.**	**"N"**	**"P"**	**Dissolved Salts (TDS, Na, Cl)**	**Sulfate**	**TSS**	**TOC**	**Virus**	**Bacteria & Protozoan**
1	BNR Chem	Aerator	BNR RO Filter	BNR Chem	RO Filter	RO Filter	RO Filter	Chem RO Filter	RO Filter Chem	RO Filter
2	Chem	Aerator	IX or Micro and Chem	Chem	RO or EDR	IX or Micro and Chem	IX or Micro	Micro and Chem	Micro and Chem	Micro and Chem
3	Chem	Aerator	NSF	Chem	EDR	EDR	NSF	NSF Chem	NSF Chem	NSF Chem

Chem = Chemical Treatment
EDR = Electrodialysis Reversal
IX = Ion Exchange
NSF = Natural Soil Filtration
RO = Reverse Osmosis
UV = Ultraviolet Light

BNR = Biological Nutrient Removal
F = Media Filtration
Micro = Microfiltration
03 = Ozone
WL = Wetlands

land were used to recharge 30 million gallons per day. Recovery was via wells, 100 feet deep and 24 inches in diameter with a capacity of 3,000 gallons per minute. These wells intercepted the underflow from the recharge basins, provided low turbidity, and reduced TOC water for discharge to the river. Electrodialysis can be used in conjunction with this system to address the chloride, sodium, sulfate and TDS issues. Chemical treatment with its ability to aid in the reduction of ammonia and phosphorus would finish the treatment process. Chemical treatment would also serve as a multiple barrier to TOC, virus, bacterial and protozoan concerns.

This scenario brings up many issues which will need further research. Due to the fact that water will be deposited into the ground, it no longer remains a surface water resource but becomes a groundwater resource. Once this occurs the "right of capture" scenario comes into play. Also, "wellhead protection" concerns arise if any land owner in the radius of influence is using groundwater for human consumption or contact. It is also possible that some type of permit with the TNRCC might be required.

APPENDIX A
MEMORANDUM ON PRELIMINARY ENVIRONMENTAL REVIEW

FREESE • NICHOLS

Simon W. Freese, P.E. 1900-1990
Marvin C. Nichols, P.E. 1896-1969

MEMORANDUM

To: David Sloan

From: Tammy Sullivan

Re: Preliminary Environmental Review of Edinburg/McAllen Reuse Project

Date: June 21, 1996

Pursuant to your request, I have performed a preliminary "fatal flaw" environmental review of the Edinburng/McAllen Reuse Project. The McAllen Wastewater Treatment Plant (WWTP) No. 2 has a treatment capacity of 10 MGD (15.5 cfs), while McAllen WWTP No. 3 has a design capacity of 4 MGD (6.2 cfs). The Edinburg WWTP currently has a treatment capacity of 3.8 MGD (5.9 cfs) (F&N, 1996).

McAllen WWTP #2

The McAllen WWTP#2 discharges to the Mission Floodway Channel which drains into the Arroyo Colorado, Segment 2202. The floodway channel is not a designated segment. Segment 2202, Arroyo Colorado Above Tidal, extends from 100 meters downstream of Cemetery Road to FM 2062 in Hidalgo County and is classified as water quality limited. Designated water uses are contact recreation and intermediate quality aquatic habitat.

The segment is currently not supporting its use for contact recreation due to high fecal coliform levels (TNRCC, 1994). Phosphorus, nitrate and chlorophyll a levels exceed the screening criteria for the segment. There are a total of 26 permitted outfalls in the segment, 18 domestic and 8 industrial. The total permitted wastewater flow in the segment is 32.38 MGD (50.1 cfs). Domestic effluents are identified as the major contributors of nutrients to the segment during periods of normal flow.

The USGS has maintained a chemical and biochemical analysis sampling station near Harlingen at U.S. Highways 83 and 77 since 1986 (Station 08470400). Flows are only measured during a sampling event. The stream flow was measured on 37 occasions between 1986 and 1992 and averaged 246 cfs.

An intensive survey of the water quality in the Arroyo Colorado was conducted in December 1987 (Davis, 1989). The survey involved the collection of water, sediment and biological samples. The samples were analyzed for the presence of approximately 135 chemical parameters. The study determined that some water quality impairment had occurred in Segment 2202 due to the presence of several chemicals. The presence of the chemicals was attributed primarily to agricultural runoff and irrigation return flows. Urban runoff was suspected of being a secondary contributor. Dissolved oxygen levels in Segment 2202 were determined to be adequate for maintaining the intermediate aquatic life designated use and were not expected to produce appreciable instream stress.

If the discharge from McAllen WWTP #2 were discontinued there would be a reduction in flow. Potential environmental effects of a reduction in flow are low dissolved oxygen levels and the affects associated with reduced flows into the bays and estuaries (e.g. Laguna Madre). The permitted flow from the McAllen WWTP #2 is approximately six percent of the average flow measured at the Arroyo Colorado at Harlingen, Texas sampling station. Although the literature reviewed did not include estimated inflows to Laguna Madre, the flow from the McAllen WWTP #2 would probably be insignificant. A total of 53 dissolved oxygen measurements were taken in Segment 2202 between 1989 and 1992. Only one of the measurements was below the criteria of 4.0 mg/l. In addition, the water quality survey performed in 1987 did not identify low dissolved oxygen as a potential problem in Segment 2202. Based on the information reviewed for this memorandum, it does not appear that there would be significant environmental effects if the discharge from McAllen WWTP #2 were discontinued.

McAllen WWTP #3 and Edinburg WWTP

McAllen WWTP #3 discharges to a drainage ditch with Hidalgo County Drainage District No. 1. The drainage ditch ultimately drains to the North Floodway. Edinburg WWTP currently discharges to a drainage ditch which also drains to the North Floodway. Improvements to the Edinburg WWTP are proposed which would include diverting the WWTP discharge to the San Juan holding pond prior to discharge to the North Floodway. None of the drainage ditches nor the North Floodway are designated stream segments.

None of the literature reviewed provided information on the water quality or estimated flows in the North Floodway. Both McAllen and Edinburg are at the upstream end of the North Floodway watershed. Mr. John Sturgis, TNRCC Region 15 Water Program Manager, indicated that flow in the drainage ditches and the floodway is intermittent.

The primary impacts associated with discontinuing the discharges from McAllen WWTP #2 and from Edinburg would be potential reduced flows to Laguna Madre. The combined flows from the two plants is approximately 12.1 cfs. Although there was no data in the literature reviewed regarding the flows to Laguna Madre, the 12.1 cfs is probably insignificant. Based on the information reviewed for this memorandum, it does not appear that there would be significant environmental effects if the discharges from the McAllen WWTP #3 and Edinburg WWTP were discontinued.

Indirect Effects

If reuse by the Cities of Edinburg and McAllen is successful, there may be an indirect effect of additional reuse by other communities, further reducing effluent discharge to the Arroyo Colorado and Laguna Madre. The cumulative effects of the reduced flows will require additional evaluation if and when more cities choose effluent reuse as an alternative water supply.

REFERENCES:

Davis, Jack R., 1989. Results of Intensive Priority Pollutant Monitoring in Texas - Phase II. Austin, Texas.

Freese and Nichols, 1996. Edinburg/McAllen Reuse Feasibility Study. Technical Memorandum No. 1. Baseline Data.

TNRCC, 1994. State of Texas Water Quality Inventory 94. Surface Water Quality Monitoring Program. Austin, Texas.

APPENDIX B
AWWA ARTICLE ON DRINKING WATER STANDARDS

An update of the federal regs

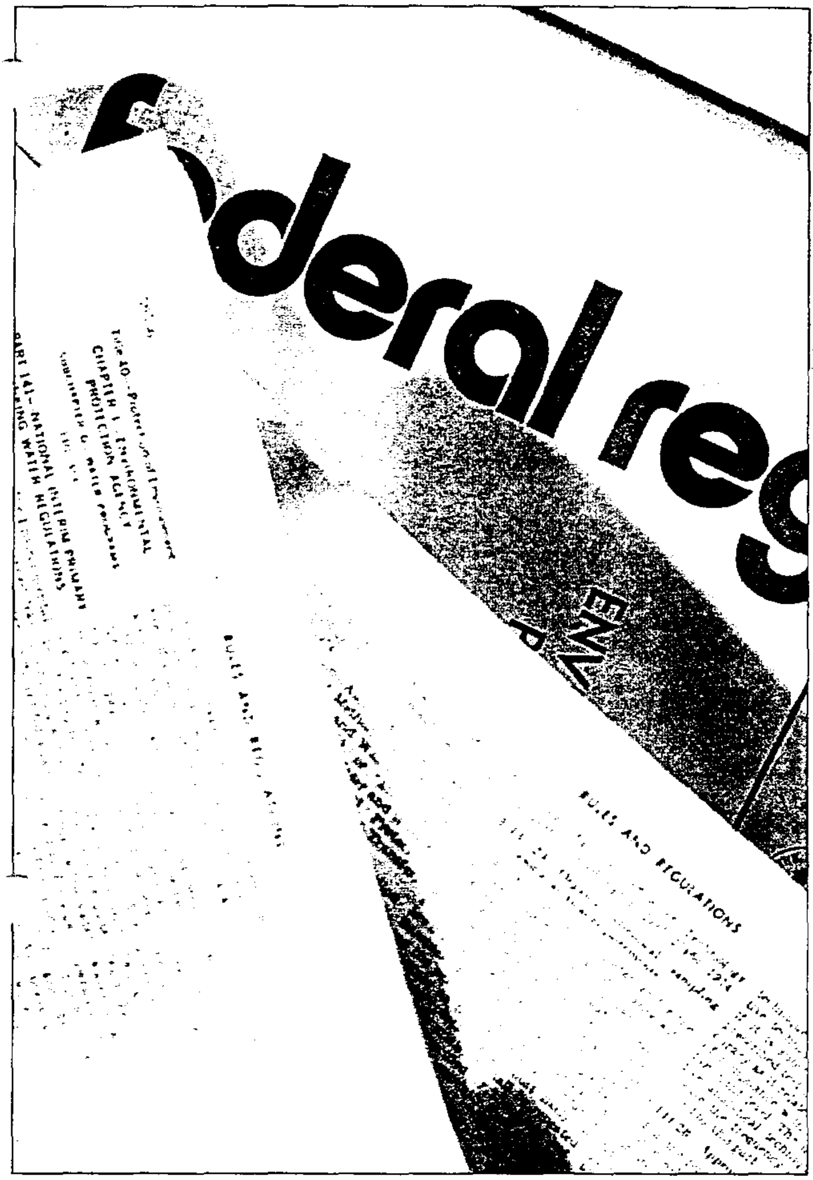
Because of resource limitations and pending reauthorization of the Safe Drinking Water Act, the pace of regulatory activity has slowed considerably.

Frederick W. Pontius

The Safe Drinking Water Act (SDWA) amendments of 1986 set an ambitious schedule for the establishment of new regulations. Several new regulations were proposed or promulgated each year from 1988 through 1994.[1–5] The pace of regulation development by the US Environmental Protection Agency (USEPA) has slowed considerably, however, because of resource limitations and in anticipation of SDWA reauthorization. Basic information regarding SDWA requirements has been summarized elsewhere.[6] The status of current and anticipated regulations is reviewed here.

Current numerical drinking water standards and best available technology are summarized in Tables 1 and 2. The status of promulgated, proposed, and anticipated regulations is summarized in Tables 3–5. Dates for anticipated agency actions are based on USEPA's published regulatory agenda[7] and on information released by the agency through Jan. 15, 1996; these dates can change as priorities change within the agency. Several regulatory sched-

This article reports the current developments related to rules promulgated or proposed under the Safe Drinking Water Act, such as the Lead and Copper Rule, Phase V Rule, the Disinfectants/Disinfection By-products Rule (including the Enhanced Surface Water Treatment Rule and the Information Collection Rule), the Radionuclides Rule, and the Sulfate Rule. Anticipated new rules that will update analytical methods, reestablish regulatory priorities, and streamline revisions to current regulations are reviewed as well.



USEPA filled more than a few pages in the Federal Register from 1988 through 1994, when several new regulations were proposed or promulgated each year.

ules are directly tied to Congressional approval of the agency's fiscal year (FY) 1996 budget.[8]

Promulgated rules: few changes expected

Few changes or revisions have been made to rules promulgated to date. Table 3 summarizes the status of promulgated USEPA drinking water regulations. Key issues regarding rules under active revision are discussed in the following sections; refer to previous reviews for details of rules that are not discussed here.

Lead and Copper Rule. anges to the Lead and Copper Rule have been under development for several years[9–12] and are expected to be proposed in 1996. Technical changes to the rule[13,14] will be made following the agency's usual rule-making process. (Technical changes under consideration by USEPA were discussed in reference 4.) The rule will likely be amended as a result of the Dec. 6, 1994, decision by the US Court of Appeals for the District of Columbia Circuit on the petitions for judicial review filed by the Natural Resources Defense Council (NRDC) and AWWA.[15] The court agreed with NRDC that USEPA did not adequately explain why the SDWA does not regulate lead content in transient noncommunity water systems such as restaurants and hotels. The court remanded that portion of the rule so that USEPA could correct this technical error. The court disagreed, however, with NRDC's claim that the Lead and Copper Rule is illegal under the SDWA and that USEPA should have set a maximum contaminant level (MCL) for lead rather than a treatment technique requirement. The court upheld USEPA's rule in this regard.

AWWA challenged USEPA's broad definition of control that held water systems responsible for portions of the distribution system that they do not own. The court ruled in favor of AWWA, vacating the rule insofar as it deems privately owned lead service lines to be within the control of a public water system for the purpose of obligating the system to replace them.[16] The basis of this ruling, however, was procedural in nature, and the agency's response is anticipated in the impending proposal.

WWA challenged USEPA's broad definition of control that held water systems responsible for portions of the distribution system that they do not own.

Phase V. The Phase V rule promulgated a maximum contaminant level goal (MCLG) and MCL for nickel of 0.1 mg/L. The Nickel Development Insti-

TABLE 1 USEPA drinking water standards and best available technologies for regulated contaminants

Contaminant	Regulation	Status	MCLG *mg/L*	MCL *mg/L*	Best Available Technology*	Reference
Organics						
Acrylamide	Phase II	Final	Zero	TT*	PAP	47
Alachlor	Phase II	Final	Zero	0.002	GAC	47
Aldicarb	Phase II	Delayed	0.001	0.003	GAC	48
Aldicarb sulfone	Phase II	Delayed	0.001	0.002	GAC	48
Aldicarb sulfoxide	Phase II	Delayed	0.001	0.004	GAC	48
Atrazine	Phase II	Remanded	0.003	0.003	GAC	47,49
Benzene	Phase I	Final	Zero	0.005	GAC, PTA	50
Benzo(a)pyrene	Phase V	Final	Zero	0.0002	GAC	51
Bromodichloromethane	D/DBP	Proposed	Zero	NA	EC	21
Bromoform	D/DBP	Proposed	Zero	NA	EC	21
Carbofuran	Phase II	Final	0.04	0.04	GAC	47
Carbon tetrachloride	Phase I	Final	Zero	0.005	GAC, PTA	50
Chloral hydrate	D/DBP	Proposed	0.04	TT	EC	21
Chlordane	Phase II	Final	Zero	0.002	GAC	47
Chloroform	D/DBP	Proposed	Zero	NA	EC	21
2,4-D	Phase II	Final	0.07	0.07	GAC	47
Dalapon	Phase V	Final	0.2	0.2	GAC	51
Di(2-ethylhexyl) adipate	Phase V	Final	0.4	0.4	GAC, PTA	51
Di(2-ethylhexyl) phthalate	Phase V	Final	Zero	0.006	GAC	51
Dibromochloromethane	D/DBP	Proposed	0.06	NA	EC	21
Dibromochloropropane (DBCP)	Phase II	Final	Zero	0.0002	GAC, PTA	47
Dichloroacetic acid	D/DBP	Proposed	Zero	NA	EC	21
p-Dichlorobenzene	Phase I	Final	0.075	0.075	GAC, PTA	50
o-Dichlorobenzene	Phase II	Final	0.6	0.6	GAC, PTA	47
1,2-Dichloroethane	Phase I	Final	Zero	0.005	GAC, PTA	50
1,1-Dichloroethylene	Phase I	Final	0.007	0.007	GAC, PTA	50
cis-1,2-Dichloroethylene	Phase II	Final	0.07	0.07	GAC, PTA	47
trans-1,2-Dichloroethylene	Phase II	Final	0.1	0.1	GAC, PTA	47
Dichloromethane (methylene chloride)	Phase V	Final	Zero	0.005	PTA	51
1,2-Dichloropropane	Phase II	Final	Zero	0.005	GAC, PTA	47
Dinoseb	Phase V	Final	0.007	0.007	GAC	51
Diquat	Phase V	Final	0.02	0.02	GAC	51
Endothall	Phase V	Final	0.1	0.1	GAC	51
Endrin	Phase V	Final	0.002	0.002	GAC	51
Epichlorohydrin	Phase II	Final	Zero	TT	PAP	47
Ethylbenzene	Phase II	Final	0.7	0.7	GAC, PTA	47
Ethylene dibromide (EDB)	Phase II	Final	Zero	0.00005	GAC, PTA	47
Glyphosate	Phase V	Final	0.7	0.7	OX	51
Haloacetic acids (sum of 5; HAA5)†	D/DBP					
	Stage 1	Proposed		0.060	EC	21
	Stage 2	Proposed		0.030	EC + GAC	21
Heptachlor	Phase II	Final	Zero	0.0004	GAC	47
Heptachlor epoxide	Phase II	Final	Zero	0.0002	GAC	47
Hexachlorobenzene	Phase V	Final	Zero	0.001	GAC	51
Hexachlorocyclopentadiene	Phase V	Final	0.05	0.05	GAC, PTA	51
Lindane	Phase II	Final	0.0002	0.0002	GAC	47
Methoxychlor	Phase II	Final	0.04	0.04	GAC	47
Monochlorobenzene	Phase II	Final	0.1	0.1	GAC, PTA	47
Oxamyl (vydate)	Phase V	Final	0.2	0.2	GAC	51
Pentachlorophenol	Phase II	Final	Zero	0.001	GAC	48
Picloram	Phase V	Final	0.5	0.5	GAC	51
Polychlorinated biphenyls (PCBs)	Phase II	Final	Zero	0.0005	GAC	47
Simazine	Phase V	Final	0.004	0.004	GAC	51
Styrene	Phase II	Final	0.1	0.1	GAC, PTA	47
2,3,7,8-TCDD (dioxin)	Phase V	Final	Zero	3×10^{-8}	GAC	51
Tetrachloroethylene	Phase II	Final	Zero	0.005	GAC, PTA	47
Toluene	Phase II	Final	1	1	GAC, PTA	47
Toxaphene	Phase II	Final	Zero	0.003	GAC	47
2,4,5-TP (silvex)	Phase II	Final	0.05	0.05	GAC	47
Trichloroacetic acid	D/DBP	Proposed	0.3	NA	EC	21
1,2,4-Trichlorobenzene	Phase V	Final	0.07	0.07	GAC, PTA	51
1,1,1-Trichloroethane	Phase I	Final	0.2	0.2	GAC, PTA	50
1,1,2-Trichloroethane	Phase V	Final	0.003	0.005	GAC, PTA	51
Trichloroethylene	Phase I	Final	Zero	0.005	GAC, PTA	50

*AA—activated alumina; AD—alternative disinfectants; AR—aeration; AX—anion exchange; CC—corrosion control; C-F—coagulation and filtration; Cl_2—chlorination; D—disinfection; DC—disinfection system control; DEF—diatomaceous earth filtration; DF—direct filtration; EC—enhanced coagulation; ED—electrodialysis; GAC—granular activated carbon; IX—ion exchange; LS—lime softening; LSLR—lead service line replacement; NA—not applicable; OX—oxidation; PAP—polymer addition practices; PE—public education; PR—precursor removal; PS—performance standard; PTA—packed-tower aeration; RO—reverse osmosis; SPC—stop prechlorination; SWT—source water treatment; TT—treatment technique

†Sum of the concentrations of mono-, di-, and trichloroacetic acids and mono- and dibromoacetic acids

USEPA drinking water standards and best available technologies for regulated contaminants (Continued)

Contaminant	Regulation	Status	MCLG mg/L	MCL mg/L	Best Available Technology*	Reference
Trihalomethanes (sum of 4; TTHMs)‡	Interim	Final	NA	0.10	AD, PR, SPC	52,53
	D/DBP					
	Stage 1	Proposed	NA	0.080	EC	21
	Stage 2	Proposed	NA	0.040	EC + GAC	21
Vinyl chloride	Phase I	Final	Zero	0.002	PTA	50
Xylenes (total)	Phase II	Final	10	10	GAC, PTA	47
Inorganics						
Antimony	Phase V	Final	0.006	0.006	C–F,§ RO	51
Arsenic	Interim	Final	NA	0.05	NA	52
Asbestos (fibers/L > 10 µm)	Phase II	Final	7 MFL	7 MFL	C–F,§ DF, DEF, CC, IX, RO	47
Barium	Phase II	Final	2	2	LS,§ IX, RO	48
Beryllium	Phase V	Final	Zero	0.004	C–F,§ LS,§ AA, IX, RO	51
Bromate	D/DBP	Proposed	Zero	0.010	DC	21
Cadmium	Phase II	Final	0.005	0.005	C–F,§ LS,§ IX, RO	47
Chlorite	D/DBP	Proposed	0.08	1.0	DC	21
Chromium (total)	Phase II	Final	0.1	0.1	C–F,§ LS (Cr III),§ IX, RO	47
Copper	LCR	Final	1.3	TT	CC, SWT	9
Cyanide	Phase V	Final	0.2	0.2	CL, IX, RO	51
Fluoride	Fluoride	Final	4	4	AA, RO	54
Lead	LCR	Final	Zero	TT	CC, PE, SWT, LSLR	9
Mercury	Phase II	Final	0.002	0.002	C–F (influent ≤ 10 µg/L)§ LS,§ GAC, RO (influent ≤10 µg/L)	47
Nickel	Phase V	Final	0.1	0.1	LS,§ IX, RO	51
Nitrate (as N)	Phase II	Final	10	10	IX, RO, ED	47
Nitrite (as N)	Phase II	Final		1	IX, RO	47
(both as N)	Phase II	Final	10	10	IX, RO	47
Selenium	Phase II	Final	0.05	0.05	C–F (Se IV),§ LS,§ AA, RO, ED	47
Sulfate	Sulfate	Proposed	500	500	RO, IX, ED	34
Thallium	Phase V	Final	0.0005	0.002	IX, AA	51
Radionuclides						
Beta-particle and photon emitters	Interim	Final		4 mrem		
	R	Proposed	Zero	4 mrem	C–F, IX, RO	32
Alpha emitters	Interim	Final		15 pCi/L		
	R	Proposed	Zero	15 pCi/L	C–F, RO	32
Radium 226 + 228	Interim	Final		5 pCi/L		
Radium 226	R	Proposed	Zero	20 pCi/L	LS,§ IX, RO	32
Radium 228	R	Proposed	Zero	20 pCi/L	LS,§ IX, RO	32
Radon	R	Proposed	Zero	300 pCi/L	AR	32
Uranium	R	Proposed	Zero	20 µg/L	C–F,§ LS,§ AX, LS	32
Microbials						
Cryptosporidium	ESWTR	Proposed	Zero	TT	C–F, SSF, DEF, DF, D	23
E. coli	TCR	Final	Zero	††	D	55
Fecal coliforms	TCR	Final	Zero	TT	D	55
Giardia lamblia	SWTR	Final	Zero	TT	C–F, SSF, DEF, DF, D	56
Heterotrophic bacteria	SWTR	Final**		TT	C–F, SSF, DEF, DF, D	56
Legionella	SWTR	Final**	Zero	TT	C–F, SSF, DEF, DF, D	56
Total coliforms	TCR	Final	Zero	‡‡	D	55
Turbidity	SWTR	Final		PS	C–F, SSF, DEF, DF, D	56
Viruses	SWTR	Final**	Zero	TT	C–F, SSF, DEF, DF, D	56

*AA—activated alumina; AD—alternative disinfectants; AR—aeration; AX—anion exchange; CC—corrosion control; C–F—coagulation and filtration; Cl_2—chlorination; D—disinfection; DC—disinfection system control; DEF—diatomaceous earth filtration; DF—direct filtration; EC—enhanced coagulation; ED—electrodialysis; GAC—granular activated carbon; IX—ion exchange; LS—lime softening; LSLR—lead service line replacement; NA—not applicable; OX—oxidation; PAP—polymer addition practices; PE—public education; PR—precursor removal; PS—performance standard; PTA—packed tower aeration; RO—reverse osmosis; SPC—stop prechlorination; SWT—source water treatment; TT—treatment technique

†Sum of the concentrations of mono-, di-, and trichloroacetic acids and mono- and dibromoacetic acids

‡Sum of the concentrations of bromodichloromethane, dibromochloromethane, bromoform, and chloroform

§Coagulation–filtration and lime softening are not best available technology for small systems for variances unless treatment is already installed.

**Final for systems using surface water; also being considered for groundwater systems

††If a repeat total coliform sample is fecal coliform– or *E. coli*–positive, the system is in violation of the MCL for total coliforms. The system is also in violation of the MCL for total coliforms if a routine sample is fecal coliform– or *E. coli*–positive and is followed by a total coliform–positive repeat sample.

‡‡No more than 5 percent of the samples per month may be positive. For systems collecting fewer than 40 samples per month, no more than 1 sample per month may be positive.

TABLE 2 USEPA proposed standards for disinfectants[21]

Disinfectant	Regulation	Status	Maximum Residual Disinfectant Level Goal *mg/L*	Maximum Residual Disinfectant Level* *mg/L*	Best Available Technology†
Chlorine‡	D/DBP	Proposed	4 (as Cl_2)	4.0 (as Cl_2)	DC
Chloramines§	D/DBP	Proposed	4 (as Cl_2)	4.0 (as Cl_2)	DC
Chlorine dioxide	D/DBP	Proposed	0.3 (as ClO_2)	0.8 (as ClO_2)	DC

*Maximum residual disinfectant level for chlorine and chloramine may be exceeded on a short-term basis to address water quality problems. Compliance is based on an annual average of monthly averages.

†DC—disinfection system control

‡Measured as free chlorine

§Measured as total chlorine

tute and others filed a petition for review of the nickel standard. On Feb. 23, 1995, the US Court of Appeals for the District of Columbia Circuit issued a ruling to vacate and remand the MCLG and MCL for nickel.[17] Although USEPA must reconsider the MCLG and MCL for nickel, no action is planned because of resource constraints.

Proposed rule promulgation delayed

Promulgation schedules for all currently proposed rules are being revised. Table 4 reviews the status of proposed USEPA drinking water regulations.

Disinfectant/Disinfection By-products (D/DBP) Rule. Proposed regulations for disinfectants and disinfection by-products have been under development for several years. In 1994 a negotiated rule-making process was completed, referred to as a regulatory negotiation or "reg neg."[18-20] The D/DBP Rule was proposed July 29, 1994.[21] Its provisions are identical to the draft rule previously reviewed.[22] Stage 1 was to be promulgated in December 1996. However, the complexity of this rule and the delay in promulgation of the Information Collection Rule (ICR) have forced USEPA to reconsider the schedule for promulgating the D/DBP Rule.

Enhanced Surface Water Treatment Rule (ESWTR). This rule was proposed July 29, 1994,[23] also as a result of the D/DBP Rule reg neg. The provisions of this proposal are identical to the draft rule reviewed previously[24] and involve expanding the scope of the Surface Water Treatment Rule (SWTR) to provide protection against *Cryptosporidium*. Public concern and media attention to *Cryptosporidium* may force the agency to prepare a separate rule or guidance to protect against this organism as an interim measure until the ESWTR is promulgated. A limited cryptosporidiosis outbreak among AIDS patients in Las Vegas, Nev., was attributed to small numbers of oocysts in treated drinking water, even though no oocysts were detected by the water utility and the treated water is of exceptionally high quality.[25,26]

Promulgation schedules for all currently proposed rules are being revised.

Information Collection Rule. The ICR was proposed Feb. 10, 1994.[27] Of the three rules related to the reg neg, it is to be implemented first because its purpose is to collect data critical to the development of the other two rules. Provisions of the ICR have been previously reviewed.[28,29] Technical and administrative complexities of the ICR have caused several implementation delays; promulgation is now expected in early 1996, and monitoring is expected to begin in late 1996. Suggestions to help utilities prepare for the ICR have been provided.[30,31]

Of the three rules related to the reg neg, the ICR is to be implemented first because its purpose is to collect data critical to the development of the other two rules.

Several revisions to the proposed ICR are expected in the final rule. Microbial monitoring will be eliminated for surface water systems that serve between 10,000 and 100,000 people. The protozoa trigger in the source water for finished water microbial monitoring will be increased from 1/L to 10/L. The virus trigger will remain at 1/L. If either source water trigger is reached, then microbial monitoring of finished water will be required. Particle counting will be allowed as a substitute for protozoa monitoring in finished water. Monitoring for *Clostridium perfringens* and coliphage is expected in the final rule but may not be included because of lack of resources to prepare performance evaluation samples.

Pilot-scale testing for systems reaching the trigger for total organic carbon is expected to be required for systems serving more than 500,000 people. Systems that serve between 100,000 and 500,000 people and that reach the trigger will be allowed to conduct bench-scale testing.

Status of promulgated USEPA drinking water regulations

Rule	Final Rule Published	Status	Legal Activity	Possible Congressional Activity
Analytical Methods	Dec. 5, 1994 (59 *FR* 62466)	Rule effective Jan. 6, 1995		
Drinking Water Priority List	Jan. 14, 1991 (56 *FR* 1470)	Revised list was due January 1994; USEPA decided not to revise the list pending SDWA reauthorization.		New process for selecting contaminants for regulation to replace current SDWA requirement to regulate 25 contaminants every 3 years
Fluoride	Apr. 2, 1986 (51 *FR* 11396)	USEPA published notice of intent to not revise existing MCL Dec. 29, 1993.		
Lead and Copper	June 7, 1991 (56 *FR* 26460); correction notices published July 15, 1991 (56 *FR* 32112), June 29, 1992 (57 *FR* 28785), and June 30, 1994 (59 *FR* 33860)	USEPA to propose technical changes	US District Court ruled Dec. 6, 1994, on lawsuits filed by the Natural Resources Defense Council and AWWA. Court upholds treatment technique approach; rules in favor of AWWA.	Provisions limiting lead in certain materials and submersible pumps may be added to SDWA.
Phase I VOCs	July 8, 1987 (52 *FR* 23690); correction notices published July 1, 1988 (53 *FR* 25108), and July 1, 1994 (59 *FR* 34320)	Analytical methods and monitoring revised in Phase II; additional changes under consideration		Monitoring relief expected for small systems
Phase II SOCs and IOCs	Final rule for 33 contaminants published Jan. 30, 1991 (56 *FR* 3600); final rule for five contaminants published July 1, 1991 (56 *FR* 30266); correction notice published July 1, 1994 (59 *FR* 34320)	Changes regarding monitoring triggers and MDLs are under consideration.	Petitions for review were filed on four contaminants; US Court of Appeals ruling Aug. 21, 1992, upheld USEPA's rule in its entirety. US Court of Appeals ruled Feb. 21, 1995, that USEPA must reconsider the MCLG and MCL for atrazine.	Monitoring relief expected for small systems
Phase V SOCs and IOCs	July 17, 1992 (57 *FR* 31776); correction notice published July 1, 1994 (59 *FR* 34320)	Changes regarding monitoring triggers and MDLs are under consideration.	Nickel Development Institute et al filed a petition for review of the nickel standard. US Court of Appeals issued an order Feb. 23, 1995, to vacate and remand the MCLG and MCL for nickel.	Monitoring relief expected for small systems
Primacy withdrawal process	June 28, 1995 (60 *FR* 33658)	Rule in effect		
Surface Water Treatment Rule	June 29, 1989 (54 *FR* 27488)	Enhanced Surface Water Treatment Rule has been proposed; separate rule guidance being considered for *Cryptosporidium*		
Total Coliform Rule	June 29, 1989 (54 *FR* 27547); partial stay published Jan. 15, 1991 (56 *FR* 1556)	Rule in effect; no revisions planned		
Trihalomethanes	Nov. 29, 1979 (44 *FR* 68624); BAT established Feb. 28, 1983 (48 *FR* 8406); analytical methods revised Aug. 3, 1993 (58 *FR* 41344)	Proposed D/DBP Rule to revise regulations for trihalomethanes		

TABLE 4 **Status of proposed USEPA drinking water regulations**

Rule	Proposal Published	Status	Legal Activity	Possible Congressional Activity
Class V Injection Wells	Aug. 28, 1995 (60 *FR* 44652)	USEPA evaluating public comments; final rule due Nov. 1996		
Disinfectants/ Disinfection By-products	July 29, 1994 (59 *FR* 38668)	USEPA evaluating public comments. New schedule being developed		Regulation deadlines may be included in SDWA.
Enhanced Surface Water Treatment Rule	July 29, 1994 (59 *FR* 38832)	Public comments being accepted until May 30, 1996. New schedule being developed		Regulation deadlines may be included in SDWA.
Information Collection Rule	Feb. 10, 1994 (59 *FR* 6332)	USEPA preparing final rule; promulgation expected early 1996		Regulation deadlines may be included in SDWA.
Radionuclides	July 18, 1991 (56 *FR* 33056)	New regulatory schedule to be set within 75 days of approval of USEPA's FY 1996 budget. USEPA plans to defer action on this rule.	Rule subject to court action	Congress may prohibit USEPA from spending FY 1996 money to promulgate a radonuclide regulation.
Sulfate	First proposed as part of Phase V, July 17, 1992 (57 FR 31776); New proposal published Dec. 20, 1994 (59 *FR* 65578)	USEPA plans to defer action on this rule.	Rule subject to court action	Congress may allow regulation of another contaminant of greater health concern in place of sulfate.

Distribution of the water utility data entry software, data entry video, and *Federal Register* notice is scheduled for May 1996. Monitoring would begin in January 1997.

Radionuclides Rule. USEPA's proposed rule for radionuclides was published July 18, 1991.[32] Because of the controversy over the proposed radon standard, Congress delayed promulgation of a final radon standard through FY 1994 and FY 1995 but indicated that the agency could proceed with promulgating standards for other radionuclides.[33] Because the proposed rule was developed as an interrelated package, the agency chose to delay promulgation of the entire radionuclides rule package. For FY 1996, USEPA is deferring action on promulgating regulations for all radionuclides.

Because of the controversy over the proposed radon standard, Congress delayed promulgation of a final radon standard through FY 1994 and FY 1995 but indicated that the agency could proceed with promulgating standards for other radionuclides.

Sulfate. A proposed rule for sulfate was published Dec. 20, 1994.[34] On Jan. 27, 1995, the South Dakota Department of Health requested assistance from the Centers for Disease Control and Prevention, National Center for Environmental Health, to conduct an investigation of possible increased incidence of diarrhea in infants who ingest water containing high concentrations of sulfate. Results of this study were released in December 1995.[35,36] The target population was infants born in South Dakota between Jan. 1, 1995, and Mar. 31, 1995, in 19 counties with high sulfate concentrations in drinking water. No significant difference in diarrhea incidence was found in infants who ingested water containing 500 mg/L or more of sulfate. Overall, an infant's risk of diarrhea in homes with sulfate concentrations greater than 500 mg/L was about the same as that in homes with lower sulfate concentrations. The number of infants included (276) was modest, and replication of this study in a larger population is needed.

Anticipated rules delayed

Table 5 summarizes the status of anticipated USEPA drinking water regulations.

Analytical methods update. Periodically, USEPA updates and revises analytical methods to incorporate newer technology. This anticipated rule will propose new methods or newer versions of existing methods

Status of anticipated USEPA drinking water regulations

Anticipated Rule	Schedule	Status	Legal Activity	Possible Congressional Activity
Aldicarb, aldicarb sulfone, and aldicarb sulfoxide	USEPA plans to defer action on this rule.	Final rules set July 1, 1991 (56 *FR* 30266); MCLs postponed May 27, 1992 (57 *FR* 22178)		
Analytical methods	Proposal due March 1996; final rule due March 1997; delay expected	Proposed rule under development		
Arsenic	New regulatory schedule to be set within 75 days of approval of USEPA's FY 1996 budget	USEPA planning to conduct research to narrow health effects uncertainty	Rule subject to court action	Possible delay of rule pending National Academy of Sciences study of arsenic health effects
Atrazine	USEPA plans to defer action on this rule.		The Court of Appeals dismissed a petition by Ciba-Geigy Feb. 21, 1995, but nevertheless required USEPA to reconsider the MCLG and MCL for atrazine.	
Groundwater Disinfection Rule	New regulatory schedule to be set within 75 days of approval of USEPA's FY 1996 budget	USEPA released draft rule July 31, 1992[37] agency reformed workgroup; new approaches to be considered	Rule subject to court action	
Lead and Copper Rule revisions	Proposed rule expected early 1996; final rule expected 1997	Proposed rule in final stages of agency approval		
Monitoring triggers and MDLs	Proposal due March 1996; final rule due Jan. 1997; delay expected	Proposed rule under development		
Nickel	USEPA plans to defer action on this rule.	USEPA must reconsider the nickel MCLG and MCL		
Phase VIb SOCs and IOCs	New regulatory schedule to be set within 75 days of approval of USEPA's FY 1996 budget; USEPA plans to defer action on this rule.	USEPA informally released draft rule in summer 1994; most contaminants are low priority.	Rule subject to court action	New process for selecting contaminants for regulation and for setting standards is expected.
Reformatting of drinking water regulations	Proposed rule expected March 1996; final rule expected June 1997; delay expected	Proposed rule under development		
Streamlining chemical monitoring	Draft rule issued Nov. 7, 1995; proposed rule expected Dec. 1996; final rule expected Dec. 1998	USEPA considering comments on draft rule		
Streamlining public notification requirements	Proposed rule expected Dec. 1996; final rule expected Dec. 1998	Proposed rule under development		
Underground injection control program streamlining rule	Proposal due March 1996; final rule due March 1997; delay expected	Proposed rule to reduce reporting under development		

and at the same time withdraw approval of older, outdated methods. The new additional methods to be proposed will include immunoassays.

Ground Water Disinfection Rule. Proposal of the Ground Water Disinfection Rule (GWDR) has been delayed several times. A draft rule was made available for public comment July 31, 1992.[37] The GWDR will apply to both community and noncommunity systems. Provisions of the draft rule have been summarized previously.[38] The agency reconvened a workgroup to develop a proposed rule, and alternative approaches to the draft rule are being considered[39] (see page 47).

USEPA established regulatory priorities

Resource constraints forced the agency to reconsider its regulatory priorities. During the spring of 1995, USEPA held a series of stakeholder meetings as part of the process of setting regulatory priorities.[41] Stakeholders met for three and a half days

TABLE 6 Summary of USEPA Office of Water draft redirected investments and disinvestments

Activity at Office of Water Headquarters	Current (FY 1995)	Redirected (Proposed Beginning FY 1996)	Preferred (More Resources Needed)
Contaminant occurrence data (for DWPL)†	Base*	More	More
Risk assessment methodologies†	Base	Base	More
Cost-effect analysis†	Base	More	More
Treatment technology for small systems†	Base	More	More
Standards and risk characterization for microbes and DBPs	Base	More	More
ICR†			
D/DBP Rules I and II†			
ESWTR I and II†			
GWDR			
Other standards and risk characterizations	Base	Defer‡	Defer§
Radon and other radionuclides			
Arsenic			
Phase Vib			
Sulfate			
Aldicarb			
Nickel			
Atrazine			
Partnership for Safe Water†	Base	Base	More
Revise requirements for chemical monitoring for public water systems†	Base	Base	Base
Public water system supervision (PWSS) program**,††	Base	Less	More
Safe drinking water information systems**	Base	Less	More
Wellhead protection program†	Base	Less	Base
Underground injection control (UIC) program††	Base	Less	Base
Comprehensive state groundwater protection programs (CSGWPP)††	Base	Less	Base
Groundwater indicators (data collection and analysis)††	Base	Less	Base
Source water protection for surface waters††	Base	Less	More
Standards for total triazines†			New
Streamline laboratory analytical methods approval process†			New
Laboratory performance evaluation redesign†			New
Consumer awareness initiative†			New

*Base—resource levels same as FY 1995; more—increase in resources over FY 1995; less—decrease in resources from FY 1995; defer—allocation of resources postponed

†Broad stakeholder support

‡Arsenic *research* maintained; some health advisories; risk characterization for total triazines, including atrazine

§Do regulations for radon and a few other contaminants based on sound occurrence and risk analysis; arsenic research maintained; more health advisories; risk characterization for total triazines, including atrazine

**Includes implementation support

††USEPA did not ask stakeholders about the UIC and CSGWPP programs, groundwater indicators, and various aspects of the PWSS program.

to discuss the rankings of 35 drinking water contaminants or subjects in terms of their priority for regulation or research. The intent of the meetings was not to reach consensus on the priority assigned to each contaminant or subject but to provide input to USEPA as it developed regulatory priorities. Rankings for regulatory priorities were developed and released by USEPA June 21, 1995;[41] they have been previously reviewed.[42]

Stakeholders indicated at the initial regulatory reassessment meeting Mar. 13, 1995, that they did not want to address existing regulations. The agency, however, has a statutory mandate to review existing rules, although it does not have the resources to conduct these reviews. In the future, the agency hopes to consider contaminants regulated in the past as candidates for future priority lists when new information indicates that they should be reviewed again.[43]

USEPA streamlining revisions to current regulations

As part of USEPA's efforts to realign regulatory development priorities, the agency has initiated work on three streamlining rules: (1) reformatting existing drinking water regulations; (2) revising existing regulations for monitoring triggers; and (3) revising existing public notification requirements.

Reformatting of drinking water regulations. This rule will reformat the current drinking water regulations to make them easier to understand and follow. The rule is not intended to change any of the regulatory requirements, but it will revise the text of the *Code of Federal Regulations* to reduce burden or duplication or to streamline requirements.

Streamlining rule for chemical monitoring requirements. Current chemical monitoring requirements vary by contaminant, by source of supply, and by system size. After an initial series of samples is monitored, sampling frequency increases or decreases based on the results of the initial series. USEPA intends to simplify and improve the cost-effectiveness of the current requirements by reducing the number of variables on which the sam-

Current chemical monitoring requirements vary by contaminant, source of supply, and system size.

pling frequencies turn, by providing greater latitude for state discretion in customizing the sampling frequencies to local circumstances, by consolidating subsections wherever possible, and by clarifying ambiguous language. A process by which states may design alternative monitoring frameworks based on USEPA-defined criteria will also be considered. A draft rule was issued for public comment Nov. 7, 1995.[44]

Failure to reauthorize the SDWA in the 103rd Congress means that USEPA must continue to establish mandated drinking water regulations.

Streamlining rule for public notification requirements. The agency plans to review and streamline existing public notification requirements for drinking water to allow states increased flexibility to design programs that will ensure notice to the public in a timely and effective manner. A public meeting held June 26, 1995,[45] solicited stakeholder input about how current requirements could be improved.

Draft redirection plan released

On Nov. 19, 1995, USEPA released for public comment a draft comprehensive drinking water program redirection plan.[46] The agency developed this proposal after considering the results of the stakeholder meetings just discussed. The plan includes

- establishing priorities and new schedules for setting safety standards based on health risks and sound science;
- supporting the Partnership for Safe Water; and
- simplifying and streamlining monitoring requirements for chemical contaminants and allowing further tailoring of monitoring to local contaminant threats.

USEPA's Drinking Water Program Redirection Proposal is available on the Internet (http://earth1.epa.gov/docs/owow/ogwdw/docindex.html).

Table 6 summarizes the agency's plan to invest or disinvest in specific regulatory activities. FY 1995 funding is used as a base, with regulatory activities to receive the same, more, or less funding, depending on priority. The agency is currently considering public comments on the draft proposal.

SDWA reauthorization to bring change

Failure to reauthorize the SDWA in the 103rd Congress means that the USEPA must continue to establish mandated drinking water regulations. US government shutdowns and resource limitations in general are causing substantial delays.

In January 1995, expectations were high that reauthorization of the SDWA would be addressed early in the 104th Congress. These expectations were not realized, and exactly when the SDWA will be reauthorized is uncertain because of disagreement over key issues. Senate passage of S. 1316 provides some hope for passage of a reauthorization bill in 1996. Action on the SDWA in the 104th Congress becomes less likely, however, as time passes and presidential politics accelerate. Should the House of Representatives pass a reauthorization bill that substantially deviates from the Senate bill, reauthorization in the 104th Congress becomes less likely. Nevertheless, reforms to the SDWA and changes to USEPA's drinking water program are expected when SDWA reauthorization does occur.

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APPENDIX F

LOWER RIO GRANDE VALLEY
DEVELOPMENT COUNCIL

EDINBURG/McALLEN REUSE FEASIBILITY STUDY

TECHNICAL MEMORANDUM NO. 3
FEASIBILITY EVALUATION

DECEMBER 5, 1996

Prepared For:

Lower Rio Grande Valley
Development Council
City of Edinburg
City of McAllen
Texas Water Development Board

Prepared By:

Perez/Freese and Nichols, L.L.C.
CH2M Hill
Freese and Nichols, Inc.

LRV96107
PFN96196

PEREZ / FREESE • NICHOLS, L.L.C.

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TECHNICAL MEMORANDUM NO. 3
FEASIBILITY EVALUATION

LIST OF TABLES

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1. EXECUTIVE SUMMARY

1.1 Introduction

This Technical Memorandum (TM) addresses the overall feasibility of planned, indirect potable reuse in the Edinburg and McAllen domestic water systems. Previous memoranda included discussions of water quality, public health issues, and candidate treatment processes. This memorandum includes four specific treatment scenarios, with comparative costs for each. Four reuse system configurations are also presented, with preliminary costs for conveyance in addition to treatment. One system is described for Edinburg, two for McAllen, and a regional system to serve both cities is evaluated.

1.2 Recommended Treatment Alternative

Of the four treatment scenarios evaluated, three are projected to have similar costs, while the fourth is substantially higher. A definitive process selection is not necessary at this time; the important conclusion is there are several treatment schemes which are technically feasible for a potable reuse system. The costs projected for these systems therefore provide a valid basis for comparing reuse costs with the costs of other water supply options.

1.3 Feasibility

The estimated present worth costs of implementing potable reuse are summarized below. These figures may be compared to the estimated costs to obtain additional raw water from the Rio Grande River and provide the additional treatment anticipated to be needed within the next 3-5 years. These costs are also contained in the table below.

	Reuse Cost ($M/MG)	Cost of Irrigation Rights ($M/MG)
Edinburg (New WTP)*	15.55	8.71
(Existing WTP)	8.11	3.31
Edinburg/McAllen Regional*	12.45	8.50
McAllen North*	13.87	8.29
McAllen South	7.83	3.74

* Systems providing additional water treatment capacity.

For reuse alternatives which incorporate new water treatment facilities, and for alternatives using existing facilities, the present worth cost is greater than the cost currently associated with purchase and conversion of irrigation water rights. However, the costs are in a range which suggests reuse is a viable water supply option worthy of further investigation and consideration.

2. TREATMENT PROCESSES

A variety of treatment processes are currently available for the reclamation of wastewater effluent. All of the scenarios presented have been developed to address contaminants of concern. The specific concerns, as discussed in TM No. 2, include:

- Pathogenic microorganisms
- Excessive nutrients (nitrogen and phosphorus)
- Total Organic Carbon (TOC) and the resulting formation of THMs and other disinfection byproducts (DBPs)
- Toxins
- Aesthetic contaminants, especially Total Dissolved Solids (TDS)

Current water quality characteristics have also been considered in order to maintain a raw water quality equal to or better than currently exists. The following is a discussion which highlights critical aspects of the recommended treatment processes and compares them to other processes. Any of the proposed treatment processes could be incorporated into either city's current treatment systems.

2.1 Biological Nutrient Removal

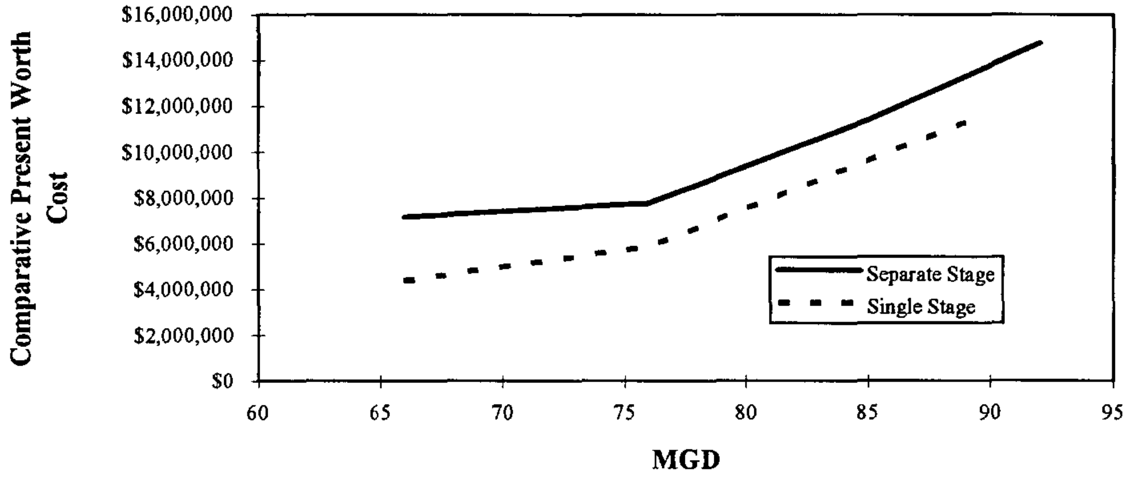
Wastewater effluent is typically high in nutrients such as nitrogen and phosphorus which encourage algae growth (eutrophication) in large bodies of water. Excessive algae will diminish the clarity of the water and affect its taste and odor, and may lead the public to mistrust the raw water supply. For these reasons, in addition to others, it is necessary that excessive nitrogen and phosphorus be removed from the wastewater effluent prior to blending in a raw water reservoir. Biological nutrient removal (BNR) describes a group of processes which remove nitrogen and phosphorus through natural means.

One form of nitrogen present in wastewater is ammonia-nitrogen. The removal of ammonia-nitrogen is of primary concern because of the oxygen demand exerted when the compound is released to the environment. Both cities currently address the ammonia-nitrogen issue through partial nitrification. Nitrification is the biological conversion of ammonia to nitrate. BNR could complete this process by simultaneously removing nitrate and phosphorus.

The removal of nitrogen by this process occurs in two steps. In the first, ammonia is converted aerobically to nitrate, and in the second step nitrates are converted to nitrogen gas and released to the atmosphere. Treatment systems which can accomplish this most efficiently include the same basic anoxic/aerobic components. However, significant differences exist among the systems with regard to the arrangement and number of process components, as well as the number and destination of recycle side streams. The more common processes are: A/O (anoxic/oxic), Bardenpho, UCT (University of Capetown) and VIP (Virginia Initiative Plant) processes.

BNR systems have been demonstrated to be cost effective for nutrient removal in many municipal wastewater treatment plants, both in new facilities and as retrofit projects. It appears to be feasible to modify the existing aeration basins in the Edinburg and McAllen wastewater treatment plants for some type of anoxic/oxic treatment system. Hence, a BNR system appears to be a cost effective type of biological treatment to address nutrient removal. Figure 2.1 graphically compares single stage nitrification and denitrification systems to separate stage systems. From this data, which was compiled from a nutrient removal study done for the Metro Wastewater Reclamation District in Denver, Colorado, it can be seen that single stage systems are more cost effective. Although the plant size range shown in this figure is larger than the Edinburg and McAllen plants, the difference between the systems becomes greater as the flow is smaller, and the conclusion appears applicable to smaller plants as well.

Figure 2.1 - Cost Comparison of Single vs. Separate Stage Treament for Nutrient Removal



Other methods which could be used for nitrogen removal include denitrifying filters, fixed film systems and selective ion exchange. Wetland systems were described in TM-2, but are not considered a viable treatment alternative and are not included in any of the proposed treatment scenarios. Wetland systems cannot provide the level of reliability needed and do not handle variations in flow very well.

2.2 Chemical Treatment

As described previously, chemical treatment can aid not only in the removal of phosphorus, but also heavy metals, other suspended organic and inorganic materials, COD and BOD. The chemical treatment system most commonly applied and proven in water reclamation applications is high lime treatment with two-stage recarbonation. The addition of sufficient lime to water raises the pH and converts bicarbonates and carbonates to hydroxides. This conversion results in the precipitation of phosphorus, calcium, magnesium and heavy metals. As the precipitates thus formed settle from the water, suspended organic and inorganic materials are enmeshed with the falling particles and removed as well. The high pH is also an effective method of virus/bacterial inactivation. Recarbonation is a term applied to the addition of carbon dioxide to the high pH, lime treated water so the pH is lowered and the hydroxides are reconverted to carbonates and bicarbonates. Recarbonation protects downstream process units from scaling and improves their effectiveness.

Since high lime treatment precipitates phosphorus, calcium, and magnesium, an overall reduction in TDS is possible. With hard waters, a 10-15% reduction in TDS can be achieved.

Metal salts have also been used for phosphorus and particulate removal. The chemicals of interest are either iron or aluminum based and are generally suitable for addition within the conventional wastewater treatment train or as a tertiary step, depending on the degree of phosphorus removal required. Extensive data are not available on the effectiveness of alum or ferric chloride in meeting discharge limits. In addition, metal salts nutrient removal is a function of stoichiometric and equilibrium reactions and, therefore, highly dependent on metal salt dose. Fluctuations in water characteristics such as pH, nutrient concentrations and interfering reactions make control using metal salts more difficult and unpredictable. Treatment with metal salts can also lead to increases in chloride and sulfate concentrations which are already of concern in both cities' water systems.

2.3 Disinfection

This is usually the final barrier that prevents pathogenic microorganisms from becoming a public health threat. There are four primary methods of disinfection: chlorine, chlorine dioxide, ultraviolet irradiation and ozonation. Chlorination systems are reliable and flexible and the equipment is relatively easy to control and operate. However, the properties which make it an excellent disinfectant, strong oxidizing properties, also make it hazardous to handle. Chlorine gas is becoming more tightly regulated, and its use as a primary disinfectant is known to cause THM formation. However, chlorine is used almost universally for providing a disinfection residual in water distribution systems to prevent recontamination of potable water.

Chlorine dioxide is a strong oxidant which has been given increasing attention as an alternative to chlorine for the disinfection of water and wastewater. Unlike chlorine, it does not react with dissolved organics to produce THMs, nor does it react with ammonia. Chlorine dioxide does generate chlorite and chlorate DBPs (disinfection by-products). It must be generated onsite. It is not used in many locations nationally due to high operating costs, although it is currently used at several water treatment plants in the lower Rio Grande Valley, including those of Edinburg and McAllen. Chlorine dioxide has been shown to be ineffective at Cryptosporidium inactivation at water temperatures below 5°C. However, water temperatures below 5°C would be relatively rare in the lower Rio Grande Valley.

Another recommended disinfection process is ultraviolet irradiation. UV disinfection offers safety advantages over chlorination and has not shown any toxic effect on receiving waters. Also, this process is more effective than chlorine for the inactivation of Cryptosporidium in wastewater. UV disinfection could effectively replace chlorination/dechlorination of effluent whether reclaimed or discharged.

The fourth disinfection process, ozone, is relatively safe and possesses excellent viricidal and bactericidal properties. It is effective for disinfecting water known to contain protozoa. It is the most effective method known to inactive Cryptosporidium other than heat treatment. One other advantage to ozone is its excellent ability to elevate DO levels in effluent, often to saturation levels. This would allow effluent to match the high raw water DO levels (8.8 mg/L compared to an average of 4.5 mg/L and 7.5 mg/L at the wastewater plants). For the above reasons ozone is considered the preferred process for producing reclaimed water that exceeds the current raw water quality. UV would be the next in line with chlorine being the least preferred disinfection process. Chlorine dioxide may be a viable candidate for continued use at the water treatment plants, but is probably not cost effective for use at the wastewater treatment plants.

2.4 Filtration

The two methods considered were conventional and the NSF (natural soil filtration) system. Filtration is typically used for achieving supplemental removals of suspended solids (including particulate BOD) from wastewater effluents of biological and chemical treatment processes. Filtration can also aid in the removal of chemically precipitated phosphorus. Conventional filtration at wastewater treatment plants usually is comprised of single media but can be designed to contain multiple filtration media with different specific gravities. The proposed treatment scenarios include multi-media filtration to provide adequate removal of suspended solids. This will allow effective application of UV for disinfection.

The NSF process will not provide the level of treatment and reliability necessary in treating the reuse water and is not a recommended alternative. If it were to be used, it should be restricted to the final process at the WWTP and serve only to polish the effluent and create a psychological barrier between effluent and drinking water.

2.5 Granular Activated Carbon

GAC reduces organics through adsorption. Adsorption is the accumulation of material along the interface of the carbon, the liquid-solid boundary. Since adsorption is a surface phenomenon, the more surface area the carbon contains, the greater the inherent capacity to hold organic material. Organic materials accumulate at this interface due to the physical binding of the molecules to the solid surface. The enormous amounts of surface area which activated carbon contains makes it highly effective for the removal of organic compounds.

Even after conventional treatment including coagulation, sedimentation and filtration, soluble organic materials that are resistant to biological breakdown will persist in the effluent. These remaining materials are often referred to as refractory organics. The largest contribution of GAC filtration to the treated water quality will be the reduction in refractory organics and overall TOC. Other benefits which will be realized are the removal of taste, odor and color constituents. This process is included in the treatment scenarios requiring additional organic removal.

2.6 Microfiltration

Microfiltration removes suspended particles, some bacteria, and viruses that accumulate on particles. The main purpose of its inclusion in the proposed scenarios is as a pretreatment to RO, where it could be a cost effective replacement of flocculation and sedimentation.

2.7 Reverse Osmosis

RO is a high or low pressure membrane process which removes a variety of contaminants: chloride, nitrogen, sodium, sulfate, TDS, TSS, TOC, virus and bacteria. EPA-funded studies have also demonstrated that, on a pilot scale level, RO is effective for removing specific synthetic organic contaminants such as herbicides and pesticides from contaminated groundwater.

3. SITE SPECIFIC CONSIDERATIONS FOR TREATMENT SYSTEMS

Local conditions in the Rio Grande Valley impact the selection of treatment processes. The following section outlines the main issues and their importance.

3.1 Blending Limits

For both cities, treated wastewater effluent is being considered as a water source to augment current water supplies. It is recommended the raw water supply not include more than 50% reclaimed water. This allows for dilution of reclaimed water and retains the human health protection provided by the environment. Operational experience may eventually justify relaxing this limit. However, limiting the recycle to no more than 50% of the total supply on average is a good management practice that should be employed until more is known.

3.2 Total Dissolved Solids

TDS is another concern, not only in the wastewater and raw water, but also in the drinking water. Existing raw water data indicate an average concentration of 863 mg/L and a high of 1,650 mg/L. Current WWTP effluent is estimated to be 300 to 600 mg/L higher than the raw water depending on the point of sampling. It is recommended that good drinking water should have a TDS less than 1,000 mg/L and preferably less than 500. It is possible with current membrane processes to remove most TDS from the water at either the WTP or the WWTP. Before large reductions in the TDS are done, special attention must be paid to corrosion and other impacts which might occur in the distribution system. In general, the objective of this study regarding TDS is to maintain current finished water levels.

3.3 Recontamination of Effluent

If ozone is incorporated at either city's WWTP, a notable improvement in disinfection quality will be achieved. If this water is then mixed with Rio Grande water, much of the benefit gained will be lost since Rio Grande water is relatively high in fecal coliform (average of 1,172 CFU/100 mL and a maximum of 100,000 CFU/100 mL) . Furthermore, it is reasonable to expect Cryptosporidium to be present in the Rio Grande. Ozone is the most reliable way to guard against Cryptosporidium. For this reason it is recommended that ozone treatment be incorporated at the WTPs of both cities. This will make certain that both cities' water systems are utilizing the applied technology in a logical and cost effective manner.

A similar argument could be made about GAC and its effect on TOC of the treated water. The Rio Grande TOC averages 5.3 mg/L with a maximum of 36 mg/L. The TOC of the wastewater is expected to average about 10 mg/L. Thus, without treatment, the wastewater could increase the raw water TOC. However, since the raw water is already a little high in TOC, a more effective application would be the use of GAC at the WTPs. Application of GAC at the WWTPs is worthy of consideration due to the lower cost of implementation, but a detailed evaluation will be necessary to prevent excessive TOC levels at the WTPs.

4. TREATMENT SYSTEMS FOR CONSIDERATION IN THIS STUDY

Four treatment scenarios have been developed for consideration in this study. Each of the scenarios provides multiple contaminant barriers against pathogens to protect public health and each is expected to provide a finished water quality equal or superior to existing water quality. The scenarios are primarily aimed at determining technical and economic feasibility of potable reuse of wastewater effluent. If reuse is pursued, other goals such as improved overall water quality may dictate the use of treatment scenarios not included in this study.

For each proposed scenario, a general schematic is provided, along with normalized costs for the sake of comparison. The costs assume a 10 mgd wastewater treatment plant and a 20 mgd water treatment plant. Present worth is calculated using a 3% discount rate and a 20 year period. A 10 year period was also evaluated, but did not result in any change in the relative ranking of alternatives.

The costs presented are comparative, not comprehensive. They are order of magnitude estimates based on cost curves for similar processes and projects. The costs have been modified to reflect a lower than average labor cost. They do not reflect the full cost of implementing any of the alternatives. Since the costs are comparative, the relative cost effectiveness of the alternatives is demonstrated. However, a more detailed estimate is necessary before a budget for implementation can be established.

4.1 Alternative 1

Alternative 1 is represented in Figure 4.1. This treatment alternative addresses water quality concerns with a more conventional approach. Improvements to both the current WWTP and the WTP are outlined. Flows would first be treated with a BNR system at the WWTP for nutrient reduction. It is anticipated that modifications to existing facilities would allow a retrofit system to be installed. This would be of significant cost savings as compared to constructing an entirely new BNR system. After BNR, the reclaimed water would be treated with conventional filtration and UV disinfection before discharge into the raw water source. Any unused flow would be diverted to the Laguna Madre or used for nonpotable reuse.

At the WTP it is anticipated that 100% of the water will be treated using the scenario outlined in Figure 4.1. High lime treatment will be followed with recarbonation, then GAC filtration and finally ozone disinfection. Although some reduction in TDS may be accomplished by the high lime treatment, a sidestream RO treatment step will be required for 15-20% of the flow to maintain TDS levels equivalent to raw water levels. Chlorination of the finished water (as currently practiced) will be required so a residual is maintained in the distribution system. Table 4.1 lists the costs associated with this treatment scenario.

Figure 4.1 - Treatment Alternative 1

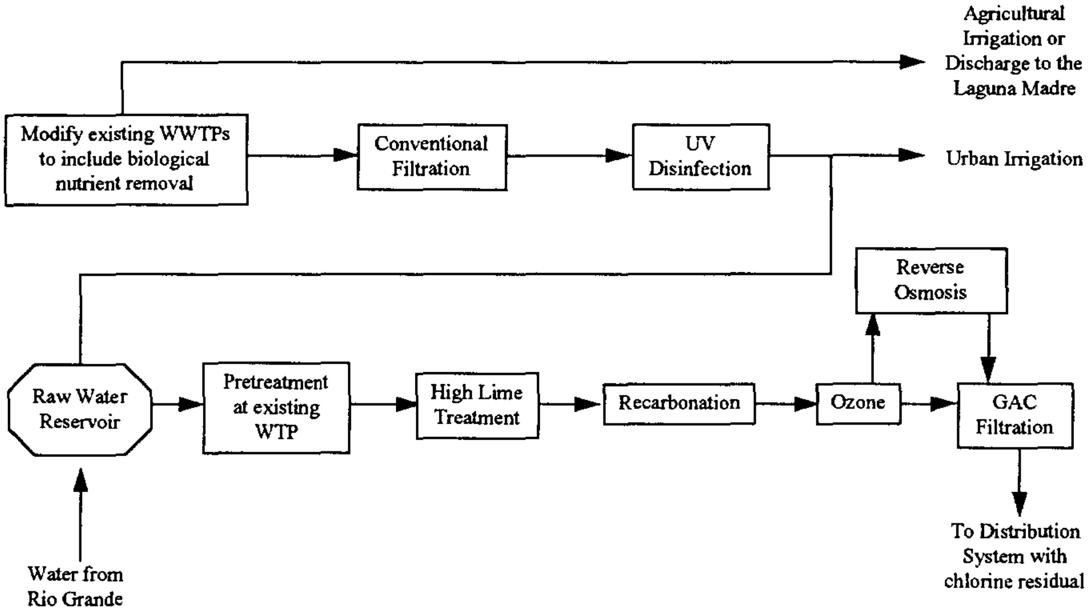


Table 4.1 - Comparative Costs for Treatment Alternative 1

Technology	Flow Rate MGD	Capital Costs ($M)	O & M Costs ($M)	Present Worth Costs ($M)
BNR	10	3.00	0.22	
Filtration	10	3.00	0.40	
UV	10	0.52	0.03	
Subtotal of improvements at WWTP		**6.52**	**0.65**	
Lime/Recarbonation	20	0.66	0.32	
Ozone	20	3.36	0.23	
Sidestream RO	3.5	3.76	0.98	
GAC	20	6.69	1.78	
Subtotal of improvements at WTP		**14.47**	**3.31**	
TOTALS		**20.99**	**3.96**	**79.81**

4.2 Alternative 2

Alternative 2 is represented graphically in Figure 4.2. The changes at the WWTP will be identical to those described in Alternative 1. At the WTP, the use of an RO system will improve water quality appreciably over any current treatment technologies. To make the RO system operate efficiently, it is essential that adequate pretreatment be provided. In this case microfiltration is the recommended process. Once the water has gone through the membrane treatment systems it will be treated with ozone before final chlorination. Table 4.2 outlines the costs associated with Alternative 2.

Figure 4.2 - Treatment Alternative 2

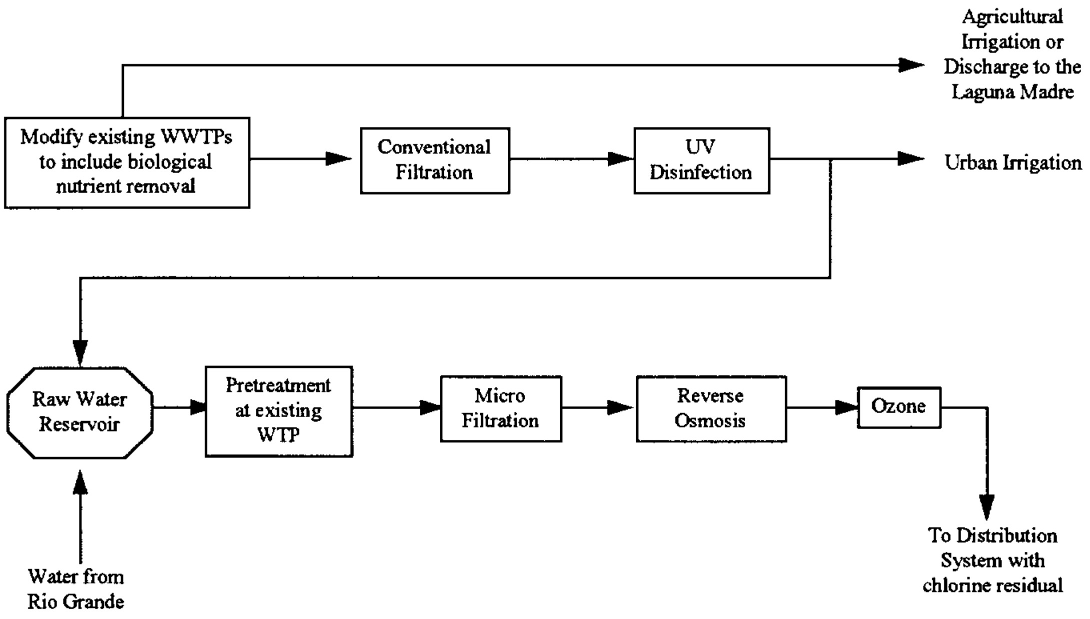


Table 4.2 - Comparative Costs for Treatment Alternative 2

Technology	Flow Rate MGD	Capital Costs ($M)	O & M Costs ($M)	Present Worth Costs ($M)
BNR	10	3.00	0.22	
Filtration	10	3.00	0.40	
UV	10	0.52	0.03	
Subtotal of improvements at WWTP		**6.52**	**0.65**	
MF	20	9.09	1.35	
RO	20	17.30	4.67	
Ozone	17	2.98	0.21	
Subtotal of improvements at WTP		**29.37**	**6.23**	
TOTAL		**35.89**	**6.88**	**138.12**

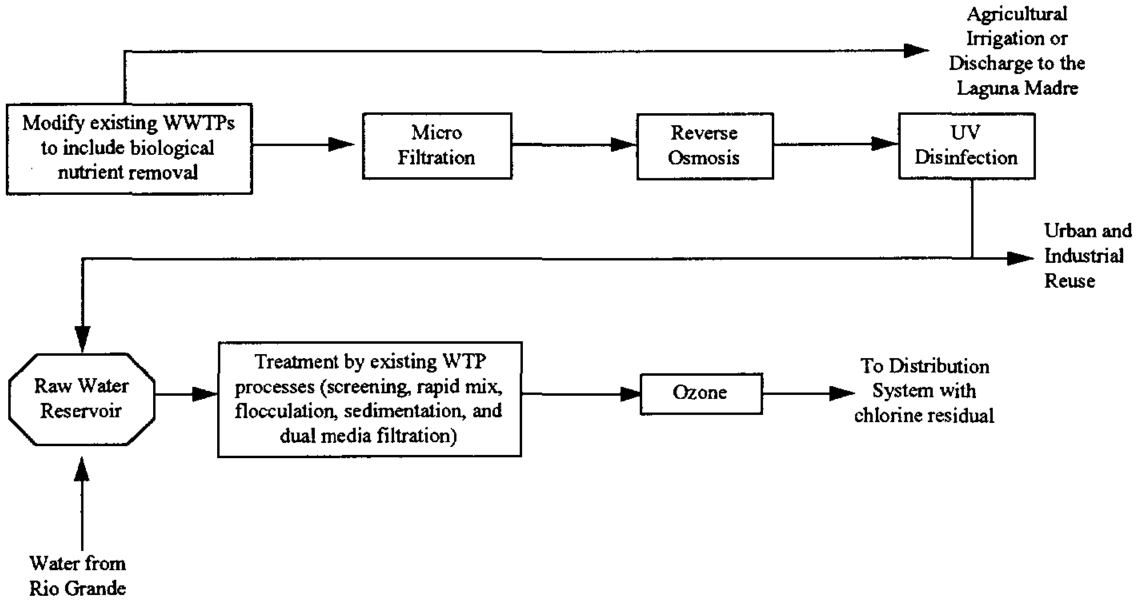
4.3 Alternative 3

Alternative 3 is represented in Figure 4.3. Alternative 3 differs considerably from the first two alternatives in that most of the treatment is provided at the WWTP. The BNR recommendation is similar to that in the first two alternatives. After that a combined MF, RO membrane treatment process is applied followed by UV disinfection. This will enhance the overall effluent quality in comparison to previous alternatives. The WTP side of the system includes relatively minor improvements in the existing flocculation, sedimentation, and filtration processes. The only new process is the addition of ozone disinfection prior to final chlorination. Costs for this alternative are shown in Table 4.3.

Table 4.3 - Comparative Costs of Treatment Alternative 3

Technology	Flow Rate MGD	Capital Costs ($M)	O & M Costs ($M)	Present Worth Costs ($M)
BNR	10	3.00	0.22	
MF	10	6.00	0.70	
RO	10	9.40	2.50	
UV	8.5	0.47	0.02	
Subtotal of improvements at the WWTP		18.87	3.44	
Ozone	17	2.98	0.21	
TOTALS		**21.85**	**3.65**	**76.16**

Figure 4.3 - Treatment Alternative 3



4.4 Alternative 4

Alternative 4 is represented in Figure 4.4. Alternative 4 is similar to Alternative 3, except that a high lime, filtration, and GAC system replaces the MF and RO treatment units. Like alternative 3, most of the treatment is provided at the WWTP. This alternative enhances the overall effluent quality in comparison to alternatives 1 and 2. The WTP side of the system has limited improvements, as discussed under alternative 3.

Since this alternative would result in an increase in TDS, a sidestream TDS removal process is required. For the purpose of this analysis, 15 to 20% of the WTP flow is assumed to be treated by RO. It is estimated that this level of treatment will produce a finished water with a TDS similar to that of the Rio Grande. If a lower TDS is desired, a larger volume of the water could receive RO treatment. Costs for this alternative are shown in Table 4.4.

Figure 4.4 - Treatment Alternative 4

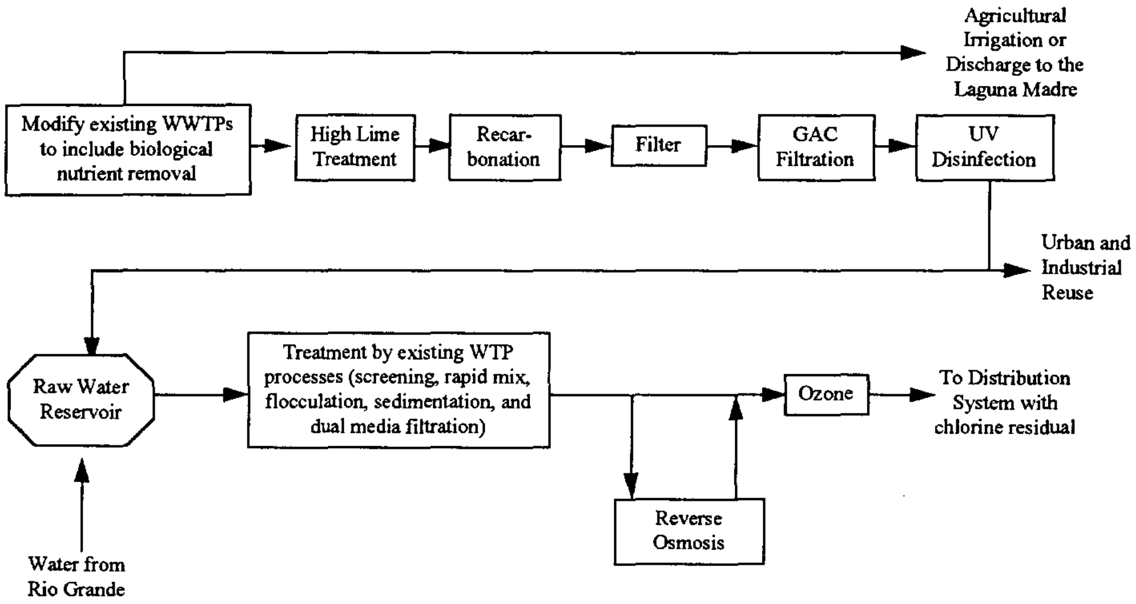


Table 4.4 - Comparative Costs of Treatment Alternative 4

Technology	Flow Rate MGD	Capital Costs ($M)	O & M Costs ($M)	Present Worth Costs ($M)
BNR	10	3.00	0.22	
Lime/Recarb	10	0.50	0.25	
Filter	10	3.00	0.40	
GAC	10	4.90	1.40	
UV	10	0.52	0.03	
Subtotal of improvements at WWTP		**11.92**	**2.30**	
Sidestream RO	3.5	3.68	0.96	
Ozone	20	3.36	0.23	
Subtotal of improvements at WTP		**7.04**	**1.19**	
TOTAL		**18.96**	**3.49**	**70.75**

4.5 Alternative 5

It was suggested that a fifth alternative be considered that provides MF and GAC treatment at the WWTP and sidestream RO and ozonation at the WTP. This appeared to be a cost effective alternative, but the TOC load on the GAC units would be excessive. The resulting biological growth on the GAC filters likely would cause hydraulic plugging unless a very rigorous predisinfection program was followed. In addition, carbon regeneration would be required 4 to 8 times a year. Due to these problems, this alternative was determined to be too costly and infeasible to implement.

4.6 Comparison of Alternatives

The four alternative potable reuse approaches can be compared and judged using four criteria: cost, quality of water produced, waste residuals generated, and land requirements. Figure 4.5 shows how the different treatment alternatives compare on the basis of present worth cost per mgd of reclaimed water. Alternative 2 is clearly the most expensive, while the other alternatives have similar costs. A sensitivity analysis of the different cost factors was made to determine how variations in the estimates impact the selection of treatment systems. The sensitivity analysis showed no changes in the preferred alternatives over the range of probable variations in the cost estimates.

Figure 4.5 - Comparative Present Worth Costs of Treatment Alternatives

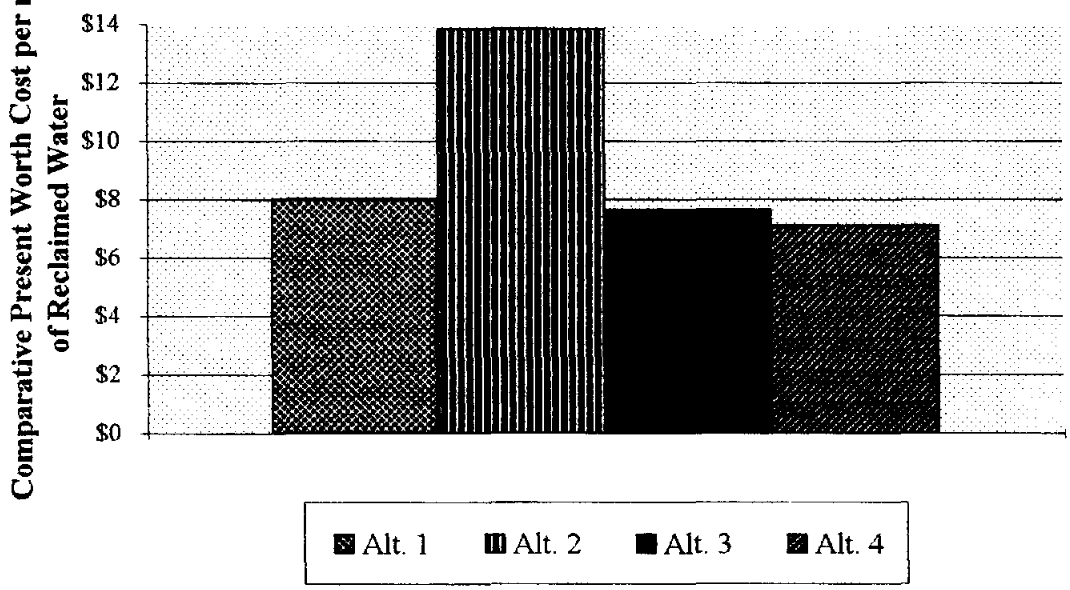


Table 4.5 presents a comparison of the various contaminant barriers and the expected percent removal of categories of contaminants. Table 4.6 shows quantity estimates for the waste residuals generated by each alternative. Table 4.7 shows footprint estimates (land requirements) for the alternatives.

Based on the material presented above, Alternatives 3 and 4 are the preferred options. They produce a high quality water at a reasonable cost. Each has a waste stream that must be managed, brine on the one case and lime sludge on the other. Quantities are less than for alternatives 1 and 2. Which alternative is ultimately used may be a function of how easily these waste streams can be managed.

Table 4.5

TREATMENT ALTERNATIVE COMPOSITE CONTAMINANT BARRIER EFFECTIVENESS

(Percent Removals & Number of Barriers)

Gross Contaminant Category	Alternative No. 1		Alternative No. 2		Alternative No. 3		Alternative No. 4	
Suspended Solids/Turbidity	99.82%	4	99.99%	4	99.99%	4	99.9%	5.5
Total Dissolved Solids	10%	0.1	92.5%	1	92.5%	1	20%	0.2
Biological Oxygen Demand	99.68%	4	99.86%	4	99.99%	4	99.99%	5.5
Total Organic Carbon	95.68%	4	98.79%	4	99.12%	4	98.5%	5.5
Volatile Organic Chemicals	89%	2	89%	2	90.1%	3	92.33%	4
Total Nitrogen	88.38%	2	96.25%	2	96.63%	3	93.36%	3.5
Total Phosphorus	97%	2	97.38%	2	99.8%	3	99.87%	3.5
Radionuclides	91.25%	2	97.38%	2	98.43%	3	97%	3.5
Heavy Metals	87.75%	2	97.38%	2	98.43%	3	95.77%	3.5
Protozoan Cysts	7.4-log	6	11.7-log	6	13.6-log	6	11.4-log	7.5
Bacteria	11.2-log	6	13.6-log	6	16-log	6	15.7-log	7.5
Viruses	10.6-log	6	11.1-log	6	13.4-log	6	15.1-log	7.5

Table 4.6

WASTE RESIDUALS GENERATED BY ALTERNATIVES			
	Waste		
Unit	**Source**	**Quantities**	**Treatment**
Biological Nutrient Removal	Activated Sludge	2,100 dry lb/MG	Thickening, Digestion, Dewatering
Tertiary Filtration	Backwash Wastewater	125 dry lb/MG	Equalization, Decant
UV Disinfection	None		
Lime/Recarbonation	Lime	5,500 dry lb/MG	Thickening, Dewatering
Ozone Disinfection	Off Gas Ozone Residual		Catalytic or Thermal Destruction
GAC Filtration	Backwash Wastewater	125 dry lb/MG in a tertiary filtration application	
		5 dry lb/MG in a post-filter absorber application	
	Spent GAC	Alt. 1 = 2 reactivations/yr. 16,000 dry lb/yr/mgd	Land dispose
		Alt. 4 = 4 reactivations/yr. 32,000 dry lb/yr/mgd	Land dispose
		Alt. 5 = Excessive reactivations/yr.	Excessive disposal
Microfiltration	Backwash Wastewater	250 dry lb/MG	Equalization, Decant
Reverse Osmosis	Concentrate	10 to 15% of	Discharge
Conventional WTP	Coagulant Sludge	200 dry lb/MG	Thickening, Dewatering
	Backwash Wastewater	25 dry lb/MG	Equalization, Decant

Table 4.7

Land Requirements for Alternatives (sf)					
Unit Process	**Footprint (sf/mgd)**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**
Biological Nutrient Removal	5000	50,000	50,000	50,000	50,000
Tertiary Filtration	300	3,000	3,000		
UV Disinfection	40	400	400	400	400
Lime/Recarbonation	1000				10,000
GAC Filtration	300				3,000
Microfiltration	1250			12,500	
Reverse Osmosis	1250			12,500	
Subtotal of Land at WWTP		**53,400**	**53,400**	**75,400**	**63,400**
Lime/Recarbonation	1000	28,000			
Ozone Disinfection	150	4,200		3,000	3,000
GAC Filtration	300	8,400			
Microfiltration	1250		25,000		
Reverse Osmosis	1250		25,000		
Subtotal of Land at WTP		**84,000**	**50,000**	**3,000**	**3,000**
Total New Land Required		**137,400**	**103,400**	**78,400**	**66,400**

5. REUSE ALTERNATIVES FOR EDINBURG AND McALLEN

Four system configurations have been developed for application of potable reuse in the study area. The proposed treatment alternatives can be applied to each configuration for an overall plan of implementation. Each of the configurations is described in the following paragraphs, and preliminary cost estimates have been prepared for the conveyance facilities to allow an overall assessment of reuse feasibility. Facilities are sized for maximum use of reclaimed water in each system.

5.1 Edinburg System

The City of Edinburg is expanding its WWTP to 5.9 mgd and upgrading the plant to provide improved effluent quality. This project will also result in the redirection of effluent to the San Juan Holding Pond. For this study it is assumed effluent will be withdrawn from the San Juan Holding Pond to make use of the natural detention time offered by this arrangement. A reclaimed water flow of 6 mgd is assumed for sizing purposes. A 6 mgd pump station and approximately 25,000 feet of 18" diameter pipeline would convey the reclaimed water to the existing Edinburg Reservoir as shown in Figure 5.1. Due to space restrictions at the Edinburg WTP, some of the treatment alternatives may not be feasible at the existing plant. It may be preferable to construct the additional treatment facilities as part of the WTP No. 2 proposed for construction adjacent to the Edinburg Reservoir. The cost for additional conventional treatment facilities is included for treatment alternative 1 in Edinburg.

5.2 Edinburg/McAllen Regional System

Due to the close proximity of the McAllen WWTP No. 3 to the Edinburg Reservoir, a regional water treatment plant located near the Edinburg Reservoir could accept suitable effluent from both cities, blended with raw water from the Rio Grande, and treat the water to provide an additional source of supply to both cities. It is anticipated the McAllen WWTP No. 3 will soon be expanded to a capacity of 6 mgd. This flow, combined with the 6 mgd assumed available from Edinburg, would make 12 mgd of effluent available. To maintain the 50% limit on effluent in the raw water, a plant size of at least 24 mgd would be needed. To provide detention of the raw water, a 432 million gallon reservoir is assumed, giving an 18 day storage time equal to the detention provided currently by the Edinburg Reservoir. A 6 mgd pump station and approximately 7,000 feet of 18" diameter pipeline would convey effluent from the McAllen WWTP No. 3 to the new reservoir. Conveyance facilities for the Edinburg effluent would be similar to those described for the separate Edinburg System, but the total pipe length is assumed to be 29,500 feet to the new reservoir. The facilities proposed for this system are shown in Figure 5.2.

5.3 McAllen North System

Due to the relative locations of WWTP No. 3 and the main water treatment facility (WTP No. 2), it does not appear practical to use effluent from WWTP No. 3 to supplement raw water to the existing treatment facilities. However, there are plans to locate an additional water treatment plant in the northwest part of the City of McAllen (See Figure 5.3) to provide additional capacity in this rapidly developing area. This plant could readily accommodate supplemental flows from WWTP

No. 3. Assuming a 6 mgd effluent contribution, a minimum water treatment capacity of 12 mgd would be recommended. Similar to the regional system, a new reservoir with a detention time of 18 days (216 million gallons) is proposed. Effluent would be conveyed by a 6 mgd pump station and 19,500 feet of 18" diameter pipeline.

5.4 McAllen South System

As shown in Figure 5.4, the McAllen WWTP No. 2 is located relatively near Boeye Reservoir which provides raw water storage for WTP No. 2. Conveyance of effluent from the 10 mgd plant would require a 10 mgd pump station and approximately 14,500 feet of 24" diameter pipeline. It should be noted that Boeye Reservoir does not provide the duration of storage included in the other systems. This could be mitigated by providing an effluent storage reservoir near WWTP No. 2, but this is not included in the cost estimates provided.

5.5 Evaluation of Alternatives

Table 5.1 lists the conveyance costs associated with each system, based on costs for similar components recently bid in the lower Rio Grande Valley. Table 5.2 and Figure 5.5 show the relative costs of each reuse alternative using treatment system 1, 3 and 4, including the transmission and storage requirements described above. The costs shown in Figure 5.5 also include the cost of providing conventional water treatment capacity for the Regional System, the McAllen North System, and for treatment alternative 1 on the Edinburg System. These options are shown to have substantially higher costs, but result in new capacity for the respective systems. Because of the proposed blending limits, the new capacity proposed (and included in the cost) is double the capacity of effluent reclaimed.

TABLE 5.1
SUMMARY OF CONVEYANCE AND STORAGE COSTS

SYSTEM	REUSE QUANTITY (MGD)	PROBABLE CONSTRUCTION COST			
		PUMP STATION	PIPELINE	RESERVOIR	TOTAL
Edinburg	5	$325,000	$950,000		$1,275,000
	6	$300,000	$950,000		$1,250,000
Regional	10	$600,000	$1,349,000	$4,320,000	$6,269,000
	12	$650,000	$1,349,000	$5,184,000	$7,183,000
McAllen North	5	$325,000	$673,000	$2,160,000	$3,158,000
	6	$300,000	$673,000	$2,592,000	$3,565,000
McAllen South	8.5	$350,000	$616,250		$966,250
	10	$375,000	$616,250		$991,250
SYSTEM	**REUSE QUANTITY (MGD)**	**PROJECTED ANNUAL OPERATION & MAINTENANCE COST**			
		PUMP STATION	**PIPELINE**	**RESERVOIR**	**TOTAL**
Edinburg	5	$66,040	$2,500		$68,540
	6	$92,979	$2,500		$95,479
Regional	10	$110,291	$3,650	$4,320	$118,261
	12	$149,324	$3,650	$5,184	$158,158
McAllen North	5	$57,163	$1,950	$2,160	$61,273
	6	$78,054	$1,950	$2,592	$82,596
McAllen South	8.5	$60,152	$1,450		$61,602
	10	$76,349	$1,450		$77,799

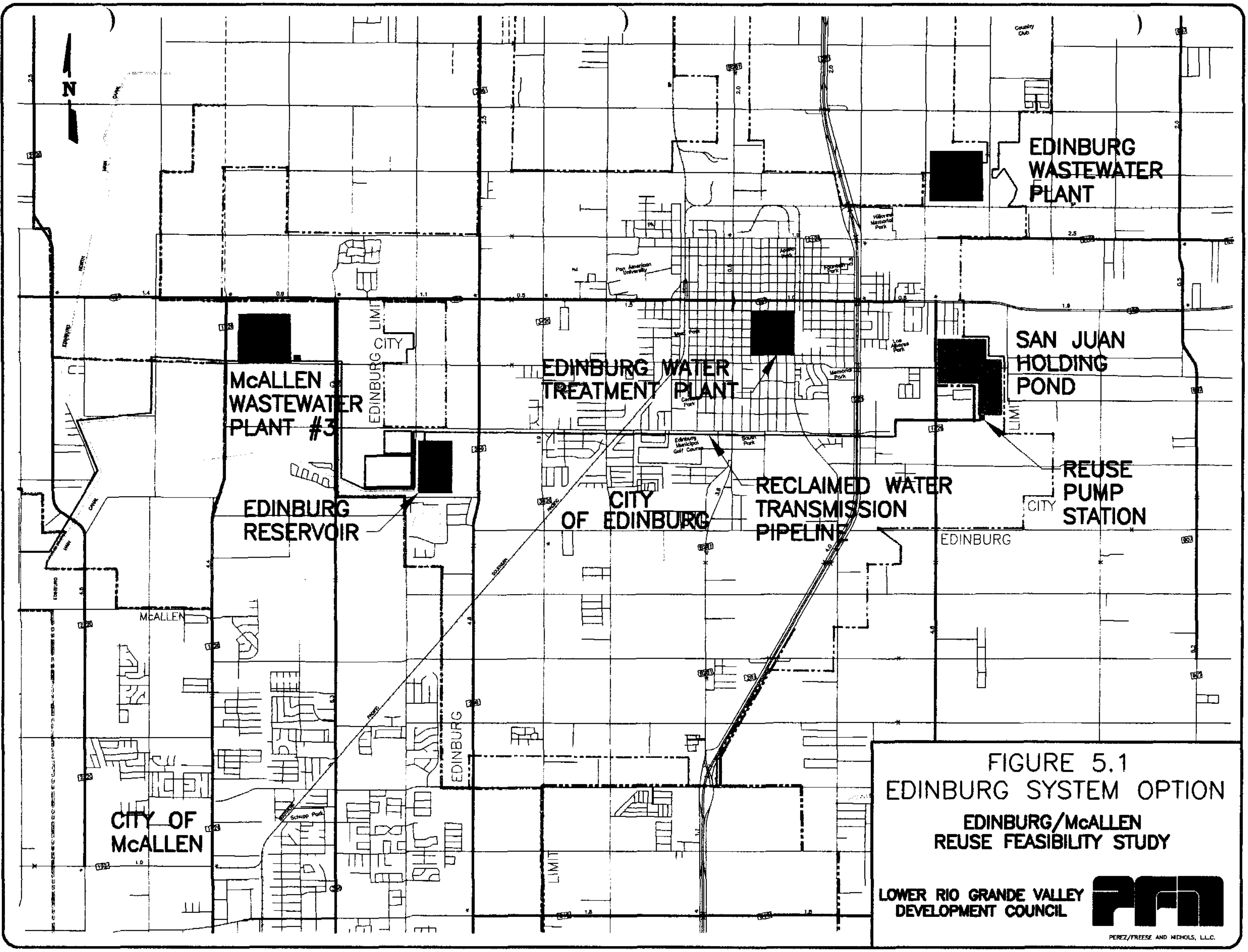


FIGURE 5.1
EDINBURG SYSTEM OPTION

EDINBURG/McALLEN
REUSE FEASIBILITY STUDY

LOWER RIO GRANDE VALLEY
DEVELOPMENT COUNCIL

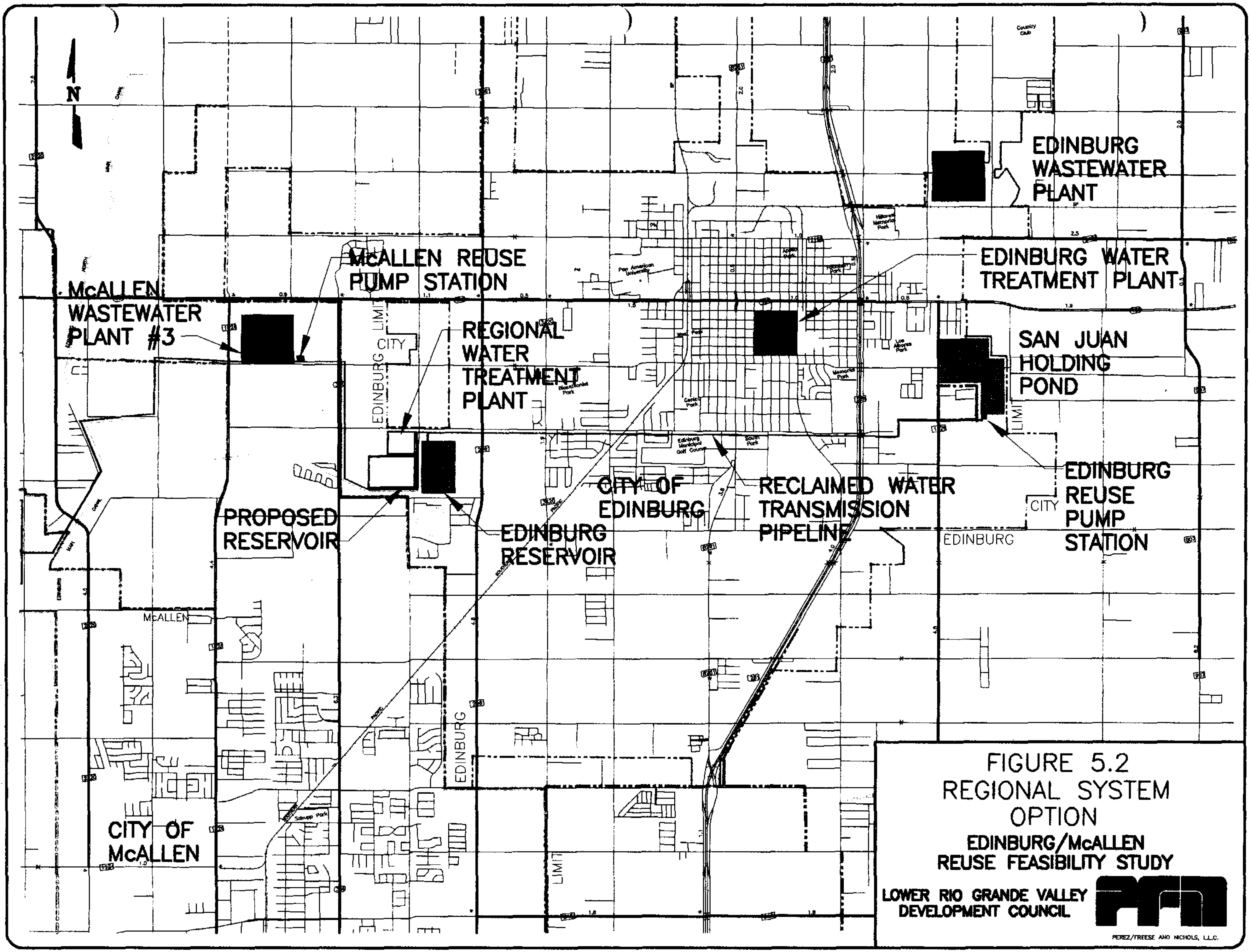


FIGURE 5.2
REGIONAL SYSTEM
OPTION

**EDINBURG/McALLEN
REUSE FEASIBILITY STUDY**

**LOWER RIO GRANDE VALLEY
DEVELOPMENT COUNCIL**

PEREZ/FREESE AND NICHOLS, L.L.C.

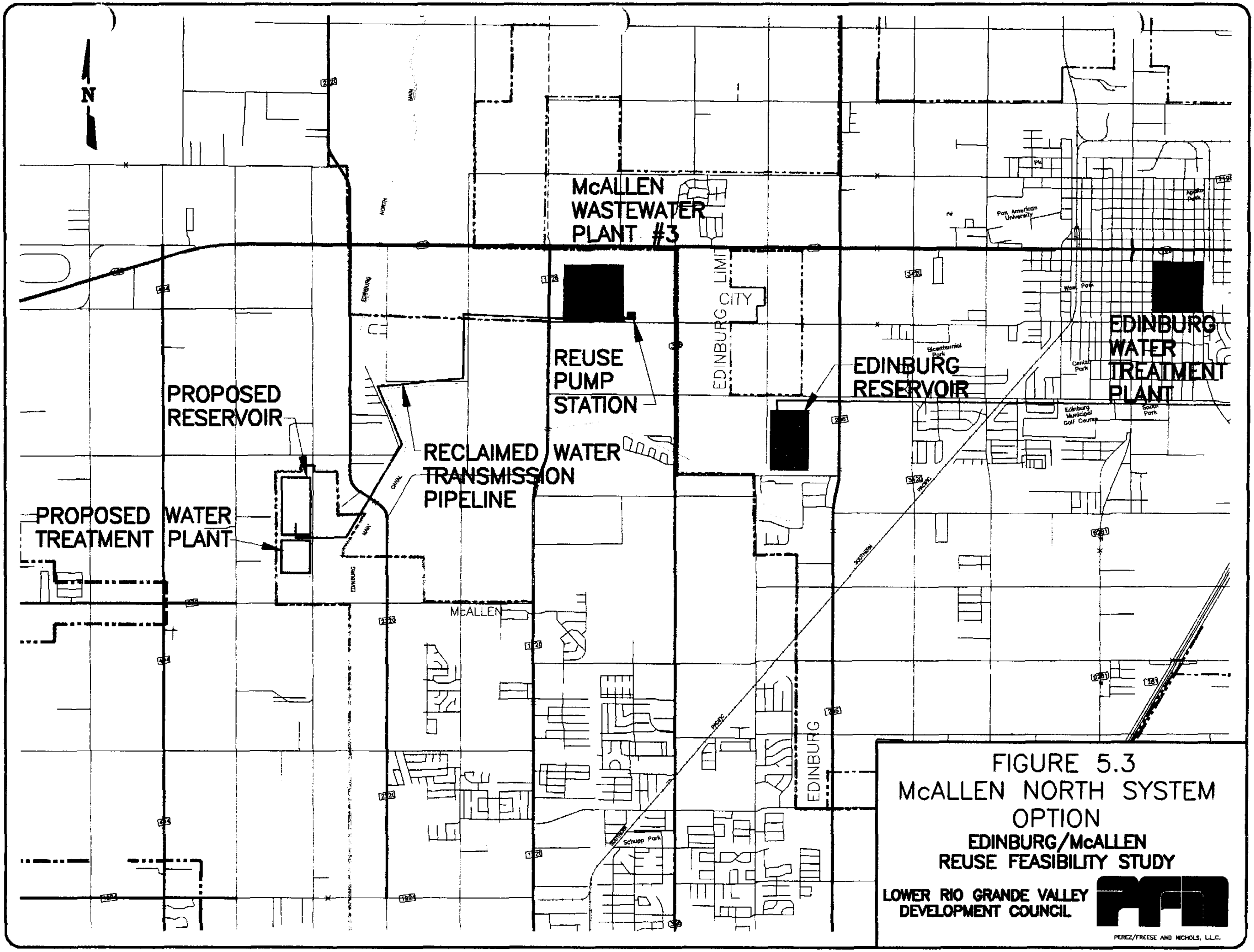


FIGURE 5.3
McALLEN NORTH SYSTEM OPTION

EDINBURG/McALLEN REUSE FEASIBILITY STUDY

LOWER RIO GRANDE VALLEY DEVELOPMENT COUNCIL

PEREZ/FREESE AND NICHOLS, L.L.C.

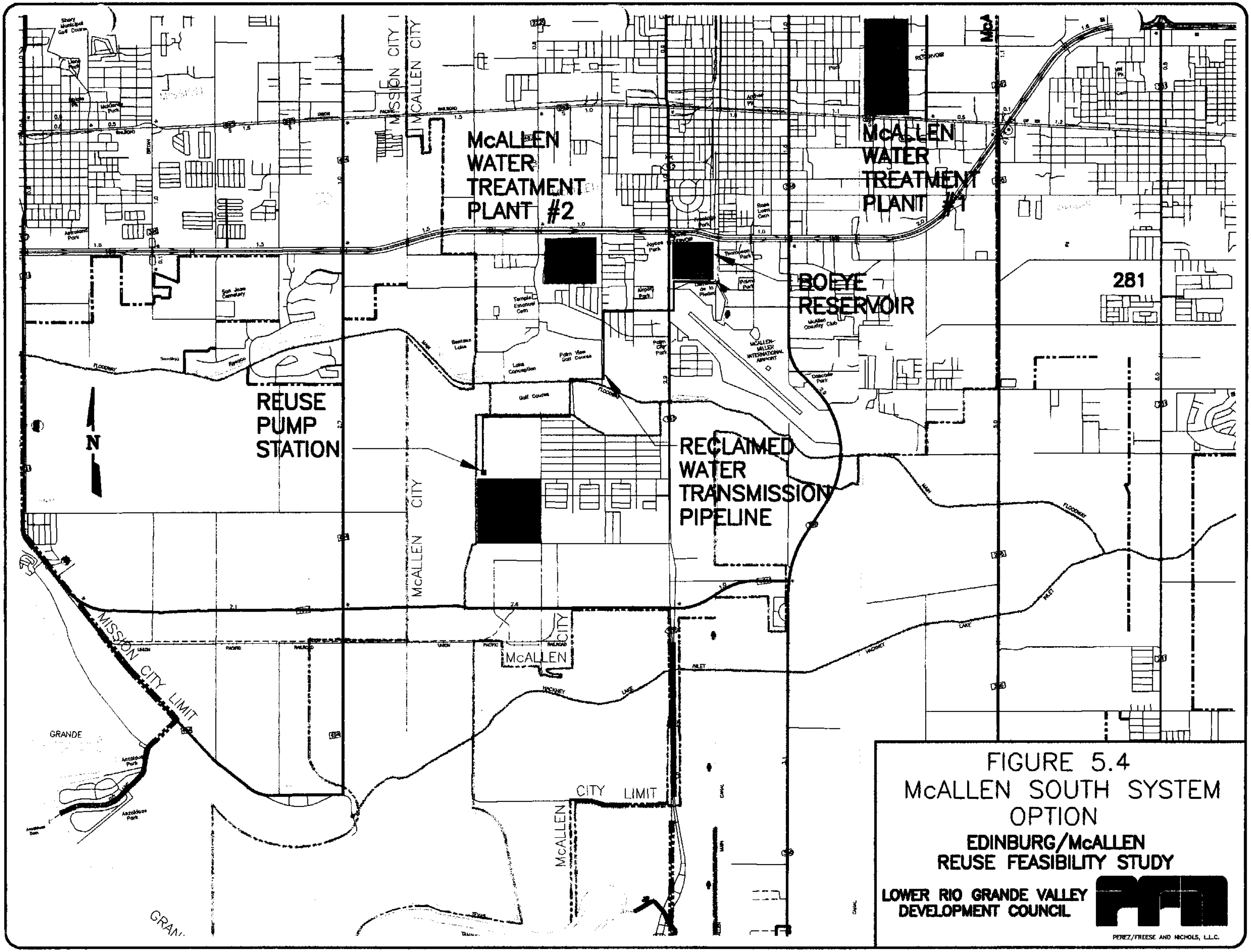


FIGURE 5.4
McALLEN SOUTH SYSTEM OPTION

EDINBURG/McALLEN REUSE FEASIBILITY STUDY

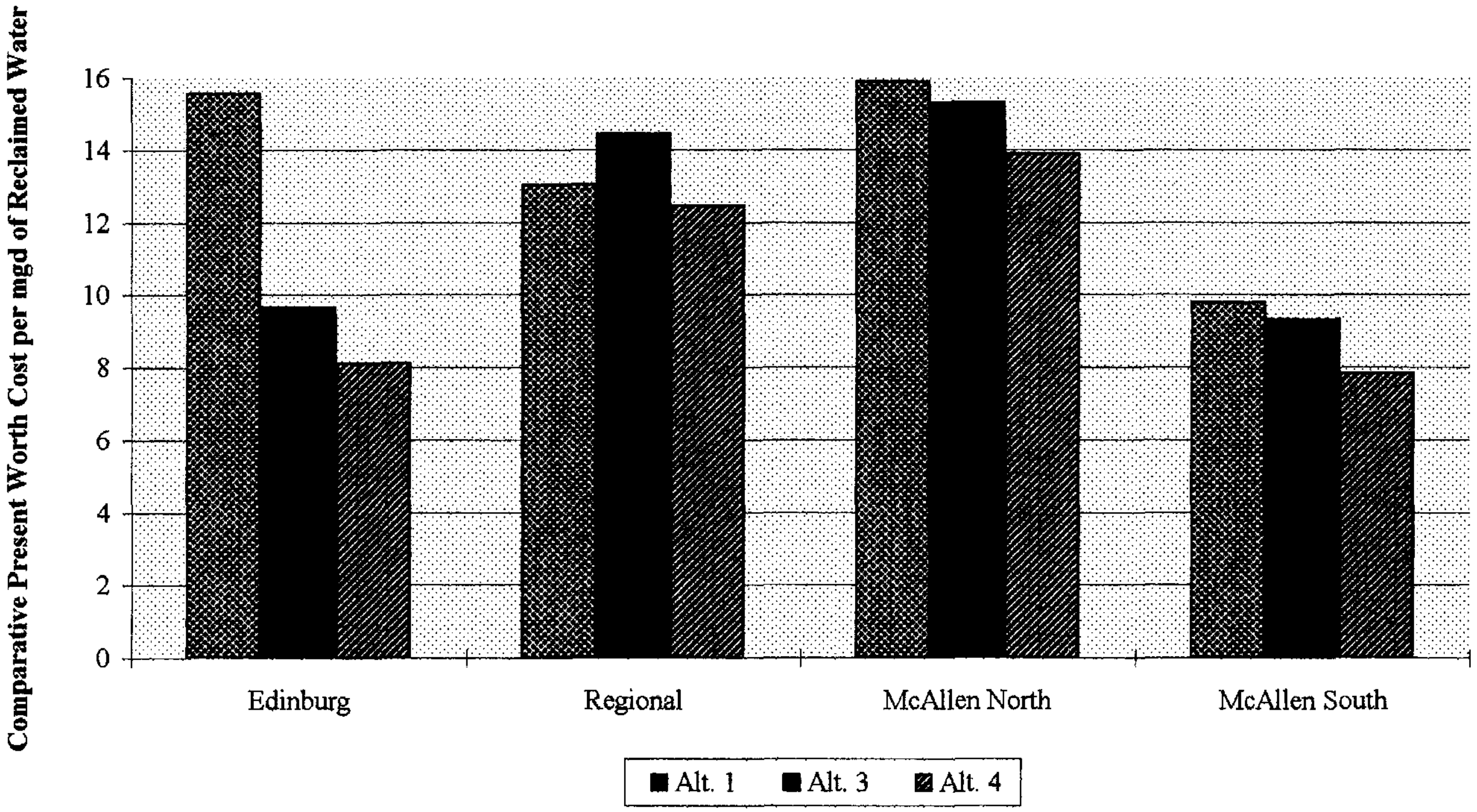
LOWER RIO GRANDE VALLEY DEVELOPMENT COUNCIL

PEREZ/FREESE AND NICHOLS, L.L.C.

Table 5.2
Present Worth Costs of Reuse Alternatives

System	Reuse Quantity MGD	Probable Construction Costs, US$ M				Annual O&M Costs, US$ M				Total Present Worth
		WWTP Impr.	Conveyance	New WTP	WTP Impr.	WWTP Impr.	Conveyance	New WTP	WTP Impr.	
Edinburg										
Alternative No. 1	6.0	$4.28	$1.28	$9.60	$10.78	$0.29	$0.10	$1.53	$2.61	$93.33
Alternative No. 3	5.1	$12.56	$1.25	- - -	$2.00	$2.02	$0.07	- - -	$0.16	$49.28
Alternative No. 4	6.0	$7.06	$1.28	- - -	$4.87	$1.45	$0.10	- - -	$0.84	$48.77
Regional										
Alternative No. 1	12.0	$7.59	$7.18	$19.20	$15.59	$0.49	$0.16	$3.07	$3.47	$156.53
Alternative No. 3	10.2	$21.85	$6.27	$16.00	$3.36	$3.80	$0.12	$2.56	$0.23	$147.31
Alternative No. 4	12.0	$13.45	$7.18	$19.20	$8.08	$2.25	$0.16	$3.07	$1.35	$149.52
McAllen North										
Alternative No. 1	6.0	$4.28	$3.59	$9.60	$10.78	$0.29	$0.08	$1.53	$2.61	$95.35
Alternative No. 3	5.1	$12.56	$3.13	$8.00	$2.00	$2.02	$0.06	$1.28	$0.16	$78.06
Alternative No. 4	6.0	$7.06	$3.59	$9.60	$4.87	$1.45	$0.08	$1.53	$0.84	$83.14
McAllen South										
Alternative No. 1	10.0	$6.52	$0.99	- - -	$20.07	$0.43	$0.08	- - -	$4.21	$97.80
Alternative No. 3	8.5	$18.87	$0.97	- - -	$5.44	$3.22	$0.06	- - -	$0.31	$78.69
Alternative No. 4	10.0	$11.92	$0.99	- - -	$10.19	$2.08	$0.08	- - -	$1.55	$78.30

Figure 5.5 - Comparative Present Worth Costs of Treatment and Reuse Alternatives



6. DETERMINATION OF FEASIBILITY

To determine the feasibility of implementing potable reuse, several factors must be considered, including public health, technical reliability, cost and public acceptance. The development of alternatives which protect public health, using proven technology has been an integral part of this study. Preliminary indications from the Citizens Advisory Committees are that a properly executed reuse project can obtain public acceptance in Edinburg and McAllen. One of the primary objectives of this TM No. 3 is to evaluate the economics of reuse.

6.1 Conventional Supply Costs

The previous sections detail the basis for projected reuse costs. These costs can be compared to the cost of additional conventional water supply. In the lower Rio Grande Valley, the conventional water supply is the Rio Grande River. Since all available rights to Rio Grande water are already allocated, increases can only be obtained by purchasing rights from other users, typically from holders of irrigation rights. Due to the higher priority assigned to municipal rights, 2 acre-feet of Class B irrigation rights must be purchased to obtain each additional acre-foot of municipal water rights. Municipal rights currently may be obtained for approximately $800 per acre-foot. To receive water at the cities' reservoirs through the canal systems operated by the Hidalgo County irrigation districts, the cities must pay pumping charges of $0.1268 per 1000 gallons for Edinburg and $0.08 per 1000 gallons for McAllen. Seepage and evaporation losses (25% for Edinburg and 10% for McAllen) are deducted from each city's available supply. To utilize options for additional water from the United Irrigation District, the City of McAllen will be assessed pumping costs of $0.14 per 1000 gallons and losses of 15%.

The resulting costs for each mgd of additional supply are $0.90 million per mgd capital cost and $0.03-0.05 million per mgd annual cost. Using a discount rate of 3%, an evaluation period of 20 years, and including the loss factors, the present worth cost for purchasing additional Rio Grande water rights is $1.51-2.11 million per net mgd.

6.2 Future Treatment Requirements

It should be noted the scenarios proposed provide a significantly higher level of public health protection than is provided by the current supply and treatment systems. This is consistent with other projects developed for planned potable reuse. This study is not intended to evaluate the level of treatment provided by the existing facilities. However, new drinking water regulations (the Enhanced Surface Water Treatment Rule and the Disinfection-Disinfection Byproducts Rule) are anticipated in the next 3-5 years which likely will result in additional treatment requirements for the cities of Edinburg and McAllen. One strategy for complying with the expected regulations is the addition of ozone disinfection and biologically active GAC filtration. This approach has been determined in some evaluations to be competitive with the use of enhanced coagulation. Adapting the costs developed for the reuse treatment alternatives, GAC and ozone treatment would require $0.50 million per mgd for construction of the additional facilities and have additional annual operation and maintenance costs of $0.10 million per mgd.

Some of the reuse alternatives result in additional treatment capacity as well. To allow appropriate comparison with these alternatives, an allowance for additional treatment capacity should be considered. We estimate conventional treatment capacity to cost approximately $0.80 million per mgd, with operation and maintenance costs of about $0.35 per 1000 gallons. To provide peak capacity for high demand periods, twice the average value of the additional rights should be considered for the additional treatment capacity.

If all the above treatment costs are considered, the additional cost for new supplies of Rio Grande water is $7.85-8.71 million per mgd, or approximately $1.55 per 1000 gallons. If only the incremental costs of treatment improvements are considered (using existing plant capacity), the cost for new supplies is estimated at $3.30-3.74 million per mgd, or about $0.65 per 1000 gallons.

6.3 Conclusions

It is apparent from the above comparison that the Cities of Edinburg and McAllen may purchase additional Rio Grande water at current rates more economically than they can treat wastewater effluent using the scenarios prepared for this study. However, when future additional treatment costs are considered, the differences narrow. For options using existing treatment capacity (Edinburg and McAllen South) reuse costs range from $1.44 to 1.80 per 1000 gallons, compared with conventional costs of approximately $0.65 per 1000 gallons. For options which provide additional treatment capacity (McAllen North and the Regional System) reuse costs range from $2.29 to 2.93 per 1000 gallons, compared with conventional costs of approximately $1.55 per 1000 gallons. These estimates are necessarily based on generalized information which does not apply equally to each situation.

If water rights continue to increase in cost as expected, the option of reuse may become attractive from an economic standpoint. Other considerations should also be noted regarding this subject. It is assumed above that sufficient additional water rights are available at the stated cost to meet the needs of each city. However, recent water shortages have brought this assumption into question. Water rights can only be exercised when sufficient water is available for allocation to the intended users. Low storage levels have already resulted in curtailment of irrigation allotments this year. If water supplies continue to decrease, rationing of supplies could eventually be extended to municipal users as well. It should also be noted the economy in the Lower Rio Grande Valley is highly dependent on agriculture. Excessive conversion of irrigation rights to municipal water supply could eventually affect the area economy.

It appears potable reuse is a feasible alternative for augmenting potable water supplies for the cities of Edinburg and McAllen. Although it currently does not appear to be the lowest cost option, the value of a water source independent of the Rio Grande River makes this option worth further study. An implementation plan which includes specific recommendations for subsequent research will be included in the final report.